## Chapter 1

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# CHAPTER 1

# Basic Botany, Physiology, and Environmental Effects on Plant Growth

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In order to gain a working knowledge of horticulture, it is necessary to understand the life cycles of plants, their various structures and how they function, and how plants develop in reaction to the environment.

### **Gymnosperms and Angiosperms**

Nearly all of the plants we use in horticulture are vascular plants. Vascular plants contain tissues which transport water and dissolved materials. The vascular system may be likened to the circulatory system in animals, or the plumbing in your house.

A few of these plants, like ferns and horsetails, do not produce seed. They reproduce by spores. The vast majority of vascular plants do produce true seed; these can be further divided into two large groups: **gymnosperms** and **angiosperms**.

Gymnosperms and angiosperms are similar in many ways: they photosynthesize, or produce sugars; they have vascular systems to transport water, minerals and other materials; and they reproduce by seed. But they vary in some important ways.

Gymnosperms do not have true flowers, and although they produce seeds, the seeds are not enclosed in fruits. Most of the gymnosperms we use in horticulture produce their seeds in cones. Examples are pine, spruce, cedar and juniper. A surprising member of this group is the ginkgo. Angiosperms produce flowers and develop fruits that contain seeds. This group can be further divided into **monocotyledons** (monocots) and **dicotyledons** (dicots). Monocots and dicots differ in a number of ways:

- 1. **Monocots produce one cotyledon,** or seed leaf, when they emerge from seeds while **dicots produce two cotyledons**;
- 2. Monocot flower parts are generally in multiples of three (for example, tulips have six "petals") while dicot flower parts are generally in multiples of four or five (for example, a rose has petals in multiples of five).
- 3. Monocot leaves are long and narrow with **parallel veins** (for example, corn and bermuda grass) while dicots have variously shaped leaves with **netted veins** (as found in maples and cucumbers).
- 4. The internal root, leaf, and stem structures vary significantly between monocots and dicots (see section on stems).

In this introductory chapter, we are focusing on Angiosperms, or flowering plants.

## Life Cycles

Flowering plants can be classified by the number of growing seasons required to complete their life cycle. **Annuals** pass through their entire life cycle from seed germination to seed production in one growing season, and then die. Examples include marigold, zinnia, calendula, cucumber and tomato. Some annuals like pansy are called winter annuals, because they germinate in fall, overwinter, produce seed in spring, and then die. Plants like impatiens are perennial in their native tropical habitats, but we can use them in colder regions as if they were annuals.

**Biennials** are plants which start from seeds and produce vegetative structures (usually only foliage) and food storage organs (roots) the first season. During the first winter, the plant is **vernalized**. That is, it is stimulated to produce reproductive structures during the following growing season. In the second season, flowers, fruit, and seeds develop to complete the life cycle, and the plant dies. Carrots, beets, cabbage, celery, onions, hollyhock, foxglove, and sweet william are all biennials.

Plants which are botanically classified as biennials may, in some cases, complete their life cycle in only one growing season. This situation occurs when drought, variations in temperature, or other climatic conditions cause the plant to physiologically pass through the equivalent of two growing seasons, in a single growing season. This phenomenon is referred to as **bolting**. Also, some specific biennials, like 'Foxy' foxglove, act as annuals because they have been specifically bred to do so.

**Perennial** plants live for three or more years. Once they reach maturity, they generally produce flowers and seeds each year. Perennials are called herbaceous if their top dies back to the ground each winter and new stems grow from the roots each spring. Most of our flower garden perennials are herbaceous. Trees and shrubs are classified as woody perennials, since their top growth persists and develops woody tissue.

### **Principal Parts of Vascular Plants**

The parts of a plant can be divided into two groups; **vegetative parts** and **sexual reproductive parts**. The vegetative parts include the stems, leaves, leaf buds and roots. Sexual reproductive parts are those involved in the production of seed: flower buds, flowers, fruits, and seeds.



### **Principle Parts of a Vascular Plant**

### Roots

A thorough knowledge of plant root systems is essential in order to understand plant growth, flowering, and fruiting. The structure and growth habits of roots have a pronounced effect on the size and vigor of plants, method of propagation, adaptation to certain soil types, and response to cultural practices and irrigation.

Roots typically form the below-ground portion of a plant. They are characterized by the presence of a **root cap**, and the absence of nodes, internodes, buds, leaves and flowers. The principal functions of roots are to **absorb nutrients and water**, to **anchor the plant** in the soil, to furnish **physical support** for the stem, and to serve as **food storage** organs. In some plants, they are used for propagation.

### **Types of Roots**

The **radicle**, or seedling embryo root, develops into one of two major types of root systems: **taproot** or **fibrous**. In taprooted plants, the radicle develops into a central, often fleshy root which continues to elongate downward into the soil. A taproot becomes the central and most important feature of such a root system, with a rather limited amount of secondary branching. Some trees, especially nut trees like pecan, have a long taproot with very few lateral or fibrous roots. This makes them difficult to transplant and necessitates planting only in deep, well-drained soil. Taproots are the principal edible parts of carrot, parsnip and salsify. Most herbaceous dicots have taproots, often with many branching lateral roots. One factor which causes shrubs and dwarf trees to remain smaller than standard trees is the lower activity of the cambium tissue in the lateral roots.

If plants that normally develop a taproot are undercut so that the taproot is severed early in the plant's life, the root loses its taproot characteristic and develops a lateral root system. This is done commercially in nurseries so that trees, which naturally have taproots, will develop a compact, root system. This allows a higher rate of transplanting success.

A fibrous root system develops on plants whose primary root ceases to elongate, leading to the development of numerous secondary roots, which branch repeatedly and form a wide-spreading root system. Most herbaceous monocots (like grasses) have fibrous root systems. Fibrous roots remain small in diameter because of a lack of cambial activity.

 Taproot of Carrot
 Fibrous Root of Grass

The quantity and distribution of plant roots influence a plant's absorption of moisture and nutrients. The depth and spread of roots depends on the inherent growth characteristics of the plant and physical characteristics of the soil. Roots penetrate much deeper in a loose, well-drained soil than in a heavy, poorly-drained soil. A dense, compacted layer in the soil restricts or even stops root growth.

During early development, a seedling absorbs nutrients and moisture from just the few inches of soil surrounding it. Therefore, the early growth of most horticultural crops which are seeded in rows benefits from band applications of fertilizer, placed a few inches to each side and slightly below the seeds, and irrigation in the zone immediately around the young plant.

As plants become established, lateral or feeder root systems develop laterally and usually extend far beyond the spread of the branches. For most cultivated crops, roots meet and overlap between the rows. The greatest concentration of feeder roots occurs in the top 12 inches of soil, but significant numbers of lateral roots may grow downward from these roots to provide an effective absorption and anchoring system several feet deep.

### Parts of a Root

A growing root has four major sections: the **root** cap, the root tip or meristem, the zone of elongation and the maturation zone. The root cap, outside the very tip of the root, consists of cells that are sloughed off as the root grows through the soil. The root cap covers and protects the meristem (root tip), which manufactures new cells. The meristem is an area of cell division and growth. Behind it is the zone of elongation, in which cells increase in size through food and water absorption. These cells, by increasing in size, push the root through the soil. In the maturation zone, cells change into specific tissues such as epidermis, cortex, and vascular tissue. The epidermis, or outermost layer of cells surrounding the root, is responsible for taking up water and minerals. Root hairs are specialized epidermal cells which perform much of the water and nutrient uptake. **Cortex cells** move water from the epidermis into the middle of the root, and also serve as a site of food storage. Vascular tissue, located in the center of the root, conducts water and nutrients upward, and synthates downward.

**Root Structure** Endodermis (Casparian strip) Pericycle Phloem Cambium Xvlem Primary Xylem Zone of Maturation Root Ha Cortex Epidermis Primary Xylem and Phloem Cortex Cells (Food storage) Zone of Elongation Cell Division (Mitosis) Meristematic Zone Root Tip Root Cap

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### **Roots as Food**

Some plants such as dahlia and the sweet potato produce underground storage organs called **tuberous roots**. They are true roots, not stems, and have neither nodes or internodes.

Carrot, parsnip, salsify, and radish are elongated taproots.

### Stems

A stem is the main axis of a plant. Stems generally extend upward, and often produce secondary stems called branches. In some plants, stems are horizontal at ground level, and some plants even produce underground stems. A stem can be differentiated from a root because all stems have **nodes** and **internodes**, while roots do not. A node is the region of stem where leaves are attached. The region between two nodes is called an internode.

#### Parts of a Stem



The length of an internode depends on many factors. Decreasing fertility can decrease internode length. Too little light can result in a long internode, creating a "spindly" plant. This situation is known as **etiolation**. Growth produced early in the season has the greatest internode length. Internode length decreases as the growing season nears its end. Vigorously growing plants tend to have greater internode lengths than less vigorous plants. Internode length varies with competition from surrounding stems or developing fruit. If the energy for a stem has to be divided among three or four stems, or if the energy is diverted into fruit growth, internode length is shortened.

Stems help us define a plant's habit. A tree is a perennial woody plant, generally with one main stem called a trunk, and generally over 25 feet tall at maturity. A shrub is a perennial woody plant with one or more main stem, generally less than 25 feet tall at maturity. Vines, which may be annual or perennial, develop long, trailing stems that grow along the ground unless they are supported by another plant or structure. Some twining vines circle their support clockwise (hops and honeysuckle) while others circle counter-clockwise (pole beans and Dutchman's pipe vine). Climbing vines support themselves with aerial roots (English ivy and poison ivy), slender tendrils which encircle the supporting object (cucumber, gourds, grapes, and passion-flowers), or tendrils with adhesive tips (Virginia creeper and Japanese creeper).

In addition to giving plants their characteristic form (upright, prostrate, shrubby, etc.), stems support buds and leaves, and serve as conduits for carrying water, minerals, and sugars. Inside the stem is the vascular system, which transports food, water and minerals and offers skeletal support for the plant. The vascular system is composed of two types of complex tissue - xylem and phloem. Xylem tissue conducts water and minerals up from the roots, while phloem conducts synthates manufactured in the plant to wherever they are needed.

In monocots, the vascular tissues form individual bundles of paired xylem and phloem. These bundles are scattered throughout the simple, undifferentiated ground tissue that fills the stem.

In dicots, individual bundles are arranged in a ring, with xylem towards the inside and phloem towards the outside. In young dicots, the individual bundles are still discreet. In older plants, the bundles merge to form continuous bands of xylem and phloem.

The central core of a dicot stem is filled with simple pith tissue. The space between the epidermis and the vascular bundles is filled with simple cortex tissue.

In older dicot stems, the bands of xylem and phloem are separated by a thin band of cells known as the vascular cambium. This is a lateral meristem (site of cell division and active growth), and is responsible for the increase in stem girth in woody dicots.

Towards the inside of the vascular cambium, new xylem (or wood) cells are formed each year, contributing to the formation of countable "rings" in the cross-section of a tree. Towards the outside of the vascular cambium, new phloem cells are formed each year, but these layers are very thin and cannot be easily distinguished as rings.

As a woody plant ages, the oldest phloem mingles with cork and bark and may eventually be removed from the tree. The oldest xylem becomes the central heartwood of the tree. This difference in vascular systems is of practical interest to horticulturists because certain herbicides are specific to either monocots or dicots. An example is 2,4-D, which kills dicots but not monocots.



### **Texture and Growth of Stems**

Many **woody** stems have a central region called **pith.** Surrounding this pith, most of the girth of woody stems is called wood, which is composed of rings of dead xylem tissue. Generally, one ring of xylem is added to the wood per year; by counting the rings we can estimate the age of a woody stem. Fruit trees and ornamental trees and shrubs are examples of plants with woody stems.

A cane is a stem which has a relatively large pith, and usually lives only one or two years. Examples of plants with canes include rose, grape, and raspberry.

While the potential for cambial activity in many herbaceous dicots does exist, those annuals and perennials that are sensitive to cold temperatures will not experience any increase in stem girth. Their above-ground vegetative parts are destroyed every fall and new herbaceous shoots must develop each spring. Of the angiosperms, only woody dicots (trees and shrubs) grow in stem diameter.

Monocots, however, have no vascular cambium at all and; therefore, no potential for increased girth or "woodiness". They are always herbaceous.

Stems may be long, with great distances between nodes (branches of trees, runners on strawberries), or compressed, with short distances between nodes (fruit spurs, crowns of strawberry plants, dandelions). Stems can be above the ground like most stems with which we are familiar, or below the ground (potato tubers, Siberian iris rhizomes). All of these various stems have one thing in common: they have nodes divided by internodes.

### **Diversified Stem Development**

**Modified Stems**. Although typical stems are aboveground trunks and branches, modified stems can be found both above and below ground. The aboveground modified stems are crowns, stolons, and spurs. Below-ground stems include bulbs, corms, rhizomes, and tubers.

#### Above-ground stem modifications:

**Crowns** (strawberries, dandelions, African violets) are compressed stems with short internodes.

A **stolon** is a horizontal stem that lies along the top of the ground. Strawberries and spider plants have runners, or stolons. The leaves on strawberry runners are small, but are located at the nodes, which are easy to see.

A **crown**, found on many herbaceous perennials, is a region of compressed stem tissue from which new shoots are produced, generally found near the surface of the soil.



A **runner**, or stolon, is a specialized stem at soil surface that forms a new plant at one or more of its nodes.

Spurs are short, stubby, side stems that arise from the main stem and are common on such fruit trees as pears, apples and cherries, where they may bear fruit. If severe pruning is done close to fruit-bearing spurs, the spurs can develop into long, non-fruiting stems.



#### **Below-ground stems:**

The **tuber**, like any other stem, has nodes that produce buds. The eyes of potato are actually the nodes on the stem. Each eye contains a cluster of buds.



A tuber is an enlarged portion of an underground stem.

**Rhizomes** are specialized stems which grow horizontally at or just below the soil surface. Some rhizomes are compressed and fleshy such as those of iris; they can also be slender with elongated internodes such as quackgrass. Quackgrass, or witchgrass, is a noxious weed principally because of the spreading capability of its rhizomes.

Rhizome

Stolon



Tulips, lilies, daffodils, and onions produce bulbs: shortened, compressed, underground stems surrounded by fleshy scales (leaves) that envelop a central bud located at the tip of the stem. If you cut through the center of a tulip or daffodil bulb in late fall, you can see all the flower parts in miniature within the bulb. Many bulbs require a period of low-temperature exposure before they begin to send up new growth. Both the temperature and length of this treatment are critical.



A bulb is composed of a short stem plate, closely spaced buds and fleshy leaves. Lilies and onions are bulbs.

**Corms** are somewhat similar to bulbs, but do not have fleshy scales. A corm is a solid, swollen stem whose scales have been reduced to a dry, leaf-like covering.



A corm, as in gladiolus and crocus, is compressed stem with reduced scaly leaves.

#### Stem Use

Stems can be used for **plant propagation.** Aboveground stems can be divided into sections with internodes and nodes. These sections are called **stem cuttings**; they produce roots to form a new plant when treated properly. Below-ground stems are also good propagative tissues: rhizomes can be divided into sections; small bulblets form at the base of mature bulbs; cormels form under mature corms; and tubers can be cut into pieces containing eyes, or nodes with buds. Stems are used as **food**. The edible portions of asparagus and kohlrabi are stem tissue. The edible parts of broccoli are composed of stem tissue, flower buds, and small leaves. The edible part of white potato is a fleshy underground tuber. Although the name suggests otherwise, the edible part of the cauliflower is proliferated stem tissue.

### Leaves

The primary function of leaves is to photosynthesize, or capture energy from the sun and convert it to sugars for later use. Leaves are green because they contain chlorophyll, the green pigment involved in photosynthesis. They are generally broad, to intercept a maximum amount of sunlight.

### Parts of a Leaf

The blade of a leaf is the expanded, thin structure on either side of the **midrib** or main vein. The **blade** is usually the largest and most conspicuous part of a leaf. The **petiole** is the stalk which supports the leaf blade. The base of the petiole is attached to the stem at a **node**. The small angle formed between the petiole and the stem is called the **leaf axil**. A bud or cluster of buds is usually located in the axil. The petiole is absent in some leaves, in which case the leaf is described as **sessile**, and is attached directly to the stem.



The leaf blade is composed of several layers. On the top and bottom is a layer of protective cells called the **epidermis**. Some leaves have **hairs** that are an extension of epidermal cells. The African violet has so many hairs that the leaf feels velvety.

Covering the epidermis is the **cuticle**, which is composed of a waxy substance called **cutin** that protects the leaf from dehydration and prevents penetration of some diseases. Leaves grown in higher light intensity have a thicker layer of cuticle than leaves grown in less light. When plants are moved from shade to sun, they should be moved gradually in order to allow more cuticle to develop, to protect the leaves from the shock of rapid water loss or sun scald. The waxy cuticle also repels water and can shed pesticides if spreader-sticker agents are not used (many pesticide formulations contain an additive that promotes the product's penetration of the cuticle).

On the underside of leaves, some pairs of epidermal cells surround openings to the interior of the leaf. These **guard cells** regulate the passage of water, oxygen, and carbon dioxide through the leaf through the openings, called **stomates**. The opening and closing of stomates is determined mostly by the weather. Conditions that cause large water losses from plants (high temperature, low humidity) stimulate guard cells to close. Mild weather conditions promote opening of stomates.

The middle layer of the leaf, the **mesophyll**, is located between the upper and lower epidermis. This is the layer in which photosynthesis occurs. The mesophyll is divided into a dense upper layer, called the **palisade**, and a lower layer, called the **spongy** layer, that contains much air space. The cells in these two layers contain chloroplasts which are the actual site of the photosynthetic process.

Leaf Parts



### **Types of Leaves**

A number of rather distinct types of leaves occur on plants. Leaves, commonly referred to as foliage, are the most common and conspicuous and, as previously stated, serve as the manufacturing centers where the photosynthetic activity of the plant occurs. Scale leaves are found on rhizomes and are also the small, leathery, protective leaves which enclose and protect buds. Seed leaves, or cotyledons, are modified leaves which are found on embryonic plants in seeds, and commonly serve as storage organs. **Spines** and **tendrils**, as found on barberry and pea respectively, are specially modified leaves which protect the plant or assist in supporting the stems. Storage leaves, found in bulbs and succulents, serve as food storage organs. Other specialized leaves include **bracts**, which are often brightly colored. The showy structures on dogwoods and poinsettias are actually bracts, not petals.

### **Venation of Leaves**

The vascular bundles from the stem extend through the petiole and spread out into the blade. The term **venation** refers to the patterns in which veins are distributed in the blade. Two principal types of venation are **parallel-veined** and **net-veined**.

Parallel-veined leaves are those in which numerous veins run essentially parallel to each other. The most familiar type of parallel veining found in plants of the grass family where the veins run from the base to the apex of the leaf. Another type of parallel-venation is found in plants such as banana, calla, and pickerel-weed, in which the parallel veins run laterally from the midrib. **All of these parallelveined plants are monocots.** 

Net-veined leaves, also called reticulate-veined, have veins which branch from the main rib and subdivide into finer veinlets which spread in a complicated network. This system of veins gives the leaf more resistance to tearing than most parallelveined leaves. Net-venation may be either pinnate or palmate. In pinnate (feather-like) venation, the veins extend laterally from the midrib to the edge, as in apple, cherry and peach. In palmate venation, like grape and maple leaves, the principal veins extend outward like the fingers of a hand from the base of the leaf blade. **Net-veined leaves occur in dicots.** 



### Leaves as a Means of Identifying Plants

Leaves are useful in identifying species and varieties of horticultural plants. The shape of the leaf blade and the type of margin are important as identifying characteristics. Simple leaves have one single blade. Compound leaves have several separate blades, called leaflets, arising from the same petiole.



Simple

Palmate Compound





Pinnate Compound

Double Pinnate Compound

A deeply lobed leaf may appear to be a compound leaf, but if the leaflets are connected by narrow bands of blade tissue, it is classified as a simple leaf (for example, marigold, dahlia and tomato). If the leaflets have separate stalks and, particularly, if these stalks are jointed at the point of union with the main leaf-stalk, the leaf is called compound (for example, honey locust and pea shrub). Some leaves may be doubly compound, with the leaflets divided into secondary leaflets.

Leaflets do not have axillary buds at the base of their stalks. Only leaf petioles have axillary buds. If axillary buds are not present, you are probably looking at a leaf<u>let</u> - not a leaf.

### Shape of the Leaf Blade

The following are some common shapes which are found in leaves and leaflets.

Linear:	Narrow; several times longer than wide; approximately the same width throughout.
Lanceolate:	Longer than wide; tapering toward the apex and base.
Elliptical:	2 or 3 times longer than wide; tapering to an acute or rounded apex and base.
Ovate:	Egg-shaped; basal portion wide; tapering toward the apex.
Cordate:	Heart-shaped; tapering to an acute

apex, with the base turning in and forming a notch where the petiole is attached.



### Shape of the Blade Ends

The following are common shapes of the leaf tip (apex) and leaf base (point where leaf joins to petiole).

Acuminate:	Tapering to a long, narrow point.
Acute:	Ending in an acute angle, with a sharp, but not acuminate, point.
Obtuse:	Tapering to a rounded edge.
Sagittate:	Arrowhead-shaped, with two pointed lower lobes.
Truncate:	Having a relatively square end.



### Leaf Margins

Variations in leaf margins help in distinguishing closely related plants.

Entire:	Smooth, with no teeth or notches.
Serrate:	Having small, sharp teeth pointing toward the apex.
Dentate:	Having teeth ending in an acute angle, pointing outward.
Crenate:	Having rounded teeth.
Sinuate:	Having a pronounced sinuous or wavy margin.
Incised:	Having sharp, deep irregular teeth or incisions.
Lobed:	Having incisions that extend less than halfway to the midrib.
Cleft:	Having incisions that extend more than halfway to the midrib.

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Incised Lacerate Pectinate Ciliate Lobed Cleft Parted

#### Leaf Arrangement Along a Stem

The various ways leaves are arranged along a stem are also used to help identify plants. A rosulate arrangement is one in which the basal leaves form a rosette around the stem with extremely short nodes. Opposite leaves are positioned across the stem from each other, two leaves at each node. Alternate or spiral leaves are arranged in alternate steps along the stem with only one leaf at each node. Whorled leaves are arranged in circles along the stem, with three or more leaves at each node.

#### **Types of Leaf Arrangement**



#### Leaves as Food

The leaf blade is the principal edible part of several horticultural crops including chive, collard, dandelion, endive, kale, lettuce, cabbage, parsley, spinach, and Swiss chard. The edible parts of leek and Florence fennel are clusters of fleshy leaf bases. The edible bulbs of onions and scallions are primarily leaf tissue. The leaf petiole is the edible portion of celery and rhubarb.

### **Buds**

A bud is an undeveloped shoot from which embryonic leaves or flower parts arise. Our temperate zone trees and shrubs typically develop a protective outer layer of small, leathery, bud scales on those buds that overwinter, while our annuals and herbaceous perennials have naked buds in which the outer leaves are green and somewhat succulent.

Overwintering buds of many perennial plants require exposure to a certain number of days below a critical temperature before they can resume growth in the spring. This dormancy period varies for different plants. The flower buds of forsythia require a relatively short cold period, and resume growth in early spring. Many peach varieties require from 700 to 1,000 hours of temperatures below 45 degrees F (7 degrees C) before they resume growth. During this dormancy period, fully dormant buds can withstand very low temperatures, but after the dormancy requirement is satisfied, buds become more susceptible to weather.

**Lateral buds** are located on the sides of the stem. Most lateral buds arise in leaf axils, and are called **axillary buds**. In some instances, more than one bud is formed. Adventitious buds are those which arise at sites other than the stem apex or leaf axil. Adventitious buds may develop at stem internodes; at the edge of leaf blades; from callus tissue at the cut end of stems or roots; or in a plant's root system.



### **Buds as Food**

Enlarged buds or parts of buds form the edible portion of some horticultural crops. Cabbage and head lettuce are examples of unusually large terminal buds. Succulent axillary buds are the edible parts of Brussels sprouts. In the case of globe artichoke, the fleshy basal portion of the bracts of the flower bud are eaten along with the solid stem portion of the bud. Broccoli is the most important horticultural plant in which edible flower buds are consumed (along with portions of the stem and small leaves).

### **Flowers**

Flowers, generally the showiest parts of plants, are important in sexual reproduction. Plants that are pollinated by insects, bats and other animals are often ornamental and fragrant in order to attract pollinators. Plants that are pollinated by wind or rain are generally not as showy (for example, corn).

### Parts of the Flower

As the reproductive part of the plant, the flower contains the **male pollen grains** and/or the **female ovules**, plus accessory parts such as **petals**, **sepals**, **and nectarglands**.

The **perianth** is composed of the **calyx** and the **corolla**. The calyx is divided into **sepals**, which are small, often green, leaf-like structures at the base of the flower. Sepals protect the flower when in bud.

The corolla is divided into petals, which are often highly colored. The shape, arrangement and number of flower petals is useful in identifying plants. Flowers of dicots typically have sepals and/or petals in multiples of four or five. Monocot flowers typically have these parts in multiples of three.

The **pistil** is the female part of the plant. It is in the center of the flower, and consists of the **stigma**, **style**, and **ovary**. The stigma, a sticky structure located at the top of the pistil, receives pollen during pollination. The pollen then grows down through the tubelike style to the ovary, which contains the ovules, or eggs.

The **stamen** is the male reproductive organ. It consists of an **anther** (pollen sac) on top of a threadlike **filament**, which holds the anther in position so the pollen it contains may be dispersed by wind or carried to the stigma by insects or other pollinators.

#### Parts of the Flower



### **Types of Flowers**

Flowers that have a stamen, pistils, petals, and sepals are called **complete** flowers. If any of these parts are missing, the flowers are designated **incomplete**. For example, anemones do not have petals (the showy parts are actually sepals), and are called incomplete flowers.

Most flowers have functional stamens and pistils, and are referred to as **perfect** flowers. Flowers lacking either stamens or pistils are called imperfect. In other words, perfect flowers are both male and female, while imperfect flowers are either male or female. Pistillate (female) flowers possess a functional pistil but lack stamens. **Staminate** (male) flowers have stamens but no pistil. Plants in which pistillate and staminate flowers occur on the same plant are called **monoecious**; examples are begonia and corn. Plants in which pistillate and staminate flowers occur on separate plants are called **dioe**cious; examples are holly and yew. Since hollies are dioecious, and both male pollen and female ovules are required to produce the berry fruits, both a male holly and a female holly must be planted into a landscape in order to obtain fruit. Some plants bear only male flowers at the beginning of the growing season, but later develop flowers of both sexes; examples are cucumbers and squash.

### Flowers and Plant Classification

Plants can be placed in a hierarchy based on how closely they are botanically related. This relatedness is based primarily on flower structures; this explains why flowers are so useful in identifying plants. We know many plants by common names, but in order to communicate with plant professionals around the world, we use the scientific language of plant nomenclature. Each plant is identified by a unique botanical Latin name. The system of binomial nomenclature provides a double name for plants, called its **genus** and **species**. The first, or generic name, is followed by a descriptive, or specific, name. Modern plant classification, or **taxonomy**, is based on a system of binomial nomenclature developed in the 1700's by the Swedish physician, Carl von Linne (remembered today by his Latin name, Linnaeus). Prior to Linnaeus, people had tried to classify plants by leaf shape, plant size, flower color, etc. None of these systems proved workable. Linnaeus's revolutionary approach based classification on the flowers and/or reproductive parts of a plant. This has proven to be the most reliable system, since flowers are the plant part least influenced by environmental changes. For this reason, a knowledge of the flower and its parts is essential to plant identification.

### **How Seeds Form**

Pollination is the transfer of pollen from an anther to a stigma. This may occur by wind or rain, or by pollinators such as bats, birds and insects. Windpollinated flowers lack showy floral parts and nectar, since they do not need to attract a pollinator. Many flowers that are brightly colored or patterned and contain a fragrance or nectar must attract pollinating insects, birds, or bats. In the process of searching for food, these pollinators transfer pollen from anther to stigma, and from one flower to another.

The stigma contains a chemical which excites the pollen, causing it to grow a long tube down through the style, to the ovules inside the ovary. After breaking through the ovule, the pollen grain releases two sperm nuclei: one combines with the female egg cell to form an **embryo**, and the other combines with polar nuclei in the embryo sac to form the **endosperm** (food storage tissue). This process is called **double fertilization**. If the fertilization process is successful, the embryo and endosperm and surrounding protective tissues develop into a seed.

Some plants are **self-fertile**; that is, the pollen and ovules of a single plant can unite to form seeds containing viable embryos. Most plants, even those that are self-fertile, can be **cross pollinated**; this process combines genetic material from more than one plant, and produces stronger seed and more vigorous offspring. Consequently, more plants reproduce by cross-pollination than self-pollination.

### **Types of Inflorescences**

Some plants bear only one flower per stem; these are called **solitary flowers**. Other plants produce an **inflorescence**, a term which refers to a cluster of flowers and how they are arranged on a floral stem.

Some examples of inflorescences are **spike**, **raceme**, corymb, umbel, and head. A spike has many stemless florets, each attached to an elongated flower stem; an example is gladiolus. A raceme is similar to a spike except the florets are on small stems (pedicels) attached to the central axis; an example is snapdragon. A corymb's florets are on stalks, called pedicels, and are arranged at random along the peduncle in such a way that the florets create a flat, round top; an example is yarrow. An umbel is similar except that the pedicels all arise from one point on the peduncle; an example is dill. A head, or composite, inflorescence is composed of two distinct types of stemless florets. Usually, fertile disk florets crowd the central button and are surrounded by generally sterile, strap-like ray florets, often wrongly referred to as "petals".

#### Some types of Inflorescences



### Fruit

Botanically, the true fruit is the enlarged ovary around the newly developed seeds. But in practical horticulture, we often refer to fruits as the accessory tissues of the flower which develop around the true fruit.

### **Parts of Fruit**

The only parts of a fruit which are genetically representative of both the male and female flowers are the seeds (mature ovules). The rest of the fruit arises from the maternal plant, and is therefore genetically identical to that female parent. This explains why a pumpkin can be cross-pollinated by a squash and still produce a predictable-tasting pumpkin, yet the seeds of that pumpkin will produce a new plant that is a hybrid between the pumpkin and the squash.

### Types of Fruit

Just as flowers are useful in identifying plants, fruits are also characteristic of specific plants. Fruits can be classified as **simple fruits**, **aggregate fruits**, or multiple fruits. Simple fruits are those which develop from a single ovary. These include cherries and peaches (called drupes), pears and apples (called pomes), and tomatoes (called berries). Tomatoes are a botanical fruit since they develop from the flower, as do squash, cucumbers, and eggplant. All of these fruits develop from a single ovary. Some types of simple fruit are dry, with papery, leathery or hard tissue. Examples are peanut (an example of a fruit type called legumes), poppy (typical of fruits called capsules), maple (a samara), and acorn (a true nut).

Aggregate fruits, such as raspberries, come from a single flower which has many ovaries. The flower appears as a simple flower, with one corolla, one calyx, and one stem, but with many pistils (and therefore many ovaries). The ovaries are fertilized separately and independently. Incomplete pollination can produce misshapen fruit. Strawberry and blackberry are aggregate fruits born on an edible. enlarged receptacle, which is fused to the fruits and eaten as part of them. We sometimes call these "accessory" or "false" fruits, since the fleshy, juicy part is not the biological fruit, or ripened ovary itself.



receptacle

Numerous achene-like flowers which bloom within fleshy covering

Multiple fruits are derived from a tight cluster of separate, independent flowers borne on a single structure. Each flower has its own calyx and corolla. Examples of multiple fruits are pineapple, fig and beet.



### Seed

The seed, or matured ovule, has three parts. The **embryo** is a miniature plant in an arrested state of development. Most seeds contain a built-in food supply called the endosperm (orchid is an exception). The endosperm can be made up of proteins, carbohydrates, or fats. The third part is the hard outer covering, called a **seed coat**, which protects the seed from disease and insects and prevents water from entering the seed (this would initiate the germination process before the proper time).

Parts of a Seed



Germination begins when the seed absorbs water through the **seed coat**, and ends when the green plant begins photosynthesis. Successful germination requires the proper environmental conditions: favorable **temperatures**, correct **light** levels, and adequate **moisture** and **aeration**. The absorbed water activates hormones and enzymes which convert stored food into simpler food materials, and activate essential growth processes. The embryo begins to grow through cell division and enlargement, causing the young seedling to burst from the seed, sending its **radicle** downward to develop into a root system, and its **plumule** upward to develop into the stem and leaves. With uptake of water from the soil by the young root system and photosynthesis by the young green tissue, germination is complete.

In many plants, the **cotyledons** (seed leaves) are the first structures to emerge above ground. Monocots have one cotyledon while dicots have two cotyledons. The cotyledons of many plants are similar, while their true leaves can vary greatly.

#### Germination of a Dicot



Bean



# Physiology: Plant Growth and Development

Three major plant functions that are essential for plant growth and development are photosynthesis, respiration, and transpiration.

### **Photosynthesis**

One of the major differences between plants and animals is the ability of plants to internally manufacture their own food. For this process of photosynthesis, a plant requires **chlorophyll** within its tissue, energy from **light**, **carbon dioxide** from the air, and **water** from the soil. If any of these ingredients is lacking, photosynthesis cannot proceed. Photosynthesis literally means "to put together with light."

#### Photosynthesis

 $\begin{array}{ll} \mbox{light} \\ \mbox{CARBON DIOXIDE + WATER} \rightarrow \mbox{SUGAR + OXYGEN + WATER} \\ \mbox{chlorophyll} \end{array}$ 

$$\begin{array}{c} \text{light} \\ 6 \text{ CO}_2 + 12 \text{ H}_2 0 \xrightarrow{} C_6 \text{H}_{12} 0_6 + 6 \text{ 0}_2 + 6 \text{ H}_2 0 \\ \text{chlorophyll} \end{array}$$

Plants store the energy from light first in **simple sugars**, such as glucose. This food may be converted back to water and carbon dioxide, releasing the stored energy through the process called **respiration**. This energy is required for all living processes and growth. Simple sugars can also be converted to more complex sugars and starches (carbohydrates) which may be transported to the stems and roots for use or storage, or they may be used as building blocks for other synthates, such as oils, pigments, proteins, and cell walls.

Any green plant tissue can photosynthesize. **Chloroplasts** in these cells contain the green pigment, chlorophyll, which traps the light energy. Leaves are the primary site of photosynthesis due to their special structure. The internal tissue (mesophyll) contains cells with abundant chloroplasts in an arrangement that promotes easy movement of water and air. The protective upper and lower epidermal layers of the leaf include many stomates that regulate movement of the gases involved in photosynthesis into and out of the leaf.

#### Leaf Cross Section



Photosynthesis is dependent on the availability of light. Generally, as sunlight increases in intensity, photosynthesis increases. This results in greater production. Many garden crops, such as tomatoes, respond best to maximum sunlight. Tomato production is greatly reduced as light intensities drop. Only a few "greenhouse" tomatoes produce fruit when sunlight is minimal in late fall and early spring.

Water plays an important role in plants in several ways. First, it maintains a plant's **turgor**, or the firmness of plant tissue. Turgor pressure in a cell can be compared to air in an inflated balloon. Water pressure or turgor is needed by plant cells to maintain shape and ensure cell growth. Second, water is split into hydrogen and oxygen by the energy of the sun that is absorbed by the chlorophyll in plant leaves. This oxygen is released into the atmosphere while the hydrogen is used in carbohydrate synthesis. Third, water dissolves minerals from the soil and transports them up from the roots and throughout the plant, where they serve as raw materials in the development of new plant tissues. The soil surrounding plants must provide adequate water to be pulled into the plant by transpiration (evaporation of water from the leaves' stomates).

Photosynthesis also requires carbon dioxide (CO<sub>2</sub>) which enters the plant through the stomates. Carbon and oxygen are used in the manufacture of carbohydrates. Carbon dioxide in the air is plentiful enough so that it does not limit plant growth outdoors. However, since carbon dioxide is consumed in making sugars and is not replenished by plants at a rapid rate, a tightly closed greenhouse in midwinter may not let in enough outside air to maintain an adequate carbon dioxide level. Under such conditions, production of roses, carnations, tomatoes, and many other crops can be increased by adding carbon dioxide to the growing area.

Temperature affects photosynthesis rates. Photosynthesis occurs at its highest rate in the temperature range 65 to 85 degrees F (18 to 27 degrees C) and decreases when temperatures are above or below this range.

### Respiration

Carbohydrates made during photosynthesis are of value to the plant when they are converted into energy, which is used for other plant processes like plant growth. The process by which sugars and starches are slowly oxidized to release energy is called respiration. It is similar to the burning of wood or coal to produce heat (energy).

#### Respiration

 $C_6H_{12}O_6 + 6 O_2 + 6 H_2O \rightarrow 6 CO_2 + 12 H_2O + Energy$ 

This equation is precisely the opposite of that used to illustrate photosynthesis, although more is involved than just reversing the reaction. However, it is appropriate to consider photosynthesis to be a building process, and respiration to be a breakingdown process.

Water/CO <sub>2</sub> Oxygen (breakdown) Energy Released Carbon Dioxide + Water (in sun + chlorophy Sugar	Respiration	Photosynthesis		
Nitrogen Phosphorous Potash Calcium Other elements	Water/CO <sub>2</sub> Oxygen (breakdown) Sugar Energy Released Vitrogen Phosphorous Dalcium Other elements	Carbon Dioxide + Water (in sun + chlorophyll) Oxygen Sugar Water		

The differences and similarities between photosynthesis and respiration can be summarized as follows:

#### Photosynthesis

- 1. Produces food.
- 2. Captures energy.
- 3. Occurs in cells containing chloroplasts.
- 4. Releases oxygen.
- 5. Uses and produces water.
- 6. Uses carbon dioxide.
- 7. Rate is dependent on light.

#### Respiration

- 1. Uses food for plant energy/growth.
- 2. Releases energy.
- 3. Occurs in all cells.
- 4. Uses oxygen.
- 5. Uses and produces water.
- 6. Produces carbon dioxide.
- 7. Rate is independent of light.

### **Transpiration**

Transpiration is the process by which a plant loses water, primarily through leaf stomates. The amount of water lost through transpiration depends on several environmental factors such as temperature, humidity, and wind or air movement. Transpiration is a necessary process by which about 90% of the water that enters plant roots is lost through the stomates. The remaining 10% of water is used in chemical reactions and in plant tissues. Transpiration is not simply water loss; it is the process by which water is pulled up into plants. The water in a plant's xylem forms a continuous column. As water evaporates through leaf stomates, more water is drawn into plant roots. The process of transpiration provides for **mineral transport** from the soil into the plant, cooling of plant parts through evaporation, translocating sugars and plant chemicals, and maintaining turgor pressure.

### Environmental Factors That Affect Plant Growth

Plant growth and distribution are limited by the environment. Any one environmental factor that is less than ideal becomes a limiting factor in plant growth. For example, only plants adapted to limited amounts of water can live in deserts.

Many plant problems are caused by environmental stress, either directly or indirectly. Therefore, it is important to understand the environmental aspects that affect plant growth. These factors include **light**, **temperature**, **water**, **humidity**, and **nutrition**.

### Light

Light has three principal characteristics that affect plant growth: **quantity**, **quality**, and **duration**.

Light quantity refers to the **intensity** or concentration of light. It varies with the season of the year. Maximum light occurs in the summer; minimum light in winter. The more light a plant receives (up to a point), the better it is able to photosynthesize (capture energy). As light quantity decreases, the photosynthetic process decreases. If light quantity is too high, it can be decreased in a garden or greenhouse by using cheesecloth or lath shading above the plants. Low light quantities can be increased by surrounding plants with white reflective material, or with artificial lights.

Light quality refers to the color or wavelength reaching plant surfaces. Sunlight can be separated into red, orange, yellow, green, blue, indigo, and violet light. Red and blue light have the greatest effect on plant growth because they are the best qualities of light for photosynthesis. In addition, red light affects flowering. Green light is least effective to plants, which appear green because they reflect green light. Among artificial lights, a combination of cool white and warm white fluorescent tubes provide excellent quality light for green growth, and are excellent for starting seedlings indoors. Fluorescent "grow lights" provide a mixture of red and blue light that imitates sunlight quite closely, but they are costly and generally not of any greater value than regular fluorescent lights. Incandescent bulbs produce high levels of red light, but generally produce too much heat to be a valuable light source for plants.

Light duration, or photoperiod, refers to the amount of time per day that a plant is exposed to sunlight. Some plants' flowering process is controlled by photoperiod, and plants are classified into three categories, depending on their exact response. These are short-day, long-day, and dayneutral. When the photoperiod concept was first recognized in the 1920's, it was thought that the length of light periods triggered flowering in some plants, so the various categories of responses were named according to the light period's length. It was later discovered that it is not the length of the light period but the length of uninterrupted dark period that is critical to floral development. The categories of responses retain their early names, making it somewhat confusing at first.

Short-day plants (actually long-night plants) form their flowers only when the day length is less than a critical length, generally about 12 hours. Short-day plants include many spring- and fall-flowering plants such as chrysanthemum and poinsettia. Long-day plants (actually short-night plants) form flowers only when day lengths exceed 12 hours. They include many summer-flowering plants, such as rudbeckia and California poppy, as well as many vegetables including beet, radish, lettuce, spinach, and potato. Day-neutral plants form flowers regardless of day length. Some plants do not really fit into any category but may respond to combinations of day lengths. The petunia flowers regardless of day length, but flowers earlier and more profusely under long days.

This concept is important in manipulating those plants that respond to day length. For example, chrysanthemums are easily scheduled throughout the year. They produce leaves and stems under long-day (short-night) conditions. Such conditions occur naturally in summer, and can be created in winter by breaking up the long winter night with light (greenhouse growers set timers to turn on lights for a few hours in the middle of each night, creating two "short nights"). The plants produce flowers naturally under the short-day conditions of winter, and they can be forced to flower in summer by artificially providing short-day conditions (greenhouse grower pull black shade cloths over chrysanthemums at the end of the work day, and remove the cloths in the morning; this creates a "long night").

### Temperature

Temperature affects plant productivity and growth. Many plant processes proceed faster in warm conditions, and slow down in cool conditions. Plants generally tolerate the coolest temperatures when they are dormant (well below freezing in many cases), the warmest temperatures as young seedlings (generally 60-80 degrees F), and temperatures somewhat cooler than seedling temperatures when they are actively growing, mature plants.

Incorrect temperatures, both high and low, can produce undesirable effects. Under high temperatures and long days, cool-season crops such as spinach bolt (produce undesirable flowers) rather than producing the desired leaves. Temperatures that are too low for a warm-season crop such as tomato prevent fruit set. Adverse temperatures also cause stunted growth and poor quality; for example, lettuce grown at high temperatures becomes bitter.

Sometimes temperatures are used in connection with day length to manipulate the flowering of plants. Chrysanthemums flower for the longest period of time if daylight temperatures remain at 59 degrees F (15 degrees C). Christmas cacti form flowers in response to short days and cool temperatures. Daffodils flower if the bulbs are placed in cold storage (35 to 40 degrees F (2 to 4 degrees C)) beginning in October, to promote bulb maturation. The bulbs are transferred to a cool greenhouse in midwinter where top growth begins, and the flowers are ready for cutting in 3 to 4 weeks.

**Thermoperiod** refers to daily temperature change. Plants produce maximum growth when exposed to a day temperature that is about 10 to 15 degrees higher than the night temperature. This allows the plant to photosynthesize and respire at optimum rates in the day, and to slow the rate of respiration during the cooler night. High temperatures increase the respiration rate, sometimes above the rate of photosynthesis. In such a situation, the products of photosynthesis would be used more rapidly than they were produced, and the plant would not grow. **For growth to occur, photosynthesis must exceed respiration.**  Temperatures lower than optimum for specific plants result in poor growth. Photosynthesis is slowed by low temperatures. When photosynthesis is slowed, growth is slowed, resulting in lower yields. Not all plants grow best in the same temperature range. For example, snapdragons grow best when nighttime temperatures are 55 degrees F (12 degrees C), while poinsettias prefer 62 degrees F (17 degrees C). Cyclamens do well under very cool conditions, while many bedding plants prefer warmer temperatures. Knowing the specific temperature preferences of crops allows more efficient production; for example, peas are far more productive in the cool spring than in summer.

Winter temperatures determine how far north (and south) plants can grow. Perennial plants are classified as either hardy or nonhardy, depending upon their ability to withstand cold temperatures. Cold New England winters prevent the growth of many plants altogether. Other plants may be slightly injured in some winters when unseasonably low temperatures occur early in the fall or late spring. After a plant's winter dormancy is met, early spring thaws can cause premature bud break in some plants; this may be followed by freezing damage if temperatures drop again. Late spring frosts often destroy entire peach crops in Northern New England.

# Review of How Temperature Affects Plant Processes:

Photosynthesis:	Increases somewhat within a range of temperatures.
<b>Respiration:</b>	Rapidly increases as tempera- ture rises.
Transpiration:	Increases with temperature.
Flowering:	Is partially triggered by tem- perature in some plants.
Sugar storage:	Low temperatures reduce energy use and increase sugar storage.
Dormancy:	Is fulfilled by cold tempera- tures.
Bud Development In Spring:	May occur too early in a spring

### Water

Water is a major component of plants, composing as much as 95% of some plant tissues. It serves many roles in plants. Water is responsible for maintaining the **turgor** pressure (firmness) of tissue; water is involved in the **opening and closing of stomates**, thus regulating transpiration; water's evaporation from plant surfaces helps **regulate plant temperatures**; water accounts for much of the **cell growth in root tips** that moves roots outward into new soil; water acts as the **solvent for minerals** moving upward in the xylem, and for carbohydrates moving through the phloem to their site of use or storage; and water is an essential raw **material for photosynthesis**.

Water is important to plants not only as liquid, but also as vapor. **Relative humidity** is the percentage of water vapor in the air compared to the total amount of water the air could hold at a given temperature and pressure. For example, if a pound of air at 75 degrees F holds 3 grams of water as vapor, while it could hold a total of 4 grams of water vapor, then the relative humidity (RH) is :

Warm air can hold more water vapor than cold air. That means that if the amount of water vapor in the air remains constant, then as the temperature increases, the relative humidity decreases. Also, as the temperature decreases, the relative humidity increases until it reaches 100%, at which time the air can hold no more. If the temperature continues to drop, water condenses and falls out of the air (in nature, we call this precipitation).

Water vapor moves from a place of high relative humidity to one of low relative humidity. The greater the difference in humidity, the faster water moves. This is an important concept in transpiration. The spaces between plant cells (intercellular space) can be occupied by air and water vapor. When the relative humidity in the intercellular space near stomates approaches 100%, and the stomates open, water vapor leaves the plant (if the relative humidity outside the leaf were also 100%, the stomates would not open). As the vapor moves out, a cloud of high humidity is formed around the stomate. This cloud of humidity helps slow transpiration and cool the leaf. If air movement blows the humid cloud away, transpiration increases as the stomates keep opening to balance the humidity. This is why plants exposed to windy environments may experience water stress.



Dots represent Relative Humidity

### **Plant Nutrition**

Many people confuse plant nutrition with plant fertilization. Plant nutrition refers to the needs and uses of the basic chemical elements in the plant. Fertilization is the term used when these materials are supplied to the environment around the plant. A lot must happen before a chemical element supplied in a fertilizer can be taken up and used by the plant.

Plants need 17 elements for normal growth. Carbon, hydrogen, and oxygen are found in air and water. Nitrogen, potassium, magnesium, calcium, phosphorous, and sulfur are found in the soil. The latter six elements are used in relatively large amounts by the plant and are called macro-nutrients. There are eight other elements that are used in much smaller amounts; these are called micronutrients or trace elements. The micronutrients, which are found in the soil, are iron, zinc, molybdenum, manganese, boron, copper, cobalt, and chlorine. All 17 elements, both macro-nutrients and micro-nutrients, are essential for plant growth.

Most of the nutrients that a plant needs are dissolved in water and then absorbed by the roots. Ninety-eight percent of these plant nutrients are absorbed from the soil solution and only about 2% are actually extracted from the soil particles by the root. Most of the nutrient elements are absorbed as charged ions, or pieces of molecules (which are the smallest particle of a substance that can exist and still retain the characteristics of the substance). Ions may be positively charged cations or negatively charged anions. Positive and negative are equally paired so that there is no overall charge. For example, nitrogen may be absorbed as nitrate  $(NO_{0})$ which is an anion with one negative charge. The potassium ion (K<sup>+</sup>) is a cation with one positive charge. Potassium nitrate (K<sup>+</sup>NO<sub>3</sub><sup>-</sup>) would be one nitrate ion and one potassium ion. However, calcium nitrate  $(Ca^{++}NO_{a}^{-})_{a}$ ) would have two nitrate ions and one calcium ion because the calcium cation has two positive charges.

The balance of ions in the soil is very important. Just as ions having opposite charges attract each other, ions having similar charges compete for chemical interactions and reactions in the environment. Some ions are more active than others or can compete better. For example, both calcium (Ca<sup>++</sup>) and magnesium (Mg<sup>++</sup>) are cations with two charges, but magnesium is more active. If both are in competition to be absorbed, the magnesium will be absorbed.

This explains why the results of a soil test may indicate that, while there is sufficient calcium in the soil, the plant may still exhibit a calcium deficiency because of an excess of the more active magnesium. What may be expressed as a deficiency in one micronutrient may really be caused by an excess of another.

In order for the ions to be easily absorbed, they must first be dissolved in the soil solution. Some combinations of ions are easily dissolved, such as potassium nitrate. When other ions combine, they may precipitate or fall out of solution and thus become unavailable to the plant. Many of the micronutrients form complex combinations with phosphorous and calcium and precipitate out of the soil solution so the nutrients cannot be easily taken up by the plant. The pH, which is a measurement of acidity or alkalinity, greatly affects these chemical reactions. If the soil pH is extremely high (alkaline), many of the micronutrients precipitate out of the solution and are unavailable to the plant. When the soil pH is extremely low (acid), some of the micronutrients become extremely soluble and ion levels may become high enough to injure the plant. The effect of pH varies with the ion, the types of ions in the soil, and the type of soil. Therefore, not only is the amount of the nutrient important, but also the soil pH.

Adequate water and oxygen must be available in the soil. Water is required for nutrient movement into and throughout the roots. Oxygen is required because the mineral ions must be moved into the root cells across their membranes. This is an active absorption process, utilizing energy from respiration. Without adequate oxygen from the soil, there is no energy for nutrient absorption.

Anything that lowers or prevents the production of sugars in the leaves can lower nutrient absorption. If the plant is under stress due to low light or extremes in temperature, nutrient deficiency problems may develop. The stage of growth or how actively the plant is growing may also affect the amount of nutrients absorbed. Many plants go into a rest period, or dormancy, during part of the year. During this dormancy, few nutrients are absorbed. Plants may also absorb different nutrients just as flower buds begin to develop.

Nutrients transported from the root to the cell by the vascular system move into the cell through a cell membrane. There are three different ways this happens. First, an entire molecule or ion pair may move through the membrane. If the cell is using energy or active transport to absorb the ions, then only one of the ions in the pair is pulled into the cell. The other will follow to keep the number of positive and negative charges even. Most anions (negative ions) are actively absorbed.

The second way of keeping the charges inside the cell balanced and absorbing a new ion is to exchange one charged ion for another ion with the same charge. A hydrogen ion  $(H^+)$  is often released so that the cell can absorb another positive ion such as potassium  $(K^+)$ . Since this is a simple, passive exchange, absorption energy may not be required. Cations may be absorbed by this passive method.

Both of the methods mentioned above may be passive or active. However, the third method, the carrier system, is always active absorption, requiring energy. Scientists have discovered that within the cell membrane there are specialized chemicals that act as carriers. The carrier, through chemical changes, attracts an ion from outside the cell membrane and releases it inside the cell. Once the ion is inside the cell, it is attached to other ions so that it does not move out of the cell. Complex chemical reactions are involved in the entire process. Although nutrients can be absorbed passively, research has shown that active absorption must take place if the plant is to grow and be healthy. The factors we discussed earlier about absorption by the root are also true for absorption by the cell. A quick review of some of the factors that affect nutrient absorption: type of ion, soil pH, solubility of ion pairs, water, soil oxygen, sugar supply, plant stress, and temperature.

*Foliar Absorption: A Special Case.* Under normal growing conditions, plants absorb most nutrients, except carbon, hydrogen, and oxygen, from the soil. However, some nutrients can also be absorbed by the leaves if they are sprayed with a dilute solution. The factors that affect absorption by the cell are still important because the nutrient must enter the cell to be used by the plant. Care must be taken that the concentration of the nutrient is not too high or the leaf will be injured. Also, the leaf is covered by a thin layer of wax called the cuticle that the nutrient must get around or through before it can enter the cell.

### **Macronutrient Outline**

#### Nitrogen (N)

•

Absorbed as  $NO_3^-$ ,  $NH_4^+$ . Leaches from soil, especially  $NO_3^-$ . Mobile in plant.

Nitrogen excess: Succulent growth, dark green color, weak spindly growth, few fruits, may cause brittle growth especially under high temperatures.

- Nitrogen deficiency: Reduced growth, yellowing (chlorosis), reds and purples may intensify with some plants, reduced lateral breaks. Symptoms appear first on older growth.
- Action notes:

In general, the best  $NH_4^+/NH_3^-$  ratio is 1/1. High  $NH_4^+$  under low sugar conditions (low light) can cause leaf curl.

Uptake inhibited by high P levels.

N/K ration extremely important.

Indoors, best N/K ration is 1/1 unless light is extremely high.

In soils with high CHO/N ratio more N should be applied.

### Phosphorus(P)

Absorbed as  $H_2PO_4^-$ ,  $HPO_4^-$ Does not leach from soil readily. Mobile in plant.

- Phosphorus excess: Shows up as micronutrient deficiency of Zn, Fe, or Co.
- Phosphorus deficiency: Reduced growth, color may intensify, browning or purpling in foliage in some plants, thin stems, reduced lateral breaks, loss of lower leaves, reduced flowering.

Action notes: Rapidly "fixed" on soil particles when applied under acid conditions fixed with Fe, Mg and Al.

Under alkaline conditions fixed with Ca. Important for young plant and seedling growth. High P interferes with micronutrient absorption and N absorption. Used in relatively small amounts when compared to N and K. May leach from soil high in bark or peat.

#### Potassium(K)

Absorbed as K<sup>+</sup> Leaches from soil. Mobile in plant.

- Potassium excess: Causes N deficiency in plant and may affect the uptake of other positive ions.
- Potassium deficiency: Reduced growth, shortened internodes, marginal burn or scorch (brown leaf edges), necrotic (dead) spots in the leaf, reduction of lateral breaks and tendency to wilt readily.
- Action notes: N/K balance is important. High N/low K favors vegetative growth; low N/ high K promotes reproductive growth (flower, fruit).

### Magnesium (Mg)

Absorbed as Mg<sup>++</sup> Leaches from soil. Mobile in plant.

- Magnesium excess: Interferes with Ca uptake.
- Magnesium deficiency: Reduction in growth, marginal chlorosis, interveinal chlorosis (yellow between the veins) in some species. May occur with middle or lower leaves, reduction in seed production, cupped leaves.
- Action notes:

Mg is commonly deficient in foliage plants because it is leached and not replaced. Epsom salts at a rate of 1 teaspoon per gallon may be used 2 times a year. Mg can also be absorbed by leaves if sprayed in a weak solution. Dolomitic limestone can be applied in outdoor situations to rectify a deficiency.

### Calcium (Ca)

Absorbed as Ca<sup>++</sup>, moderately leachable. Limited mobility in plant.

• Calcium excess:

Interferes with Mg absorption. High Ca usually causes high pH which then precipitates many of the micronutrients so that they become unavailable to the plant.

 Calcium deficiency: Inhibition of bud growth, death of root tips, cupping of maturing leaves, weak growth, blossom end rot of many fruits, pits on root vegetables. •Action notes:

Ca is important to pH control and is rarely deficient if the correct pH is maintained. Water stress, too much or too little, can affect Ca relationships within the plant causing deficiency in the location where Ca was needed at the time of stress.

### Sulfur (S)

Absorbed as  $SO_4^-$ . Leachable. Not mobile.

- Sulfur excess: Sulfur excess is usually in the form of air pollution.
- Sulfur deficiency:

S is often a carrier or impurity in fertilizers and rarely deficient. It may be also absorbed from the air and is a by-product of combustion. Symptoms are a general yellowing of the affected leaves or the entire plant.

• Action notes: Sulfur excess is difficult to control.

### **Micronutrient Outline**

The majority of the micronutrients are not mobile; thus, deficiency symptoms are usually found on new growth. Their availability in the soil is highly dependent upon the pH and the presence of other ions. The proper balance between the ions present is important, as many micronutrients are antagonistic to each other. This is especially true of the heavy metals where an excess of one element may show up as a deficiency of another. If the pH is maintained at the proper level and a fertilizer which contains micronutrients is used once a year, deficiency symptoms (with the exception of iron deficiency symptoms) are rarely found on indoor plants. Many of the micronutrients are enzyme activators.

#### Iron(Fe)

Absorbed as Fe<sup>++</sup>, Fe<sup>+++</sup>.

• Iron deficiency:

Interveinal chlorosis primarily on young tissue, which may become white.

Fe deficiency may be found under the following conditions even if Fe is in the soil:

Soil high in Ca, poorly drained soil, soil high in Mn, high pH, high P, soil high in heavy metals (Cu, Zn), oxygen deficient soils or when nematodes attack the roots.

Fe should be added in the chelated form; the type of chelate needed depends upon the soil pH.

 Iron toxicity: Rare except on flooded soils.

### Boron(B)

Absorbed as  $BO_3^-$ .

- Boron excess: Blackening or death of tissue between veins.
- Boron deficiency: Failure to set seed, internal breakdown, death of apical buds.

### Zinc (Zn)

Absorbed as Zn++.

- Zinc excess: Appears as Fe deficiency. Interferes with Mg.
- Zinc deficiency: "Little leaf," reduction in size of leaves, short internodes, distorted or puckered leaf margins, interveinal chlorosis.

### Copper (Cu)

Absorbed as Cu<sup>++</sup>, Cu<sup>+</sup>.

- Copper excess: Can occur at low pH. Shows up as Fe deficiency.
- Copper deficiency: New growth small, misshapen, wilted. May be found in some peat soils.

### Manganese (Mn)

Absorbed as Mn<sup>++</sup>.

 Manganese excess: Reduction in growth, brown spotting on leaves. Shows up as Fe deficiency. Found under acid conditions.

• Manganese deficiency: Interveinal chlorosis of leaves followed by brown spots producing a checkered red effect.

### Molybdenum (Mo)

Absorbed as MoO<sub>4</sub>.

• Molybdenum deficiency: Interveinal chlorosis on lower or midstem leaves, twisted leaves (whiptail).

### Chlorine (Cl)

Absorbed as Cl<sup>-</sup>.

- Chlorine deficiency: Wilted leaves which become bronze then chlorotic then die; club roots.
- Chlorine toxicity: Salt injury, leaf burn, may increase succulence.

### Cobalt (Co)

Absorbed as Co<sup>++</sup>. Needed by plants recently established. Essential for Nitrogen fixation. Little is known about its deficiency or toxicity symptoms.

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# CHAPTER 2

# **Soils and Fertilizers**

Reviewed by Tom Buob, UNH Cooperative Extension and Joe Homer, Natural Resource Conservation Service

Soil is formed when rock (parent material) is broken down by climate and vegetation over a period of time. Soil is weathered rock fragments and decaying remains of plants and animals (organic matter). It contains varying amounts of air, water, and micro-organisms. It furnishes mechanical support and nutrients for growing plants.

Fertilizers are materials containing plant nutrients that are added to the environment around the plant. Generally, they are added to the water or soil, but some can also be added to the air or sprayed on the leaves. Fertilizer is not plant food; plants produce their own food using water, carbon dioxide, and energy from the sun. This food (sugars and carbohydrates) is combined with the plant nutrients to produce protein, enzymes, vitamins, and other elements essential to plant growth.

### Soils

A desirable surface soil in good condition for plant growth contains approximately 50% solid material and 50% open or pore space. The mineral component is usually made up of many different kinds and sizes of particles, ranging from those visible to the unaided eye to particles so small that they can only be seen with the aid of a very powerful (electron) microscope. This mineral material comprises about 45% to 48% of the total volume. Organic material makes up about 2% to 5% of the volume and may contain both plant and animal material in varying stages of decomposition. Under ideal or near-ideal moisture conditions for growing plants, soil or pore spaces contain about 25% air and 25% water based on the total volume of soil.

Although most New England soils developed under forest vegetation, climatic conditions from the southern to northern New England and from sea level to the highest mountains vary considerably and have resulted in rather marked effects on the soils that have formed. The glaciers, in recent geologic time, left loose, stony debris which is presently being changed into soil and accounts for New England's soils being thin and very young.

The percentage of mineral matter and organic matter in a cubic foot of surface soil varies from one soil to another, and within the same soil, depending on the kinds of crops grown, frequency of tillage, and wetness or drainage of the soil. Content of organic matter will usually be high in soils that have not been cultivated over long periods of time. Soils that are tilled frequently and have relatively small amounts of plant residues worked into the soil are usually low in organic matter. Plowing and tilling the soil increases the amount of air in the soil, which increases the rate of organic matter decomposition. Further tillage leaves the soil open without cover. Erosion caused by wind and rain can easily move the finer clay particles and organic matter content off the land. Soils with poor drainage or high water tables usually have higher organic matter content than those which are well drained. As a result, decomposition of plant material is slowed and organic matter builds up in the soil.

Since either air or water fills pore spaces, the amount of air in a soil at a particular time depends on the amount of water present in the pore spaces. Immediately after a rain, there is more water and less air in the pore spaces. Conversely, in dry periods, a soil contains more air and less water. Increasing organic matter content usually increases water-holding capacity, but addition of large amounts of decomposed organic material can reduce water capacity until the material has partially decomposed. Dark brown or black soils usually have high organic matter content.

As defined above, a soil contains four principal components: **mineral matter, organic matter, water, and air**.

### Soil Horizons or Layers

Most soils have three distinct principal layers or horizons. Each layer can have two or more subhorizons. The principal horizons (collectively called the soil profile) are: A, surface soil; E, the subsurface; and B, the subsoil. Beneath the soil profile lies: C, the parent material; and R, rock, similar to that from which the soil developed. Horizons usually differ in color, texture, consistency, and structure. In addition, there are usually considerable differences in chemical characteristics or composition.



#### Soil Profile

Leaf Litter

Mineral horizons at the surface showing organic matter enrichment

Subsurface horizon showing depletion of organic matter, clay, iron, and aluminum compounds

Subsoil horizon showing enrichment of clay material, iron, aluminum, or organic compounds.

Horizons of loosened or unconsolidated material

Hard bedrock

The **surface** and **subsurface** are usually the coarsest layers. The surface soil contains more organic matter than the other soil layers. Organic matter gives a gray, dark-brown, or black color to the surface horizon, the color imparted depending largely upon the amount of organic matter present. Soils that are highest in organic matter usually have the darkest surface colors. The surface layer is usually most fertile and has the greatest concentration of plant roots of any horizon of the soil. Plants obtain much of their nutrients and water from the surface soil.

The **subsoil** layer is usually finer and firmer than the surface soil. Organic matter content of the subsoil is usually much lower than that of the surface layer. Subsoil colors are strong and bright; shades of red, brown, and yellow are frequently observed. The subsoil supports the surface soil and may be considered the soil reservoir, providing storage space for water and nutrients for plants, aiding in temperature regulation of the soil, and supplying air for the roots of plants.

The bottom horizon, or **parent material**, is decomposed rock that has acquired some characteristics of the subsoil and retained some characteristics of the rock from which it weathered. It is not hard, like rock, but may show the form or structure of the original rocks or layering if it is in a water-laid deposit. The parent material influences soil texture, natural fertility, rate of decomposition (and thus rate of soil formation), acidity, depth, and in some cases, topography (or lay of the land) on which the soil is formed.

### **Physical Properties of Soil**

The physical properties of a soil are those characteristics which can be seen with the eye or felt between the thumb and fingers. They are the result of soil parent materials being acted upon by climatic factors (such as rainfall and temperature), and affected by topography (slope and direction, or aspect) and vegetation (kind and amount, such as forest or grass) over a period of time. A change in any one of these influences usually results in a difference in the type of soil formed. Important physical properties of a soil are **color**, **texture**, **structure**, **drainage**, **depth**, **and surface features** (stoniness, slope, and erosion).

The physical properties and chemical composition largely determine the suitability of a soil for its planned use and the management requirements to keep it most productive. To a limited extent, the fertility of a soil determines its possible uses, and to a larger extent, its yields. However, fertility level alone is not indicative of its productive capacity, since soil physical properties usually control the suitability of the soil as growth medium. Fertility is more easily changed than soil physical properties.

### Soil Color

Color is an obvious and easily determined soil property. It is one of the most useful properties for soil appraisal and identification because other characteristics can be inferred from soil color. Generally, soil color is a reflection of: 1) parent material from which the soil is derived, 2) amount of organic matter, and 3) degree of oxidation and or saturation.

Surface soil colors may vary from light brown to dark brown or black. Lighter colors indicate low amounts of organic matter whereas darker colors indicate higher amounts. Lighter colors in the surface horizons are frequently associated with soils having relatively rapid oxidation of organic matter as a result of properties that favor the decomposition of organic matter. These include sandy or gravelly textures, or highly leached well drained soils that often have relatively high annual temperatures. In soils without amendments darker colors frequently occur in soils where the oxidation of organic matter is slowed by properties that favor the accumulation of organic matter, such as high water table conditions (poor drainage) or low annual soil temperature. Adding organic material (manure) to gardens results in dark, rich surface soils.

Subsoil colors generally are indications of the air and water relationships that occur in the soil. Light brown to yellow subsoil colors indicate a good state of oxidation with a relatively free movement of air and water. Subsoils that are mottled with a mix of rusty brown and gray colors indicate a fluctuating water table and a variable state of oxidation. These are subsoils that may be periodically saturated, often times for two to eight weeks in the spring, that dry out during the summer as water tables drop.

Gray subsoil colors indicate a poor state of oxidation (reduced soil conditions) due to saturation for extended periods of time.

Gray colored subsoils usually indicate extended periods of saturation or a layer that may have restricted drainage (i.e. hardpan). Most mottled subsoils that have a mix of gray and rusty brown colors suggest an environment that is alternately wet and then dry often due to seasonal fluctuations in the water table. Yellow-to-brown colors in the subsoil indicate that iron coatings on soil particles are oxidized, implying good aeration. In contrast, wet soils have gray colors indicating that iron coatings on soil particles have been chemically and biologically reduced, implying saturation and poor aeration.

In wooded or previously wooded sites soils may have a gray or ashy colored layer directly below a dark surface. This gray color is the result of a soil forming process, not wetness. Also, in some areas of New Hampshire gray colors are a result of the gray color of the "parent rock" from which the soil was developed.

### Texture

Texture refers to the relative amounts of differently sized soil particles, or the fineness/coarseness of the mineral particles in the soil. Soil texture depends on the relative amounts of sand, silt, and clay. In each texture class, there is a range in the amount of sand, silt, and clay that class contains.

The coarser mineral particles of the soil are called **sand**. These particles vary in size. Most sand particles can be seen without a magnifying glass. All feel rough when rubbed between the thumb and fingers.

Relatively fine soil particles that feel smooth and floury are called **silt**. When wet, silt feels smooth but is not slick or sticky. When dry, it is smooth, and if pressed between the thumb and finger, will retain the imprint. Silt particles are so fine that they cannot usually be seen by the unaided eye and are best seen with a microscope.

**Clays** are the finest soil particles. Clay particles can be seen only with the aid of a very powerful (electron) microscope. They feel extremely smooth when dry, and become slick and sticky when wet. Clay will hold the form into which it is molded.

**Loam** is a textural class of soil that has moderate amounts of sand, silt, and clay. Loam contains approximately 7% to 27% clay, 28% to 50% silt, and 50% sand.

Although there are approximately 20 classes of soil texture, most surface soils in New England fall into five general textural classes. Each class name indicates the size of the mineral particles that are dominant in the soil. Texture is determined in the field by rubbing moist-to-wet soil between the thumb and fingers. These observations can be checked in the laboratory by mechanical analysis or by separation into clay, silt, and various-sized sand groups. Regardless of textural class, all soils in New Hampshire contain sand, silt, and clay, although the amount of a particular particle class may be small.

# Principal Surface Soil Classes Found in New England:

- 1. Loam When rubbed between the thumb and fingers, approximately equal influence of sand, silt, and clay is felt.
- 2. Sandy loam Varies from very fine loam to very coarse. Feels quite sandy or rough, but contains some silt and a small amount of clay. The amount of silt and clay is sufficient to hold the soil together when moist.
- 3. Silt loam Silt is the dominant particle in silt loam, which feels quite smooth or floury when rubbed between the thumb and fingers.
- 4. Silty clay loam Noticeable amounts of both silt and clay are present in silty clay loam, but silt is a dominant part of the soil. It is smooth to the touch when dry, but when moist, it becomes somewhat slick/sticky.
- Clay loam Clay dominates a clay loam, which is smooth when dry and slick/sticky when wet. Silt and sand are usually present in noticeable amounts in this texture of soil, but are overshadowed by clay.

Other textural designations of surface soils are sands, loamy sands, sandy clay loams, and clays. In each textural class there is a range in the amount of sand, silt, or clay that class may contain. The composition of each textural class does not allow for overlap from one class to another.

Texture influences many different characteristics of soil. A brief comparison between sandy and clay soils will highlight these points. Coarse-textured or sandy soils allow water to enter at a faster rate and to move more freely in the soil. In addition, the relatively low water-holding capacity and the large amount of air present in sandy soils allows them to warm up faster than fine-textured soils. Sandy soils are also more easily tilled and more readily worked in the spring. They are well-suited for the production of special crops such as vegetable and certain fruits. Soil particles are grouped together to form structural pieces called peds or aggregates. In surface soil, the structure will usually be granular unless it is disrupted. The soil aggregates will be rounded and vary in size from that of a very small shot to that of a large pea. If organic matter content is low and the soil has been under continuous cultivation, the soil structure may be quite indistinct. If the soil is fine-textured with high organic content, it may have a blocky surface structure.

Structure of the soil is closely related to air and water movement within it. Good structure allows rapid movement of air and water, while poor structure slows down this movement. Water can enter a surface soil that has granular structure more rapidly than one that has little structure. Since plant roots move through the same channels in the soil as air and water, good structure allows extensive root development while poor structure discourages it. Water, air, and plant roots move more freely through subsoils that have blocky structure than those with a flaky horizontal structure. Good structure of the surface soil is promoted by an adequate supply of organic matter, and by working the soil only when moisture conditions are fitting.

*Soil consistency*. This terminology describes the tendency of the soil to crumble or to stick together when moist. "Friable" indicates a soil that will form a ball when squeezed but will crumble when handled. "Plastic" would relate to a soil high in silt or clay particles that would tend to remain stuck together. By working a heavy clay soil when it is too wet, one can destroy its natural structure or compact it.

*Tilth*. Tilth is the result of tillage practices. It is the physical or mechanical conditioning of the soil to render it more suitable for gas exchange and moisture movement needed for good plant growth.

Growing plants also change the soil structure as they send their roots into the soil for mechanical support and to gather water and nutrients. The roots of plants, as they grow, tend to enlarge the openings in the soil. When they die and decay, they leave channels for movement of air and water. In addition to the plants that we see, there are vertebrates (moles, gophers), invertebrates (slugs, earthworms), bacteria, fungi, and very small plants (algae) growing in the soil which can be seen only with the aid of a microscope. All of these organisms enrich the soil by adding organic matter when they die.

NAME	SHAPE	DESCRIPTION	WHERE COMMONLY FOUND IN SOILS
Single grain	001 - 10 - 10 - 10 - 10 - 10 - 10 - 10	Usually individual sand grains not held together	Sandy or loamy textures
Granular		Porous granules held together by organic matter and some clay	A horizons with some organic matter
Platy		Aggregates that have a thin vertical dimension with respect to lateral dimensions	Compacted layers and sometimes E horizons
Blocky		Roughly equidimensiona peds usually higher in clay than other structura aggregates	al B horizons with clay I
Prismatic		Structural aggregates that have a much greater vertical than lateral dimension.	In some B horizons
Massive		No definite structure or compact shape; usually hard.	C horizons or transported material.

### Drainage

Soil drainage is defined as the rate and extent of water movement in the soil: that is, movement across the surface as well as downward through the soil. Slope is a very important factor in soil drainage. Other factors include texture, structure, and physical condition of surface and subsoil layers. Soil drainage is indicated by soil color. Clear, bright colors indicate well-drained soils. Mixed, drab, and dominantly gray colors indicate imperfection in drainage. Low-lying areas within the landscape receive run-off water. Frequently, the water from these areas must escape by lateral movement through the soil or by evaporation from the surface, as poor structure and other physical influences do not allow drainage through the soil. Often soils in the stream terraces and flood banks are poorly drained due to groundwater moving upward in these areas.



Too much or too little water in the soil is equally undesirable. With too much water, most plants will suffocate. Where there is too little water, plants will wilt and eventually die. The most desirable soil moisture situation is one in which approximately one-half of the pore space of the surface soil is occupied by water.

Soil **porosity** is defined as the number, size, and formation of the open spaces in the soil. Soil porosity is related to the number and size of open (air) spaces in the soil and depends on the size and arrangement of the individual soil particles present. The smaller pores permit liquids to rise against gravity by capillary action. The larger pores are those which allow excess water to drain from the soil profile.

Effects of Texture on Capacity to Hold Water





Available Moisture Storage Capacity for Various Textured Soils

С



### Depth

The effective depth of a soil for plant growth is the vertical distance into the soil from the surface to a layer that essentially stops the downward growth of plant roots. The barrier layer may be rock, sand, gravel, heavy clay, or a partially cemented layer. Terms that are used to express effective depth of soil are:

Very shallow:	Soil surface is less than 10 inches from a layer that retards root devel- opment.
Shallow:	Soil surface is 10 to 20 inches from a layer that retards root development.
Moderately deep:	Soil surface is 20 to 36 inches from a layer that retards root development.
Deep:	Soil surface is 36 to 60 inches from a layer that retards root development.
Very deep:	Soil surface is 60 inches or more from a layer that retards root devel- opment.

Soils that are deep, well-drained, and have desirable texture and structure are suitable for the production of most crops. Deep soils can hold more plant nutrients and water than can shallow soils with similar textures. Depth of soil and its capacity for nutrients and water frequently determine the yield from a crop, particularly annual crops grown through the summer months.

Plants growing on shallow soils also have less mechanical support than those growing in deep soils. Trees growing in shallow soils are more frequently blown over by wind than are those growing in deep soils.

The physical characteristics of soil strongly influence **erosion**. Soils that have lost part or all of their surface are usually harder to till and have lower productivity than those that have desirable thickness of surface soil. To compensate for surface soil loss, better fertilization, liming, and other management practices should be used. Increasing the organic matter content of an eroded soil often improves its tillage characteristics, as well as its water and nutrient capacity.

The principal reasons for soil erosion in New Hampshire are:

- insufficient vegetative cover
- overexposure through the use of cultivated crops on soils not suited to cultivation

• improper equipment and methods used in preparation and tillage of the soil

Soil erosion can be held to a minimum by:

- producing crops to which the soil is suited
- adequate fertilization and liming to promote vigorous growth of plants
- thorough and proper soil preparation
- proper tillage methods
- mulching

### **Components of Soil**

#### **Organic Matter**

Organic matter in soil consists of the remains of plants and animals. When temperature and moisture conditions are favorable in the soil, earthworms, insects, bacteria, fungi, and other types of plants and animals use the organic matter as food, by breaking it down into simpler compounds and soil nutrients. Through this process, materials are made available for use by growing plants.

The digested and decomposing organic material also helps develop good air-water relationships. In sandy soil, organic material occupies some of the space between the sand grains, thus binding these together and increasing water-holding capacity. In a finely textured or clay soil, organic material creates aggregates of the fine soil particles, allowing water to move more rapidly around these larger particles. This grouping of the soil particles into aggregates (or peds) makes it easier to work.

Organic matter content depends primarily on the kinds of plants that have been growing in a soil, the long-term management practices, temperature, and drainage. Soils that have native grass cover for long periods usually have a relatively high organic matter content in the surface area. Those that have native forest cover usually have relatively low organic matter content. In either case, if the plants are grown on a soil that is poorly drained, the organic matter content is usually higher than where the same plants are grown on a well-drained soil. This is due to differences in available oxygen and other substances needed by the organisms that attack and decompose the organic material. Soils in a cool climate have more organic matter than those in a warm climate.

In New Hampshire, it is common to use cover crops to protect sloping land from soil erosion during the fall, winter, and early spring period. Because of the modest amount of organic matter contributed and its rapid decomposition, cover crops used in the garden setting contribute very little organic matter to soil but their value to soil protection cannot be ignored. Both winter rye and oats are commonly used as cover crops. Oats will winterkill and are easily incorporated into soil with a rototiller in the spring. Winter rye grows aggressively in the spring and its springtime incorporation into soil may pose a problem if excessive rye canopy develops during a protracted period of wet weather.

*Muck*. One of the terms associated with organic matter is muck. Muck in its pure form is nothing more than an accumulation of decaying or decayed vegetable matter. It may be entirely devoid of any mineral soil. Soils containing more than 10% of this material are unsatisfactory for growing most plants. It is usually too soggy when wet and it dries out too much when exposed to the air. However, it is an excellent source of humus to add to other mineral soils.

*Humus*. This is a term which is often misused even by experienced gardeners. True humus is vegetable and animal matter that has been modified from the original tissue through decomposition. It is the ultimate end product formed by the decay and oxidation of organic matter by the soil organisms. It is not the black material one buys in bags or bales. It is not even the rough compost obtained from piles of leaves, grass clippings, or manure, etc. While humus will eventually be derived from this material, only the final end product of complete decomposition can be called humus. With true humus there is no offensive smell and the organic source of the humus can not be determined. It is this humus which makes up the organic faction in the soil that is so important to the chemical reactions in the soil.

#### Water and Air

All water in the soil ultimately comes from precipitation (rain, snow, hail, or sleet), entering the soil through cracks, holes, and openings between the soil particles. As the water enters, it pushes the air out. Oxygen is taken up by roots for respiration. If anaerobic (lack of oxygen) conditions persist for too long, the roots will die.

Plants use some water, some is lost by evaporation, and some moves so deep into the soil that plant roots cannot reach it. If it rains very hard or for a long time, some of it is lost through run-off. When organic matter decomposes in the soil, it gives off carbon dioxide. This carbon dioxide replaces some of the oxygen in the soil pores. As a Chapter 2 Soils and Fertilizers

result, soil air contains less oxygen and more carbon dioxide than the air above the soil surface. Carbon dioxide is dissolved by water in the soil to form a weak acid. This solution reacts with the minerals in the soil to form compounds that can be taken up and used as foods by the plants.

#### Plant Nutrients

Plants need 17 elements for normal growth. Carbon, hydrogen, and oxygen (which come from air and water) and nitrogen (which is in the soil) make up 95% of plant solids. Although the atmosphere is 78% nitrogen, it is unavailable for plant use. However, certain bacteria which inhabit nodules on the roots of legumes are able to fix nitrogen from the air into a form available to plants.

The other 13 essential elements are iron, calcium, phosphorus, potassium, copper, sulphur, magnesium, manganese, zinc, boron, chlorine, cobalt and molybdenum. These elements come from the soil. With the exception of calcium, magnesium, phosphorus, and potassium, there is usually a large enough quantity of each of these elements in the soil for cultivation of crops.

### **Cation Exchange Capacity**

Soils consist of solids, liquids and gases. The solid portion (or phase) consists of the minerals (sand, silt and clay) and the organic matter. Since soils naturally have a strong negative charge, they attract cations (positively charged ions) such as calcium  $(Ca^{++})$ , magnesium  $(Mg^{+})$  and potassium  $(K^{+})$ . Cation exchange is the ability of a soil to trade one cation for another, either between soil particles or between soil particles and the soil solution. Cation Exchange Capacity (CEC) is a measure of the soil=s ability to adsorb (attach to the surface) cations and then release them to the soil solution or to plant roots. The CEC of a soil is related to the amount of clay mineral and the amount of organic matter in the soil. Since most New Hampshire soils do not have a high percentage of clay, the organic matter fraction plays an important role in determining this value. A soil with a higher CEC with hold more cations and will help protect against leaching losses of these cations. Another soil property related to CEC is **base saturation**. This is a measure of the percentage of the CEC sites which are occupied by basic cations such as calcium, magnesium, potassium and sodium. Soils with high pH and or a history of being limed would likely have high base saturation percentages. Soils with a low pH and or no history of liming would have a low base saturation. In soils like these, the CEC sites would be occupied by acidic cations such as aluminum  $(Al^{3+})$ and hydrogen (H<sup>+</sup>).

### Soil pH

Soil pH is a measure of the amount of hydrogen in soil taken from a scale that measures the hydrogen (acid forming) ion activity of soil or growth media. The reading expresses the degree of acidity or alkalinity in terms of pH values, very much like heat and cold are expressed in degrees Centigrade or Fahrenheit. The Centigrade temperature scale is centered around zero degrees or the freezing point of water, and thermometers are used to measure intensities of heat and cold above and below this point. The scale of measuring acidity or alkalinity contains 14 divisions known as pH units. It is centered around pH 7 which is neutral. Values below 7 constitute the acid range of the scale and values above 7 make up the alkaline range.



The measurement scale is not a linear scale but a logarithmic scale. That is, a soil with a pH of 8.5 is ten times more alkaline than a soil with a pH of 7.5, and a soil with a pH of 4.5 is ten times more acid than a soil with a pH of 5.5.

The pH condition of soil is one of a number of environmental conditions which affect the quality of plant growth. A near-neutral or slightly acidic soil is generally considered ideal for most plants in the northeast. Some types of plant growth can occur anywhere in a 3.5 to 10.0 range. With some notable exceptions, a soil pH of 6.0 to 7.0 requires no special cultural practices to improve plant growth.

The major impact that pH extremes have on plant growth is the availability of plant nutrients and concentration of the plant-toxic minerals (such as aluminum) in the soil. In highly acidic soils, calcium, phosphorous, and magnesium become tied up and unavailable, and manganese can be concentrated in toxic levels. At pH values of 7 and above, phosphorus, iron, copper, zinc, boron, and manganese become less available.

By the application of certain materials to the soil, adjustments can be made in pH values. To reduce acidity, apply a material that contains some form of lime. Ground agricultural limestone is the most frequently used. The finer the grind the more rapidly it becomes effective. Different soils will require a different amount of lime to adjust the reaction to the proper range. The texture of the soil, organic matter content, crop, and soil type are all factors to consider in adjusting pH. For example, soils low in organic matter require much less lime than soils high in organic matter to make the same pH change.

Wood ash is often used as a soil amendment. It contains potash (potassium), phosphate, boron, and other elements. Wood ash can be used to raise soil pH with twice the weight of ash applied as limestone for the same effect. Ash should not come into contact with germinating seedlings or plant roots as it may cause root damage. Incorporate the ash into the soil in the spring. Check pH yearly if you use wood ashes. Never use coal ash or large amounts of wood ash (no more than 20 lbs. per 1000 square feet), as toxicity problems may occur.

If pH is too high, elemental sulfur or aluminum sulfate can be added to the soil to reduce alkalinity. Most ornamental plants require slightly to strongly acidic soil. These species develop iron chlorosis when grown in soils in the alkaline range. Iron chlorosis is often confused with nitrogen deficiency since the symptoms (a definite yellowing of the leaves) are similar. This problem can be corrected by applying chelated iron sulfate to the soil to reduce the alkalinity and add iron. The term chelate comes from the Greek word for claw. Chelates are chemical claws that help hold metal ions, such as iron, in solution, so that the plant can absorb them. Different chemicals can act as chelates, from relatively simple natural chelates like citrate to more complex, manufactured chemicals. When a chelate metal is added to the soil, the nutrient held by the chelate will remain available to the plant. Most nutrients do not require the addition of a chelate to help absorption. Only a few of the metals, such as iron, benefit from the addition of chelates. The types of chelate used will depend on the nutrient needed and the soil pH.

### A Guide for Estimating Moisture Content of Soil

% OF FIELD	ADEQUACY OF SOIL MOISTURE	RESPONSE TO PHYSICAL MANIPULATION			
CAPACITY	FOR PLANT GROWTH	LOAMY SAND, SANDY LOAM	SILT LOAM, LOAM	SILTY CLAY LOAM	
100 plus	Saturated soil - too much moisture and too little air in the soil; can damage plants if this condition persists	Free water appears on soil when squeezed	Same as sandy Ioam	Same as sandy loam	
100	Excess moisture has drained into subsoil after rainfall or irrigation and optimum amounts are available in root zone for plant growth	When squeezed, no free water appears on surface, but it leaves a wet outline on your hand	Same as sandy Ioam	Same as sandy Ioam	
		Forms weak ball; usually breaks when bounced in hand	Forms a very pliable ball; sticks readily	Ribbons out (can be formed into a thin strand when rolled between thumb & forefinger), has a slick feeling	
75	Adequate moisture for plant growth	Tends to ball under pressure, but breaks easily when bounced in hand	Forms a ball, somewhat plastic, sticks slightly with pressure	Forms a ball, ribbons out between thumb and forefinger, has slick feeling	
	Marginal moisture for plant growth; time toirrigate				
50	Inadequate moisture for plant growth	Appears too dry; will not form a ball with pressure	Somewhat crumbly, but holds together with pressure	Somewhat pliable, balls under pressure	
25	Moisture in soil is unavailable for plant growth	Dry, loose, falls through fingers	Powdery, sometimes crusty, but easily broken down into a powdery condition	Hard, cracked, difficult to break down into a powdery condition	
0					

Note: Soil sample was at 4 to 6 inches depth. Adapted from: Craig, C.L. 1976. Strawberry Culture in Eastern Canada. Agric. Canada Publications 1585:19

### **Fertilizers**

There are 17 elements essential to plant growth. Nitrogen, phosphorous and potassium are considered fertilizer macronutrients because plants require them in quantity for maximum growth. Calcium, magnesium, and sulfur are secondary macronutrients but usually are either present in sufficient quantities or are added coincidentally with other materials (e.g., lime). The other 11 nutrients, called micronutrient, are just as important but necessary in smaller amounts. If plants lack any of these elements, they exhibit signs of nutrient deficiency.

### **Fertilizers Analysis**

The fertilizer analysis given on the package refers to the amount of an element present in a formulation based on percentage of weight. All fertilizers are labeled with three numbers, giving the percentage by weight of nitrogen (N), phosphate ( $P_2O_5$ ), and potash ( $K_2O$ ) respectively. However, to simplify matters, these are usually just referred to as nitrogen, phosphorus and potassium or N, P, and K.

Some soil test labs report phosphorus results in terms of P and others in terms of  $P_2O_5$ . In order to compare results you may need to convert phosphorus to phosphate, or vice versa. To convert P to  $P_2O_5$  you would multiply by 2.29. (This factor is related to the molecular weight of the two products). To convert  $P_2O_5$  to P multiply by 0.43. To convert potassium (K) to potash (K<sub>2</sub>O) multiply K values by 1.2. To convert potash (K<sub>2</sub>O) to potassium multiply the K<sub>2</sub>O value by 0.83. For example, if we have a 100 pound bag of 10-10-10, there are 10 pounds of N, 10 pounds of P<sub>2</sub>O<sub>5</sub>, 10 pounds of K<sub>2</sub>O and 70 pounds of filler. The amount of actual phosphorus (P) in the bag is 4.3 pounds (10 pounds of phosphate x 0.43).

Filler can be important so that we can evenly spread the fertilizer and avoid burning plants with too much fertilizer. A 100-pound bag of fertilizer labeled 0-20-10 would have 0 pounds of N, 20 pounds of  $P_2O_5$ , 10 pounds of  $K_2O$ , and 70 pounds of filler.

For many years, there has been a model label law which many states have adopted for the classification of fertilizers. The law also establishes minimum levels of nutrients allowable and provides specific labeling requirements. To date, model label legislation has not met with total acceptance, so there are still differences from state to state as to what constitutes a fertilizer and the type of information on labels. Even so, the information contained on fertilizer labels has been well standardized, and the consumer is protected by state laws requiring manufacturers to guarantee the claimed nutrients.

The law requires that the manufacturer guarantees accuracy of what is claimed on the label. In some cases, a fertilizer will contain secondary nutrients or micronutrients not listed on the label because the manufacturer does not want to guarantee their exact amounts. The gardener/consumer is assured that nutrients listed on the label are actually contained in the fertilizer.

On fertilizer labels, the initials W.I.N. and W.S.N. stand for Water Insoluble Nitrogen and Water Soluble Nitrogen, respectively. The water soluble nitrogen (W.S.N.) dissolves readily and is usually in very simple form, such as ammoniacal nitrogen (ammonia) or nitrate nitrogen. Nitrogen which will not dissolve readily may exist in other forms in the fertilizer. These are usually organic forms of nitrogen (with the exception of urea) that must be broken down into simpler forms before it can be used. Water insoluble nitrogen (W.I.N.) is referred to as a slow-release nitrogen source and delivers nitrogen at different rates according to the amount and kind of material in its composition.

The best fertilizer to use depends on many factors, such as the nutrients needed, soil structure, soil chemistry, and method of applying the fertilizer.

### **Complete Versus Incomplete**

A fertilizer is said to be complete when it contains nitrogen, phosphorus, and potassium. The manufacturers of commercial fertilizers are required to state the amounts of nutrients on the container as a guaranteed analysis. Examples of commonly used fertilizers are 10-10-10, 16-16-16, and 20-10-5. An incomplete fertilizer will be missing one of the major components.

The fertilizer ratio indicates the proportion of nitrogen, phosphate, and potash contained in the fertilizer. The specific fertilizer ratio you will need depends on the soil nutrient level. For example, a 1-1-1 ratio (10-10-10, 15-15-15, 20-20-20) is widely used at the time of lawn establishment, but established lawns generally respond better to fertilizer ratios high in nitrogen. Two of the more common complete fertilizers used by homeowners for flowers and vegetables are 10-10-10 and 5-10-10.

### **Special Purpose Fertilizers**

When fertilizer shopping, you will find fertilizers packaged for certain uses or types of plants such as Camellia Food, Rhododendron and Azalea Food, or Rose Food. The camellia and rhododendron/azalea fertilizers belong to an old established group, the acid plant fertilizers. Some of the compounds used in these fertilizers are chosen because they have an acid reaction, so they are especially beneficial to acid-loving plants where soil is naturally neutral or alkaline. The other fertilizers packaged for certain plants do not have as valid a background of research. For example, the next time you are shopping, compare the fertilizer ratios of different brands of rose fertilizers.

A soil test should be performed before the purchase of any expensive, special-purpose fertilizers. It is not possible to make a blanket statement that one fertilizer is best for every area of a particular state. It is true that different plants use different nutrients at different rates. What is unknown is the reserve of nutrients already in the soil. This changes with every soil type and location.

### **Slow-Release Fertilizers**

Plants can absorb nutrients continuously, so it is beneficial to provide them with a balance of nutrients throughout their growth. Perhaps the most efficient way to achieve this is to apply a slowrelease fertilizer, which releases nutrients at a rate that makes them available to the plants over a long period. Slow-release fertilizers contain one or more essential elements. These elements are released or made available to plants over an extended period.

Slow-release fertilizers can be categorized according to their release mechanism. The three major types of nutrient release mechanisms are: (1) materials that dissolve slowly, (2) materials containing microorganisms which release nitrogen, and (3) granular materials with membranes made of resin or sulfur to control the rate of nutrient release into the soil.

Sulfur-coated urea is a slow-release fertilizer with a covering of sulfur around each urea particle. Different thicknesses of sulfur control the rate of nitrogen release, which increases with temperature. Watering does not affect its release rate. Sulfur-coated urea applied to the soil's surface releases nitrogen more slowly than if incorporated into the soil. This material generally costs less than other slow-release fertilizers, and it supplies the essential element, sulfur. When fertilizer products coated with multiple layers of resin come into contact with water, the layers swell and increase the pore size in the resin so that the dissolved fertilizer can move into the soil. Release rate depends on the coating thickness, temperature, and water content of the soil. There is often a large release of fertilizer during the first two or three days after application. Release timing can be from 0 to 6 months, depending on the coating.

Slow-release fertilizers need not be applied as frequently as other fertilizers, and higher amounts can be applied without danger of burning. Plants may use the nitrogen in slow-release fertilizers more efficiently than nitrogen in other forms, since it is released over a longer period of time and in smaller quantity. Slow-release fertilizers are generally more expensive than other types. The real benefit, however, is the frequency of application, which is much lower than conventional fertilizers.

Urea formaldehyde and sulfur-coated urea have been used as turf fertilizer, while resin-coated fertilizers are predominantly used in container growing.

Caution should be used in applying slow-release fertilizers around trees or shrubs, as they may keep the plant in growth late in the summer. The lateseason growth may not harden off completely, and excessive winter damage may occur.

The table below compares slow-release fertilizers and conventional fertilizers.

### **Comparison of Fertilizers**

#### **Slow Release Fertilizers**

#### Advantages

- 1. Fewer applications
- 2. Low burn potential
- Release rate varies depending on fertilizer characteristics

#### Conventional Fertilizers Advantages

- 1. Fast acting
- 2. Some are acid-forming
- 3. Low cost

#### Disadvantages

- 1. Unit cost is high
- 2. Availability is limited
- 3. Release rate is governed by factors other than plant need

#### Disadvantages

- 1. Greater burn potential
- 2. Solidifies in bag when wet
- 3. Some nitrogen forms leach readily
#### Manures or Sewage Sludge

#### Advantages

- 1. Low burn potential
- Disadvantages
- 1. Salts may build
- up 2. Bulky
- 3. Odor
- Contains micronutrient
   Conditions the soil

2. Relatively slow-release

- 4. Expensive per pound for actual
- nutrient 5. Contains weed seed
- 5. Contains weed seed
- 6. Heavy metals may be present in sewage sludge from large cities or industrial areas

### **Organic Fertilizers**

The word organic, applied to fertilizers, simply means that the nutrients contained in the product are derived solely from the remains or by-products of a once-living organism. Urea is a synthetic organic fertilizer, an organic substance manufactured from inorganic materials. Cottonseed meal, blood meal, bone meal, hoof and horn meal, and all manures are examples of organic fertilizers. When packaged as fertilizers, these products will have the fertilizer ratios stated on the labels. Some organic materials, particularly composted manures and sludges, are sold as soil conditioners and do not have a nutrient guarantee, although small amounts of nutrients are present. Most are high in one of the three major nutrients and low in the other two, although you may find some fortified with nitrogen, phosphorus, or potash for a higher analysis. Many are low in all three. In general, organic fertilizers release nutrients over a fairly long period; the potential drawback is that they may not release enough of their principal nutrient at a time to give the plant what it needs for best growth. Because organic fertilizers depend on soil organisms to break them down to release nutrients, most of them are effective only when soil is moist and soil temperature is warm enough for the soil organisms to be active.

Plants cannot differentiate between chemical or organic sources of basic nutrient elements. Research has also indicated that sources of basic mineral plant nutrients have no impact upon plant growth, vigor, flavor, or human nutritional value. Cottonseed meal is a by-product of cotton manufacturing; as a fertilizer, it is somewhat acidic in reaction. Formulas vary slightly, but generally contain 7 percent nitrogen, 3 percent phosphorus, and 2 percent potash. Cottonseed meal is readily available to plants in warm soils, and there is little danger of burn. For general garden use, apply 2 to 5 pounds per 1000 square feet. Cottonseed meal is frequently used for fertilizing acid-loving plants such as azaleas, camellias, and rhododendrons.

Blood meal is dried, powdered blood collected from beef processors. It is a rich source of nitrogen — so rich, in fact, that it may do harm if used in excess. The gardener must be careful not to use more than the amount recommended on the label. In addition to supplying nitrogen, blood meal supplies certain of the essential trace elements, including iron.

Fish emulsion, a complete fertilizer, is a partially decomposed blend of finely pulverized fish. No matter how little is used, the odor is intense — but it dissipates within a day or two. Fish emulsion is high in nitrogen and is a source of several trace elements. In the late spring, when garden plants have sprouted, an application of fish emulsion followed by a deep watering will boost the plant's early growth spurt. Contrary to popular belief, too strong a solution of fish emulsion can burn plants, particularly those in containers.

Manure is also a complete fertilizer, but low in the amounts of nutrients it can supply. Manures vary in nutrient content according to the animal source, bedding material used, and what the animal has been eating, but a fertilizer ratio of 1-1-1 is typical. Manures are best used as soil conditioners instead of nutrient sources. The straw or litter in some manures can help add organic matter to the soil, however barnyard manure usually contains large numbers of weed seeds. Commonly available manures include horse, cow, pig, chicken, and sheep. The actual nutrient content varies widely: the highest concentration of nutrients is found when manures are fresh. As it is aged, leached, or composted, nutrient content is reduced. However, the subsequent reduction in salts will reduce the chances of burning plants. Ammonia toxicity may be another concern. Fresh manure should not be used where it will contact tender plant roots. Commercially dried manures are very expensive for the benefits received. Typical rates of manure applications vary from a moderate 70 pounds per 1000 square feet to as much as one ton per 1000 square feet.

Sewer sludge is a recycled product of municipal sewage treatment plants. Two forms are commonly available: activated and composted. Activated sludge has higher concentrations of nutrients (approximately 6-3-0) than composted sludge, and is usually sold in a dry, granular form for use as a general purpose, long-lasting, non-burning fertilizer. Composted sludge is used primarily as a soil amendment and has a lower nutrient content (approximately 1-2-0). There is some question about the long-term effects of using sewage sludge products in the garden, particularly around edible crops. Heavy metals, such as cadmium, are sometimes present in the sludge, and may build up in the soil. Possible negative effects vary, not only with the origin of the sludge, but also with the characteristics of the soil where it is used. It may be appropriate to have the sludge analyzed for heavy metals.

The following table shows the approximate nutrient content of manures and common organic fertilizers plus the suggested yearly rates of application per 1000 square feet of garden area. Rates given are for materials used singly; if combinations of two or more materials are used or some chemical fertilizer is used, the rate should be reduced accordingly.

Type of Dry Manure or Fertilizer	Nitrogen %	Phosphorus %	Potassium %	Suggested Approx. Rate (lbs. per 1000 Sq Ft of garden area)
Chicken manure	2.0-4.5	3.0-4.6	1.2-2.4	125
Horse manure	.5-1.0	.25	.37	700
Dairy manure	1.2-2.7	5.6-1.4	2.0-3.6	600
Sheep manure	1-1.5	.35	.7-1.3	3 700
Green sand	0	0	4-7	50
Granite dust	0	0	3-5	50
Rock phosphate	0	33.0	0	100

Compared to synthetic fertilizer formulations, organic fertilizers contain relatively low concentrations of actual nutrients, but they perform other important functions which the synthetic formulations do not. Some of these functions are: increasing organic content of the soil; improving physical structure of the soil; and increasing bacterial and fungal activity, particularly the mycorrhiza fungus, which alone makes other nutrients more available to plants.

### Fertilizers Combined with Pesticides

The major reason for buying a fertilizer combined with a pesticide is convenience. It is very convenient to combine everything you need in one application, but it is also very expensive. The problem is that the timing for a fertilizer application often does not coincide with the appearance of a disease or an insect problem. In the case of a number of turfgrass diseases, a primary cause of disease infestation is merely a lack of proper fertilizer.

A fertilizer-insecticide combination, when applied at the proper stage of a pest's life-cycle, can do an adequate job of controlling the turf pest while also giving the grass "a shot in the arm" to help its recovery. However, fertilizers with pesticides intended for use with turf or ornamentals should not be used in the vegetable garden where it may contaminate food crops. Always read the label carefully.

### **Fertilizers Formulation**

Fertilizers come in many shapes and sizes. Different formulations are made to facilitate types of situations in which fertilizer is needed. Packaging for all formulations must show the amount of nutrients contained, and sometimes it tells how quickly a nutrient is available. Some of the formulations available to the homeowner are: water-soluble powders, slow-release pellets, slow-release collars or spikes, liquids, tablets, and granular solids.

Liquid fertilizers come in a variety of different formulations, including complete formulas and special types that offer just one or two nutrients. All are made to be diluted with water; some are concentrated liquids themselves, others are powder or pellets. Growers of container plants often use liquid fertilizers at half the recommended dilution twice as frequently as recommended so that the plants receive a more continuous supply of nutrients.

### **Fertilizer Application**

Computing the amount of fertilizer needed for a given area is rather tricky at first, but after a few times, this becomes second nature. Following is an example of a fertilizer determination for a lawn.

Since the element that is often the one usually lacking in most soils and also required more by most plants is nitrogen, many fertilizer recommendations are based on this element. For vegetable gardens, flower beds, small fruit plantings, etc. the rule of thumb is 1 lb. of actual nitrogen per 1,000 sq. ft. for maintenance and 2 lbs. of nitrogen at the time of establishment (worked into the soil).

*Example.* Determine the amount of ammonium sulfate needed by a 5000 square-foot lawn if 1 pound of nitrogen per 1000 square feet is required.

Lawn: 5000 square feet Fertilizer: ammonium sulfate (21-0-0) Rate: 1 pound of nitrogen per 1000 square feet

- 1. Since we need 1 pound of nitrogen for every 1000 square feet and we have 5000 square feet, we need 5 pounds of nitrogen.
- 2. Ammonium sulfate is 21 percent nitrogen (round to 20 percent).
- 3. 20 percent is the same as 0.20 or 1/5. This means that we need 5 pounds of fertilizer to get 1 pound of nitrogen.
- 4. Since we need 5 pounds of nitrogen,  $5 \times 5 = 25$  pounds of fertilizer.

#### Total fertilizer needed =

N application rate lawn size <u>(lbs./1000 sq. ft.)</u> x (sq. ft.) = 1 x 5000 = 25 lb. N content of fertilizer 1000 0.20 1000 fertilizer expressed as a decimal

Nitrogen fertilizers do not burn or damage plants if they are applied correctly. Fertilizers are salts, much like our familiar table salt, except that they contain various plant nutrients. When a fertilizer is applied to a soil, nearby water begins to move very gradually towards the area where the fertilizer has been applied. Salts in the fertilizer begin to diffuse or move away from the place where they had been applied. This dilutes the fertilizer and distributes it through a much larger area. If tender plant roots are close to the area where the fertilizer is placed, water will be drawn from these roots and from the surrounding soil. The more salt or fertilizer applied, the more water will be drawn from nearby roots. As water is drawn from the roots, plant cells begin to dehydrate and collapse, and the plant roots burn or dehydrate to a point from which they cannot recover. If soil moisture is limited, most of the water drawn towards the salt will come from plant roots and the damage will be severe.

Two rules should be kept in mind when applying a fertilizer during hot weather when soil moisture is limited: 1) do not over-apply nitrogen fertilizers; and 2) make sure adequate moisture is present after applying fertilizers high in salts. The following table is a chart of commonly used garden fertilizers high in salt content or burn potential. The last column is the practical measure of relative saltiness. A higher number indicates greater saltiness.

#### **Relative Saltiness**

Material	Nutrient level	<u>per weight</u>
		of nutrient
Ammonium nitrate	33 percent Nitrogen	1.49
Ammonium sulfate	21 percent Nitrogen	1.63
Potassium nitrate	14 percent Nitrogen	2.67
Natural organic fertilizer	5 percent Nitrogen	0.41
Urea formaldehyde	38 percent Nitrogen	0.13
Urea	45 percent Nitrogen	0.81
Superphosphate	20 percent Phosphore	us 0.21
Potassium chloride	60 percent Potash	0.87
Potassium sulfate	50 percent Potash	0.43
Dolomite	30 percent Calcium	—
	20 percent Magnesiu	m —
Gypsum	33 percent Calcium	0.12
Epsom salts	16 percent Magnesiu	m 1.38

Soluble salts will accumulate on top of the soil in a container and form a yellow-to-white crust. A ring of salt deposits may form around the pot at the soil line or around the drainage hole. Salts will also build up on the outside of clay pots. Soluble salts accumulate when fertilizer is applied repeatedly without sufficient water to leach or wash the old fertilizer's salts through the soil. It also occurs when water evaporates from the soil and minerals, but salts stay behind. As the salts in the soil become more concentrated, plants find it harder to take up water. If salts build up to an extremely high level, water can be taken out of the root tips, causing them to die. Soluble-salt problems commonly occur on plants in containers but are rarely a problem in the garden. The best way to prevent soluble salt injury is to stop the salts from building up. Water correctly. When water is applied, allow water to drain through the bottom holes and then empty the drip plate. Water equal to one-tenth the volume of the pot should drain through each time you water. Do not allow the pot to sit in water. If you let the drained water be absorbed by the soil, the salts that were washed out are taken back into the soil. Salts can be reabsorbed through the drainage hole or directly through a clay pot.

Potted plants should be leached every 4 to 6 months. Leach a potted plant before fertilizing to avoid washing away all newly added fertilizer. Leaching is done by pouring water on the soil and letting it drain completely. The amount of water used for leaching should equal twice the volume of the pot. For example, a 6-inch pot will hold 10 cups of water, so 20 cups of water are used in leaching. Keep the water running through the soil to wash the salts out. If a layer of salts has formed a crust on top of the soil, you should remove the salt crust before you begin to leach. Do not remove more than ¼-inch of soil. It is best not to add more soil to the top of the pot. If the soluble salt level is extremely high or the pot has no drainage, repot the plant.

The level of salts that will cause injury varies with the type of plant and how it is being grown. A plant grown in the home may be injured by salts at a concentration of 200 ppm. The same plant growing in a greenhouse where the light and drainage are good will grow well until salts reach concentrations 10 times that level, or 2000 ppm. Some nurseries and plant shops leach plants to remove excess salts before the plant is sold. If you are not sure that has been done, leach a newly purchased plant the first time you water it.

Soil type dictates the frequency of fertilizer application. Sandy soils require more frequent applications of nitrogen and other nutrients than do clay-type soils. Other factors affecting frequency of application include the type of crop, the level of crop productivity required, frequency and amount of water applied, and type of fertilizer applied and its release rate.

### Timing

The type of crop influences timing and frequency of application since some crops are heavier feeders of particular nutrients than others. Root crops require less nitrogen fertilization than do leafy crops. Corn is a heavy feeder of nitrogen, while most trees and shrubs are generally light nitrogen-feeders. Corn may require nitrogen fertilization every four weeks, while most trees and shrubs perform nicely with one, good, well-placed application every year or two. A general rule of thumb is that nitrogen is for leafy top growth; phosphorus is for root and fruit production; and potassium is for cold hardiness, disease resistance, and general durability.

Proper use of nutrients can control plant growth rate and character. Nitrogen is the most critical nutrient in this regard. If tomatoes are fertilized heavily with a nitrogen fertilizer into the summer, the plants may be all vine and no fruit. This is also the case with potatoes, which will show excess vining and poor tuber formation. If slow-release fertilizers or heavy amounts of manure are used on crops that form fruit or vegetables, leaf and vine growth will continue into late summer, and fruit and vegetable development will occur very late in the season.

Remember that a nitrogen application will have its greatest effect for three to four weeks after application. If tomatoes are fertilized heavily on June 1, there may be no flower production until July 1, which will, in turn, delay fruit ripening until late August. For this reason, it is important to plant crops with similar fertilizer needs close together to avoid improper rates of application.

Late fertilization (after July 1) of trees and shrubs can cause new flushes of growth to occur on woody plants that are normally adjusting themselves for the coming winter. This may delay dormancy of woody plants and cause severe winter die back in new growth.

The following suggestions about groups of garden plants are given as general guides. Gardeners should be aware that individual species within these groups vary considerably. After each group of plants, the need for the primary nutrients (nitrogen, phosphorus, and potassium) is indicated as high, medium, or low.

Vegetables	High
Herbs	Medium to Low
Lawns	Medium to High
Fruits	Medium
Annual flowers	Medium
Perennial flowers	Medium to Low
Deciduous shrubs	Medium to Low
Evergreen shrubs	Low
Deciduous shade trees	Medium to Low
Evergreen shade trees	Low

### **Application Methods**

There are different methods of applying fertilizer depending on its formulation and the crop needs.

**Broadcasting** — A recommended rate of fertilizer is spread over the growing area and left to filter into the soil or incorporated into the soil with a rototiller or spade. Broadcasting is used over large garden areas or when time or labor is limited.

**Banding** — Narrow bands of fertilizer are applied in furrows 2 to 3 inches from the garden seeds and 1 to 2 inches deeper than the seeds or plants. Careless placement of the fertilizer band too close to the seeds will burn the roots of the seedlings. The best technique is to stretch a string where the seed row is to be planted. With a corner of a hoe, dig a furrow 3 inches deep, 3 inches to one side, and parallel with the string. Spread one-half the suggested rate of the fertilizer in the furrow and cover it with soil. Repeat the banding operation on the other side of the string, then sow seeds underneath the string.

For widely spaced plants, such as tomatoes, fertilizers can be placed in bands 6 inches long for each plant or in a circle around the plant. Place the bands 4 inches from the plant base. If used in the hole itself, place the fertilizer at the bottom of the hole, work it into the soil, and place a layer of soil about 2 inches deep over the fertilized soil before putting the plant in the hole.

Banding is one way to satisfy the needs of many plants (especially tomatoes) for phosphorus as the first roots develop. When fertilizers are broadcast and worked into soil, much of the phosphorus is locked up by the soil and is not immediately available to the plant. By concentrating the phosphorus in the band, the plant is given what it needs even though much of the phosphorus stays locked up.

**Starter solutions** — Another way to satisfy the need for phosphorus when setting out transplants of tomatoes, eggplant, peppers, or cabbage is through the use of a liquid fertilizer high in phosphorus, as a starter solution. Follow directions on the label.

**Side-Dressing** — Dry fertilizer is applied as a side dressing after plants are up and growing. Scatter fertilizer on both sides of the row 6 to 8 inches from the plants. Rake it into the soil and water thoroughly.

**Foliar Feeding** – Foliar feeding is used when insufficient fertilizer was used before planting; a quick growth response is wanted; micronutrients (such as iron or zinc) are locked into the soil; or when the soil is too cold for the plants to use the fertilizer applied to the soil. Foliar-applied nutrients are absorbed and used by the plant quite rapidly. Absorption begins within minutes after application and, with most nutrients, it is completed within 1 to 2 days. Foliar nutrition can be a supplement to soil nutrition at a critical time for the plant, but not a substitute. At transplanting time, an application of phosphorus spray will help in the establishment of the young plant in cold soils. For perennial plants, early spring growth is usually limited by cold soil, even when the air is warm. Under such conditions, soil microorganisms are not active enough to convert nutrients into forms available for roots to absorb; yet, if the nutrients were available, the plants could grow. A nutrient spray to the foliage will provide the needed nutrients immediately, allowing the plants to begin growth.

### **Improving Soil Structure**

In special cases, coarse sand, vermiculite, peat and perlite are added to heavy clays to help improve the soil texture or structure. However, these inert materials can be expensive and large quantities are needed to do any good. In some cases, they can make the situation worse by causing clays to "set up" similar to concrete. Compost, manures, and other organic amendments are more effective and economical for modifying the soil structure.

Organic matter is a great soil improver for both clay and sandy soils. Good sources of organic matter include manures, leaf mold, sawdust, and straw. These materials are decomposed by soil organisms. Various factors such as moisture, temperature, and nitrogen availability determine the rate of decomposition through their effects on these organisms. Adequate water must be present, and warm temperatures will increase the rate at which the microbes work. The proper balance of carbon and nitrogen is needed for rapid decomposition. The addition of nitrogen may be necessary if large amounts of undecomposed high-carbon substances such as dried leaves, straw, or sawdust are used. Fresh green wastes, such as grass clippings, are higher in nitrogen than dry material. In the process of breaking down the organic matter, nitrogen is used by the microbes and, therefore, may become deficient in the plants.

**Peat Moss**. One of the most popular sources of organic matter which has many uses is peat moss. It is fairly uniform, readily available, and easy to work with. Peat moss is partially decomposed organic matter which was formed under water (low oxygen) in bogs and swamps. There are several types of peat available on the market. They differ somewhat because of the site and depth where they were obtained, the parent plant material and the relative stage of decomposition. The actual pH of the various peats may also vary from about pH 3.0 to pH 4.5. Generally speaking, the European and Canadian peats are the result of sphagnum moss partially decomposing under bog conditions while the "domestic" peats often contain other mosses and additional woody or herbaceous plant material such as reed and sedge. "Native" or "Michigan" type peat mosses have usually progressed further along in their decomposition and are finer to the touch, with less visible plant parts remaining in them.

They may also be darker in color. All peat moss will eventually break down in the soil and produce humus, but it is lacking in the nutrients required for adequate plant growth. A sound fertilizer program is therefore a requirement when using quantities of peat moss.

*Compost.* The use of compost is one way to avoid tying up nitrogen during decomposition. Compost is usually made by the gardener from plant wastes. Correct composting can result in a valuable nutrient and humus source for any garden. The basis of the process is the microbial decomposition of mixed raw organic materials to humus, a dark, fluffy product resembling rich soil, which is then spread and incorporated into the garden soil.

For more detailed information, refer to the composting chapter in this handbook.

Another source of inexpensive soil improvement that should not be underestimated is the cover crop. Green manures, or cover crops, such as ryegrass are planted in the garden in the fall for incorporation in the spring. For best results, seed should be sown a little before the first killing frost. In a fall garden, plant cover crops between the rows and in any cleared areas. Cover cropping provides additional organic matter, holds nutrients that might have been lost over the winter, and helps reduce erosion and loss of topsoil. Legume cover crops can increase the amount of nitrogen in the soil and reduce fertilizer needs. A deep-rooted cover crop allowed to grow for a season in problem soil can help break up a hardpan and greatly improve tilth. Incorporate green manures at least two weeks before planting vegetables. They should not be allowed to go to seed.

The "ideal" cover crop will:

- Establish satisfactory cover for soil erosion prevention over the winter.
- Add significant amounts of organic matter to the soil.
- Replace some of the fertilizer nitrogen requirement.

The following crops, which include both grasses and legumes, are possibilities for cover and/or green manure. The choice will be governed by (a) costs; (b) seeding date; (c) period of time allocated for growth; (d) vigor of establishment; (e) soil conditions and (f) eventual utilization.

Crop	Seeding Rate (Ibs/A)	Comments
Winter Rye	100	First choice for gardeners for best cover. In spring may need to rototill early two-three times for complete kill.
Sweet Clover (white)	12	Excellent growth in second year after establishment. Needs relatively high pH (>6.0)
Oats		Seed in early spring or August for cover. Winterkills totally.
Hairy Vetch	40	Costly. Winterkills. Must seed in NH by Aug. 15 for good fall cover.
Wheat (spring & winter)	90	Spring wheat: Early planting important. Winter wheat: No vigor advantage over rye as a cover crop.
Buckwheat	75	Sow June 1 - July 15. Sensitive to drought. Reseed by discing after seed development. Rapid establishment.
Alfalfa	10	Long lived perennial. Slow cover establishment in fall with August seeding. Excellent N <sup>2</sup> fixation.
Red Clover	6	Good all-purpose legume for short term (2 yr.) Rotation. Sow by Aug. 20 for reasonable fall establishment.
Ladino Clover	2	Very slow to establishment. Low-growing perennial. Perhaps use for inter-row plantings. Sow by Aug. 15.
Japanese Millet	25	Used as summer annual. Rapid growth. Good organic matter source.
Sudan or Sorghum /Sudan hyb.	30-50	Excellent summer annual. May pose problems at plow-down due to biomass.
Perennial Ryegrass	30	Long-term cover crop. Some winterkill may occur.
Field Bromegrass	20	Permanent, vigorous grass cover. Reseed by discing after seed development.

The regular addition of manures, compost, cover crops, and other organic materials can raise the soil nutrient and physical level to a point at which the need for additional synthetic fertilizers is greatly reduced. This highly desirable soil quality does not come about with a single or even several additions of organic material, but rather requires a serious soil-building program.

### **Soil Testing**

The purpose of a soil test is to supply the homeowner with enough information to make a wise fertilizer purchase. A soil test will provide information on buffer pH, soil pH, lime content, available phosphorus and potassium. The results of the soil test are mailed to the homeowner with recommendations as to what kind of fertilizer should be applied for economical growth of the desired crops. Soil tests should be performed if such tests have never been done before. A soil test need not be performed more often than every 3 to 4 years. The sample should be submitted in the fall, prior to planting or tilling, so that needed lime can be changing the pH over the winter. Fertilizers should be incorporated the next spring.

The accuracy of the soil test is a reflection of the sample taken. Be sure the sample is representative of the area to be treated. Sample the soil from 10 random areas of the garden to a depth of 6 to 12 inches. Avoid sampling unusual areas such as those near gravel roads, manure or compost spots, brush piles, or under eaves. Place the samples in a clean pail or container, and mix the soil thoroughly. Then transfer a pint of mixed soil to a container and take it to the local Extension office. Comparisons of results between home test kits, various state laboratories and commercial testing services cannot really be made because of varying extracting and analysis procedures.

### Analysis and Use of Some Common Fertilizer Materials

		Other	Rate of Application			
Name of Material	Analysis N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O	Nutrients Supplied	Dry (Ibs/cu yd)*	Liquid (Ibs/100 gals)	Speed of Reaction	Effect on pH
Primary Fertilizers						
Ammonium sulfate (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	20-0-0	S	½-1 lb/100 sqft.	2-3	Rapid	Very Acid
Sodium Nitrate NaNO <sub>3</sub>	15-0-0		¾-1¼ lb /100 sq ft	2 oz per 2 gal	Rapid	Basic
Calcium nitrate Ca(NO <sub>3</sub> ) <sub>2</sub> ,2H <sub>2</sub> O	15-0-0	Ca	¾-1½ lb/100 sq ft	3 oz per 2 gal	Rapid	Basic
Potassium nitrate KNO <sub>3</sub>	13-0-44		1⁄2-1 lb/100 sq ft	2 oz per 3 gal	Rapid	Neutral
Ammonium nitrate NH <sub>4</sub> NO <sub>3</sub>	33-0-0		¼-½ lb/100 sq ft	1¼ oz per 5 gal	Rapid	Acid
Urea CO(NH <sub>2</sub> ) <sub>2</sub>	46-0-9		¼-½ lb/100 sq ft	1-1¼ oz /5-7 gal	Rapid	SI. Acid
Mono-ammonium phosphate NH <sub>4</sub> H <sub>2</sub> PO <sub>4</sub>	12-62-0		1 lb/100 sq ft	2 oz per 3 gal	Rapid	Acid
Di-ammonium phosphate $(NH_4)_2HPO_4$	21-53-0		½-¾ lb/100 sq ft	1¼-1½ oz/per 4-5 gal	Rapid	Acid
Treble superphosphate Ca(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub>	0-40-0	Са	1-2½ lb/100 sq ft	Insoluble	Medium	Neutral
Superphosphate Ca(H <sub>2</sub> PO <sub>4</sub> ) <sub>2</sub> +CaSO <sub>4</sub>	0-20-0	Ca+S	3-8 lbs.	Insoluble	Medium	Neutral
Potassium chloride KCI	0-0-60		½-¾ lb/100 sq ft	1¼-1½ oz/4-5 gal	Rapid	Neutral
Potassium sulfate K <sub>2</sub> SO <sub>4</sub>	0-0-50	S	½-1 lb/100 sq ft	Not advisable	Rapid	Neutral
Urea formaldehyde	38-0-0		3-5 lb/100 sq ft	Insoluble	Slow	SI. Acid
Additives						
Limestone, Dolomitic	None	Ca+Mg	5-20 lb	Insoluble	Slow	Basic

Hydrated Lime Ca(OH) <sub>2</sub>	None	Са	2 lb/100 sq ft (Not advisable)	Relatively insoluble	Rapid	Basic
Gypsum (calcium sulfate) CaSO <sub>4</sub>	None	Ca+S	2-5 lb/100 sq ft	Insoluble	Medium	Neutral
Sulfur	None	S	1-2 lb/100 sq ft	Insoluble	Slow	Acid
Epsom salts (magnesium sulfate) MgSO₄.7H₂O	None	Mg+S	8-12 oz/100 sq ft	11⁄4	Rapid	Neutral
Aluminum sulfate Al <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	None	S	1 tsp. per 6" pot (Not advisable)	20	Rapid	Very Acid

		Other	Rate of Application			
Name of Material	Analysis N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O	Nutrients Supplied	Dry (lbs/cu yd)*	Liquid (Ibs/100 gals)	Speed of Reaction	Effect on pH
Complete						
Complete soluble (mixtures)	20-20-20 20-5-30 16-32-16	Var. Var.	Not advisable as dry	1½-2½ oz/3-5 gal	Rapid	Various
Complete dry (mixtures)	10-10-10 5-10-10	Var. Var.	2 lb/100 sq ft 2-3 lb/100 sq ft	Relatively insoluble Relatively insoluble	Various Various	Various Various
Organic	5-10-3	Var.	2-4 lb/100 sq ft	Relatively insoluble	Various	Various
Plastic coated pellets	Variable			Insoluble	Slow	Various
Magnesium ammonium phosphate	7-40-6	Mg		Insoluble	Slow	Neutral
Organics						
Activated sludge	Usually 5-4-0	)	3-5 lb/100 sq ft	Insoluble	Medium	Acid
Animal tankage	Usually 7-9-0	)	3-4 lb/100 sq ft	Insoluble	Medium	Acid
Castor pomace	5-1-1		3-5 lb/100 sq ft	Insoluble	Slow	
Cottonseed meal	7-2-2		3-4 lb/100 sq ft	Insoluble	Slow	Acid
Dried blood	12-0-0		2-3 lb/100 sq ft	Insoluble	Medium	Acid
Hardwood ashes	0-1-5		3-10 lb/100 sq ft	Insoluble	Medium	Basic
Hoof and horn metal	13-0-0		2-3 lb/100 sq ft	Insoluble	Slow	
Linseed meal	5-1-1		3-5 lb/100 sq ft	Insoluble	Slow	Acid
Seaweed (kelp)	Usually 2-1-7	15	2-3 lb/100 sq ft	Insoluble	Slow	
Soy bean meal	6-0-0		3-5 lb/100 sq ft	Insoluble	Slow	
Steamed bone meal	Usually 3-20	-0	5 lb/100 sq ft	Insoluble	Slow	Basic
Trace						
MnSO <sub>4</sub>		S	3-6 oz/100 sp. ft			
FeSO <sub>4</sub>		S	8-12 oz/100 sp. ft			
Chelated iron (8-12%)		Fe	1-2 oz/100 sp. ft	1⁄4		
Borax		В	1/2 oz/100 sp. ft			
CuSO <sub>4</sub>		Cu+S	1-2 oz /100 sp. ft			
FTE		many				

\*These rates are also appropriate per 100 sq ft

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# CHAPTER 3

## **Basics of Entomology**

Edited and revised by Dr. Alan Eaton, University of New Hampshire Cooperative Extension

Insects and mites are among the oldest, most numerous, and most successful creatures on earth. It is estimated that over 100,000 different species live in North America. In the typical backyard, there are probably 1,000 insects at any given time. While insects which cause problems for humans are heard about most often, it is important to note that the vast majority are either beneficial or harmless. Insects pollinate fruits and vegetables, provide food for birds and fish, and produce useful products such as honey, wax, shellac, and silk. In addition, some insects are beneficial because they feed on other insects that are considered pests by humans.

Although the number of pest species compared to the total number of insect species is very small (less than 3% of all insects are classified as pests), the troubles for humans wrought by this group reach astonishing proportions. Insects annually destroy millions of dollars worth of crops, fruits, shade trees and ornamental plants, stored products, household items, and other materials valued by man. They transmit diseases of humans and domestic animals. They attack humans and pets, causing irritation, blood loss, and in some instances, death.

This chapter is designed to present basic principles that apply to the identification of insects and mites on horticultural crops, especially those commonly encountered in New England.

### **Basics of Classification**

Identification of the thousands of species of insects would be impossible if they were not organized around a standard classification system. By grouping organisms based on the degrees of similarity among them, we can arrive at a system of classification. At the highest level of this classification system, organisms are divided into five kingdoms. Insects are placed in the Animal Kingdom. The Animal Kingdom has major divisions known as **phyla**. Several of the phyla which contain agricultural pests are:

- Arthropoda (insects, spiders, crayfish, millipedes)
- Nematoda (roundworms, trichina)
- Platyhelminthes (flatworms, flukes, tapeworms)
- Mollusca (snails, slugs, clams)

Insects belong to the phylum Arthropoda. Arthropods are a very important group of animals, as they represent more than three-fourths of the animal species known to exist. Characteristics that place an animal in the phylum Arthropoda include body segmentation and **skeletons outside** (exoskeleton) of their bodies.

The phylum Arthropoda is divided into **classes**. Table 1 describes a few of the more important classes and presents some characteristics that are used to distinguish between the various Arthropod classes. Insects belong to the class Insecta. For an Arthropod to be further classified in the class Insecta, it must have **3 body segments and 3 pairs oflegs**. Classes are further divided into orders. The more important orders of the class Insecta are described in Table 2.

Class	Examples	Body Regions	Pairs of Legs	Agricultural Importance
Crustacea	Crayfish Sowbugs	2	5	Sowbugs can be minor pests.
Arachnida	Spiders, Mites Ticks	6, 2	4	Some mites are major plant pests.
Symphyla	Symphylan	2	12	Symphylans can be serious pests.
Insecta	Bugs, Beetles Butterflies	s, 3	3	Large number are pests.

#### Table 1. Classes of the Phylum Arthropoda

Table 2. Some Orders of the Class Insecta

Order	Common Name	Meta- morphosis	Mouth- parts	Wings
Collembola	Springtails	none	chewing	none
Orthoptera	Crickets Grasshoppers	gradual	chewing	2 pair
Isoptera	Termites	gradual	chewing	2 pair
Thysanoptera	Thrips	gradual	rasping- sucking	2 pair
Hemiptera	True Bugs	gradual	piercing- sucking	2 pair
Homoptera	Aphids, Scales	gradual	piercing- sucking	2 pair
Coleoptera	Beetles, Weevils	complete	chewing	2 pair
Lepidoptera	Butterflies, Moths	complete	chewing or siphoning	2 pair
Hymenoptera	Bees, Wasps, Ants	complete	chewing	2 pair
Diptera	Flies	complete	various	1 pair
Siphonaptera	Fleas	complete	sucking	none
Dermaptera	Earwigs	gradual	chewing	2 pair
Thysanura	Silverfish	gradual	chewing	none

Insect orders are further broken down into a classification known as family. The family is a more finite grouping of very closely related insects. Family names end with "idae." Aphidae (aphids), Muscidae (houseflies), and Blattidae (cockroaches) are examples of families of insects.

Families are further divided into genera and species. These are the most finite levels of our classification system. The housefly, *Musca domestica*, serves here as an example of classification:

Kingdom:	Animalia
Phylum:	Arthropoda
Class:	Insecta
Order:	Diptera
Family:	Muscidae
Genus:	Musca
Species:	domestica
Common name:	housefly

The most commonly found insects also acquire common names and sometimes one species will have several common names. For example, *Heliothis zea*, when found on corn, is called the corn earworm, but when it is found on tomatoes it is called the tomato fruitworm. Common names are often used to refer to large groups of insects, such as families or orders. The term beetle refers to the entire order Coleoptera, which includes thousands of different species. The term moth refers to thousands of species in the order Lepidoptera.

### Insect Form and Structure -Morphology

All adult members of the class Insecta possess the following characteristics: **three body regions; three pairs of legs; one pair of antennae; and zero to two pairs of wings**. Legs and other appendages are often greatly modified to suit the insect's environment; the form of its appendages is often used to classify an insect.

### Head, Thorax and Abdomen

The adult insect's body is made up of three regions: **head, thorax, and abdomen**, but the division is not always obvious between thorax and abdomen. An insect's body is not supported by a bony skeleton, but by a tough body wall, or **exoskeleton**. The tough covering of skin is referred to as the **cuticle**. The cuticle contains a layer of wax which determines its permeability to water and prevents desiccation or drying. The cuticle of each segment is formed into several hardened plates called **sclerites**, which are separated by infolds or sutures to give them flexibility. The cuticle of the immature stage is not usually as hardened as that of the adult.

The thorax is made up of three segments: **prothorax**, **mesothorax**, **and metathorax**. Each of these segments bears a pair of legs. The wings are attached to the mesothorax and metathorax, never to the pro-thorax.

The abdomen may have 11 or 12 segments, but in most cases they are difficult to distinguish. Some insects have a pair of appendages at the tip of the abdomen. They may be short, as in grasshoppers, termites, and cockroaches; extremely long, as in mayflies; or curved, as in earwigs.



### Legs

The most important characteristic of an insect is the presence of three pairs of jointed legs. These are almost always present on adult insects and are generally present in the other stages as well. In addition to walking and jumping, insects often use their legs for digging, grasping, feeling, swimming, carrying loads, building nests, and cleaning parts of the body. The legs of insects vary greatly in size and form and are used in classification. Leg adaptations of some insects (left to right): jumping (grasshopper), running (beetle), digging (mole cricket), grasping (praying mantis), swimming (diving beetle).



### Wings

Venation (the arrangement of veins in wings) is different for each species of insect; thus, it serves as a means of identification. Systems have been devised to designate the venation for descriptive purposes. Wing surfaces are covered with fine hairs or scales, or they may be bare. Note that the names of many insect orders end in "-ptera," which comes from the Greek word meaning "with wings." Thus, each of these names denotes some feature of the wings. Hemiptera means half-winged; Hymenoptera means membrane-winged; Diptera means two-winged; Isoptera means equal wings.



### Antennae

The main features of the insect's head are the eyes, antennae, and mouthparts. The antennae are a prominent and distinctive feature of insects. Adult insects have one pair of antennae located on the head usually between or in front of the eyes. Antennae are segmented, vary greatly in form and complexity, and are often referred to as horns or "feelers." They are primarily organs of smell, but serve other functions in some insects.



#### blood-sucking lice, fleas, mosquitoes, and the socalled biting flies. In the siphoning types, as seen in butterflies and moths, the mandibles are absent and the labial and maxillary palpi are greatly reduced. Houseflies have sponging mouthparts.

Some types of insect mouthparts: A. Chewinglapping (honey bee); B. Piercing-sucking (plant bug); C. Sponging (housefly); D. Siphoning, coiled (butterfly)



### **Mouthparts**

The most remarkable and complicated structural feature of an insect is the mouth. Great variations exist in form and function of insect mouthparts. And although insect mouthparts differ considerably in appearance, the same basic parts are found in all types. Most insects are divided into two broad categories by the type of mouthparts they possess — those with mouthparts adapted for **chewing** and those with mouthparts adapted for **sucking**.

There are intermediate types of mouthparts: rasping-sucking, as found in thrips; and chewinglapping, as found in honey bees, wasps, and bumble bees. Sucking types are greatly varied. Piercingsucking mouthparts are typical of the Hemiptera (bugs), Homoptera (aphids, scales, mealybugs), The mouthparts of immature insects tend to be more varied than those of the adults, although nymphs have mouthparts similar to those of the adults. Larval forms generally have the chewing type regardless of the kind possessed by the adults. In some adult insects, the mouthparts are vestigial (no longer used for feeding).

### Insect Development — Metamorphosis

In higher animals, the most important development takes place before birth (in the embryonic stage); in insects, it occurs after birth or egg hatch. The immature period of an insect is primarily one of growth, feeding, and storing up food for the pupal and adult stages which follow. Many insects feed very little or not at all during their adult lives. One of the distinctive features of insects is the phenomenon called metamorphosis. The term is a combination of two Greek words: *meta*, meaning change, and *morphe*, meaning form. It is commonly defined as a marked or abrupt change in form or structure, and refers to all stages of development. Insects undergo one of four types of metamorphosis.

Some insects do not go through a metamorphosis, but rather gradually increase in size while maintaining the same characteristics. Others experience a gradual metamorphosis, going through a nymph stage.

In the case of gradual metamorphosis, the stages are: **egg**, **nymph**, **and adult**. In some insects, fertilization of the egg by sperm is not necessary for reproduction. This type of reproduction is known as **parthenogenesis**. Aphids are notable examples of insects that can reproduce by parthenogenesis.

Insects that undergo complete metamorphosis go through the following stages: **egg, larva, pupa, and adult**.

The immature insect sheds its outer skeleton (molts) at various stages of growth, since it outgrows the hard covering or cuticle more than once. Most insects do not grow gradually as many other animals do. They grow by stages. When their skeleton gets too tight, it splits open and the insect crawls out, protected by a new and larger skeleton that has formed underneath the old one. The stage of life between each molt is called an **instar**. Following each molt, the insect increases its feeding. The number of instars, or frequency of molts, varies considerably between species and to some extent with food supply, temperature, and moisture.

The pupal stage is one of profound change. It is a period of transformation from larva to adult. Many tissues and structures, such as prolegs, are completely broken down and true legs, antennae, wings, and other structures of the adult are formed.

The adult insect does not grow in the usual sense. The adult period is primarily one of reproduction and is sometimes of short duration. Their food is often entirely different from that of the larval stage.



### **Identifying Insects**

Most home gardeners can classify an insect by the common name of its order, identifying it as a beetle, wasp, or butterfly. The ability to classify an insect to the order level gives the gardener access to much valuable information. This information would include the type of mouthparts the insect has (this tells us how it feeds and gives clues towards methods of control), its life cycle (and proper timing for best control), and type of habitation.

*Specific Insect Orders*. For your reference, the insect orders have been divided into three sections: those containing insects important to the gardener; those containing insects of lesser importance to the gardener; and common "non-insect" pests in New England. The orders containing insects of importance to home gardeners will be considered in detail.

# Insect Orders Important to the Gardener:

### **Coleoptera - Beetles, Weevils**

- Adults have hardened, horny, outer skeleton
- Adults have two pairs of wings, the outer pair hardened and the inner pair membranous
- Chewing mouthparts
- Adults usually have noticeable antennae
- Larvae with head capsule, three pairs of legs on the thorax, no legs on the abdomen. Weevil larvae lack legs.
- Complete metamorphosis



### Dermaptera - Earwigs

- Adults are moderate-sized insects
- Chewing mouthparts
- Gradual metamorphosis
- Elongate, flattened insects with strong, movable forceps on the abdomen
- Short, hardened outer wings; folded, membranous, "ear-shaped" inner wings
- Adults and nymphs similar in appearance



### Diptera - Flies, Mosquitoes, Gnats, Midges

- Adults have only one pair of wings, are rather soft-bodied, and are often hairy
- Adults have sponging (housefly) or piercing (mosquito) mouthparts
- Larvae may have mouth hooks or chewing mouthparts
- Most larvae are legless
- Larvae of advanced forms, housefly and relatives, have no head capsule, possess mouth hooks, and are called maggots; lower forms, such as mosquito larvae and relatives, have a head capsule
- Complete metamorphosis



### Hemiptera - Stink Bug, Plant Bug, Squash Bug, Boxelder Bug

- Have gradual metamorphosis; stages are egg, nymph, adult
- Have two pairs of wings; second pair is membranous, the first pair are "half-wings" -- membranous with thickening on basal half
- Adults and nymphs usually resemble one another
- Have piercing-sucking mouthparts
- Adults and nymphs are both damaging stages



### Homoptera - Scale Insects, Mealybugs, Whiteflies, Aphids, Cicadas, Leafhoppers.

- Generally small, soft bodied-insects; cicadas may be large and hard-bodied
- Winged and unwinged forms
- All stages have sucking mouthparts
- Have gradual metamorphosis
- Many are carriers of plant pathogens





### Hymenoptera - Bees, Ants, Wasps, Sawflies, Horntails

- Adults have two pairs of membranous wings
- Larvae have no legs (wasps, bees, ants) or three pairs of legs on thorax and more than four pair of legs on abdomen (some sawflies)
- Generally have chewing mouthparts
- Rather soft-bodied or slightly hard-bodied adults
- Complete metamorphosis

#### Lepidoptera - Butterflies, Moths

- Adults are soft-bodied, with four well-developed membranous wings covered with small scales
- Larvae have chewing mouthparts
- Adult mouthparts are a coiled, sucking tube; feed on nectar
- Larvae are caterpillars; worm-like, variable in color, voracious feeders
- Larvae generally have legs on the abdomen as well as the thorax
- Complete metamorphosis



### Neuroptera - Lacewings, Antlions, Snakeflies, Mantispids, Dobsonfly, Dustywing, Alderfly

- Insect predators, many are aquatic
- Two pairs of membranous wings
- Chewing mouthparts
- Complete metamorphosis





### Orthoptera - Grasshopper, Cricket, Praying Mantid

- Adults are moderate to large, often rather hardbodied
- Gradual metamorphosis
- Adults usually have two pairs of wings. Forewings are elongated, narrow, and hardened; hindwings are membranous with extensive folded area
- Chewing mouthparts; both adults and nymphs are damaging
- Hind legs of many forms are enlarged for jumping
- Immature stages are called nymphs and resemble adults, but are wingless



### Thysanoptera - Thrips

- Adults are small, soft-bodied insects
- Mouthparts are rasping-sucking
- Varied metamorphosis (a mixture of complete and gradual)
- Found on flowers or leaves of plants
- Wings in two pairs, slender, feather-like, with fringed hairs



# Insect Orders of Lesser Importance to the Gardener:

<u>Order</u>	Examples
Anoplura	sucking lice
Collembola	springtails
Diplura	no common examples
Ephemeroptera	Mayflies
Embioptera	webspinners
Isoptera	termites
Mallophaga	chewing lice
Mecoptera	scorpionflies
Odonata	dragonflies and damselflies
Plecoptera	stoneflies
Protura	no common examples
Psocoptera	booklice, barklice
Siphonaptera	fleas
Strepsiptera	no common examples
Thysanura	silverfish and bristletails
Trichoptera	caddisflies
Zoraptera	no common examples

# Common "Non-Insect" Pests Found in New England:

### Arachnida - Spiders, Spider Mites, Ticks

a. Spider mites: tiny, soft-bodied animals with two body regions, thick waists, four pairs of legs, no antennae.

#### Common species:

- Two-spotted mites and near relatives two spots on the back, may be clear, green, orange, or reddish; usually hard to see without a magnifying glass.
- European red mite carmine red with white spines.
- Clover mites brown or gray, flat, very long front legs.
- b. Spiders: resemble mites except that most are larger, and the two body regions are more clearly distinct from one another (thin waist). Most spiders are beneficial predators.

c. Ticks: resemble large mites and are important agriculturally and medically in that they are parasites of animals and humans.

#### **Diplopoda - Millipedes**

These are elongated invertebrates with two visible body regions: the head and body. They generally have a round cross section, and all but the first four or five body segments possess two pairs of legs. Millipedes are generally inoffensive creatures that feed on fungus and decaying plant material, but at times, they can be fairly destructive to vegetables or plants in greenhouses.

### **Chilopoda - Centipedes**

Centipedes strongly resemble millipedes, except that they have longer antennae, a flat crosssection, and only one pair of legs on each body segment. They are beneficial predators of other arthropods.

### Crustacea - Sowbugs, Pillbugs

These are oval with a hard, convex, outer shell made up of a number of plates. Sowbugs are highly dependent on moisture. Generally, they feed on decaying plant material, but they will sometimes attack young plants.

### **Types of Insect Injury**

### **Injury by Chewing Insects**

Insects take their food in a variety of ways. One method is by chewing off the external parts of a plant. Such insects are called chewing insects. It is easy to see examples of this injury. Perhaps the best way to gain an idea of the prevalence of this type of insect damage is to try to find leaves of plants which have no sign of injury from chewing insects. Cabbageworms, armyworms, grasshoppers, Colorado potato beetles, and fall webworms are common examples of insects that cause injury by chewing.

### **Injury by Piercing-Sucking Insects**

A second important way insects feed on growing plants is by piercing the epidermis (skin) and sucking sap from plant cells. In this case, only internal liquid portions of the plant are swallowed, even though the insect feeds externally on the plant. These insects have a slender, sharp, pointed portion of the mouthparts which are thrust into the plant and through which sap is sucked. This results in a very different, but nonetheless severe injury. The hole made in this way is so small that it cannot be seen with the unaided eye, but the withdrawal of the sap results in minute spotting of white, brown, or red on leaves. fruits. or twigs: curling leaves: deformed fruit; or general wilting, browning, and dying of the entire plant. Aphids, scale insects, squash bugs, leafhoppers, and plant bugs are wellknown examples of piercing-sucking insects.

### **Injury by Internal Feeders**

Many insects feed within plant tissues during part or all of their destructive stages. They gain entrance to plants either in the egg stage, when their mothers deposit eggs into the plant tissue, or after they hatch from the eggs, by eating their way into the plant. In either case, the hole of entry is almost always minute and often invisible. A large hole in a fruit, seed, nut, twig, or trunk generally indicates where the insect has come out, not where it entered.

The chief groups of internal feeders are indicated by their common group names: borers in wood or pith; worms or weevils in fruits, nuts, or seeds; leaf miners; and gall insects. Each group, except the third, contains some of the foremost insect pests of the world. Nearly all of the internal feeding insects live inside the plant during only part of their lives, and emerge usually as adults. Control measures are most effective when aimed at emerging adults or the immature stages prior to entrance into the plant.

Leaf miners are small enough to find comfortable quarters and an abundance of food between the upper and lower epidermis of a leaf.

### **Injury by Subterranean Insects**

Almost as secure from human attack as the internal feeders are those insects that attack plants below the surface of the soil. These include chewers, sap suckers, root borers, and gall insects. The attacks differ from the above-ground forms only in their position with reference to the soil surface. Some subterranean insects spend their entire life cycle below ground. For example, the woolly apple aphid, as both nymph and adult, sucks sap from roots of apple trees causing the development of tumors and subsequent decay of the tree's roots. In other subterranean insects, there is at least one life stage that has not taken up subterranean habit. Examples include wireworms, root maggots, pillbugs, strawberry root weevils, and grape and corn rootworms. The larvae are root feeders, while the adults live above ground.

### Injury by Laying Eggs

Probably 95% of insect injury to plants is caused by feeding in the various ways just described. In addition, insects may damage plants by laying eggs in critical plant tissues. The periodical cicada deposits eggs in one-year-old growth of fruit and forest trees, splitting the wood so severely that the entire twig often dies. As soon as the young hatch, they desert the twigs and injure the plant no further.

Gall insects sting plants and cause them to produce a structure of deformed tissue. The insect then finds shelter and abundant food inside this plant growth. It is not known exactly what makes the plants form these elaborate structures when attacked by the insects. However, it is clear that the growth of the gall is initiated by the oviposition of the adult (laying eggs inside plant tissue), and its continued development results from secretions of the developing larva. The same species of insect on different plants causes galls that are similar, while several species of insects attacking the same plant cause galls that are greatly different in appearance. Although the gall is entirely plant tissue, the insect controls and directs the form and shape it takes as it grows.

### **Use of Plants for Nest Materials**

Besides laying eggs in plants, insects sometimes remove parts of plants for the construction of nests or for provisioning nests. Leaf-cutter bees nip out rather neat, circular pieces of rose and other foliage, which are carried away and fashioned together to form thimble-shaped cells.

### Ways in Which Insects Injure Plants

- **Chewing** devouring or notching leaves; eating wood, bark, roots, stems, fruit, seeds; mining in leaves. Symptoms: ragged leaves, holes in wood and bark or fruit and seed, serpentine mines or blotches, wilted or dead plants, or presence of "worms."
- **Sucking** removing sap and cell contents and injecting toxins into plant.

Symptom: usually off-color, misshapen foliage and fruit.

- Vectors of diseases carrying pathogens from plant to plant, e.g., elm bark beetle - Dutch elm disease, various aphids - virus diseases. Symptoms: wilt; dwarf,off-color foliage.
- **Excretions** honeydew deposits lead to the growth of sooty mold, and the leaves cannot perform their manufacturing functions. A weakened plant results. Symptoms: sooty black leaves,

twigs, branches, and fruit.

- **Gall formation** galls may form on leaves, twigs, buds, and roots. They disfigure plants, and twig galls often cause serious injury.
- **Oviposition scars** scars formed on stems, twigs, bark, or fruit. Symptoms: scarring, splitting, breaking of stems and twigs, misshapen and sometimes infested fruit.

#### • Injection of toxic substances -

Symptoms: scorch, hopper burn.



#### Examples of insect injury to plants.

### Insects as Disseminators of Plant Diseases

In 1892, it was discovered that a plant disease (fire blight of fruit trees) was spread by an insect (the honeybee). At present, there is evidence that more than 200 plant diseases are disseminated by insects. The majority of them, about 150, belong to the group known as viruses, 25 or more are due to parasitic fungi, 15 or more are bacterial diseases, and a few are caused by protozoa or mycoplasms.

Insects may spread plant diseases in the following ways:

- by feeding, laying eggs, or boring into plants, they create an entrance point for a disease that is not actually transported by them;
- they carry and disseminate the causative agents of the disease on or in their bodies from one plant to a susceptible surface of another plant;
- they carry pathogens on the outside or inside of their bodies and inject plants hypodermically as they feed;
- the insect may serve as an essential host for some part of the pathogen's life cycle, and the disease could not complete its life cycle without the insect host.

Examples of insect-vectored (insect-carried) plant diseases, their causative agents, and vectors include:

<u>Disease</u>	Vector
Dutch Elm Disease (fungus)	Small Beetle
Fireblight (bacterial)	Pollinating Insects
Tomato spotted wilt (virus)	Thrips
Cucumber Mosaic (virus)	Aphids
X-Disease of Peach (mycoplasm	n) Leafhoppers

### **Benefits and Value of Insects**

Insects must be studied carefully to distinguish the beneficial from the harmful. People have often gone to great trouble and expense to destroy insects, only to learn later that the insect destroyed was not only harmless, but was actually saving their crops by eating destructive insects.

## Insects are Beneficial to the Gardener in Several Ways:

- Insects aid in the production of fruits, seeds, vegetables, and flowers by pollinating the blossoms. Most common fruits are pollinated by insects. Melons, squash, and many other vegetables require insects to carry their pollen before fruit set. Many ornamental plants, both in the greenhouse and outdoors, are pollinated by insects (chrysanthemums, iris, orchids, and yucca).
- Insects destroy various weeds in the same ways that they injure crop plants.
- Insects improve the physical condition of the soil and promote its fertility by burrowing throughout the surface layer. Also, the dead bodies and droppings of insects serve as fertilizer.
- Insects perform a valuable service as scavengers by devouring the bodies of dead animals and plants and by burying carcasses and dung.

#### **Beneficial Insects**





Assassin bug

Predacious stink bug

Green Lacewings

Damsel bug

-



Pirate bug



Common species that cause no damage in the garden and help control other injurious insects.



Many of the benefits from insects enumerated above, although genuine, are insignificant compared with the good that insects do fighting among themselves. There is no doubt that the greatest single factor in keeping plant-feeding insects from overwhelming the rest of the world is that they are fed upon by other insects. Insects that eat other insects are considered in two groups known as predators and parasites.

**Predators** are insects (or other animals) that catch and devour other creatures (called the prey), usually killing and consuming them in a single meal. The prey is generally smaller and weaker than the predator.

**Parasites** are forms of living organisms that live on or in the bodies of living organisms (called the hosts) from which they get their food, during at least one stage of their existence. The hosts are usually larger and stronger than the parasites, and are not killed promptly. Some continue to live in close association with the parasite, rather than be killed.

#### **Soil Preparation**

For most fruits and vegetable crops, maintain a slightly acidic soil (around pH 6.5). If in doubt, have a soil analysis done through your local Extension office. The appropriate pH allows vegetable plants to have access to all the necessary soil nutrients and provides a suitable environment for earthworms and microorganisms. Follow recommended fertilizer practices. Supplement chemical fertilizers with organic material or compost to help assure that all trace elements and major nutrients are available. Feed the soil, not just the plants; providing an appropriate environment for all soil life will result in healthy plants which can resist pests and diseases.

When using manure and compost, be sure they are worked into the soil. Otherwise, millipedes, white grubs, and other pests may be encouraged. If these insects become a problem, you may be using too much; consider other means of adding organic matter, such as cover-cropping or mulching.

When diseased plant material is added to compost to be used on the garden, delay using the compost until all material has decayed beyond recognition. Compost piles must be hot (160 degrees F.) to kill disease organisms, insect eggs, and weed seeds. Till the soil in the fall to expose those stages of pests which live near the surface of the soil to natural enemies and weather, and to destroy insects in crop residues. If you do not till in the fall, do so early enough in the spring to give remaining vegetation time to degrade before planting time.

### **Plant Selection**

Plant crops that are suited to the soil and climate of your area. If you do plant vegetables or fruits that are not normally grown in your area, do your best to provide necessary conditions. For example, watermelons prefer a light, warm, well-drained soil; don't try to plant in heavy clay without first adding copious amounts of compost or other soil-lightening material, and allow the soil to warm up before seeding or setting plants out.

Use disease-free, insect-free, certified seed if available. Select disease/insect-resistant or tolerant species and varieties. Resistance in plants is likely to be interpreted as meaning immune to damage. In reality, it distinguishes plant varieties that exhibit less insect or disease damage when compared with other varieties under similar circumstances. Some varieties may not taste as good to the pest. Some may possess certain physical or chemical properties which repel or discourage insect feeding or egg laying. Some may be able to support insect populations with no appreciable damage or alteration in quality or yield.

Select plants that are sturdy and have well-developed root systems. Diseases and insects in young seedlings may start in greenhouses or plant beds and cause heavy losses in the garden. Buy plants from a reputable grower who can assure you that they are disease/insect-free, or grow your own from seed.

Avoid accepting plants from friends if there is any chance of also getting free insects or diseases!

### **Cultural Practices**

The most effective and most important of all practices is to observe what is going on in the garden. Many serious disease or insect problems can be halted or slowed early by the gardener who knows what to look for and regularly visits the garden for the purpose of trouble-shooting. **Rotation**. Do not grow the same kind of produce in the same place each year. Use related crops in one site only once every three or four years. Some related crops are as follows: (a) chives, garlic, leeks, onions, shallots; (b) beets, Swiss chard, spinach; (c) cabbage, cauliflower, kale, Brussels sprouts, broccoli, kohlrabi, turnips, rutabagas, Chinese cabbage; (d) peas, broad beans, snap beans; (e) carrots, parsley, celery, celeriac, parsnips; (f) potatoes, eggplant, tomatoes, peppers; (g) pumpkins, squash, watermelons, cucumbers, muskmelons; (h) endive, salsify, lettuce.

*Interplantings.* Avoid placing all plants of one kind together; alternate groups of different plants within rows or patches. If an insect lays eggs or otherwise attacks a specific species, the presence of other species in the area can interrupt progress of the attack by diluting the odor of the preferred plants. This can also slow the spread of diseases and pests, giving the gardener more time to deal with them.

*Thinning.* Thin young plants to a proper stand. Overcrowding causes weak growth and subsequent insect and disease problems.

*Watering.* Water in the morning, so plants have time to dry before the cool evening when fungus infection is most likely. Drip irrigation prevents foliage from getting wet at all when watering. For plants susceptible to fungus infections, such as tomatoes, leave extra space between plants to allow good air flow and orient rows so that prevailing winds will help foliage dry quickly after a rain or watering. While this may reduce the number of plants per square foot, yields may still be higher due to reduced disease problems. To prevent spreading diseases, stay out of the garden when the plants are wet with rain or dew.

*Time Planting.* Time plantings in such a way that the majority of the crop will avoid the peak of insect infestations. For example, carrot rust fly problems can be avoided by delaying planting until June 1 and harvesting by late August. Keep a record of the dates insect problems occur. Also, by planting warm-weather crops after the soil has warmed, problems with seed and root rots will be avoided, and growth will be more vigorous.

**Sanitation**. Do not use tobacco products such as cigarettes or cigars when working in the garden. Tomato, pepper, and eggplant are susceptible to a mosaic virus disease which is common in tobacco and may be spread by your hands. Remove infected leaves from diseased plants as soon as you observe them. Dispose of severely diseased plants before they contaminate others. Clean up crop refuse as soon as harvesting is finished. Old sacks, baskets, decaying vegetables, and other rubbish which may harbor insects and diseases should be kept out of the garden.

*Staking plants*. Staking or planting them in wire cages prevents the fruit from touching the soil. This also helps prevent fruit rots. Caging helps reduce sun scald often seen in staked tomatoes, since caged plants do not require as much pruning, leaving a heavier foliage cover. Boards or a light, open mulch such as straw, placed beneath melons, will prevent rotting.

**Avoid injury to plants**. Cuts, bruises, cracks, and insect damage are often sites for infection by disease-causing organisms. In cases where fruit is difficult to remove, such as with cucumbers and watermelons, cut them instead of pulling them off the plant. If you cultivate your garden, avoid cutting into the plant roots.

*Mulching*. Use a mulch to reduce soil splash, which brings soil-borne pathogens into contact with lower leaves.

*Weed control.* Control weeds and grass. They often harbor pests and compete for nutrients and water. They provide an alternate source of food and can be responsible for pest build-up. They provide cover for cutworms and slugs.

### **Mechanical Controls**

*Handpicking.* Inspect plants for egg clusters, bean beetles, caterpillars, and other insects as often as possible. Handpick as many as possible. If you don't like squashing the pests, knock the insects and egg clusters into a coffee can or quart jar with a small amount of water, and then pour boiling water over them. Kerosene is often recommended, but poses a disposal problem once you have finished; besides, water is cheaper.

**Traps**. Use appropriate insect traps to reduce certain insect populations. A simple, effective Japanese beetle trap can be made from two milk jugs or a single milk jug and a plastic bag. The bait used to attract the beetles is available at most farm and garden supply centers. Place traps away from desirable plants. Most scent-based insect traps are used for monitoring populations, not for control of pests.

Light traps, particularly blacklight or blue light traps (special bulbs that emit a higher proportion of ultraviolet light that is highly attractive to nocturnal insects), are good insect-monitoring tools, but provide little or no protection for the garden. While they usually capture a tremendous number of insects, a close examination of light-trap collections shows that they attract both beneficial and harmful insects that would ordinarily not be found in that area. Those insects attracted but not captured remain in the area, and the destructive ones may cause damage later. Also, some wingless species as well as those species only active during the day (diurnal, as opposed to nocturnal) are not caught in these traps. Consequently, the use of a light trap in protecting the home garden is generally of no benefit and, in some instances, detrimental.

Upturned flower pots, boards, newspaper, etc. will trap earwigs, sowbugs, and slugs; collect them every morning, and feed them to pet frogs, toads, turtles, and fish, or destroy them with boiling water. Indoors, white flies can be caught with yellow sticky traps, made with boards painted yellow and lightly coated with oil or grease. There are also commercial sticky traps available through some catalogs.

**Barriers**. Aluminum foil and other reflective mulch has been shown to repel aphids. However, the environmental impact and energy consumption involved in making aluminum foil deserves consideration. Spread crushed eggshells or hydrated lime around plants to discourage slugs. While heavy mulch is good for weed control, it gives slugs a place to hide.

*Exclusion*. Various materials can be used to physically block or repel insects and keep them from damaging plants. Place wood ash, cardboard tubes, or orange juice cans around seedlings to keep cutworms away from plant stems. Use paper bags over ears of corn to keep birds and insects out; do not cover until pollination is complete. Net-covered cages over young seedlings will help prevent insect, bird, and rabbit damage. Cheesecloth screens for

cold frames and hot beds will prevent insect egglaying; sticky barriers on the trunks of trees and woody shrubs will prevent damage by crawling insects. Floating row covers of spun bonded polyethylene are a little more expensive, but their effectiveness in excluding insects is proven by the number of commercial growers that use them, particularly on cole crops and strawberries. Remember that such materials can exclude pollinating insects.

### **Biological Controls**

**Predators, Parasites, and Pathogens.** The garden and its surrounding environment are alive with many beneficial organisms that are present naturally; however, they may not be numerous enough to control a pest before damage is done. Actually, parasites and predators (usually other types of insects) are most effective when pest populations have stabilized or are relatively low. Their influence on increasing pest populations is usually minimal since any increase in parasite and predator numbers depends on an even greater increase in pest numbers. Disease pathogens, however, seem to be most effective when pest populations are large.

Take advantage of the biological control already taking place in your garden by encouraging natural predators, such as preying mantids, ladybugs, lacewings, ground beetles, and others. Purchased natural predators are often effective for only a short period, however, since they tend not to remain in the place where they are put. Research the likes and dislikes of these helpers as to foods, habitat, etc. Provide these conditions where possible; some beneficial insect suppliers now offer a formulation for feeding/attracting the beneficials to keep them in the garden longer.

Learn to recognize the eggs and larvae of the beneficial insects, and avoid harming them. You can often find preying mantid egg cases in weedy lots; just bring the twig with the cluster into the garden and set it in a place where it will not be disturbed. Spiders, toads, and dragonflies are also beneficial, and should not be a source of fright to the gardener; in most cases, they are harmless to people.

Learn to recognize parasites and their egg cases; for example, the tomato hornworm is often seen with a number of white cocoons, a little larger than a grain of rice, on its back. These were produced by parasitic wasps. The hornworm will die and more wasps will emerge. You may wish to leave such parasitized caterpillars alone, rather than killing them.

### Pesticides

### **Nonsynthetic Pesticides**

**Botanicals**. Natural pesticidal products are available as an alternative to synthetic chemical formulations. Some of the botanical pesticides are toxic to fish and other cold-blooded creatures and should be treated with care. Safety clothing should be worn when spraying these, because some may be more toxic than synthetics. Botanical insecticides break down readily in soil and are not stored in plant or animal tissue. Often their effects are not as long-lasting as those of synthetic pesticides.

Insecticide	<u>Use Against</u>
Pyrethrum	Aphids, leafhoppers, spider mites, cabbageworms.
Rotenone	Spittlebugs, aphids, potato beetles, chinch bugs, spider mites, carpenter ants.
Ryania	Codling moths, Japanese beetles, squash bugs, potato aphids, onion thrips, corn earworms.
Sabadilla	Grasshoppers, codling moths, moths, armyworms, aphids, cabbage loopers, blister beetles.

Some of these products may be very difficult to find, expensive, and may not be registered for use in New England.

In addition to botanical insecticides, some biological products can help in the battle against insects. Bacillus thuringiensis is an effective product commonly used against caterpillars; B.T., as it is known, is a bacterium that gives the larvae a disease, and is most effective on young larvae. Presently, there is research underway to develop strains that work against other types of insect larvae. Several formulations are available to the gardener under different trade names to provide effective control of several caterpillars without harming humans and domestic animals. More than 400 insect species are known to be affected by this important insect pathogen. Bacillus thuringiensis is quite slow in its action. For example, caterpillars that consume some of the spores will stop eating within 2 hours, but may

continue to live and move around until they die, which may be as long as 72 hours. When this occurs, the untrained gardener may assume the material was ineffective because of the continued pest activity and impatiently apply a chemical pesticide. *B.t. kurstaki* seffective on caterpillars. *B.t. israelensis* is used for larvae of mosquitoes, black flies and fungus gnats. *B.t. san diego* is used for Colorado potato beetle larvae. *B.t. bui bui* may soon be available for Japanese beetle control.

*Nosema locustae* is a disease organism which shows some promise for controlling grasshoppers. There are claims that this parasite may be effective for up to five years after initial application. In some areas, this parasite is available commercially under different trade names. It is still too early to make extensive claims about its effectiveness in home gardens.

**Enlist the aid of birds**. In rural areas, chickens, guineas, and other domestic fowl can be released in unused areas of the garden to eat grubs and insects. Wild birds will also help, but they aren't as controllable. Provide appropriate conditions (i.e., shelter, nesting material, water) to encourage insect-eating birds.

**Soaps**. Commercial insecticidal soap (a special formulation of fatty acids) has been proven effective against aphids, leafhoppers, mealybugs, mites, pear psylla, thrips, and whiteflies. Homemade soap sprays also work to some extent: use three table-spoons of soap flakes (not detergent) per gallon of water and spray on plants until dripping. Repellent sprays, such as garlic sprays and bug sprays (made from a puree of bugs), have been found useful by some gardeners, but their effectiveness is questionable. Some researchers believe that bug sprays may work if a disease is present in the insect, which is spread through the spray to other insects. Be careful! Homemade soap sprays can injure some plants.

### **Synthetic Pesticides**

Synthetic pesticides, by their simplest definition, are those pesticides made by humans in chemical laboratories or factories. Examples of these include malathion, diazinon, and sevin. The real surge of development of synthetic pesticides began in World War II with the discovery of DDT. For more information, refer to the Pesticides chapter.

### Summary

Insects constitute one class of the phylum Arthropoda, and yet they are one of the largest groups in the animal kingdom. The insect world is made up of individuals that vary greatly in size, color, and shape. Although most insects are harmless or even beneficial to humans, the few that cause damage have tremendous impact. Harmful species can usually be recognized with some basic knowledge of their host, habits, life cycle, and the type of damage they inflict. Feeding damage varies due to the type of mouthparts an insect possesses. Harmful insects can be controlled in many ways without resorting to the use of pesticides. Good cultural practices and proper selection of plant varieties, coupled with mechanical and biological controls, will control insect populations. Use insecticides judiciously, wisely, and safely. Read and follow label directions carefully when applying any pesticide.

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# CHAPTER 4

## **Plant Pathology**

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The organisms which cause plant disease can destroy crops from the time the seed is put into the ground until the crop is harvested and during storage. Some diseases are capable of totally destroying a crop, while others may cause only cosmetic damage. However, cosmetic damage may be equivalent to total destruction in the case of ornamental plants, certain fruits and vegetables.

While many biological organisms can cause plant diseases, the vast majority are caused by fungi. Disease control with chemicals is tricky because it involves killing the fungus, without killing the host, and proper timing of applications is essential.

A basic understanding of diseases and how they develop will give an appreciation for the complexity of the problem and demonstrate the importance of cultural practices in management of plant diseases.

### **Plant Diseases In History**

Certain diseases have had tremendous impacts on our society. Perhaps foremost among these is potato late blight which caused the potato famine in Ireland (1845); as a result, approximately 2 million people either starved to death or emigrated to the United States.

Downy mildew ruined the French wine industry until Bordeaux mixture was accidentally discovered as a control against the fungus.

Two forest tree diseases which caused great economic losses in America are Dutch elm disease and chestnut blight. Both were introduced accidentally to the United States. Chestnut blight completely destroyed the most valuable trees in the Appalachians, while Dutch elm disease continues its destruction today.

These examples are prominent because they caused so much damage. However, plant diseases cause variable amounts of damage from year to year, often depending upon weather patterns.

### **Disease Defined**

Plant disease is the rule rather than the exception. Every plant has disease problems of one sort or another. Fortunately, plants either tolerate these maladies, or they are not very serious in most years. Plant pathologists consider almost any abnormal growth pattern by a plant to be a 'disease'.

Plant diseases are caused by a large array of biotic (living) agents such as fungi, nematodes, bacteria, and viruses. Plant diseases are also caused by a large array of abiotic (nonliving) factors such as nutrient deficiencies and water or temperature stress; or sometimes by a combination of factors. Both groups of agents are capable of causing abnormal and harmful physiological processes in the host plant.

One must distinguish between infectious diseases, caused by biotic agents, and noninfectious disorders (abiotic agents). Infectious organisms can be defined as follows:

Fungus:	an organism with no chlorophyll, that reproduces by means of structures called spores, and usually has filamentous growth; e.g., molds, yeasts, mushrooms.
Bacterium:	a single-celled, microscopic organ- ism with cell walls and no chloro- phyll; reproduces by fission.
Phytoplasma:	a microscopic, bacteria-like organ- ism that lacks a cell wall, and therefore appears filamentous.
Virus:	a submicroscopic, subcellular particle consisting of nucleic acid and protein that requires a host cell in which to multiply. (It is not known if a virus is a living or nonliving agent).
Viroid:	a virus-like particle that lacks the outer protein coat of a virus particle.
Nematode:	a microscopic roundworm, usually living in soil, which feeds on plant cells.
Parasitic	
Seed Plant:	a higher plant with chlorophyll that lives parasitically on other plants, e.g., mistletoe, dodder

Fungi and bacteria cause plant diseases such as leaf spot and fruit, stem, or root rot. Plant viruses, viroids, and mycoplasmas often cause growth distortion, stunting, and abnormal coloration. Nematodes can cause stunting and root distortion. Parasitic seed plants cause a general weakening of the host plant.

# Conditions Necessary for Disease

In order for disease to occur, three conditions must be met. First, it is necessary to have a susceptible host plant. Each species of plant is capable of being infected by only certain organisms (pathogens). The plant must be in a stage of development susceptible to infection by the disease agent.

The second requirement is the presence of an active pathogen in a stage of development conducive to infecting the host plant. If there is no pathogen present, there can be no disease. The third condition is an environment suitable for the pathogen to infect the plant. Temperature and moisture are important factors.

#### Symptoms, Signs, Syndromes

A **symptom** is the physical expression of disease by the plant. Examples of symptoms are:

blights:	sudden, often widespread death of twigs, foliage, flowers
cankers:	dead places on bark and cortex of stems; often discolored and raised or sunken
galls:	abnormal, localized swellings on leaf, stem, or root tissue
rots:	general decomposition and destruc- tion of tissue
necrosis:	death of tissue
spots:	circular or irregular lesions on above-ground tissue

A **sign** is the visible presence of the pathogen, such as a fungal fruiting body or bacterial discharge associated with the disease:

conks:	fungal fruiting structures formed on rotting woody plants (shelf or bracket fungi)
mycelia:	masses of fungal threads (hyphae) which compose the vegetative body of the fungus
ooze (flux):	viscid mass of juices composed of host and parasite substances found exuding from some diseased plants
pycnidia:	minute, fungal, asexual fruiting structures, usually globose and black, formed on plant surfaces
rhizomorphs:	string-like strands of fungal mycelia sometimes found under the bark of trees

A disease **syndrome** is the group of signs and symptoms which collectively characterize a disease. Familiarity with a disease's signs or symptoms is often not enough to diagnose a disease; it is necessary to know the syndrome and case history. Seeing a spot on a leaf does not tell much, but finding pycnidia in that spot and knowing the plant species and recent weather conditions might be sufficient information to diagnose the disease. Often, laboratory work is necessary for diagnosis.

### **Disease Development**

It is important to understand how plant diseases develop in order to control them. By the time it becomes obvious that a plant has a disease, it is generally too late to do anything about it in that growing season. Plants cannot be cured in the way people expect their own ills to be cured. The process by which diseases develop can be broken into four distinct phases:

Inoculation: This is the introduction of the pathogen to the host plant tissue. Wind, or rain, or running water can move pathogens and introduce them to a host plant, as can birds, insects, people, or equipment. Some pathogens move themselves short distances, but most rely on other means. Inoculum is any part of the pathogen that comes in contact with the host plant.

Penetration: This is the process of getting inside the plant. It may be an active or passive process. Some pathogens produce enzymes to dissolve the cuticle and directly attack and penetrate plant cells. Some pathogens can swim through water on a plant's surface and enter the plant through natural openings (such as stomata, lenticels, or hydathodes) or through wounds. Some pathogens are introduced into the plant by insects, pruning tools, or driving rain.

- Infection: When the pathogen invades the plant tissue and establishes a parasitic relationship between itself and the host, infection has occurred.
- Disease: When the host plant responds to the presence of the pathogen, a "disease" exists. The host's response usually results in the development of symptoms of the disease, such as blight, spots or necrosis.

### **Control of Diseases**

The importance of understanding the disease development process becomes obvious when considering control options. By the time symptoms are expressed, the pathogen (with few exceptions) is already inside the host plant. Therefore, control efforts, in most cases, must occur before penetration has taken place. The overall principle in effective disease control is to keep the inoculum density of the pathogen at very low levels.

Success in controlling plant disease will occur when a combination of the following methods of control are used:

- Avoidance: A grower can avoid certain diseases by choice of geographic area or choice of planting site. Disease can also be avoided by planting at a time that does not favor disease development. Using disease-free planting stock or modifying cultural practices also helps to avoid disease.
- Exclusion: A grower can inspect stock for signs of disease and reject or treat any which is suspect. Plant quarantines are designed to exclude certain pests from areas that are free of that pest. Elimination of carrier insects can help exclude disease-causing organisms.
- Eradication: Once a disease is established in an area, eradication is unlikely. However, significant reduction in disease inoculum can be attained by destroying diseased plants or alternate hosts, by rotating crops, or by certain soil treatments.
- Protection: Spraying or dusting plants with fungicides or bactericides can protect them from disease. Sometimes modifying cultural practices or the environment may protect the crop. Control of carrier insects will also protect plants.

Resistance: Breeding and selection are used to develop resistant crops. Resistance can be enhanced through proper culture of a crop. Resistance is not immunity; improper culture of a resistant variety may negate the resistance. Therapy: There are a few diseases which can be treated with chemicals or heat to gain a degree of control.

Familiarity with crops and the diseases and insects that affect them is useful in planning management programs. Some diseases occur every season; others occur sporadically. Some can be managed easily by using proper cultural and/or chemical methods; others must be tolerated. Knowing which problem falls into which category comes with experience. Knowing the proper method to use at the proper time is a part of integrated pest management (IPM).

### Summary

Plant diseases are to be expected. Fortunately, there are few truly devastating diseases in most years.

For disease to occur, there must be a susceptible host, a suitable environment, and a living pathogen. When all three conditions are met, disease occurs. Severity of the disease depends on the degree to which the conditions are met.

Disease development follows a precise course of events. Inoculation occurs first, usually followed by penetration of the host . Infection occurs when the pathogen invades the host tissue. Only when the host responds has disease occurred. By this time, it is usually too late to control the disease.

Disease management involves more than the use of chemicals for protection. Avoidance, eradication, exclusion, resistance, and therapy all have a role in disease management. A combination of these will give best results.

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# CHAPTER 5

# **Diagnosing Plant Damage**

Edited and revised by Dr. Cheryl Smith, University of New Hampshire Cooperative Extension

Diagnosis of plant problems is often a very difficult task since there can be many different causes for a given symptom, not all of which are pathogenic organisms. Soil nutrition and texture, weather conditions, lighting and many other environmental and cultural conditions influence the overall health of a plant. Insect damage can sometimes be confused with plant diseases caused by microorganisms or abiotic factors. Knowing a complete history of the plant is essential to making an accurate diagnosis. Also, a plant specimen should be in the early stages of disease-development when it is examined in order for an accurate diagnosis to be made. Once it has decayed, secondary organisms invade the tissue and evidence of the primary pathogen is often obscured.

For these reasons, it is difficult to construct a foolproof key for the diagnosis of plant problems. Even with the necessary laboratory equipment at one's disposal, it is often difficult to determine the exact cause of a plant's problem. The following pages provide an aid to diagnosing some of the common problems of urban plants. This chapter was constructed for Master Gardeners to help solve consumers' plant problems -- it is not meant for diagnosis of commercial production problems or for use by laboratory diagnosticians. The information provided is by no means comprehensive and other resources will be needed for many of your diagnoses. *The Ortho Problem Solver* is particularly useful as it contains color pictures. Other references are listed at the end of this chapter.

This chapter should help you, as a Master Gardener, ask the right questions to determine the cause of the problem or, at least, to narrow down the possibilities. For example, since both dry weather and excess fertilizer can cause marginal leaf burn, you would want to ask the grower about recent rainfall in the area and fertilizer application. Or, since wilt can result from both dry and waterlogged soil, you would want to ask about rainfall and how well the soil drains. In many cases, you will not be able to determine what caused the problem, but if you can narrow down the possibilities and mention these when you send the sample to a diagnostic laboratory, you will save the diagnostician a lot of time.

The chapter describes a systematic approach to diagnosis.

The following is a list of suggested questions to ask a grower when you are attempting to diagnose a problem.

### **Questionnaire for the Diagnosis of Plant Problems**

Compiled by Charles H. Williams, Extension Specialist, Ornamentals

Usually when definite reasons can't be given for the poor growth or death of plants, it is often because some facts have been overlooked. Although these facts may seem minor, they all help. The following checklist is designed to assemble this information. Because these questions may direct you to areas you have overlooked, when you answer them you may be able to diagnose the problem, the cause may be due to insects, diseases, the plant's environment or certain cultural practice.

#### I. General History

1.	Name and address of inquirer
	Phone No
2.	Kind of plant (Botanical & Common Name)
	Variety or cultivar Approximate age of plant Heightft.;widthft.
3.	When was the problem first noticed this year?
4.	Has the plant recently been transplanted? When? Month Year
5.	Is the plant considered winter hardy for your area?
6.	Are other plants of the same kind nearby? How near and what it their condition?
7.	Are there other types of plants nearby which are also affected?
8.	Has the plant or nearby plants been sprayed or dusted for disease or insect control?
9.	Have herbicides or any turf "weed and feed" materials been used in the vicinity? How near and when?
10.	Is there any evidence of mechanical injuries from lawn mowers, automobiles, machinery, heavy pruning, people, animals or faulty planting?
11.	Was the plant planted or treated by professional tree experts or a landscape maintenance firm, etc If so, when and with what?
12.	Is the plant shaded by buildings, plants or other objects for the whole or part of the day?
13.	Is the plant in an exposed location for sun and wind?
14.	If the plant is near a building, does it primarily face north, south, east or west?
15. Describe the care given the plant in question for the past 2 years.

	A. Fertilizer (kind and amount; foliar or soil application)			
	B. Irrigation (method and frequency)			
	C. Pruning			
	D. Any other practice or treatments?			
16.	Comment on unusual weather conditions. (Extreme temperatures, late or early frost, heavy wind, hail and ice storms, drought periods, excessive rainfall or flooding) Present season: Previous season:			
17.	Do cement, asphalt or other types of pavement occur near the plant?			
	What type? How near? How long has it been there?			
18.	Are there gas, water, steam, sewer or other pipes or conduits in the ground near the plant or has anything leaked near the plants?			
19.	Has the plant been exposed to salt used for ice control along a street or highway or along walk ways? (A salty mist stirred up by auto traffic can cause foliar damage to conifers. A similar problem occurs along seacoasts following storms.)			
20.	Soil in which the plant is growing.			
	A. How deep is the surface soil above rock, hardpan or subsurface layers of soil?			
	B. Is the soil primarily clay?, loam?, sand?			
	C. What is the internal drainage of the site? Good Poor Poor			
	Excessive(Good, poor or excessive internal drainage may be determined by the rate at which water disappears from a test hole. A hole may be dug to a depth of 3 feet, filled with water and a record kept of the time required for the water to disappear. Fill the hole with water 3 times and record the time of disappearance after each filling. If water remains in the test hole one or more days, drainage is poor and in need of improvement. If water drains away repeatedly in less than three minutes, drainage is excessive.)			
21.	Has a soil analysis for pH, major elements, and total soluble salts, etc. been done lately for the area?			
22.	Have the roots around the plant been disturbed by digging or has the level of soil been raised or lowered by filling or grading operations? If so, when and what was the change of level?			
23.	Is there grass or other plants growing over the roots of the affected plants?			
24.	What mulch or winter protection practices were carried out?			
25.	Has anything been dumped or accidentally spilled in the area?			
26.	Has any unusual activity taken place in the area recently?			

# II. Description of Trouble

# Foliage (leaves, needles)

1.	1. Off color? (Yellow, brown spots, etc.)Des	cribe		
2.	<ol> <li>Symptoms appear on upper leaf surface?</li> <li>Lower leaf surface?</li> </ol>			
3.	3. Edges of leaves brown? Edg	es of leaves tattered?		
4.	<ol> <li>Deformed? (galls, twisted, rolled, blisters, callus, etc.)</li> <li>Describe</li> </ol>			
5.	5. Leaves wilted?			
6.	<ol> <li>Partially devoured by insects? (Holes, leaf mines, leaves of Collect or Describe</li></ol>	Partially devoured by insects? (Holes, leaf mines, leaves chewed on peripheral or interveinal) Collect or Describe		
7.	7. Any foreign substance noted on surface?	Describe		
Twigs	gs			
1.	1. Off color? Describe			
2.	<ol> <li>Deformed? (Swollen, lesions, cankers, galls, etc.)</li> </ol>	Describe		
3.	3. Bark split?			
4.	<ol> <li>Dark or colored streaks in wood under bark?</li> </ol>			
5.	5. Channels in wood or under bark? Describ	e		
6.	<ol> <li>Twig girdled by insects, old label, or price tag?</li> </ol>			
Flower	vers			
1.	1. None developed			
2.	2. Off color (spots on petals, etc.) Describe			
3.	3. Deformed? Describe			
4.	4. Chewed by insect?			

Fruit	(berries,	pods,	cones,	etc.)
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1.	None formed		
2.	Off color? Describe		
3.	Deformed? Describe		
4.	Chewed upon or hollowed out by insect? (Describe insect as caterpillar, maggot, grub, beetle, etc.)		
5.	Failed to mature or dropped too early?		
Trunk,	Branches, Roots		
1.	Oozing sap, flow of resin, or holes with "sawdust" noted? Describe		
2.	Dark streaks in wood under bark?		
3.	Discolored bark? Swollen? Constricted?		
4.	Bark split, cracked or separated from wood?		
5.	Evidence of insects under bark? (Remove dead bark and determine extent of injury.) (Collect insect specimen.)		
6.	Any foreign substance on bark? Describe		
7.	Any unusual growth on main stem at or just under soil line?		
8.	Are some roots exposed or observed to wrap around others?		
9.	Was the container, burlap, wire basket, trunk wrap, etc. removed at time of planting?		
10	0. Upon digging, does the root system of the affected plant:		
	A. appear to be similar to "normal" plants of the same species?		
	B. have any lesions or growths on it?		
	C. show evidence of rot, discoloration, or symptoms of the outer root tissue separating from the inner core, etc.		

Additional Comments, Observations, Sketches, etc.

# A Systematic Approach to Diagnosing Plant Damage

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# I. Define the Problem

### • Plant Identification and Characteristics -Growth and Appearance of the Identified Plant - Normal? - Abnormal?

Determine if a *real* problem exists. It is essential that the plant be correctly identified (genus, species and cultivar or variety) so that the *normal* appearance of that plant can be established either by personal knowledge or utilizing plant reference books. Many horticultural plants, or structures on those plants such as fruit-seeds, lenticels, etc. may appear to be abnormal to the person who is not familiar with the specific plant. For example, the 'Sunburst' honey locust might appear to be suffering from a nutrient deficiency because of its chlorotic yellow-green leaf color, but it was selected because of this genetic characteristic ... it is not abnormal for this plant. Therefore, it is not a problem.

Always compare the diseased plant with a healthy or normal plant, since normal plant parts or seasonal changes sometimes are mistakenly assumed to be evidence of disease. Examples are the brown, spore-producing bodies on the lower surface of leaves of ferns. These are normal propagative organs of ferns. Also in this category are the small, brown, club like tips that develop on arborvitae foliage in early spring. These are the male flowers, not deformed shoots. Small galls on the roots of legumes, such as beans and peas, are most likely nitrogen-fixing nodules essential to normal development and are not symptoms of root-knot nematode infection. The leaves of some plants, such as some rhododendron cultivars, are covered by conspicuous fuzzlike epidermal hairs. This is sometimes thought to be evidence of disease, but it is a normal part of the leaf. Varieties of some plants have variegated foliage that may resemble certain virus diseases. These examples illustrate the importance of knowing what the normal plant looks like before attributing some characteristics to disease.

In describing the plant "abnormality", distinguish between symptoms and signs: Symptoms are changes in the growth or appearance of the plant in response to living or nonliving damaging factors. Many damaging factors can produce the same symptoms; symptoms are not definitive. Signs are evidence of the damaging factor (pest or pathogen life stages, secretions; mechanical damage; chemical residue; records of weather extremes or chemical applications; damage patterns). Patterns of damage often provide excellent diagnostic clues.

### • Examine the Entire Plant and Its Community

In defining a plant problem, it is essential to determine the *real* primary problem. There are foliage symptoms that may occur due to root damage. The primary problem would be root damage, not chlorosis of the foliage, -examine the roots. In general, if the entire top of the plant or entire branches are exhibiting abnormal characteristics, examine the plant downward to determine the location of the primary damage.

Some pathogens and insects as well as nonliving factors are only damaging if the plant has been predisposed by other primary factors. For example, borers generally only attack trees that are already predisposed to moisture or other physical stress. Premature dropping of leaves by foliage plants (i.e. Ficus benjamina) and of needles by conifers frequently causes alarm. Evergreen plants normally retain their leaves for 3-6 years and lose the oldest gradually during each growing season (Figure 1). This normal leaf drop is not noticed. However, prolonged drought or other stress factors may cause the tree as a whole to take on a yellow color for a short period and may accelerate leaf loss. If the factors involved are not understood, this often causes alarm. The leaves that drop or turn vellow are actually the oldest leaves on the tree, and their dropping is a protective mechanism which results in reduced water loss from the plant as a whole.

# Figure 1. Normal vs Abnormal Needle Drop or Leaf Drop from Evergreens.



Nondeciduous plants normally retain their leaves or needles for several years, but eventually they fall. This drop is usually gradual and production of new leaves obscures loss of older leaves.

- A. **Normal** If drop is confined to older leaves, alarm is unnecessary because it is a normal response to a condition of stress (e.g. drought). Unfavorable growing conditions, such as drought, may accelerate leaf fall so that it becomes apparent and of concern.
- B. **Abnormal** If newly produced leaves are lost, it is a problem. Drop of current year's leaves may result from pathogen or insect attack or from chemical deficiencies or toxicities.

# II. Look for Patterns

Here is where we start making the distinction between living and nonliving factors that cause plant damage.

• Nonuniform Damage Pattern (*living Factors*) vs Uniform Damage Pattern on Plant Community, Plant, Plant Part (*nonliving Factors*).

Living Factors: There is usually no discernable widespread pattern of damage. Living organisms generally produce no uniformly repeated pattern of damage on a planting (Figures 2-4). Damage produced by living organisms, such as pathogens or pests, generally results from their using the plant as a food source. Living organisms are generally rather specific in their feeding habits and do not initially produce a wide-spread, discernable damage pattern. Plants become abnormal: Tissues are destroyed, become deformed, or proliferate into galls.

Living organisms are specific, i.e. damage may be greatest on or limited to one species of plant.

Living organisms multiply and grow with time, therefore they rarely afflict 100 percent of the host plants at one time. The damage is progressive with time. Likewise, the damage, generally, is initially limited to only one part of the plant and spreads from that initial point of attack with time.

Living organisms usually leave "signs", i.e. excrement, cast skins, mycelium, eggs....

Nonliving Factors: Damage patterns produced by nonliving factors such as frost or applications of toxic chemicals (Figure 5) are generally recognizable and widespread: Damage will usually appear on all leaves of a certain age (for example on all the leaves forming the plant canopy at the time a toxic spray was applied) or exposure (i.e. all leaves not shaded by overlapping leaves on the southwest side of a plant may be damaged by high temperatures resulting from intense sunlight). Damage will likely appear on more than one type or species of plant (look for similar damage patterns on weeds, neighboring plants, etc.) and over a relatively large area.

# Figure 2.

### Patterns on plant canopy:

A. Entire or Major Portion of Top Dying: If all or a major

portion of a tree or shrub dies, suspect a problem with the roots. Look for Damaging Factor at the Junction of Normal and Abnormal Plant Tissue.

**Gradual Decline** of the entire plant or a major portion of it is caused by living factors such as root rots, vascular wilts and rootfeeding insects or borers.

**Sudden Decline** is generally caused by a nonliving factor such as a toxic chemical in the soil or drastic climate changes such as freezing or drought.

B. Single Branch Dying: If only scattered damage occurs in the plant canopy, suspect that the primary

suspect that the primary problem is related to the foliage or aerial environment, - not the roots.

**Gradual Death of Branch:** If scattered branches start to decline and eventually die, suspect a living organism such as a canker pathogen, a shoot blight or borers.

**Sudden Death of Branch:** If a branch dies suddenly, and especially if affected branches are concentrated on one side of the plant, suspect a nonliving factor such as weather (wind, snow, etc.), animal damage, or chemical drift.







A. **Shoot Dieback Caused by Nonliving Factors:** Sudden dying back of a shoot usually indicates a nonliving cause such as climatic or chemical damage, -not a living factor. Damage caused by nonliving factors usually results in a sharp line between affected and healthy bark and plant tissues. The exception would be bacterial blights which can kill shoots quickly.

If dieback is more gradual and there is also cracking of the bark and wood, suspect winter injury.



B. **Shoot Dieback (Blight) Caused by Living Factors:** Gradual decline of shoots and retention of dead leaves may indicate a living factor.

The margin between affected and healthy tissue is often irregular and sunken.

There may be small pinlike projections or bumps over surface of dead bark: These are spore producing structures of pathogenic fungi.

However, small, woody bumps radiating from all sides of twigs of Dwarf Alberta Spruce are pulvinus, -woody projections where needles were attached. This is a taxonomic identifying characteristic of spruce.



A. Death of the tips of conifer needles producing a uniform pattern usually indicates a nonliving factor such as toxic chemical or unfavorable climatic condition. Air pollutants frequently cause tip burn on conifers as do certain soilapplied herbicides or excess fertilizer. Drought and freezing may have a similar effect. In these cases all needles of a specific growth period are usually affected, and usually the same length on each needle is affected. The margin between the affected tissue, usually reddish brown, and healthy tissue is sharp and distinct.



B. Damage by living organisms such as fungi and insects to needles usually occurs in a random, scattered pattern and rarely kills all needles of a particular growth period. Needles are usually affected over varying lengths and often appear straw yellow or light tan in color. Black fruiting bodies of the causal fungus may be present on diseased needles.

## Figure 5.

### Foliar Chemical Spray Injury Pattern on Leaf



Spots are usually uniformly and evenly distributed over the leaf surface and generally will be of uniform size. Color is usually uniform across the spot.

The margin between affected and healthy tissue is usually sharp. Injury pattern does not spread with time or move to previously undamaged plants or plant tissue.

#### Figure 6.

Leaf Damage Pattern by Nonliving Factors, i.e. toxic chemical taken up through roots or from polluted air filtered through the leaf or from moisture stress.



Injury from chemicals taken up by plants from soil through roots or from air through leaves usually results in scorching (necrosis) of leaf margins and interveinal areas. If severe, necrotic tissue may drop out giving a ragged appearance. Similar patterns are produced by moisture stress. If uptake of the toxic chemical is by a fully expanded leaf, toxicity is marginal and interveinal. If by a nonexpanded leaf, toxicity occurs in the veins.

# III. Delineate Development

As already mentioned, another clue for distinguishing between living and nonliving factors causing plant damage is to observe the development of the patterns over time.

Living organisms generally multiply with time, producing an increasing spread of the damage over a plant or planting with time.

Nonliving factors generally damage the plant at a given point in time, for example death of leaf tissue caused by a phytotoxic chemical is immediate and does not spread with time (Figure 5). There are exceptions. If a nonliving damaging factor is maintained over time, the damage will also continue to intensify over time: For example, if a toxic soil or air chemical is not removed, damage to plants within the contaminated area will continue to develop (Figure 6), but damage will not spread to plants in uncontaminated areas: Nonliving Factors Are Not Progressive. This again re-emphasizes the necessity of piecing together multiple clues to identify the most probable factor causing plant damage.

# **IV. Determine Causes**

Patterns of damage and distribution and patterns of development of damage over time have been valuable in making the gross distinction between damage caused by living factors and damage caused by non-living factors. Additional clues must be obtained to distinguish among factors within the living and nonliving categories.

# **Distinguishing Among Living Factors:**

To further identify which subcategory of living factors caused the damage requires a close examination of the symptoms and signs.

*Symptoms* are the modified appearance of the affected plant, for example necrotic tissues, chlorosis, cankers, galls, leaf distortion.

*Signs* are the presence of the actual organism or evidence directly related to it. Visual observation of the insect on the leaf, presence of fungal mycelium, spores, insect egg masses, insect frass, mite webbing, etc. Signs can be used as clues in identifying the specific living organism that produced the plant damage.

A combination of clues from both symptoms and signs are required for preliminary distinction between damage caused by pathogens and insect-mite damage.

# Symptoms and Signs of Pathogens

Differentiating between bacterial and fungal pathogens is not always clear cut, but certain symptoms are distinctive (Figures 7 and 8; Table 2).

#### Fungal Diseases (Figure 7).

Fungal leaf spots and stem rots are characterized by various symptoms: Dry texture, concentric rings, discoloration and fruiting structures. Fungal leaf spots and stem rots are usually dry or papery, especially in dry climates. The most distinguishing clue of a fungal disease is the presence of signs: Mycelium (common under conditions of high humidity and excessive moisture) and fruiting bodies of the fungus itself. The fruiting bodies range in size from microscopic to those easily detected with the naked eye. They are found within the leaf spot or stem rot area. Each type of fungus has its own characteristic structures which enable plant pathologists to identify them.

**Foliar Pathogens:** The leaf spots caused by fungi generally have distinct margins (Figure 7). They are usually circular with concentric rings resulting from growth of the fungus from the center point of initial infection outward. The condition of the leaf tissue and associated color ranges from dead (necrotic tan) in the center to recently dead (darker brown ring), to dying (darker ring with possible light yellow, chlorotic edge indicating the advancing edge of the fungal infection). The margins of fungal leaf spots (Figure 7) and stem rots (Figure 3) can be brightly discolored, such as purple (Fusarium stem rot) or yellow (*Helminthosporium*leaf spots), making these symptoms quite striking.

**Root and Stem Pathogens:** Root rots and vascular wilts result from fungal infections and destruction of root and stem tissues. The most common visual symptom is gradual wilting of the above ground shoots, and symptoms of nutrient deficiency.

#### Bacterial Diseases (Figure 8).

Bacteria do not actively penetrate healthy plant tissue like fungi. They enter through wounds or natural openings such as leaf stomata or twig lenticels. Once bacteria enter the plant, they reproduce rapidly, killing the plant cells.

**Bacterial galls:** In some cases, toxic materials are produced that cause plant tissues of roots, stems or leaves to grow abnormally as in crown gall.

Bacterial leaf spot disease: The bacteria usually enter through leaf stomata or hydathodes. Symptoms include water-soaking, slimy texture, fishy or rotten odor, confined initially between leaf veins resulting in discrete angular spots. Many bacterial leaf spots, such as Xanthomonas leaf spot on Philodendron (also called red edge disease), expand until they reach a large leaf vein. This vein frequently acts as a barrier and inhibits the bacteria from spreading further. A chlorotic halo frequently surrounds a lesion. Lesions may enlarge through coalescence to develop blight lesions. Some lesions exude fluid containing bacteria. Water-soaking frequently occurs in bacterial leaf spot diseases, such as Erwinia blight of Dieffenbachia. Holding the leaf to light usually reveals the water-soaking. The ability of the bacteria (usually Erwinia species) to dissolve the material holding plant cells together results in a complete destruction of leaf or stem integrity. Some fungi also produce this symptom, but usually not as extensively as bacteria. In final stages, cracks form in the tissue and disintegration follows.

**Vascular wilt:** In some cases, the bacteria poison or plug the vascular water conducting tissues and cause yellowing, wilting, browning and dieback of leaves, stems and roots.

# Table 2. Symptoms & Signs of Fungal and Bacterial Leaf Spots

Abnormality	Fungal	Bacterial
Water-soaking	non common	common
Texture	dryish-papery	slimy-sticky
Odor	usually none	fishy, rotten
Pattern	circular with concentric rings	irregular- angular; initially does not cross veins
Disintegration	uncommon	common
Color changes	common: red, yellow, purple halos	uncommon
Pathogen structures	common - mycelia, spores	uncommon

# Figure 7. Fungal Leaf Spots



Spots usually vary in size, generally round, occasionally elongate.

Zones of different color or texture may develop giving the spot a bull's eye effect: The deadest tissue (tan) is in the center of the spot where the fungal spore germinated. Then as the fungus moves outward from that point of dead tissue to healthy tissue the foliage color changes from dead tan in the center to healthy green on the perimeter.

Spots are usually not limited by leaf veins. Figure 8.

### **Bacterial Leaf Spots**



Bacterial leaf spots are often angular because they are initially limited by the leaf veins.

Color of the bacterial spots is usually uniform. Bacteria are one-celled organisms that kill as they go. Tissue may first appear oily or water-soaked when fresh, but on drying becomes translucent and papery.

#### Viral Diseases (Figure 9).

Viruses are "submicroscopic" entities that infect individual host plant cells. Once inside a plant cell, they are able to infect other cells. Viruses are obligate parasites: They can only replicate themselves within a host's cell. Because the virus commandeers the host cell to manufacture viruses identical to itself, the plant cell is unable to function and grow normally. In the virus infected plant, production of chlorophyll may cease (chlorosis, necrosis); cells may either grow and divide rapidly or may grow very slowly and be unable to divide (distortion, stunting). The symptoms of most virus diseases can be put into Chapter 5 Diagnosing Plant Damage four categories:

1) Lack of Chlorophyll formation in normally green organs.

*Foliage* may be mottled green and yellow, mosaic, or ringed (yellow and other pigmented ring patterns), or be a rather uniform yellow (virus yellows).

*Veins:* Vein clearing is a common first symptom of some viral diseases. The veins have a somewhat translucent appearance. In vein banding there is a darker green, lighter green or yellow band of tissue along the veins.

- Stunting or other growth inhibition: The reduction in photosynthesis, because of less chlorophyll, leads to shorter internodes, smaller leaves and blossoms and reduced yield.
- Distortions of leaves and flowers, witches' brooms or rosettes result from nonuniform growth or uncontrolled growth of plant tissues.
- 4) Necrotic areas or lesions: Being obligate parasites, viruses require the survival of their host plant for their own procreation. Hence, viruses rarely cause death. Necrosis that does occur is usually confined to discrete areas of the plant; necrosis rarely occurs to such an extent that the entire plant is killed.

# Figure 9. Vein Clearing and Mosaic Leaf Patterns



Left side of leaf: vein clearing (chlorosis) with interveinal tissue remaining green usually indicates a virus disease or the uptake and xylem translocation of a herbicide such as diuron. This is in contrast to the leaf veins remaining green with surrounding chlorotic tissues usually associated with nutrient deficiencies such as iron deficiency.

Right side of leaf: Mosaic is a patchwork of green and yellow areas over the surface of the leaf. The leaf may also be puckered and distorted. These symptoms usually indicate a virus disease, especially if the yellow areas blend gradually into the green areas. If margins are distinct, mottling may indicate a nutritional problem or genetic variegation.

# Viruses Typically Discolor, Deform or Stunt

**Plants** rather than induce necrosis or cause death. Expressed symptoms (chlorosis, stunting, distortions) can be valuable clues for virus identification, but can be easily confused with symptoms induced by other problems such as nutritional disorders, spray injuries, or certain feeding damage induced by mites or insects. In addition, because of their extremely small size, the virus or signs of the virus are not visible to the unaided eye. The virus particles are detectable within the plant through the electron microscope.

Viruses are transmitted from plant to plant by insects, mites, fungi and nematodes, rubbing, abrasion or other mechanical means (including grafting or other forms of vegetative propagation). Viruses are occasionally transmitted in seed. Because of the nature of virus transmission, virus symptoms generally spread with time from one infected plant tissue to other plant tissues or from one infected plant to other plants in the community.

#### Nematodes:

Plant nematodes are microscopic roundworms that damage plant tissues as they feed on them. Many feed on or in root tissues. A few feed on foliage or other above-ground organs.

**Shoot Nematodes** (*Aphelenchoides*spp.) — Foliar nematodes feed inside leaves between the major veins causing chlorosis and necrosis. Injury is most often seen at the base of older foliage. When plants with a net-like pattern of veins become infested with foliar nematodes, the tissues collapse in wedge-shaped areas and then change color.

**Root Nematodes** — The most common above-ground symptoms caused by rootinfesting nematodes result from damaged root systems: Moisture and nutrient stress symptoms and general stunting are common. The root lesion nematodes (*Pratylenchus* spp.) and burrowing nematodes (*Radopholus similis*) destroy the root cortex tissues as they feed. The root-knot nematodes (*Meliodogyne* spp.) inject growth-regulating substances into root tissues as they feed, stimulating the growth of large tender cells and causing overgrowth of root tissues to form visible, swollen "galls" or "knots". Other root nematodes stunt growth, apparently by killing root meristems.

# Symptoms and Signs of Insects, Mites and Other Animals

#### Insects

The location of the feeding damage on the plant caused by the insect's feeding, and the type of damage (damage from chewing or from sucking mouth parts) are the most important clues in determining that the plant damage was insect-caused and aide in identifying the responsible insect.

An insect's life cycle (complete or incomplete) is important when attempting to detect the insect or design a control program.

# **Feeding Habits**

### Chewing Damage or Rasping Damage

- Entire Leaf Blade Consumed by various caterpillars, canker worms, and webworms. Only tougher midvein remains.
- Distinct Portions of Leaf Missing. Distinct notches cut from leaf margin (black vine weevil adult), circular holes cut from margin of leaf (leaf cutter bees), small randomly scattered holes in leaf (beetles, chafers, weevils, grass-hoppers).
- Leaf Surfaces Damaged: "Skeletonization" of leaf surface. Slugs, beetle larvae, pearslug (pear sawfly larvae), elm leaf beetle, and thrips.
- Leaves "rolled": Leaves that are tied together with silken threads or rolled into a tube often harbor leafrollers or leaftiers.
- Leaf Miners Feed Between the Upper and Lower Leaf Surfaces. If the leaf is held up to the light, one can see either the insect or frass (excrement) in the damaged area (discolored or swollen leaf tissue area), i.e. boxwood, holly, birch, elm leaf miners.
- Petiole and Leaf Stalk Borers burrow into the petiole near the blade or near the base of the leaf. Tissues are weakened and the leaf falls in early summer. Sectioning the petiole reveals insect-larva of a small moth or sawfly larva, i.e. maple petiole borer.
- Twig Girdlers and Pruners, i.e. vine weevil and twig girdling beetle.

- **Borers Feed** under the bark in the cambium tissue or in the solid wood or xylem tissue, i.e. Mountain pine beetle and smaller European elm bark beetle galleries. Damage is often recognized by a general decline of the plant or a specific branch. Close examination will often reveal the presence of holes in the bark, accumulation of frass or sawdust-like material or pitch, i.e. raspberry crown borer, Pine pitch moth.
- **Root Feeders**, larval stages of weevils, beetles and moths cause general decline of plant, chewed areas of roots, i.e. sod webworm, Japanese beetle and root weevil.

### **Sucking Damage**

In addition to direct mechanical damage from feeding, some phloem-feeding insects cause damage by injecting toxic substances when feeding. This can cause symptoms which range from simple stippling of the leaves to extensive disruption of the entire plant. Insect species which secrete phytotoxic substances are called toxicogenic (toxin-producing) insects. The resulting plant damage is called "phytotoxemia" or "toxemia".

- **Spotting or Stippling** result from little diffusion of the toxin and localized destruction of the chlorophyll by the injected enzymes at the feeding site. Aphids, leafhoppers, and lygus bugs are commonly associated with this type of injury.
- **Leaf curling or Puckering** More severe toxemias such as tissue malformations develop when toxic saliva causes the leaf to curl and pucker around the insect. Severe aphid infestations may cause this type of damage.
- **Systemic Toxemia** In some cases the toxic effects from toxicogenic insect feeding spread throughout the plant resulting in reduced growth and chlorosis. Psyllid yellows of potatoes and tomatoes and scale and mealy bug infestations may cause systemic toxemia. Examples:
  - General (uniform) "stipple" or Flecking or Chlorotic Pattern on leaf i.e. adelgid damage on spruce needles and bronzing by lace bugs.
  - **Random Stipple Pattern** on leaf, i.e. leafhoppers, mites.
  - Leaf and Stem "distortion" associated with

off-color foliage = aphids (distortion often confused with growth regulator injury) i.e. rose aphid, black cherry aphid, leaf curl plum aphid.

- **Galls, Swellings** on leaf and stem tissue may be caused by an assortment of insects, i.e. aphids, wasps, midge, mossyrose gall wasp, popular petiole gall midge, azalea leaf gall.
- **Damaged Twigs** Split: damage resembling split by some sharp instrument is due to egg laying (oviposition) by sucking insects such as tree hoppers and cicadas. Splitting of the branch is often enough to kill the end of the branch, i.e. cicada.
- **Root, Stem, Branch Feeders** General Decline of Entire Plant or Section of a Plant as indicated by poor color, reduced growth or dieback. Scales, mealybugs, pine needle scale.

# **Insect Life Cycles**

Knowledge of life cycles assists in identifying the damaging insect.

# Incomplete Life Cycle:

Insects resemble the adult upon hatching, except they are smaller and without wings. As the insect grows, it sheds its skin or molts leaving cast skins as a diagnostic sign.

Lygus bugs, leafhoppers, and grasshoppers are examples of insects with incomplete life cycles.

# **Complete Life Cycle**

Eggs, larva (caterpillar, wormlike or grub-like creature that may feed on various plant parts) pupa (relatively inactive, often enclosed in some form of cocoon), adult insect completely different in appearance. The larval stage with chewing and rasping feeding is most dangerous.

*Examples of insects with complete life cycles are butterflies, moths, weevils, beetles and flies.* 

# **Other Animal Damage**

**Arachnids** have sucking mouth parts and have 8 legs instead of six like the insects. **Spider Mites** have incomplete life cycles (mite resembling adult throughout life cycle). Damage is often a characteristic stipple pattern on leaf which then becomes pale color on underside (severe infestation causes leaf bronzing and death). Presence of "dirty" foliage - small fine webbing on the underside of the foliage mixed with eggs and frass. **Eriophyid Mites** - Distorted new growth, leaf margins roll, leaf veins swell and distort the leaf, (symptoms often confused with growth regulator damage).

**Crustacea** - Sowbugs and pill bugs feed on decaying vegetation. Not considered to be damaging to live plants.

**Mollusca** - Slugs and snails. Feeding injury to low growing foliage resembles Skeletonizing or actual destruction of soft tissue. Signs: presence of "silvering" and slime trails on foliage.

**Miscellaneous Animals** - Millipede and centipedes (arthropods) feed on decaying plant vegetation (many small legs, brownish or white in color, vary in size from  $\frac{1}{2}$ -2"). Not considered injurious to live plants.

**Small Mammals** - Chewing of bark and cambium tissue on small trees and shrubs in most frequently caused by rodents (mice, rabbits, squirrels, and possibly beavers). Signs: Note teeth marks.

**Large Mammals** - Branches torn or clean cut by cattle, goats, deer and horses.

**Birds** - Yellow-bellied sap-sucker (even rows of holes in the tree trunk). Missing flower petals, puncture splitting of bark.

# **Distinguishing Among Nonliving Factors**

If patterns of damage in the field planting and on the individual plant are uniform and repeated, this indicates that a nonliving factor is the probable cause of the damage. We will now examine additional information and clues to discover whether the nonliving damaging factor was a mechanical, physical, or chemical factor.

Look for Changes in the affected plant's environment caused by the three categories of Nonliving Factors: 1) Mechanical Factors (Damage/Breakage) plant damage caused by site changes - "construction damage", transplanting damage, "Lawn mower blight", abrasion, bruising. 2) Physical Factors environment or weather changes causing extremes of temperature, light, moisture-aeration. 3) Chemical factors - chemical pesticide applications, aerial and soil pollutants, nutritional disorders.

# **Mechanical Factors**

Close visual examination and questioning will often determine if the stems or roots have been broken or girdled or if the leaves have been bruised, punctured or broken. For example, if a large *Fiscus elastica* is dropped while being transplanted and the stem is broken, rapid wilting of the portion of the plant above the break will occur. Examine the plant site for signs of recent excavation, construction, paving, etc.

# **Physical Factors**

### Environmental Factors

Primary sources of diagnostic information are damage patterns and weather records to pinpoint the time and location of weather extremes. Records help indicate the factor that caused the plant damage.

#### **Temperature Extremes:**

**Heat:** The highest leaf temperatures will occur in the early afternoon when the sun is located in the southwest quadrant of the sky. Therefore, lethal leaf temperatures produced by absorption of solar radiation will occur primarily on unshaded leaves on the outer surface of the plant canopy on the southwest side. Portions of leaves shaded by other leaves or leaves on the shaded northeast side may be undamaged. The most severe damage occurs on the leaves most exposed and furthest from the vascular (roots, stem, leaf vein) source of water, i.e. leaves on outer perimeter of plant, leaf tips and interveinal areas.

**Cold:** Damage will occur on the least hardy plants and will be most severe on the least hardy tissues of those specific plants. In fall acclimation, cold hardiness is first achieved by the terminal buds, and then with time the lower regions achieve hardiness; the branch crotches are often the last tissues to achieve cold hardiness. And, generally, the root systems will not survive as low a temperature as will the tops -root systems are damaged at higher temperatures than are the tops. On the other hand, after hardiness has been achieved, if warm temperatures induce deacclimation (i.e. in the early spring), the terminals (buds) are first to become less cold hardy.

Portion of plant damaged will indicate if low temperature damage occurred before plant achieved cold hardiness in the fall, or if it occurred after cold hardiness was lost in the spring: reverse patterns are produced.

On a given structure (i.e. leaf or bud) the damage will be death of exposed, nonhardy tissues in a recognizable (repeated) pattern. For example, frost damage to foliage, i.e. conifer needles, in the spring will uniformly kill all needles back toward the stem. Frost cracks are longitudinal separations of the bark and wood generally on the southwest sides of the trunk -most likely to occur because of daily, wide temperature fluctuations. Freezing death of dividing cells on the outer portions of leaf folds while inside the bud will cause a distorted or lace-like leaf blade because of nonuniform cell division and growth during leaf expansion. Cold damage to the root system is primarily a concern with containergrown plants where the root temperature fluctuates more and can be expected to reach lower temperatures than would occur with the same plant if fieldgrown. Cold damage to the root system can be detected by examining the roots: Damage generally occurs from the periphery of the root ball (near the container edge) and evidence includes blackened or spongy roots with lack of new growth or new root hairs. Above ground symptoms generally will not be evident until new shoot growth begins in the spring; at that time leaf expansion may be incomplete (small leaf size) because of the restricted uptake of water and nutrients by the damaged root system. With increased air temperatures, the water loss from the shoots and leaves may exceed the root uptake capacity and the plants may defoliate due to this water deficit.

**Plants Vary in their Cold Tolerance:** The cold tolerance (hardiness) of various plants in the landscape has been rated by the USDA (see Plant Hardiness Zone Map, USDA-ARS Misc. Pub. Np. 814). The "indicator plants" listed for the various cold hardiness zones on the map are useful in surveying a group of landscape plants, observing which ones show cold damage and then estimating how low the temperature dropped based on the damaged/undamaged indicator plants.

**Light Extremes:** Plants can acclimate to various conditions, but the primary requirement for acclimation is time. Plants respond adversely to rapid changes in the environment. Rapid change from low to high light intensity will result in destruction of the chlorophyll pigments in the leaf (yellowed and necrosis - sunburn). Rapid change from high to low light intensity will result in reduced growth and leaf drop; new leaves will be larger. "Sun leaves" are smaller, thicker and lighter green in color than are "shade leaves". Flowering will be reduced, delayed or absent under low light.

Oxygen and Moisture Extremes: Here we are primarily considering the root environment where oxygen and moisture are inversely related. Waterlogging (moisture saturation) of the root environment results in oxygen deficiency; without oxygen, root metabolism and growth come to a standstill. Consequently, uptake of water and nutrients is restricted with subsequent wilting and nutritional deficiency symptoms occurring on the above ground portions of the plant. Drought and water logging produce many of the same symptoms on the above ground portion of the plant: the first symptoms will be chlorosis and abscission of older leaves. Under severe, continuing moisture stress, wilting and necrosis will occur on the tips and interveinal regions of recently expanded leaves and new growth (Figure 6).

# **Chemical Factors**

*Field Patterns of Plant Injury Related to Chemical Applications* 

**Look For Application, Drift, or Runoff Accumulation Patterns in the Field** (Figure 10): the pattern of plant injury in a field or other group of plants and the date of injury appearance can be helpful in relating the damage to a specific chemical application.

**Damage Diminishing Uniformly From One Side to the other** (Figure 10.A, Spray Drift): A pattern in a field, yard or on a group of plants that starts on one side and diminishes gradually and uniformly away from that area is typical of wind-drifted droplets.

# Damage in Individual Spots or Irregular Pat-

**terns** (Figure 10.B): Low lying areas in a field where air masses settle would enhance the accumulation of fumes from volatile chemicals, would be frost pockets, and might enhance pathogens. These damage spots might also be related to differences in the soils texture, organic matter, pH or moisture. High pH spots might induce nutritional disorders such as iron deficiency, increase the toxicity of triazine herbicides, etc.

Damage in Linear Stripes at Regular Intervals,

(Figure 10.C), indicates nonuniform application of a chemical. Regularly recurring stripes of damaged plants at intervals within the width of the application equipment (fertilizer applicator, pesticide spray boom, etc.) indicate an over-sized or worn nozzle, improper setting on one applicator opening, or an overlap in application. Another cause may be carry over of a residual chemical from bands applied the year before, this pattern would match row width and direction from the previous season.

**Damage At Ends of Field,** (Figure 10.D), may be due to double application of a chemical either the year before or the year the injury is observed.

Damage on One Part of the Field Only with a **Definite Break Between the Damaged Portion** and the Remainder of the Field, (Figure 10.E), 1) Was the equipment reloaded or recalibrated at the break-point? If so, a mistake might have been made in the chemical selected or the rate of application, or the equipment might not have been adequately cleaned of a toxic chemical: the toxic residue was removed in the application of the first load of chemical. Check equipment-use records. 2) Check tillage methods, dates and soil conditions (moisture) -resulting differences in soil texture or depth of tillage may cause differences in dilution of carry over chemical residue. differences in volatilization and dilution of an applied chemical.

#### Damage Intensity Increasing Along a Broad

**Band**, (Figure 10.F) indicates inadequate mixing or poor agitation of a wettable chemical powder in a spray tank resulting in increased concentration of the applied chemical toward the end of the tank load.

#### Figure 10.

Illustrations of patterns of plant damage related to chemical applications to field or bed plantings.



- A) Drift of spray droplets.
- B) Spots of injury from low temperature or accumulation of volatile chemicals or accumulation of chemical runoff in low areas of field; or, injury associated with soil variables.
- C) Stripes indicating overlapping application pattern, or one or more faulty applicator openings.
- D) Plant injury at end of field due to double application.
- E) Definite break between injured and uninjured sections of the plantings: Application discontinued or change in applied chemical.
- F) Increasing injury within an application band due to poor mixing or inadequate chemical agitation.

# Chemical Injury Patterns on an Individual Plant

A general uniform pattern of damage occurring over several plant species and over a relatively large area indicates a nonliving factor such as a chemical phytotoxicity. Questions-answers, records, the plant symptoms and knowledge about the mobility within the plant of common chemicals (nutrients and pesticides) should help determine which chemical caused the damage.

Patterns of injury symptoms on an individual plant that develop because of deficiency, excess or toxicity of a chemical differ depending primarily upon whether the chemical causes damage directly on Contact, or is absorbed and distributed within the plant through Phloem-Translocation or through Xylem-Translocation.

# Symptoms from Direct Contact of Chemicals with the Plant:

Shoot-Foliage Contact: Symptoms from shootcontact or chemicals occur over the general plant canopy. If the toxic chemical is applied directly to the above ground parts of the plant (shootfoliage contact chemical), the physical pattern of application may be detected, i.e. spray droplet size, etc. If the toxic chemical is spray-applied, the pattern of the spray droplets or areas where spray accumulated to runoff along the leaf edges will show the most severe damage. If it is a toxic gas (volatile chemical acting as an aerial pollutant), the areas between the leaf veins and along the leaf margins where the concentration of water within the leaf is lower will be the first to show damage. Injury from foliar applications of insecticides, fungicides and fertilizers is primarily of the direct-contact type and is typified by chlorotic-necrotic spotting, especially interveinally and along leaf edges and other areas where chemicals concentrate and are least diluted by inter-cellular moisture. Examples of shoot-foliage contact chemicals are foliar-applied fertilizer salts and herbicides such as paraquat, acifluorfen, dinoseb, and herbicidal oils. Fungicides and insecticides may also cause injury to some plants.

**Root Contact:** Toxic contact chemicals in the root zone, including excess fertilizer, result in poor root development or death. Symptoms from rootcontact chemicals are localized where the chemical contacts the root but also result in general symptoms in the shoot. The shoots may show water and nutrient stress symptoms, i.e. reduced growth, wilting, nutrient deficiency symptoms. The injury symptoms on the shoot and foliage from root damage by direct contact with toxic chemicals or excessive salts resembles a drying injury -the roots are unable to obtain water. This will result in a general stunting of the plant. In severe cases, wilting can occur even though the soil is wet. Lower Leaves generally wilt first and this is followed by drying of the leaf margins. Many factors injuring or inhibiting root growth may produce similar shoot symptoms: Nematodes, soil compaction, cold weather, salinity, nutritional disorders and certain herbicides (dinitroanilines, DCPA, and diphenamid) cause root inhibition.

# Symptoms of Deficient or Toxic Trans-located Chemicals

The effects of mobile chemicals absorbed by the plant are dependent upon whether the chemical is transported in the phloem or in the xylem. If transported solely in the xylem system, the chemical will move upward in the plant in the xylem-transpiration stream.

- Toxic symptoms from xylem-translocated chemicals occur primarily in the <u>older</u> foliage.
- Deficiency symptoms of xylem-transported (phloem-immobile) nutrient ions will occur first in the <u>new growth.</u>

If the chemical is translocated in the phloem, it may move multidirectional from the point of absorption, i.e. it may move from the shoot to the root or the reverse.

Toxic symptoms from phloem-translocated chemicals occur primarily in the <u>new growth</u> and <u>meristematic</u> regions of the plant.

Deficiency symptoms of phloem-retranslocated nutrient ions occur first in the <u>older foliage</u>.

# Xylem Translocated Chemicals Move Primarily Upward in the Plant to the Foliage

Chemicals are translocated upward in the xylem (apoplastic movement) of the plant from the point of absorption. Symptoms occur in tissues formed after the toxicity or deficiency occurs.

• Toxic Chemicals -xylem translocated. When toxic chemicals are translocated to fully expanded, older leaves, the toxicity symptoms generally appear on the leaf margins and interveinal areas. When toxic chemicals are translocated to immature, young leaves, the toxicity symptoms generally appear associated with the veins, especially the midrib.

**Photosynthetic-Inhibiting Chemicals** - Injury from translocated toxic chemicals is primarily to the foliage. Plant injury generally progresses from the lower, older foliage to the top. Individual leaves show greatest injury (chlorosis) along their tips and margins or along the veins. Examples of xylemtranslocated herbicides include the photosynthetic inhibitors such as triazine, urea and uracil herbicides.

**Shoot-Inhibiting Chemicals** - Examples of toxic chemicals absorbed by the roots and translocated in the xylem to the shoots are the "shoot inhibiting herbicides". The shoot inhibitors cause malformed and twisted tops with major injury at the tips and edges of the leaves; looping of the leaves may occur since the base of the leaf may continue to grow while the leaf tips remain twisted together. Thiocarbamate herbicides cause these symptoms on both grasses and broad leaves. Alachlor and metolachlor herbicides cause similar injury symptoms on grasses.

# • Deficiency Nutrient Ions, xylem-translocated (phloem immobile)

Several nutrient ions are translocated upwards in the xylem and are immobile after incorporation into plant tissues. They cannot be withdrawn and retranslocated in the phloem to the new growth when deficiencies develop in the root zone. Deficiency symptoms of Phloem-Immobile nutrient ions develop on the new growth. Boron and calcium are quite phloem-immobile which means that if the external supply becomes deficient, the symptoms of boron and calcium deficiency will appear in the new growth. And, with severe deficiencies, the terminal bud dies. Iron, manganese, zinc, copper and molybdenum are also relatively phloem-immobile and are not readily withdrawn from the older leaves for translocation through the phloem to younger leaves and organs. Deficiency symptoms are most pronounced on the new growth.

# Phloem Translocated Chemicals Move Multidirectionally from Point of Application or Source of the Chemical to the Meristematic Regions.

### Toxic Chemicals - Phloem translocated

Injury from Phloem-translocated toxic chemicals - primarily to new leaves and roots because of translocation of the chemicals to the meristems. Whether taken up by the roots or shoots, these compounds are moved through the living plant cells and phloem (symplastic movement) to both the root and shoot tips. The young tissue (shoots or roots) will be discolored or deformed and injury may persist for several sets of new leaves. Examples of phloem-translocated toxic chemicals, whether absorbed by the roots or shoots, include the herbicides 2,4-D, dicamba, picloram, glyphosate, amitrole, dalapon, sethoxydim and fluazifopbutyl. These compounds move to the meristems and typically injure the youngest tissues of the plant.

# Deficient Nutrient Ions - Phloem mobile

If Phloem Mobile Nutrient Ions become deficient in the root zone, these ions may be withdrawn from the older plant tissues and retranslocated in the phloem to the new growth. In such situations, deficiency symptoms will first occur on the older leaves. Elements that may be withdrawn from older leaves and retranslocated in the phloem to younger leaves and storage organs include nitrogen, phosphorus, potassium, magnesium, chlorine and, in some plant species, sulfur. Sulfur: In plant species where sulfur can be withdrawn from the older leaves and translocated to the newer growth, deficiency symptoms may initially occur on the older leaves or over the plant in general. In plants where sulfur is not readily re-translocated, the older leaves may remain green and the sulfur deficiency symptoms occur only on the new growth.

# Key to Symptoms of Chemical Disorders on Individual Plants

# I. Symptoms Appearing First or Most Severely on New Growth

(root and shoot tips, new leaves, flowers, fruits, buds)

# A. Terminal Bud Usually Dies. Symptoms on new growth.

- Basal part of young leaves and internal tissues of organs may become necrotic. One of the earliest symptoms is failure of the root tips to elongate normally. Terminal shoot meristems also die giving rise to a witch's broom. Young leaves become very thick, leathery, and chlorotic; in some species young leaves may be crinkled due to necrotic spots on leaf edges during development. Young leaves of terminal buds become light green then necrotic and the stem finally dies back from the terminal bud. Rust colored cracks and corking occur on young stems, petioles, and flower stalks. "Heart rot" of beets, "stem crack" of celery ... Boron Deficiency
- 2. Necrosis occurs at tip and margin of leaves causing a definite hook at leaf tip. Calcium is essential for the growth of shoot and root tips (meristems). Growing point dies. Margins of young leaves are scalloped and abnormally green and, due to inhibition of cell wall formation, the leaf tips may be "gelatinous" and stuck together inhibiting leaf unfolding. Stem structure is weak and peduncle collapse or shoot topple occurs near terminal bud. Ammonium or Magnesium Excess may induce a calcium deficiency in plants ... **Calcium Deficiency**

Differentiating between calcium and boron deficiency symptoms: When calcium is deficient, there is a characteristic hooking of the youngest leaf tips. However, when boron is deficient, the breakdown occurs at the bases of the youngest leaves. Death of the terminal growing points is the final result in both cases.

3. Tissue Breakdown -necrosis and firing of the tip and margins of the leaf. The ammonium cation itself may become phytotoxic and result in breakdown of the plant tissue (proteolysis= breakdown of plant proteins) initially producing a wet, dark-green, "steamed" appearance at the leaf tips and margins. This destroyed tissue eventually desiccates and becomes a light tan color. Excess ammonium may also induce calcium deficiency (abnormally dark green foliage, scalloped leaf margins, weak stem structure, death of terminal bud or growing point of the plant, premature shedding of the blossoms and buds) ... **Ammonium Excess** 

# B. Terminal Bud Remaining Alive. Symptoms on new growth.

- 1. Interveinal chlorosis on young leaves.
- a. Interveinal chlorosis on young leaves with larger veins only remaining green. Necrotic spots usually absent; with extreme deficiencies, however, young leaves are almost white and may have necrotic margins and tips; necrotic areas may extend inward. Potassium, Zinc or Copper Excess can inhibit uptake of iron. High pH may also induce iron deficiency ... **Iron Deficiency**

Iron deficiency symptoms are similar to those of magnesium deficiency, but iron deficiencies occur in young leaves first: Iron accumulated in older leaves is relatively immobile in the phloem.

- b. Interveinal chlorosis with smallest veins remaining green producing a checkered or finely netted effect. Grey or tan necrotic spots usually develop in the chlorotic areas; the dead spots of tissue may drop out of the leaf giving a ragged appearance. Poor bloom -both in size and color. Potassium excess can inhibit uptake of manganese... **Manganese Deficiency**
- c. Stunted new growth with interveinal chlorosis: Young leaves are very small ("little leaf"), sometimes missing leaf blades altogether, and internodes are short giving a rosette appearance... **Zinc Deficiency**
- 2. Interveinal chlorosis is not the main symptom on new growth
  - a. Wilting and loss of turgor of young, terminal leaves and stem tips is common. Symptoms are highly dependent upon plant species. In some species younger leaves may show interveinal chlorosis while tips and lobes of older leaves remain green followed by veinal chlorosis and rapid, extensive necrosis of leaf blade ... **Copper Deficiency**

There are no known reports of  $H_z PO_4^{-1}$  toxicity; however, plants may take up the phosphate anion in luxury amounts. Phosphorus excess is associated with impeded uptake and possible deficiency of copper and sometimes of zinc... **Phosphorus Excess** 

b. Leaves light green, veins lighter in color than adjoining interveinal areas. Leaves over entire plant may become yellowish green, roots and stems are small in diameter and are hard and woody. Young leaves may appear to be uniformly yellow. Some necrotic spots ... **Sulfur Deficiency** 

In plant species where the sulfur is not withdrawn from older leaves and retranslocated to the new growth, leaves matured prior to onset of sulfur deficiency remain green: This retention of green color in older foliage distinguishes sulfur deficiency in these species from nitrogen deficiency where the nitrogen is translocated from the older foliage into the new leaves. With nitrogen starvation, old leaves as well as new leaves turn yellow.

c. Shoot inhibition causing malformed and twisted tops with major injury at the tips and edges of the leaves ... **Xylem-Translocated "Shoot-Inhibiting Chemicals**"

Examples of toxic xylem-transported chemicals include the thiocarbamate herbicides (symptoms on grasses and broad leaf plants) and alachlor and metolachlor (symptoms on grasses)

d. Young tissues discolored or deformed and injury may persist for several sets of new leaves...**Toxic Phloem-Translocated Chemi**cals

*Examples of Toxic Phloem-Transported Chemicals include the herbicides 2,4-D; dicamba; picloram; glyphosate; amitrole; dalapo; sethoxydim and fluazifopbutyl.* 

# II. Symptoms Do Not Appear First on Youngest Leaves:

Effect general on whole plant or localized on older, lower leaves.

# A. Chlorosis General, no interveinal Chlorosis. Effects usually general on whole plant.

1. Visible symptoms include yellowing and dying of older leaves. Foliage light green, growth stunted, stems slender, yellow ... Nitrogen Deficiency

Plants receiving enough nitrogen to attain limited growth exhibit deficiency symptoms consisting of a general chlorosis, especially in older leaves. In severe cases, these leaves become completely yellow and then light tan as they die. They frequently fall off the plant in the yellow or tan stage.

 Older leaves wilt. Entire leaf is affected by chlorosis, but edges and leaf tissues near main veins often retain more color (chlorophyll) ... Zinc Excess

# B. Vein-Clearing, Chlorosis-Necrosis at Leaf Tips and Margins, older-younger foliage ... Xylem-Transported Photosynthetic-Inhibitors

When toxic chemicals are xylem-translocated to older, fully-expanded leaves, the toxicity symptoms generally occur on the margins and interveinal areas of the leaf. When translocated to young, expanding leaves, toxicity symptoms are generally associated with the veins, especially the midrib.

*Examples of Xylem-Translocated, Photosynthetic Inhibitors include the triazine, urea and uracil herbicides.* 

# C. Interveinal Chlorosis. Interveinal Chlorosis first appears on oldest leaves.

1. Older leaves chlorotic, usually necrotic in late stages. Chlorosis along leaf margins extending between veins produces a "Christmas tree" pattern. Veins normal green. Leaf margins may curl downward or upward with a puckering effect. Necrosis may suddenly occur between the veins. Potassium or calcium excess can inhibit uptake of magnesium... **Magnesium Deficienc**y

When the external magnesium supply is deficient, interveinal chlorosis of the older leaves is the first symptom because as the magnesium in the chlorophyll is remobilized, the mesophyll cells next to the vascular bundles retain chlorophyll for longer periods than do the parenchyma cells between them. Leaves lose green color at tips and between veins followed by chlorosis or development of brilliant colors, starting with lower leaves and proceeding upwards. The chlorosis/brilliant colors (unmasking of other leaf pigments due to the lack of chlorophyll) may start at the leaf margins or tips and progress inward interveinally producing a "Christmas" tree pattern. Leaves are abnormally thin, plants are brittle and branches have a tendency to curve upward. Twigs are weak, subject to fungus infection, leaves usually drop prematurely; plant may die the following spring.

- 2. Smaller veins in older leaves may turn brown. Small necrotic spots in older leaves spread from the margins inwards, and finally the entire leaf blade desiccates. At severe, advanced stages, young leaves also display this spotting... Manganese Excess
- 3. Chlorotic areas (pale yellow) on whole plant; leaf edges curl upward ... **Molybdenum Deficiency**

General symptoms are similar to those of nitrogen deficiency: Interveinal chlorosis occurs first on the older or midstem leaves, then progresses to the youngest. Sometimes, as in the "whiptail" disease, plants grown on ammonium nitrogen may not become chlorotic, but develop severely twisted young leaves, which eventually die. Other characteristic molybdenum deficiency symptoms include marginal scorching and rolling or cupping of leaves. With molybdenum deficiency, nitrogen deficiency symptoms may develop in the presence of adequate levels of nitrate nitrogen in the root environment and high levels of nitrate nitrogen in the plant. Nitrate nitrogen must be reduced in the plant before it can be utilized. Molybdenum is required for this reduction, and if molybdenum is deficient, nitrate may accumulate to a high level in the plant, and at the same time the plant may exhibit nitrogen deficiency symptoms. Molybdenum differs from other trace nutrients in that many plants can develop in its absence provided that ammonium nitrogen is present. Molybdenum appears to be essential for the nitrate-reducing enzyme to function.

4. Foliar marginal necrosis is the most common symptom of fluoride toxicity along with chlorosis along and between the veins in fluorine-sensitive plants. With many plants, the marginal necrosis is preceded by the appearance of gray or lightgreen, water-soaked lesions which later turn tan or reddish-brown. Injury generally occurs at the tips of the leaves first, then moves inward and downward until a large part of the leaf is affected ...**Fluoride Excess** 

# D. Leaf Chlorosis is Not the Dominant Symptom. Symptoms appear on older leaves at base of plant.

- 1. Plant dark Green
- a. At first, all leaves are dark green and growth is stunted. Purple pigment often develops in older leaves, particularly on the underside of the leaf along the veins. Leaves drop early... **Phosphorus Deficiency**

Phosphorus deficiency is not readily identified by visual symptoms alone. Visual symptoms of phosphorus deficiency are not always definite, but many phosphorus deficient plants exhibit off-color green foliage with purple venation, especially on the underside of leaves, and plants are stunted and remain stunted even when fertilizers supplying potassium and nitrogen are applied. Older leaves assume a purple-bronze color. Small growth, especially root development; spindly growth with tips of older leaves often dead. Phosphorus is phloem retranslocated from older leaves to new growth. Often enhanced by cold soil temperatures.

Aluminum appears to affect root growth in particular: root tips blacken, no longer lengthen, and become thickened. Excess aluminum accumulation in roots reduces their capacity for translocating phosphorus. Amelioration involves suppression of aluminum activity, for example by liming soil to bring the pH above 5.5. The toxic amount of aluminum in a soil will depend upon other soil properties such as pH and phosphorus content and upon the plant grown. Media amendments such as perlite may release toxic quantities of aluminum if the media pH is extremely acid... **Aluminum Excess** 

- b. Leaves are thick and brittle and deep green. In acute toxicity, older leaves wilt and scorch from the margins inward ... **Nitrate Excess**
- 2. Necrotic spots develop on older leaves
- a. Margins of older leaves become chlorotic and then burn, or small chlorotic spots progressing to necrosis appear scattered on old leaf blades, calcium excess impedes uptake of potassium cations... **Potassium Deficiency**

Potassium deficiency symptoms first appear on the recently matured leaves of the plant (not on the young, immature leaves at the growing point). In some plants, the first sign of potassium deficiency is a white specking or freckling of the leaf blades.

low temperatures; nematodes; root weevils. Examples of Root Direct-contact Toxic Chemicals include excess salts or presence of toxic chemicals such as the herbicides DPA, dinitroanilines, diphenamid.

Leaves often become bronze colored ... **Chloride Deficiency** 

With time, the symptoms become more pronounced on the older leaves, and they become mottled or yellowish between the veins and scorched at the margins. These progress upward until the entire leaf blade is scorched. If sodium cations are present and taken up in place of  $K^{+1}$ , leaf flecking (necrotic spots scattered on leaf surface) and reduced growth occur. Seed or fruit is shriveled. Potassium is phloem retranslocated from old leaves to new growth.

- b. Tips and edges of leaves exhibit necrotic spots coalescing into a marginal scorch. Symptoms appear from the plant's base upwards with older leaves being affected first. In advanced, severe toxicity, necrotic spots with a pale brown center also appear in the inner parts of the leaf blade... **Boron Excess**
- c. Mottling and necrotic spots primarily on margins and interveinally may be due to excessive amounts of fertilizers or pesticides applied as foliar sprays ... **Direct-Contact of Toxic Chemical with Shoot & Foliage**

Examples of shoot direct-contact toxic chemicals producing this type of symptom include the shootfoliage applied herbicides paraquat, acifluofen, dinoseb and the herbicidal oils.

3. Reduced growth and wilting of older leaves with development of chlorotic and necrotic spots. Roots become stunted in length and thickened, or club-shaped, near the tips: the shoots remain normal but may show nutrient and moisture stress. Under severe conditions, root tips may be killed causing general stunting of the plant or wilting followed by marginal drying of the lower leaves first... **Direct-Contact Injury by Toxic Chemicals** or other factors in the root zone, i.e. low temperatures; nematodes; root weevils.

- 4. Marginal scorching that may progress to general leaf scorching. Generally no spotting ... **Excess Salt or Sodium Excess**
- 5. Intense yellow or purple color in leaves. Molybdenum excess or toxicity in field-grown plants is rarely observed. Plants appear to tolerate relatively high tissue concentrations of molybdenum. Isolated reports of symptoms from excess molybdenum include development of intense yellow color in tomato leaves and intense purple color in cauliflower leaves... **Molybdenum Excess**

# **References, Laboratory Analyses**

If you have identified the plant and have narrowed the probable cause down through the various categories (i.e. distinguished between living and nonliving - then if living distinguished between pathogens and animal factors - then if pathogen, distinguished between fungal and bacterial organisms), you will probably need assistance in identifying the specific responsible organism or nonliving factor. But, by now you know what specialist to contact (plant pathologist, entomologist, physiologist ...) and what specific reference book would provide further assistance in narrowing down the search for the specific factor causing the observed plant damage. Laboratory analyses and examination may be required to further narrow the range of probably causes.

# V. Synthesis of Information to Determine Probable Causes of plant Damage

The detective work to find the "signs" (residues of the living, damaging organism or nonliving factor, records, etc.) is time consuming and methodical. But, without this process of elimination and synthesis, the probability of making a correct diagnosis is low.

# Table 3. Summary:

# Systematic Approach to Diagnosing Plant Damage

- I. Define the problem (determine that a "real" problem exists):
  - A. Plant Identification and Characteristics. Establish what the "normal" plant would look like at this time of year. Describe the "abnormality": Symptoms & Signs.
  - B. Examine the Entire Plant and its Community. Determine the primary problem and part of the plant where the initial damage occurred.

#### II. Look for Patterns: On more than one plant? On more than one plant species?

- A. Non-uniform Damage pattern (scattered damage on one or only a few plant species) is indicative of Living Factors (pathogens, insects, etc.)
- B. Uniform Damage Pattern over a large area (i.e. damage patterns on several plant species) and uniform pattern on the individual plant parts indicate Nonliving Factors (mechanical, physical, or chemical factors).

#### III. Delineate Time-development of Damage Pattern

- A. Progressive spread of the damage on a plant, onto other plants, or over an area with time indicates damage caused by Living Organisms.
- B. Damage occurs, does not spread to other plants or parts of the affected plant. Clear line of demarcation between damaged and undamaged tissues. These clues usually indicate Nonliving Damaging Factors.

# IV. Determine Causes of the Plant Damage. Ask questions and gather information.

- A. Distinguish Among Living Factors
  - 1. Pathogens Symptoms and signs.
  - Insects, mites and other Animals
     Symptoms and signs.
- B. Distinguish Among Nonliving Factors
  - 1. Mechanical Factors
  - 2. Physical Factors
    - a. Temperature extremes
    - b. Light extremes
    - c. Oxygen and moisture extremes
    - d. Weather records
  - 3. Chemical Factors
    - a. Analyze damage patterns in fields and other plantings
    - b. Injury patterns on individual plants
    - c. Pesticide-pollutant phytotoxicities - damage patterns
    - d. Nutritional disorders key to nutritional disorders
    - e. Spray records
- C. References (check reports of damaging factors on identified plant); may need Laboratory Analyses to narrow range of probably causes.

#### V. Synthesis of Information to Determine Probable Causes

# Literature Useful for Diagnosing Plant Diseases & Disorders

# I. Miscellaneous

# The Ortho Home Gardener's Problem Solver.

1993. Smith, C. A. ed. Ortho Books, San Ramon, CA. 400 pp.

*The Organic Gardener's Handbook of Natural Insect and Disease Control.* 1992. B. A. Ellis and F. M. Bradley, eds. Rodale Press, Emmaus, PA. 534 pp.

# **II. Floriculture**

### Compendium of Flowering Potted Plant Dis-

*eases.* 1995. Daughtrey, M. L., Wick, R. L. and Peterson, J. L. APS Press, St. Paul, MN 90 pp.

*Compendium of Ornamental Foliage Plant Diseases.* 1987. Chase, A. R. APS Press, St.Paul, MN. 100 pp.

*Diseases of Annuals and Perennials.* Chase, A. R., Daughtrey, M. and Simone, G. W. Ball Publishing Co., Batavia, IL. 202 pp.

*Ball Field Guide to Diseases of Greenhouse Ornamentals.* 1992. G. W. Ball Publishing Co., Batavia, IL. 218 pp.

# III. Woody Ornamentals & Trees

*Compendium of Elm Diseases*. 1981. Stipes, R. J. and Campana, R. J. A. R. APS Press, St. Paul, MN. 96 pp.

# Compendium of Rhododendron and Azalea

*Diseases.* 1986. Coyier, D. L. and Roane, M. K. APS Press, St. Paul, MN. 65 pp.

*Compendium of Rose Diseases.* 1983. Horst, R. K. APS Press, St. Paul, MN. 50 pp.

*Diagnosing Injury to Eastern Forest Trees.* 19?? Anonymous. Publications Distribution Center, 112 Agricultural Administration Building, University Park, PA. 16802.

*Diseases of Trees and Shrubs*. 1987. Sinclair, W. A., Lyon, H. W. and Johnson, W. T. Cornell University Press. Ithaca, NY. 575 pp.

*Insects That Feed on Trees and Shrubs, 2nded.* 1991. Johnson, W. T. and Lyon, H. W. Cornell University Press. Ithaca, NY. 560 pp.

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*Compendium of Apple and Pear Diseases.* 1990. Jones, A. L. and Aldwinkle, H. S. APS Press, St. Paul, MN. 100 pp.

*Compendium of Blueberry and Cranberry Diseases.* 1995. Caruso, F. L. and Ramsdell, D. C. APS Press, St. Paul, MN. 87 pp.

*Compendium of Grape Diseases*. 1988. Pearson, R. C. and Goheen, A. C. APS Press, St. Paul, MN. 121 pp.

*CompendiumofRaspberry andBlackberry Diseases and Insects.* 1991. Ellis, M. A., Converse, R. H., Williams, R. N., and Williamson, B. APS Press, St. Paul, MN. 122 pp.

*Compendium of Stone Fruit Diseases.* 1996. Ogawa, J. M., Zehr, E. I., Bird, G. W., Ritchie, D. F., Uriu, K. and Uyemeoto, J. K. APS Press, St. Paul, MN. 122 pp.

*Compendium of Strawberry Diseases.* 1984. Maas, J. L. APS Press, St. Paul, MN. 138 pp.

# V. Turfgrass

**Compendium of Turfgrass Diseases, 2nded.** 1983. Smiley, R. W., Dernoeden, P. H and Clarke, B. APS Press, St. Paul, MN. 204 pp.

# VI. Vegetables

*Compendium of Bean Diseases*. 1991. Hall, R. APS Press, St. Paul, MN. 102 pp.

*Compendium of Cucurbit Diseases*. 1996. Zitter, T., Hopkins, D. L. and Thomas, C. E. APS Press, St. Paul, MN. 87 pp.

*Compendium of Pea Diseases*. 1984 Hagedorn, D. J. APS Press, St. Paul, MN. 57 pp.

*Compendium of Onion and Garlic Diseases.* 1994. Schwartz, H. F. and Mohan, S. K. APS Press, St. Paul, MN. 70 pp.

*Compendium of Tomato Diseases.* 1991. Jones, J. B., Jones, J. P., Stall, R. E. and Zitter, T. A. APS Press, St. Paul, MN. 100 pp.

# Diseases and Pests of Vegetable Crops in

*Canada.* 1994. Howard, R. J., Garlend, J. A., and Seaman, W. L. 554 pp.

# **VII. Field Crops**

*Compendium of Corn Diseases, 2nd ed.* 1980. Shurtleff, M. C. APS Press, St. Paul, MN. 105 pp.

*Diseases of Field Crops in Canada*. 1985. Martens, J. W., Seaman, W. L. and Atkinson, T. G. The Canadian Phytopathological Society, Harrow, Ontario, Canada. 160 pp.

#### VIII. Disease Indices

*Diseases and Pests of Ornamental Plants, 5th edition.* 1978. P. P. Pirone. John Wiley and Sons, Inc., New York, NY. 566 pp.

*Westcott's Plant Disease Handbook, 5th edition.* 1990. Horst, K. Van Nostrand Reinhold Co., Inc., NY 953 pp.

Titles in **BOLD** lettering are highly recommended. cas 12/96

# CHAPTER 6 Pesticide Use and Safety

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# CHAPTER 6

# **Pesticide Use and Safety**

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Pesticides may be useful when nonchemical methods fail to provide adequate control of pests and when pest populations reach a level of economic injury. The suffix "-cide" literally means kill. The term pesticide refers to a chemical substance that will kill pests. Since it is physically impossible to eradicate an entire population of pests, pesticides are used as a tool to control or manage pest populations to a level of tolerance. Because of government regulations, chemicals used to attract or repel pests and to regulate plant growth or function are also classed as pesticides. Also, some biologicals are also classified as pesticides.

Understanding the proper use of pesticides is imperative to their effectiveness and to your safety.

# Terminology

The wording "insecticides and pesticides" is incorrect because insecticides are pesticides.

# Types and functions of pesticides include the following:

Insecticides	control insects	Predacides	control pest animals
Miticides	control mites	Repellents	keep pests away
Acaricides	control mites, ticks, and spiders	Attractants	lure pests
Nematicides	control nematodes	Growth	stop, speed up, or otherwise
Fungicides	control fungi	Regulators	change normal plant or insect processes
Bactericides	control bacteria		-
Herbicides	control plants (herbicides kill plants, not just weeds)	Desiccants, Defoliants	used to remove or kill leaves and stems
Rodenticides	control rodents	Antitranspirants	reduce water loss from plants
Avicides	control birds	Antidesiccants	used to protect plants from winter damage, drought, wind
Piscicides	control fish		burn, and transplant shock
Molluscicides control mollusks, such as slugs and snails			(effectiveness is being ques- tioned by recent research)

Pesticides can be grouped according to how they
work. Many work in more than one way.

Contact poisons:	Kill pests simply by touching them.	In-furrow:
Stomach poisons:	Kill when swallowed.	Sidedress:
Systemics:	Kill best by being taken into the blood of the animal or sap of the plant upon which the pest is feeding.	Spot treatment
Translocated herbicides:	Move from the point of initial application to circulate through- out the plant. The circulation of toxin ensures the kill of the entire plant.	<b>Pesticide</b> The formulation pesticide and of Pesticides are pro-
Fumigants:	Gasses which kill when they are inhaled or otherwise absorbed by pests.	kills the pest(s) added chemica easy and safe t
Selective pesticides:	Kill only certain kinds of plants or animals, for example, 2,4-D used for lawn weed control, kills broad leaved plants but does not harm grass.	follow. Emulsifiable concentrates (EC or E)
Nonselective pesticides:	Kill most plants or animals.	
The following ter pesticides:	rms describe when to apply	
Pre-emergence:	Use before plants emerge from soil.	
Pre-plant:	Use before crop is planted by applying to the soil.	Solutions (S)
Post-emergence:	Use after the crop or weeds have germinated.	
Terms which des	cribe how to use pesticides:	Flowables
Band:	Application to a strip over or along each crop row.	(F or L)
Broadcast:	Uniform application to an entire, specific area by scattering.	Aerosols (A)
Dip:	Immersion of a plant in a pesti- cide.	
Directed:	Aiming the pesticide at a portion	

Foliar:	Application to the leaves of plants.
In-furrow:	Application to or in the furrow in which a plant is growing.
Sidedress:	Application along the side of a crop row.
Spot treatment:	Application of a pesticide to a small section or area of a crop.

# **Formulations**

on describes the physical state of a determines how it will be applied. rarely applied full strength. The e pesticide formulation that actually ) is termed the active ingredient. The al(s), those which make the product to formulate or apply, are termed the nts. Common pesticide formulations

dry.

	or animals, for example, 2,4-D used for lawn weed control, kills	Emulsifiable concentrates		
	broad leaved plants but does not harm grass.	(EC or E)	The active ingredient is mixed with an oil base (often listed as	
Nonselective pesticides:	Kill most plants or animals.		petroleum derivatives) forming an emulsion which is diluted with water for application. ECs are common in the home garden	
The following ter pesticides:	rms describe when to apply		trade, being easy to mix and use. They can cause a minor surface bronzing of light-colored fruit.	
Pre-emergence:	Use before plants emerge from soil.		They should be protected from freezing temperatures which can	
Pre-plant:	Use before crop is planted by applying to the soil.	Solutions (S)	break down the emulsifier. These formulations are premixed, ready to use. They are often used in household pest products.	
Post-emergence:	Use after the crop or weeds have germinated.			
Terms which des	scribe how to use pesticides:	Flowables		
Band:	Application to a strip over or along each crop row.	(F or L)	A flowable, or liquid, can be mixed with water to form a suspension in a spray tank.	
Broadcast:	Uniform application to an entire, specific area by scattering.	Aerosols (A)	These are very low-concentrate solutions, usually applied as a	
Dip:	Immersion of a plant in a pesti- cide.		fine spray or mist. They are generally sold in aerosol cans	
Directed:	Aiming the pesticide at a portion of a plant, animal or structure.		and are a very expensive source of pesticide.	
Drench:	Saturating the soil with a pesti- cide.	Dusts (D)	Made by adding the active ingredients to a fine, inert powder or talc; generally used	

Granules (G)

Granular formulations are made by adding the active ingredient to coarse particles (granules) of inert material like fired clay particles.

Wettable powders (WP or W)

Wettable powder formulations are made by combining the active ingredient with a fine powder. They look like dusts, but they are made to mix with water. These formulations need continuous agitation to maintain a suspension and are thus difficult for home gardeners to use. When mixing a WP, first mix the measured quantity with a small amount of water, forming a slurry, (a paper cup with a popsicle stick makes a good disposable mixing container) then add it and the additional water to the spray tank. The spray tank must be frequently shaken to maintain the suspension.

Soluble powders (SP)	Made of an active ingredient in powder form; dissolves in water.
Baits (B)	A bait formulation is made by adding the active ingredient to an edible or attractive substance. Baits are often used to control slugs, snails, ground-dwelling insects, and rodents.

Gardeners often attempt to compare a spray with a dust. It should be noted that dusts are a type of formulation, but sprays are not a formulation; they are one means of applying several different formulations such as wettable powders or emulsifiable concentrates that are mixed with water.

# Surfactants, Additives, or Adjuvants

When added to a pesticide, a surfactant reduces the surface tension between two unlike materials, such as a spray film and a solid surface. For example, by adding a surfactant to a sprayer, oil and water will mix and can be sprayed on plant surfaces. With increasing emphasis on safe application of pesticides, such factors as droplet size, spray pattern, and pesticide drift have focused more attention on surfactants to give ideal coverage for pesticides. However, surfactants can sometimes increase the phytotoxicity of a pesticide. Sometimes, surfactants are already added to the formulation.

Surfactants include: activators; compatibility agents; deflocculators; detergents; dispersants; emulsifiers; foam and drift suppressants; and spreading, sticking, and wetting agents. These materials are added to a spray mix to help keep the pesticide in suspension; improve cohesiveness and dispersion of the spray; and increase the wetting (or coverage) of the leaves, fruits, and stems.

This section focuses on surfactants that act as spreading, sticking, and wetting agents. They are most useful when spraying the hard-to-wet foliage of such plants as azalea, boxwood, camellia, carnation, conifer, euonymus, gardenia, gladiolus, holly, iris, narcissus, peony, rose, and yew. Whether a spray rolls off or sticks to a plant surface depends on the physical and chemical properties of the spray mixture and the physical properties of the surface itself. If the surface tension of the mixture is high, or if the plant surface is waxy, the spray droplets will roll off.

A **spreader** or film extender (spreader-activator) is a substance that, when added to a pesticide mix, increases the area that a given volume of spray will cover and improves the contact between the pesticide and the plant surface. A spreading agent builds spray deposits and improves weatherability. Most wettable powder insecticides benefit from the addition of a spreader.

A **sticker** or adhesive is a material that, when added to a spray mix or dust, improves the adherence (tenacity) to a plant surface rather than increasing the initial deposit. Commercial sticking agents are oily in consistency and increase the amount of suspended solids retained on plant surfaces by coating the particles with a resin or varnish-like film. Most fungicides, especially wettable powders, benefit greatly from the use of stickers. Stickers may be judged in terms of resistance to wind and water, length of adherence, and mechanical or chemical action.

A **wetting agent** is a material that, when added to a pesticide, lowers the interfacial tension between a liquid and a solid; in this case, a plant surface. Effectiveness is measured by the increase in spread of a liquid over a solid surface and the ability of the spray film to make complete contact with it. When a wetting agent reduces surface tension, spreading naturally occurs.

The pesticide label should state whether a surfactant is needed or should be added to a spray mix for certain applications and should indicate restrictions in the selection of compatible surfactants. In many cases, surfactants have been designed specifically for use with fungicides, insecticides, or herbicides.

All commercial spreading, sticking, and wetting agents should be mixed strictly according to label directions. Adding more surfactant than recommended may cause excessive runoff, resulting in a poor spray deposit and reduced pest control. In general, if the spray mix contains one or more pesticides produced or formulated by the same company, use a surfactant sold or recommended by that company. Surfactants are sold separately from pesticides and are not subject to EPA registration.

Although choosing an effective surfactant to accompany a specific pesticide is no simple task, the label will state whether a surfactant is needed and the brand that should be used.

# **The Pesticide Label**

All the printed information including the label on the product, brochures, and flyers from the company or its agent about a pesticide product is called labeling. The label printed on or attached to a container of pesticide will tell how to use the product correctly and what special safety measures need to be taken. Specific parts of the label include the following:

**Brand name:** Each company uses brand names to identify its products. The brand name shows up plainly on the front panel of the label.

**Type of formulation:** The same pesticide may be available in more than one formulation.

**Ingredient statement:** Each pesticide label must list the names and amounts of the active ingredients and the amount of inert ingredients in the product.

**Common name and chemical name:** Pesticides have complex chemical names derived from their chemical composition. Some have also been given a shorter name, or common name, to make them easier to identify. Pesticides may be sold under several brand names, but you may find the same common name or chemical name on all of them. **Net contents:** The net contents tells how much is in the container. This can be expressed in gallons, pints, pounds, quarts, or other units of measure.

**Name and address of manufacturer:** The law requires the maker or distributor of a product to print the name and address of the company on the label.

**Registration number:** A registration number must be on every pesticide label. It shows that the product has been approved by the E.P.A. for the uses listed on the label.

**Establishment number:** The establishment number tells which factory made the chemical.

**Precautionary statements:** A section with a title similar to "Hazards to Humans and Domestic Animals" will tell the ways in which the product may be poisonous to man and animals. It will also describe any special steps necessary to avoid poisoning, such as the kind of protective equipment needed. If the product is highly toxic, this section will inform physicians of the proper treatment for poisoning.

**Environmental hazards:** The label tells how to avoid damage to the environment. Some examples are: "This product is highly toxic to bees exposed to direct treatment or residues on crops." "Do not contaminate water when cleaning equipment or when disposing of wastes," and "Do not apply where runoff is likely to occur."

**Physical and Chemical Hazards:** lists specific fire, explosion, or chemical hazards that the product may have.

**Signal words and symbols:** Some pesticides may be hazardous to people. You can tell how toxic a product is by reading the Signal Word and Symbol on the label.

Signal Words	Toxicity	Approx. Human Lethal Dosage	Symbol
Danger Poison	Highly toxic	A taste to a teaspoonful	Skull and Crossbones
Warning	Moderately toxic	A teaspoonful to a tablespoonful	none
Caution	Low toxicity; relatively nontoxic	An ounce to more than a pint	none

Highly toxic pesticides are generally not sold in the lawn and garden trade. All products must bear the statement "Keep Out of Reach of Children." In some pesticide literature, the term LD50 is used to give an indication of toxicity. LD50 stands for lethal dosage necessary to kill 50% of a test population of animals. The LD50 values are measured from 0 up. The numbers after the 50 represent the milligrams (mgs.) of the substance per kilogram (kg.) of body weight necessary to kill 50% of the test population. The lower the LD50 value the more poisonous a pesticide is, for example an LD50 of 5 is more poisonous than an LD50 of 20 because only 5 mgs. per kg. of body weight are necessary to kill 50% of the test population.

**Statement of practical treatment:** If swallowing or inhaling the product or getting it in the eyes or on the skin would be harmful, the label contains emergency first aid measures and states types of exposure requiring medical attention. The pesticide label is the most important information you can take to the physician when someone has been poisoned. Without the label, it is difficult for the physician to help.

**Directions for use:** These instructions will explain several important items -

- The pests the product will control
- The crops, animals, or other item the product can be used on safely
- How the product should be applied
- How much to use
- Where and when the material should be applied
- Application to harvest periods

When used on fruits or vegetables, there may be a period of time that must pass from the time of application until it is safe to pick and use the crop. Known as the application to harvest period and expressed as "days to harvest," this is the time required for the residue to drop to safe levels. It is often listed as a number in parentheses following the crop name. It is a mistake to assume that a residue can be washed off.

**Misuse statement:** This section will remind you that it is a violation of Federal law to use a product in a manner inconsistent with its labeling.

**Storage and disposal directions**: Every pesticide should be stored and disposed of correctly. This section will tell you how to store and dispose of the product.

**Application Equipment** 

Using the same sprayer equipment for weed control and then for insect control is neither safe nor desirable. No matter how well a tank is rinsed after use of a herbicide, a residue will be left in the tank and in the gaskets, hoses and parts. If the same tank is then used with an insecticide to spray a plant, it is possible to kill the plant with the herbicide left in the tank. The wisest policy is to maintain two sprayers, one for herbicides and another for insecticides and fungicides. Have them clearly labeled according to use. Always wash after each use.

Pesticide application equipment comes in all shapes, sizes, types, and prices. Select equipment according to common sense.

Proportioner or Hose-End Sprayer: These inexpensive small sprayers are designed to be attached to a garden hose. A small amount of pesticide is mixed with water, usually no more than a pint, and placed in the receptacle attached to the hose. A tube connects this concentrate to the opening of the hose. When the water is turned on, the suction created by the water passing over the top of the tube pulls the pesticide concentrate up and into the stream of hose water. The stream can reach into medium-high trees if water pressure is high. Problems are encountered from poor spray distribution and clogging of nozzles. The metering out of the concentrate into the stream of hose water is very inaccurate, since it is determined by the water pressure. Proportioners put out an excessively high volume of spray for most needs, using excessive pesticide. These sprayers are popular due to low cost, but the low purchase price is quickly negated by the cost of excessive pesticides used. All hose-end proportioners should be equipped with an anti-siphon device to prevent back-siphoning of toxic chemicals into the water system.

**Trombone Sprayer:** The trombone sprayer is a medium-sized, hand-held piece of equipment. A spray mixture in the correct dilution is prepared in a container such as a bucket. The intake tube of the sprayer is inserted into the mixture in the bucket. Pump pressure is created by operating the sprayer in a trombone-like motion. The pesticide is pulled up the hose and out the end of the sprayer. A uniform concentration of the spray can be maintained, since the pesticide is mixed with a known quantity of water. When using a wettable powder, agitate the spray mixture frequently to keep it in suspension. Trombone sprayers are excellent for spraying trees and shrubs, are easy to wash and keep clean, but require some effort to operate. **Compressed Air Sprayer** (backpack or tank sprayer): Spray is mixed in a small tank (generally 1 to 5 gallons) and the tank is carried over the shoulders. A hand-operated pump supplies pressure during application. A uniform concentration spray can be maintained since the pesticide is mixed with a known quantity of water. Frequent agitation of the spray mixture is necessary when using a wettable powder formulation. Applicator has excellent control over coverage, making this sprayer a good choice for treating dwarf fruit trees, vegetables, and ornamentals. Spray will not reach into tall trees. As water weighs approximately 8.23 lbs per gallon, small tanks are easier to use than large tanks.

**Small Power Sprayers:** These have the advantage of being motor-driven, so the operator does not have to stop to pump up the tank. They are lightweight, since the spray in the tank is concentrated and diluted with air as it is sprayed. Power sprayers provide uniform pressure, but are generally too expensive for home garden use.

**Hand Duster:** The duster may consist of a squeeze tube or shaker, a plunger that slides through a tube, or a fan powered by a hand crank. Uniform coverage of foliage is difficult to achieve with many dusters. Dusts are more subject to drift than liquid formulations due to their light weight and poor sticking qualities.



# **Calibrating Sprayers and Spray Patterns**

The usual approach consumers use when applying a pesticide over a given area is to mix a tablespoon or two of a certain pesticide and apply it to a problem area. This is acceptable if the label gives recommended rates in teaspoons or tablespoons per gallon. But some pesticides, specifically herbicides and insecticides for lawns, do not give rates in tablespoons or teaspoons per gallon. Instead, they give rates of application in teaspoons or tablespoons per 100 or 500 square feet. Unfortunately, the consumer all too often solves this problem by guessing how much to use. This can be dangerous; too concentrated may be too toxic; too little will not control the problem. It is irresponsible of the consumer to apply chemicals at improper rates. It is dangerous to him/herself, neighbors, and the environment.

A better approach is to calibrate the sprayer. The calibration of a home sprayer is relatively easy. Once it has been done, it has been done for the life of the sprayer, provided the nozzle remains unchanged, clean, and adequate pressure is used. It must be kept in mind that the rate at which the liquid is applied varies with the pressure and size of the opening in the nozzle. High pressure and a large opening in the nozzle permit more liquid to be applied over a given area than low pressure and/or smaller nozzle. For calibrating a sprayer, the procedure is as follows:

- 1) Fully pressurize the sprayer and determine delivery time. This is done by spraying water through the sprayer into a pint jar. Mark this delivery time on the sprayer for future use.
- 2) Calculate the area to be treated. Measure the area that is to be sprayed. Multiply length times width to determine the area of a rectangle. The area of a triangle is calculated by multiplying the base times the height and dividing by 2. Most areas can be calculated by combining rectangles and triangles or subtracting triangles from rectangles.
- 3) If the area is large, divide it into sections equal to the size of the delivery area.
- 4) Spray an area with water, at normal working speed, for 30 seconds. Measure the area sprayed. This tells how much area can be sprayed in 30 seconds and therefore the amount that is applied over that area (see item 1). For example, assuming that it has been established: 30 seconds of spraying delivers ½ cup and 30 seconds of spraying will cover 100 square feet; then 1000

square feet require 5 cups spray (.5 x 10) delivered or, 1 quart + 1 cup or, 40 ounces (If the label calls for 3 tablespoons of pesticide for 1000 square feet). Then, 3 tablespoons of pesticide must be mixed with 40 ounces of water to achieve proper spray coverage. Many commercial-type chemicals are given in pounds to the acre or quarts to 100 gallons of water. To convert rates to equivalents used by a consumer, consult the pesticide conversion chart at the end of this chapter.

Either compressed-air sprayers or hose-end sprayers can be used. Hose-end sprayers do not meter out the pesticide as evenly as compressed-air sprayers. However, compressed-air sprayers do not maintain pressure as evenly as hose-end sprayers unless frequently pumped. Some hose-end sprayers will not continue to spray pesticide if the thumb hole is not covered. Other hose-end sprayers use a trigger device to control the spraying.

The spray pattern best used to cover an area of ground is one which will give uniform coverage with little spray overlap. Overlap can be a problem, causing certain areas to end up with an extra dose of pesticide. The spray pattern used to apply the pesticide should be continuous and uninterrupted. If an herbicide is being applied, the sprayer should not be slowed down or stopped at each weed. If the herbicide has been mixed correctly and the sprayer is properly calibrated, the continuous uninterrupted flow of chemical will be sufficient for good control.

The spray pattern should be directed so that the applicator does not walk through it while spraying. The spray pattern should form an arc no more than 3 to 4 feet on either side of the operator. The sprayed area should have a small amount of overlap to ensure coverage. There can be a time when overlap may be beneficial. If good spray coverage is questionable such as when using hose end sprayers, cut the application rate in half and apply the pesticide first in an east-west pattern, then in a northsouth direction. This gives better coverage with devices typically poor in their metering capabilities.

When the mixture on the label is in teaspoons or tablespoons per gallon and the plants are upright such as shade trees, fruit trees, shrubs, and vegetables, spray the leaves until pesticide solution drips from the leaves. Don't forget to spray the underside of leaves for good coverage. Spray Pattern with a Single Application (A) and a Double Application (B)



# **Proper Application**

When applying pesticides, wear the protective clothing and equipment the label recommends. To prevent spillage of chemicals, always check application equipment for leaking hoses or connections and plugged, worn, or dripping nozzles before adding pesticide. Before spraying, clear all people, pets, and livestock from the area. To minimize drift, apply pesticides only on days with no breezes. If moderate winds come up while you are working, stop immediately. Reduce drift by spraying at a low pressure and using a large nozzle opening. Generally, the safest time of day to spray to reduce the hazard of drift is early morning.

Vaporization is the evaporation of an active ingredient during or after application. Pesticide vapors can cause injury. High temperatures increase vaporization. Choose pesticide formulations that do not evaporate easily, and spray during the cool part of the day to reduce vaporization. Some products, like 2,4-D, are very volatile and can move for miles under favorable conditions. They should not be used near highly sensitive plants like grapes and tomatoes. Do not apply when it is windy nor when temperatures following application will reach above 85 degrees F.

# **Cleaning Equipment**

Thoroughly clean all equipment immediately after use. Pesticides should not be stored mixed. If you have excess pesticide mixed which cannot be used, spray it over an area that it will not harm. Check the pesticide label to determine safe areas. Thoroughly clean all spray equipment inside and out with clean water. Don't forget to flush the hoses and nozzles. Be careful that the cleaning water does not damage crops. Do not dump the rinse water in one place where it will be concentrated and may become a pollutant. Spray the rinse water over a broad area so that the pesticide will be further diluted. **NEVER RINSEPESTICIDES DOWNTHEDRAIN!**  To clean 2,4-D type herbicides from hand spray equipment such as a 3-gallon garden sprayer, use household ammonia. Thoroughly rinse the equipment with fresh water after spraying. Fill the spray equipment with an ammonia solution, using ½ cup of ammonia to 3 gallons of water. Let the equipment soak for 18 to 24 hours. Always spray part of this mixture through the pump, hose, and nozzles at the beginning and end of the soaking period. NOTE: 2,4-D cannot be completely removed from a sprayer once used in it. **DONOT USE THIS SPRAYER TO APPLY OTHER PESTICIDES TO DESIRABLE PLANTS.** 

# **Storage and Disposal**

Gardeners should store all pesticides in their original containers, in a locked cabinet. NO EXCEP-**TIONS IF YOU ARE CONCERNED ABOUT CHILDREN'S LIVES!** They should be protected from temperature extremes, some can be damaged upon freezing, others can be altered by heat. Do not store pesticides in the home! Empty containers must be triple rinsed before being placed in refuse cans destined for a sanitary landfill. Wrap containers in newspaper and secure before disposal. Some states have special chemical dumps for pesticides; however, N.H. does not have such dump sites. The bottle should be rinsed out first, pouring the rinse water into the spray tank. Rinse three times, allowing 30 seconds to drain between each rinse. Never use empty pesticide containers for other uses, never allow children to play with empty containers. If possible, break the containers before disposal. Do not burn paper containers.

# **Using Pesticides Safely**

# **Protective Clothing**

If special protective clothing is required, the label will tell you the kind of protection to use. Pesticides sold in the home garden trade generally do not require special protective clothing. Many professionally used and highly toxic chemicals do. Anytime you handle pesticides, you should wear a longsleeved shirt and long-legged trousers (or a coverall-type garment) and shoes. Additional protection is available by wearing unlined neoprene or rubber gloves, a wide-brimmed plastic hard hat that covers the back of the neck, and goggles or face shield to protect the eyes. Rubber gloves and goggles are particularly important when mixing or pouring pesticides. Toxic commercial pesticides may also require neoprene boots, chemical cartridge respirators, face masks, neoprene suit, or even gas masks. These more toxic chemicals should not be used in a home garden setting. After using any pesticide, wash your hands and arms thoroughly with soap and water. Never eat. drink. or smoke before washing your hands. If you have been doing a lot of spraying or dusting, remove your clothes, take a shower, and put on clean clothes. Clothing should be laundered separately from the family wash. The washer should be run empty with detergent after cleaning pesticide-contaminated clothing. If you get sprayed, change and shower immediately. Use first aid procedures if necessary.

# **Safety Precautions**

Most pesticides can cause severe illness, or even death, if misused. But every registered pesticide can be used safely. Many accidental pesticide deaths are caused by eating or drinking the product, particularly by young children. Some applicators die or are injured when they breathe a pesticide vapor or get a pesticide on their skin. Pesticides can poison you in two ways. Acute poisoning, or toxicity measured by an LD50 number, can kill or injure you after one exposure. Chronic toxins. on the other hand, will not produce an effect until there have been a sufficient number of exposures. However, the number of exposures necessary to produce an effect varies with the kind of pesticide and the health and size of the person exposed. LD50 is not a measure for chronic toxicity. If an applicator uses organophosphate (diazinon, malathion) or carbamate (carbaryl, furadan) insecticides with any regularity, it would be wise to ask a physician about a test to check the cholinesterase level of the blood. These pesticides destroy this enzyme, which is necessary to carry nerve impulses to the brain. Although chronic toxicity is not poisonous immediately, over the long run it can be serious. Always use safety precautions and treat all pesticides with respect. To prevent accidents with pesticides, use and store pesticides away from children, keep pesticides in their original containers, and take care to always follow label directions.

# Symptoms of Pesticide Poisoning

Awareness of the early symptoms and signs of pesticide poisoning is important. Unfortunately, all pesticide poisoning symptoms are not the same. Each chemical family (organophosphates, carbamates, chlorinated hydrocarbons, etc.) attacks the human body in a different way. Fumigants and solvents can make a person appear to be drunk. The symptoms are poor coordination, slurring of words, confusion, and sleepiness. Common pesticides like organophosphates and carbamates injure the nervous system. The symptoms develop in stages, usually occurring in this order:

Mild Poisoning or Early Symptoms of Acute Poisoning: Fatigue, headache, dizziness, blurred vision, excessive sweating and salivation, nausea and vomiting, stomach cramps or diarrhea.

Moderate Poisoning or Early Symptoms of Acute Poisoning: Unable to walk, weakness, chest discomfort, muscle twitches, constriction of pupil of the eye, earlier symptoms become more severe.

Severe or Acute Poisoning: Unconsciousness, severe constriction of pupil of the eye, muscle twitches, convulsions, secretions from mouth and nose, breathing difficulty, death if not treated. Illness may occur a few hours after exposure. If symptoms start more than 12 hours after exposure to a pesticide, you probably have some other illness. Check with your physician to be sure.

# **First Aid Procedures**

Read the "Statement of Practical Treatment" on each label. The directions listed can save lives. If a pesticide gets on the skin, remove the substance as quickly as possible. Remove all contaminated clothing. Prompt washing may prevent sickness even when the spill is very large. Detergents work better than soap in removing pesticides. Don't forget the hair and fingernails. If a pesticide is inhaled, get to fresh air right away. Loosen all tightfitting clothing. If needed, give artificial respiration immediately -- do not stop until victim is breathing well or medical help arrives. Get the victim to a physician. Do not administer anything to a poison victim unless you are trained in first aid, otherwise you may compound the injury. In case of poisoning, call a physician and give the following information: describe the victim by name, age, and sex, and identify yourself and your relationship to the victim. Have the package or poison in your hand and identify what the victim took and how much was taken. Keep calm -- you have enough time to act -- but don't delay unnecessarily. Poisoning information is available by contacting your local poison control center.

# Pesticides and the Environment

# **Direct Kill**

Fine mists of herbicides can drift to nearby crops or landscape plants and kill them. Bees and other pollinators can be killed if a crop is treated with a pesticide when they are in the field. The natural enemies of pest insects can also be killed by pesticides. Life in streams or ponds can be wiped out by accidental spraying of ditches and waterways, runoff from sprayed fields, and careless container disposal. If more than one pesticide will control the pest, choose the one that is the least hazardous to the environment and most useful for the situation. To protect beneficial insects, avoid excessive use of insecticides -- spray only when crop and pest populations require.

# **Protecting Insect Pollinators**

Gardeners should give special consideration to protecting insect pollinators, such as the honey bee, from insecticide poisoning. Insecticides highly toxic to bees have restricted application times when being applied to crops frequented by honey bees. Bees are not active in late evening and early morning. Do not apply insecticides when temperatures are unusually low because residues will remain toxic much longer.

# Persistence and Accumulation

Although most pesticides break down quickly, remaining in the environment only a short time before being changed into harmless products, some pesticides break down slowly and stay in the environment for a long time. These are called persistent pesticides. Some persistent pesticides can build up in the bodies of animals, including man. These pesticides are called accumulative. Most persistent pesticides have very limited usage or have been removed from the market. For example, chlordane is a persistent pesticide and its use was limited to termite and fire ant control but it is now off the market.

# **Pesticides Move in the Environment**

Pesticides become problems when they move off target. This may mean drifting off the target if in the form of dust or mist, moving with soil particles by erosion, leaching through the soil, being carried out as residues on crops or livestock, or evaporating and moving with air currents.

# **Safe Use Precautions**

Following safety precautions and using common sense can prevent harm from pesticides. Here are the minimum safety steps you should take.

- Before buying a pesticide, identify the pest to be controlled. Then find out which pesticide will control it. If there is a choice of several, choose the least hazardous product.
- Before purchase, read the label of the pesticide you intend to buy to ensure that the host plant (and pest) are listed on the pesticide label and that the pesticide is not phytotoxic to the plant being protected. Also check safety conditions for use, such as special equipment, protective clothing, restrictions on use, and environmental precautions needed.
- Before applying the pesticide, read the label again be sure of proper application and safety measures, including protective clothing and equipment needed, the specific warning and precautions, with what it can be mixed, mixing instructions, application to harvest period for fruit and vegetables, crops to which it can or cannot be applied, and other special instructions.

# Compatibility

Compatibility occurs when two or more pesticides can be mixed together without reducing their effectiveness or harming the target. For instance, carbaryl (Sevin) is often combined with a miticide such as Kelthane in order to kill both insects and mites at one time. Synergism is the action of two materials of the same type which used together produce a greater effect than the sum of the materials when used alone. One of the materials when used alone may not affect the pest, but greatly increases the total effect of the two when used together. Example: Chemical A kills 60%, Chemical B kills 20%, Chemical A and B together kill 98% of the pests. Synergism may increase control or require less chemical. It may also be more harmful to a nontarget organism. A synergistic effect can also be undesirable, causing death or damage to the organism that is being protected. It should be stressed that no chemicals should be mixed together unless the label specifically says they are compatible.

Resistance concerns over insects developing immunity can often be reduced by switching to a different type (chemical group) of pesticides.

# Home Garden Versus Commercial Pesticides

Some pesticides are packaged specifically for home garden use. These products are packaged in small quantities, i.e., pints, quarts, ounces, or pounds. They are seldom highly toxic pesticides and are usually in low concentrations. The label rate is given in spoonfuls per gallon or pounds per 1000 square feet.

Because of the small label size, home garden products may not list all of the plants and/or pests for which the product may be registered for use. For example, one manufacturer sells Diazinon 25% EC as Fruit and Vegetable Insect Control and Diazinon Insect Spray. Both are basically the same product, but plants and pests listed vary greatly. This situation causes some confusion in pesticide application and stimulates the purchase of excessive amounts of pesticides.

Products packaged for the commercial grower may appear to be less expensive, but consumers should not be tempted to use them. They are generally more toxic than those for home use and require special protective clothing and equipment for application. These products are more concentrated and in larger containers than the consumer could expect to use or safely store, and are much more difficult to calibrate and mix correctly, since rates are usually based on a per-acre system.

A few products extremely toxic to humans or the environment are classified by the E.P.A. as **RESTRICTED USE PESTICIDES**. The label will state "restricted use pesticides for retail sale to and application only by certified applicators, or person under their direct supervision." A license from the State Department of Agriculture is required by law for purchase and use of restricted use pesticides. Restricted pesticides cannot be sold to home gardeners.

# Pesticides and Organic Gardening

Although it is questionable whether we could raise all crops without the use of pesticides, it is certainly true that we can reduce the amount of pesticides we use by careful and efficient use. There are some steps to consider before automatically turning to a pesticide. First, determine if control measures are really needed. Is the problem severe enough to warrant treatment? If the cost of treatment is less than the predicted loss, the economic threshold has been reached, and treatment is necessary. Consider alternative control measures. Some examples are cultivating instead of using an herbicide, and removing and destroying diseased plant parts rather than using a pesticide.

The next step is integrated control. This is probably the best answer to pest control. In this situation, the wise use of pesticides is combined with alternative methods, such as conservation practices, to encourage natural enemies of the pest. For example, a simple integrated control program could be used on a garden. Some pests can be picked off by hand. A biological, *Bacillus thuringiensis*, can be used for caterpillars. Chemicals can be used to spot treat the worse areas showing some damage.

# Pesticides and the Law

The registration and use of pesticides are governed by the E.P.A. and the NH Department of Agriculture. Under the amended Federal Insecticide, Fungicide, and Rodenticide Act (Federal Environmental Control Act of 1972) it is illegal to use a pesticide on a crop unless the crop is listed on the label. You may not exceed the given rate of application on the label. Fines and other penalties change and vary according to laws broken.

Under the law you are liable for misuse of pesticides on your property. Recent court rulings extend your liability to include misuse by commercial applicators you hire. Serious misuse by gardeners usually results from drift, leaching of a pesticide onto non-target plants, or the direct treatment of the plant by a wrong pesticide. If you sell your crop, you must have a pesticide license. For more details call the N. H. Pesticide Control Division at 271-3550.

# **Pesticide Conversion Chart**

The measurements given below are approximate and should be used as a general guideline if the directions for mixing small quantities are not given on the pesticide label.

### Liquid Measure:

Amount per 100 gallons		Amount per gallon
1⁄4	pint	
1	pint	1 teaspoon
1	quart	2 teaspoons
1	gallon	
2	gallons	5 tablespoons
4	gallons	1/3 pint
11	gallons	

# Dry Weight:

Amount per 100 gallons		Amount per gallon
1⁄2	pound	1/12 ounce
1	pound	1/6 ounce
2	pounds	1/3 ounce
3	pounds	1/2 ounce
4	pounds	2/3 ounce
6	pounds	4/5 ounce
16	pounds	2 3/5 ounce
20	pounds	

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# CHAPTER 7

## **Plant Propagation**

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Plant propagation is the process of multiplying the numbers of a species, perpetuating a species, or maintaining the youthfulness of a plant. There are two types of propagation, sexual and asexual. Sexual reproduction is the union of the pollen and egg, drawing from the genes of two parents to create a new, third individual. Sexual propagation involves the floral parts of a plant. Asexual propagation involves taking a part of one parent plant and causing it to regenerate itself into a new plant. Genetically it is identical to its one parent. Asexual propagation involves the vegetative parts of a plant: stems, roots, or leaves.

The advantages of sexual propagation are that it may be cheaper and quicker than other methods; it may be the only way to obtain new varieties and hybrid vigor; in certain species, it is the only viable method for propagation; and it is a way to avoid transmission of certain diseases. Asexual propagation has advantages, too. It may be easier and faster in some species; it may be the only way to perpetuate some cultivars; and it bypasses the juvenile characteristics of certain species.

## **Sexual Propagation**

Sexual propagation involves the union of the pollen (male) with the egg (female) to produce a seed. The seed is made up of three parts: the outer seed coat, which protects the seed; the endosperm, which is a food reserve; and the embryo, which is the young plant itself. When a seed is mature and put in a favorable environment, it will germinate, or begin active growth. In the following section, seed germination and transplanting of seeds will be discussed.

#### Seed

To obtain quality plants, start with good quality seed from a reliable dealer. Select varieties to provide the size, color, and habit of growth desired. Choose varieties adapted to your area which will reach maturity before an early frost. Many new vegetable and flower varieties are hybrids, which cost a little more than open pollinated types. However, hybrid plants usually have more vigor, more uniformity, and better production than nonhybrids and sometimes have specific disease resistance or other unique cultural characteristics. Although some seeds will keep for several years if stored properly, it is advisable to purchase only enough seed for the current year's use. Good seed will not contain seed of any other crop, weeds, seeds, or other debris. Printing on the seed packet usually indicates essential information about the variety, the year for which the seeds were packaged, and germination percentage you may typically expect, and notes of any chemical seed treatment. If seeds are obtained well in advance of the actual sowing date or are stored surplus seeds, keep them in a cool, dry place. Laminated foil packets help ensure dry storage. Paper packets are best kept in tightly closed containers and maintained around 40 degrees F. in a low humidity.

Some gardeners save seed from their own gardens; however, such seed is the result of random pollination by insects or other natural agents, and may not produce plants typical of the parents. This is especially true of the many hybrid varieties. (See Vegetables chapter for information on saving vegetable seed.) Most seed companies take great care in handling seeds properly. Generally, do not expect more than 65% to 80% of the seeds to germinate. From those germinating, expect about 60% to 75% to produce satisfactory, vigorous, sturdy seedlings.

#### Germination

There are four environmental factors which affect germination: water, oxygen, light, and heat.

#### Water

The first step in the germination process is the imbibition or absorption of water. Even though seeds have great absorbing power due to the nature of the seed coat, the amount of available water in the germination medium affects the uptake of water. An adequate, continuous supply of water is important to ensure germination. Once the germination process has begun, a dry period will cause the death of the embryo.

#### Light

Light is known to stimulate or to inhibit germination of some seed. The light reaction involved here is a complex process. Some crops which have a requirement for light to assist seed germination are ageratum, begonia, browallia, impatiens, lettuce, and petunia. Conversely, calendula, centaurea, annual phlox, verbena, and vinca will germinate best in the dark. Other plants are not specific at all. Seed catalogs and seed packets often list germination or cultural tips for individual varieties. When sowing lightrequiring seed, do as nature does, and leave them on the soil surface. If they are covered at all, cover them lightly with fine peat moss or fine vermiculite. These two materials, if not applied too heavily, will permit some light to reach the seed and will not limit germination. When starting seed in the home, supplemental light can be provided by fluorescent fixtures suspended 6 to 12 inches above the seeds for 16 hours a day.

#### Oxygen

In all viable seed, respiration takes place. The respiration in dormant seed is low, but some oxygen is required. The respiration rate increases during germination, therefore, the medium in which the seeds are placed should be loose and well-aerated. If the oxygen supply during germination is limited or reduced, germination can be severely retarded or inhibited.

#### Heat

A favorable temperature is another important requirement of germination. It not only affects the germination percentage but also the rate of germination. Some seeds will germinate over a wide range of temperatures, whereas others require a narrow range. Many seeds have minimum, maximum, and optimum temperatures at which they germinate. For example, tomato seed has a minimum germination temperature of 50 degrees F. and a maximum temperature of 95 degrees, but an optimum germination temperature of about 80 degrees. Where germination temperatures are listed, they are usually the optimum temperatures unless otherwise specified. Generally, 65 to 75 degrees F. is best for most plants. This often means the germination flats may have to be placed in special chambers or on radiators, heating cables, or heating mats to maintain optimum temperature. The importance of maintaining proper medium temperature to achieve maximum germination percentages cannot be over-emphasized.

Germination will begin when certain internal requirements have been met. A seed must have a mature embryo, contain a large enough endosperm to sustain the embryo during germination, and contain sufficient hormones or auxins to initiate the process.

### **Methods of Breaking Dormancy**

One of the functions of dormancy is to prevent a seed from germinating before it is surrounded by a favorable environment. In some trees and shrubs, seed dormancy is difficult to break, even when the environment is ideal. Various treatments are performed on the seed to break dormancy and begin germination.

#### **Seed Scarification**

Seed scarification involves breaking, scratching, or softening the seed coat so that water can enter and begin the germination process. There are several methods of scarifying seeds. In acid scarification, seeds are put in a glass container and covered with concentrated sulfuric acid. The seeds are gently stirred and allowed to soak from 10 minutes to several hours, depending on the hardness of the seed coat. When the seed coat has become thin, the seeds can be removed, washed, and planted. Another scarification method is mechanical. Seeds are filed with a metal file, rubbed with sandpaper, or cracked with a hammer to weaken the seed coat. Hot water scarification involves putting the seed into hot water (170 to 212 degrees F). The seeds are allowed to soak in the water, as it cools, for 12 to 24 hours and then planted. A fourth method is one of warm, moist scarification. In this case, seeds are stored in nonsterile, warm, damp containers where the seed coat will be broken down by decay over several months.

#### Seed Stratification

Seeds of some fall-ripening trees and shrubs of the temperate zone will not germinate unless chilled underground as they over winter. This so called "after ripening" may be accomplished artificially by a practice called stratification. The following procedure is usually successful. Put sand or vermiculite in a clay pot to about 1 inch from the top. Place the seeds on top of the medium and cover with 1/2 inch of sand or vermiculite. Wet the medium thoroughly and allow excess water to drain through the hole in the pot. Place the pot containing the moist medium and seeds in a plastic bag and seal. Place the bag in a refrigerator. Periodically check to see that the medium is moist, but not wet. Additional water will probably not be necessary. After 10 to 12 weeks, remove the bag from the refrigerator. Take the pot out and set it in a warm place in the house. Water often enough to keep the medium moist. Soon the seedlings should emerge. When the young plants are about 3 inches tall, transplant them into pots to grow until time for setting outside.

Another procedure that is usually successful uses sphagnum moss or peat moss. Wet the moss thoroughly, then squeeze out the excess water with your hands. Mix seed with the sphagnum or peat and place in a plastic bag. Seal the bag and put it in a refrigerator. Check periodically. If there is condensation on the inside of the bag, the process will probably be successful. After 10 to 12 weeks remove the bag from the refrigerator. Plant the seeds in pots to germinate and grow. Handle seeds carefully. Often the small roots and shoots are emerging at the end of the stratification period. Care must be taken not to break these off. Temperatures in the range of 35 to 45 degrees F (2 to 7°C) are effective. Most refrigerators operate in this range. Seeds of most fruit and nut trees can be successfully germinated by these procedures. Seeds of peaches should be removed from the hard pit. Care must be taken when cracking the pits. Any injury to the seed itself can be an entry path for disease organisms.

### **Starting Seeds**

#### Media

A wide range of materials can be used to start seeds, from plain vermiculite or mixtures of soilless media to the various amended soil mixes. With experience, you will learn to determine what works best under your conditions. However, keep in mind what the good qualities of a germinating medium are. It should be rather fine and uniform, yet well-aerated and loose. It should be free of insects, disease organisms, and weed seeds. It should also be of low fertility or total soluble salts and capable of holding and moving moisture by capillary action. One mixture which supplies these factors is a combination of 1/3 sterilized soil, 1/3 sand or vermiculite or perlite, and 1/3 peat moss.

The importance of using a sterile medium and container cannot be over-emphasized. The home gardener can treat a small quantity of soil mixture in an oven. Place the slightly moist soil in a heat-resistant container in an oven set at about 250 degrees F. Use a candy or meat thermometer to ensure that the mix reaches a temperature of 180 degrees F. for at least 1/2 hour. Avoid overheating as this can be extremely damaging to the soil. Be aware that the heat will release very unpleasant odors in the process of sterilization. This treatment should prevent damping-off and other plant diseases, as well as eliminate potential plant pests. Growing containers and implements should be washed to remove any debris, then rinsed in a solution of 1 part chlorine bleach to 9 parts water.

An artificial, soilless mix also provides the desired qualities of a good germination medium. The basic ingredients of such a mix are sphagnum peat moss and vermiculite, both of which are generally free of diseases, weed seeds, and insects. The ingredients are also readily available, easy to handle, lightweight, and produce uniform plant growth. "Peat-lite" mixes or similar products are commercially available or can be made at home using this recipe: 4 quarts of shredded sphagnum peat moss, 4 quarts of fine vermiculite, 1 tablespoon of superphosphate, and 2 tablespoons of ground limestone. Mix thoroughly. These mixes have little fertility, so seedlings must be watered with a diluted fertilizer solution soon after they emerge. Do not use garden soil by itself to start seedlings; it is not sterile, is too heavy, and will not drain well.

#### Containers

Flats and trays can be purchased or you can make your own from scrap lumber. A convenient size to handle would be about 12 to 18 inches long and 12 inches wide with a depth of about 2 inches. Leave cracks of about 1/8-inch between the boards in the bottom or drill a series of holes to ensure good drainage.

You can also make your own containers for starting seeds by recycling such things as cottage cheese containers, the bottoms of milk cartons or bleach containers, and pie pans, as long as good drainage is provided. At least one company has developed a form for recycling newspaper into pots, and another has developed a method for the consumer to make and use compressed blocks of soil mix instead of pots.

Clay or plastic pots can be used and numerous types of pots and strips made of compressed peat are also on the market. Plant bands and plastic cell packs are also available. Each cell or mini-pot holds a single plant which reduces the risk of root injury when transplanting. Peat pellets, peat or fiber-based blocks, and expanded foam cubes can also be used for seeding.

#### Seeding

The proper time for sowing seeds for transplants depends upon when plants may safely be moved out-of-doors in your area. This period may range from 4 to 12 weeks prior to transplanting, depending upon the speed of germination, the rate of growth, and the cultural conditions provided. A common mistake is to sow the seeds too early and then attempt to hold the seedlings back under poor light or improper temperature ranges. This usually results in tall, weak, spindly plants which do not perform well in the garden.

After selecting a container, fill it to within 3/4 inch of the top with moistened growing medium. For very small seeds, at least the top ¼-inch should be a fine, screened mix or a layer of vermiculite. Firm the medium at the corners and edges with your fingers or a block of wood to provide a uniform, flat surface.

For medium and large seeds, make furrows 1 to 2 inches apart and 1/8 to ¼-inch deep across the surface of the container using a narrow board or pot label. By sowing in rows, good light and air movement results, and if damping-off fungus does appear, there is less chance of it spreading.

Seedlings in rows are easier to label and handle at transplanting time than those which have been sown in a broadcast manner. Sow the seeds thinly and uniformly in the rows by gently tapping the packet of seed as it is moved along the row. Lightly cover the seed with dry vermiculite or sifted medium if they require darkness for germination. A suitable planting depth is usually about twice the diameter of the seed.

Do not plant seeds too deeply. Extremely fine seed such as petunia, begonia, and snapdragon are not covered, but lightly pressed into the medium or watered in with a fine mist. If these seeds are broadcast, strive for a uniform stand by sowing half the seeds in one direction, then sowing the other way with the remaining seed in a crossing pattern.

Large seeds are frequently sown into some sort of a small container or cell pack which eliminates the need for early transplanting. Usually 2 or 3 seeds are sown per unit and later thinned to allow the strongest seedling to grow.

#### Seed Tape

Most garden stores and seed catalogs offer indoor and outdoor seed tapes. Seed tape has precisely spaced seeds enclosed in an organic, water-soluble material. When planted, the tape dissolves and the seeds germinate normally. Seed tapes are especially convenient for tiny, hard-tohandle seeds. However, tapes are much more expensive per seed. Seed tapes allow uniform emergence, eliminate overcrowding, and permit sowing in perfectly straight rows. The tapes can be cut at any point for multiple-row plantings, and thinning is rarely necessary.

#### Pregermination

Another method of starting seeds is pregermination. This method involves sprouting the seeds before they are planted in pots or in the garden. This reduces the time to germination, as the temperature and moisture are easy to control. A high percentage of germination is achieved since environmental factors are optimum. Lay seeds between the folds of a cotton cloth or on a layer of vermiculite in a shallow pan. Keep moist, in a warm place. When roots begin to show, place the seeds in containers or plant them directly in the garden. While transplanting seedlings, be careful not to break off tender roots. Continued attention to watering is critical. When planting seeds in a container that will be set out in the garden later, place 1 seed in a 2- to 3-inch container. Plant the seeds at only ½ the recommended depth. Gently press a little soil over the sprouted seed and then add about ¼ inch of milled sphagnum or sand to the soil surface. These materials will keep the surface uniformly moist and are easy for the shoot to push through. Keep in a warm place and care for them as for any other newly transplanted seedlings.

A convenient way to plant small, delicate, pregerminated seeds is to suspend them in a gel. You can make a gel by blending cornstarch with boiling water to a consistency that is thick enough so the seeds will stay suspended. Be sure to cool thoroughly before use. Place the gel with seedlings in a plastic bag with a hole in it. Squeeze the gel through the hole along a premarked garden row. Spacing of seeds is determined by the number of seeds in the gel. If the spacing is too dense, add more gel; if too wide, add more seeds. The gel will keep the germinating seeds moist until they establish themselves in the garden soil.

#### Watering

After the seed has been sown, moisten the planting mix thoroughly. Use a fine mist or place the containers in a pan or tray which contains about 1 inch of warm water. Avoid splashing or excessive flooding which might displace small seeds. When the planting mix is saturated, set the container aside to drain. The soil should be moist but not wet.

Ideally, seed flats should remain sufficiently moist during the germination period without having to add water. One way to maintain moisture is to slip the whole flat or pot into a clear plastic bag after the initial watering. The plastic should be at least 1 inch from the soil. Keep the container out of direct sunlight, otherwise the temperature may rise to the point where the seeds will be harmed. Many home gardeners cover their flats with panes of glass instead of using a plastic sleeve. Be sure to remove the plastic bag or glass cover as soon as the first seedlings appear. Surface watering can then be practiced if care and good judgement are used. Lack of uniformity, overwatering, or drying out are problems related to manual watering. Excellent germination and moisture uniformity can be obtained with a low-pressure misting system. Four seconds of mist every 6 minutes or 10 seconds every 15 minutes during the daytime in spring seems to be satisfactory. Bottom heat is an asset with a mist system. Subirrigation or watering from below may work well, keeping the flats moist. However, as the flats or pots must sit in water constantly, the soil may absorb too much water, and the seeds may rot due to lack of oxygen.

#### **Temperature and Light**

Several factors for good germination have already been mentioned. The last item, and by no means the least important, is temperature. Since most seeds will germinate best at an optimum temperature that is usually higher than most home night temperatures, special warm areas must often be provided. The use of thermostatically controlled heating cables is an excellent method of providing constant heat.

After germination and seedling establishment, move the flats to a light, airy, cooler location, at a 55 to 60 degree F. night temperature and a 65 to 70 degree F. day reading. This will prevent soft, leggy growth and minimize disease troubles. Some crops, of course, may germinate or grow best at a different constant temperature and must be handled separately from the bulk of the plants.

Seedlings must receive bright light after germination. Place them in a window facing south, if possible. If a large, bright window is not available, place the seedlings under a fluorescent light. Use two 40-watt, cool-white fluorescent tubes or special plant growth lamps. Position the plants 6 inches from the tubes and keep the lights on about 16 hours each day. As the seedlings grow, the lights should be raised.

## **Seed Requirements**

PLANT	APPROXIMATE TIME TO SEED BEFORE LAST SPRING FROST	APPROXIMATE GERMINATION TIME (days)	GERMINATION TEMPERATURE (degrees F.)	GERMINATION IN LIGHT (L) OR DARK (D)
Begonia	12 weeks or	10 - 15	70	I
Browallia	TZ WEEKS OF	15 20	70	L
Coronium	more	10 20	70	
Geranium		10-20 E 10	70 FF	
		5-10	55	D
Pansy (Viola)		5 - 10	65	D
Vinca		10 - 15	70	D
Dianthus	10 weeks	5 - 10	70	-
Impatiens		15 - 20	70	L
Petunia		5 - 10	70	L
Portulaca		5 - 10	70	D
Snapdragon		5 - 10	65	L
Stock		10 - 15	70	-
Verbena		15 - 20	65	D
Ageratum	8 weeks	5 - 10	70	L
Alyssum		5 - 10	70	-
Broccoli		5 - 10	70	-
Cabbage		5 - 10	70	-
Cauliflower		5 - 10	70	-
Celosia		5 - 10	70	-
Coleus		5 - 10	65	L
Dahlia		5 - 10	70	-
Egoplant		5 - 10	70	-
Head lettuce		5 - 10	70	L
Nicotiana		10 - 15	70	L
Pepper		5 - 10	80	-
Phlox		5 - 10	65	D
		0.0		-
Aster	6 weeks	5 - 10	70	-
Balsam		5 - 10	70	-
Centurea		5 - 10	65	D
Marigold		5 - 10	70	-
Tomato		5 - 10	80	-
Zinnia		5 - 10	70	-
Cucumber	1 wooko	5 10	95	
Coomoo		5 10	00 70	-
CUSIIIUS Muskmalar	01 1655	5-10 E 10	10	-
NUSKITEION		5-10	00	-
Squasn		5-10	85	-
vvatermelon		5 - 10	85	-

## **Transplanting and Handling**

If the plants have not been seeded in individual containers, they must be transplanted to give them proper growing space. One of the most common mistakes made is leaving the seedlings in the seed flat too long. The ideal time to transplant young seedlings is when they are small and there is little danger from setback. This is usually about the time the first true leaves appear above or between the cotyledon leaves (the cotyledons or seed leaves are the first leaves the seedling produces). Don't let plants get hard and stunted or tall and leggy.

Seedling growing mixes and containers can be purchased or prepared similar to those mentioned for germinating seed. The medium should contain more plant nutrients than a germination mix, however. Some commercial soilless mixes have fertilizer already added. When fertilizing, use a soluble house plant fertilizer, at the dilution recommended by the manufacturer, about every 2 weeks after the seedlings are established. Remember that young seedlings are easily damaged by too much fertilizer, especially if they are under any moisture stress.

To transplant, carefully dig up the small plants with a knife or wooden plant label. Let the group of seedlings fall apart and pick out individual plants. Gently ease them apart in small groups which will make it easier to separate individual plants. Avoid tearing roots in the process. Handle small seedlings by their leaves, not their delicate stems. Punch a hole in the medium into which the seedling will be planted. Make it deep enough so the seedling can be put at the same depth it was growing in the seed flat. Small plants or slow growers should be placed 1 inch apart and rapid-growing, large seedlings about 2 inches apart. After planting, firm the soil and water gently. Keep newly transplanted seedlings in the shade for a few days, or place them under fluorescent lights. Keep them away from direct heat sources. Continue watering and fertilizing as in the seed flats.

Most plants transplant well and can be started indoors, but a few plants are difficult to transplant. These are generally directly seeded outdoors or sown directly into individual containers indoors. Examples include zinnias and cucurbits, such as melons and squash.

#### **Containers for Transplanting**

There is a wide variety of containers from which to choose for transplanting seedlings. These containers should be economical, durable, and make good use of space. The type selected will depend on the type of plant to be transplanted and individual growing conditions. Standard pots may be used, but they waste a great deal of space and may not dry out rapidly enough for the seedling to have sufficient oxygen for proper development.

There are many types of containers available commercially. Those made out of pressed peat can be purchased in varying sizes. Individual pots or strips of connected pots fit closely together, are inexpensive, and can be planted directly in the garden. When setting out plants grown in peat pots, be sure to cover the pot completely. If the top edge of the peat pot extends above the soil level, it may act as a wick, and draw water away from the soil in the pot. To avoid this, tear off the top lip of the pot and then plant flush with the soil level.

Community packs are containers in which there is room to plant several plants. These are generally inexpensive. The main disadvantage of a community pack is that the roots of the individual plants must be broken or cut apart when separating them to put out in the garden.

Compressed peat pellets, when soaked in water, expand to form compact, individual pots. They waste no space, don't fall apart as badly as peat pots, and can be set directly out in the garden. If you wish to avoid transplanting seedlings altogether, compressed peat pellets are excellent for direct sowing.

Community packs and cell packs, which are strips of connected individual pots, are also available in plastic and are frequently used by commercial bedding plant growers, as they withstand frequent handling. In addition, many homeowners find a variety of materials from around the house useful for containers. These homemade containers should be deep enough to provide adequate soil and have plenty of drainage holes in the bottom.

#### Hardening Plants

Hardening is the process of altering the quality of plant growth to withstand the change in environmental conditions which occurs when plants are transferred from a greenhouse or home to the garden. A severe check in growth may occur if plants produced in the home are planted outdoors without a transition period. Hardening is most critical with early crops, when adverse climatic conditions can be expected.

Hardening can be accomplished by gradually lowering temperatures and relative humidity and reducing water. This procedure results in an accumulation of carbohydrates and a thickening of cell walls. A change from a soft, succulent type of growth to a firmer, harder type is desired.

This process should be started at least 2 weeks before planting in the garden. If possible, plants should be moved to a 45 to 50 degree F. temperature indoors or outdoors in a shady location. A cold frame is excellent for this purpose. When put outdoors, plants should be shaded, then gradually moved into sunlight. Each day, gradually increase the length of exposure. Don't put tender seedlings outdoors on windy days or when temperatures are below 45 degrees F. Reduce the frequency of watering to slow growth, but don't allow plants to wilt. Even coldhardy plants will be hurt if exposed to freezing temperatures before they are hardened. After proper hardening, however, they can be planted outdoors and light frosts will not damage them.

The hardening process is intended to slow plant growth. If carried to the extreme of actually stopping plant growth, significant damage can be done to certain crops. For example, cauliflower will make thumb size heads and fail to develop further if hardened too severely. Cucumbers and melons will stop growth if hardened.

#### **Propagation of Ferns by Spores**

Though ferns are more easily propagated by other methods, some gardeners like the challenge of raising ferns from spores. One tested method for small quantities follows:

Put a solid, sterilized brick (bake at 250 degrees F. for 30 minutes) in a pan and add water to cover the brick. When the brick is wet throughout, squeeze a thin layer of moist soil and peat (1:1) onto the top of the brick. Pack a second layer (about an inch) on top of that. Sprinkle spores on top. Cover with plastic (not touching the spores) and put in a warm place in indirect light. It may take up to a month or more for the spores to germinate. Keep moist at all times. A prothallus (one generation of the fern) will develop first from each spore, forming a light green mat. Mist lightly once a week to maintain high surface moisture; the sperm must be able to swim to the archegonia (female parts). After about three weeks. fertilization should have occurred. Pull the mat apart with tweezers in 1/4-inch squares and space them  $\frac{1}{2}$ -inch apart in a flat containing a 2-inch layer of sand. <sup>1</sup>/<sub>4</sub>-inch of charcoal. and about 2 inches of soil/peat mix. Cover with plastic and keep moist. When fern fronds appear and become crowded, transplant to small pots. Gradually reduce the humidity until they can survive in the open. Light exposure may be increased at this time.

## **Asexual Propagation**

Asexual propagation, as mentioned earlier, is the best way to maintain some species, particularly an individual that best represents that species. Clones are groups of plants that are identical to their one parent and that can only be propagated asexually. The Bartlett pear (1770) and the Delicious apple (1870) are two examples of clones that have been asexually propagated for many years.

The major methods of asexual propagation are cuttings, layering, division, budding and grafting. Cuttings involve rooting a severed piece of the parent plant; layering involves rooting a part of the parent and then severing it; and budding and grafting is joining two plant parts from different varieties.

### Cuttings

Many types of plants, both woody and herbaceous, are frequently propagated by cuttings. A cutting is a vegetative plant part which is severed from the parent plant in order to regenerate itself, thereby forming a whole new plant.

Take cuttings with a sharp blade to reduce injury to the parent plant. Dip the cutting tool in rubbing alcohol or a mixture of one part bleach : nine parts water to prevent transmitting diseases from infected plant parts to healthy ones. Remove flowers and flower buds from cuttings to allow the cutting to use its energy and stored carbohydrates for root and shoot formation rather than fruit and seed production. To hasten rooting, increase the number of roots, or to obtain uniform rooting (except on soft, fleshy stems), use a rooting hormone, preferably one containing a fungicide. Prevent possible contamination of the entire supply of rooting hormone by putting some in a separate container for dipping cuttings.

Insert cuttings into a rooting medium such as coarse sand, vermiculite, soil, water, or a mixture of peat and perlite. It is important to choose the correct rooting medium to get optimum rooting in the shortest time. In general, the rooting medium should be sterile, low in fertility, drain well enough to provide oxygen, and retain enough moisture to prevent water stress. Moisten the medium before inserting cuttings, and keep it evenly moist while cuttings are rooting and forming new shoots. Place stem and leaf cuttings in bright, indirect light. Root cuttings can be kept in the dark until new shoots appear.

#### **Stem Cuttings**

Numerous plant species are propagated by stem cuttings. Some can be taken at any time of the year, but stem cuttings of many woody plants must be taken in the fall or in the dormant season.

**Tip cuttings:** Detach a 2 to 6-inch piece of stem, including the terminal bud. Make the cut just below a node. Remove lower leaves that would touch or be below the medium. Dip the stem in rooting hormone if desired. Gently tap the end of the cutting to remove excess hormone. Insert the cutting deeply enough into the media to support itself. At least one node must be below the surface.

Tip cuttings



Medial cuttings

**Medial cuttings:** Make the first cut just above a node, and the second cut just above a node 2 to 6 inches down the stem. Prepare and insert the cutting as you would a tip cutting. Be sure to position right side up. Axial buds are always above leaves.

#### Cane cuttings:



Cut cane-like stems into sections containing one or two eyes, or nodes. Dust ends with fungicide or activated charcoal. Allow to dry several hours. Lay horizontally with about half of the cutting below the media surface, eye facing upward. Cane cuttings are usually potted when roots and new shoots appear but new shoots from dracaena and croton are often cut off and re-rooted in sand.





The eye refers to the node. This is used for plants with alternate leaves when space or stock material are limited. Cut the stem about  $\frac{1}{2}$ -inch above and  $\frac{1}{2}$ -inch below a node. Place cutting horizontally or vertically in the medium.

**Double Eye:** 



This is used for plants with opposite leaves when space or stock material is limited. Cut the stem about 12-inches above and 12inches below the same node. Insert the cutting vertically in the medium with the node just touching the surface.

**Heel cutting:** 



This method uses stock material with woody stems efficiently. Make a shield-shaped cut about halfway through the wood around a leaf and axial bud. Insert the shield horizontally into the medium.

#### Leaf Cuttings

Leaf cuttings are used almost exclusively for a few indoor plants. Leaves of most plants will either produce a few roots but no plant, or just decay.

#### Whole leaf with petiole:



Detach the leaf and up to  $1\frac{1}{2}$ inches of petiole. Insert the lower end of the petiole into the medium. One or more new plants will form at the base of the petiole. The leaf may be severed from the new plants when they have their own roots, and the petiole reused.

## Whole leaf



without petiole: This is used for plants with sessile leaves. Insert the cutting vertically into the medium. A new plant will form from the axillary bud. The leaf may be removed when the new plant has its own roots.

**Split vein:** 



Detach a leaf from the stock plant. Slit its veins on the lower leaf surface. Lay the cutting, lower side down, on the medium. New plants will form at each cut. If the leaf tends to curl up, hold it in place by covering the margins with the rooting medium.

Leafsections:



This method is frequently used with snake plant and fibrous rooted begonias. Cut begonia leaves into wedges with at least one vein. Lay leaves flat on the medium. A new plant will arise at the vein. Cut snake plant leaves into 2-inch sections. Consistently make the lower cut slanted and the upper cut straight so you can tell which is the top. Insert the cutting vertically. Roots will form fairly soon, and eventually a new plant will appear at the base of the cutting. These and other succulent cuttings will rot if kept too moist.

#### **Root Cuttings**

Root cuttings are usually taken from 2 to 3 year old plants during their dormant season when they have a large carbohydrate supply. Root cuttings of some species produce new shoots, which then form their own root systems, while root cuttings of other plants develop root systems before producing new shoots.

#### **Plants with**

#### large roots:



Make a straight top cut. Make a slanted cut 2 to 6 inches below the first cut. Store about 3 weeks in moist sawdust, peat moss, or sand at 40 degrees F. Remove from storage. Insert the cutting vertically with the top approximately level with the surface of the rooting medium. This method is often used outdoors.

## Plants with small roots:



Take 1 to 2 inch sections of roots. Insert the cuttings horizontally about 12 inch below the medium surface. This method is usually used indoors or in a hotbed.

#### Layering

Stems still attached to their parent plants may form roots where they touch a rooting medium. Severed from the parent plant, the rooted stem becomes a new plant. This method of vegetative propagation, called layering, promotes a high success rate because it prevents the water stress and carbohydrate shortage that plague cuttings.

Some plants layer themselves naturally, but sometimes plant propagators assist the process. Layering is enhanced by wounding one side of the stem or by bending it very sharply. The rooting medium should always provide aeration and a constant supply of moisture.

#### **Tip layering:**

Dig a hole 3 to 4 inches deep. Insert the shoot tip and cover it with soil. The tip grows downward first, then bends



ward first, then bends sharply and grows upward. Roots form at the bend, and the recurved tip becomes a new plant. Remove the tip layer and plant it in the early spring or late fall. Examples:

purple and black raspberries, trailing blackberries.

#### Simple layering:



Bend the stem to the ground. Cover part of it with soil, leaving the last 6 to 12 inches exposed. Bend the tip into a vertical position and stake in place. The sharp bend will often induce rooting, but wounding the lower side of the branch or loosening the bark by twisting the stem may help. Examples: rhododen-

#### Compound

layering:

This method works for plants with flexible stems. Bend the stem to the



rooting medium as for simple layering, but alternately cover

and expose stem sections. Wound the lower side of the stem sections to be covered. Examples: heart-leaf philodendron, pothos.

#### Mound (stool) layering:



Cut the plant back to 1 inch above the ground in the dormant season. Mound soil over the emerging shoots in the spring to enhance their rooting. Examples: gooseberries, apple rootstocks.



Airlayering: Air layering is used to propagate some indoor plants with thick stems, or to rejuvenate
them when they become leggy. Slit the stem just below a node. Pry the slit open with a toothpick. Surround the wound with wet unmilled sphagnum moss. Wrap plastic or foil around the sphagnum moss and tie in place. When roots pervade the moss, cut the plant off below the root ball. Examples: dumbcane, rubber tree.

The following propagation methods can all be

dron, honeysuckle.

considered types of layering, as the new plants form before they are detached from their parent plants.

## Stolons and

runners:

A stolon is a horizontal, often fleshy stem that can root, then produce new shoots where it touches the medium. A runner is a slender stem that originates in a



leaf axil and grows along the ground or downward from a hanging basket,
producing a new plant at its tip. Plants that produce stolons or

runners are propagated by severing the new plants from their parent stems. Plantlets at the tips of runners may be rooted while still attached to the parent, or detached and placed in a rooting medium. Examples: strawberry, spider plant.

**Offsets:** 



Plants with a rosetted stem often reproduce by forming new shoots at their base or in leaf axils. Sever the new shoots from the parent plant after they have developed their own root system. Unrooted offsets of some species may be removed and placed in a rooting medium. Some of these must be cut off, while others may be simply lifted off of the parent stem. Examples: date palm, haworthia, bromeliads, many cacti.

- **Separation:** Separation is a term applied to a form of propagation by which plants that produce bulbs or corms multiply.
- **Bulbs:** New bulbs form beside the originally planted bulb. Separate these bulb clumps every 3 to 5 years for largest blooms and to increase bulb population. Dig up the clump after the leaves have withered. Gently pull the bulbs apart and replant them immediately so their roots can begin to develop. Small, new bulbs may not flower for 2 or 3 years, but large ones should bloom the first year. Examples: tulip, narcissus.

Corms:



A large new corm forms on top of the old corm, and tiny cormels form around the large corm. After

form around the large corm. After the leaves wither, dig up the corms and allow them to dry in indirect light for 2 or 3 weeks. Remove the cormels, then gently separate the new corm from the old corm. Dust all new corms with a fungicide and store in a cool place until planting time. Examples: crocus, gladiolus.

## Division

Plants with more than one rooted crown may be divided and the crowns planted separately. If the stems are not joined, gently pull the plants apart. If the crowns are united by horizontal stems, cut the stems and roots with a sharp knife to minimize injury. Divisions of some outdoor plants should be dusted with a fungicide before they are replanted. Examples: snake plant, iris, prayer plant, day lilies.



## Grafting

Grafting and budding are methods of asexual plant propagation that join plant parts so they will grow as one plant. These techniques are used to propagate cultivars that will not root well as cuttings or whose own root systems are inadequate. One or more new cultivars can be added to existing fruit and nut trees by grafting or budding.

The portion of the cultivar that is to be propagated is called the scion. It consists of a piece of shoot with dormant buds that will produce the stem and branches. The rootstock, or stock, provides the new plant's root system and sometimes the lower part of the stem. The cambium is a layer of cells located between the wood and bark of a stem from which new bark and wood cells originate. (See Fruit chapter for discussion of apple rootstock).

Four conditions must be met for grafting to be successful: the scion and rootstock must be compatible; each must be at the proper physiological stage; the cambial layers of the scion and stock must meet; and the graft union must be kept moist until the wound has healed.

#### Cleft grafting:





Cleft grafting is often used to change the cultivar or top growth of a shoot or a young tree (usually a seedling). It is especially successful if done in the early spring. Collect scion wood 3/8 to 5/8 inch in diameter. Cut the limb or small tree trunk to be reworked, perpendicular to its length. Make a 2-inch vertical cut through the center of the previous cut. Be careful not to tear the bark. Keep this cut wedged apart. Cut the lower end of each scion piece into a wedge. Prepare two scion pieces 3 to 4 inches long. Insert the scions at the outer edges of the cut in the stock. Tilt the top of the scion slightly outward and the bottom slightly inward to be sure the cambial layers of the scion and stock touch. Remove the wedge propping the slit open and cover all cut surfaces with grafting wax.

#### **Bark grafting:**

Unlike most grafting methods, bark grafting can be used on large limbs, although these are often infected before the wound can completely heal. Collect scion wood 3/8 to 1/2 inch in diameter when the plant is dormant, and store the wood wrapped in moist paper in a plastic bag in the refrigerator. Saw off the limb or trunk of the rootstock at a right angle to itself. In the spring, when the bark is easy to separate from the wood, make a 12-inch diagonal cut on one side of the scion, and a  $1\frac{1}{2}$ inch diagonal cut on the other side. Leave two buds above the longer cut. Cut through the bark of the stock, a little wider than the scion. Remove the top third of the bark from this cut. Insert the scion with the longer cut against the wood. Nail the graft in place with flatheaded wire nails. Cover all wounds with grafting wax.

#### Whip or tongue grafting:



This method is often used for material 1/4 to  $\frac{1}{2}$  inch in diameter. The scion and rootstock are usually of the same diameter, but the scion may be narrower than the stock. This strong graft heals quickly and provides excellent cambial contact. Make one 2<sup>1</sup>/<sub>2</sub>-inch long sloping cut at the top of the rootstock and a matching cut on the bottom of the scion. On the cut surface. slice downward into the stock and up into the scion so the pieces will interlock. Fit the pieces together, then tie and wax the union.

**Care of the Graft:** Very little success in grafting will be obtained unless proper care is maintained for the following year or two. If a binding material such as strong cord or nursery tape is used on the graft, this must be cut shortly after growth starts to prevent girdling. Rubber budding strips have some advantages over other materials. They expand with growth and usually do not need to be cut, as they deteriorate and break after a short time. It is also an excellent idea to inspect the grafts after 2 or 3 weeks to see if the wax has cracked, and if necessary, rewax the exposed areas. After this, the union will probably be strong enough and no more waxing will be necessary.

Limbs of the old variety which are not selected for grafting should be cut back at the time of grafting. The total leaf surface of the old variety should be gradually reduced as the new one increases until at the end of 1 or 2 years, the new variety has completely taken over. Completely removing all the limbs of the old variety at the time of grafting increases the shock to the tree and causes excessive suckering. Also, the scions may grow too fast, making them susceptible to wind damage.

## **Budding**

Budding, or bud grafting, is the union of one bud and a small piece of bark from the scion with a rootstock. It is especially useful when scion material is limited. It is also faster and forms a stronger union than grafting.



**Patch budding:** Plants with thick bark should be patch budded. This is done while the plants are actively growing, so their bark slips easily. Remove a rectangular piece of bark from the rootstock. Cover this wound with a bud and matching piece of bark from the scion. If the rootstock's bark is thicker than that of the scion, pare it down to meet the thinner bark so that when the union is wrapped the patch will be held firmly in place.



when the bark is not slipping. Slice downward into the rootstock at a



45 degree angle through 1/4 of the wood. Make a second cut upward from the first cut. about one inch. Remove a bud and attending chip of bark and wood from the scion shaped so that it fits the rootstock wound. Fit the bud chip to the stock and wrap the union.

**T-budding:** 

This is the most commonly used budding technique. When the bark is slipping, make a vertical cut (same axis as the root stock)



through the bark of the rootstock. avoiding any buds on the stock. Make a horizontal cut at the top of the vertical cut (in a T shape) and loosen the bark by twisting the knife at the intersection. Remove a shield-shaped piece of the scion, including a bud, bark. and a thin section of wood. Push the shield under the loosened stock bark. Wrap the union, leaving the bud exposed.

#### Care of Buds

Place the bud in the stock in August. Force the bud to develop the following spring by cutting the stock off 3 to 4 inches above the bud. The new shoot may be tied to the resulting stub to prevent damage from the wind. After the shoot has made a strong union with the stock, cut the stub off close to the budded area.

### Plant Tissue Culture for the Home

Although technical procedures for aseptic culture of plant cells, tissues, and organs are as diverse as the plant material on which they are practiced, a simplified general procedure can be followed in the home. All that is needed are a few basic supplies which can easily be obtained. The procedures outlined in this section can be used in the home to propagate various species of plants, both easy (African violets, coleus, chrysanthemums) and difficult (orchids, ferns, weeping figs) to propagate.

#### **Medium Preparation**

For 2 pints of tissue culture medium, mix the following ingredients in a 1-quart home canning jar:

#### 1/8 cup sugar

1 teaspoon all-purpose, soluble fertilizer mixture. Check the label to make sure it has all of the major and minor elements, especially ammonium nitrate. If the latter is lacking, add 1/3 tsp. of a 35-0-0 soluble fertilizer.

1 tablet (100 mg) of inositol (myo-inositol) which can be obtained at most health food stores

1/4 of a pulverized vitamin tablet which has 1 to 2 mg of thiamine

4 Tablespoons coconut milk (cytokinin source) drained from a fresh coconut. The remainder can be frozen and used later.

3 to 4 grains (1/400 teaspoon!) of a commercial rooting compound which has 0.1 active ingredient IBA

- Fill the jar with distilled or deionized water. If purified water is not available, water that has been boiled for several minutes can be substituted.
- Shake the mixture and make sure all materials have dissolved.

• Baby food jars with lids, or other heatresistant glass receptacles with lids can be used as individual culture jars. They should be half filled with cotton or paper to support the plant material. The medium should be poured into each culture bottle to the point where the support material is just above the solution.

When all bottles contain the medium and have the lids loosely screwed on, they are ready to be sterilized. This can be done by placing them in a pressure cooker and sterilizing them under pressure for 30 minutes or placing them in an oven at 320 degrees F. for 4 hours. After removing them from the sterilizer, place them in a clean area and allow the medium to cool. If the bottles will not be used for several days, wrap groups of culture bottles in foil before sterilizing and then sterilize the whole package. Then the bottles can be removed and cooled without removing the foil cover. Sterilized water, tweezers, and razor blades, which will be needed later, can be prepared in the same manner.

#### **Plant Disinfestation and Culture**

Once the growing medium is sterilized and cooled, plant material can be prepared for culture. Because plants usually harbor bacterial and fungal spores, they must be cleaned (disinfested) before placement on the sterile medium. Otherwise, bacteria and fungi may grow faster than the plants and dominate the culture.

Various plant parts can be cultured, but small, actively growing portions usually result in the most vigorous plantlets. For example, ferns are most readily propagated by using only ½ inch of the tip of a rhizome. For other species, ½ to 1 inch of the shoot tip is sufficient. Remove leaves attached to the tip and discard. Place the plant part into a solution of 1 part commercial bleach to 9 parts water for 8 to 10 minutes. Submerge all plant tissue in the bleach solution. After this time period, rinse off excess bleach by dropping the plant part into sterile water. Remember, once the plant material has been in the bleach, it has been disinfested and should only be touched with sterile tweezers.

After the plant material has been rinsed, remove any bleach-damaged tissue with a sterile razor blade. Then remove the cap of a culture bottle containing sterile medium, place the plant part onto the support material in the bottle making sure that it is not completely submerged in the medium, and recap quickly.

Transferring should be done as quickly as possible in a clean environment. Therefore, scrub hands and counter tops with soap and water just before beginning to disinfest plant material. Rubbing alcohol or a dilute bleach solution can be used to wipe down the working surface.

After all plants have been cultured, place them in a warm, well-lit (no direct sunlight) environment to encourage growth. If contamination of the medium has occurred, it should be obvious within 3 to 4 days. Remove and wash contaminated culture bottles as quickly as possible to prevent the spread to uncontaminated cultures.

When plantlets have grown to sufficient size, transplant them into soil. Handle as gently as possible because the plants are leaving a warm, humid environment for a cool, dry one. After transplanting, water the plants thoroughly and place them in a clear plastic bag for several days. Gradually remove the bag to acclimate the plants to their new environment; start with one hour per day and gradually increase time out of the bag over a two-week period until the plants are strong enough to dispense with the bag altogether.



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# CHAPTER 8

## Pruning

Edited and revised by William Lord and David Seavey, University of New Hampshire Cooperative Extension.

To prune or not to prune? This is a question that faces gardeners and landscape enthusiasts often. Most feel they should, but are not sure when, why or how. Pruning is accepted practice for the orchard, fairly frequently carried out in the rose garden, but rather haphazard elsewhere. Most often it is only performed when a shrub or tree begins to encroach on its neighbor, a path, or a building.

Pruning is often looked upon as the answer to make a barren tree fruitful. Carried out correctly, it will -- eventually. However, years of neglect cannot be rectified in one season. The unknowing pruner who cuts because he or she thinks that it should be done but does not know how often ends up with no flowers or fruit at all, due to excessive pruning or carrying out the operation at the wrong time of the year.

This chapter explains the reasons for pruning, the proper techniques and tools to use, and when various types of plants should be pruned.

## **Reasons for Pruning**

The reasons for pruning can be grouped under the four following categories:

- training the plant
- maintaining plant health
- improving the quality of flowers, fruit, foliage, or stems
- restricting growth.

#### **Training the Plant**

The first pruning of young trees and shrubs consists of removing broken, crossing, and pestinfested branches.

With **trees**, the rule of pruning away 1/3 of the top growth at transplanting to compensate for root loss is not necessary for properly grown nursery plants. Excessive pruning at transplanting, according to research, reduces growth hormones necessary for root development and delays plant establishment.

As a rule, the central leader of a tree should not be pruned unless a leader is not wanted, as is the case with some naturally low-branched trees or where multiple-stemmed plants are desired.

Trees with a central leader such as linden, sweet gum, or pin oak may need little or no pruning except to eliminate multiple leaders or branches competing with the central leader; these should be shortened. Some pruning may be necessary to maintain desired shape and shorten extravigorous shoots.

The height of the lowest branch can be from a few inches above the ground (for screening or windbreaks) to 12 feet or more above the ground (as needed near a street or patio). Lower limbs are usually removed over a period of years, beginning in the nursery and continuing for several years after transplanting, until the desired height of trimming is reached.

For greatest strength, branches selected for permanent scaffolds must have wide angle of attachment with the trunk. Branch angles of less than 30 degrees from the main trunk result in a very high percentage of breakage while those between 60 and 70 degrees have a very small breakage rate. Vertical branch spacing and radial branch distribution are important. If this has not been done in the nursery it can at least be started the following spring after transplanting.

Major scaffold branches of shade trees should be spaced at least 8 inches and preferably 20 inches vertically. Closely spaced scaffolds may restrict growth of the central leader. Scaffolds will be long, weak, and with few lateral branches.



Scaffold branches of trees should have proper vertical and radial spacing on the trunk.

Radial branch distribution should allow 5 to 7 scaffolds to fill the circle of space around a trunk. Radial spacing prevents one limb from overshadowing another, which, in turn, reduces competition for light and nutrients. Remove or prune shoots that are too low, too close, or too vigorous in relation to the leader and scaffold branches.

When deciduous shrubs are planted bare-root, some pruning may be necessary. Light pruning of roots may be needed if any are broken, damaged, or dead.

Shrubs transplanted with a ball of soil or from a container require little, if any, pruning. Occasionally, branches may have been damaged in transit, and these should be removed at the time of planting.

Most evergreen trees and shrubs are sold in a container or B&B (balled and burlapped) and, as with deciduous shrubs, require little pruning of branches.

#### **Maintaining Plant Health**

In pruning to maintain plant health, first consider sanitation, which includes the elimination of dead, dying, or diseased wood. Any dying branch or stub can be the entry point or build-up chamber for insects or pathogens that could spread to other parts of the tree. When removing diseased wood such as a fungal canker or fire blight, it is important that the cut be made in healthy wood, beyond the point of infection, with a sterile blade.

The development of a sound framework through proper thinning will help prevent disease and loss of vigor while maintaining good form.

Evergreen shrubs will benefit from thinning cuts. It will allow penetration of light and air throughout the shrub, increase the total leaf surface, and create an environment less attractive to mites and insects.

## Improving the Quality of Flowers, Fruit, Foliage, or Stems

The more flowers and fruit a plant produces, the smaller they become, as can be seen on an unpruned rose bush or fruit tree. Pruning reduces the amount of wood and so diverts energy into the production of larger, though possibly fewer, flowers and/or fruit. Most flowering shrubs will bloom either on 1-year old growth or on new growth. Properly timed pruning will increase the production of wood that will bear flowers.

Some deciduous shrubs have colored barks which are especially delightful in winter. The best color is produced on young stems; the greatest stem length and most intense color results from hard pruning.

#### **Restricting Growth**

Over time, trees and shrubs will often grow to sizes that exceed the space allowed for them. Where space is limited, regular pruning becomes necessary to keep plants in bounds. Regular pruning is necessary on formal hedges to maintain a uniform growth rate. To reduce labor, select plants according to size at maturity and avoid planting too close.

## **Pruning Tools**

Pruning shears are good for branches up to  $\frac{1}{2}$ -inch in diameter.. There are two styles of hand shears: scissor action and anvil cut. In the anvil style, a sharpened blade cuts against a broad, flat plate. In the scissor style, a thin, sharp blade slides closely past a thicker (but also sharp) blade. The scissor style usually costs more, but makes cleaner, closer cuts. The anvil type is faster and recommended for thinning evergreens.



**Lopping Shears** 

Lopping shears have long handles and are operated with both hands. They are recommended primarily for removing stems in deciduous shrubs. Even the cheapest can cut ½-inch diameter material. The better ones can slice through branches of 2 inches or more, depending on plant species.

Pole pruners have a cutter with a hook above and a cutting blade beneath. The cutter is on a pole and is operated by pulling downward on a rope. The poles can either be in sections that fit together or telescoping and can be made of several materials. Wooden poles are heavy. Aluminum poles are light but can conduct electricity if they touch an overhead wire. Fiberglass or some type of plastic compound is probably the best choice. Poles can be fitted with saws, but are often cumbersome.

Use of pole pruners can be dangerous, as material cut overhead can fall on the operator (unless it hangs up in other branches); exercise caution and wear head and eye protection.



Combination pole saw pruner

Hedge shears have long, flat blades and relatively short handles, one for each hand. Power hedge shears are also available. All hedge shears have a negative impact on plant health and appearance when in an informal planting.



Hedge shears

There are many makes and models of pruning saws. Fineness of cutting edge is measured in points (teeth per inch). An 8-point saw, such as an apple saw, is most desirable for delicate, close work. Average saws are about 6 points, while  $4\frac{1}{2}$ -point saws are for fairly heavy limbs.

A fixed-blade saw with a leather scabbard is safer and easier to use. Folding saws either require a screwdriver (for a slotted-head holding screw) or will have a protruding wing nut, which can scar the trunk when a limb is cut. If the saw suddenly folds while in use, the operator's fingers can be injured.

Blades can be either straight or curved. Many prefer a curved blade that cuts on the draw stroke. A double-edged saw has fine teeth on one side, coarse on the other; these can be difficult to use in densely branched plants.

Bow saws are good only where no obstruction exists for a foot or more above the area to be cut.



Chain saws come in a variety of sizes, both gas and electric. However, in general, chainsaws are not appropriate for pruning live plant material. They are better suited to tree removal and cutting firewood.

#### Care of Tools

Clean and oil tools regularly. Wipe an oily cloth on blades and other surfaces after each use. Keep cutting edges sharp. Several passes with a good oilstone will usually suffice. Wooden handles should be painted, varnished, or regularly treated with linseed oil. Use tools properly. Don't twist or strain pruners or loppers. Keep the branch to be cut as deeply in the jaws and near the pivot as possible. Don't cut wire with pruning tools.

## **Pruning Techniques**

### **Twigs and Small Branches**

When pruning twigs and small branches, always cut back to a vigorous bud or an intersecting branch. When cutting back to a bud, choose a bud that is pointing in the direction you wish the new growth to take. Be sure not to leave a stub over the bud or cut too close to the bud.

#### Proper pruning angle



When cutting back to an intersecting (lateral) branch, choose a branch that forms an angle of no more than 45 degrees with the branch to be removed. Also, the branch that you cut back to should have a diameter at least half that of the branch to be removed.

Make slanting cuts when removing limbs that grow upward; this prevents water from collecting in the cut and expedites healing.



### Thick, Heavy Branches

Large branches should be removed flush with the collar at the base of the branch, not flush with the trunk.



The collar is an area of tissue that contains a chemically protective zone. In the natural decay of a dead branch, when the decay advancing downward meets the internal protected zone, an area of very strong wood meets an area of very weak wood. The branch then falls away at this point, leaving a small zone of decayed wood within the collar. The decay is stopped in the collar. This is the natural shedding process when all goes according to nature's plan. When the collar is removed, the protective zone is removed, causing a serious trunk wound. Wooddecay fungi can then easily infect the trunk. Even if the pruned branch is living, removal of the collar at the base still causes injury to the tree.

For over half a century, the recommendations for pruning have been to flush-cut and paint. These recommendations have no basis in scientific fact. The flush-cut increases the tree injury, which the paint hides. The paint is primarily cosmetic, a psychological treatment for the person doing the pruning, to show that he or she has done something to "help" the tree. In fact, paints or wound dressings may trap moisture and increase disease problems.

When cutting branches over  $1\frac{1}{2}$  inches in diameter, use a 3-part cut. This is accomplished by first sawing the bottom of the branch, 6 to 12 inches out

from the trunk and about 1/3 of the way through the branch. Next, make a second cut from the top, about 3 inches further out from the undercut, until the branch falls away. The resulting stub can then be cut back to the collar of the branch without danger of tearing the bark from the trunk. If there is danger of the branch damaging other limbs below or objects on the ground, it must be properly roped and supported, then carefully lowered to the ground after the second cut.

#### **Root Pruning**

A tree growing in the woods or landscape for several years may develop long roots, running 15 to 25 feet or more away from the plant. These, along with many-branched side roots, physically support the tree. The area in a 3-foot radius of the trunk of the tree contains very few of the small feeding roots essential to gathering nourishment for the tree.

These roots are usually located quite some distance from the trunk, branching off the long main roots. As a consequence, if the tree were to be dug and moved, a major part of the necessary feeding roots would be cut off in the balling operation; the tree might easily die when transplanted. This is the reason nurserymen root-prune nursery plants, to force them to grow a large number of small feeding roots near the base of the plant which are moved in the balling operation and ensure growth after transplanting.

To make it possible to safely dig small trees or shrubs in the woods, such trees should be rootpruned a year or so before they are moved. In the spring, sever half the roots by forcing a sharp spade into the soil around the plant alternately leaving a shovel width of untouched soil between cuts. The circle of cuts should be slightly smaller than the size of the ball that will eventually be dug. In the fall, sever the other half of the roots, thus cutting all the roots that are at a depth of a foot or less. The tree can then be moved the following spring.

Recent research indicates that most of the new roots grow from the cut end. Therefore, a root ball 4 to 6 inches larger than the root-pruned area must be dug to get the newly developed roots.

Root pruning is also used to force a vigorously growing fruit tree, wisteria vine, or dogwood into bloom. Using a spade to cut the roots early in the spring, as explained above, is all that is sometimes necessary to force a tree, shrub, or vine into bloom the following year.

## **Pruning Shrubs**

#### **Deciduous Shrubs**

The pruning recommended for most deciduous shrubs consists of thinning out, gradual renewal, and rejuvenation pruning.

In **thinning out**, the first cuts are made close to the ground with a saw or loppers to remove the oldest, largest stems. This is followed by removal of vigorous branches where they join weaker side shoots. This allows light into the shrub center and promotes a "fountain" shape. Considerable growth can be cut out without changing the plant's natural appearance or habit of growth. Plants can be maintained at a given height and width for years by thinning out. This method of pruning is best done with pruning shears, loppers, or a saw (not hedge shears). The ultimate goal is to develop a shrub containing 7 to 12 stems, all of different ages. Each year, one or two stems are eliminated and replaced by others.



In **gradual renewal** pruning, a few of the oldest and tallest branches are removed at or slightly above ground level on an annual basis. Some thinning may be necessary to shorten long branches or maintain a symmetrical shape.



To **rejuvenate** an old, overgrown shrub, 1/3 of the oldest, tallest branches can be removed at or slightly above ground level before new growth starts.

When the shrub to be pruned is grown for its flowers, the pruning must be timed to minimize disruption of the blooming. Spring flowering shrubs bloom on last season's growth and should be pruned soon after they bloom. This allows for vigorous growth during the summer, to provide flower buds for the following year.

Some examples of shrubs that bloom on last season's growth:

Cercis chinensis	Chinese Redbud
Chaenomelesjaponica	Japanese Quince
Deutzia species	Spring-flowering deutzias
Forsythia species	Forsythias
Kerriajaponica	Kerria
Lonicera species	Honeysuckle
Magnoliastellata	Star Magnolia
Pieris species	Japanese Pieris
<i>Rhododendrons</i> pecies	Azaleas
<i>Rosa</i> species	Rambling rose species
Spiraeaspecies	Early white spirea species
Syringa species	Lilac species
Viburnum species	Viburnum
Weigela florida	Old-fashioned weigela

Some shrubs that bloom after June usually do so from buds which are formed the same spring. Such shrubs should be pruned in late winter to promote vigorous growth in the spring.

Some examples of shrubs that bloom on current season's growth:

Abeliaxgrandiflora	Butterfly bush
Buddleia davidii or globosa	Japanese beauty bush
Clethra alnifolia	Summersweet
Hibiscus syriacus	Shrub althea
Hydrangeaarborescens	Hills of Snow
Hydrangea paniculata	PeeGee Hydrangea
Hypericum species	Saint Johnswort
<i>Rosa</i> species	Bush Rose
Spirea bumalda	Anthony Waterer
	Spirea
Symphoricarpos	Coralberry

#### **Evergreen Shrubs**

For most evergreen shrubs, thinning is the most desirable procedure. First, establish the desired perimeter on the top and sides of the plant. Shoots that have grown past this point are removed where they join another branch inside the interior of the shrub. Shoots that extend to the perimeter are allowed to remain. Approximately one out of every three or four shoots is removed .



Most of the pruning should be done as soon as the ground thaws in the spring. Pruning during late fall and winter often results in sun scald. Touch-up pruning, on a small scale, can be done throughout the summer months.

## **Pruning Hedges**

Hedges consist of plants set in a row so as to merge into a solid, linear mass. They have served gardeners for centuries as screens, fences, walls, and edgings.

A well-shaped hedge is no accident. It must be trained from the beginning. The establishment of a deciduous hedge begins with the selection of nursery stock. Choose young trees or shrubs 1 to 2 feet high, preferably multiple-stemmed. When planting, cut the plants back to 6 or 8 inches. This will induce low branching. Late in the first season or before bud-break in the next, prune off half of the new growth. In the following year, again trim off half the new growth to encourage branching.

In the third year, start shaping. Hedges are often shaped with flat tops and vertical sides. This unnatural shaping is seldom successful. The best shape, as far as the plant is concerned, is a natural form -- rounded or slightly pointed top with sides slanting to a wide base. After plants have been pruned initially to induce low branching, the low branching will be maintained by trimming the top narrower than the bottom, so that sunlight can reach all of the leaves on the plant.



The same principles used with the thinning process involving shrubs also applies to hedge pruning. Die back will result if new growth is continually sheared off. Shearing stimulates bud break on the shrub surface which eventually severely shades the center of the plant. Thinning the plant will promote small diameter branches that resist winter breakage. It also allows snow to filter down into the plant rather than sitting on the top.

What can be done with a large, overgrown, barebottomed, and mis-shapen hedge? If it is deciduous, the answer is fairly simple. In the spring, before leaves appear, prune to one foot below the desired height. Then thin carefully for the next few years to give it the shape and fullness desired. If hedge plants have declined too much or they are located in the shade, remove them and replant.

Rejuvenating evergreen hedges is more difficult. As a rule, evergreens cannot stand the severe pruning described above. Arborvitae and yew are exceptions; other evergreen hedges may have to be replaced.

Hand pruners are useful for removing small diameter branches. Larger branches can be removed with loppers and/or a pruning saw.

## **Pruning Roses**

All roses need some type of pruning. If roses are not pruned for a number of years, plants deteriorate in appearance, often develop more than the usual disease and insect problems, and the flowers become smaller and smaller.

Hybrid Tea, Grandiflora, and Floribunda roses require annual pruning in the spring, after winter protection has been removed. As a guideline, follow the old saying that roses are pruned when the forsythia blooms. If rosebushes are pruned too early, injury from repeated frost may make a second pruning necessary. The only tools necessary are sharp hand pruners and gloves. If the rose collection is large, a small saw and loppers will also help. Loppers are used to cut out large dead canes.

Remove branches that are dead, damaged, diseased, thin, weak, growing inward, and branches that cross or interfere with other branches. Proper pruning encourages new growth from the base making the plant healthy and attractive and resulting in large blossoms. Cut at least 1 inch below damaged areas. Remove all weak shoots. If two branches rub or are close enough that they will do so soon, remove one. On old, heavy bushes, cut out one or two of the oldest canes each year.

Cut back the remaining canes. The height to which a rose should be cut will vary depending upon the normal habit of the particular cultivar. The average pruning height for Floribundas and Hybrid Teas is between 12 and 18 inches, but taller growing Hybrids and most Grandifloras may be left at 2 feet.

Make cuts at 45-degree angles above a strong outer bud. Aim the cut upward from the inner side of the bush to push growth outward and promote healthy shoots and quality flowers.

Other types of roses have special pruning needs:

A **rose standard**, or tree rose, is a Hybrid Tea, Grandiflora, or Floribunda budded at the top of a tall trunk. Prune tree roses as you do Hybrid Teas, cutting the branches to within 6 to 10 inches of the base of the crown in order to encourage rounded, compact, vigorous new growth.

**Miniature roses** are 6 to 12 inches high, with tiny blooms and foliage. Miniature roses do not need special pruning. Just cut out dead growth and remove the hips.

Old-fashioned **Rambler roses** have clusters of flowers, each usually less than 2 inches across. They often produce canes 10 to 15 feet long in one season. Ramblers produce best on year-old wood, so that this year's choice blooms come on last year's growth. Prune immediately after flowering. Remove some of the large, old canes. Tie new canes to a support for the next year.

Large-flowering **climbing roses** have flowers more than 2 inches across, borne on wood that is 2 or more years old. Canes are larger and sturdier than those of Ramblers. Many flower just once in June, but some, called ever-blooming climbers, flower more or less continuously. This group should be pruned in autumn, any time before cold weather sets in. First cut out dead and diseased canes. After this, remove 1 or 2 of the oldest canes each season to make room for new canes. The laterals, or side shoots, are shortened 3 to 6 inches after flowering. If the plant is strong, keep 5 to 8 main canes, which should be tied to the trellis, fence, wall, or other support. If it is not strong, leave fewer canes.

## **Pruning Shade Trees**

Young shade trees may require pruning to develop a good framework. If the tree is recently planted, wait until the following spring to prune; this will benefit root development. Multiple leaders and crowded branches should be removed before bud break. Avoid mid-summer, late fall, or early winter pruning. A few tree species will bleed when pruned but this is not harmful.

Storm damage can be remedied at any time of the year. Dead branches are removed at the collar; painting wounds is not recommended.

## Pruning Vines and Ground Covers

The pruning of ornamental vines is similar to the pruning of ornamental shrubs. Flowering vines are pruned according to flower production; those that flower on new wood are pruned before new growth begins, those that flower on last season's growth are pruned immediately after flowering.

Vines that are grown for foliage are pruned to control growth and direction. Timing is less critical than for flowering vines.

Ground cover plants require very little pruning. Dead or damaged stems should be removed whenever observed. Some trailing ground covers, such as English ivy, may need pruning to prevent encroachment on lawn areas or other plants.

## Training and Pruning Apple Trees

#### **Nonbearing Apple Trees**

Proper training and pruning are essential for development of structurally strong, productive apple trees that will bear high quality fruits continuously and annually. Since pruning reduces potential fruit production, the ideal management system is one that requires a minimal amount of pruning to achieve the goals of exceptional fruit quality and sturdy tree structure. The use of dwarf trees is highly recommended. Not only will dwarf trees bear fruit at a much younger age than full-sized trees on seedling rootstock, these trees will also require much less pruning effort.

#### The Planting Year

Ordering quality nursery stock will reduce the time and effort needed for tree training. Heavily branched (or feathered) one-year old nursery trees will naturally fruit more heavily earlier in the life of the orchard. These trees will rarely need pruning at planting except to eliminate oversized branches branches with a diameter exceeding  $\frac{1}{2}$  to  $\frac{1}{3}$  the diameter of the trunk or leader. Whenever a branch does need to be pruned, whether on these newly planted trees or later when these trees mature, it is important that the entire branch is cut out. If instead, you prune offending branches by simply cutting off a portion of the end, you will not solve the structural problem the branch is causing. Rather, the branch will regrow in a vigorous and upright manner, creating unwanted shading of other wood, delaying fruiting.

Branches are most productive at an angle some 60 to 75° from the vertical leader or trunk - not quite, but nearly flat. The branches on well feathered nursery trees will naturally develop wide, strong crotches. The few that are too upright growing can easily be tied down or spread to a wider angle.

The use of a tree training stake is the key first step to properly training young apple and pear trees. Dwarf trees frequently require some sort of support in part because they bear fruit so young in life. Staked trees are easy to train - simply tie the leader or trunk to the stake. Lateral limbs that need spreading can be pulled down into position with soft twine or string tied to the stake. And staked trees will bear fruit earlier and be more productive than trees that are not staked. Electrical conduit pipe (3/4 to 1 inch in diameter) and pressure treated wood (2 inches in diameter) are ideal tree stakes. Use stakes 8 to 10 feet long, setting them up to 3 feet into the soil to insure good anchorage.

While well branched trees are the ideal, you often will have to settle for trees that have only a few or perhaps no branches. Again, newly planted trees should be tied to a tree training stake. If the few branches they do have are uniformly distributed around the tree, then no pruning is required. If the tree is one-sided, or becomes one-sided after an oversized branch or two is removed, then perhaps the best course of action is to remove them all and start over. This will often be the case when a tree comes with only one or two branches. For trees that have been pruned back to a single trunk or leader (whip), cut the leader off at a height of 36 inches above the ground to encourage the development of wide-angled branches.

#### The Year After Planting

Beginning in the second year, pruning in the late winter or very early spring should be an annual management practice. If the trees grew exceptionally well the previous summer, or came from the nursery with many laterals, some thinning of laterals may be necessary. More that 5 to 7 laterals at this stage may cause crowding. Crowding means shade, and shaded wood will produce few flower buds and fruit.

How do you select branches to remove? First, remove any branches that are oversized just as we did at planting. Oversized branches will create internal shade problems, limiting fruit production in the future. Once again, any branch over ½ the diameter of the trunk where it joins the trunk is a candidate for removal. Be sure to follow the complete removal rule. Completely remove the offending branch - removing a portion of it will not solve the problems it will soon create. You should also remove any excessively low branches. Branches less than 20 to 22 inches above the ground will be difficult to mow under and will likely produce inferior quality fruit as they sag under crop loads.

Some limb spreading may be necessary in this second spring. Limbs can be positioned at the desired angle by simply tying them down using the tree stake as an anchor. Check the leader to be sure it is properly tied to the stake. Once again, no tipping of branches is recommended. There is no easier way to delay and reduce fruiting than by tipping or heading back branches. Remember, deer are tip pruners and trees that deer prune bear few if any fruits!

#### Year Three and Beyond

The basic pruning rules we have practiced in the first two years of the tree's life do not change as the tree ages although the size of some of our pruning cuts might. We continue to train the leader to the stake and eliminate any oversized branches that develop. Some branches that didn't seem too vigorous in years 1 and 2 may become problems, growing at a much faster rate than other parts of the tree. These excessively large branches will need to be removed, again by cutting them out completely. And some shade problems may develop as growing branches crowd each other. Again, completely eliminate a branch or two to eliminate shading rather than cutting back all branches.

Additional limb spreading may be needed for certain upright-growing branches, especially with cultivars like Delicious and Macoun which have a natural upright growth tendency.

Balance is the key. Branches should be relatively uniform in size and evenly distributed around the trunk. The top of the tree should be narrow compared to the lower portion, as shading of the lower branches will reduce fruit production. The trunk or leader should be straight, again to reduce shading on the lower branches. And branches should be positioned at an appropriate angle to intercept the most sunlight possible. The key tools for achieving these goals are a tree training stake, whole limb pruning, and limb spreading.



#### **Bearing Apple Trees**

When pruning is underway, older, bearing trees should be pruned first. Young, nonbearing apple trees and stone fruits should not be pruned until after March 1 to minimize chances of winter injury.

The balance between vegetative and fruiting growth is influenced by the crop load, fertilization, and pruning. Fruiting may be poor because vigor is too high or too low. Excessive vigor can be the result of inadequate fertilization, no pruning, excessive cropping, or shading of fruiting wood. Good fruiting wood requires moderate vigor and exposure to good light levels.

Light is the source of energy that produces the crop. Bearing wood that is shaded is low in vigor and produces small, poorly colored fruits. Good light exposure is necessary for the development of flower buds as well as optimum size, color, and sugar content of the fruit. Studies have shown that a typical tree canopy is composed of different layers or zones in respect to light exposure. As shown below, an outside zone of leaves and fruit receives a high proportion of direct light and light levels above those required for good growth and fruiting; a second zone receives adequate light exposure; and a third, inner zone receives inadequate light exposure and is unproductive.



The relative proportion of these zones in a tree is influenced by tree size and shape. As tree size increases, the percentage of the tree that is shaded and unproductive (third zone) increases. Trees that have wide tops and narrow bottoms also have a high percentage of shaded areas in the tree canopy. Trees should be cone-shaped, or larger at the bottom than the top, to maximize adequate light exposure.

Good light exposure in the tree canopy can also be maintained by a good pruning program. Ideally, pruning should remove unproductive wood and develop a uniform distribution of vigor and light exposure throughout the tree. Proper pruning can also help to maintain desired tree size and shape.



Pruning should be done on a regular basis and consist of moderate cuts made throughout the tree to distribute vigor and provide good light penetration. Heading cuts should only be used where branching is desired or in areas where vigor is low. Drooping or low-hanging branches should be removed or pruned to a lateral that is positioned above horizontal. Remove crossing, dead, or damaged limbs. Watersprouts should be removed unless one is needed for the development of new bearing surface. Watersprouts can be easily removed by hand as they develop in the summer.



Without regular annual pruning, trees often become overly thick, and irregular bearing may occur. Spray penetration is reduced, and problems such as scale may develop in the dense areas of the tree. With this type of tree, make many thinning cuts throughout the tree with emphasis on the upper, outer portions of the tree. This will open up areas into the tree canopy as well as re-establish good tree shape.

Avoid bench cuts to outward-growing limbs unless necessary. Such cuts result in weak limbs and an umbrella shape that creates a sucker problem. Remove no more than 2 large limbs per year. If large amounts of pruning are required, it should be spread over a 2 to 3 year period. In addition, such pruning should be preceded and followed for 1 to 2 years by a reduction or elimination of nitrogen application, depending on soil type, variety, and grower experience.

The excess vigor that can result from severe pruning can decrease fruit quality. The effect is much the same as from excessive nitrogen application, and may include excessively large, poorly colored, soft apples which will not store well. Vegetative growth competes with fruit for calcium; thus, under conditions of excessive vigor, calcium related disorders such as bitterpit may develop.

## **Pruning Other Fruit Trees**

The general purpose of pruning fruit trees is to regulate growth, increase yields, improve fruit size and quality, and reduce production costs. Pruning is necessary to shape trees for convenience of culture and repair of damage.

Most pruning is done during the dormant season, preferably just before active growth begins in the spring. At this time, pruning wounds heal quickly, flower buds can be easily recognized, and injury from low winter temperature is avoided. Summer pruning (from late July through mid August) may be done to help train trees to the desired form and maintain small tree size. Summer pruning should consist of making thinning cuts of branches of  $\frac{1}{2}$ inch diameter or smaller. Do not prune larger branches at this time. It should be remembered that all pruning has a dwarfing effect. For maximum yield of high quality fruit, prune only as necessary to establish a tree with a strong framework capable of supporting heavy crops annually without damage and to maintain a tree sufficiently open to allow penetration of sunlight, air, and spray material for good fruit development and pest control.

Pear, cherry, and apricot trees are trained to the leader system recommended for the apple. Special attention should be given to the selection of scaffold limbs for sweet cherry because it is subject to winter injury and splitting at the point where the limbs join the main stem of the tree. It is essential that the crotch angles be as wide as possible to ensure a strong framework, and the rule about removing oversized branches is always obeyed.

The plum may also be pruned in a manner similar to the apple. European and prune types generally develop into well-shaped trees, even if little pruning is done. Thinning out excessive growth constitutes the bulk of pruning after heading back to 30 to 36 inches at the time of planting. Varieties of the Japanese type are usually a little more vigorous, and may need some heading back as well as thinning of excessive growth after they come into bearing.

Peach trees are usually trained to the open-center system. Newly planted trees should be headed to about 30 inches in height, just above a lateral branch or bud. If the tree is branched when it comes from the nursery, select 3 or 4 laterals, well-spaced up and around the trunk, for the permanent scaffold limbs. The lowest limb should be about 15 inches and the highest about 30 inches from the ground. Cut these back to two buds each, and remove all other laterals. If no desirable laterals are available, head the tree to the desired height and cut out all side branches to one bud. A number of shoots will develop during the season, from which you can select scaffold limbs. Selection can be made during the summer or delayed until just before growth begins the second season.

Once the scaffold system of the young peach tree is established, prune as little as possible until the tree begins to bear. Remove all strong, upright shoots growing in the center of the tree, and lightly head back terminal growth on the scaffold limbs to outward-growing laterals. This aids in the development of an open-center tree.

As fruit is borne on wood of the previous year's growth, it is necessary that the peach be pruned annually to stimulate new growth and maintain production near the main body of the tree. Pruning of the mature peach tree consists mainly of moderate thinning and heading back to outward-growing laterals to keep the tree low and spreading. A height of 8 or 9 feet is usually preferred.

## When pruning fruit trees for best production, remember these basic concepts:

- Pruning results in strong growth close to the pruning cut. Pruning reduces the number of shoots so remaining shoots are stimulated. However, total shoot growth and size of the limb is reduced.
- (2) Two types of pruning cuts are heading back (tipping) and thinning out (bulk). Heading is cutting off part of a shoot or branch to stimulate branching and stiffen the limb. Thinning cuts remove the entire shoot or branch at its junction with a lateral, scaffold, or trunk. Thinning cuts are less invigorating, improve light penetration, and can redirect the limb.





- (3) Limb position affects vigor and fruitfulness.
- Vertical or upright branches, typical in the tops of trees, produce the longest shoots near the end of the limb and tend to be excessively vigorous and not very fruitful. Fruit are often of poor quality and subject to limb rub. Limbs growing slightly above horizontal are more apt to develop a uniform distribution of vigor and fruitfulness. Light distribution tends to be even, and because fruit hang along the branch, they are less prone to limb rub. Limbs growing below horizontal tend to develop suckers along the upper surface. Excess sucker growth will result in shading. Hangers, or limbs developing on the underside of branches or scaffolds, are heavily shaded and low in vigor. Fruit developing on such wood is of poor size and color.
- (4) Pruning alters the balance between the tree top and root system. Thus, a pruning program should be developed along with a good fertilization program. Severe pruning and/or excess fertilization can increase excessively the vigor of the tree and decrease fruiting.

#### **Special Training System**

The foregoing suggestions for pruning fruit trees are concerned with training for maximum production of high quality fruit. In addition, many home gardeners prune for decorative purposes.

Numerous training systems, based on the art of *espalier*, which originated in France and Italy about 400 years ago, have been devised. Some are quite elaborate, requiring considerable time and patience as well as detailed knowledge of the plant's growth characteristics. The easiest espalier system is the horizontal cordon. Apples, pears, and plums adapt well to this system. The trees are usually supported by a wall, fence, or wire trellis. Training to the fourtier cordon or four-wire trellis is relatively easy.

An espalier system can serve to separate yard areas and to provide an effective way of producing a large volume of high quality fruit in a limited area. Trees trained in this fashion should be grafted on dwarfing rootstock. Otherwise, they tend to grow too large and are difficult to hold within bounds.





**Second Winter** 

A simple, four-wire trellis may be constructed by setting 8-foot posts 2 feet in the ground, spacing them 12 feet apart, and running wires through the posts at heights of 18, 36, 54, and 72 inches. Plant two unbranched whips of the desired variety 6 feet apart between each two posts.

Before growth begins in the spring, cut off the whip just above the first bud, below the point where the whip crosses the lowest wire. Usually three or more shoots will develop near the point of the cut. Retain the uppermost shoot and develop it as the central leader. The other two can be developed into main scaffold branches to be trained along the lower wire, one on each side of the central stem. Remove all other growth. The two shoots selected for scaffold limbs should be loosely tied to the wire as soon as they are 10 to 12 inches long. Twine, plastic chainlink ties, or other suitable material may be used. Tie the shoots so that they are nearly horizontal. This reduces vegetative vigor and induces flower bud formation. If the end of the shoot is tied below the horizontal, however, new growth at the end will stop, and vigorous shoots will develop along the upper side. At the end of the first season, the lateral branches on the lower wire should be established and the central leader should have grown above the second wire.

During the dormant pruning at the end of the first winter, cut the central leader off at a bud just below the second wire. Repeat the process of the previous spring by developing two scaffold branches to tie to the second wire and allow the central leader to grow above the third wire.

This process is repeated during the next two seasons, at which time a total of eight scaffolds, four on each side of the tree, should be firmly established. The leaders should be bent to form one of the scaffolds, rather than being cut off at the top wire.

By the end of the fourth season, the trees should be in heavy production. All pruning is then done during the spring and summer months. After new growth in the spring is about 2 inches long, cut it off, and also removing about <sup>1</sup>/<sub>4</sub> of the previous season's growth. Terminals of the scaffold are left untouched.

About the first of August, or as soon as new growth reaches 10 to 12 inches in length, cut it back to two or three buds. Repeat about a month later, if necessary. This encourages fruit bud formation and prevents vigorous growth from getting out of bounds.

## **Training and Pruning Small Fruit**

#### Grapes.

For grapes to be most productive, they must be trained to a definite system and pruned rather severely. There are several training systems used. The two most common are the vertical trellis and the overhead arbor. Both of these are satisfactory in the home planting if kept well-pruned.

Of the many variations of the vertical trellis, the single-trunk, four-arm, Kniffin system is the most popular. Posts are set 15 to 20 feet apart and extend 5 feet above the ground. Two wires are stretched between the posts, the lower being about 2½ feet above the ground and the upper, at the top of the posts. The vine is set between the posts and trained to a single trunk with four semipermanent arms, each cut back to 6 to 10 inches in length. One arm is trained in each direction on each wire.

During annual winter pruning, one cane is saved from those that grew from near the base of each arm the previous summer. This cane is cut back to about ten buds. The fruit in the coming season is borne on shoots developing from those buds. Select another cane from each arm, preferably one that grew near the trunk, and cut it back to a short stub having two buds. This is a renewal spur. It should grow vigorously in the spring and will be the likely source of the new fruiting cane selected the following winter. All other growth on the vine should be removed. This leaves four fruiting canes, one on each arm, with eight to ten buds each, and four renewal spurs, one on each arm, cut back to two buds each.

The same training and pruning techniques may be effectively used in training grapes to the arbor system. The only difference is that the wires supporting the arms are placed overhead and parallel with each other instead of in a horizontal position. Overhead wires are usually placed 6 to 7 feet above the ground.

If an arm dies, or for any reason needs to be replaced, choose the largest cane that has grown from the trunk near the base of the dead arm and train it to the trellis wire. To renew the trunk, train a strong shoot from the base of the old trunk to the trellis as though it were the cane of a new vine. Establish the arms in the same manner as for a new vine, and cut off the old trunk. Pruning may be done anytime after the vines become dormant. In areas where there is danger of winter injury, pruning may be delayed until early spring. Vines pruned very late may bleed excessively, but there is no evidence that this is permanently injurious.

#### **Blueberries.**

Until the end of the third growing season, pruning consists mainly of removing low spreading canes and dead and broken branches. As the bushes come into bearing, regular annual pruning will be necessary. This should done between January and March. Select six to eight of the most vigorous, uprightgrowing canes for fruiting wood and remove all others.

After about 5 or 6 years, a cane begins to lose vigor and fruit production is reduced. At the dormant pruning, remove the older canes of declining vigor and replace with strong, vigorous new shoots that grew from the base of the bush the previous season. Keep the number of fruiting canes to six or eight, and remove the rest. Head back excessive terminal growth to a convenient berry-picking height.



Pruning blueberries, before and after

#### Brambles

Most brambles benefit from some form of support. They may be grown on a trellis, trained along a fence, or tied to stakes.

A simple trellis, the T-trellis, is used in many home gardens. Two wires are set about 4 feet above ground and spaced 2 feet apart by a lateral cross arm attached to posts set 15 to 20 feet apart in the row. Fruiting canes are tied to these wires in the spring.

If individual plant stakes are used for support, they are driven into the ground about 1 foot from each plant and allowed to extend 4 or 5 feet above the ground. Canes are tied to the stake at a point about midway between the ground and the tips of the canes, and again near the ends of the canes. Canes of bramble fruits are biennial in nature; the crowns are perennial. New shoots grow from buds at the crown each year. Late in the summer, the new canes develop fruit buds. Early in the second season, fruit-bearing shoots grow from these buds. After fruiting, the old canes die.

These fruiting canes may be removed any time after harvest. They should be cut off close to the base of the plant, removed from the planting, and destroyed. Some growers, as a sanitation practice, do this immediately after harvest. Most, however, wait until the dormant pruning.

The dormant pruning is usually delayed until danger of severe cold is past and accomplished before the buds begin to swell. It consists of the removal of all dead, weak, and severely damaged canes, and the selection and pruning of the fruiting canes for the coming season. Where possible, fruiting canes ½-inch or more in diameter are selected. Only three to four canes should be left per foot of row.

Black raspberries should be topped in the summer when the young shoots are about 24 inches high; purple raspberries, when about 30 inches high. Summer-topping consists of removing the top 3 to 4 inches of the new shoots by snapping them off with the fingers or cutting them with shears or a knife. Where trained to supports, let them grow 6 to 8 inches taller before topping.

At the dormant pruning, thin each plant until only four or five of the best canes remain. Cut the lateral branches of the black raspberry to 9 to 12 inches long; those of the purple raspberry to 12 to 15 inches long.



Pruning black rasberries, Before and after

Red raspberries should not be summer-topped. At the dormant pruning, where the hill system of culture is used, thin until only seven or eight of the best canes remain per hill.

If the plants are grown in hedgerows, keep the width of the rows to 18 inches or less, and remove all plants outside the row areas. Thin the canes within the hedgerows to 6 to 8 inches apart, saving the best canes.



Pruning red rasberries, before and after

Where the canes are supported either by a trellis or stakes, cut the canes back to a convenient height for berry-picking, usually 4 or 5 feet. Grown as upright, self-supporting plants, whether in hills or in hedgerows, the canes should be cut back to about 3 feet in height. Any lateral branches should be cut to about 10 inches in length.

For everbearing red raspberries, most growers prune everbearing cultivars to produce a single fall crop on the tips of new canes only. In this system, all canes are pruned to ground level in early spring each year.

New shoots of erect blackberries should be summertopped when they are 30 to 36 inches high. To prevent the planting from becoming too thick and reducing yields, it may be necessary to remove excess sucker plants as they appear. This can be done either with a hoe or by hand. In the hedgerow type of culture, leave only three or four shoots per running foot of row. Grown in hills, four to five new shoots may be allowed to develop in each hill.

At the dormant pruning, where supports are used, head the canes to 4 to 5 feet in height. Canes grown without support should be headed to 3 feet. Cut lateral branches back to 15 or 18 inches long.

Trailing blackberries require little pruning. All dead and weak canes should be removed after harvest or at the dormant pruning. They should be thinned to seven or eight of the best canes per hill, cut to about 5 feet in length, and tied to either a stake or trellis.

## Summary

Pruning is the removal of parts of a woody plant for a specific purpose. These purposes include: training the plant; maintaining plant health; improving the quality of flowers, fruit, foliage, or stems; and restricting growth.

## CHAPTER 9 Indoor Plants

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# CHAPTER 9

## **Indoor Plants**

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This chapter is designed to familiarize you with the basic aspects of tropical plant care rather then attempting to acquaint you with specific cultural requirements of the hundreds of commonly grown plants in the foliage industry. Bear in mind that in most cases, homes and offices are environments poorly suited to the needs of tropical plants. Thus the task of the indoor plant gardener is to select plants that can best withstand the conditions of a specific indoor location.

## **Selecting an Interior Plant**

Select only those foliage plants which appear to be free of insects and diseases. Check the undersides of the foliage and the axils of leaves for signs of insects or disease. Select plants that look sturdy, clean, well-potted, and shapely.

Choose plants with healthy foliage. Avoid plants which have yellow or chlorotic leaves, brown leaf margins, wilted foliage, spots or blotches, spindly growth or torn leaves. Plants which have new flowers and leaf buds along with young growth are usually of superior quality.

Remember that it is easier to purchase a plant which requires the same environmental conditions your residence has than to alter the environment of your home or office to suit the plants.

#### **Transporting House Plants**

When transporting plants, remember the two seasons of the year that can cause damage to the plants, the hot summer and the cold winter months. In the summer, avoid placing plants in a car and leaving the car shut, because temperatures will rise and destroy the plant in a short period of time. If you have to travel for any distance at all, the plant can be burned by the sun shining on it, even though the air conditioner is on and it's comfortable in the car. Shade the plant from direct sun while it is in the car.

During winter months, wrap plants thoroughly before leaving the store to carry them to your car. A short run from the store to the car in very low temperatures can kill or severely damage plants. Wrap plants thoroughly with newspaper or paper bags, place in the front of the car, and turn on the heater. The trunk of most cars is too cold to carry plants safely during winter months.

On an extended trip, make special arrangements so that plants will not be frozen or damaged by cold weather. Many foliage plants will be damaged considerably if the temperature drops much below 50° F., so maintain as warm a temperature as possible around these plants when transporting them from one location to another.

#### Acclimatization

Research conducted in Florida in the late 1970s revealed an interesting phenomenon. Tropical plants grown in full sun have leaves (so-called sun leaves) which are structurally different from the leaves of plants grown in shade (shade leaves). Sun leaves have fewer chloroplasts, and thus less chlorophyll. Their chloroplasts are located deep inside the leaves and the leaves are thick, small, and many in number. Shade leaves have greater numbers of chloroplasts and thus more chlorophyll, are thin, broad, and few in number. When plants are grown in strong light, they develop sun leaves which are photosynthetically very inefficient. If these same plants are placed in low light, they must either remake existing sun leaves or drop their sun leaves and grow a new set of shade leaves which are photosynthetically more efficient. To reduce the shock which occurs when a plant with sun leaves is placed in shade, gradually reduce the light levels it is exposed to. This process is called acclimatization.

Chapter 9 Indoor Plants

The gardener should acclimatize plants when placing them outdoors in summer by gradually increasing light intensities, and reverse the process before plants are brought indoors in the fall. For newly purchased plants grown in high-light conditions, acclimatize them by initially locating them in a high-light (southern exposure) area of your home and gradually moving them to their permanent, darker location over a period of 4 to 8 weeks.

## **Environmental Factors**

Light, water, temperature, humidity, ventilation, fertilization, and soil are chief factors affecting plant growth, and any one of these factors in incorrect quantity will prevent proper plant growth indoors.

#### Light

Light is probably the most limiting factor for indoor plant growth. The growth of plants and the length of time they remain active depend on the amount of light they receive. Light is necessary for all plants because they use this energy source to photosynthesize. When examining light levels for tropicals, consider three aspects of light: intensity, duration, and quality.

Light **intensity** influences the manufacture of plant food, stem length, leaf color, and flowering. A geranium grown in low light tends to be spindly and the leaves light green in color. A similar plant grown in very bright light would tend to be shorter, better branched, and have larger, dark green leaves. Indoor plants can be classified according to their light needs by high, medium, and low light requirements. The intensity of light a plant receives indoors depends upon the nearness of the light source to the plant (light intensity decreases rapidly as you move away from the source of light). The direction the windows in your home face will affect the intensity of natural sunlight that plants receive. Southern exposures have the most intense light, eastern and western exposures receive about 60% of the intensity of southern exposures, and northern exposures receive 20% of a southern exposure. A southern exposure is the warmest, eastern and western are less warm, and a northern exposure is the coolest. Other factors which can influence the intensity of light penetrating a window are the presence of curtains, trees outside the window, weather, seasons of the year, shade from other buildings, and the cleanliness of the window. Reflective (lightcolored) surfaces inside the home/office will increase the intensity of light available to plants. Dark surfaces will decrease light intensity.

Day-length or **duration** of light received by plants is also of some importance, but only to some plants. Poinsettia, kalanchoe, and Christmas cactus bud and flower only when day-length is shorter than a critical number of hours (specific to each plant). Most flowering indoor plants are indifferent to daylength.

Low light intensity can be compensated by increasing the time (duration) the plant is exposed to light, as long as the plant is not sensitive to day-length in its flowering response. Increased hours of lighting allow the plant to make sufficient food to survive and/or grow. However, plants require some period of darkness to develop properly, and thus should be illuminated for no more than 16 hours. Excessive light is as harmful as too little light. When a plant gets too much direct light, the leaves become pale, sometimes burn, turn brown, and die. Therefore, during the summer months, protect plants from too much direct sunlight.

Additional lighting may be supplied by either incandescent or fluorescent lights. Incandescent lights produce a great deal of heat and are not very efficient users of electricity. If artificial lights are to be used as the only source of light for growing plants, the **quality** of light (wavelength) must be considered. For photosynthesis, plants require mostly blues and reds, but for flowering, infrared light is also needed. Incandescent lights produce mostly red, and some infrared light, but are very low in blues. Fluorescent lights vary according to the phosphorus used by the manufacturer. Coolwhite lights produce mostly blue light, and are low in red light. Foliage plants grow well under coolwhite fluorescent lights, which are also cool enough to position quite close to plants. Blooming plants require extra infrared which can be supplied by incandescent lights, or special horticultural-type fluorescent lights.

#### Water

Over watering and under watering account for a large percentage of tropical plant losses. The most common question gardeners ask is, "How often should I water my plants?" There is not a good answer to this question. Some plants like drier conditions than others. Differences in potting medium and environment influence water needs. Watering as soon as the soil crust dries can result in over watering.

Plant roots are usually in the bottom 2/3 of the pot, so do not water until the bottom 2/3 starts to dry out slightly. You can't tell this by looking. You have to feel the soil. For a 6-inch pot, stick your index finger about 2 inches into the soil (approximately to the second joint of your finger). If the soil feels damp, don't water. Keep repeating the test until the soil is barely moist at the 2-inch depth. For smaller pots, 1 inch into the soil is the proper depth to measure.

Water the pot until water runs out of the bottom. This serves two purposes. First, it washes out all the excess salts (fertilizer residue). Second, it guarantees that the bottom 2/3 of the pot, which contains most of the roots, receives sufficient water. However, don't let the pot sit in the water that runs out. After a thorough watering, wait until the soil dries at the 2-inch depth before watering again.

When you test for watering, pay attention to the soil. If your finger can't penetrate 2 inches deep, you either need a more porous soil mix or the plant is becoming root-bound.

#### Temperature

Most house plants tolerate normal temperature fluctuations. In general, indoor foliage plants grow best between 70 and 80 degrees F. during the day and from 60 to 68 degrees F. at night. Most flowering indoor plants prefer the same daytime range but grow best at nighttime temperatures from 55 to 60 degrees F. The lower night temperature induces physiological recovery from moisture loss, intensifies flower color, and prolongs flower life. Excessively low or high temperatures may cause plant failures, stop growth, or cause spindly appearance and foliage damage or drop. A cooler temperature at night is actually more desirable for plant growth than higher temperatures. A good rule of thumb is to keep the night temperature 10 to 15 degrees lower than the day temperature.

#### Humidity

Atmospheric humidity is expressed as a percentage of the moisture saturation of air. To provide increased humidity, attach a humidifier to the heating or ventilating system in the home, or place gravel trays (in which an even water level is maintained) under the plant containers. This will increase the relative humidity in the vicinity of the containers. As the moisture around the pebbles evaporates, the relative humidity is raised. Another way to raise humidity is to group plants close together. You can also spray a fine mist on the foliage, although this is of doubtful effectiveness for total humidity modification. Do this early in the day so that the plants will be dry by night. This lessens the chance of disease, since cool dampness at night provides an ideal environment for disease infection.



A layer of gravel or pebbles increases the humidity level.

#### Ventilation

Indoor plants, especially flowering varieties, are very sensitive to drafts or heat from registers. Forced air dries the plants rapidly, overtaxes their limited root systems, and may cause damage or plant loss. Plants are sensitive to gas used for cooking or heating. Some plants refuse to flower, while others drop flower buds and foliage when exposed to gas. Blended gas is more toxic to plants than natural gas. Tomato plants are extremely sensitive to gas. They will turn yellow before the escaping gas is detected by household members, and are sometimes used in greenhouses as indicator plants for excessive ethylene gas (resulting from incomplete combustion in gas furnaces).

#### Fertilization

Indoor plants, like most other plants, need fertilizers containing three major plant nutrients: nitrogen (N), phosphorus (P), and potassium (K). They are available in many different combinations and under a multitude of brand names. Each brand should be analyzed on the label, indicating specifically how much water-soluble elemental nitrogen, phosphate, or potash is available in every pound of the product. The majority of these fertilizers are about 20-20-20. The first figure indicates available nitrogen; the second, available phosphate; and the third, watersoluble potassium. Commercial fertilizers used for indoor plants are sold in granular, crystalline, liquid, or tablet forms. Each should be used according to instructions on the package label. Frequency and amount of fertilizer application varies with the

fertilizer product, the plant species and season of the year. In general, fertilize young, actively growing plants more than more mature, slowly growing plants; and fertilize at full recommended strength in spring and summer, and at half-strength in fall and winter. In New Hampshire, fertilization can often be eliminated from November through late March due to the reduced light levels of our short winter days.

#### **Soluble Salts**

Reduced growth, brown leaf-tips, dropping of lower leaves, small new growth, dead root-tips, and wilting are all signs of high soluble salts. These salts eventually accumulate on top of the soil forming a yellow to white crust. A ring of salt deposits may be formed around the pot at the soil line or around the drainage hole. Salts will also build up on the outside of clay pots.

Soluble salts are minerals, like fertilizers, dissolved in water. When water evaporates from the soil, the minerals or salts stay behind. As the salts in the soil become more and more concentrated, plants find it harder and harder to take up water. If salts build to an extremely high level, water can be taken out of the root-tips, causing them to die.

High soluble salts damage the roots directly, and because the plant is weakened, it is more susceptible to attack from insects and diseases. One of the most common problems associated with high salt levels is root rot. The best way to prevent soluble salt injury is to stop the salts from building up. Water correctly. When you water, allow some water to drain through, and then empty the drip plate. Water equal to 1/10 the volume of the pot should drain through each time you water. DO NOT ALLOW THE POT TO SIT IN WATER. If you allow the drained water to be absorbed by the soil, the salts that were washed out are taken back into the soil. Salts can be reabsorbed through the drainage hole or directly through a clay pot.

Plants should be leached every 4 to 6 months. You should leach a plant before you fertilize, so that you don't wash away the fertilizer you just added. Leaching is accomplished by pouring a lot of water on the soil and letting it drain completely. The amount of water used for leaching should equal twice the volume of the pot. A 6-inch pot will hold 10 cups of water, so 20 cups of water are used to leach a plant in a 6-inch pot. Keep the water running through the soil to wash the salts out. If a layer of salts has formed a crust on top of the soil, you should remove the salt crust before you begin to leach. If the soluble salt level is extremely high or the pot has no drainage, repot the plant.

The level of salts that will cause injury varies with the type of plant and how it is being grown. A plant grown in the home may be injured by salts at a much lower level than it can tolerate under the ideal conditions of a greenhouse. Some plant shops leach plants to remove excess salts before the plant is sold. If you are not sure that has been done, leach a newly purchased plant the first time you water it.

## Media

The potting soil, or media in which a plant grows, must be of good quality. It should be porous for root aeration and drainage, but also capable of water and nutrient retention. Most commercially prepared mixes are termed artificial, which means they contain no soil. High-quality artificial mixes may contain slow-release fertilizers, which take care of a plant's nutritional requirements for several months.

#### **Preparing Artificial Mixes**

Artificial mixtures can be prepared with a minimum of difficulty. Most mixes contain a combination of organic matter, such as peat moss or ground pine bark, and an inorganic material, like washed sand, vermiculite, or perlite. Materials commonly used for indoor plants are the peat-lite mixtures, consisting of peat moss and either vermiculite or perlite. Here are some comments concerning the ingredients for these mixes.

**Peat Moss** is readily available baled or bagged; sphagnum peat moss is recommended. Such materials as Michigan peat, peat humus, and native peat are usually too decomposed to provide necessary structural and drainage characteristics. Most sphagnum peat moss is acid in reaction, with a pH ranging from 4.0 to 5.0 It usually has a very low fertility level. Do not shred sphagnum peat moss too finely.

**Vermiculite** is a sterile, lightweight, mica-like natural rock. When it is heated to approximately 1800° F., its plate like structure expands. Vermiculite will hold large quantities of air, water, and nutrients needed for plant growth. Its pH is usually in the 6.5 to 7.2 range. Vermiculite is available in four particle sizes. For horticultural mixes, sizes 2 or 3 are generally used. If at all possible, the largersized particles should be used, since they give much better soil aeration. Vermiculite is available under a
variety of trade names. Always purchase "horticultural-grade" expanded vermiculite. "Constructiongrade" vermiculite often contains contaminants which can damage or even kill plant roots.

**Perlite** is a sterile material produced by heating volcanic rock to approximately 1800° F. The result is a very lightweight, porous material that is white in color. Its principal value in soil mixtures is aeration. It does not hold water and nutrients as well as vermiculite. The pH is usually between 7.0 and 7.5. Perlite can cause fluoride burn on some foliage plants, usually on the tips of the leaves. The burn progresses from the tip downward. This damage looks very similar to damage from high soluble salts, low relative humidity, and lack of water. If you suspect fluoride to be the cause of such a problem, you may want to repot the plant into a media lacking perlite, and also check your water for high fluoride levels. Typically, fluoride toxicity is seen on members of the Lily family (Aloe, Spider Plant, Cast-Iron Plant, Asparagus Fern).

A good formula for artificial mix follows:

- 1 bushel shredded peat moss
- 1 bushel perlite or vermiculite
- 1/2 cup finely ground agricultural lime
- 1/3 cup 20% superphosphate

This artificial mixture is very low in trace or minor elements, therefore, it is important to use a fertilizer that contains these trace elements.

#### **Soil Mixes for Specific Plants**

Soil-based media can be mixed to provide the most efficient composition for the type of plant to be grown. According to generally accepted standards, we can divide indoor plant soil mixes into four distinct groups, according to the type of plant to which they are most suited.

#### **Foliage Plants**

This soil should be moderately rich, have a good base of clay loam, and hold moisture and fertility adequately. It must be a crumbly, well-structured soil. It is generally made up of one part of good garden loam, one part of clean sand or perlite, and half to one part of either peat moss, compost, leaf mold, or vermiculite. Mixing about 1 teaspoon of superphosphate with each quart of mixed potting soil is desirable and encourages good root growth after repotting. If the garden soil is alkaline, sphagnum peat moss will have enough acid reaction to neutralize the mixture. This soil is used for all foliage plants and some flowering plants that do not prefer a rich soil.

#### **Flowering House Plants**

This soil is often referred to as humus soil because it contains about 50% humus-rich materials or similar ingredients. It is important that the soil does not become so rich that it is soggy after watering. Two parts of sphagnum, or one part sphagnum and one part vermiculite, are added to one part garden loam and one part clean sand. Also add 1 teaspoon of superphosphate per quart of soil mixture. This soil is generally used for African violets, gloxinias, begonias, calla lilies, and other tropical flowering plants.

#### **Cacti and Succulents**

This soil does not need any humus material. It is composed of equal parts of sand, garden soil, and vermiculite or perlite. It is preferred for cacti and other fleshy leaved, desert-type succulents.

#### Orchids

Fir-tree bark or Osmunda fiber is generally used in glazed or plastic pots. The container should be large enough so that new growth is 1 to 2 inches from the rim of the container.

Any soil containing garden loam should be pasteurized. This can be done easily at home. Spread the soil on a cookie tray and bake it at 180° F. for 30 minutes. Do not heat it longer than 30 minutes, and be aware that it will smell unpleasant while baking. Alternatively, a purchased potting soil can be used in these mixes; such materials are already pasteurized.

#### Containers

There are many types of containers from which to choose. A good container should be large enough to provide room for soil and roots, have sufficient head room to provide a reservoir for proper watering, provide bottom drainage, and be attractive without competing with the plant it holds. Containers may be fabricated of ceramics, plastic, fiberglass, wood, aluminum, copper, brass, and many other materials.

#### **Clay and Ceramic Containers**

Unglazed and glazed porous clay pots with drainage holes are widely used. Ornate containers are often nothing but an outer shell to cover the plain clay pot. Clay pots absorb and lose moisture through their walls. Frequently the greatest accumulation of roots is next to the walls of the clay pot, because moisture and nutrients accumulate in the clay pores. Although easily broken, clay pots provide excellent aeration for plant roots and are considered by some to be the best type of container for a plant. Plants in porous pots generally require more frequent watering than plants in nonporous pots.

Ceramic pots are usually glazed on the outside, sometimes also on the inside. Those without drainage holes should be used only as decorative cachepots, to hold a suitably drained pot. Small novelty containers have little room for soil and roots and are largely ornamental. They should be avoided. It should be noted that putting pot chips, clay pot shards or gravel in the bottom of a pot does not improve soil drainage; they only provide a small space beneath the soil where some excess water can drain inside the pot.

#### **Plastic and Fiberglass Containers**

Plastic and fiberglass containers are usually quite light and easy to handle. They have become popular in recent years because they are relatively inexpensive and often quite attractive in shape and color. Plastic pots are easy to sterilize or clean for reuse, and because they are not porous, they need less frequent watering and tend to accumulate fewer salts.

# Repotting

Actively growing indoor plants need repotting from time to time. This occurs very rarely with some slower-growing plants, more frequently with others. Foliage plants require repotting when their roots have filled the pot and are growing out the bottom of the pot.



When repotting becomes necessary, it should be done without delay. The pot selected for repotting should be no more than 2 inches larger in diameter than the pot the plant is currently growing in; should have at least one drainage hole; may be either clay, ceramic, or plastic; and must be clean. Wash soluble salts from clay pots with water and a scrub brush, and wash all pots in a solution of 1 part liquid bleach to 9 parts water.

Potting media should be coarse enough to allow good drainage, yet have sufficient water retention capabilities. Most plants are removed easily from their pot if the pot is held upside-down while knocking the lip of the container sharply upon the edge of a table. Hold your hand over the soil, straddling the plant between the fore and middle fingers while knocking it out of its present container.



Potting media should be moistened before repotting begins. To repot, place a layer of potting mix in the bottom of the pot with some new soil. If the plant has become root-bound cut and unwind any roots that circle the plant, otherwise the roots will never develop normally. If the old soil surface has accumulated salts, the top inch should be removed. Set the rootball on the layer of the new medium. Fill medium around the sides between the rootball and pot. Do not add media above the original level on the rootball, unless the roots are exposed or it has been necessary to remove some of the surface medium. Do not pack the medium; to firm or settle it, tap the pot on a level surface or gently press the medium with your fingers.



After watering and settling, the medium level should be sufficiently below the level of the pot to leave headroom. Headroom is the space between the medium level and the top of the pot that allows for watering a plant. A properly potted plant has enough headroom to allow water to wash through the medium to thoroughly moisten it.

# **Training and Grooming**

Some houseplants require training and grooming to perform well. Pinching is the removal of 1 inch or less of new stem and leaf growth, just above a node. This leaves the plant attractive and stimulates new growth. It can be a one-time or continuous activity, depending on the need and the desires of the plant owner. If a plant should be kept compact, but wellfilled out, frequent pinching may be required.



Pruning of an entire branch or section of a plant thins the plant, encourages an open appearance, and allows more light penetration.

Disbudding is the removal of some flower buds either to obtain larger blooms from a few choice buds or to prevent flowering of a very young plant (or recently rooted cutting) that would not bear the physical drain of flowering early.

Ivies and hoya, as well as philodendron and arrowhead, are frequently grown on trellises. It is important to keep plants clean and neat. It not only improves the appearance of plants but reduces the incidence of insects and disease problems. Remove all spent flowers, dying leaves, and dead branches. Keep leaves dust-free by washing plants with warm water. If tips of leaves become brown and dry, trim them off neatly with sharp scissors.

# **Care of Special Potted Plants**

Too little light, excessive heat, and improper watering are the usual causes of failure of gift plants. These plants are grown in a greenhouse, where the night temperatures are usually cool, there is ample light, and the air is moist. When they are brought into a dry home, where the light is poor and the temperatures are maintained for human comfort, results are frequently disappointing. Do not expect to keep a gift plant from year to year. Enjoy them while they are attractive and in season and then discard.

#### **Poinsettia Care**

The poinsettia requires bright light and should be kept away from drafts. A temperature between 65 and 70 degrees F. is ideal. Keep plants well-watered but do not overwater. Some of the newer, longlasting varieties can be kept attractive all winter.

Gardeners frequently ask whether they can carry their poinsettias over to bloom again next year. It is questionable whether the results are worth the effort, as the quality of home-grown plants seldom equals that of commercially grown plants. However, for those who wish to try, the following procedure can be followed.

After the bracts fade or fall, set the plants where they will receive indirect light and temperatures around 55 to 60 degrees. Water sparingly during this time, just enough to keep the stems from shriveling. Cut the plants back to within 5 inches of the ground and re-pot in fresh soil. As soon as new growth begins, place in a well-lighted window. After danger of frost, place the pot outdoors in a partially shaded spot. Pinch the new growth back to get a plant with several stems. Do not pinch after September 1st. About Labor Day, or as soon as the nights are cool, bring the plant indoors. Continue to grow in a sunny room with a night temperature of about 65 degrees. Since the poinsettia blooms only during short days, exclude artificial light, either by covering with a light-proof box each evening or by placing in an unlighted room or closet for a minimum of 12 hours of darkness each night. Plants require full light in the daytime, so be sure to return them to a sunny window. Start the short-day treatment on October 1st to have blooms by Christmas.

#### Azaleas

Azaleas require direct sunlight to remain healthy. A night temperature of 60 degrees will prolong bloom. Keep the soil constantly moist. If the leaves should turn yellow, the soil may not be acid enough. Use an acid fertilizer sold especially for azaleas. Do not use softened water. When repotting, use a mixture high in acid peat moss.

Azaleas can be planted, pot and all, in a shady spot in the garden during the summer months. Examine them frequently and keep them watered during dry periods. Greenhouse azaleas are not hardy, and need to be brought indoors before freezing weather.

Azaleas need a cool rest treatment before they are forced into bloom. Place the plants in a room with filtered light and a temperature between 35-50 degrees F. During this rest period, flower buds will develop. Then place in a well-lighted, warm (65° F.) room around January 1 to bring them into bloom. Unless you have the proper growing conditions for the azalea, you should not attempt to carry the plants over.

#### Gardenia

Gardenias grown indoors need special care. They demand an acid soil and should receive the same nutritional care as azaleas. The night temperature should be near 60 degrees and the humidity around the plant should be kept high. High temperature and low light intensity will result in flower bud drop.

#### Amaryllis

The secret of growing amaryllis is to keep the plants actively growing after they finish blooming. Keep the plants in full sun, with a night temperature above 60 degrees. As soon as danger of frost has passed, set the plants in the garden in a semishaded spot. In the fall, before danger of frost, bring them in, stop watering them to allow old growth to die back, and store them in a cool, dark place to rest. They will be ready to force again about November 1. Bring them into a warm light room and water moderately to begin new growth.

#### **Christmas Cactus**

The Christmas cactus has become increasingly popular with the development of several new varieties. At least three related species are sold in addition to a number of cultivars. All have similar cultural requirements.

The secret of good bloom seems to be one of tem-

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perature and photoperiod control. They will develop buds and bloom if given bright light, short days, and night temperatures between 55 and 65 degrees F. Christmas cacti bloom best when somewhat pot-bound. Repotting is necessary only about once in 3 years. Full sunlight is beneficial in midwinter, but bright sun during summer months can make plants look pale and yellow.

Christmas cacti require less water from October to March than they do when growth is active from April to September. A rest period is very important if plants are to bloom abundantly. Dormancy should be started about the middle of September and continued for 8 weeks. Care should be taken that soil never becomes water-logged during the dark days of winter.

#### Cyclamen

Cyclamen require full sunlight and a night temperature of between 50 and 60 degrees. They are heavy users of water and must be watered whenever the surface of the soil is dry. Flower buds will fail to develop if night temperature is too high or if light is poor.

Cyclamen can be carried over, but as with the poinsettia, homegrown plants are seldom equal to those grown by a commercial grower. Let the plants die down after they finish flowering. Repot the fleshy tuber in June with the top of the tuber above the soil line. Allow resting tubers to dry, but not to become shriveled.

# **Plant Lists**

The remainder of this chapter is composed of lists of plants that will withstand specific indoor conditions of light intensity, temperature, and cultural form.

#### PLANT DIRECT LOW BRIGHT AVERAGE (by common name) LIGHT LIGHT LIGHT LIGHT Aluminum plant Х Х Areca palm х х Asparagus - Sprengeri X Х Asparagus - Meyeri х Х Aloe vera Х Х Boston fern Х X Burro's tail Х Х Chinese evergreen Х Х Х Coleus X X Corn plant х Х Х Croton X х Dumb cane Х Х Х Devil's ivy х х X Х Fiddleleaf fig Х X False aralia Х Х German ivy - green Х Х German ivy - variegated Х Х Gold dust dracaena Х Х Grape ivy х х Heartleaf philodendron х Х х Jade plant Х Х Japanese aralia Х Х Kangaroo ivy Х Х Maidenhair fern X X Moses-in-the-cradle х Х Norfolk island pine Х Parlor palm Х Х х Peperomia х х Piggyback х х Ponytail palm Х х Rubber plant х х Schefflera Х х Х Snake plant Х Х х Х Spider plant Х Х Strawberry begonia Х Swedish ivy х Х X Tahitian bridal veil Х Х Х Velvet plant Х Х Wandering Jews X Х Х Weeping fig Х

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#### **Light Requirements of Selected Indoor Plants**

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#### **Temperature Requirements of Selected Indoor Plants**

# Cool temperature plants grow best at 50-60°F during the day and 45-55°F at night.

Azalea Cacti and Succulents<sup>2,3</sup> (during winter rest periods only) Camellia Cast-iron plant<sup>2</sup> Chrysanthemum Citrus (grapefruit, lemon, orange) Creeping fig Daffodil, Narcissus Easter lily<sup>2</sup> Euonymus japonica (Spindle tree) lvy<sup>2</sup> Hyacinth Hydrangea Japanese aralia Jasmine Jerusalem cherry Miniature rose Mock orange Norfolk Island pine Persian violet Primrose Tulip Tree ivy Wandering Jew White calla lily Zephyr lily

Medium temperature plants grow best at 60-65°f during the day and 55-60°f at night. Amaryllis Asparagus fern Avocado Baby's tear Begonia Bird's nest fern Bromeliads<sup>3</sup> **Bush violet** Cacti and Succulents<sup>1,3</sup> Cast-iron plant<sup>1</sup> Christmas cactus Citrus<sup>1</sup> Coleus Crown of thorns<sup>3</sup> Earth star<sup>3</sup> Easter lilv<sup>1</sup> English ivy<sup>1</sup> German Ivv Gold-dust tree **Hibiscus** Kangaroo vine<sup>3</sup> Living stones<sup>3</sup> Palms Panda plant Peperomia **Piggyback plant** Pilea Podocarpus Purple passion plant Schefflera Shamrock plant Snake plant<sup>3</sup> Staghorn fern<sup>3</sup> Strawberry begonia

# High temperature plants grow best at 70-80°f during the day and 64-70°f at night.

African violets Bromeliads Cacti and Succulents<sup>1,2</sup> Caladium calathea (Peacock plant) Chinese evergreen Coconut palm Copperleaf Cordyline Croton Crown of thorns<sup>2</sup> Dracaena Earth star<sup>2</sup> False aralia Ficus Geranium Golden pothos Hen and chicks Impatiens Kangaroo vine<sup>2</sup> Living stones<sup>2</sup> Peace lily Philodendron Prayer plant Purple velvet plant<sup>2</sup> Sensitive plant Snake plant Staghorn fern<sup>2</sup> Swiss cheese plant Screw pine

<sup>1</sup> Will also do well at high temperatures.

<sup>2</sup> Will also do well at medium temperatures.

<sup>3</sup> Will also do well at cool temperatures.

# Plants for Specific Indoor Gardening Uses

#### **Plants That Will Grow in Water:**

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#### Plants That Will Usually Withstand Adverse House Conditions and Abuse:

Scientific Name	Common Name	Scientific Name	Common Name
Aglaonema modestum	Chinese Evergreen	Aglaonema modestum	Chinese Evergreen
Crassula arborescens	Jade Plant	Anthurium aemulum	Climbing Anthurium
Dieffenbachia (all varieties)	Dumbcane	Aspidistra elatior	Iron Plant
Hedera helix	English ivy	Chamaedorea elegans	Dwarf Parlor Palm
Hemigraphis colorata	Hemigraphis	Cissus rhombifolia	Grape Ivy
Hoya carnosa	Wax plant	Crassula arborescens	Jade Plant
Monstera deliciosa	Cutleaf Philodendron	Dieffenbachia amoena	Dumbcane
Pellionia pulchra	Satin Pellionia	Dracaena fragrans	Massangeana
Philodendron cordatum	Philodendrons		Dracaena
Philodendron micans	(all climbing types)	Euphorbia mili	Crown of Thorns
Piper nigrum	Black Pepper	Ficus elastica	Indian Rubber Tree
Piper ornatum	Celebes Pepper	Ficus benjamina 'Exotica'	Java Fig
Scindapsus aureus	Devil's Ivv	Hemigraphis colorata	Hemigraphis
Scindapsus pictus	Painted Devil's Ivv	Howeia belmoreana	Kentia Palm
Stephanotis floribunda	Stephanotis	Pandanus veitchii	Screw pine
Svngonium nodonhvllum	Arrowhead	Peperomia obtusifolia	Peperomia
oyngomann podopnynann	Syngonium	Philodendron cordatum	Philodendron
Tradescantia (all varieties)	Wandering Jew	Sansevieria trifasciata	Snakeplant
		Sansevieria laurentii	Golden stripe
		Sansevieria zeylanica	Sansevieria
		Scindapsus aureus	Devil's Ivy
		Syngonium podophyllum	Arrowhead,

Arrowhead, Syngonium

# Plants Well-Suited for Large-Container Decorative Specimens:

Scientific Name	Common Name
Acanthus mollis	Artists Acanthus
Acanthus montanus	Mountain Acanthus
Alocasia cuprea	Giant Caladium
Alsophila australis	Australian Tree Fern
Codiaeum pictum	Croton
Dieffenbachia amoena	Spotted Dumbcane
Fatshedera lizei	Botanical Wonder
Fatsia japonica	Japan Fatsia
Ficus eburnea	Ivory Fig
Ficus elastica 'Variegata'	Variegated India Rubber
Ficus lyrata	Fiddleleaf Fig
Monstera deliciosa	Cutleaf Philodendron
Pandanus veitchii	Screwpine
Philodendron elongatum	Philodendron
Philodendron giganteum	Giant Philodendron
Philodendron x mandaianum	Philodendron
Philodendron panduraeforme	Philodendron
Philodendron selloum	Philodendron
Philodendron x wendlandii	Philodendron
Polyscias paniculata 'variegata'	Jagged-leaf Aralia
Schefflera digitata	Schefflera
Strelitzia reginae	Bird of Paradise

# Low, Creeping Plants for Ground Covers in Interior Planting Boxes:

Scientific Name	Common Name			
Episcia cupreata	Episcia			
Ficus pumila	Creeping Fig			
Ficus radicans	Climbing Fig			
Fittonia verschafeltii	Silver Fittonia			
Hedera helix	Hahn's Star English Ivy			
Hemigraphis colorata	Hemigraphis			
Pellionia daveauana	Pellionia			
Pellionia pulchra	Pellionia			
Philodendron cordatum	Heartleaf Philoden- dron			
Pilea nummulariifolia	Creeping Artillery Plant			
Saxifraga sarmentosa	Strawberry Begonia			
Scindapsus aureus	Devil's Ivy			
Tradescantia (all varieties)	Wandering Jew			
Vinca major 'variegata'	Variegated Vinca			

#### Plants That Withstand Dry, Warm Locations:

Scientific Name	Common Name		
Bromeliads	All species and varieties		
Cacti	All species and varieties		

# Vines and Trailing Plants for Totem Poles and Trained Plants:

Scientific Name	Common Name		
Anthurium almulum	Climbing Anthurium		
Cissus antarctica	Kangaroo Vine		
Cissus discolor	Begonia Cissus		
Cissus rhombifolia	Grape Ivy		
Clerodendrum Balfouri	Glorybower	(	
Ficus pumila	Creeping Fig		
Vanilla fragrans 'Marginata'	Vanilla		

#### Plants Suitable for Tropical Terrariums:

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#### **Plants Suitable for Desert Dish Gardens**

**Common Name** 

Medicine Plant

Cylinder cactus

Curiosity plant

Toy cypress, watch

Jade plant

**Rosary Vine** 

Painted lady

Mexican snowball

Hens and chickens

Rainbow cactus

Lace cactus

frilled fan

Tiger jaws

Button cactus

Crested euphorbia,

Miniature gasteria,

Zebra haworthia

Pearl plant

Living stones

Powder puff cactus

Golden star cactus

Thimble cactus

miniature ox tongue

Pearl plant, wart plant

Golden barrel cactus

chain

Bishop's cap

spots

Calico hearts, leopard

Scientific Name	Common Name	Scientific Name	
Aglaonema commutatum	Chinese evergreen	Adromischus	
Begonia boweri	Miniature begonias		
Chamaedorea elegans	Neanthe bella, parlor	Aloe	
	palm	Astrophytum myriostigma	
Cissus antarctica 'Minima'	Dwarf kangaroo ivy	Cephalocereus nobilis	
Coffea arabica	Arabian coffee plant	Cereus peruvianus	
Cordyline terminalis	Dura di La La	'Monstrosus'	
minima Baby Tr	Dwarf ti plant	Crassula	
Cryptanthus bivittatus minor	Dwarf rose-stripe earth star	Crassula lycopodioides	
Dizgygotheca elegantissima	False aralia	Crassula rupestris	
Dracaena sanderana	Belgian evergreen	Echeveria Derenbergi	
Dracaena surculosa	Gold dust dracaena	Echeveria elegans	
Ficus diversifolia	Mistletoe fig	Echeveria secunda	
Ficus pumila 'Minima'	Dwarf creeping fig	var. glauca	
Fittonia verschaffeltii	Mosaic plant	Echinocactus Grusonii	
Maranta leuconeura kerchoveana	Praver plant	Echinocereus pectinatus var. neomexicanua	
Nephrolepis exaltata cvs.	Boston fern	Echinocereus reichenbachi	
Peperomia sandersii	Watermelon	Echinocereus micromeris	
•	peperomia	Euphorbia lactea cristata	
Pilea cadierei 'Minima'	Aluminum plant		
Pilea depressa	Miniature pilea	Faucaria tigrina	
Pilea microphylla	Artillery plant	Gasteria liliputana	
Pilea nummulariifolia	Creeping Charlie		
Pteris species	Brake ferns, table	Haworthia	
	ferns	Haworthia fasciata	
Saintpaulia cultivars	Miniature African	Haworthia margaritifera	
	VIOIETS	Lithops species	
Selaginella	Club moss, moss fern	Mammillaria bocasana	
Selaginella kraussiana	Creeping club moss	Mammillaria elongata	
Selaginella emmeliana	Sweat plant	Mammillaria fragilis	
Sinningia pusilla (and other miniature cultivars)	Miniature gloxinias		

Arrowhead vine, Nephthytis

Syngonium

#### Plants Suitable for Desert Dish Gardens cont.

Scientific Name	Common Name
Opuntia erectoclada	Dominoes, pincushion cactus
Opuntia microdasys	Bunny ears
Opuntia vilis	Dwarf tree opuntia
Portulacaria afra	Elephant bush
Portulacaria afra variegata	Rainbow bush
Rebutia kupperiana	Scarlet crown cactus
Rebutia minuscula	Red crown cactus
Sedum	Stonecrop
Sedum acre	Golden carpet, gold moss
Sedum adolphi	Golden sedum
Sedum dasyphyllum	Golden glow
Sedum lineare	Carpet Sedum
Sedum morganianum	Burro's tail
Sedum multiceps	Miniature Joshua tree
Sedum pachyphyllum	Jelly beans
Sedum X rubrotinctum	Christmas cheer
Stahlii	Coral beads

# CHAPTER 10

# **The Vegetable Garden**

Edited and revised by by Dr. Otho Wells, University of New Hampshire Cooperative Extension

When planning your garden, it is important to ask a few basic questions:

Who will be doing the work? Will the garden be a group project with family members or friends who will work willingly through the season to a fall harvest, or will you be handling the hoe alone, in between camping and swimming? Remember, a small weed-free garden will produce more than a large weedy mess.

What do you and your family like to eat? Although the pictures in the garden catalog look delicious, there is no value in taking up gardening space with vegetables that no one eats. Make a list of your family's favorite vegetables, ranked in order of preference. This will make a useful guide in deciding how much to plant of each. Successive plantings of certain crops, such as beans, will give a longer harvest period and increase your yield. List recommended varieties and planting dates.

How do you plan to use the produce from your garden? If you plan to can, freeze, dry, or store part of the produce, this will be a factor not only in planning the size of the garden but also in selecting the varieties grown. Some varieties have much better keeping quality than others. Care should be used in choosing the seeds, making sure the varieties you select are adapted to your area and intended use.

How much space is available? That is, how much area can be converted into usable garden space, not simply how much empty ground is available.

# **Some Planning Hints**

- Plan the garden on paper first. Draw a map showing arrangement and spacing of crops. If you wish to keep the garden growing all season, you may need a spring, summer, and fall garden plan.
- Plan the garden and order seeds by January or February. Some plants may be started indoors as early as late-February.
- In your plan, place tall and trellised crops on the north side of the garden so they won't shade the shorter vegetables.
- Group plants by length of growing period. Plant spring crops together so that later crops can be planted in these areas when the early crops mature. Consider length of harvest as well as time to maturity. Place perennial crops to the side of the garden where they will not be disturbed by annual tillage.

## Locating the Garden

- Vegetables grow best in a level area with loose, well-drained soil, and at least 6 hours of sun (8 to 10 hours is ideal).
- Use contour rows or terraces on sloped or hillside sites to avoid erosion. South-facing slopes are warmer and less subject to damaging frosts.
- Avoid placing the garden in low spots, at the base of a hill, or at the foot of a slope bordered by a solid fence. Such areas are slow to warm up in the spring, and frost settles in these places, since cold air naturally drains into low areas.
- Avoid windy locations; if you must plant in a windy spot, build or grow a windbreak.
- Locate near a good and easily accessible supply of water if possible.
- Choose a spot near your home so it is convenient to work in the garden when you have a few minutes.
- Avoid planting near trees and shrubs; they compete for nutrients and water, and may cause excessive shading.
- Sites too near buildings may result in plants not receiving enough sunlight. Observe shading patterns through the growing season; if possible, before starting the garden. If you have a shaded area you wish to use anyway, plant shade-tolerant crops.
- Try not to plant related vegetables in exactly the same location in the garden more often than once in 3 years. Rotation prevents the buildup of insects and disease. Use old plans as guides for rotating crops.
- Avoid locating the garden on a site where buildings with lead paint have stood; soil lead may be present in toxic amounts. If you are unsure about your chosen location, have the soil tested for lead content, or have tissue analyses done on some leafy vegetables.

# **Soil Preparation**

The ideal vegetable garden soil is deep, friable, well-drained, and has high organic matter content. Proper soil preparation provides the basis for good seed germination and subsequent growth of garden crops. Careful use of various soil amendments can improve garden soil and provide the best possible starting ground for your crops.

## **Soil Testing**

Check soil fertility and pH by having your soil analyzed at least once every 3 years. Soil pH measures the degree of acidity or alkalinity of the soil. Vegetables vary to some extent in their requirements, but most garden crops will do well with a soil pH of 6.2 to 6.8. This is a little below neutral, or slightly acid (sour). If soil pH is too high or low, poor crop growth will result, largely due to the effects of pH on the availability of nutrients to plants. A soil test will also give you a relative idea of the nutrient level in the soil.

Soil test kits are available for checking soil at home. Soil samples may also be sent to your local Extension office for testing. Extension will mail results to you with recommendations for correcting any deficiencies or other problems that may exist. For best results, carefully follow the instructions for taking the soil sample.

Make basic nutrients and pH adjustments to the soil by adding required fertilizers and lime (or acidifiers). In new garden spots, remove sod with a spade and put it in a compost pile to decay. Plow, spade, or rotary till the soil. Work only when soil moisture conditions are right. To test, pick up a handful of soil and squeeze it. If it stays in a ball it is too wet. If it crumbles freely, it should be about right. Excessively dry soil is powdery and clumpy and may be difficult to work. If soil sticks to a shovel, or if when spading, the turned surface is shiny and smooth, it is still too wet. Working soils when excessively wet can destroy soil structure, which may take years to rebuild. Plowing with a tractor when the soil is wet is especially damaging, causing the formation of a compaction layer that will inhibit root growth. Soils with adequate humus levels generally allow more leeway because of their improved structural qualities.

Just prior to planting, break up large clods of soil and rake the bed level. Small-seeded vegetables germinate best in smooth, fine-surfaced soil. Do not pulverize the seedbed soil. This destroys the structure and promotes crusting and erosion problems.

# Equipment

The type of equipment used to prepare your garden will depend on the size of the garden, your physical ability, time, and budget. Options include handdigging with a spade or shovel, tilling with a power rotary tiller, using a small garden tractor, or a fullsized farm tractor.

# **Tilling the Soil**

It was once assumed that gardens should be turned yearly with a moldboard plow, mostly for weed and pest control. While garden plowing is still a common practice, turning the soil completely over has been found to be detrimental in some cases, causing soil compaction, upsetting balances of microorganisms, and often causing layers of coarse organic material to be buried below the influence of insects and microbes which would otherwise cause breakdown of the material. Chisel plowing, which does not have this disruptive effect, is one alternative, but it is limited to sandy or loamy soils and many farmers who work gardens do not have chisel plows. In addition, gardeners in other-than-rural areas have trouble finding a farmer who will come to plow and disk the garden for a reasonable price (or at all). Roto-tilling most home gardens is sufficient, as long as plant debris accumulation is not out of hand. Rotary tilling mixes the upper layers of soil rather than completely turning the soil over, and the effects produced are generally desirable. One possible harmful effect of roto-tilling is the formation of a compaction layer just beyond the reach of the tines. This also occurs when a moldboard plow is used to the same depth every year, but at a somewhat deeper level. Use of deep-rooted cover crops or double-digging can do much to prevent or alleviate this problem when it exists. Small gardens can be designed using raised beds which may be worked entirely by hand if the area is small enough.

Gardeners often wonder whether to plow/till in the spring or fall. Working the soil in fall has several advantages over the traditional spring plowing. It allows earlier spring planting, since the basic soil preparation is already done when spring arrives. Turning under large amounts of organic matter is likely to result in better decomposition when done in the fall, since autumn temperatures are higher than those of early spring, and there is more time for the process to take place. Insects, disease organisms, and perennial weeds may be reduced by killing or inactivating them through burial or exposure to harsh winter weather. The physical condition of heavy clay soils may be improved by the alternate freezing and thawing, which breaks up tightly aggregated particles. Also, snow is trapped between the hills of roughly-plowed soil, so more moisture is retained than on flat, bare ground. Incorporation of limestone or rock fertilizers in the fall gives them time to become integrated with the soil and influence spring plant growth.

Fall plowing alone is not recommended for hillside or steep garden plots, since soil is left exposed all winter, subject to erosion when spring rains come. If a winter cover crop is grown to improve soil and prevent erosion, the ground will have to be tilled in the fall to prepare the soil for seed, and again in spring to turn under the green manure. Spring plowing is better for sandy soils and those where shallow tilling is practiced. Generally, most gardens must be disked or rotary-tilled in the spring to smooth the soil for planting.

#### **Soil Amendments**

Any addition to the soil which improves its physical or chemical condition is considered a soil amendment. Many types of amendments are available to the home gardener.

#### Amendments to Change pH and Nutrient Levels:

Lime and sulfur are common amendments used to change soil pH. The correct soil pH is essential for optimum plant growth. Dolomitic limestone adds calcium and magnesium as it increases pH. Sulfur itself may acidify alkaline soil. The amount to add depends on the current and desired pH, one good reason to have garden soil checked periodically.

Wood ashes are often used as a soil amendment. They contain potash (potassium), phosphate, boron, and other elements. Wood ashes can be used to raise soil pH with twice as much ash applied as limestone for the same effect. Ashes should not come into contact with germinating seedlings or plant roots as they may cause root burn. Spread in a thin layer over the winter, and incorporate into the soil; check pH yearly if you use wood ashes. Never use coal ashes or large amounts of wood ash (no more than 20 lbs. per 1000 square feet), as toxicity problems may occur. Other amendments are added specifically to improve soil nutrient levels. Greensand is a source of potassium. Greensand is relatively low in potassium which is readily dissolved. Other nutritional amendments that can be purchased for garden use include cottonseed meal and kelp meal as well as an array of synthetic fertilizers. The organic amendments are particularly useful where a trace element deficiency exists, while synthetic fertilizers are generally more available, less expensive, and have quicker results.

#### Amendments to Improve Soil Qualities:

In special cases, coarse sand, peat, vermiculite, and perlite are sometimes added to heavy clays to help improve soil texture (the ratio of sand:silt:clay) or structure. However, these inert materials can be expensive and large quantities are needed to do any good. Compost, manures, and other amendments usually serve the purpose more economically and just as well.

Organic matter is a great soil improver for both clay and sandy soils. Good sources of organic matter include manures, leafmold, sawdust, straw, and others. These materials are decomposed in the soil by soil organisms. Various factors, such as moisture, temperature, and nitrogen availability determine the rate of decomposition through their effects on these organisms. Adequate water must be present, and warm temperatures will increase the rate at which the microbes work. The proper balance of carbon and nitrogen in the material is needed to ensure adequate nutrient availability both to growing plants and decomposing organisms. Adding nitrogen may be necessary if large amounts of undecomposed leaves, straw, sawdust, or other high-carbon substances are used. Nitrogen is used by the decayers to make proteins for their own bodies, and if it is not present in sufficient amounts, the microbes have no qualms about stealing the plants' share.

The use of compost is one way to get around the decomposition problem. Compost is usually made by the gardener from plant and/or animal wastes. Correct composting is an art which can result in a valuable nutrient and humus source for any garden. The basis of the process is the microbial decomposition of mixed raw organic materials to a dark, fluffy product resembling rich soil, which is then spread and worked into the garden soil.

Animal manures are commonly used as a garden soil amendment. The value of manure in terms of the nutrients it contains varies. Fresh horse, sheep, rabbit, and poultry manures are quite high in nitrogen and may even burn plants if applied directly to a growing garden. They are best applied in the fall and tilled under. Manure usually has fewer total nutrients than synthetic fertilizers in terms of N, P, & K, but is a valuable soil-builder. Unfortunately, manures may be a source of weed seeds; if this is a problem, composting in a hot pile may help. In urban areas, manure may be hard to come by, but country dwellers usually find it plentiful.

Another source of inexpensive soil improvement that should not be underestimated is the cover crop. Green manures, or cover crops, such as annual rye, ryegrass, and oats are planted in the garden in the fall for incorporation in the spring. For best results, seed should be sown a month before the first killing frost. In a fall garden, plant cover crops between the rows and in any cleared areas. Cover cropping provides additional organic matter, holds nutrients that might have been lost over the winter, and helps reduce erosion and loss of topsoil. Legume cover crops can increase the amount of nitrogen in the soil and reduce fertilizer needs. A deep-rooted cover crop allowed to grow for a season in problem soil can help break up hardpan and greatly improve tilth. Incorporate green manures at least 2 weeks before planting vegetables; they should not be allowed to go to seed before incorporation.

The regular addition of manure, compost, cover crops, and other organic materials can raise the soil nutrient and physical level to a point at which the addition of synthetic fertilizers is no longer needed. or is at least greatly reduced. This comes about not only through the intrinsic fertilizing value of the amendment, but also through the increased action of microorganisms on soil and humus particles; humic acid (and other acids) helps to release previously locked-up nutrients naturally present in the soil, and the extra surface area provided by humus serves as a reserve, holding nutrient elements until they are needed by plants. This highly desirable soil quality does not come about with a single or even several additions of organic material, but rather requires a serious, long-term, soil-building program. Information is widely available in books and magazine articles on this subject.

Remember, your soil is alive and constantly changing. By keeping it fertile and rich, many gardening problems may be diminished. Soil is the base for plant growth, and much attention should be paid to getting and keeping it in the best condition.

# **Selecting Gardening Equipment**

Garden catalogs and stores are full of gardening tools, many highly specialized; some are very useful, others are nice but not necessary, and some are gimmicks. The gardening equipment you need depends on the size of your garden, your age and strength, and whether you want to get the job done in a hurry or prefer to take your time. The minimum equipment needed by most gardeners includes a shovel or spade, a hoe, a rake, and a trowel. A wide selection of styles is available in each of these tools, and the choice is really one of personal preference and price range. You can get the best value for the price range you choose by knowing each tool's uses and particular qualities to look for when comparison shopping.

#### Hand Tools for Cultivating

A garden **shovel** with a pointed blade is lighter and smaller than most other shovels and is well suited for use in the garden. Shovels are earth movers with dish-shaped blades mounted to the handle at an angle. A **spade** has a flat blade and is designed for cutting rather than lifting or moving soil. Spades are excellent for shaping straight-sided trenches and for edging beds. For general purpose digging, lifting and moving, a long-handled shovel is ideal. Both shovels and spades come with long or short handles in standard or D-shaped styles. Choice of handle style will depend on personal preference; long handles offer greater leverage and are less tiring to use in many cases. Short handles are often thicker and stronger than long ones.



A **spading fork** is another useful digging tool. It is ideal for breaking and turning heavy soils and for loosening subsoil layers when double digging a bed. Turning coarse compost, spreading mulches, and digging root crops are other jobs suitable for a spading fork.

A **hoe** is essential in any garden for preparing the seed bed, removing weeds, and breaking up encrusted soil. Several different hoe styles are available. The pointed hoe with a heart-shaped blade is lightweight and useful for opening seed furrows and cultivating between plants. The hula, or action hoe, is a type of scuffle hoe which is very lightweight and maneuverable. Pushing and pulling it just under the soil surface eliminates newly emerging weeds and breaks up any crust on the soil surface. This type of hoe is most easily used on soil which is not compacted, since the blade is relatively thin and lacks the clod-breaking capabilities of a heavier hoe; it is also less effective in cases where weeds have gotten a good start. Other types of scuffle hoes are somewhat more sturdy, and are used with a pushing motion rather than pushing and pulling. Probably the most commonly used hoe is the square-bladed hoe, which lends itself well to many garden tasks.

A sturdy **rake** is useful in clearing the garden of rocks and debris. It is also helpful in spreading mulches and smoothing seedbeds. The size of the rake right for you depends on your size and strength and the uses you intend to put it to. As the number of tines increases, the rake weight also increases; avoid choosing a rake so heavy it will tire you after a short period of use. The length of the rake handle is important too; the tip of the handle should come up to your ear when standing upright. A handle that is too short will make your work harder, causing excess bending and back strain.

Especially in the spring, a **trowel** will be in constant use for those many digging jobs that need not be done with full-sized tools. The trowel is perfect for transplanting seedlings and bulbs or digging shallow-rooted weeds. Small hand cultivators, often sold in sets with trowels, are good for weeding in small areas and between closely spaced plants. Another useful small digging tool is appropriately named a digger (a.k.a. weeder, cultivator, asparagus knife). This tool is available from most hardware or discount stores for a few dollars. It is indispensable for digging up weeds with long taproots, such as dandelions or Queen Anne's lace, or for prying out quackgrass rhizomes. It consists of a long (10 to 14 inch) solid metal rod with a two-pronged blade at one end and a handle at the other. This tool is practically indestructible and well worth the small investment of its price.



Some other tools that may have a place in the garden tool shed include the pickaxe, mattock, and wheel cultivator. Pickaxes are used to break up extremely hard-packed or stony soil. Mattocks are for the same purpose, but are equipped with a cutting blade for areas where larger roots need to be removed. A mattock may also be used to chop up debris for composting. A wheel cultivator has a number of attachments for soil preparation and weed control and may prove a good investment for those with larger gardens.

#### **Power Tools for Cultivating**

The power **rotary tiller** is probably the power tool most commonly purchased by gardeners. Whether or not a gardener needs a rototiller depends on the size of the garden, the gardener's capabilities, and the intended uses of the tiller. Tiller selection may be based on the nature of the work to be done, the quality of the machine, and ease of repair, as well as personal preference. The tiller's engine powers rotating blades, or tines, which can make garden soil loose and fluffy, ready for planting. It can also chop up plant debris and mix it into the soil. Incorporating organic matter and manures into the garden is easily accomplished with a tiller, reducing the tendency to procrastinate this necessary chore. The ability of the tiller to do these jobs effectively is a function of its weight, strength, design, type of tines, and type of soil. A heavy, powerful tiller is most effective on stony clay soils, while in a small garden or one with light soil, a smaller tiller is more appropriate. Very lightweight tillers, known as soil blenders, are designed mainly for raised-bed gardening; however, they are not widely available and generally must be mail-ordered.

Roto-tillers are available with front-mounted or rear-mounted times. Rear-tined tillers are generally better able to self-propel on all but the rockiest soils. They travel straight and can produce a footprintfree seedbed. Rear-tined tillers often have a number of attachments available for a variety of uses, such as hilling potatoes, making raised beds, even plowing snow! The price of a rear-tined rototiller is considerably higher, in most cases, than that of the front-tined type; consideration should be given to the payback time necessary for such a large investment.



If gardening is simply a hobby, or if the garden is small, a front-tined tiller may be suitable. Fronttined tillers are usually light in weight, but may require considerable strength to guide them through the soil. Operating this type of tiller is comparable to handling a large floor polisher such as those used in schools and hospitals; mainly, leverage is required for control. New gardeners are sometimes scared away from these tillers because of the initial experience of having a tiller run away with them. The front-tined tiller may not make as straight a pass as the heavier rear-tined type, but it is much easier to turn. Due to this increased maneuverability, the front-tined tiller is easy to use in small gardens and in corner areas.

The purchase of a tiller is a major investment as garden tools go. Features to look for include heavy cast-iron, steel plate and tubing, heavy bearings, strong welds used in construction, and easily operable controls. Ask to look at the operator's manual and try to determine how simply a tune-up can be performed; you may save yourself a great deal of trouble and money if you can replace plugs and points yourself, particularly if you have no truck on which to load the tiller. Also consider the locations of service centers and parts dealers.

Careful attention to your needs, abilities, and price range is important. Talk to people who have the types of tillers you are interested in. If possible, borrow or rent various types of machines and send for information before buying.

If you are considering the purchase of a used rototiller, plan to do so well ahead of time so you will not be rushed into a purchase. If you do not know much about such equipment, it might be helpful to have a mechanically-minded friend look over the machines you are considering. Above all, test each tiller for ease of starting and operation. An engine that smokes or runs roughly may require a lot of work. Tines should operate smoothly and freely. Check the welds in the handles to see that they are strong; re-welding may mean that the handles have broken at some time, a common problem in older tillers. Look at the dipstick if there is one; low oil or very sludgy oil may mean that the tiller has been maintained poorly. The oil and other fluids may also be checked by opening the drain plugs. Look for excessive dirt around the engine or in the air filter. This may also mean bad maintenance habits. Ask the owner for an operator's manual and ask where the machine has been serviced in the past. A good tiller is a long-term investment, so plan carefully before you buy.

#### **Other Power Tools**

There are few other power tools needed in the vegetable garden. Cordless tools come with various cultivating attachments. Most are rechargeable and can make garden chores more pleasurable; these tools are especially useful to those with physical disabilities which limit strength.

A garden shredder is nice to have for a large garden with a lot of plant wastes. There are hand-operated shredders which are slow but useful if wastes become available in small quantities and are not too coarse. Gasoline shredders are quite expensive, and may be disappointing to the gardener who wants to chip branches and other large materials. They are best used for shredding leaves, small branches, and other plant wastes (though sunflower stalks would probably be too much for one). A chipper, on the other hand, will chip large branches and other coarse material, but the cost of \$1000 or more makes the chipper uneconomical for the home gardener.

#### Carts/Wheelbarrows

A wheelbarrow or cart is very handy to have in and around the garden area. It should be easy to handle when full, with good maneuverability. Durable construction is well worth paying for to ensure a long, useful life. Be sure to choose the size appropriate for your physical abilities and garden needs. A wheelbarrow generally requires more strength and control than do most garden carts, but many of the small carts generally available are made of relatively flimsy metal and, though inexpensive, are not particularly long-lasting or suitable for heavy items such as rocks. Again, consider your needs. If you plan to haul only light straw, leaves, sawdust, and such materials, then one of the small carts may be suitable. For heavier jobs, you may need a wheelbarrow; or investigate some of the newer garden carts, especially those with bicycle-size tires, which make easy work of hauling. They are made of heavy plywood and metal, but are well-balanced and easy to maneuver. These carts do, however, involve a sizeable investment (up to several hundred dollars) and a large storage space. Therefore, only serious gardeners or those with other uses for such a cart find these carts economical. One alternative is to build your own from one of several plans available from gardening magazines or private companies.

#### Watering Equipment

Watering is one garden job that most gardeners must do at least occasionally. An adequate water supply may make a big difference in garden yields. Purchase of watering equipment depends upon available facilities, water supply, climate, and garden practices. If there is no outdoor spigot near the garden, the expense of having one installed may be greater than the benefits gained except in very drought-prone areas or in the case of a gardener who is fully dependent on the season's produce. Where rainfall is adequate except for a few periods in the summer, it is wise to keep watering equipment simple; a rain barrel or a garden hose with a fan-type sprinkler will suffice. A water breaker for small seedlings is a nice extra. But, in areas where there are extended periods of hot weather without precipitation, the local water supply is likely to be short. Overhead sprinklers are wasteful of water, so in this case, a drip irrigation system may be in order. Drip irrigation puts water right at the roots and doesn't wet plant leaves, helping to prevent disease. Timers are available that allow automatic watering with drip and some other systems.

However, this type of system is relatively expensive and may be considered a nuisance by some gardeners because of maintenance and placement requirements. Determine whether cultural practices such as mulching, close plant spacing, shading, or wide bed planting will meet most of your extra water needs. Then purchase watering gadgets accordingly.

# **Soil Testing Equipment**

Soil test kits can be purchased in various sizes and levels of sophistication. These are handy but not always necessary; soil testing does not have to be done more frequently than once a year for most gardening purposes. If inexpensive garden soil tests are offered through Extension, it is often preferable to have them do the tests, as results are likely to be more accurate. Some gardeners like to monitor the soil quality frequently, though, making a soil test kit a worthwhile purchase. An electronic pH tester is on the market for those who like gadgets.

# **Seeding and Planting Tools**

Depending on the size of your garden and your physical abilities, you may want to consider a row seeder. Seeders with wheels make easy work of sowing long rows of corn or beans or other vegetables. Seeders are available which make a furrow, drop the seeds properly spaced, and close up the furrow behind the seed, all in one pass. They do not perform quite as well on small-seeded crops, and it is not really worth the effort of setting up a seeder for small areas. A hand-held seeder is probably a better choice for this type of work. Broadcast seeders are available for sowing seeds such as rye or wheat for a cover crop, but are generally not necessary for the average home gardener, since broadcasting is easily done by hand once the proper technique is learned.

#### Environmental Monitoring Equipment

Serious gardeners often invest in various types of equipment that allow them to monitor the microclimate around the garden or indoors. A rain gauge is an inexpensive device that helps the gardener determine if enough rain has fallen for garden plants. A maximum-minimum thermometer is a costly, but often useful, device to measure nightly lows and daytime highs within an area; these are especially valuable in a greenhouse. Soil thermometers measure soil temperature and the internal temperature of a compost pile. Light and watering meters can be purchased for indoor plant monitoring.

## **Trellises/Cages**

Trellises and cages for vining plants save space and keep fruits off the ground, reducing the amount of stooping required for harvest and damage to plants. Look for heavy-duty materials and sturdy design that will stand up to rain, wind, and drying. Wire should be of a heavy gauge and wood should be treated with non-phytotoxic (i.e., not toxic to plants) materials. Metal parts should be rustproof or at least rust-resistant. If you build your own, you will probably save a considerable amount of money and get better quality for the price.

# **Composting Equipment**

If you wish to make compost regularly, it will be helpful to have compost bins in some form. You can construct two bins out of planks or concrete blocks. Make the bins about 4 feet high, 4 feet wide, and as long as desired, and open at one end for easy access. Leave spaces between blocks or planks for aeration. Plant refuse may be accumulated in one bin while the composting process is taking place in the other. A third bin may be desirable for near-finished or finished compost storage.

A simple, portable compost bin can be made with three or four sturdy, used pallets, which are simply stood on their ends in a square or open square and lashed or otherwise held together. This type of bin can be disassembled for easy turning and emptying and then reassembled around the new pile. A chicken wire cage supported by three or four wooden stakes will also work satisfactorily, but is somewhat less sturdy.

There are also ready-made and kit composters available, including slat-sided cylinders into which refuse is added from above and compost removed at ground level. Rotating barrels for easy turning are also available; gardeners who have physical disabilities may find either of these types easier to deal with than the standard compost bin.

Whichever type of compost maker you use, it's a good idea to make use of the nutrients which will leach out from under the pile. This is easily done by locating the composter in the garden (which also reduces hauling time) or under a large fruit tree. Or, make some provision to catch the run-off from the pile and use it as liquid fertilizer.

## **Harvesting Equipment**

Harvesting equipment varies depending on the size and type of garden, whether or not food is to be stored, and the way in which it is to be processed. Baskets are useful to most gardeners. They may be purchased at garden or farm supply stores or sometimes may be scrounged from local grocery stores or fruit stands. Berry baskets for small fruits, baskets with handles for carrying vegetables, and peck or bushel baskets for storage are all useful. Fruit pickers are nice and easy to use for tall fruit trees. A sharp knife for cutting vegetables off plants is handy and helps prevent plant damage.

Food processing equipment includes canners, blanchers, dehydrators, and sealers for frozen food packages. There is even a home vacuum-packer available. A food mill is inexpensive and very useful for making sauces and juices; a blender or food processor is also useful to the gardener with extra food. More specialized tools include corn cutters which remove kernels from the cob, bean Frenchers and shellers, cherry pitters, strawberry cappers, apple corers and peelers, jelly strainers and thermometers, and many more. For canning, a large kettle or pot is indispensable for preparing food prior to canning. A jar lifter will prevent burned fingers; a funnel for transferring food to jars reduces messiness. As always, choices depend on individual needs.

#### **Purchase and Maintenance**

When purchasing tools, buy for quality rather than quantity. Your tools will be in frequent use throughout the garden season. Cheap tools tend to break or dull easily and may end up making a job unnecessarily difficult and frustrating. Quality tools will last and tend to increase in value with time if well-kept. Tools should be lightweight for easy handling, but heavy enough to do the job properly. Metal parts should be of steel, which will stay sharp, keep its shape, and outlast softer metals. Consumers' magazines and gardening publications frequently have articles explaining what to look for in tools and listing alternatives to local hardware stores, which often carry a single line of tools. Several excellent books featuring garden tools have been published and may be available at the library.

Keeping a tool clean and sharp will increase its usefulness and lengthen its life. Learn the techniques of sharpening each tool and practice them frequently. Professional gardeners often carry sharpening stones or files while working and sharpen after every hour or so of use. Clean your tools after each use. One effective method is to keep a five gallon bucket filled with sand and used motor oil in the tool shed. At the end of the gardening day, remove clinging dirt from tools by plunging them into the oily sand several times. This will keep the tools cleaned and oiled, and will help prevent rusting.

The last and perhaps most important step in tool care is to put tools in their proper places. Tools left in the garden will rust and break and can be a safety hazard. Some gardeners paint handles with a bright color to make their tools easy to spot. And, if each tool has its own place in the storage area, it is simple to determine if tools are missing before closing up.

Before winter sets in, sharpen tools, then coat metal parts lightly with oil and rub wooden handles with linseed oil. Drain power tools of gasoline and obtain filters, mufflers, and tune-up parts so that a fall or late-winter tuning can get the machine ready for early spring jobs. Have maintenance done, if needed, in the winter, when demand is lowest and you can afford to let the repairer take his or her time.

In fall, any trellises or cages that have been outdoors should be cleaned and stored inside if possible. Traps and other pest control devices should also be stored if the pest season is over. Cold frames and other season extenders should be protected from damage by ice and snow or high winds, and once their job is done, should be repaired if necessary and put away if possible. Tools with wheels like cultivators, seeders, and carts should be oiled and stored. Thoughtfully selected and cared for, your tools will give many years of service. This extra help in the garden will pay for itself in time.

# Seed for the Garden

Choosing and purchasing vegetable seeds is one of the most enjoyable gardening pastimes. Thumbing through colorful catalogs and dreaming of the season's harvest is one way to make winter seem a little warmer. Seed purchased from a dependable seed company will provide a good start toward realizing that vision of bounty. Keep notes about the seeds you purchase - their germination qualities, vigor of plants, tendencies toward insects and disease, etc. From this information you can determine whether one seed company is not meeting your needs, or whether the varieties you have chosen are unsuitable for your area or gardening style. For example, if powdery mildew is a big problem on squash family plants in your area, the next year you may want to look for mildew-resistant varieties.

# **Saving Seed**

Saving your own vegetable seed is another pleasurable activity. It offers a sense of self-sufficiency and saves money. You can maintain a variety that is not available commercially, which helps to perpetuate a broad genetic base of plant materials. Breeders often search for old-time varieties when attempting to improve commercial plants, since the heirloom vegetables (as they are sometimes called) often have inbred disease- and pest-resistance or cold-hardiness. Participation in a seed-saver's exchange can be a rewarding experience. Extra seeds that you have may be traded for unusual types that are not available through other sources.

There are certain considerations that should be kept in mind when saving seed, however. Hybrid varieties are not likely to be the same as the parent plants; therefore, only open-pollinated varieties should be used for home seed production. Some seed dealers have responded to the increasing interest in seedsaving by clearly marking open-pollinated varieties in their catalogs. Another consideration in saving seed is the possibility of carrying seed-borne diseases into the next year's crop. Many commercially grown seeds are grown in dry areas unsuitable to fungal, viral, and bacterial diseases which may be present in your region. Take care to control diseases which can be carried in seed. Another weatherrelated factor is the speed of drying of seeds, which can be adversely affected by frequent rains and/or humidity.

And finally, if you've ever saved squash seed during a season in which you had more than one type of squash planted, you have probably seen the weird results that may be obtained from crosspollination! Saving seeds from cross-pollinated crops is not generally recommended for the novice because of problems with selection, requirements for hand pollination and isolation, biennial habits, and genetic variability.

Some common self-pollinated annual plants from which seed may be saved include lettuce, beans and peas, herbs, and tomatoes.

#### Saving beans and peas:

Allow seed pods to turn brown on the plant. Harvest pods, dry for 1 to 2 weeks, shell, and then store in a cool (below 50° F.), dry environment in a paper bag.

#### Saving lettuce seed:

Cut off seed stalks when fluffy in appearance, just before all the seeds are completely dried. Seeds will fall off the stalk and be lost if allowed to mature on the plant. Dry the harvested seed stalk further, shake seeds off, and then store in a cool, dry environment in an envelope or small glass jar.

#### Saving herb seeds:

Herbs vary in the way their seeds are produced. In general, allow herb seeds to stay on the plants until they are almost completely dry. Some seed heads, such as dill, will shatter and drop their seeds as soon as they are dry. Watch the earlyripening seeds; if they tend to fall off, harvest the other seed heads before they get to that point, leaving several inches of stem attached. Hang several stems upside down, covered with a paper bag to catch falling seed, in a warm, dry place until the drying is complete. Remove seeds from the seed heads and store in envelopes or small glass jars. Some herb seeds, dill, celery, anise, cumin, coriander, and others are used for flavoring and are ready to use once dry.

#### Saving tomato seeds:

Pick fruit from desirable plants when ripe. Cut fruit and squeeze out pulp into a container. Add a little water, then let ferment 2 to 4 days at room temperature, stirring occasionally. When seeds settle out, pour off pulp and spread seeds thinly to dry thoroughly. Store in an envelope or glass jar in a cool, dry place. For all kinds of saved seeds, be sure to mark the storage containers clearly with permanent (preferably waterproof) ink, indicating the variety and date saved. Seeds will remain viable for some time if properly stored. To test for germination, sprout seeds between moist paper towels; if germination is low, either discard the seed or plant enough extra to give the desired number of plants.

#### Viability of Vegetable Seeds

(Average number of years seeds may be saved)

Vegetable	Years	Vegetable	Years
Asparagus	3	Leek	1
Bean	3	Lettuce	5
Beet	4	Muskmelon	5
Broccoli	5	Mustard	4
Brussels sprouts	5	Onion	1
Cabbage	5	Parsley	2
Carrot	3	Parsnip	1
Cauliflower	5	Pea	3
Celery	5	Pepper	4
Chinese cabbage	5	Pumpkin	5
Collard	5	Radish	5
Corn	5	Rutabaga	5
Cress, water	5	Spinach	5
Cucumber	5	Squash	5
Eggplant	5	Sweet corn	2
Endive	5	Tomato	4
Kale	5	Turnip	5
Kohlrabi	5	Watermelon	5

# **Depth for Planting Vegetable Seeds**

The depth to cover seeds when you plant them depends on a number of factors such as the size of the seed, the type of soil you have, and the season of the year.

As a general rule, vegetable and flower seeds should be covered about 4 to 5 times their lateral diameter or width (not their length). There are exceptions, however; read the packet directions. Some seeds require light for germination and should not be covered at all. These instructions apply to seeds planted both inside and out.

#### **Starting Seed Indoors**

To start seeds indoors, it is important to have enough light. More homegrown seedlings are probably lost to this one factor than to any other. Vegetable seedlings grown under low-light conditions are likely to be leggy and weak, and many will fall over under their own weight after they are 3 to 4 inches tall. If you do not have a sunny room or back porch with a southern exposure, you will probably need supplemental lights. A simple fluorescent shop light with one warm-white and one cool-white bulb (or with grow lights) will suffice.

It is probably easiest to use a soilless or peat-lite mix to start seedlings, since garden soil contains disease organisms which can be highly destructive to small plants. Soil can be sterilized in the oven by baking it at 200° F. until the internal soil temperature is 180° F. It should be held at that temperature for 30 minutes. This is a smelly process, but it works. Garden soil that is high in clay should be conditioned with compost or perlite to prevent excess moisture and/or shrinkage. You can mix your own peat-like mix if you prefer, 50% vermiculite or perlite and 50% fine sphagnum peat is excellent for starting seeds. Fertilizer at half the normal strength may be added to the mixture. Mix well before using.

Many types of containers can be used to start seeds. Flats or other large containers may be used; plant in rows and grow seedlings until they have one or two sets of true leaves, then transplant into other containers for growing to the size to transplant outdoors. Seedlings may also be started in pots, old cans, cut-off milk cartons, margarine tubs, egg cartons, or other throwaways. The pop-out trays found at garden centers are easy to use and reusable. Peat pots are nice, especially for large seeds. Sow one or two large seeds directly in each peat pot.

Thin to one seedling per pot. Peat pots may be planted directly in the garden; do not allow the edges of the pot to stick out above the soil, since they will act as a wick and moisture will evaporate from this exposed surface.

Regardless of the type of container chosen, fill it 3/4 full with seed-starting mixture and sow the seeds. Cover to the specified depth and water the mix. If your home is dry, it may help to cover the containers with plastic wrap to maintain a steadier moisture level. Seeds and seedlings are extremely sensitive to drying out. They should not be kept soaking wet, however, since this condition is conducive to damping-off, a fungus disease deadly to seedlings. Damping-off can be prevented or diminished by sprinkling milled sphagnum moss, which contains a natural fungicide, on top of the soil.

Another option is to use peat pellets or cubes, which are pre-formed and require no additional soil mix. The pellets or cubes are soaked until thoroughly wet, then seeds are planted in the holes provided. The whole pellet or cube may then be planted without disturbing the roots. The only disadvantage to this method is the expense.

#### **Starting Seed Outdoors**

Many seeds may be sown directly in the garden. If garden soil is quite sandy, or is mellow with a high content of organic matter, seeds may be planted deeper. Young seedlings can emerge quite easily from a sandy or organic soil. If garden soil is heavy with a high silt and/or clay content, however, the seeds should be covered only 2 to 3 times their diameter. In such soils, it may be helpful to apply a band of sand, fine compost, or vermiculite 4 inches wide and <sup>1</sup>/<sub>4</sub> inch thick along the row after seeds are planted. This will help retain soil moisture and reduce crusting, making it easier for seedlings to push through the soil surface.

Soil temperature has an effect on the speed of seed germination. In the spring, soil is often cold and seeds of some plants will rot before they have a chance to sprout. The following chart gives optimum soil temperatures.

#### **Plant Production Data Chart**

Сгор	Days to Emergence From Seeding	Optimum Germination Soil Temperature Range	Number of Weeks to Grow Transplants	
Beans	5 - 10	65° - 85°	1	
Beets	7 - 10	50° - 85°	1	
Broccoli	3 - 10	50° - 85°	5 - 7	
Cabbage	4 - 10	50° - 85°	5 - 7	
Carrots	12 - 18	50° - 85°	1	
Cauliflower	4 - 10	50° - 85°	5 - 7	
Celery	9 - 21	50° - 65°	10 - 12	
Chard, Swiss	7 - 10	65° - 85°	1	
Corn, Sweet	5-8	65° - 85°	1	
Cucumber	6 - 10	65° - 85°	4 (peat pots)	
Eggplant	6 - 10	65° - 85°	6 - 9	
Lettuce	6 - 8	50° - 65°	3 - 5	
Melons	6 - 8	65° - 85°	3 - 4 (peat pots)	
Onion	7 - 10	65° - 85°	8	
Parsley	15 - 21	50° - 85°	8	
Peas	6 - 10	50° - 65°	1	
Pepper	9 - 14	65° - 85°	6 - 8	
Radish	3-6	50° - 65°	1	
Spinach	7 - 12	50° - 65°	1	
Squash	4 - 6	65° - 85°	3 - 4 (peat pots)	
Tomato	6 - 12	65° - 85°	5 - 7	
Turnip	4 - 8	50° - 65°	1	

<sup>1</sup> transplants not recommended

When planting the fall garden in midsummer, the soil will be warm and dry. Therefore, cover the seeds 6 to 8 times their diameter. They may need to be watered regularly with a sprinkler or a sprinkling can to promote germination. Moisture can also be retained with a shallow mulch or by covering the row with a board until the seeds are up. Pre-sprouting is a useful technique for planting in cold soils, as well. However, seed must be handled very carefully once sprouted to prevent damaging new root tissue.

#### **Row Planting**

A string stretched between stakes will provide a guide for nice straight rows, if desired. Use a hoe handle, a special furrow hoe, or a grub hoe to make a furrow of the appropriate depth for the seed being planted. Sow seed thinly; it may help to mix very small seed with coarse sand to distribute the seeds more evenly. Draw soil over the seed, removing stones and large clods. Firming soil over seeds improves uptake of soil moisture, hastening germination. Water the seeds in to improve soil/seed contact. When plants have grown to 4 to 6 inches tall, thin according to seed packet instructions to provide adequate room for growth.

## **Broadcast Planting**

Many crops may be sown in wide rows or beds instead of in long, single rows. Crops such as spinach, beans, peas, beets, lettuce, and carrots are especially suited to this type of culture. Sow seed evenly over the area, then rake it in. Firm soil over the seeds. Thin young plants to allow room for growth.

# Hill Planting

Larger vegetables such as melons, squash, corn, and cucumbers may be planted in hills. Soil is mounded to a foot or so in diameter, at the recommended spacing. Plant 4 to 6 seeds per hill, firming the soil well. Thin the seedlings to 3 to 5 plants per hill.



# **Transplants for the Garden**

Most gardeners use transplants in the garden at some time or another to give long season plants a chance to grow to maturity under their preferred weather conditions, or just to lengthen the harvest season.

Due to the amount of time, attention and need for controlled growing conditions, many gardeners prefer to purchase plants for their gardens. However, for a larger choice in varieties and the control of plant production from seed to harvest, others choose to start their own.

## **Annual Plants**

Transplants of annual vegetables and flowers should be stocky, healthy, free from disease, and have good roots. They should not be too small or too mature. Be sure plants have been hardened-off so that they will easily adapt to environmental change, but they should not be so hardened that they are woody and yellow. Successful transplanting is achieved by interrupting plant growth as little as possible. This is one of the advantages of using peat pots or peat pellets, which do not have to be removed when transplanting.

Have garden soil prepared before transplanting. All additives which require time to break down, such as manures, limestone, rock fertilizers, and green manures, should be incorporated several weeks before planting. Quick-acting lime and fertilizers and well-decayed compost may be added just before planting.

Transplant on a shady day, in late afternoon, or in early evening to prevent wilting. It helps to water the plants several hours before transplanting; when using bare-root plants, soak the roots thoroughly an hour or two before setting them out in the garden. They should not be allowed to dry out completely at any time. Handle plants carefully. Avoid disturbing the roots or bruising the stems.

Dig a hole large enough to hold the roots of the plants. Set the plants slightly deeper than previously planted and at recommended intervals. Press soil firmly around the roots of transplants. Pour about a cup of starter solution in the hole around the plant. Use a solution of about half the strength recommended for that type of plant during the normal growing season. Fish emulsion or diluted manure tea may also be used. For a few days after transplanting, protect the plants from wind and sun by placing newspaper or cardboard on their south sides, or by covering with jugs, baskets, or flower pots. Water the plants once or twice during the next week if there is insufficient rain.

#### **Perennial Plants**

When buying small fruit plants and perennial crowns such as asparagus, order early or buy from reliable local outlets. Discount department stores often allow plants to dry up, so watch for this, especially if you are buying sale plants. Select varieties that will do well in your growing conditions. For perennial plants, it will pay to do some research to find out what the major disease and insect pests are and buy resistant varieties. Dormant, bareroot plants and 1- or 2-year-old crowns are preferred. Look for roots that are full, slightly moist, and have color. Roots that are dry brown or soggy black are indicative of poor storage and will probably not give good results. Check crowns for signs of viable buds. Inspect plants for signs of insects or disease. If you receive plants by mail which are not satisfactory, do not hesitate to send them back.

Once you have the plants, keep the roots moist (but not soaking wet) by misting occasionally, and do not allow them to freeze or be exposed to high temperatures. If it is necessary to keep the crowns for more than a few days, place in cold storage (not freezing) or else heel in a trench of moist soil in a shaded location. Pack soil firmly against roots to eliminate any air pockets.

Transplant crowns according to directions, digging holes large enough to give the roots plenty of room to spread. Remove any roots which are discolored or dried out. Perennial plants appreciate a dose of compost mixed into the bottom of the hole.

Once transplanted, shade the plants if necessary and water when needed. Extra care at the beginning of their growth will result in productive, healthy plants.

# **Transplant Production Data**

Easily Survive Transplanting	Require Care in the Operation	Not Successfully Transplanted by Usual Methods
Broccoli	Beets	Beans
Cabbage	Carrots (young)	Peas
Cauliflower	Celery	
Eggplant	Chard	
Lettuce	Melon	
Chinese cabbage	Squash	
Onion	Corn	
Tomatoes		
Pepper		

(Ease of transplanting)

# Irrigating the Home Garden

Adequate soil moisture is essential for good crop growth. A healthy plant is composed of 75% to 90% water, which is used for the plant's vital functions, including photosynthesis, support (rigidity), and transportation of nutrients and sugars to various parts of the plant. During the first 2 weeks of growth, plants are becoming established and must have water to build their root systems.

While growing, vegetable crops need about an inch of water per week in the form of rainwater, irrigation water, or both, from May to September. Keep a rain gauge near the garden or check with the local weather bureau for rainfall amounts, then supplement rainfall with irrigation water if needed. There are ways, however, to reduce the amount of water you have to add.

During dry periods, one thorough watering each week of 1 to 2 inches of moisture (65 to 130 gallons per 100 square feet) is usually enough for most soils. Soil should be wetted to a depth of 5 to 6 inches each time you water and not watered again until the top few inches begin to dry out. Average garden soil will store about 2 to 4 inches of water per foot of depth.

#### **Reducing Water Demands**

All of this water, however, may not be available to plants, particularly if the soil is a heavy clay. Clay particles hold soil moisture tightly. If, for example, there are 4½ inches of water per foot of this type of soil, there may be as little as 1½ inches available for plants. A relatively high level of humus in the soil, brought about by the addition and breakdown of organic matter, can improve this proportion to some extent. By causing clay particles to form aggregates or large clumps of groups of particles, humus also adds air spaces to tight clays, allowing moisture to drain to lower levels as a reserve, instead of puddling and running off the top of the soil.

The moisture-holding capacity of sandy soils is also improved by the addition of organic matter. Though most soil water in sandy soil is available, it drains so quickly that plants are unable to reach water after even a few days following a rain. Humus in sandy soil gives the water something to cling to until it is needed by plants. Addition of organic matter is the first step in improving moisture conditions in the garden.

Mulching is a cultural practice which can significantly decrease the amount of water that must be added to the soil. A 6 to 8 inch organic mulch can reduce water needs by as much as ½ by smothering weeds (which take up and transpire moisture) and by reducing evaporation of moisture directly from the soil. Organic mulches themselves hold some water and increase the humidity level around the plant. Black plastic mulch also conserves moisture.

Shading and the use of windbreaks are other moisture-conserving techniques. Plants that wilt in very sunny areas can benefit from partial shade during the afternoon in summer. Small plants, in particular, should be protected. Air moving across a plant carries away the moisture on the leaf surfaces, causing the plant to need more water. In very windy areas, the roots often cannot keep up with leaf demands, and plants wilt. Temporary or permanent windbreaks can help tremendously.

During those times when cultural practices simply aren't enough, when rainfall is sparse and the sun is hot, watering can benefit the garden with higher yields, or may save the garden altogether in severe drought years. Irrigation practices, when properly used, can benefit the garden in many ways:

- Aids in seed emergence.
- Reduces soil crusting.
- Improves germination and plant stand.
- Reduces wilting and checking of growth in transplants.
- Increases fruit size of tomato, cucumber, and melon.
- Prevents premature ripening of peas, beans, and sweet corn.
- Maintains uniform growth.
- Improves the quality and yields of most crops.

#### **Irrigation Methods**

The home gardener has several options for applying water to plants - a watering sprinkler can, a garden hose with a fan nozzle or spray attachment, portable lawn sprinklers, a perforated plastic soaker hose, drip or trickle irrigation, or a semi-automatic drip system. Quality equipment will last for a number of years when properly cared for. When deciding on which type of watering equipment to use there are a number of things to consider.

Several types of drip or trickle equipment are available. The soaker hose is probably the least expensive and easiest to use. It is a fibrous hose that allows water to seep out all along its length at a slow rate. There are also hoses with holes in them that do basically the same thing; water drips out the holes. With the latter type, a flow regulator usually has to be included with the system so that water can reach the end of the hose, yet not be sprayed out at full force. A special double-wall type of irrigation hose has also been developed which helps to maintain an even flow. Finally, there is the emitter type system, best used for small raised-bed or container gardens, in which short tubes, or emitters, come off a main water supply hose; emitters put water right at the roots of the desired plants. This is generally the most expensive form of irrigation and the most complex to set up, but it has the advantage that the

weeds in the area are not watered, and evaporation from the soil is minimized. This type of system is best used in combination with a coarse mulch or black plastic. Drip systems generally have some problems with clogging from soil particles and/or mineral salts from water taken from springs or wells. New designs take into consideration the clogging problem; some include filters and selfflushing emitters. It is wise to make a complete investigation and comparison before purchasing a drip irrigation system.

# Some basic techniques and principles for watering:

- Adjust the flow or rate of water application to about ½ inch per hour. Much faster than this will cause run-off, unless the soil has exceptionally good drainage. To determine the rate for a sprinkler, place small tin cans at various places within the sprinkler's reach, and check the level of water in the cans at 15 minute intervals.
- When using the oscillating type of lawn sprinklers, place the sprinkler on a platform higher than the crop to prevent water from being diverted by plant leaves and try to keep the watering pattern even by frequently moving the sprinkler, overlapping about ½ of each pattern.
- 3. Do not get foliage wet in the evening; this can encourage diseases. Morning watering is pre-ferred.
- 4. Perforated plastic hoses or soaker hoses should be placed with holes down (if there are holes) along one side of the crop row or underneath mulch. Water is allowed to soak or seep into the soil slowly.
- 5. It is best to add enough water to soak the soil to a depth of 5 to 6 inches. It takes approximately 2/3 gallon of water for each square foot or 65 to 130 gallons for 100 square feet of garden area. This varies with the nature of the soil. Frequent, light waterings will only encourage shallow rooting which will cause plants to suffer more quickly during drought periods, especially if mulches are not used. On the other hand, too much water, especially in poorly drained soils, can be as damaging to plant growth as too little water.

6. By knowing the critical watering periods for selected vegetables, you can reduce the amount of supplemental water you add. This can be important where water supplies are limited. In general, water is most needed during the first few weeks of development, immediately after transplant, and during development of edible storage organs.

Specifically, the critical watering periods for selected vegetables are:

Asparagus	Spear production, fern development	
Broccoli	Head development	
Cabbage	Head development	
Cauliflower	Head development	
Beans	Pod filling	
Carrot	Seed emergence, root development	
Corn	Silking, tasseling, ear development	
Cucumber	Flowering, fruit development	
Eggplant	Flowering, fruiting	
Lettuce	Head development; moisture should be constant	
Melons	Flowering, fruit development	
Peas	Pod filling	
Tomato	Flowering, fruiting	

7. In areas prone to repeated drought, look for drought-resistant varieties when buying seed or plants.

# Fertilizing the Garden

The amount of fertilizer to apply to a garden depends on the natural fertility of the soil, the amount of organic matter present, the type of fertilizer used, and the crop being grown. The best way to determine fertilizer needs is to have the soil tested. Soil testing is available through your local Extension agent, and with soil test kits which can be purchased from garden shops and catalogs. Vegetables fall into three main categories according to their fertilizer requirements: heavy feeders, medium feeders, and light feeders. It may be advantageous to group crops in the garden according to their fertilizer requirements to make application easier. For a complete discussion of fertilizers, refer to the Soils chapter.

# Weed Control in the Garden

The old saying, "One year's weed - seven years' seed," contains more truth than myth, as most gardeners soon learn. Weeds (some native and some introduced) are remarkably adapted to conditions in the area where they grow, usually much more so than the imported cultured vegetables we prize so highly for food. Many weeds which would otherwise not be growing in a lawn or natural area appear to spring up as if by magic when the soil is cultivated. Weed seeds may remain viable for those 7 (or more) years when conditions are not right for their growth. Then, brought to the surface by tilling, and uninhibited by sod, shade, or other factors, they germinate and become the pests that take water, nutrients, sunlight, and space from vegetable plants.

#### **Beneficial Weeds**

Many plants considered weeds in the garden have positive attributes. Some, such as morning glory, and even thistles, have flowers that rival those intentionally planted in flower beds. In fact, seeds of some weeds are sold by seed companies as flowering plants.

Other native plants are edible, providing nutritious variety to the regular diet: dandelions, purslane, chickweed, cress, mustards, and lamb's quarters all offer greens; blackberries produce sweet fruits; Jerusalem artichokes, or sunchokes, are nothing but the tubers of the native sunflower. Before attempting to eat wild plants, be sure that you have properly identified them. A course from a person knowledgeable about wild edibles is probably the best way to learn; books often do not make fine distinctions between edible and non-edible wild plants. Weeds are often a habitat for various insects, some of which are beneficial to the garden. They provide shelter, pollen, and nectar for such insects as bees and predators of garden pests, such as praying mantis.

Wild plants also have other virtues. Parts of some plants are used in natural dyes and other homemade products. Weeds can be a good source of nitrogenous materials for the compost pile if pulled before flowering. Many have long roots which bring elements from the subsoil into their above-ground tissues; when the weeds are pulled or tilled and allowed to decay in the garden, these elements are made available to other plants. Finally, the presence of some native plants can indicate certain soil problems, e.g., deficiencies, pH changes, soil compaction, etc. A small number of books are available with detailed information on this subject.

#### **Control Methods**

Despite all this goodness, most gardeners won't tolerate weeds in their vegetable plots. Perhaps it is an overreaction to the first garden he or she allowed to go completely to weeds or perhaps it's the unruly appearance of weeds. This may be a sensible approach. If one doesn't have time to ruthlessly destroy morning glory vines after enjoying the first few flowers and before they go to seed, the garden will soon become one glorious display of morning glories and little else.

#### **Cultivation:**

There are several ways to rid the garden of most problem plants. Since mature weeds extract large quantities of moisture and nutrients from the soil, it is more beneficial (and easier) to remove weeds when they are young and tender. Handpulling and digging are okay for small gardens and raised beds. Those with larger spaces usually prefer at least a hoe. There are manual-powered rotary cultivators that do a good job on long rows and pathways as long as the soil is not too wet or dry and the weeds are small. In large gardens, a rotary tiller of appropriate size makes the work easy and fast, but it is not the most pleasant chore to get behind a smoky, noisy engine on a hot summer day. Manual and powered rotary cultivators are usually unable to turn under weeds very close to vegetable plants without damaging the vegetables. Hand-pulling or hoeing with a light touch are best for removing weeds near vegetable plants. Deep cultivation with any instrument is likely to damage roots or stems of crop plants.

Turning under weeds, especially before they flower, provides organic matter to the soil. Hand-pulled weeds, except for rhizomatous grasses, may be laid on top of the soil to dry out and will eventually have the same effect. However, if rain is predicted in the area within a day or two, it's best to collect the weeds and add them to the compost pile; rain will wash soil around the roots and some weeds will survive. If weeds have started to go to seed, leaving them in the garden is not a good idea. Composting may not destroy weed seeds if the pile doesn't heat up enough after the weeds are added. Grasses that spread by rhizomes or stolons for example, quackgrass also present a problem if not completely dried up. In these cases, despite their potential value as organic material, it's better to let the trash collectors take the weeds. or burn them and spread the ashes in the garden (if local ordinances permit). Reducing weed growth around the garden by mowing or other means will also help prevent the spread of weeds and seeds to the garden area.

Cultivation is best done when the soil is somewhat moist, but not wet. Working wet soil will change the structure, especially of heavy soils. When it is too dry, weeds are difficult to pull and hoeing is also hard. A day or two after a rain or irrigation is probably the best time to cultivate. If you have a choice, remember that the work will be much more pleasant in the cool temperatures of early morning or evening. On hot summer afternoons, you are likely to fatigue more easily, get a sunburn, or suffer from sun poisoning, sunstroke, or worse. Wear protective clothing if you must work when it's sunny, and stop frequently for rest and refreshment. Controlling weeds when they are small will greatly reduce labor.

#### **Mulching:**

Mulching can be an alternative to weeding if you have a reliable source of mulching materials. Thick layers of organic mulch will not allow most annual weeds to poke through, and those that do are usually easily pulled. Weeds with runners are often not so easily controlled, and black plastic may be a better choice where these prevail. For paths, newspaper, old carpeting, or other such materials, covered with sawdust, will provide excellent weed suppression.

#### **Close Spacing:**

Once vegetable plants are established, if they have been planted close enough to each other, they will shade the soil and prevent the growth of many weed seedlings. This is the effect achieved by a well-planned raised bed, in which plants are spaced so that the foliage of adjacent plants touches and forms a closed canopy at a mature growth stage.

#### **Other Practices:**

Some gardeners are experimenting with various types of no-till gardening to reduce weed problems and prevent erosion and moisture loss. The standard farm no-till practice of sowing a fall cover crop and then killing it with a herbicide, and planting vegetables in the dead sod, after a recommended waiting period, is one method. However, there are no herbicides recommended for use in established home vegetable gardens to kill emerged weeds at the present time. Use of weed-killers normally recommended for lawns or other areas is not advised, and until a safe herbicide is available for growing weeds, this type of no-till practice is unsafe for growing vegetables in the home garden. One alternative is the use of a living sod, mowed regularly, which has many of the benefits of no-till and does not necessitate the use of herbicides. This practice works best with raised beds, so that only the paths need to be mowed.

The use of cover crops over several seasons or years in a particularly weedy section can also reduce weed problems. However, this method requires leaving that part uncultivated, reducing gardening space. Cover crops must also be mown or harvested regularly, which can be timeconsuming and/or difficult without appropriate tools. Investigate crop rotations thoroughly before using them to control weeds. All of the above techniques are still in the experimental stage for home gardeners. Try them in small sections of the garden to determine their effectiveness.

# **Planting Guide**

The Vegetable Planting Guide can be used to determine the approximate proper amount of crop to plant for the desired yield, the amount of seed or transplants required for that amount of crop, and proper spacing between plants in a row.

In intensive, raised-bed gardens, use the in-row figures between all plants; i.e., use equidistant spacing between plants. Sow seeds to a depth 3 to 5 times the diameter of the seed. For mid-summer plantings, sow up to twice this depth.

Crop	Suggested	Seeds or	eeds or Planting Dis		Depth of	Average Planting
	feet of row or amount per person⁵	plants (P) per 100 ft of row	Between Rows	BetweenPlants or Hills (H)	Planting (Inches)	Date in New Hampshire⁴
Asparagus	15-20	60-70 (P)	36-48	18	6-8	April 20-May 15
Beans Pole Snap	10 20-30¹	½ lb. 3/4 lb.	36 24	24 (H) 2-4	1 1	May 15-June 15 May 15-July 1
Beets	10-15 <sup>1</sup>	1oz.	12-18	2-3	1/2	April 25-July 1
Broccoli and Brussel Sprouts	5 plants	1/8oz. or 67(P)	24-36	24-30	1/4	May 10- July 1
Cabbage Early Late	5 plants 10 plants	1/8oz. or 67-100 (P)	24-36 24-36	12-18 18-24	1/4 1/4	May 10 July 1
Carrots	50-75 <sup>1</sup>	½0Z.	12-18	2-3	1/2	May 1-July 1
Cauliflower	5	1/8oz. or 67 (P)	24-36	24-30	1/4	May 10-July 1
Swiss Chard	5	1oz.	18-24	6-8	1/2	May 1-July 1
Sweet Corn Early Midseason Late	20 20 20	1/4lb.	24-36	6	1 8 9	May 1-July1
Cucumbers	10-15	1/2oz.	48-72	48 (H)	3/4	May 25-June 15
Eggplant	2 plants	1 pkt. or 67 (P)	24-36	18	1/4	May 25-June 15
Lettuce Head Leaf	5-10 <sup>1</sup> 5 <sup>1</sup>	1/4oz. or 75-100(P) 1/4oz.	12-18 12-18	15-18 6	1/4 1/4	May 1-July 1 May 1-Aug. 1
Melons Muskmelons Watermelons	10-25 10-15	1/2oz. or 60-100(P) 1oz. or 50-60 (P)	72-96 96-144	48 (H) 60 (H)	3/4 3/4	June 1-June 15 June 1-June 15
Onions	10-20	1lb. (sets)	12-18	1-3	1/2	April 20-May 15
Parsnips	5-10	1/2oz.	18-24	2-4	1/2	May 1-May 15

#### Planting Chart for the Home Garden

Сгор	Suggested	Seeds or plants (P)	Planting Dist	Planting Distance (Inches)		Average Planting
	feet of row		Between Rows	BetweenPlants	Planting	Date in
	or amount	per 100 ft		or Hills (H)	(Inches)	New Hampshire <sup>4</sup>
	per person⁵	of row			-	
Peas						
Early & Late	50-150 <sup>1</sup>	1lb.	18-36	1-2	1	April 15-July 15
Peppers	2 plants	1 pkt. or 67 (P)	18-24	18	1/4	Mav 25-June 20
			-	-	-	
Pumpkins <sup>2</sup>	1 hill	1oz.	36	48 (H)	1	May 25-June 10
Radishes	5 <sup>1</sup>	1oz.	112-18	1	1/2	April 15-Aug. 15
Rhubarb	5-10	40-50 (P)	48	24-30	2-3	April 20-May 15
Rutabagas	10-20	1/4oz.	18-24	6-8	1/2	June 1-July 1
Spinach	25¹	1oz.	12-18	3-4	1/2	April 10-May 10
Squash <sup>2</sup>						
Summer	1 hill	1oz.	36	48 (H)	1	May 25-July 1
Winter	20-30	1oz.	72-96	72 (H)	1	May 25-June 10
Tomatoes	15 plants <sup>3</sup>	1 pkt. or 25-67(P)	24-48	18-36	1/4	May 25-June 10

<sup>1</sup> Make two or more plantings or plant early, midseason, and late varieties at same time. Suggested amount is for each planting.

<sup>2</sup> Planting distance is for bush types. If large vine types are planted, allow more space.

<sup>3</sup> If only early varieties are planted, allow 15 plants per person. If main crop varieties are grown, plant 8-10 plants per person.

<sup>4</sup> The exact date may vary with the season, soil type and local planting conditions.

<sup>5</sup> Assuming you freeze, store and can vegetables at home, these are the vegetable needs per person.

# **Intensive Gardening Methods**

The purpose of an intensively grown garden is to harvest the most produce possible from a given space. More traditional gardens consist of long, single rows of vegetables spaced widely apart. Much of the garden area is taken by the space between the rows. An intensive garden reduces wasted space to a minimum. The practice of intensive gardening is not just for those with limited garden space; rather, an intensive garden concentrates work efforts to create an ideal plant environment, giving better yields with less labor.

Though its benefits are many, the intensive garden may not be for everyone. Some people enjoy the sight of long, straight rows in their gardens. Others prefer machine cultivation to hand weeding; though there is often less weeding to do in intensive plantings because of fewer pathways and closely spaced plants, the weeding that must be done is usually done by hand or with hand tools. Still other gardeners like to get their gardens planted in a very short period of time and have harvests come in all at once. The intensive ideal is to have something growing in every part of the garden at all times during the growing season.

A good intensive garden requires early, thorough planning to make the best use of time and space in the garden. Interrelationships of plants must be considered before planting, including nutrient needs, shade tolerance, above- and below-ground growth patterns, and preferred growing season. Using the techniques described below, anyone can develop a high-yielding intensive garden.

#### The Raised Bed

The raised bed or growing bed is the basic unit of an intensive garden. A system of beds allows the gardener to concentrate soil preparation in small areas, resulting in effective use of soil amendments and creating an ideal environment for vegetable growth.



Beds are generally 3 to 4 feet wide and as long as desired. The gardener works from either side of the bed, reducing the incidence of compaction caused by walking on the soil.

Soil preparation is the key to successful intensive gardening. To grow so close together, plants must have adequate nutrients and water. Providing extra synthetic fertilizers and irrigation will help, but there is no substitute for deep, fertile soil high in organic matter. Humus-rich soil will hold extra nutrients, and existing elements that are "locked up" in the soil are released by the actions of earthworms, microorganisms and acids present in a lifefilled soil, making them available for plant use.

If your soil is not deep, double-dig the beds for best results. Remove the top 12 inches of soil from the bed. Insert a spade or spading fork into the next 10 to 12 inches of soil and wiggle the handle back and forth to break up compacted layers. Do this every 6 to 8 inches in the bed. Mix the top soil with a generous amount of compost or manure, and return the mixture to the bed. It should be somewhat fluffy and may be raised slightly. To create a true raised bed, take topsoil from the neighboring pathways and mix it in as well.

This is a lot of work! Try it in one or two beds for some of your most valuable plants; if you like the results you can proceed to other beds as you have time. One nice thing about raised bed gardening is that it breaks work into units. Instead of gazing desperately at a garden full of weeds, thinking you'll never have time to clean it up, you can look at each bed and say, "I can do that in half an hour today!" Other chores are accomplished with the same ease.

By their nature, raised beds are a form of wide-bed gardening, a technique by which seeds and transplants are planted in wide bands of several rows or broadcast in a wide strip. In general, the goal is to space plants at equal distances from each other on all sides, such that leaves will touch at maturity. This saves space, and the close plantings reduce moisture loss from surrounding soil.

## **Vertical Gardening**

The use of trellises, nets, strings, cages, or poles to support growing plants constitutes vertical gardening. This technique is especially suited, but not limited, to gardeners with a small garden space. Vining and sprawling plants, such as cucumbers, tomatoes, melons, and pole beans are obvious candidates for this type of gardening. Some plants entwine themselves onto the support, while others may need to be tied. Remember that a vertical planting will cast a shadow, so beware of shading sun-loving crops, or take advantage of the shade by planting shade-tolerant crops near the vertical ones. Plants grown vertically take up much less space on the ground, and though the yield per plant may be (but is not always) less, the yield per square foot of garden space is much greater. Because vertically growing plants are more exposed, they dry out faster and may need to be watered more frequently than if they were allowed to spread over the ground. This fast drying is also an advantage to those plants susceptible to fungus diseases. A higher rate of fertilization may be needed, and soil should be deep and well-drained to allow roots to extend vertically rather than compete with others at a shallow level.





#### Interplanting

Growing two or more types of vegetables in the same place at the same time is known as interplanting. Proper planning is essential to obtain high production and increased quality of the crops planted. This technique has been practiced for thousands of years, but is just now gaining widespread support in this country. To successfully plan an interplanted garden the following factors must be taken into account for each plant: length of the plant's growth period, its growth pattern (tall, short, below or above ground), possible negative effects on other plants (such as the allelopathic effects of sunflowers and Jerusalem artichokes on nearby plants), preferred season, and light, nutrient and moisture requirements. Interplanting can be accomplished by alternating rows within a bed (plant a row of peppers next to a row of onions), by mixing plants within a row, or by distributing various species throughout the bed. For the beginner, alternating rows may be the easiest to manage at first.

Long-season (slow to mature) and short-season (quick to mature) plants like carrots and radishes, respectively, can be planted at the same time. The radishes are harvested before they begin to crowd the carrots. An example of combining growth patterns is planting smaller plants close to larger plants, radishes at the base of beans or broccoli. Shade tolerant species like lettuce, spinach, and celery may be planted in the shadow of taller crops. Heavy feeders, such as cabbage family crops, should be interplanted with less gluttonous plants.

Interplanting can help keep insect and disease problems under control. Pests are usually fairly crop-specific; that is, they prefer vegetables of one type or family. Mixing families of plants helps to break up large expanses of the pest-preferred crop, helping to contain early pest damage within a small area, thus giving the gardener a little more time to deal with the problem. One disadvantage is that when it does come time to spray for pests, it's hard to be sure that all plants are protected.

# Spacing

Individual plants are closely spaced in a raised bed or interplanted garden. An equidistant spacing pattern calls for plants to be the same distance from each other within the bed; that is, plant so that the center of one plant is the same distance from plants on all sides of it. In beds of more than two rows, this means that the rows should be staggered so that plants in every other row are between the plants in adjacent rows. The distance recommended for plants within the row on a seed packet is the distance from the center of one plant to the center of the next. This results in an efficient use of space and leaves less area to weed and mulch. The close spacing tends to create a nearly solid leaf canopy. acting as a living mulch, decreasing water loss, and keeping weed problems down. However, plants should not be crowded to the point at which disease problems arise or competition causes stunting.

# **Succession and Relay Planting**

Succession planting is an excellent way to make the most of an intensive garden. To obtain a succession of crops, plant something new in spots vacated by spent plants. Early sweet corn after peas is a type of succession.

Planting a spring, summer, and fall garden is another form of succession planting. Cool season crops (broccoli, lettuce, peas) are followed by warm season crops (beans, cucumbers, etc).

Relaying is another common practice, consisting of overlapping plantings of one type of crop. For instance, sweet corn may be planted at 2-week intervals for a continuous harvest. This requires some care, though; crops planted very early are likely to get a slower start because of low temperatures. In the case of corn, it can be disastrous to have two varieties pollinating at the same time, as the quality of the kernels may be affected. Give early planted corn extra time to get started, for best results. Another way to achieve the same result is to plant, at once, various varieties of the same vegetable; for example, you can plant an early-season, a mid-season, and a late-season corn at the same time and have a lengthy harvest.

Starting seeds indoors for transplanting is an important aspect of intensive gardening. To get the most from the garden plot, a new crop should be ready to take the place of the crop being removed. Several weeks may be gained by having 6-inch transplants ready to go into vacated areas. Don't forget to recondition the soil for the new plants.

# Planning an Intensive Garden

Begin planning your garden early. In January or February, when the cold days of winter seem neverending, pull out last-year's garden records and dig into the new seed catalogs. As with any garden, you must decide what crops you want to grow based on your own likes and dislikes, as well as how much of each you will need. An account of which cultivars were most successful or tasted best is helpful in making crop choices. Use the charts below, and your own experience, to determine which crops are likely combinations.

Good gardening practices such as watering, fertilizing, crop rotation, composting, and sanitation are especially important in an intensive garden. An intensive garden does require more detailed planning, but the time saved in working the garden and the increased yields make it well worthwhile. Use your imagination and have fun!

#### Intensive Spacing Guide

Note: To determine spacing for interplanting, add the inches for the two crops to be planted together, and divide the sum by 2. For example, if radishes are planted next to beans, add 2 inches + 4 inches = 6 inches, then divide 6 inches by 2 inches = 3 inches. The radishes should be planted 3 inches from the beans.

Plant	Inches	Plant	Inches
Asparagus	15-18	Lettuce, head	10-12
Beans, pole	6-12	Lettuce, leaf	4-6
Beans, bush	4-6	Melons	18-24
Beets	2-4	Mustard	6-9
Broccoli	12-18	Onion	2-4
Brussels sprouts	15-18	Peas	2-4
Cabbage	15-18	Peppers	12-15
Cabbage, Chines	se10-12	Potatoes	10-12
Carrots	2-3	Pumpkins	24-36
Cauliflower	15-18	Radishes	2-3
Cucumber	12-18	Rutabaga	4-6
Chard, Swiss	6-9	Spinach	4-6
Collards	12-15	Squash, summer	18-24
Endive	15-18	Squash, winter	24-36
Eggplant	18-24	Sweet corn	15-18
Kale	15-18	Tomatoes	18-24
Kohlrabi	6-9	Turnip	4-6
Leeks	3-6		

#### **Plants Grouped According to Nutrient Needs**

Heavy Feeders	Light Feeders	Soil Builders
Asparagus	Carrot	Alfalfa
Beet	Garlic	Beans, broad
Broccoli	Leek	Beans, snap
Brussels sprouts	Mustard greens	Clover
Cabbage	Onion	Peas
Cantaloupe	Parsnip	
Pepper	Celery	
Collard	Rutabaga	
Shallot	Cucumber	
Eggplant	Turnip	
Endive		
Kale		
Kohlrabi		
Lettuce		
Parsley		
Pumpkin		
Rhubarb		
Spinach		
Squash, summer		
Squash, winter		
Strawberry		
Sunflower		
Tomato		
Watermelon		

#### **Economic Value of Crops**

It is difficult to evaluate the economic value of crops grown in the vegetable garden due to the different lengths of time they require for maturity and harvest, the availability of varieties and vegetables types not generally found in the marketplace, and the lack of comparison values for vegetables that are not acceptable by commercial standards (cracked tomatoes, crooked cucumbers, etc.), but which are perfectly usable by the gardener. Nevertheless, several studies have attempted to determine which crops bring the most value per square foot of garden space, partly to aid small-space gardeners in making decisions about what to plant. Of course, if no one in the family likes beets, there is no point in growing them just because they are economically valuable, but this list may help you determine

#### Top 15 Vegetables in Economic Value<sup>1</sup>:

Tomatoes	Beets
Green bunching onions	Cucumbers
Carrots	Peppers
Leaf lettuce	Broccoli
Swiss Chard	Head Lettuce
Summer squash	Turnips (greens&roots)
Edible pod peas	Beans (pole, bush)

Onion storage bulbs

<sup>1</sup> Values based on pounds produced per square foot, retail value per pound at harvest time, and length of time in the garden.

#### Low-Value Crops:

(not recommended for small spaces) Corn Squash Melons Pumpkins Miniature varieties or trellising may increase value per square foot.

# **Container Gardening**

If you don't have space for a vegetable garden, or if your present site is too small, consider raising fresh, nutritious, homegrown vegetables in containers. A window sill, patio, balcony, or doorstep can provide sufficient space for a productive container garden. Problems with soil-borne diseases, nematodes, or poor soil can also be overcome by switching to container gardening.


Growing vegetables that take up little space, such as carrots, radishes and lettuce, or crops that bear fruits over a period of time, such as tomatoes and peppers, for best use of space and containers. Dwarf or miniature varieties often mature and bear fruit early, but most do not produce as well overall as standard varieties. With increasing interest in container gardening, plant breeders and seed companies are working on vegetables specifically bred for container culture. These varieties are not necessarily miniatures or dwarf and may produce as well as standard types if properly cared for.

The amount of sunlight that your container garden spot receives may determine which crops can be grown. Generally, root crops and leaf crops can tolerate partial shade, but vegetables grown for their fruits generally need at least 8 hours of full, direct sunlight each day, and perform much better with 10 to 12 hours. Available light can be increased somewhat by providing reflective materials around the plants, e.g., aluminum foil, white-painted surfaces, marble chips.

Container gardening lends itself to attractive plantscaping. A dull patio area can be brightened by the addition of baskets of cascading tomatoes or a colorful herb mix. Planter boxes with trellises can be used to create a cool shady place on an apartment balcony. Container gardening presents opportunities for many innovative ideas.

#### **Containers**

There are many possible containers for gardening. Clay, wood, plastic, metal are some of the suitable materials. Containers for vegetable plants must (1) be big enough to support plants when they are fully grown, (2) hold soil without spilling, (3) have adequate drainage, and (4) never have held products that would be toxic to plants or people. Consider using barrels, cut-off milk and bleach jugs, window boxes, baskets lined with plastic (with drainage holes punched in it), even pieces of drainage pipe or cement block. If you are building a planting box out of wood, you will find redwood and cedar to be the most rot-resistant, but bear in mind that cedar trees are much more plentiful than redwoods. Wood for use around plants should never be treated with creosote or pentachlorophenol (Penta) wood preservatives. These may be toxic to plants and harmful to people as well.

Some gardeners have built vertical planters out of wood lattice lined with black plastic and then filled with a lightweight medium; or out of welded wire, shaped into cylinders, lined with sphagnum moss, and filled with soil mix.

Depending on the size of your vertical planter, 2inch diameter perforated plastic pipes may be needed inside to aid watering.



Whatever type of container you use, be sure that there are holes in the bottom for drainage so that plant roots do not stand in water. Most plants need containers at least 6 to 8 inches deep for adequate rooting.

As long as the container meets the basic requirements described above it can be used. The imaginative use of discarded items or construction of attractive patio planters is a very enjoyable aspect of container gardening. For ease of care, dollies or platforms with wheels or casters can be used to move the containers from place to place. This is especially useful for apartment or balcony gardening so that plants can be moved to get maximum use of available space and sunlight, and to avoid destruction from particularly nasty weather.

#### Media

A fairly lightweight potting mix is needed for container vegetable gardening. Soil straight from the garden usually cannot be used in a container because it may be too heavy, unless your garden has sandy loam or sandy soil. Clay soil consists of extremely small (microscopic) particles. In a container, the bad qualities of clay are exaggerated. It holds too much moisture when wet, resulting in too little air for the roots, and it pulls away from the sides of the pot when dry. Container medium must be porous in order to support plants, because roots require both air and water. Packaged potting soil available at local garden centers is relatively lightweight and may make a good container medium. Soilless mixes such as peat-lite mix are generally too light for container vegetable gardening, not offering enough support to plant roots. If the container is

also lightweight, a strong wind can blow plants over, resulting in major damage. Also, soilless mixes are sterile and contain few nutrients, so even though major fertilizers are added, no trace elements are available for good plant growth. Add soil or compost if you wish to use a sterile mix. For a large container garden, the expense of prepackaged or soilless mixes may be quite high. Try mixing your own with one part peat moss, one part garden loam, and one part clean, coarse (builder's) sand, and a slow-release fertilizer (14-14-14) according to container size. Lime may also be needed to bring the pH to around 6.5. In any case, a soil test is helpful in determining nutrient and pH needs, just as in a large garden.

#### Planting

Plant container crops at the same time you would if you were planting a regular garden. Fill a clean container to within  $\frac{1}{2}$  inch of the top with the slightly damp soil mixture. Peat moss in the mix will absorb water and mix much more readily if soaked with warm water before putting the mix in the container. Sow the seeds or set transplants according to instructions on the seed package. Put a label with the name, variety, and date of planting on or in each container. After planting, gently soak the soil with water, being careful not to wash out or displace seeds. Thin seedlings to obtain proper spacing when the plants have two or three leaves. If cages, stakes, or other supports are needed, provide them when the plants are very small to avoid root damage later.

#### Watering

Pay particular attention to watering container plants. Because the volume of soil is relatively small, containers can dry out very quickly, especially on a concrete patio in full sun. Daily or even twice daily watering may be necessary. Apply water until it runs out the drainage holes. On an upstairs balcony, this may mean neighbor problems, so make provisions for drainage of water. Large trays filled with coarse marble chips work nicely. However, the soil should never be soggy or have water standing on top of it. When the weather is cool, container plants may be subject to root rots if maintained too wet. Clay pots and other porous containers allow additional evaporation from the sides of the pots and watering must be done more often. Small pots also tend to dry out more quickly than larger ones. If the soil appears to be getting excessively dry (plants wilting every day is one sign), group the containers together so that the foliage creates a canopy to help shade the soil and keep it cool.

On a hot patio, you might consider putting containers on pallets or other structures that will allow air movement beneath the pots and prevent direct contact with the cement. Check containers at least once a day, and twice on hot, dry, or windy days. Feel the soil to determine whether or not it is damp. Mulching and windbreaks can help reduce water requirements for containers. If you are away a lot, consider an automatic drip emitter irrigation system.

#### Fertilizing

If you use a soil mix with fertilizer added, then your plants will have enough nutrients for 8 to 10 weeks. If plants are grown longer than this, add a water-soluble fertilizer at the recommended rate. Repeat every 2 to 3 weeks. An occasional dose of fish emulsion or compost will add trace elements to the soil. Do not add more than the recommended rate of any fertilizer, since this may cause fertilizer burn and kill the plants. Container plants do not have the buffer of large volumes of soil and humus to protect them from over-fertilizing or over-liming. Just because a little is good for the plants does not guarantee that a lot will be better.

#### **General care**

Vegetables grown in containers can be attacked by the various types of insects and diseases that are common to any vegetable garden. Plants should be periodically inspected for the presence of foliage-feeding and fruit-feeding insects as well as the occurrence of diseases. Protect plants from very high heat caused by light reflection from pavement. Move them to a cool spot or shade them during the hottest part of the day. Plants should be moved to a sheltered location during severe rain, hail, or wind storms, and for protection from early fall frosts.

#### Indoor container gardening with vegetables

If you want fresh, home-grown vegetables over the winter, or if you don't have an outdoor space in which you can place containers, it is worth trying some indoor container gardening. Of course you cannot have a full garden in the house, but a bright, sunny window can be the site for growing fresh food all year. Some smallfruited tomatoes and peppers, several types of lettuce, radishes, and many herbs are among the plants you can include in the indoor garden.

Follow directions given above for preparing pots and for watering, fertilizing, etc. However, note that plants will dry out less quickly indoors and will also grow more slowly, needing less fertilizer. To make watering easy it is wise to set the pots in large trays with an inch or two of decorative stones in them. Not only will this prevent your having to move the plants in order to water them, which may discourage you from watering when you should, but it will also provide humidity, which is a major requirement, especially during winter when the house is warm and dry.

As mentioned before, a sunny window, preferably south-facing, is almost a must for indoor vegetable growing. Fruiting vegetables such as tomatoes and peppers will also need supplemental light, such as a combination warm-white/ cool-white fluorescent fixture, during winter months. Insufficient light will result in tall, spindly plants and failure to flower and set fruit.

Herbs are a first choice for many indoor gardeners. Many are less demanding than vegetable plants, and cooks find it pleasant to be able to snip off a few sprigs of fresh parsley or chop some chives from the windowsill herb garden. Chives grow like small onions with leaves about 6 inches tall. These plants prefer cool conditions with good light, but will grow quite well on a windowsill in the kitchen. One or two pots of chives will provide leaves for seasoning salads and soups. Plant seeds in a 6-inch pot. The plants should be about 1 inch apart over the entire surface area. It will require about 12 weeks from the time seeds are planted until leaves can be cut. For variety, try garlic or Chinese chives, which grow in a similar fashion, but have a mild garlic flavor.

Parsley seeds can be planted directly into 6-inch pots, or young, healthy plants can be transplanted from the garden. One vigorous plant per pot is enough. Standard parsley develops attractive, green, curly leaves about 6 or 8 inches tall. Italian, or flat-leaved, parsley has a slightly stronger flavor and is a favorite for pasta dishes. Leaves can be clipped about 10 to 12 weeks after planting the seeds.

Cilantro, or the leaves of the young coriander plant, can be grown in the windowsill garden. Cilantro is used in Oriental and Mexican dishes, but it is not available in most grocery stores and must be used fresh. Grow cilantro as you would parsley. Thyme and other herbs will also grow well indoors if given the right conditions.

The small-fruited varieties of tomatoes such as Tiny Tim, Small Fry, and the paste tomato, Roma, may be raised quite satisfactorily in the home. They will challenge your gardening ability, and supply fruits which can be eaten whole, cooked, or served with salad. The Tiny Tim tomato grows to a height of about 12 to 15 inches. Small Fry, which is about 3 feet tall, and Roma will need more space and should be located on an enclosed porch or in a sun room. Several varieties have been developed for hanging baskets; they may be worth experimenting with.

Some of the small-fruited peppers may be grown as indoor plants. Like tomatoes, they require warm, bright conditions in order to grow well indoors. Fruits will be ready to harvest from peppers and tomatoes about ten weeks after planting. Whiteflies and aphids may present a problem on indoor tomato and pepper plants. Keep a close watch for these pests so they do not get a good start in your planting. Yellow sticky traps, either purchased or homemade, are effective in trapping whiteflies. Insecticidal soap or other pesticide approved for vegetable plants can be used to control aphids. Fortunately, you will be less likely to experience problems with such outdoor pests as tomato hornworms and early blight than you would if plants were outside.

For a quick-growing crop, try radishes. These must be grown very rapidly if they are to be crisp and succulent. Scatter radish seeds on moist soil in a 6-inch pot. Cover with ¼-inch of soil and place a piece of glass or plastic wrap over the pot to conserve moisture until the seeds germinate. Carrots are slower, but can be grown in the same way; use the small-rooted varieties, such as Little Finger, for best results indoors.

Experiment with various types of lettuce. Leaf lettuce and the miniature Tom Thumb butterhead are some to try. Space them according to package directions. Keep lettuce moist and in a very sunny spot.

If light is limited, an old standby for fresh taste and high food value is sprouted seeds. Almost any seeds can be sprouted: corn, barley, alfalfa, lentils, soybeans, rye, peas, radish, mung beans, sunflowers, etc. Use only special seeds for sprouting available from health food or grocery stores to avoid the possibility of getting seeds treated with pesticides. Use any wide-mouthed container such as a Mason or mayonnaise jar. Soak seeds overnight, drain, and place in the container. Cover with a double cheesecloth layer held with rubber bands, or a sprouting lid. Set the container in a consistently warm spot and rinse and drain seeds two or three times daily. In 3 to 5 days, sprouts will be 1 to 3 inches long and ready for harvesting.

## Information for Growing Vegetables in Containers

Vegetable <sup>1</sup>	Light Requirements <sup>2</sup>	Minimum Container Size	<b>Distance (")</b> Plants in Containers	Days from Seed to Harvest	Comments
Beans, bush	FS	2 gal.	2-3	45-60	Several plantings, week intervals
Beets	FS/PS	½ gal.	2-3	50-60	Thin plants when 6-8" tall
Carrots	FS/PS	1 qt.	2-3	65-80	Several plantings, 2-week intervals
Cabbage	FS/PS	3 gal.	12-18	65-120	Requires fertile soil
Chard, Swiss	FS/PS	½ gal.	4-6	30-40	Harvest leaves
Cucumbers	FS	3 gal.	14-18	70-80	Require hot weather, vining types need support
Eggplant	FS	3 gal.	1 plant per	75-100	Requires fertile soil container
Kale	FS/PS	2 gal.	10-15	55-65	Harvest leaves
Lettuce, leaf	PS	½ gal.	4-6	30-35	Harvest leaves
Mustard greens	PS	½ gal.	4-5	35-40	Several plantings 2-week intervals
Onions, green	FS/PS	½ gal.	2-3	70-100	Requires lots of moisture
Peppers, Bell	FS	2 gal.	1 plant per	110-120	Require hot weather container
Squash, summer	FS	3 gal.	1 plant per	50-60	Plant only bush type container
Tomatoes	FS	3 gal.	1 plant per	55-100	Stake and prune or cage container
Tomatoes, cherry	FS	1 gal.	1 plant per	55-100	Helps to stake & prune container
Turnips	FS/PS	3 gal.	2-3	30-60	Harvest roots & leaves

<sup>1</sup>Consult seed catalogs for varieties adapted to container culture

 $^{2}$  FS = Full Sun FS/PS = Full sun; tolerates partial shade PS = Partial shade

## Vegetable Gardening in the Fall Planting for a Fall Harvest

By planning and planting a fall vegetable garden it is possible to have fresh vegetables up to and even past the first frosts. At the time when retail vegetable prices are on the rise, you can be reaping large and varied harvests from your still-productive garden site.

Many varieties of vegetables can be planted in midsummer to late summer for fall harvests. Succession plantings of warm season crops, such as corn and beans, can be harvested until the first killing frost. Cool season crops, such as kale, turnips, mustard, broccoli, cabbage, etc., grow well during the cool fall days and withstand light frosts. Timely planting is the key to a successful fall garden. Refer to the planting chart for latest planting dates.

When planting fall crops, prepare the soil by restoring nutrients removed by spring and summer crops. A light layer of compost or aged manure, or a small application of complete chemical fertilizer will boost soil nutrients in preparation for another crop.

Dry soil may make working the soil difficult and inhibit seed germination during the midsummer period. Plant fall vegetables when the soil is moist after a rain, or water the area thoroughly the day before planting. Seeds may be planted in a shallow trench to conserve moisture. Cover the seeds about twice as deeply as you do in the spring. An old-time trick for germinating seeds in midsummer is to plant the seeds, water them in well, and then place a board over the row until the sprouts just reach the soil surface; at that time remove the board. Plastic will also work, but must be completely anchored so the soil does not dry out underneath or the plastic blow away. An organic mulch on top will help keep soil cool. Mulching between rows can also help keep soil cool and decrease soil drying. In severe hot weather a light, open type of mulch, such as loose straw or pine boughs, may be placed over the seeded row. This must be removed as soon as seedlings are up so that they receive full sun. Starting transplants in a shaded cold frame or in a cool indoor area is another possibility.

Once young plants are established, a heavier mulch may be used to hold moisture and control weeds. Irrigate when necessary so the young plants have sufficient moisture. Fall plantings often have few insect problems, as they avoid the peak insect activity period of midsummer. However, some insects, such as cabbageworm and corn earworm, may be even worse late in the year than in summer; vigilance is still required! Avoid some pests and diseases by planting crops of different families than were originally in that section of the garden.

Some of the best quality vegetables are produced during the warm days and cool nights of the fall season. These environmental conditions add sugar to sweet corn and crispness to carrots. Parsnips and rutabagas are examples of crops that are very much improved by a touch of frost.

Protection of vegetable plants during cold periods may extend your season even further. Though in the hot days of summer the last thing you want to think about is planting more crops to take care of, look ahead to the fall garden, which offers its own satisfaction through prolonged harvest of fresh vegetables, savings in food costs, and the knowledge that you're making full use of your gardening space and season.

## **Care of Fall Crops**

The beginning of fall garden care comes when the weather and the radio station announce the first arrival of frost. Your main concern then should be to harvest all ripe, tender crops. Tomatoes, summer squash, melons, eggplant, cucumbers and peppers are some of the crops that cannot withstand frost and should be picked immediately. Store the vegetables in a place where they can be held until needed for eating or processing. If the frost warning is mild, predicting no lower than a 30° F., try covering tender plants in your garden that still hold an abundance of immature fruit. Baskets, burlap, boxes, row covers, blankets, or buckets help protect them from the frost. Warm days after the frost will still mature some of the fruit as long as the plants have this nightly frost protection. Much will depend on the garden's microclimate. If your spot is low and unsheltered, it is likely to be a frost pocket. Gardens sheltered from winds and on the upper side of a slope are less susceptible to early frost damage.

When using a cold frame to extend the harvest season, be sure to close the top on frosty nights to protect the plants from the cold. When the sun comes out the next morning and the air warms, open the cold frame again; leave it closed if daytime temperatures are low. Spun bonded row covers work well for season extension. Cool-season crops such as cabbage, cauliflower, broccoli, spinach, and Brussels sprouts can withstand some cold. In fact, their flavor may be enhanced after a frost. They cannot stay in the garden all winter, but do not need to be picked immediately when frost comes. Kale, spinach, evergreen bunching onions, lettuce, parsley, parsnips, carrots, and salsify are some crops that may survive all winter in the garden. Mulch these overwintering vegetables with 8 inches of mulch to prevent heaving of the soil. Most of these vegetables can be dug or picked in early spring.

Now is the time to prepare perennial vegetables for winter, too. Most will benefit from a topdressing of manure or compost and a layer of mulch, which reduces damage from freezing and thawing. Dead leaf stalks of perennial vegetables such as asparagus and rhubarb should be cut to the ground after their tops are killed by frost, though some people prefer to leave asparagus stalks until late winter to hold snow over the bed. Don't forget strawberry beds. Remove weeds that you let grow when you were too busy last summer. You can transplant some of the runner plants if you carefully dig a good-sized ball of soil with the roots. Mulch the bed well with a light material. Old raspberry canes can be cut back at this time or late in the winter.

When tender crops have been harvested and overwintering crops cared for, pull up all stakes and trellises in the garden except those stakes that are clearly marking the sites of overwintering plants. Clean stakes and trellises of remnants of plant materials and soil. Hose them down and allow to dry. Tie stakes in bundles and stack them so that they won't get lost over the winter. If possible, roll up wire trellises and tie them securely. Store these items inside your attic, barn, or shed in an area where they are out of the way, and where rodents and other animals cannot get to them to use as winter nests.

## **Preparing Soil for Winter**

Pull up all dead and unproductive plants and place this residue on top of the soil to be tilled under, or in the compost heap. Remove any diseased or insect-infested plant material from the garden that may shelter overwintering stages of disease and insect pests. If this plant material is left in the garden, you are leaving an inoculum of diseases and insects which will begin to reproduce the next spring and add to your pest problems. The best thing to do is to remove infested plant material from the garden or burn it. Burning will kill any diseases or insects that may be in plant wastes. Spread the ashes on the garden to get the benefit of mineral nutrients. Check laws in your area before burning anything; you may need a permit. If you live near a wooded area, burning may be too risky. In this case, haul the diseased material away.

Clean-up also gives you the chance to add compost to the garden. Compost contains highly nutritious, decomposed plant material and beneficial organisms, and is an excellent soil-builder. By spreading compost and other wastes on the soil and plowing them in, you are adding nutrients to the soil for next year's crop. The beneficial insects and microorganisms in the compost will help integrate the compost with the soil, and the added humus will improve soil structure.

Don't overlook other excellent sources of organic material available during the fall. Leaves are abundant, and neighbors will usually be glad to give their leaves away. Put some on the garden now and store some for next year's mulch. Leaves will mat if put on in too thick a layer, and will not decompose quickly. You can help leaves break down more easily by running a lawn mower back and forth over the pile. Put the shredded leaves directly onto the garden or compost them. Sawdust and wood chips are easy to obtain from sawmills and many farms and stables want to get rid of manure piles before winter sets in.

If you wait until spring to add organic material to the garden, it may not have time to decompose and add its valuable nutrients to the soil by the time you are ready to plant, and you may have to delay planting to a later date. Hot (very fresh) manure can also burn young seedlings. By adding these materials in the fall, you give them plenty of time to decompose and blend into the soil before planting time. If you don't have enough organic material for the entire garden, try to cover those areas that you want especially rich for next summer's crop.

If the weather stays dry enough before the ground freezes, you can plow or rototill in the fall. Turning under vegetation in the fall allows earlier planting in the spring and is especially good for heavy soils, since they are exposed to the freezing and thawing that takes place during the winter. This helps to improve soil structure. If you have a rainy fall, or if the garden is steep and subject to erosion, you may decide you'd rather plant a cover crop for winter garden protection. A cover crop decreases erosion of the soil during the winter, adds organic material when it is incorporated in the spring, improves soil tilth and porosity, and adds valuable nutrients. Winter cover crops can be planted as early as August 1 but should not be planted any later than mid-September. They should make some growth before hard frost kills them. Where you have fall crops growing, you can sow cover crop seed between rows a month or less before expected harvest. This way the cover crop gets a good start, but will not interfere with vegetable plant growth.

Prepare the soil for cover crop seed by tilling under plant wastes from the summer. Ask at the seed store what the best type of cover crop for your area is and at what rate (pounds per 100 square feet) to plant it. Broadcast the seed, preferably before a rain, and rake it evenly into the soil. Spring planting may be delayed somewhat by the practice of cover cropping, since time must be allowed for the green manure to break down. If you have crops that need to be planted very early, you may prefer to leave a section of the garden bare or with a stubble mulch.

When time or weather conditions prohibit either tilling or cover cropping, you may wish to let your garden lie under a mulch of compost, plant wastes, or leaves all winter to be plowed or tilled under in the spring. However, if you want to plant early the next spring, a mulch of heavy materials such as whole leaves may keep the soil cold long enough to delay planting. In this case, chop them fine enough that they will break down over the winter. The addition of fertilizer high in nitrogen will also help break down organic matter more quickly.

Some cover crops suitable for winter use are in the table on the next page. Mixtures of legumes and non-legumes are effective as well.

## **Cover Crops**

Туре	Legume/ Non-Legume	Amount to sow per 100 sq. ft. (Oz.)	When to Sow	When to Turn Under	Effects	Notes
Alfalfa	L	1/2	Spring Late Summer	Fall Spring	Fixes 150-250 lbs. N/ac./yr.; deep roots break up hard soil, trace elements to surface	Loam, fairly fertile soil; needs warm temps. For germination. Lime if pH is low. Hardy. In mtns sow by Aug. 10. Drought - tolerant. Innoculate
Barley	Ν	4	Fall Spring	Spring Fall	Adds organic matter; improves soil aggregation.	Prefers medium- rich, loam soil. Lime if pH is low. Not as hardy as rye. Tolerates drought.
Buckwheat	Ν	2-1/2	Spring Summer	Summer Fall	Mellows soil; rich in potassium	Must leave part of garden in cover crop during season. Grows quickly. Not hardy.
Crimson Clover	L	1/3	Spring Fall	Fall	Fixes 100-150 lbs. N/ac/yr.	Not reliably hardy. Sow before mid- Sept in Piedmont and mountains.
				-1 5		Not drought- tolerant. Lime if pH is low. White clover somewhat hardier.
Fava beans	L	Plant 8" apart	Early spring	Early summer	Some types fix 700-100 lbs. N/acre in as little as 6 wks.	Will grow on many soil types. Medium drought tolerance. Likes cool growing weather. Good for
			Late summer	Fall	Use small-seeded rather than large- Seed table types.	mountain areas. If planted in early spring can grow late vegetables. Innoculate with same bacteria as for hairy vetch.
Oats	N	4	Spring	Summer	Adds organic	Needs adequate
			Fall	Spring	soil aggregation	hardy; tolerates low pH.
Rye, winter	Ν	3-1/2	Fall	Spring	Adds organic matter; improves soil aggregation.	Very hardy. Can plant till early October
Vetch, hairy	L	2-1/2	Early fall	Spring	Fixes 80-100 lbs. N/acre/yr.	Innoculate; slow to establish. Fairly hardy. Till under before it seeds; can become a weed.
Wheat, winter	Ν	4	Fall	Spring	Add organic matter; improves soil aggregation.	Same as barley.

## **Care of Garden Equipment**

Clean-up of tools and equipment is another important practice related to the garden which should not be ignored in the fall. Proper clean-up of tools now will leave them in top shape and ready to use when spring comes. Clean, oil, and repair all hand tools. Repaint handles or identification marks that have faded over the summer. Sharpen all blades and remove any rust. Power tools should be cleaned of all plant material and dirt. Replace worn spark plugs, oil all necessary parts, and sharpen blades. Store all tools in their proper place indoors, never outdoors where they will rust over the winter.

Unless you are lucky enough to live in a warm area where a cold frame will protect vegetables all winter, you will need to clean up the frame when all vegetables have been harvested. Remove all remaining plant material and spread it on the cold frame soil. Spade the plant refuse and any other organic material into the soil in the cold frame as thoroughly as possible. Do not leave the top on the cold frame over the winter, as the cold air or the weight of snow may crack or break the glass. Remove the top, wash it thoroughly, and store it on its side in a protected indoor area where it will not get broken.

Successful gardening doesn't stop when frost comes, but continues throughout the fall and early winter months. When following good garden care practices during this time, your garden will be ready for the growth of healthy vegetables next spring.

## **Season Extenders**

To get the most out of a garden, you can extend the growing season by sheltering plants from cold weather both in early spring and during the fall. Very ambitious gardeners harvest greens and other cool-weather crops all winter by providing the right conditions. There are many ways to lengthen the growing season, and your choice depends on the amount of time and money you want to invest.



## **Cold Frames and Hot Beds**

Cold frames, sun boxes, and hot beds are relatively inexpensive, simple structures providing a favorable environment for growing cool-weather crops in the very early spring, the fall, and even into the winter months. Some are elaborate and require a large investment, but are reasonable for those who are serious about having fresh vegetables during the winter.

Cold frames and sun boxes have no outside energy requirements, relying on the sun for their source of heat. Hot beds are heated by soil heating cables, steam-carrying pipes, or fresh strawy manure buried beneath the rooting zones of the plants. Heat is collected by these frames when the sun's rays penetrate the sash, made of clear plastic, glass, or fiberglass. The ideal location for a cold frame is a southern or southeastern exposure with a slight slope to ensure good drainage and maximum solar absorption. A sheltered spot with a wall or hedge to the north will provide protection against winter winds. Sinking the frame into the ground somewhat will also provide protection, using the earth for insulation. To simplify use of the frame, consider a walkway to the front, adequate space behind the frame to remove the sash, and perhaps weights to make raising and lowering of glass sashes easier. Some gardeners make their cold frames lightweight enough to be moved from one section of the garden to another. Another possibility is the Dutch light, which is a large but portable greenhouse-like structure which is moved around the garden.

New designs in cold frames include passive solar energy storage. For example, barrels painted black and filled with water absorb heat during the day and release it at night. The solar pod, shown on next page, is one design which provides for this type of heat storage. Other new cold frames are built with a very high back and a steep glass slope and insulated very well; these may also include movable insulation that is folded up during the day and down at night or during extremely cold weather.





In early spring, a cold frame is useful for hardeningoff seedlings which were started indoors or in a greenhouse. This hardening-off period is important, as seedlings can suffer serious setbacks if they are moved directly from the warmth and protection of the house to the garden. The cold frame provides a transition period for gradual adjustment to the outdoor weather. It is also possible to start coolweather crops in the cold frame and either transplant them to the garden or grow them to maturity in the frame.

Spring and summer uses of the cold frame center around plant propagation. Young seedlings of hardy and half-hardy annuals can be started in a frame many weeks before they can be started in the open. The soil in a portion of the bed can be replaced with sand or peat moss or other medium suitable for rooting cuttings.

Fall is also a good time for sowing some coolweather crops in frames. If provided with adequate moisture and fertilization, most cool-season crops will continue to grow through early winter in the protected environment of the cold frame. Depending on the harshness of the winter and whether or not additional heating is used, your frame may continue to provide fresh greens, herbs, and root crops throughout the cold winter months.

Growing frames can be built from a variety of materials; wood and cement block are the most common. If you use wood, choose wood that will resist decay, such as a good grade of cypress or cedar, or use pressure-treated wood. Never use creosote-treated wood or wood treated with pentachlorophenol, since these substances are harmful to growing plants. Wood frames are not difficult to build. Kits may also be purchased and easily assembled; some kits even contain automatic ventilation equipment. There is no standard-sized cold frame. The dimensions of the frame will depend on amount of available space, desired crops, size of available window sash, and permanency of the structure. Do not make the structure too wide for weeding and harvesting; 4 to 5 feet is about as wide as is convenient to reach across. The sash of the frame should be sloped to the south to allow maximum exposure to the sun's rays.

Insulation may be necessary when a sudden cold snap is expected. A simple method is to throw burlap sacks filled with leaves over the sash on the frame at night to protect against freezing. Or, bales of straw or hay may be stacked against the frame.

Ventilation is most critical in the late winter, early spring, and early fall on clear, sunny days when temperatures rise above 45 degrees. The sash should be raised partially to prevent the buildup of extreme temperatures inside the frame. Lower or replace the sash each day early enough to conserve some heat for the evening.

In summer, extreme heat and intensive sunlight can damage plants. This can be avoided by shading with lath or old bamboo window blinds. Watering should be done early so that plants dry before dark, to help reduce disease problems.

You may convert your cold frame to a hotbed. For a manure-heated bed: dig out to 2 feet deep (deeper to add gravel for increased drainage); add an 18-inch layer of strawy horse manure; cover with 6 inches of good soil. For an electric heated bed: dig out area 8 inches deep; lay down thermostatically controlled electric cable in 6 to 8-inch long loops, evenly spacing cable, but never crossing; cover with 2 inches of sand or soil; lay out hardware cloth to protect cable; cover with 4 to 6 inches of good soil.

## **Cloches and Row Covers**

The cloche (pronounced *klosh*) was originally a bellshaped glass jar set over delicate plants to protect them from the elements. The definition has expanded, however, to include many types of portable structures which shelter plants from drying winds and cold air.

Bend wire frame over plants and secure in soil. Drape clear plastic over wire and fasten with clothpins. Fold plastic back on hot days.



Bend fiberglass panel over the row and secure it with stakes.



Build a wood frame and cover it with clear plastic.



The idea is to provide a greenhouse-like atmosphere for seeds and small plants in order to get an early start on the season, or to extend the fall garden as long as possible. Cloches are set out over individual plants or are made into tunnels for whole rows. They trap solar radiation and moisture evaporating from the soil and plants. The hotkap and the cut-off plastic jug are simple forms. More elaborate ones are fiberglass tunnels, special plastic cloches, spunbonded row covers with slits in them to allow some aeration, and panes of glass connected by specially designed hinges to form a tent. There are a variety of forms on the market now, some which work and some which don't, and some are easily constructed from materials around the home. Cloches are generally lightweight, portable, and reusable. It is preferable to have a design which can be closed completely at night to prevent frost damage and opened or completely removed during the day for good air circulation. Cloches should be anchored, or heavy enough that they don't blow away.

### Greenhouses

There is an almost overwhelming selection of greenhouses on the market, and plans for building even more types are available. If you intend to purchase or build a greenhouse, it is wise to investigate the alternatives thoroughly, preferably visiting as many operating home greenhouses as possible. List your needs and wants ahead of time and determine the uses you will put your greenhouse to. Then compare on that basis. Many companies will send free specifications and descriptions of the greenhouses they offer; look in gardening magazines for their ads.

The conservation-minded person may find an attached solar greenhouse desirable. The initial cost is generally higher for a solar greenhouse than for the simpler free-standing, uninsulated types, but for maximum use with lower heating bills, one can insulate north and side walls, provide liberal glass area for winter sun-catching, and make use of some type of solar radiation storage. When attached to a house, these greenhouses can be used for supplementary household heating, but there is a trade-off between heating the home and growing plants (especially heat-loving ones) in the greenhouse. Some researchers have concluded that a good compromise is to forget winter tomatoes and grow cool-weather crops during the winter in a solar attached greenhouse.

## Shading

It is not always easy to start seeds or young plants for fall crops in the hot and dry conditions of August. One simple way to provide shade in otherwise exposed conditions is to build a portable shade frame for placing over rows after seeds are sown or transplants are set out. This can be the same type of frame used for starting early seeds, but using lath strips or an old bamboo shade instead of plastic.

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# CHAPTER 11

## **Fruit in the Home Garden**

Edited and revised by William Lord, University of New Hampshire Cooperative Extension

Success with a fruit planting depends upon how well it is planned and how well the plans are carried out. Unfortunately, it is not possible for trees to be planted and good quality fruit harvested with little or no effort. Relatively less care is required in the culture of sour cherries and pears than any of the other tree fruits, but even these cannot be expected to produce good quality fruit year after year if left unattended. Proper attention must be given to insect and disease control, pruning, fertilization, soil management, and other necessary practices.

The small fruits offer advantages over fruit trees for home culture. They require a minimum of space for the amount of fruit produced, and bear 1 or 2 years after planting. Also, pest control is typically easier than with most tree fruits. Success with a small fruit planting will depend upon the attention given to all phases of production: variety selection, soil management, fertilization, pruning, and pest control. Plant only what you can care for properly. It is better to have a small, well-attended planting than a large, neglected one.

## **Tree Fruits**

## Planning the Tree Fruit

It is desirable to locate the fruit planting as close to your home as possible. Full sunlight all day long is required for good fruit production. Where space is limited, fruit trees may be set in almost any location suitable for ornamental plants. Consider the mature size of the tree when designing the planting. Dwarf fruit trees lend themselves to ornamental plantings as well as orchards. They come into bearing earlier than standard-sized trees, occupy less space, and can be more easily pruned and sprayed with equipment normally available to the average gardener. Most nurseries now carry dwarf and semi-dwarf apple trees of several varieties. Dwarf pear, peach, and cherry trees are not recommended in northern areas as they lack hardiness; however, they may be worth trying in extreme southern New Hampshire.

#### Size of Planting

Space, site, size of family, available time, and pollination requirements determine size of the planting. Choose fruits based on family preference, adaptability, and available space. Never attempt to plant more than you can care for properly. The information in the table on page two should help you determine the size of your planting.

#### **Tree Spacing**

How far apart should the trees be set? This is an important factor, and to a large extent, it influences selection of site and varieties. The table on the next page shows the minimum desirable distances between fruit trees in home orchards. They can be set farther apart if space allows, but, for best results, should not be set closer than the minimums indicated. To maintain a bearing surface low enough for necessary pest control, trees should not be crowded.

#### Space Requirement, Yield, Bearing Age, and Life Expectancy of Tree Fruits

<u>Fruit</u>	Minimum Distance Between <u>Plants</u> (feet)	Approximate Yield Per <u>Plant</u> (bushels)	Years to First Significant <u>Production</u> (years)	<b>Life</b> <u>Expectancy</u> (years)
Apple - standard	30	8	7 to 10	35 to 45
Apple - semi-dwarf	15	4	4 to 6	35 to 45
Apple - dwarf	8	1	2 to 3	35 to 45
Pear - standard	20	3	5 to 8	35 to 45
<sup>1</sup> Pear - dwarf	12	1	3 to 4	15 to 20
Peach (and nectarine)	15	4	3 to 4	15 to 20
Plum	18	2	4 to 5	15 to 20
Cherry - sour	20	60 qt.	4 to 5	15 to 20
<sup>2</sup> Cherry - sweet	25	40 qt.	4 to 5	15 to 20
<sup>3</sup> Apricot	20	1 - 2	4 to 6	15 to 20

<sup>1</sup>Rootstock only hardy to -5 to -10 <sup>o</sup>F. Extreme southern N.H. only.

<sup>2</sup>Hardy to -10<sup>o</sup> F, bloom very early so frost-free site important.

<sup>3</sup>Similar climatic limits as sweet cherry but, blooms so early that frost is a problem in most locations.

#### **Site Selection**

The importance of selecting the best site possible for fruit planting cannot be overemphasized. Good air drainage is essential. Cold air, like water, flows downhill. For this reason, fruit buds on plants set in a low spot are more likely to be killed than those on a slope. Frost pockets; low, wet spots; and locations exposed to strong prevailing winds must be avoided. South-facing slopes encourage early bud development and can sometimes result in frost damage. Select latematuring varieties for this location.

Deep, well-drained soil of good fertility should be selected. A fertile, sandy loam or sandy clay loam is suitable for most tree fruits. Adequate drainage is the most important soil characteristic. No fruit trees will grow well or survive long in soils that are excessively wet! Poor soils may easily be improved by proper fertilization and cultural practices. Improving soil with poor internal drainage is difficult and expensive. Fertile soil is desirable; deep, well-drained soil is vital.

#### Variety Selection

Give special attention to the selection of varieties. They must be adapted to your soil and climatic conditions. Northern-most parts of New England are at the northern edge of fruit tree adaptation. Select hardy species like apple. If possible, without sacrificing too much yield or quality, select varieties with the fewest insect and disease problems.

Several varieties of the same kind of fruit maturing at different times may be planted to prolong the season. The value of certain varieties for special uses such as freezing, canning, and preserving should be considered. Some varieties may be purchased in season from commercial growers more economically than you can grow them yourself.

Cross-pollination is necessary for satisfactory fruit set in many tree fruits. Varieties that are cross-fruitful and that have overlapping bloom dates should be selected. To be certain of adequate cross-pollination, plant at least three varieties of apples.

The following table lists some varieties of tree fruits suitable for planting. The varieties are listed in the order of ripening.

#### Some Suggested Varieties for the Home Fruit Garden

(listed in order of ripening)

#### **APPLES**

- Dutchess
- Ginger Gold
- Paulared
- McIntosh
- Gala
- Cortland
- Macoun
- Golden Delicious
- Red Delicious
- Northern Spy

#### **APPLES** (scab immune)

- Redfree
- Prima
- Liberty
- Freedom
- Jonafree

#### <sup>2</sup>NECTARINES

- Mericrest
- Hardired

#### <sup>2</sup>CHERRIES (sour)

- Montmorency
- North Star

#### PEARS

- Harrow Delight
- Clapp's Favorite
- Moonglow
- Bartlett
- Seckel
- Flemish Beauty
- Harvest Queen
- At least two of the recommended pear and plum varieties should be planted. Japanese and European plums are not effective as pollinizers for each other so two varieties of the same type should be planted.
- <sup>1</sup>Shiro is not a good pollinizer. Plant three varieties if it is one of your planting choices.
- <sup>2</sup>Self-fruitful no cross pollination needed.

All of the sour cherry and peach varieties listed are sufficiently self-fruitful to set satisfactory crops with their own pollen.

<sup>2</sup>PEACHES

- Redhaven
- Reliance
- Madison

#### **CHERRIES** (SWEET)

- Sam

- Ozark Premier
- PLUMS (Hybrid)
- Underwood
- Pipestone
- Superior
- Toka

#### **PLUMS** (European)

- Earliblue
- Blue Bell
- Italian Prune
- Stanley

#### APRICOT

- <sup>2</sup>Goldcot
- Perfection

Apricots are recommended for trial planting only. The buds of currently available varieties respond to the first warm days of early spring and are usually killed by frost or low temperature common to most areas. Unless protection can be provided, a crop can be expected no more frequently than once every 4 or 5 years.

### Winter Minimum Temperature

nardiest Cultivars
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 Crop	Degrees F	
Apple	-40	
Apricot	-20	
Blackberry		
thorny	-25	
thornless	0	
Blueberry		
highbush	-20	
 hybrids	-35	
Grape		
American	-30	
vinifera	-5	
 French Hybrid	-20	
 Peach, Nectrine	-15	
Pear	-30	
 Plum	-25	
 Raspberry		
red	-30	
purple	-15	
 black	-10	
 Sour Cherry	-30	
Strawberry (unmulche	ed) 5	
Sweet Cherry	-10	

**Production Limits\*** 

## **Apple Rootstocks**

Apples, like other tree fruits, will not produce trees with the same characteristics from seed. If you plant a seed from a McIntosh apple, the fruit would likely be small, unattractive, and of poor quality. Therefore, apple trees are propagated vegetatively by either budding or grafting scion wood of the desired cultivar on a rootstock. The rootstock and scion variety maintain their respective genetic identity but are joined at the graft union and function as a unit.

- Hedelfingen Van Kristin
- **PLUMS** (Japanese) Methley
- · 1Shiro

Traditionally, apple trees have been propagated by grafting wood from desired varieties onto apple seedlings. More recently, increasing use is being made of vegetatively propagated or clonal rootstocks which offer distinct advantages over seedlings. The three major considerations in rootstock selection are:

#### Size control (Dwarfing)

Probably the most widely accepted reason for the use of clonal rootstocks is tree size control. By proper selection of rootstock, we can determine mature tree size. For example, the same variety of apple will produce a 16- to 18-foot tree on the root stock cultivar, Malling Merton (MM)111, down to a dwarf tree of 7 to 8 feet on a Malling (M)9 rootstock. Intermediate sizes can be attained by other rootstocks such as M26 and M7. Unfortunately, many apple trees offered to consumers are labeled as dwarf trees, but the buyer has no idea which rootstock has been used and how dwarf the tree will be.



#### Precocity

The earliness at which a tree produces fruit is also directly affected by the rootstock. Trees on seedling rootstocks usually do not begin fruiting until they are 7 to 10 years old. Trees on M9 rootstock will often produce crops in 2 to 3 years. Other rootstocks are intermediate in this regard. Usually, the more dwarfing the rootstock, the earlier the tree will bear fruit.

#### Stability

A major consideration in selecting apple rootstocks is the degree of anchorage provided. For example, trees on M9 rootstock are very small but because of brittle roots, must be provided some type of support. This can consist of a post, a trellis, or other means of holding the tree upright. The semi-dwarfing M7 rootstock may require support for the first few years but is often grown without support.

## **Buying Trees**

Obtain the best nursery stock available. Buy only from reputable nurseries who guarantee their plants to be true to name, of high quality, and packed and shipped correctly. Beware of bargains. High prices do not necessarily mean high quality, but good nursery stock is not inexpensive.

One-year-old trees are usually preferred. A common mistake made by many gardeners is to select oversized or ready-to-bear nursery trees. Experience has shown that younger trees bear almost as soon, are easier to keep alive, and develop into more healthy, vigorous trees than do the oversized stock. The older trees cost nurserymen more to grow and are sold for higher prices, but are usually worth less than younger trees. Fruit trees grow well from dormant, bare root stock if planted early before growth begins.

For peaches a 4-foot tree, ½-inch in diameter, is considered the ideal size for planting. Vigorous, 4to 7-foot, 1-year-old whips about 3/4-inch in diameter are preferred for apples. Pears, plums, cherries, and apples may be planted as 1- or 2-year-old trees. Either will be satisfactory as long as the trees have attained sufficient size and have good root systems.

#### When purchasing apple trees on dwarfing rootstock, be sure to specify the rootstock desired.

EM-9 is very dwarfing, has a rather weak root system, and must have mechanical support. Trees on EM-7 attain a size about 2/3 that of the same variety on seedling rootstock. EM-7 is a good choice for poorer soils. M-26 is recommended for general use in N.H. It will produce a tree that is easy to manage (10 ft.) and bears fruit early in life, generally beginning in the third year from planting. It should be staked. A 2 in. x 2 in. x 8 or 10 ft. pressure treated stake is ideal. Set the stake 2  $\frac{1}{2}$  feet in the ground at planting. The young tree should be loosely tied to the stake with soft twine or plastic electrical tape.

## **Setting the Orchard**

#### **Time of Planting**

Fruit trees should be planted in early spring (late April to mid-May). Fall planting is not recommended in New Hampshire. The important thing to remember is that trees should be dormant and the soil should have proper moisture content.

#### Handling Nursery Stock

Roots of nursery stock should never be allowed to freeze or dry out. When your order arrives, unpack the bundles immediately and inspect the trees. The roots and packing material should be moist. Check to see if the bark is withered. Withered bark indicates the trees have been allowed to dry out in storage or in transit.

If trees cannot be planted immediately, they may be held dormant in the original packing in refrigerated storage for a week or two. If refrigerated storage is not available, trees should be taken out of the bundle and heeled-in carefully in a trench of moist soil in a shaded location.

#### **Planting the Trees**

Preparation of the soil where fruit trees are to be planted should be as thorough as preparation of the soil for a vegetable garden or ornamental planting. If the places selected for trees are in a lawn, it is best to remove the turf and spade the soil deeply over an area of several square feet where each tree is to stand.

Dig the hole a little deeper and **wider** than necessary to accommodate the roots, leaving the soil loose in the bottom of the hole.

Prune the roots of young trees only where necessary to remove broken and damaged ones or to head back some that are excessively long. Should a tree be so badly scarred or damaged that there is doubt of its survival, it is wise to discard it.

Set the tree at approximately the same depth it grew in the nursery. Never set it so deep that the union of the scion and rootstock is below ground level when the hole is filled. Ideally, this graft union will be 2 - 3 inches above the soil line.

Then begin filling the hole with pulverized topsoil, shaking the tree gently to filter the soil among the roots. The soil can be fortified with a couple of quarts of **wet peat moss if desired**. Don't mix fertilizer with the soil in the planting hole. Tamp the soil firmly and thoroughly. The addition of water when the hole is about 3/4 full will aid in settling the soil around the roots and increase chances for the tree's survival. After the water has completely soaked in, finish filling the hole, leaving the soil loose on top. Do not leave a water catching basin or depression around the tree. Ice freeze damage in snow-less winters can occur.

## **Orchard Management**

#### Cultural Practices

Excellent weed control around young fruit trees should be practiced until they begin to bear fruit. Weeds must be eliminated so they will not compete for available moisture and fertilizer. Cultivation must be shallow to avoid injury to roots near the surface. The cultivated area should extend a little beyond the spread of the branches.

The use of mulch around tree fruits is not recommended as it provides ideal cover for mice which can girdle trees.

When trees are planted in rows, the area between the rows may be allowed to grow in sod or used for interplanting with low-growing vegetables or strawberries. Under sod culture, frequent, close mowing during the growing season is desirable.

Fruit trees, especially those on dwarfing rootstock, are becoming prominent in landscape designs. Under lawn culture, fruit trees can be given more attention than is usually convenient under other systems of culture. Equipment and materials for watering, pruning, spraying, and other cultural practices are essentially the same as those required for ornamental plantings. It is good practice to cultivate lightly for the first year or two, or until the tree has become firmly established. Lawn grass, if kept closely clipped, may be allowed to grow around the base of the tree in the third year, but will reduce growth and yield.

Chemicals for weed control should be used with extreme caution in the home garden. Careless use can result in severe injury to fruit trees and nearby ornamental plantings. See your county Extension educator for latest recommendations.

#### **Fertilization**

As a rule, no fertilizer is recommended or needed at planting time. After the young tree becomes established and growth begins, apply  $\frac{1}{2}$  to 3/4 lb. of a 10-10-10 fertilizer in a circle around the tree, about 16 inches from the trunk.

Because there are many soil types and varying levels of natural fertility, it is difficult to make one fertilizer recommendation which will apply equally well in all areas. Over-fertilization with either organic or inorganic materials should be avoided. Excessive vegetative growth will result, usually accompanied by delayed fruiting and possible winter injury. Contact your local Extension educator for information about a soil test that may identify specific needs in your planting. Fertilizer may be applied in early spring about 1 or 2 weeks before active growth begins. When trees are grown in a lawn area, delay fertilizing the lawn until after trees are dormant to avoid late summer growth.

The usual method of application is to scatter fertilizer evenly under the tree, starting about 2 feet from the trunk and extending to just beyond the tips of the branches.

Terminal growth and general vigor of the individual tree should be observed closely. Where growth the past year was short, increase the amount of fertilizer slightly. If growth was excessive, reduce the amount or withhold it entirely. Remember that pear and some apple varieties are highly susceptible to fire blight and excessive growth will make this disease more prevalent.

Mature, bearing trees of peach, nectarine, and sweet cherry should produce an average of 10 to 15 inches of new growth annually. From vigorous, young, non-bearing trees, about twice that amount can be expected.

In general, 8 to 10 inches of terminal growth is considered adequate for mature, bearing apple, pear, quince, plum, and sour cherry trees. About twice that amount is sufficient for young, nonbearing trees.

#### Pruning

The general purpose of pruning fruit trees is to regulate growth, increase yields, improve fruit size and quality, and reduce production costs. Pruning is necessary to shape the trees for convenience of culture and for repair of damage. The methods for pruning fruit trees are designed to produce a strong framework and maximum yield of high quality fruit. However, the key purpose of pruning is to maximize exposure to the fruiting portion of the tree to sunlight.

Most pruning is done during the dormant season, preferably just before active growth begins in the spring. At this time, pruning wounds heal faster, flower buds can be easily recognized, and injury from low winter temperature is avoided. Summer pruning may be done to help train young trees to the desired shape, remove water sprouts and other undesirable growth, and maintain smaller tree size. It should be remembered, however, that all pruning has a dwarfing effect. For maximum yield of high quality fruit, prune only as necessary to establish a tree with a strong framework capable of supporting heavy crops annually without damage and to maintain a tree sufficiently open to allow penetration of sunlight, air, and spray material for good fruit development and pest control. Pruning from September 1st through January 30th is not recommended.



Although pruning procedures vary according to the type, age, and variety, all newly planted fruit trees should be pruned in the spring before growth starts. This is necessary to stimulate lateral bud development from which to select good scaffold limbs. For a discussion of the proper pruning techniques to use on different fruit trees, see the Pruning chapter.

#### Thinning

Quite frequently, peach and apple trees set more fruit than they can mature to a desirable size. By thinning, or removing excess fruit, this difficulty can be overcome. Thinning not only allows for an increase in size of the remaining fruit on the tree, but also improves fruit color and quality, reduces limb breakage, and promotes general tree vigor. Thinning helps maintain regular annual bearing in certain apple varieties, such as Golden Delicious and Yellow Transparent, which otherwise have a tendency to bear heavy crops every other year.

Experimental results indicate that the sooner peach trees are thinned after bloom, the earlier the ripening and the larger the fruits at harvest. It is doubtful that final size of the fruits of any variety will be greatly increased by thinning if it is delayed much after the pits begin to harden. It is generally recommended that peaches be spaced at least 6 to 8 inches apart on a branch. When thinning by hand, grasp the stem or branch firmly between your thumb and forefinger and pull the fruit off with a quick motion of the second and third fingers. Remove fruits that are small, shaded, or damaged by insects or disease, leaving the large, clean fruits exposed to sunlight.

Many growers use the pole method of thinning peaches. A 4- or 5-foot section of bamboo or other light wood is used. A piece of 3/4-inch garden or spray hose about 15 inches long is forced tightly onto the end of the pole, leaving some 8 to 10" of the hose extending beyond the end of the pole. A snug fit is necessary so the hose will remain in place while being used. Many modifications of this tool are used. One of the most common is a 30-inch section of plastic pipe, 1 inch in diameter.

Remove peaches by striking the limbs about 18 inches from their tips with the flexible part of the hose, using sharp, firm blows. This dislodges any loosely attached fruits. With a little practice, you should be able to remove individual fruits by this method.

Apples should be thinned as soon as possible after the fruit has set. If full benefits are to be obtained, thinning should be completed within 20 to 25 days after full bloom. In hand-thinning apples, use the same general technique used in hand-thinning peaches. A distance of 6 to 10 inches between fruits is recommended. With varieties of Delicious apples, where greater size of individual fruits is important, the greater spacing is preferred. The center apple of a cluster is usually the largest and the best apple to leave.

Thinning plums is usually limited to the largefruited Japanese varieties. The primary concern here is to facilitate insect and disease control. Plums are usually thinned by hand to about 4 inches apart.

#### **Rodent Control**

Mice (voles) may cause serious damage to the fruit planting. They chew off the bark near ground level or below and often completely girdle a tree, causing it to die. Most of this damage takes place during winter. Mice may be controlled by trapping. This can be successful where only a few trees are involved.

Rabbits are responsible for the loss of thousands of young fruit trees each year. Perhaps the most satisfactory method of preventing rabbit and vole damage is the use of a mechanical guard. Galvanized screen or "hardware cloth" with a 1/4inch mesh is frequently used. A roll 36 inches wide may be cut lengthwise, forming two 18-inch strips. By cutting these strips into pieces 14 inches long, guards 14 by 18 inches are obtained. Roll or bend the strip around the trunk of the tree so that the long side is up and down the trunk and the edges overlap. Twist a small wire loosely about the center to prevent the strip from unrolling. Push the lower edges well into the ground. This metal guard will last indefinitely and can be left in place all year.

Perforated plastic guards are also available. Like the metal guards, these can be left in place yearround. These are not as desirable as the hardware cloth guards since they become brittle and break. In addition, they shield the trunk from sunlight and air movement increasing the potential for insect and disease damage.

Other methods of rabbit control have been successful. Ordinary whitewash has given good results in some instances. A repellent wash recommended by the USDA, containing equal parts of fish oil, concentrated lime sulfur, and water, is used by some commercial growers. Also, rabbit repellents under various trade names are available. All these materials may be applied with a paint brush, from the ground up into the scaffold limbs.

#### **Tree Fruit Spraying**

For significant insect or disease problems, it may be necessary to follow a spray program. Information on the use of chemicals for such a program is available from the Extension office.

To be successful with your spray program, spray at the proper time and do it thoroughly. Leave no portion of the tree unsprayed. To make the job easier and to ensure adequate coverage, thin out excessive growth and remove all dead and weak wood. Cut old trees back to 20 feet or less, if possible. Train younger trees so they reach a height of no more than 18 feet.

Semi-dwarf and dwarf trees should be considered when making your planting. Their small size makes the task of spraying easier.

#### Sanitation

Adopt good orchard sanitation practices. The destruction of harboring places for insects and diseases plays a large part in the control program. Conditions which encourage mice should also be eliminated.

These are some practices to include in an orchard sanitation program:

- Collect and remove debris.
- Remove and destroy all dropped fruit.
- Rake and remove apple and cherry leaves.
- Scrape loose bark from trunks, crotches, and main limbs of apple trees.
- Prune out and destroy all dead or diseased limbs, branches, and twigs.



## **Small Fruits**

In this section, general guidelines are given for small fruit plantings, and then the specific fruits are covered in some detail.

## Planning the Small Fruit Garden

Locate your small fruit planting as close to your home as possible, in full sun. Space in or near the vegetable garden is usually preferred. Where space is a limiting factor, small fruits may be used in place of ornamental plants of comparable size. Strawberries may be used as a border for a flower bed or as a ground cover. Grapes and raspberries may be planted parallel to the garden on a trellis or a fence along a property line. Blueberries may be planted to form a dense hedge or used in a foundation planting around the home. Select a site that is free from frost pockets, low/wet spots, and exposure to strong prevailing winds. Small fruits thrive best in a fertile, sandy loam soil high in organic matter, but they will give good returns on the average garden soil under adequate fertilization and good cultural practices.

Overcrowding frequently results in weak plants and low yields. It also makes insect and disease control more difficult. For best results, small fruit plants should be set no closer than the minimums indicated in the table below.

<u>Fruit</u>	Minimum Distance Between <u>Rows</u> (feet)	Minimum Distance Between <u>Plants</u> (feet)	Annual Yield <u>Per Plant</u> (quarts)	Years from Planting to 1st Significant <u>Fruit</u> (years)	Average Life <u>Expectancy</u> (years)
Blueberry	8	4	4 to 6	3	20 to 30
Blackberry (erect)	10	3	11⁄2	1	5 to 12
Raspberry (red)	9	3	11⁄2	1	5 to 12
Raspberry (black)	9	4	11⁄2	1	5 to 12
Raspberry (purple)	9	3	11⁄2	1	5 to 12
Grape (American)	10	8	15 pounds	3	20 to 30
Strawberry (regular)	4	2	*1	1	3
Strawberry (ever-bearer)	4	1	1/2	1/3	2

#### Space Requirement, Yield, Bearing Age, and Life Expectancy of Small Fruits

\* per parent plant grown in the matted row system.

Special attention should be given to the selection of varieties. They must be adapted to your soil and climatic conditions. If possible, without sacrificing too much yield or quality, select varieties with the least insect and disease problems. The following table lists some varieties of suggested small fruits. They are listed in the order of ripening, and include only those adapted for growing under Northern New England conditions.

#### Suggested Varieties for Home Small Fruit Planting (listed in order of ripening)

#### **BLUEBERRIES**

- Patriot
- \*St. Cloud
- Northland
- Blueray
- Bluecrop
- Blueiav
- \*Northblue
- \*Friendship
- Jersey

#### **BLACKBERRIES**

• Illini

#### RASPBERRIES (Red)

- · Latham
- Boyne
- Killarney
- Autumn Britain
- Redwing
- Heritage

#### RASPBERRIES (Black)

Jewel

- **RASPBERRIES** (Purple)
- Success
- · Royalty

#### STRAWBERRIES

- (Everbearing)Superfection
- (Gem, Brilliant)
- Ozark Beauty

#### **STRAWBERRIES**

(Day-neutral)Tribute

#### **STRAWBERRIES**

- (Regular)
- Earliglow
- Annapolis
- Northeaster
- Mohawk
- Cavendish
- Allstar
- Red Chief
- Primetime
- Sparkle
- \* Highbush x lowbush crosses especially suited to colder areas of New Hampshire.

Obtain the best nursery stock available. Buy only from reputable nurseries who guarantee their plants to be true to name, of high quality, and packed and shipped correctly. Beware of bargains. High prices do not necessarily mean high quality, but wellgrown plants are not expensive.

Place your order early, as soon as you decide what you want. Specify variety, size, and grade of plants desired, and time of shipment preferred. It is best to have the plants arrive at the time you are ready to set them out. When your order arrives, unpack the bundles and inspect the plants. The roots should be moist and have a bright, fresh appearance. Shriveled roots indicate that the plants have been allowed to freeze or dry-out in storage or transit. Such plants seldom survive.

If the plants cannot be set immediately, they should be kept either in cold storage or heeled-in. Wrap them in a garbage bag, or other material that will prevent their drying out, and store them at a temperature just above freezing. Strawberry plants, in small quantities, may be held in the refrigerator for a few days. If refrigerated storage is not available, remove the plants from the bundle and heel them in carefully in a trench of moist soil in a shaded location. Pack the soil firmly around the roots to eliminate all air pockets and to prevent the roots from drying out.

Blueberries are often available as container grown plants. These cost more but generally perform better than bare root stock.

#### General: Establishing the Planting

There is probably nothing that causes more disappointment and failure in small fruit plantings than the lack of careful preparation and attention to detail at the time the plantings are established. Prepare the soil properly, set the plants carefully, and generally create conditions favorable for new growth. Detailed suggestions for the establishment of each of the small fruits follows. These suggestions should be followed closely for best results.

#### General: Maintaining the Planting

Once the planting has been established, future success will depend upon the care that it is given. If the planting is to be productive and long-lived, it must be properly fertilized. Competition from weeds or other plants must be avoided. Insects and diseases must be controlled, and the plants must be properly pruned. Study the maintenance suggestions for each of the small fruit crops, and plan to care for the planting properly. To do otherwise will probably result in disappointment and wasted effort.

## **Strawberries**

Strawberries are the most widely cultivated small fruit in America. They are the favorite of many for pies, jams, jellies, preserves, and for eating fresh. Because strawberries are adaptable to a greater range of soil and climatic conditions than any other fruit, they are well-suited to the home garden and may be grown successfully in every section of northern New England.

#### **Variety Selection**

Strawberry varieties vary greatly in their adaptability to soil and climatic conditions. The varieties suggested for planting in New England are of proven merit and have been selected on the basis of plant vigor, resistance to soil borne diseases, productivity, and quality of the fruit. Virus-free plants of each variety are available.

**Earliglow** is noted for its superior dessert quality and disease resistance. The medium-large berries are very attractive with a glossy, deep-red color. It is one of the best for eating fresh, as a frozen product, and in jams and jellies. The plants are very vigorous but not highly productive in all northern areas.

**Annapolis** has excellent fruit quality, red stele resistance, and is winter hardy.

**Northeaster** is a new, very disease resistant variety from USDA. Fruits are flavorful. Especially suited to New England.

**Mohawk** is another new, flavorful, disease resistant variety from USDA.

**Cavendish** is a disease resistant variety from Canada. It produces large, flavorful fruit that sometimes color irregularly.

**Allstar**, berries are large and attractive with mild flavor. The plants are vigorous and runner freely. Resistant to red stele and Verticillium.

**Red Chief** is an extremely productive, highquality dessert berry. It is medium to large in size, of uniform deep- red color, with a firm, glossy surface. Red Chief is very resistant to red stele.

**Primetime** is another new variety from USDA. Fruits are large, firm and flavorful.

**Sparkle**, is an excellent flavored fruit, but is somewhat soft. Fruit size tends to decrease as season progresses. Plants are vigorous, copious runner producers with some resistance to red stele. Everbearing strawberries are not as good as the regular varieties, either in quality or yield. Because of consistently low yields, they are not recommended for planting in northern New England. Ozark Beauty is an everbearing variety that shows considerable promise. The plant is vigorous and produces good quality fruit. The berries are red, wedge-shaped, firm, and only slightly acid. It is a good variety for eating fresh and for freezing.

An interesting development in strawberry breeding is the production of varieties that are day-length neutral. This means that they do not respond to day-length the way that conventional varieties do, and can continue to produce over a long period of time. Although these varieties are listed with everbearers in catalogues, they are heavier producers and can be used satisfactorily in the home garden. Tribute is a vigorous variety with glossy, deep-green leaves; fruit is medium-sized in spring and summer, large in fall. Production and size drop in the heat of summer but pick up in fall. Best for fresh eating. Tristar also produces high quality fruit, but is not as productive as Tribute.

## **Establishing the Planting**

#### Site and Soil

Strawberries bloom very early in the spring, and the blossoms are easily killed by frost. In areas where late frosts are a hazard, try to select a site for your planting that is slightly higher than surrounding areas. Although strawberries grow best in a fertile, sandy loam soil with a pH of 5.7 to 6.5, they may be successfully grown in any good garden soil that is well-drained and wellsupplied with organic matter. Soil for strawberries should be thoroughly prepared for planting. It should be loose and free of lumps.

Do not set strawberries in land that has recently been in sod. A clean-cultivated crop planted on the site for a year or two will leave the soil better prepared for strawberries and will assist in controlling weeds and white grubs which are so troublesome in strawberry plantings.



#### Planting

Virus-free 1-year-old plants should be set out early in the spring, about 3 or 4 weeks before the average date of the last frost. Spacing of the plants will depend on the training system used, but they should not be crowded. They should be placed no less than 12 inches apart in rows. Spacing plants 18 inches apart in rows 4 feet apart is more desirable if space is not limited. Set each plant so that the base of the bud is at the soil level. Spread the roots out and firm the soil carefully about them to prevent air pockets which allow them to dry out. Water well when planting is finished.

#### **Maintaining the Planting**

#### Soil Management

Weeds are enemy #1 in the strawberry planting! Cultivation for weed control in strawberries should begin soon after planting and continue at approximately 2-week intervals throughout the first growing season. Cultivation must be shallow to prevent root injury. Hoe as often as necessary to remove grass and weeds growing between the plants.

Home garden strawberry plantings should be mulched in late fall. Any organic material free of weed seeds makes good mulch. Straw and pine needles are most frequently used. Mulch should be applied 2 to 4 inches deep over and around the plants after the first freezing weather in the fall. The last weekend in November is traditional in southern N.H. while mid-November is better in northern areas. This protects them from heaving and freezing injury during the winter. In mid-April (late April in northern areas), about half the mulch should be raked off the plants into the area between the rows. Mulch left around the plants will help keep the berries clean, conserve moisture, and check weed growth.

#### Fertilization

Heavy fertilization seldom proves beneficial to strawberries on good soils well-supplied with organic matter. Where a soil analysis indicates the need, about 1 lb. per 100 feet of row of a complete fertilizer, such as 10-10-10, should be cultivated into the soil before planting. The fertilizer used in the fall application should be the same analysis at the same rate and should be broadcast over the row in late August or early September. The limited root systems will not benefit from fertilizer placed in the row middles. Apply fertilizer when plants are dry and brush the material off the plants to avoid foliage injury.

Do not apply spring fertilizer to strawberries growing in heavy land because there is danger of excess vegetative growth which results in reduced yield, increased rot, later ripening, and poor quality fruit. In light, sandy soils, where nitrogen leaches out rapidly, a spring application is usually beneficial. Apply a quickly soluble nitrogen fertilizer, such as nitrate of soda, at the rate of  $\frac{1}{2}$  to  $\frac{3}{4}$  lb. per 100 feet of row before new growth begins.

#### Training

There are three basic training systems used in strawberry production. Many modifications of these systems are found. Under the matted-row system, used by most home gardeners, runner plants are allowed to set freely in all directions. The original plants should be set 18 to 24 inches apart in the row. Keeping the width of the plant bed narrow (usually 15 to 18" and no wider than 24") results in a good grade of fruit which is easy to pick.

In the hill system, plants are spaced 12 inches apart in the row. All runners are removed as soon as they appear, and the plants are encouraged to multiply in large crowns. This system is desired by many because the planting is easier to cultivate and harvest and produces larger and better berries than other systems. Many plants are required, however, and the initial cost of the planting is high. Black plastic mulch is particularly effective with this training system.

Plants in the spaced-row system are set 18 inches apart in the row. The runner plants are set in place by hand until the desired stand is obtained. They are usually spaced 6 to 12 inches apart. All late-formed runners are removed as they appear.

#### **Blossom Removal**

During the first planting season, all flower stems on the plants should be removed as soon as they appear. This strengthens the plants and allows early and vigorous runner production. The earlyformed runner plants bear the best fruit the following year.

#### Renovation

If your strawberry planting is in a vigorous condition, it may be retained for another fruiting.

Soon after harvest, remove the mulch and clip the tops of the plants to within 1 inch of the crowns with a scythe or mower. If insects and foliage diseases are prevalent, move the leaves and mulch material out of the planting, and burn them. Apply a quickly soluble nitrogen fertilizer, such as nitrate of soda, at the rate of  $\frac{1}{2}$  to  $\frac{3}{4}$  lb. per 100 feet of row to encourage vigorous top growth. Any good garden fertilizer supplying an equivalent amount of nitrogen may be used if desired. Rototill or spade row middles, narrowing the plant row to 8 to 12". During the tilling process, mulch sides of crowns lightly ( $\frac{1}{2}$ ") with loose soil. Water the planting thoroughly.

Some plant thinning may be needed, particularly in the matted-row system. Thin plants to 6 to 8 inches apart after new foliage appears. Keep the planting clean-cultivated throughout the summer, irrigating when necessary during the dry season to keep the plants growing vigorously. Fertilize again in the fall as recommended for the first year, and renew the mulch after freezing weather begins.

#### Pest Control

Birds are one of the biggest pests in the strawberry planting. It may be necessary to cover the plants with plastic netting to keep the crop from being eaten before the berries are ripe enough to harvest. Aluminum pie tins, suspended by a string or wire above the plants in such manner that they twist and turn in the breeze, have been successful in keeping birds away.

## Culture of Everbearing and Day Neutral Varieties

The everbearing varieties of strawberries are less vigorous and generally less productive than the regular varieties. Irrigation is necessary for them because the late summer and early fall crop ripens during a period when soil moisture is usually quite low. Soil preparation and fertilizer requirements before planting are the same as for regular varieties. Best yields are obtained from the everbearing varieties if they are set in early spring in the hill system about 1 foot apart, cultivated for the first 10 days to 2 weeks, and then mulched to a depth of 2 to 4 inches with pine needles or straw.

As the mulch decays, the development of a nitrogen deficiency could occur. It can be quickly overcome with the application of 10 lbs. of 10-10-10 to each 100 sq. ft. of mulched area.

Remove all runners as soon as they appear, to encourage the plants to multiply in large crowns. Blossom clusters should be removed until the plants have become firmly established. Berries will begin to ripen about a month after bloom and plants will continue to bear fruit until frost, if weed growth is kept down and adequate moisture is supplied. Allow the plants to bear fruit for the spring and fall crops the second year, then replant.

## Strawberry Growing in Pyramids and Barrels

In a garden where space is extremely limited or where the gardener wishes to use the strawberry planting as a novelty or decorative feature, the strawberry pyramid or the strawberry barrel can be useful and interesting. Pyramids may be square or round. Each step of the pyramid should have a flat surface not less than 6 to 8 inches in width. The frames for a square pyramid can be constructed out of 6-inch wide boards of a durable wood such as redwood.

A suggested soil mixture for the pyramid is two parts good garden soil, one part peat, and one part sand. In preparing a strawberry barrel, 1-inch diameter holes are made in the sides of the barrel at approximately 8-inch spacings. As the barrel is filled with successive layers of soil, strawberry plants are carefully inserted through the holes so that the roots are held firmly in contact with the soil.



List of materials necessary for a 72 inch wide, 5 level square sided pyramid where each ascending level is 12 inches less in width.

- 4 boards 6 feet long and 6 inches wide
- 4 boards 5 feet long and 6 inches wide
- 4 boards 4 feet long and 6 inches wide
- 4 boards 3 feet long and 6 inches wide
- 10 feet of 2" x 2" for corners
- 1 pound of 6 penny galvanized nails

#### **Barrel Planter**



Though the strawberry barrel may be a successful novelty, yields of fruit will be smaller than those in pyramid culture, and much more attention to planting, watering, and winter protection are required.

Damage to the strawberry plants growing under normal cultural conditions can be expected if they are not protected from extreme cold during the winter. Because plants growing in a pyramid or barrel are elevated above normal ground level and therefore are highly exposed, additional winter damage can be expected to roots, crowns, and fruit buds. Consequently, care must be taken to provide adequate winter protection. Pyramids can be mulched with 6 to 8 inches of straw after the soil is frozen. Even with careful mulching, some plant injury can be expected during severe winters.

#### Harvesting

In the home garden, strawberries should be allowed to get an overall red color and become fully ripe before harvesting. It is at this stage that the sugar content is highest and the flavor is best. It is necessary to harvest every day during the peak of the season.

Harvest the berries carefully by the stems to prevent bruising. Pick all that are ripe, since they will not keep until the next harvest. Ripe strawberries may be held for a day or two in a refrigerator.

## Grapes

Grapes are only marginally hardy in northern New England and are often severely winter damaged. Grapes should only be planted in protected sites. They are not recommended for commercial produc-

tion. Careful selection of cultivated varieties compatible with local soil and climatic conditions has led to successful production in home gardens and commercial vineyards in many sections of the region.



## Variety Selection

#### American Bunch Grapes

(These are the hardiest grapes, and the only type recommended for northern areas. )

**Beta** - Very hardy blue-black grape; it has small berries in small bunches. Beta is early ripening, and vigorous.

Valiant - Red, seeded, very hardy.

**Edelweiss** - Green, seeded, sweet, very productive.

**Swenson Red** - Very productive red grape, seeded, good flavor.

#### Seedless Table Grapes

(Hardy to  $-20^{\circ}$  F)

**Reliance** - Hardy, seedless red table grape that ripens in mid-September. It has some disease resistance.

**Canadice** -Hardy seedless red table grape. It is early ripening and has good flavor.

#### Wine Grapes (French Hybrids)

(Hardy in southern N.H. only)

**Foch**- Small berries and bunches, Burgundy type wine.

Aurore - White, makes a fruity wine.

## **Establishing the Planting**

#### Site and Soil

Grapes should be planted where they have full sun all day. They are deep-rooted plants, frequently penetrating to a depth of 6 to 8 feet under good soil conditions. They grow best on fertile sandy-loam soils high in organic matter. Deep sands or heavy clays may be used, however, if provisions are made for adequate fertilization, moisture, and soil drainage. Grapes are tolerant to a wide range of soil acidity, but prefer a pH of 5.0 to 5.8.

#### Planting

Grape vines are usually set in early spring, about 3 or 4 weeks before the average date of the last frost. Vigorous, 1-year-old plants are preferred. Allow at least 8 feet between plants. Trim the roots to about 6 inches in length in order to encourage formation of feeder roots near the trunk. Where the vines are to be set, dig the holes large enough so that the roots may be spread without crowding. Plants are set at about the same depth they grew in the nursery. Prune newly set plants to a single cane, and head it back to two buds.

#### **Maintaining the Planting**

#### Soil Management

Grapes are generally grown using shallow cultivation. A system of grass sod row middles and a shallow cultivated strip 2 feet wide under plants works well.

Although grapes are deep-rooted plants, they do not thrive in competition with weeds and grass. Cultivation to facilitate weed control should be done. It should be shallow and only as necessary to eliminate undesired vegetation.

#### **Fertilization**

Grapes require a large amount of nitrogen. Except in sandy soils, this element may be the only one needed in the fertilization program. In the home garden, <sup>1</sup>/<sub>4</sub> cup or about 3 ounces of 10-10-10 per vine should be applied after growth begins in the spring. Spread the fertilizer in a circle around the plant and 10 to 12 inches from the trunk. Repeat the application about 6 weeks later. Just before growth begins in the spring of the second year, apply 4 oz. in a 4 foot circle around each vine and about 1 foot from the trunk. Increase the amount to 8 oz. per year beginning in the third year.

Fertilizer applications to mature, bearing vines should be based on the growth and vigor of the plant. If the average cane growth is only 3 feet or less, additional nitrogen may be needed. Where proper pruning is practiced and competition from weeds and grass is kept to a minimum, however, it is doubtful that you will need to go beyond the amount recommended for a 3-yearold vine.

#### **Training and Pruning**

Much attention is given to the training and pruning of grapes. To be most productive, they must be trained to a definite system and pruned rather severely. There are several training systems used. The two most common are the vertical trellis and the overhead arbor. Both of these are satisfactory in the home planting if kept wellpruned. For detailed discussion see the Pruning chapter.

### Harvesting

For best quality, bunch grapes should be fully ripe when harvested. They will not improve in sugar content or flavor after being removed from the vine. Most varieties should be used immediately because they do not keep well after ripening. Cut the clusters off with a knife or shears to avoid bruising the fruit and damaging the vine.

## **Brambles**

Bramble fruits include the red, black, and purple

raspberries and the erect and trailing blackberries. Only red raspberries are hardy enough to be dependable producers, however. Purple and black raspberries and erect blackberries may survive in protected



sites. Trailing blackberries are not recommended. Both raspberries and blackberries will usually yield



a moderate crop of fruit the second year after planting and a full crop the third season. With good management, it is possible for gardeners to extend the pro-

ductive life of well-located plantings beyond the 6to 8-year average.

#### Variety Selection

Of the many varieties of raspberries available, few have proven hardy enough with short ripening seasons to be satisfactory for growing under New England conditions. Only top-quality 1-year-old plants of the best varieties should be planted. Obtain virus-free plants when possible.

#### Blackberries

Only one erect-type blackberry variety is suggested for planting in northern New England. It is productive, vigorous, and relatively winterhardy.

**Illini** has good hardiness and large berries of good quality. Illini plants are very thorny!

#### Raspberries

**Boyne** is the most winter hardy variety. It displays rugged, thorny canes, with vigorous growth. Fruit ripen early, are dark red, soft with good flavor.

**Killarney** is similar to Boyne with brighter, firmer fruit ripening slightly later.

**Latham** is an old, hardy variety that will grow well throughout the state. Fruits are soft, tend to crumble, and have only fair flavor.

**Autumn Britain** and **Redwing** are other early everbearers.

**Heritage** is the standard everbearer for quality. Unfortunately, it ripens too late in the fall for all but a few sites in extreme southern NH.

Black raspberries are very susceptible to virus diseases and are readily infected when grown near red varieties carrying the virus.

**Jewel** is the hardiest of the black raspberries, but still should be protected from extreme cold.

The purple raspberry is a hybrid of the red and black types. The fruits have a purple color and are usually larger than the parent varieties. They are more tart than either the reds or blacks and are best used in jams, jellies, and pies. They are excellent for quick freezing. The plants are hardy, vigorous, and very productive.

**Royalty**, a purple raspberry with good flavor, very large fruit, and high productivity, is excellent for fresh use and for jam and jelly. It is resistant to mosaic-transmitting aphids and raspberry fruit worm.

**Success** is a dark purple raspberry from New Hampshire. It is very hardy and produces high quality but soft fruit.

## **Establishing the Planting**

#### Site and Soil

Brambles grow best on deep, sandy-loam soils, well supplied with organic matter. They may be grown in almost any good garden soil, provided it is well-drained to a depth of at least 3 feet and has a high moisture-holding capacity. Although the pH of the soil is not critical, a range of 5.8 to 6.5 is considered optimum. Select a site where tomatoes, potatoes, or eggplants have not been grown. These crops often carry Verticillium wilt which lives in the soil for many years, and brambles, particularly black raspberries, are very susceptible to this disease.

#### Planting

Bramble fruits should be planted early in the spring, about 4 weeks before the average date of the last frost. Work the soil as for garden vegetables, particularly where the plants are to be set. When planting in rows, allow at least 8 feet between rows to facilitate cultivation. Red and purple raspberries may be set as close as 2  $\frac{1}{2}$  feet in the row. Black raspberries and blackberries should be set 3  $\frac{1}{2}$  to 4 feet apart in the row.

Set the plants at about the same depth they grew in the nursery. The crown should be at least 2 inches below the soil line. Spread out the roots and firm the soil carefully around them. Do not allow the roots to dry out. As the plant develops and new shoots emerge, do not allow the plant row to grow wider than two feet. Wide plant rows encourage disease problems because of increased competition among plants, and reduced air circulation.

Most bramble fruits come with a portion of the old cane attached. This serves as a handle in setting the plants. Soon after new growth begins, the handle can be cut off near the surface of the ground and destroyed, as a safeguard against possible disease infection.



#### **Maintaining the Planting**

#### **Soil Management**

Brambles grow best where there is a large amount of humus in the soil. This is most easily maintained under a permanent mulch. Mulch should be applied soon after setting the plants, and maintained throughout the life of the planting by replenishing annually or as needed.

Any good organic material is satisfactory. Two inches of wood chips or pine needles should be sufficient. Where straw, sawdust, or other material low in nitrogen is used, it may be necessary to add sufficient nitrogenous fertilizer to prevent a temporary deficiency as the mulch begins to decay. Usually about ½ lb. of nitrate of soda or 1 lb. of 10-10-10 for each 100 sq. ft. of mulched area will be enough. In addition; mulch may delay fruiting until later in the season and could increase risk of early winter injury by delaying plant hardening in the fall.

#### Fertilization

On fertile soils, or where a good mulch is maintained, it is usually unnecessary to make an application of fertilizer in the bramble planting. If growth is poor, the addition of 4 to 6 lbs. of nitrate of soda to each 100 feet of row when growth begins in the spring will be beneficial. On light, sandy soils, where phosphorus and potassium may be low, an equal amount of 10-10-10 or similar fertilizer should be used instead. Do not over-fertilize, however, because it may result in too much vegetative growth with a loss of yield and quality of fruit or in injury to the roots of the plant and burning foliage.

#### **Training and Pruning**

Refer to the Pruning chapter.

#### Harvesting

Raspberries and blackberries are highly perishable. They should be harvested as soon as ripe, handled very carefully, and either placed in cold storage or used without delay. It may be necessary to harvest daily to prevent loss of fruit and the spread of molds and other diseases in the planting.



## **Blueberries**

Many home gardeners have been successful with

highbush blueberry plantings in northern New England. They may be grown in any area where native blueberries, azaleas, mountain laurel, or rhododendrons do well. They are very exacting in soil and moisture



requirements, but require little protection from insect and disease pests.

#### Variety Selection

To provide adequate cross-pollination and to increase chances for a good crop of fruit, two or more varieties of blueberries should be planted. The following varieties suggested for planting in gardens in New England ripen over a 4- to 6-week period, beginning in mid-July and continuing through August. All are vigorous and productive under good growing conditions and produce berries of large size and good quality.

**Patriot** is a very hardy plant developed in Maine. It produces large excellent quality fruit. Patriot ripens early.

**Blueray**, very hardy and productive, is recommended for planting throughout northern New England. The fruit is large, medium-light-blue, flavorful, and resistant to cracking.

**Bluejay** is a hardy, mid-season cultivar from Michigan. Fruits are attractive and flavorful.

**Bluecrop**, although lacking in vigor, is very hardy and drought-resistant. The fruits are large, light-blue, firm, and resistant to cracking. Their dessert quality is good. Bluecrop will not tolerate poorly drained soils.

**Northland** is a hardy vigorous variety which produces high yields of small, good quality berries.

**Jersey** is a good quality late summer variety. Fruit are only medium sized and production is moderate.

In Coos county and other colder areas of the state, very hardy highbush x lowbush crosses are recommended. These include the varieties **St. Cloud, Friendship, North Country,** and **North Blue**.

## **Establishing the Planting**

#### Site and Soil

Blueberries should be planted where they have full sunlight most of the day, and far enough from the roots of trees to avoid competition for moisture and nutrients. They are shallow-rooted plants and must be heavily mulched. Supplemental irrigation will be necessary in dry periods. Adequate drainage must be provided, however, because they cannot tolerate wet feet.

They grow best in porous, moist, sandy soils high in organic matter with a pH range of 4.5 to 5.2. Have the soil tested and if it is not acid enough for blueberries, work sulfur into the area where the plants are to be set. This should be done 6 months to a year before planting. To acidify sandy soils, sulfur is recommended at the rate of 3/4 lb. per 100 sq. ft. for each full point the soil tests above pH 4.5. On heavier soils use  $1\frac{1}{2}$  to 2 lb. Once proper acidity is established, it can be maintained through the annual use of an acid fertilizer, such as ammonium sulfate .

#### Planting

Vigorous 2-year-old plants about 15 inches high are the minimum size recommended for planting. Two or three year old container grown stock is preferable to bare root stock. Set in early spring, about 3 or 4 weeks before the average date of the last frost. Blueberries are usually planted every 4-6 feet in rows 6-8 feet apart.

Give the roots plenty of room. Where the plants are to be set, dig the holes wider and deeper than necessary to accommodate the root systems. If not previously done, incorporate plenty of organic matter--well-rotted sawdust, peat moss, or leaf mold--into the soil in and around the hole. If peat moss is used, be sure to soak it well before use. Trim off diseased and damaged portions of the top and roots, and set the plants just a little deeper than they grew in the nursery. Spread the roots out, and carefully firm the soil mixture over them. Water thoroughly after planting.

## **Maintaining the Planting**

#### Soil Management

Mulching is the preferred soil management practice in the blueberry planting. The entire area around and between the plants should be mulched. Nearly any organic material is satisfactory: leaves, straw, wood chips, bark, peat moss, or sawdust. It should be applied loosely to a depth of 5 or 6 inches. Many growers use a combination mulch, a layer of leaves on the Chapter 11 Fruit in the Home Garden bottom with 2 or 3 inches of sawdust on top. Renewed annually, this heavy mulch retains moisture, keeps the soil cool in summer, and adds needed organic matter, and provides protection from low winter temperatures.

#### **Fertilization**

No fertilizer should be applied at planting time, and usually none is needed during the first growing season. On weak soils, however, the application of 2 oz. of ammonium sulfate around each plant about the first of June is beneficial.

Ammonium sulfate, at the rate of 2 oz. per plant, should be spread in a circle around each plant about 12 to 16 inches from its base just before the buds begin to swell the second spring. Increase the amount each succeeding spring by 1 oz. until each mature bush is receiving a total of 8 oz. annually. Where sawdust is used as a mulch, it may be necessary to apply additional nitrogen to prevent a deficiency as the sawdust decays. Increase fertilizer rates up to 50% as necessary to maintain good plant vigor.

#### Pruning

Refer to Pruning chapter.

#### **Pest Control**

Birds are by far the greatest pest in the blueberry planting. Covering the bushes with wire cages or plastic netting is perhaps the best method of control. Aluminum pie tins have been used successfully. They are suspended by a string or wire above the bushes in such a manner that they twist and turn in the breeze and keep the birds away.

## Harvesting

Some varieties of blueberry will bear the second year after planting. Full production is reached in about 6 years with a yield of 4 to 6 qt. per plant, depending on vigor and the amount of pruning.

Blueberries hang on the bushes well and are not as perishable as blackberries or raspberries. Picking is usually necessary only once every 3 to 7 days. Blueberries will keep for several weeks in cold storage.

For optimum flavor, do not harvest as soon as they turn blue. Rather, wait until the ring around the point of stem attachment turns blue - then the blueberry is ripe and at maximum flavor.

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# CHAPTER 12

## Lawns

Edited and revised by by Dr. John Roberts, University of New Hampshire Cooperative Extension

Producing quality lawns in New Hampshire is a relatively easy task if you follow some basic cultural practices. The climate is conducive for grass production, particularly for cool-season grass species. With proper cultural practices, a good lawn can be established and maintained.

## **Benefits of Turfgrass**

What has a lawn done for you lately?

- Front lawns of just eight average houses have the cooling effect of about 70 tons of air conditioning, while the average home-size central air unit has only a 3 to 4 ton capacity.
- Turfgrasses trap much of an estimated 12 million tons of dust and dirt released annually into the U.S. atmosphere.
- Playing fields covered with dense turf have proven safer, as demonstrated by a simple egg drop test. When a dozen raw eggs were dropped from a height of 11 feet onto a two-inch thick piece of dense turf, none broke; two thirds of them broke on thin turf from that height; and from just 18 inches up, all broke on an allweather track!
- Healthy, dense lawns absorb rainfall six times more effectively than a wheat field and four times better than a hay field. Sodded lawns can absorb 10 to 12 times more water than seeded lawns, even after two years of growth, thus preventing run-off and erosion.
- Recovery rates among hospitalized patients are often quicker when their rooms view a landscaped area than patients with non-landscaped views. Where vegetation grows, child mortality, suicide and energy consumption are less than in places where there are no plants.
- With up to 90% of the weight of a grass plant in its roots, it makes a very efficient erosion prevention device, also removing soil particles from silty water.

- Turfgrasses help purify water entering underground aquifers by its root mass and soil microbes acting as a filter to capture and breakdown many types of pollutants.
- A Gallup survey reported 62% of all U.S. homeowners felt investment in lawns and landscaping was as good or better than other home improvements. The investment recovery rate is 100 to 200% for landscape improvement, compared to a deck or patio that will recover 40 to 70%. Proper and well maintained landscaping adds 15% to a home's value according to buyers.
- Grass areas quickly affect people's moods by creating feelings of serenity, privacy, thoughtfulness or happiness and its yearly cycles of growth and color change lift human spirits and link urban inhabitants with their countryside heritage.
- A turf area just 50 feet by 50 feet absorbs carbon dioxide, ozone, hydrogen fluoride and perosyacetyle nitrate and releases enough oxygen to meet the needs of a family of four. The grass and trees along the U.S. interstate highway system release enough oxygen to support 22 million people.

## Starting a New Lawn

The following steps are critical for successful lawn establishment:

#### **Site Investigation**

The ground should gently slope (1 to 15%) <u>away</u> from the house to prevent water from entering the basement.

#### Soil Modification

If the native soil is undesirable (i.e. extremely rocky, droughty, compacted or poorly drained), modification is necessary for turfgrasses to grow vigorously. Drainlines or underground irrigation lines can be installed at this time. In poor soils, adding 4 to 6 inches of loam also will be beneficial.

#### Soil test

An inexpensive soil test helps measure the soil's pH and fertilizer needs. Obtaining soil test kits and sampling instructions can be obtained from your local UNH Cooperative Extension County Office.

#### Apply lime (if necessary)

Lime is very immobile in the soil and should be rototilled into the upper 4 to 6 inches of soil before seeding.

#### Rototill

Rototill, disc, or otherwise loosen (and incorporate lime) in the upper 6 inches of soil.

#### Rake

Rake and remove any large stones, sticks or other debris visible on the soil surface.

#### Firm soil surface

Rolling or watering helps settle the loosened soil.

#### Apply fertilizer

Preferably, a starter-type fertilizer should be applied to deliver 1 pound of actual nitrogen per 1000 square feet and raked into the upper inch.

#### Seed

Select a seed mixture containing improved varieties well suited for your lawn. Seed should be uniformly broadcast over the area using a drop or rotary spreader. This can easily be obtained by seeding in opposite directions and setting the spreader to deliver at 1/2 of desired rate.

#### Rake

Using very light pressure, rake the seed into the upper 1/4 inch of soil. While some seeds will remain visible on the surface, (birds don't eat enough seed to ruin a seeding), it's more effective than burying the seed too deeply!

#### Roll (optional)

Rolling helps pinch the seeds and soil particles together to prevent drying out.

#### Crabgrass control (spring seedings)

Unless prevented, crabgrass often predominates a spring lawn seeding. Weed killers or herbicides are available on the market that stop crabgrass seeds from germinating. Read the herbicide label carefully before purchasing a herbicide since some products can only be used on mature turf (not new seedings).

#### Mulch (optional)

A weed-free straw uniformly applied over the new seeding conserves moisture and reduces erosion on sloping ground. Apply approximately 1 bale per 1000 square feet.

#### Water

Keep the soil surface moist to prevent the seeds from drying out. This often requires light (5 to 10 minute), frequent (twice daily) watering for 2 to 3 weeks after seeding.

## **Overseeding Home Lawns**

Renovation, or overseeding, involves revitalizing an old lawn without removing all the sod. Many old, thin, and weed- infested HOME LAWNS are completely restored using this approach. Renovation is most successful when over 50% of the existing lawn is composed of desirable turfgrass species.

#### Thatch removal

Power rake the area to be overseeded as often as necessary to remove all thatch and unwanted vegetation. Thoroughness is important. Seeding into thatch results in poor germination.

#### **Clipping removal**

Using a mower, collect and remove the displaced thatch. For small areas, a bamboo rake works well.

#### Reseed

Uniformly scatter seeds over the soil surface using a drop or rotary spreader. Hand sprinkling seeds also works well on small, irregular patches that need overseeding.

#### Rake

Lightly drag or rake the seed into the upper 1/4 inch of soil.

#### Roll

Roll the area to ensure firm contact of the seed with the soil.

#### Mulch (optional)

Sprinkle weed-free straw over the seeded area.

#### Water

As with new lawns, the seed should be kept moist at all times during the germination and early seeding stages.

#### Mow

Continue mowing the lawn at approximately 2 inches.

## **Turfgrasses for Home Lawns**

#### Tips on buying seed:

The grass will likely be greener on your side of the fence if you:

- 1. Select a lawn seed mixture which performs well where it's sown (i.e. high maintenance, sunny location versus densely shaded, low maintenance location).
- 2. Select lawn seed mixtures that contain varieties (not generic 'no name' mixtures) tolerant to New Hampshire's diverse climate and soil conditions.

**Note:** While several good lawn mixtures containing improved varieties exist on the market, *availability* can be limited (especially when you're buying small quantities).

Use	Species/Mix (% by wt.)	Lbs./ 1000 sq. ft.		
Sun: Moderate to	50% Kentucky bluegr	ass		
nign maintenance	(or more) 25% perennial ryegra 25% fine fescue (not	ss 3-4 more)		
Sun:				
Low maintenance and/or droughty site	50% fine fescue 20% perennial ryegrass 20% Kentucky bluegrass 10% Dutch white clover			
	or 80% Tall Fescue 20% Kentucky bluegr	ass 7-9		
Shade:				
(less than 4 hours full sun)	70% fine fescue 20% perennial ryegra 10% Kentucky bluegr (shade tolerant variety	ss 4-5 ass y)		

### Cultural Requirements of Kentucky Bluegrass

#### (Poa pratensis)

#### General:

Provides high quality lawn. Spreading growth habit. Slow to germinate in cool weather. The predominate grass found in sod.

#### Soil:

Prefers moist, well-drained, fertile soils with a pH of 6.0 to 7.0. Has poor tolerance in strongly acidic soils (below 5.0).

#### Fertilizing:

Requires 0.5 pounds of nitrogen per 1,000 square feet per growing month.

#### Mowing:

Will tolerate various mowing heights with 2 inches preferred in most home lawns.

#### Light:

Does best in open, sunny areas; has poor dense shade tolerance. Prefers at least 4 hours of full sun per day.

#### Watering:

Can tolerate drought periods by becoming semidormant. Prefers 1 inch of water per week during the summer.

#### Varieties (partial listing):

Blacksburg, Trenton, Majestic, Victa, Baron, Gnome, Adelphi

#### Cultural Requirements of Perennial Ryegrass

#### (Lolium perenne)

#### General:

Fast germinating, wear resistant, bunch type growth habit. Effective in over-seeding and in lawn mixtures. Prone to winter injury.

#### Soil:

Similar to Kentucky bluegrass except can tolerate a more acidic soil pH.

#### Fertilizing:

Requires 0.5 pounds of nitrogen per 1,000 square feet per growing month.

#### Mowing:

Can withstand various mowing heights with 2 inches generally recommended. Sharp mower blades required.

#### Light:

Prefers sunny, open areas but has good partial shade tolerance.

#### Watering:

Requires supplemental irrigation to insure survival during extended drought periods.

#### Varieties (partial listing):

Yorktown III, Prelude II, Pinnacle, SR 4200, Palmer II, Affinity

#### **Cultural Requirements of Red Fescue**

(Festuca rubra)

#### General:

Low cultural requirements; used primarily in low-maintenance and shaded areas.

#### Soil:

Well-adapted to dry, sandy, infertile soils having a pH of 5.5 to 6.5. Has poor tolerance to poorlydrained or saline (high salt content) soils.

#### Fertilizing:

Grows well under low fertilization levels of 0.2 to 0.5 pounds of nitrogen per 1,000 square feet per growing month.

#### Mowing:

Under most home lawn conditions, red fescue should be cut 2 inches high.

#### Light:

Has excellent shade tolerance but won't dominate a Kentucky bluegrass or perennial ryegrass stand in open, sunny areas.

#### Watering:

Requires minimum irrigation. Turf quality declines if irrigated excessively.

#### Varieties (partial listing):

Reliant, Warwick, Longfellow, SR 3000, Aurora, Jamestown II
# Installation and Maintenance of Sod

Sodding your lawn allows you to enjoy instant beauty and maturity without the usual time-consuming hassles of seeding. For best results however, sod needs to be properly installed and maintained.

### Advantages of Sod Include:

- Installation of sod is possible anytime the ground isn't frozen.
- More dependable results on hillsides and steep slopes where erosion is a problem.
- Reduced encroachment of weed species, especially crabgrass, when compared to spring seedings.
- Better establishment on high-traffic areas.

### **Preparing the Soil**

- 1. Rototill or spade the soil to a depth of 4 inches.
- 2. Remove sticks, stones, roots and other debris.
- 3. Take soil test samples and ask Cooperative Extension to provide recommendations.
- 4. In accordance with soil test, mix lime into the upper 4 inches of soil. Incorporate a complete fertilizer into the upper inch of soil.
- 5. Smooth the soil by raking with a steel rake.
- 6. Firm the soil by lightly rolling. Fill in any low spots and grade down high points. A smooth, flat surface prevents later scalping by the mower.

*NOTE*: Avoid shady areas. Sod requires 4 to 5 hours of direct sunlight per day to thrive.

### Measuring and Ordering Turf

- Using a tape measure, measure the area (length, width, any unusual features), and put these measurements on a sketch.
- Ideally, take delivery on the day you plan to start laying your sod. Install all the sod delivered that day. However, any sod not installed should be unrolled in a shady area and lightly watered to prevent heating.

### Laying Your Quality Turf

- 1. Start at a straight line such as a driveway or walk.
- 2. Lay out the sod as you would a rug or tiles.

- 3. Make sure all joints are butted tightly together without overlapping or spaces between strips of sod.
- 4. Stagger the joints in each new row like rows of bricks.
- 5. Use a large sharp knife for shaping sod around trees, at flower beds, or along borders.
- 6. Completely soak the sod with at least 1 inch of water. Start watering 20 minutes after first strip is laid.
- 7. Roll the sod to smooth out small bumps and air pockets. This will assure good contact with the soil.

### **Sod Maintenance**

### Watering Schedule

- To gauge watering, simply place an empty can about 6 feet away from the sprinkler.
- When there is one inch of water in the can, it is time to move the sprinkler to the next area. Sod requires roughly one inch of water per week.
- Reflected sun along buildings dries sod quickly, so be sure to water these areas more often.

### Mowing

- Your new living carpet generally needs mowing 6-7 days after installation.
- The basic mowing rule is never remove more than 1/3 of the leaf blade during a single mowing.
- Mow when grass height reaches  $2\frac{1}{2}$  3 inches.
- Set your mower at a cutting height of 2 inches.
- For best appearance, be sure to keep your mower blades sharp.

### **Traffic Caution**

- Use your newly sodded lawn sparingly until good root establishment has taken place (2-3 weeks).
- Avoid concentrated play activities or similar rough usage for four weeks.
- There are no restrictions on visually enjoying your beautiful new lawn!

### Fertilization

- To maintain its high quality, sod should be fertilized at least 2 times during the year. Spring and fall applications are popular for many lawns. An additional summer fertilization will help insure a season long beauty!
- For more specific information on fertilization and lawn maintenance, see the appropriate sections in this chapter.

### Successful Home Lawn Establishment- A Checklist

**I seeded a new lawn and it didn't work. Why?** There are a number of reasons why initial seedings fail.

**Did you prepare the soil properly?** The final surface should be loose and non-compacted to insure a good seed to soil contact. Also, turfgrasses don't perform well in poorly-drained or compacted soils.

**Did you have the soil tested?** An inexpensive soil test will measure the soil's pH and fertilizer needs. Most New Hampshire soils are acidic, and often require lime. Seedlings fail to root deeply when the pH value drops below 5.0. With time, these grasses also become more susceptible to drought and other problems.

**Did you fertilize before seeding?** Without fertilization, young seedlings will soon lose their vigor and turn a pale yellow-green color. The net result will often be a lawn predominated by weeds. A starter-type (i.e. 10-20-10) formulation applied prior to seeding provides the nutrients needed for the first 6 to 8 weeks. Another fertilization will likely be necessary for best results.

**Did you seed too early or too late in the year?** In the cold soils of early spring or late fall it can take up to 3 weeks before some turfgrass seeds emerge. While such seedings can be successful, weed competition and erosion pose serious threats. Ideally, the optimum time to seed is between mid-August and early September (August 15 to September 10). During this period, crabgrass competition is minimal and the warm soil temperatures hasten the germination and establishment of the grass (up to 3 times faster). Seedings throughout the growing season will also succeed with proper care.

**Did you choose the right seed mixture?** In sunny locations, the grasses most often used are Kentucky bluegrass, perennial ryegrass, and (more recently) the tall fescues. While Kentucky bluegrass performs well in sunny sites, it has poor shade tolerance. Grasses that have excellent shade tolerance are the 'fine-leaf fescues' which include creeping red, chewings and hard fescues. In shady locations, seed mixtures should be comprised of at least 70% of these narrowbladed grasses. Fine-leaf fescues are also recognized for having good drought tolerance and are capable of surviving in low maintenance areas. **Did you apply the seed uniformly over the surface and rake it lightly (1/4 inch) into the soil?** A normal seed rate would be 3 to 4 pounds per 1000 square feet. If seed isn't raked in, but just left on the surface, it often dries out or washes away. Light rolling after the seed is put down also helps insure good seed to soil contact essential for best results.

**Did you irrigate frequently?** Seeds need to be kept moist for germination to occur. This often requires light (5 minute), frequent (twice a day in hot weather) watering for at least two weeks following seeding.

**Did you apply mulch?** Mulch, usually straw, helps protect the seeds from drying out and reduces erosion on steep slopes. Warning: Mulches should be <u>weed free</u>! Straw from hayfields often contain tons of weed seeds that will ruin your seeding. To avoid smothering your new grass, apply only 1 bale of straw per 1000 square feet. Roughly 3 weeks after germination, straw can be raked off if desired.

### Did you have weeds enter after the seeding?

Weeds are often more aggressive and faster to germinate than turfgrass seeds. This is a serious problem especially in the spring when many lawns are seeded. Crabgrass, in particular, will germinate in cool soils of early spring and continue to out compete young turf seedlings throughout the summer. Herbicides are on the market that are effective in preventing and controlling both crabgrass and broadleaf weeds.

#### Did you see any signs of disease or insects?

Both of these pest problems can injure and thin out young turfgrasses. If so, products can be purchased to prevent further damage.

### **Fertilization of Home Lawns**

Fertilization is one of the most important practices in lawn care. A properly fertilized lawn is more dense, darker green and has fewer weeds than one which is under (or never) fertilized! Few of our native soils contain enough of the most important nutrients needed by turfgrasses, nitrogen, phosphorous and potassium. As a result, lawns need supplemental fertilization to maintain vigorous and healthy growth.

An inexpensive soil test will determine the soils pH and overall fertility status. Contact your local UNH Cooperative Extension County office for sampling instructions and other information regarding lawn fertilization.

### Fertility Options for Home Lawns

What to buy? When to apply? Fortunately, there are several products on the market (both organic and inorganic) effective in producing desirable results. The calendar and comments below are suggested to serve only as a <u>guideline</u>.

### **New Hampshire Lawn Fertilization**

Maintenance Level	Timing	Comments
None	Never	Crabgrass galore!
Lower (1 x/yr)	Fall	Efficient & economical
Moderate (2 x/yr)	Spring & Fall	Good over-all choice
Higher (3 x/yr)	Spring, Summer &Fall	Season long beauty

### Fertility Needs During the Year

#### Fall

Fall is a recovery time for turfgrasses. The warm days and cool nights are ideal for lawns to produce new growth, both roots and leaves. Early fall is often considered the most efficient time of the year to fertilize a lawn. Fertilizers having nearly equal amounts of nitrogen, phosphorus and potassium are encouraged during this season.

### Spring

Spring also represents a time for turfgrasses to initiate new growth. While 'Mother Nature' alone helps stimulate spring green-up, most turfgrasses benefit from a fertilization. Startertype fertilizers which generally contain more phosphorus than nitrogen are commonly used in a spring feeding. Additional phosphorus helps initiate root development and early turf establishment of young seedlings.

#### Summer

Most turfgrasses turn brown and go dormant during the hot periods of summer without additional water. If a lawn is fertilized this time of year, lighter application rates of products containing mostly slow release nitrogen sources (including organics) are suggested to avoid burning of the lawn.

### **Nutrient Functions**

#### Nitrogen

Turfgrasses require nitrogen in larger quantities than other essential nutrients. It is involved with nearly all the plant growth and development processes. Increased top growth, darker green color and denser turf are generally associated with moderate (2 applications per year) nitrogen levels.

#### **Phosphorus**

The primary function of phosphorus is in the development of a strong root system and early seedling establishment.

The majority of rooting of turfgrasses occurs in the spring and fall of the year.

#### Potassium

Among its various roles, potassium helps in cell wall development and regulates water movement within the plant. Turfgrasses with adequate potassium levels have improved drought and wear tolerance. A nitrogen to potassium ratio of 4:3 is desirable to maintain during the year.

#### **Characteristics of Nitrogen Fertilizers**

#### FAST RELEASE NITROGEN FERTILIZERS

Fertilizer Name	Nitrogen (%)	Low Temperature Response	Residual N Activity (weeks)	Leaching Potential
Ammonium nitrate	33	rapid	4-6	high
Ammonium sulfate	21	rapid	4-6	high
Urea	46	rapid	4-6	high

#### SLOW-RELEASE NITROGEN FERTILIZERS

Fertilizer Name	Nitrogen (%)	Low Temperature Response	Residual N Activity (weeks)	Leaching Potential	
Synthetic Organic					
Sulfur-coated urea	22-38	mod. rapid	10-15	low	
Once	24-35	mod. rapid	15-36	low	
ScottsPoly-S products	16-40	medium	12-24	low	
IBDU	31	mod. rapid	10-16	modlow	
Nitroform	38	slow	10-30	very low	
Fluf	18	medium	6-10	low	
Nutralene	40	medium	10-16	low	
Methylene urea	39	medium	7-9	low	
Natural organic fertilizers					
<b>Ringer</b> (blood, bone, seed meals)	6	medium	10-12	low	
Sustane (turkey waste)	5	medium	10-12	low	
Milorganite (activated sludge)	6	slow	10-12	low	

Where trade names are used for identification, no product endorsement is implied nor is discrimination intended against similar materials.

### **Maintaining Home Lawns**

The following maintenance calendar and tips will be helpful for growing a healthy, attractive lawn in New Hampshire.

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Mowing												
Fertilizing												
Liming												
Crabgrass Control												
Irrigation												
Seeding												
Overseeding												
Sodding												
Thatch Removal												
Insect Control												
Broadleaf Weeds										1		

### A Home Lawn Maintenance Calendar

### Mowing

Mowing is particularly important in maintaining a dense and attractive home lawn. With proper mowing, turfgrasses help crowd out weeds, reduce disease invasion and improve a turfgrass's drought and wear tolerance.

### Height:

Most home lawns should be mowed at 2 inches. Maintaining home lawns at lower mowing heights is possible, yet more difficult. At lower mowing heights, home lawns are more likely to become infested with weeds, insects and diseases. In mid-summer, increasing the mowing height between 2 ½ and 3 inches helps prevent drought damage.

### Frequency:

As a rule of thumb, lawns maintained at 2 inches, should be mowed every 5 to 7 days during the growing season. Mowing shouldn't remove more than 40% of the leaf at one time. This prevents 'scalping' of the lower leaf blades, resulting in a loss of their dark green color and resistance to traffic and pest pressure.

#### **Mowing Equipment:**

The most common type of mower for home lawns is a rotary type (not reel or flail). This includes mulching-type mowers which chop grass leaves more finely, increasing the rate of leaf decomposition. For best results, mower blades should be periodically sharpened to avoid ragged cuts of the leaf tip.

#### **Clipping recycling:**

Frequent (weekly) mowing helps to keep the quantity of clippings small enough to filter down and not smother the turf. When mowing, leaving the clippings on the surface (not bagging) is encouraged. Clippings help return important nutrients to the lawn and conserve valuable soil moisture.

### Watering

### During the summer:

Lawns will often go semi-dormant and turn brown during the hot periods of summer without being irrigated. Death of the lawn may result from severe drought. Most lawn grasses during the summer require 1 inch of water each week to remain green and healthy. Placing an empty coffee can 5 to 10 feet away from a sprinkler is an easy and helpful way to monitor the amount of water applied.

### Time of watering:

The most efficient time to water home lawns is early in the morning! While evening waterings are convenient for most homeowners, they encourage more disease activity. Mid-day waterings are also possible (they will <u>not</u> harm the turfgrass) but the water lost to evaporation is higher.

### **Fertilization**

Fertilization is one of the most important practices in lawn care. A properly fertilized lawn is more dense, darker green and has fewer weeds than lawns under (or never) fertilized. Few of our native soils contain enough of the most important nutrients needed by turfgrasses; nitrogen, phosphorous, and potassium. As a result, lawns need supplemental fertilization to maintain vigorous and healthy growth.

What to buy? When to apply? Depending on the maintenance level desired, most lawns should be fertilized between one and three times per year. Fertilizers containing slow release nitrogen sources (including natural and synthetic organic) help reduce the threat of nitrate leaching and provide a longer response.

For more information on home lawn fertilization, see the section on fertilization in this chapter.

### Liming

To determine if lime is necessary, have the soil pH checked at a local laboratory. Since lime is slow to react (up to 6 months) and quite immobile in the soil, late fall applications are ideal. However, agricultural limestone can be safely applied throughout the year due to its low burning potential.

For newly seeded lawns, limestone should be applied <u>prior</u> to seeding and thoroughly mixed into the upper 4 to 6 inches. The desired pH for lawn grasses is between 5.5 and 7.0. Lawns containing predominantly Kentucky bluegrasses should have a minimum soil pH value of 6.0.

### Thatch

Thatch (also known as organic matter) is the layer of partially decomposed stems, roots and some leaves of grasses which accumulates at the soil surface. Thatch buildup is a naturally occurring process as older plant parts die and new tissues are generated. Bacteria in the soil feed on thatch and help break it down. Moderate ( $\frac{1}{2}$  inch) thatch layers are considered desirable in home lawns.

However, excessive thatch buildup (greater than 1 inch) is unwanted. Thick layers harbor insects and diseases, promote shallow rooting of turfgrasses (lawns will dry out faster in hot weather), and cause an overall decline in turf vigor.

### Thatch control

Powered rakes (also called dethatching or vertical thinning machines) are effective in removing thatch (1/4 inch at a time). These can be rented from garden equipment outlets. Early spring or fall mechanical thinnings are preferred as recovery of the lawn during these periods will be rapid (1 to 2 weeks). Fertilizing immediately following a dethatching also hastens the recovery time.

### **Pests of Home Lawns**

### Lawn Insects

There are naturally many different types of insects present in a lawn. Most of these are not harmful to the grass. Control for insects is not necessary unless the pest population builds up enough to cause visible damage to the lawn.

The most common above-ground insect pests in New Hampshire are chinch bugs; these feed on grass leaves and stems. Below ground, the most common pest is the white grub larvae; these feed on plant stems and roots.

### Hairy Chinch Bug:

Chinch bugs are probably the most destructive pest of home lawns. The adults are small (1/16" long), black, with white wings and red legs. The small nymphs are without wings and appear completely red. These insects damage grass by piercing the plant with their needle-like mouth parts and sucking plant juices. Rainy weather hinders chinch bug development so damage is less likely to occur during wet periods. Chinch bugs prefer to feed on bluegrass and fescues.

Chinch bugs prefer sunny areas and lawns with thatch. The overwinter adults emerge from sheltered areas and seek grass plants. Egg-laying occurs when temperatures reach 70 °F, generally in May. The eggs hatch into young nymphs which do the greatest amount of damage.

Damage to turf is first observed in June. This begins as yellowish areas which soon become dead patches. During warm weather, turf can be damaged quickly as the bug population multiplies. New adults will appear in July. A second generation occurs in August and more turf damage can be expected. In the fall, large numbers of adults are seen around building foundations.

Chinch bug damage appears quickly in hot weather and is often confused with drought damage. If chinch bugs are suspected, there are several methods of detection:

• Get down on your hands and knees and search the crown of the grass next to a damaged area. Chinch bugs are most active and visible during the heat of the day.

• Remove both ends of a can press it into the ground. Fill the can with water. Stir up the grass with your hand. The bugs should float to the top.



### White Grubs:

White grubs are the larval or grub stage of several species of beetles and chafers. The two most common in New Hampshire are the Japanese beetle and the June bug. These beetle larvae are C-shaped, and can be found feeding among the roots of grass. They are typically creamcolored with a brown head and with a dark area at the posterior end where the body contents show through the skin. White grubs feed on grass roots and most complete their development in one year (June beetles require two or three years).

Japanese beetle eggs are laid in July and August. June beetle eggs are laid in June and July. The young begin feeding on the grass roots within one or two weeks. Feeding goes on until fall when the grubs burrow deep into the ground to overwinter. In the spring, the grubs burrow upwards to the grass root level. They resume feeding until June when they transform to the pupal stage.

Adults begin emerging from the ground about the first week of June for the June beetle and the first week of July for the Japanese beetle. Evidence of an infestation of white grubs appears as grass begins to turn brown due to root damage. Usually the turf can be rolled back like a rug to reveal the white grubs.



Bird, mole, or skunk damage is a sign of grubs present. Chemical control depends on proper timing of the application. Usually chemical control isn't necessary until there are 10 grubs per square foot. Most chemicals should be applied when the grubs are near the surface (spring or late summer). The grubs are smallest in late summer and control will be better at this time.

For specific insect control recommendations and more information on other lawn insect pests, refer to Insect Fact Sheet #7, "Insect Pests of Home Lawns", by Dr. Stanley R. Swier.

# Common Turfgrass Diseases of Home Lawns:

### **Red Thread & Pink Patch**

Infected lawns often have a pink or reddish cast. Irregular patches of dead and dying leaves are also common. Upon close inspection, tiny red threads of the fungus may be observed growing from the leaf tips. Red thread and pink patch are most common on perennial ryegrasses and fine fescues, but they may be seen on any species of turfgrass. Infections are most obvious during the spring and fall during cool (65-75  $^{\circ}$ F), moist weather. Cultural management techniques include maintaining soil pH at 6.5-7.0, collection of clippings during mowing, avoiding late day watering, and aeration to improve turf growth.

### Leaf Spots and Melting Out

The initial symptoms first appear on the leaves as small purple or red colored oval spots. The centers of the spots eventually turn tan, forming dark-bordered 'eye spots'. Under moist conditions, leaf spots may coalesce and blight the entire leaf. The fungus may eventually invade the crown and roots causing the 'melting out' phase of the disease which is visible as large patches of dead and dying turfgrass. The leaf spot phase is most common during the spring and fall and the 'melting out' phase is more prevalent during the warm months of summer. Succulent growth, promoted by high nitrogen fertilization and high moisture conditions favor the development of the disease. Several cultural management practices can help reduce both phases of the disease; 1) avoid excessive fertilization with water soluble nitrogen sources, particularly in the spring, 2) raise the mower height to 2.5-3" and remove no more than 1/3 of the leaf blade at any mowing, 3) do not mow wet grass, 4) water infrequently and deeply and never mow in the late afternoon or early evening, 5) reseed damaged areas with turfgrass cultivars resistant to leaf spots. Blends of turfgrass species are preferable to monocultures.

### **Rhizoctonia Brown Patch**

Circular patches of yellow, brown and sunken grass up to several feet in diameter may develop on home lawns. Individual grass blades often develop irregular purplish-brown lesions. Under moist conditions. a gray, web like fungal growth may be visible on the infected leaves, particularly at the margins of the patch. Brown patch is most common during the hot humid weather of summer. Several successive nights of warm temperatures with high humidity often trigger outbreaks of the disease. Cultural management techniques include; 1) avoiding nitrogen fertilizer applications just prior to and during hot humid weather, 2) water early in the day ( to a depth of 6"). Kentucky bluegrass and fine fescue lawns are less susceptible to brown patch.

### Snow Molds (pink and gray)

Injury caused by snow mold fungi usually becomes evident as the snow melts in the spring. Roughly circular patches of dead, matted grass, 3-12" or greater may appear white to gray or even pink. Gray snow mold rarely damages the crowns or roots, thus lawns infected with the gray snow mold fungus usually recover quickly. Pink snow mold infections often kill the crown and roots thus infected areas often require reseeding. Snow mold fungi are most active under moist conditions at temperatures just above freezing. Ideal conditions for the development of snow molds occurs when snow cover occurs early over unfrozen ground and remains throughout the winter. Thick layers of fallen leaves also provide moist conditions favorable for snow mold development. To prevent snow mold, it is important to continue to mow the grass until growth ceases in the fall. Slow release nitrogen fertilizers should be applied at least six weeks before dormancy. In the spring, dead and matted grass should be raked from the affected areas to allow for new growth.

### Turfgrass Diseases: Cultural Management Recommendations

Cheryl A. Smith, Extension Specialist, Plant Health

Disease (pathogens)	Turfgrass Hosts	Season of Occurrence	Cultural Management Methods
Dollar Spot (Sclerotinia homeocarpa)	All species	late spring-September	avoid drought stress, water early (5-10am), avoid compaction, balanced N-P-K, reduce thatch
Leaf Spot, Melting-Out ( <i>Bipolaris, Dreschlera</i> )	All species, Kentucky bluegrasses*, ,fine fescues	spring-October	raise mowing height, avoid excess soluble N, reduce thatch, water early
Red Thread (Corticium fuciforme)	Most species perennial ryegrasses, fine fescues	spring-October	maintain balanced N-P-K, avoid low pH, light applications of N (0.5-1.0#/1000 ft2), remove clippings, avoid low pH
Powdery Mildew ( <i>Erysiphe graminis</i> )	Kentucky bluegrasses fine fescues	early summer-October (most prevalent in Sept.)	reduce shade, avoid excess N, improve air circulation
Brown Patch ( <i>Rhizoctonia solani</i> )	All species tall fescues, perennial ryegrasses	July-September	avoid excess N (especially during active growth), mow only when dry, water early (5-10am)
Pythium Blight (Pythium spp.)	All species <b>perennial ryegrasses</b>	June-mid-September	avoid night watering, avoid excess N, mow only when dry, (fungicides usually required)
Pythium Root Rot ( <i>Pythium spp</i> )	All species annual bluegrasses	March-November (periods of slow plant growth)	as above, increase organic matter, improve drainage
Anthracnose (Colletotrichum graminicola)	Bluegrasses, fescues, bentgrasses <b>annual bluegrass</b>	July-September	avoid drought stress, avoid compaction, balanced N-P-K
Summer Patch ( <i>Magnaporthe poae</i> )	Fine fescue, Kentucky bluegrass, annual bluegrass	July-September	avoid compaction, avoid drought stress, raise mowing height, lower pH in top 1" soil 6.5, avoid overwatering
Fusarium Blight ( <i>Fusarium culmorum</i> )	All species	June-September	as for summer patch
Snow Molds Gray ( <i>Typhula spp</i> ) Pink ( <i>Microdochium nivale</i> )	All species	November-April (during extended periods of cool, wet weather, 32-55 F)	continue mowing until growth ceases in the autumn, maintain pH < 7.0, avoid late N applications

\* Most susceptible species indicated by bold type.

### Weeds in Home Lawns

### **Control Methods:**

### **Cultural Control:**

Effective weed control involves the use of recommended cultural practices and the use of herbicides when necessary. Producing a dense, healthy stand of turfgrass is the best way to minimize annual grass weeds and other broadleaf weeds. The proper mowing height and frequency, fertilization and irrigation are part of the weed control program and should be practiced throughout the growing season. There are two basic groups of weeds: broadleaf weeds and weedy grasses. Broadleaf weeds consist of the familiar dandelion, chickweed, ground ivy, oxallis, plantain, and anything which is not classed as a grass. Examples of weedy grasses are quackgrass and crabgrass.

### **Chemical Control:**

Timing is important for herbicide application. The best time for annual grass weed control is late April or early May in New England. The best approach is application of a preemergence crabgrass or annual grass control herbicide about two weeks before annual grass seeds germinate. If you apply these herbicides after annual grasses appear above-ground, the application may not be effective. Preemergence herbicides control germinating weeds and provide effective control of crabgrass and other annual grass weeds for several weeks or months, depending upon dosage and products. The effectiveness of these materials is based upon their ability to provide excellent weed control with no turf injury.

There are good selective herbicides available for broadleaf weed control. In general, broadleaf weeds respond best to weed killers when they are most actively growing and/or in the seedling stage. This is usually in late spring or early fall. When equally effective, fall applications are preferable because fewer ornamental and garden plants are in an active state of growth.

### Herbicides for Broadleaf Weed Control in Turf

Trade Name	Common Name	Recommended Fl. Oz./1000 sq. ft.
TRIMEC CLASSIC	2,4-D+ MCPP + dicamba	1.2 to 1.5
SUPER TRIMEC	2,4-D 2,4-DP + dicamba	0.75 to 1.1
TURFLON D	2,4-D + triclopyr	1.1 to 1.5
WEEDONE DPC	2,4-D+ 2,4-DP	1.0 to 1.5
CONFRONT	Triclopyr + clopyralid	0.37 to 0.74

### Other Common Home Lawn Problems

# Moss and Mushrooms in Home Lawns

### Moss

Many home lawns in New Hampshire contain moss and/or algae. Moss is often found in shady conditions which have acidic, infertile, poorly-drained soils. They won't directly damage the turfgrass, but they do compete for space and can dominate sections of a lawn with time.

Mosses are small green plants which have a mass of fine stems and shallow roots. They can be a very attractive ground cover in those areas to which they are well adapted. However, if control is desired, the following practices are suggested.

Generally, moss cannot invade a vigorous, healthy lawn. Unless the basic fault(s) that allowed moss to enter in the first place is corrected, the control will be incomplete or only temporary.

For successful control of moss, maintain good soil fertility and pH values which favors dense, vigorous turf growth. Have the soil tested to determine lime and fertilizer needs. Liming alone is <u>not</u> recommended as a short-term control measure.

### Mushrooms

Mushrooms, also called *toadstools* and *puffballs*, live on organic matter in the soil. The mushroom is the above-ground fruiting or reproductive structure of a fungus. After wet weather, mushrooms will sprout (overnight) in the lawn. Most mushrooms don't damage the lawn, but are objectionable because they are unsightly.

There is no practical or permanent way to eliminate mushrooms. However:

- 1) The easiest (yet temporary) solution is to simply mow them off.
- 2) Annual dethatching to reduce the organic matter buildup also helps.
- 3) If possible, remove any buried roots, stumps and lumber that mushrooms might live on.

### **Moles in Home Lawns**

Look, there's another one! Homeowners often see large mounds of soil and ridge-like tunnels in their lawns shortly following snowmelt in early spring. This is the result of mole activity. Due to the unsightly mounds moles create, they are often considered unwanted pests in home lawns.

Runways are dug to search for food, provide protection from predators and create space for resting and breeding. The annoying mole hills are external evidence of the moles' underground tunneling activities. Unfortunately, for most homeowners, moles remain active throughout the year.

Moles are primarily carnivores. Their diets consist mainly of earthworms, grubs, beetles and insect larvae they find in the soil. A mole's appetite seems to be insatiable. They consume enough food to equal 60-80% of their body weight (averaging only 3 to 4 ounces) daily. The estimated yearly intake of food for a single mole is about 40 pounds!

In the long haul, moles are here to stay. Thorough control is difficult to obtain due to a mole's elusive life style and its ability to form an extensive network of underground tunnels of numerous nesting sites. Some farmers have trapped 100 moles annually, only to be faced with the original amount of infestation the following season!

As a result, when large populations of moles exist in a lawn, only short term and partial reductions should be expected. Often times, the easiest method for homeowners is to "wait and see". Mole activity will often subside later in the spring once the ground dries out.

For additional information on home lawn insects, diseases and other pests such as moss, mushrooms and moles, contact your local county Extension office.

### Management Practices To Reduce Ground Water Contamination In Home Lawns

- Reduce the need of pesticides by following recommended cultural practices such as proper mowing and watering which maintain a dense, vigorous lawn.
- Select pesticides and fertilizers that are resistant to leaching. For example, when possible select fertilizers that have 'slow release' or less water soluble sources of nitrogen.
- Use minimum dosage of pesticides to achieve adequate pest control. Read and follow the instructions on the label.
- Calibrate fertilizer and pesticide equipment in order to assure the desired application rate is being applied.
- If needed, when establishing new lawns, select a topsoil such that its depth, soil texture and percent organic matter are effective in absorbing fertilizers and pesticides. For example, 6 inches of a silt loam textured soil would be preferred to 3 inches of a sandy loam soil.
- Maintain soil conditions such as adequate drainage and aeration which favor microorganism activity since they are important for decomposing pesticides in the soil.
- Select turfgrass species well adapted to local environmental conditions and varieties which have a low pesticide and fertilizer demand.
- Use rinsate from washed pesticide containers and application equipment on the lawn as diluted pesticide.
- To avoid runoff and leaching, do not apply pesticides just prior to heavy rainfall. To avoid pesticide "drift" off the target area do not spray on windy days.
- When applicable, apply fertilizers and pesticides during periods of active turf growth for improved uptake by the plant.

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# CHAPTER 13

## **Woody Landscape Plants**

Edited and revised by David Seavey, U.N.H. Cooperative Extension

Woody ornamental plants are key components in a well-designed, useful environment. This large group of plants can be divided into three general categories: trees, shrubs, and vines.

**Trees** are woody plants that produce one main trunk and a more or less distinct and elevated head (height of 15 feet or more).

**Shrubs** are woody plants that usually produce multiple shoots or stems with a height of 15 feet or less.

**Vines** are climbing or crawling woody plants without self-supporting upright stems.

**Ground covers** are low-growing plants that create an attractive carpet effect.

This chapter will include considerations in selecting plants based on: function, soils characteristics, and climatic factors. Planting, fertilizing, mulching, and other cultural practices are discussed.

### Vines in the Landscape

Most vines are woody or semiwoody climbing or trailing plants. Like shrubs, trees, and ground covers, vines can be important to the interest of any garden landscape. Each species and variety of vine possesses distinctive characteristics which make it well-adapted to certain locations in the landscape plan.

### Selection

In selecting vines, as in selecting trees and shrubs, carefully review the needs of the area, and then select the most suitable plants. Vines can be useful in a variety of sites. Some vines are valued for the shade they provide when trained over an arbor. Others add interest to a planting when trained against the wall of a building or when used to frame a doorway. Some vines can be used to relieve the monotony of a large expanse of wall, being trained in a definite pattern or allowed to completely cover a wall with leafy green, while others dramatically change a plain fence. Vines can be useful to form a cascade of bloom on rough, steep banks while holding the soil in place. Vines also offer diverse visual qualities and are valued for the rich texture of their foliage, their decorative habit of growth, the fragrance of their blooms, or the beauty of their flowers. Some are valued for the graceful tracery of their simple stems or for the beauty of their leaf pattern. Vines offer a rich source of material with which to create interesting, exciting, and beautiful plantings.

Vines are generally divided into three general groups based on their method of climbing:

- (1) Some, like Boston ivy, climb by attaching small, root-like appendages to the wall as a means of support. Sometimes these are modified tendrils with small, circular discs at the tips; others, like English ivy, have small rootlets along the stem to firmly attach the vine to either brick or wood.
- (2) Vines such as clematis and grape climb by winding tendrils (or leaflike appendages which act as tendrils) around the object on which they are growing.
- (3) The third group, including bittersweet and wisteria, climb by twining. It is interesting to note that all vines do not twine in the same

direction. There is not a haphazard method of twining. The plants of each species invariably twine in one direction. As example, bittersweet twines by climbing from left to right. Hall's honeysuckle twines by climbing from right to left.

By knowing in advance how each vine climbs, the proper means of support can be provided for those selected.

### Culture

Most vines will quickly revert to a tangled mass of foliage over the ground if they are not given the proper means of support and a reasonable amount of care and maintenance. The best type of support for vines gives the required structural strength and stability, and at the same time, is neat in appearance.

Like most other plants, vines require some maintenance. Pruning is necessary to remove old wood. This may require several cuts to each stem so they can be untangled. It is often necessary to prune occasionally to keep the plant within bounds and to guide future growth. As with other plants, vines are pruned to produce better bloom. Insect and disease control is important. Watch for signs of pests, identify the cause of the problem and use appropriate control measures. Your local Extension office can help you with this process.

The area to be covered should be studied carefully to determine what type of vine should be used. Rate of growth is a critical consideration, since there are vines that exhibit rampant growth and can soon become a nuisance.

### **Ground Covers in the Landscape**

In a broad sense, ground covers include any material that covers the ground surface so that it cannot be seen from above and so that rain does not strike directly upon it. With this definition, grass, various types of paving, shrubs, and even trees could be called ground covers. However, here we are referring to ground covers as low (up to 18 inches), matforming or trailing plants, other than grasses or other plants that tolerate walking or mowing. Most ground covers are not intended to be walked upon and will be severely damaged by pedestrian traffic. When ground covers are chosen carefully and placed correctly, they greatly enhance the beauty of the landscape composition. In addition to their aesthetic value, they fulfill a number of other important functions:

- Controlling erosion on slopes
- Obstructing traffic without impeding view
- Conserving soil moisture and, during periods of extreme heat, lowering temperatures in the soil
- Reducing lawn maintenance
- Filling narrow, odd-shaped areas where mowing and edging might be difficult
- Providing vegetative growth where grass is difficult to maintain
- Producing interesting patterns with variation in height, texture, and color
- Trees and shrubs are visually tied together in beds when interplanted with ground covers.

In practice, the ground covers most frequently used are plants that are easily propagated, vigorous, and hardy.

### Selection

Selection of a ground cover will depend upon several factors. Is the area flat or sloping? Is it in sun, or partially or deeply shaded? Soil conditions must be studied. Some ground covers prefer a moist soil, rich in organic matter while others will adapt to dry, sandy situations. Give consideration to color, texture, height, and habit as well, since some ground covers tend to grow rampantly. One problem that limits the use of ground covers is the cost of installation since large numbers of small, individual plants are required. In addition, a wellprepared planting bed is essential to the establishment of ground covers and can be costly and timeconsuming. Hardiness is also a factor, especially if the ground is bare during winter months.

### Culture

Significant maintenance is necessary for the first 1 to 3 years or until the ground cover becomes established. Cultivation is necessary to control weeds; fertilization to encourage fast, vigorous growth to achieve good cover; irrigation in times of dryness; and disease and pest control. When these maintenance considerations are ignored, the progress toward achieving a good ground cover planting is disappointing.

Wherever paving, lawn, or cultivated beds are not desirable, ground covers can be successfully used. Newly cut banks, and any slopes greater than 12% are best treated with ground cover plantings. Around buildings, ground covers are superior to paving or structural controls for reducing heat, glare, noise, and dust.

### **Selecting Trees and Shrubs**

Because there are so many woody plants available for use in landscaping, we must be careful to select plants that are appropriate for our needs. Selection should be based on several different factors.

The intended purpose should influence selection of plants with appropriate shape, size, and other physical characteristics. Trees are used for shade, ornamental, screening, windbreak, and soundreducing purposes. Shrubs are used for screens, barriers, windbreaks, ornamentals, ground covers and wildlife shelters. Both trees and shrubs can be selected to provide edible fruit or nuts. Providing shade usually requires tall, sturdy, longliving species. Density of foliage, which determines the amount of shading, is important. A tree such as a Norway maple will produce a very dense shade that prevents plants or turfgrass from growing under it, while a honey locust will produce a light partial shade which is not a hindrance to other plants growing below it. Deciduous trees should be used to shade the south windows of a home in the summer, thus allowing the sun to penetrate in the winter. Screens usually require plants that produce a dense foliage. Windbreaks must be able to survive rigorous climate conditions. Evergreen plants are usually chosen for screening. Barrier plantings usually require sturdy plants with dense growth, and possibly thorns or spines.





Ornamental attributes are quite varied. Both trees and shrubs can be selected for flowers or colorful fruit, interesting foliage, fall color, interesting bark, winter colors of foliage or branches, or interesting shapes of the plants themselves.

Consider the size of mature trees and shrubs and where they are to be used. Trees that grow tall, such as the white oak, sugar maple and white ash, are suitable for larger buildings. They tend to dominate or hide onestory buildings. For attractive and proper balance with one-story buildings, trees that do not grow over about 35 feet are recommended. Shrubs that outgrow their spaces can hide windows, block walkways, or crowd out other plants. Shrubs can sometimes be kept small by pruning, but this requires continuing maintenance. Careful consideration of mature sizes will reduce the need for pruning.

Shape is especially important in selecting trees for ornamental and shade purposes. Tall trees with long, spreading or weeping branches give abundant shade. Small trees and trees of other shapes, including the pyramidal evergreens, the clump birch and the low growing hawthorn, crab apple, and dogwood are useful for ornamental purposes but do not give abundant shade.



Trunk Single, Branches Horizontal White Pine Trunk Dividing, Branches Spreading Elm Branches Pendulant Willow

Branches Ascending White Oak

Environmental conditions should influence the selection of plants. Size of the planting area is important, as are site characteristics such as sunny or shaded, wet or dry, exposed to winter winds or pollution. Plants selected should be tolerant of existing conditions, and be hardy in the appropriate climate zone.



Finally, consider how much maintenance the plant will require and any possible disadvantages including susceptibility to attack by diseases and insect pests; soft or brittle wood that is easily damaged by wind and ice; fruits and seeds that are large, messy, smelly, or otherwise obnoxious; and abundant shedding of twigs and small branches. Some examples of these conditions are killing of Lombardy poplar by Cytospora canker or by borers, breaking of Siberian elm branches by wind and ice, and the production of bad-smelling fruit by the female ginkgo. The production of fruit by the mulberry, which attracts birds, can also be an undesirable characteristic. Since this fruit is soft and decomposes rapidly when ripe, it is messy on walks and attracts flies and other insects.

### **Purchasing Trees and Shrubs**

Once the selection process is completed, plants can be purchased. Transplants can be classified into three classes according to the way they are dug and/or shipped: bare-rooted plants, balled and burlapped plants (B&B), and container-grown plants.

### **Bare-Rooted Plants**

These have had the soil washed or shaken from their roots after digging. Nearly all are deciduous trees or shrubs which are dormant. Most mail-order plants are of this class because plants in soil are too heavy to ship economically. Many tap-rooted plants, such as nut trees and some fruit and shade trees, are handled this way because they are not amenable to balling and burlapping. Plants available from mail-order nurseries in early spring with roots wrapped in damp sphagnum and packaged in cardboard or plastic containers are also bare-rooted plants. These need special attention because their roots are tightly bunched up in unnatural positions in order to force them into the package. Remove the sphagnum packing and be sure to spread the roots out to a natural position.

Evaluate the plant material at time of purchase.

- Ball size in relation to tree caliper or shrub size
- Leaf size
- Branch structure
- General health growth rate, stressed plants and damage from insects, etc. are unacceptable

Plants in the bare-root class are best planted while they are dormant, in spring. Never let the roots dry out. This is perhaps the single greatest reason for failure with bare-rooted plants. Keep roots in water or wrapped in plastic or wet paper until you are ready to place the plant in the hole, and plant as soon after obtaining them as possible. This class of plants may need extra pruning at planting time.

### Bare Root





a. bare root

b.pre-packaged



c. Balled and burlapped

d. Potted and container grown

### **Balled and Burlapped Plants**

These are likely to have been grown in nursery rows for some time and to have been root-pruned so that the root system within the balls is compact and fibrous. Such plants re-establish themselves rapidly. This method is primarily used for plants that never lose their foliage and thus are not amenable to bareroot treatment. Such plants are broadleaf evergreens like rhododendrons and azaleas, and conifers of all types. A number of deciduous trees and shrubs that have branching root systems which are easily contained in a soil ball are also sold as B&B plants.

Plants in this class are best planted in early spring prior to bud break. This will allow roots to take advantage of growth hormones produced in shoot tips. When selecting a balled and burlapped plant, be sure the ball is sound and hasn't been broken. Avoid those plants that feel loose in the soil balls. Be sure the soil ball does not dry out. These plants will usually need little if any pruning at planting. plant will cost less, and may establish faster. Don't buy plants so small they are in danger of being walked on or mowed over.

#### **Proportion of Roots to Top**

### **Container-Grown Plants**

These are usually grown in the container in which they are sold and are increasing in popularity in the nursery trade. Because of their appearance, gardeners are often misled into thinking that all they have to do is put these plants into the ground and forget about them, but they need the same careful planting and maintenance as other plants -- proper watering is critical. Container-grown plants can be planted any time during the growing season but prior to October 1st. Roots must grow out one-half inch before water absorption occurs through root tips.

Container-grown plants can easily become potbound. Their roots are contained in a limited space and coiled around one another in the container, and may fill it tightly. Some of the larger roots may have become coiled back around the trunk and begun a process called girdling.

The solution to this problem is to split the lower half of the root system and spread the roots horizontally. This practice will prune the roots, thus encouraging new laterals, prevent girdling roots and raise the lower roots closer to the soil surface. An alternative is to cut vertical slits around the root ball, in 4 to 5 evenly spaced places. If any roots are girdling the base of the stem, sever them.



When selecting plants, look for a good natural shape, free from thin spots or broken limbs. Make sure the root ball is solid and the bark is intact. Avoid container-grown plants where you can see roots circling on the surface or coming out of the drainage holes. Plants chosen should be free of any insects or diseases. Generally, the smaller sizes of a







Loose root ball is unacceptable.

Root ball of acceptable B&B plant stays firm when rocked gently.





Broken twigs are acceptable.

Broken branches, gouged trunks are unacceptable.



### **Planting Trees and Shrubs**

The proper installation of plants in the landscape involves much more than just digging holes and setting plants in them. The planter is responsible, as far as possible, for developing a satisfactory microclimate for optimum growth and development of the plant. A healthy and vigorous plant is required if the landscape is to achieve the desired effect. Healthy plants will need less maintenance in the years following establishment.

The planting hole is important since this is the environment of the plant root system. Dig a wide hole, twice as wide as the root ball if possible, and only as deep as the root ball. For very large specimens, such as trees of 4-inch caliper or more (the term caliper is derived from the use of a caliper to measure the trunk diameter) and large shrubs with a soil ball of 3 feet or more, the hole should be made up to 24 inches wider.

A traditional recommendation for preparing a planting hole for trees and shrubs has been to incorporate organic matter into the backfill soil. Recent research has cast doubt on the value of this practice. In fact, it appears that energy could be better spent digging a slightly wider hole than working organic matter into the soil. Apparently, the addition of organic matter into the backfill soil creates an interface between the amended soil and the undisturbed soil around the planting hole that is detrimental to root growth and water movement between the two soils. In tests conducted at the University of Georgia, examination of the root systems of plants in holes with amended soil revealed that the majority of the roots were confined to the original planting hole.

A better approach is to select a plant appropriate to the soil type or to replace or amend a poor soil with a better loam.

The finished planting depth after settling of the soil should be such that the plant is exactly the same depth after replanting as when growing in the nursery. Probably more plants are lost because they were planted too deep than for any other reason. Set the plant on firm native soil in the bottom of the hole. When planting a poorly drained site, set the plant so that 1 to 2 inches of the root ball are above the soil level.

**Proper Planting Depth** 



Balled and burlapped material must be handled carefully. On most species if the soil ball is broken, many of the roots will be severed from the trunk and the plant will die. Always pick the plant up by the soil ball or container, never by the trunk or stem. Set the B&B plant into the hole, remove all ropes, and fold the burlap down into the bottom of the hole. Cut away and discard the burlap if possible, especially if it is actually plastic. Remove all plastic or metal containers before placing a containerized plant in the hole. Small containers with tapered sides can be removed by turning the plant upside down and giving the top edge of the container a sharp rap. Catch the soil ball with your hands as it slips from the container. Do not break the soil ball apart. The larger-sized containers (five gallons or more) should be cut away with special cutters. If the trees' balls are in wire baskets, they also should be cut away. If plants have become overgrown in the container and the root mass is growing in a tight, compact circle around the soil ball, cut out the outer roots with a sharp knife in two or four places around the soil ball. Make the cut from the top to the bottom of the soil ball.

Bare-root plants should have the packing material and all damaged or dead roots removed. If possible, before planting, the roots should be soaked in water for at least an hour but not longer than 12 hours. Do not allow roots to be exposed to sunlight or dry out before planting. It is best to keep bare roots covered with moist burlap or some reasonable substitute until planting time. When planting into drought prone soils consider soaking the roots in an aqua gel just prior to planting.

After the B&B or container-grown plant has been placed in the hole, fill in around the plant with the backfill until the hole is 2/3 full. With bare-root plants, the soil should be worked gently in and around the roots while the plant is being supported. The most satisfactory way of removing air pockets is to fill the hole with water and firm the soil around the plant ball or roots. However, be sure not to use excessive force, since soil compaction should be avoided.



Before finishing the filling process, make certain the plant is straight and at the proper depth, then complete the filling process with the backfill. If the specimen is an individual, construct a ring of earth 2 to 3 inches high at the edge of the outside diameter of the hole to form a water basin. Plants in beds probably will not require a water basin. Water the plant thoroughly as soon as the water basin is constructed. Fill in the basin prior to winter to reduce the possibility of freezing/thawing and heaving. Organic mulches such as pine needles, bark, and wood chips provide the best environment for future root development, and are applied in November. Pull the mulch back about 6" around the base of the plant.



Soil depression retains water

Note that a complete fertilizer is not added to the backfill. Newly developing roots can be damaged by too much fertilizer. Limestone or super phosphate can be incorporated into the soil if a soil test indicates a need. Large areas should already have an established fertility level based on recommendations from soil test results before the planting of individual plants takes place. A fertility program may be delayed until the spring of the following year to provide needed nitrogen and potassium or a slow-release fertilizer, such as 18-6-12, can be applied 4 weeks after planting at a rate of 2 oz. per 4 sq. ft. area.

### **Transplanting Native Trees**

Many homeowners who transplant native plants from the woods are often disappointed because the plants die. Nursery trees are root pruned a year or more before transplanting is to occur, which results in a compact root system. This allows more of the roots to be dug up when transplanting.

For success in transplanting native plants, it is important to understand the environment in which they are growing naturally. Duplicating this environment on the new planting site is the key to the plant's survival. Some environmental factors to consider include light, soil moisture, and soil acidity. Most of our native soils are slightly acid, so you may have to adjust the soil pH in the new location. This can be determined by having the soil tested at your local Extension Office well in advance of anticipated transplanting. Soil moisture can vary within the distance of a few feet. Plants growing naturally on a slope probably require good drainage, while those growing in bogs require wet conditions. Similarly, if the soil is sandy, the plant will transplant best into sandy soil. A plant growing on the edge of the woods generally requires more light than one in a thick forest. These environmental conditions must be similar at the new location.

The following planting conditions will increase the chance of survival:

- Smaller plants transplant more successfully than mature specimens. A six-inch tall plant may be moved when dormant and bare rooted.
- Root prune by cutting around the circumference of the root area in the Spring; one year prior to the planting date. A sharp nursery spade should be used for best results. On the planting date, recut the ball, dig a trench on the outside of the circumference, under-cut the ball, and finally remove the plant.
- Dig a hole no deeper and 12 inches wider than the root system. Refill with a mixture of enough existing and native soil of the plant to accommodate the root ball or bare-root system. Avoid planting too deep.
- Firm the soil and water thoroughly.
- Mulch with approximately 2 inches of decayed sawdust, leaf mold, or other available materials in November.
- Fertilize only with superphosphate.

Adequate soil moisture is critical for several months after transplanting. Water only when necessary. Over watering will result in sure death. To determine if the soil is dry, stick your finger 1 to 2 inches below soil surface. When necessary, water slowly in order to soak the ground thoroughly.

### **Care of Trees and Shrubs**

### Pruning and Supporting Newly Installed Plants

An initial pruning may be needed immediately after planting bare-rooted plants to remove competing multiple leaders. Do not over-prune or development will be inhibited. Container-grown and B&B plants require only the removal of all broken and damaged branches. Be sure not to ruin the natural growth habit of shrubs, and do not remove the central leader of shade trees.

### Prune One Year After Planting



head back to a side branch .... or bud



Corrective pruning to improve branch structure is usually practiced the following spring after planting. With all newly planted woody plants, it is more successful to avoid heavy pruning at planting if you can ensure that the plants will be well-watered during their first year or two in the ground. Pruning reduces the leaf area; this reduces transpiration but also reduces the leaf area which produces photosynthates for root growth. Since the plant will not resume a normal growth rate until the root system is re-established, one is better off to avoid wilting by watering than by canopy pruning. This also avoids a proliferation of suckers in the inner canopy. Most shrubs do not need to be supported after planting unless bare-root stock has been planted that is quite large, or very tall B&B specimens have been used. If so, use the same techniques for shrubs that will be described for trees.

Staking and guying are rarely required. If a tree is planted in a very windy location or on a slope, support may be needed until new anchoring roots develop. Drive two stakes into the ground on opposite sides of the tree, being sure to sink them firmly into native soil. Use a wire, cushioned with rubber hose, to secure the tree to the stakes. Stake the tree at the level of its lowest branches.

All support should be removed within one year after planting. The tree should have become established in this period of time, and it has been reported that tree trunks are weakened and growth is actually reduced if the supports are left in place for longer periods of time.

Plants in your landscape will require periodic maintenance to produce the best effects. This includes winterizing, mulching, watering, pruning, and fertilization when necessary.

### **Fertilizing Trees and Shrubs**

Ornamental trees and shrubs planted in fertile, welldrained soil should not require annual fertilization. Trees and shrubs that are growing well don't require extra nutrients. If you have ornamentals that are not growing well, fertilization may be one of the practices recommended to correct the problem.

Plants which are growing poorly will exhibit any or all of these symptoms:

- light green or yellow leaves
- leaves with dead spots
- leaves smaller than normal
- fewer leaves and/or flowers than normal
- short annual twig growth
- dying back of branches at the tips
- wilting of foliage

Symptoms of poor growth may also be caused by inadequate soil aeration or moisture; by adverse climatic conditions; by improper pH; by disease or by other conditions. You should attempt to determine the specific cause in each particular situation and apply corrective measures. Do not assume that an application of fertilizer will quickly remedy any problem which is encountered.

The cause of poor growth may or may not be evident. Ornamentals transplanted or disturbed by construction within the past 5 or 10 years may be in shock, their root systems having been disturbed. Pruning to balance the top growth with root growth at the time of the injury will help, followed by adequate irrigation.

Good soil drainage to a depth of at least 2 feet is needed for ornamental trees and shrubs in the landscape planting. Plants on poorly drained soil may exhibit one or more nutrient deficiency symptoms. If the site is low, install drainage tile to remove excess water before the plants are set out. The tile must have an outlet at a lower level so the water can move out freely. If the use of tile is impractical, or a suitable outlet for the water cannot be arranged, the grade may be elevated by using fill to provide better runoff and drainage conditions.

Most trees and shrubs tolerate a wide range of soil acidity. A range of pH 6.0 to 7.0 is suitable for most landscape plants. Plants such as pine, spruce, or fir do best in a pH range of 5.0-6.0 while broad leaf evergreens such as andromeda, rhododendron, or blueberry prefer 4.5-5.5.

Soil pH can be lowered quite easily for these acidloving plants. You should first have the soil tested to determine the pH level. If the pH is too high, it can be lowered by using sulfur, iron sulfate, or aluminum sulfate. Sulfur is preferred for lowering pH.

Apply sulfur at the rate of 1  $\frac{1}{2}$  lb. per 100 sq. ft. to reduce a loam soil 1.0 pH value and make it more acid. Use half as much on sandy soil and  $\frac{1}{2}$  times as much on clay soils. After several months, test the soil again to determine the effectiveness of treatment.

Small trees and shrubs that are in need of nutrients should have ½ to 1 cup of 10-10-10 fertilizer spread evenly under their branches in early spring. Fertilization in summer may cause serious injury the following winter, by stimulating late growth that will not harden off before frost.

For large trees research indicates that complete fertilizers usually are not essential. To determine how much nitrogen is needed, measure the diameter of the tree at breast height. For each inch of diameter, apply 2-3 lbs. of a 10 percent nitrogen fertilizer such as 10-10-10 or 10-3-6. Application should be made in the spring, or in late fall after two hard frosts and before the ground freezes. If the tree is large, it is best to split the fertilizer application; one in spring and the remainder in fall. Spread the fertilizer evenly under the branches. Soluble nitrates will move into the soil quite readily.

If turfgrass is present, it is important to place the tree fertilizer beneath the grass roots to avoid burning. A crowbar is effective by punching holes 2 ½ feet apart, 10 inches deep, all around the tree extending past the tips of branches. Approximately one cupfull of fertilizer is placed in each hole followed by watering.

Depending on the reason a large tree is doing poorly, fertilization might be called for each year. However, a feeding program must be coupled with proper cultural practices. For example, neglecting necessary insect or disease control and failure to remove dead wood from a large shade tree will negate the positive effects of fertilization.

Shrubs are fertilized in the spring at bud break or in late fall during the hardening off process. A fertilizer such as 10-10-10 or 10-3-6 slow release is surface applied at a rate of 1-2 lbs. per 100 sq. ft. depending on the size of the shrubs in the bed.

A moderate rate of growth and good green color is all that is desired of woody plants. Excessive vigor, which is evident by lush green leaves and long shoot growth, is undesirable. Such plants are more susceptible to injury by cold in winter, are more likely to be broken during wind and sleet storms, and usually will have a shorter life than those making moderate growth.

### **Mulching Plants**

For year-round benefits of mulching, apply a 2-4 inch mulch of aged sawdust, fresh shredded bark or wood chips, or peat moss around shrubs, roses, and recently planted trees. This mulch will conserve moisture and help suppress the growth of weeds and grass.

Sawdust or shredded bark from the inside of a large pile may go through anaerobic decomposition and become very acid, with a pH of about 3.0 and a pungent odor. Such material is toxic to plants. In some cases, mice may tunnel in the mulch and cause damage by chewing the bark from the stems of shrubs. This is more likely to happen when coarse materials like straw or hay are used. The best control is to keep the mulch back about 6 inches from the stems, use wire mesh mouse guards, or Woody roots that anchor trees penetrate deep into the soil, but herbaceous roots that take up water and nutrients are shallow and wide-spreading. These roots function best when they do not have to compete with lawn roots. For this reason, it is desirable to mulch under trees, as far out as the branches extend if possible. A 2 to 3 inch layer of organic mulch prevents weeds, conserves water, and stabilizes soil temperatures. Both organic and inorganic mulches can be useful in the home landscape. Some of the more readily available ones include:

### Sawdust

A 2-3 inch layer of sawdust provides good weed control. If fresh sawdust is applied around growing plants, add ½ pound of actual nitrogen per 10 cubic feet of sawdust to prevent nutrient deficiency; fresh sawdust contains a great deal of carbon and very little nitrogen, and its breakdown requires that microorganisms take nitrogen from the soil. There is often a problem with crusting of fresh sawdust, with resulting impermeability to rainfall. Sawdust is best used for garden paths and around permanent plantings. It is readily available from sawmills. One problem associated with mounding sawdust close to the stems of plants is its' impermeability and water tends to run off away from the plant.

### Bark

A 2- to 3-inch layer of one of several types of bark provides good weed control. Bark is slow to decompose and will stay in place. Shredded bark decomposes more quickly than the stone types. Wood chips are often available free or for a small charge from professional tree pruning services, or may be purchased in large bags at retail stores. Bark makes a very attractive mulch, and is especially recommended for mulching around trees and shrubs.

### Hay or straw

Although not typically used around trees and shrubs, a 3- to 4-inch layer of hay provides good annual weed control. Some people use a 1-foot, compacted layer of straw, pulling back the layer for planting. This provides excellent weed control. These materials decompose quickly and must be replenished to keep weeds down. They stay in place and will improve the soil as they decay. Avoid hay which is full of weed seed and brambles. Fresh legume hay, such as alfalfa, supplies nitrogen as it quickly breaks down. Hay and straw are readily available in rural areas, but city dwellers may not be able to obtain hay. Straw, on the other hand, may be purchased at most garden centers, often commanding a high price. Both are recommended for vegetable and fruit plantings but not for ornamental plantings. Hay or straw will make a good habitat for meadow voles.

### **Pine needles**

Pine needles make an excellent mulch for acidloving plants, but can be too acidic for many plants if incorporated into the topsoil. Pine needles are readily available and are best used around shrubs and trees, particularly acid-loving types.

### **Grass clippings**

A 2-inch layer of grass clippings provides good weed control. Build up the layer gradually, using dry grass, to prevent formation of a solid mat. Clippings will decompose rapidly and provide an extra dose of nitrogen to growing plants, as well as making fine humus. Avoid crabgrass and grass full of seed heads. Also, do not use clippings from lawns which have been treated that season with herbicide or a fertilizer/herbicide combination ("weed and feed" types). They are an excellent source of nitrogen to help increase microbial activity in the compost pile, especially for those gardeners without access to manures. Be on the lookout for slugs.

#### Leaves

A 2- to 3-inch layer of leaves, after compaction, provides good weed control. Leaves will decompose fairly quickly, but are easily blown unless partially decomposed. Leaves are usually easy to obtain, attractive as a mulch, and will improve the soil once decomposed. They are highly recommended as a mulch.

#### Peat moss

A 2- to 3-inch layer of peat moss will give fair to good weed control. This material is slightly acid, and thus suitable for use with acid-loving plants. However, peat tends to form a crust if used in layers thick enough to hold weeds down, or it may be blown away. Peat is also a relatively expensive mulching material which breaks down rapidly. It is suitable for incorporation into the soil.

### Compost

A 2- to 3-inch layer of compost is a fair weed control. Most compost, however, provides a good site for weed seeds to grow but is an excellent soil amendment. A layer of compost may be used on over-wintering beds of perennials, such as asparagus or berries, to provide nutrients and help protect crowns.

### Gravel, stone, and sand

A 1-inch layer of rock will provide fair weed control. They make a good mulch for permanent plantings, as around foundation plants and in alpine gardens. None of these mulches are effective in controlling erosion; soil will wash right out from under rocks, and sand will be swept away. Availability varies with area.

### Watering Plants

Watering plants correctly is vital for developing and maintaining a landscape planting. Lack of water can cause a plant to wilt and ultimately dry up and die. Excessive water can cause root rot, in which case the plant wilts because it is oxygen-starved, and consequently, is unable to take up moisture. As a rule, plants are capable of withstanding moderate drought more easily than too much moisture. For this reason, it is important to water thoroughly, yet allow the soil to become fairly dry between waterings.

Wilting is a condition brought about in plants when roots are unable to supply sufficient moisture to the stems and leaves. Wilting for short periods of time will not harm plants; over a prolonged period, however, it will cause permanent damage. Sometimes a plant will wilt on a hot day because moisture is evaporating from the leaves faster than the roots can supply it. If there is ample soil moisture, the plant will absorb water in the evening to firm up the stems and leaves.

In late summer or early fall, it is not uncommon to experience a sustained period of wilting, particularly of broad-leaved evergreens such as rhododendrons. Latest research establishes this condition as the cause of much leaf damage typically attributed to winter desiccation. When the leaves hang down and no rain is predicted, it is advisable to provide prolonged, deep watering to keep the leaves turgid. To wet the soil at least 6 inches deep requires 1 to 2 inches of surface water.

Container-grown landscape plants may be susceptible to drought stress once they are transplanted to the landscape. Drought stress occurs because the well-drained organic mix in which the plants are grown in the nursery is prone to rapid loss of moisture due to plant transpiration (loss of water from plant leaves) and evaporation from the soil surface. Even though moisture is available in the soil surrounding the organic mix, it does not move into the transplanted root ball rapidly enough to prevent moisture stress from developing. Research has shown that the available moisture in the container mix can be depleted in about 2 days in the absence of irrigation. For this reason, these plants are watered at least every other day while in the nursery. This routine should be followed after transplanting until the root system penetrates the surrounding soil back fill (approximately 3 to 4 weeks) where moisture is available for absorption by the plant.

Care must be taken not to allow the transplanted root ball to dry out because the organic mix is very difficult to rewet once it becomes dry. Water can be applied to a drought-stressed plant where the root ball has become very dry and not successfully relieve the moisture stress because the medium does not readily absorb the applied water. In this case, water should be applied 2 or 3 times each day until the root ball has been rewet.

To maximize the effectiveness of watering practices:

#### Know the condition of the soil.

It is important to observe how quickly soil dries out after a rain or watering. For example, a claytype soil will be watered less frequently than a sandy one. Clay soil drains slowly, sandy soil quickly. The addition of organic matter to the soil will increase drainage in clay soil and moisture retention in sandy soil.

## Learn the cultural requirements of plants being grown.

Different plants have different water needs; azaleas require more moisture than lilacs. The use of good reference books will provide the gardener with this information. It is particularly important to provide a relatively high soil moisture supply for evergreen plants during the fall before the ground freezes. The leaves of such plants continue to lose water during the winter, especially when the temperature is above 40° F. If the soil is dry, the plants may become desiccated, turn brown, and die. Therefore, water shrubs several times during the late fall if the soil moisture supply is low.

## Mulch plantings to reduce the frequency of watering during dry spells.

Mulches help keep soils cool and reduce water loss through evaporation.

As with any job, to water properly, the gardener must have the right tools; hose, water breakers, sprinklers, sprinkling can, and utility pails.

When acquiring a hose, make sure it will reach all plants in the garden so the end can be placed at the base of any plant. When watering individual plants with a hose, attach a water breaker to the end. It will concentrate a soft flow of water in a small area, but will not wash away soil. Don't use a triggertype nozzle; it will wash soil away from the roots.



water breaker

trigger-type nozzle

There are many types of good sprinklers on the market. One type is a spike sprinkler on a riser that can be adjusted from 2 feet to 4 feet. This sprinkles above shrubs and small trees, providing excellent water distribution. However, much water is lost to evaporation. Sprinklers should not be used on windy days, because water will be blown away from the desired location. Sprinklers may also encourage foliar diseases such as Anthracnose on maple and Powdery Mildew on Azaleas.



spike sprinkler on riser

sprinkling can

Sprinkling cans and utility pails are adequate when watering only one or two small shrubs or trees, but are generally inadequate for watering in the landscape.

Trickle or drip irrigation is increasing in popularity. Systems are easy to set up by do-it-yourselfers.

They are also rather inexpensive when compared with other methods of irrigation. Less water is required because it is placed in the root zone. There is also a savings in electricity.

If the soil is dry when preparing a hole for a new plant, dig the hole and fill it with water the day before the plant goes into the ground. This allows the soil time to absorb water and does not create a muddy condition during the planting. Once a tree or shrub has been planted a thorough soaking after planting eliminates air pockets around roots.

It is important when planting (particularly container-grown material) to avoid covering the top of the root ball with more than  $\frac{1}{2}$  to 1 inch of native soil. Otherwise water can be diverted sideways through the native soil and not soak down into the root ball where it is needed.

When there is an extended period without rain during the summer, new plants should be deeply watered once a week. By allowing the soil surface to dry out somewhat between waterings, major root development will be at greater depths where soil moisture is highest. Plants watered frequently but lightly will have roots close to the surface, making them more vulnerable to wilting. They will not become well-established and will have little drought tolerance. This happens with automatic overhead sprinkler systems that are designed to go on for a short period of time each night and only moisten the surface. This practice also encourages foliar diseases in midsummer.

During cool seasons, less watering is necessary because evaporation from the leaves and soil is slow. Normally, abundant rainfall during spring and autumn diminishes the need for watering. During any dry autumn before the ground freezes, all garden plants should have a thorough watering to help prevent root damage from cold winter temperatures. Root damage from unusually cold temperatures shows up in the spring and early summer in the form of leaf drop because there are not enough roots to support the foliage.

With well-established groups of woody plants, watering should be done every 10 days during prolonged dry spells. Since root systems of established plants are rather widespread and deep, it is vital that enough moisture be put down to reach them. A general rule of thumb is that 1 inch of water penetrates 6 inches of soil. If a sprinkler is set up to water a group of plants, a coffee can should be placed in range of the sprinkler. When 1 inch of water accumulates in the can, 1 inch of water has been distributed in the soil.

The best time to water is in the morning when air temperatures are lower than at midday, thus reducing evaporation. Evening watering is less desirable because wet foliage at night promotes fungal disease development.

### Winterizing Trees and Shrubs

It is often necessary to give a little extra attention to plants in the fall to help them over-winter and start spring in peak condition. Understanding certain principles and cultural practices will significantly reduce winter damage of ornamentals.

*Causes of winter damage.* Types of winter damage can be divided into three categories: desiccation, freezing, and breakage.

**Desiccation**, or drying out, is a significant cause of damage, particularly on evergreens. This occurs when water is leaving the plant faster than it is being taken. There are several environmental factors that can influence desiccation. The needles and leaves of evergreens transpire some moisture even during the winter months. During severely cold weather, the ground may freeze thereby cutting off the supply of water. If the fall has been particularly dry, there may be insufficient ground moisture to supply the roots with adequate water. Water loss is greatest during periods of strong winds and during periods of sunny, mild weather. The heat of the sun can cause stomates on the lower sides of the leaves to open, increasing transpiration. Small, shallowrooted plants are often injured when alternate freezing and thawing of the soil heaves the plants from firm contact with the soil and exposes the roots to wind desiccation. Injury due to desiccation is commonly seen as discolored, burned evergreen needles or leaves. It is most severe on the side facing the wind. It can be particularly serious if plants are near a white house where the sun's rays bounce off the siding, causing extra damage.

**Freezing** injury can take several forms. New growth stimulated in early fall by late summer fertilization may not have had time to harden off sufficiently to survive sudden drops to below freezing temperatures. Ice crystals rupture cell walls. This damage will show up as dead branch tips and branches. A sharp temperature change between day and night may freeze the water within the trunk of a tree, causing it to explode or split open in a symptom called frost cracking. If not severe, these cracks seem to close when warm weather arrives, but the wood fibers within may not grow back together. Bark of young trees sometimes cracks open on the southwest side of the trunk if the warm winter sun warms the tissue and a sudden, severe drop in temperature occurs at sunset. This problem is commonly called sunscald. Both frost crack and sunscald are less common in healthy, fully hardened trees with vigorous, far reaching root systems.

The sun can also prematurely stimulate the opening of flowers or leaf buds in the spring which might be killed by freezing night temperatures. Bud injury due to the cold temperatures of winter also occurs in the dormant state on more tender trees and shrubs. Flowering shrubs, like Forsythia, may lose their flower buds, although their leaf buds usually come through. Root injury may occur in containers and planters, or balled and burlapped (B&B) stock which has been left exposed during the winter. Lethal root temperatures can start at 23° F on some species.

**Breakage** of branches is usually related to snow and ice. Two causes of damage by snow and ice are weight and careless snow removal. High winds compound the damage done when ice is on the plant. Damage may take the form of misshapen plants or may actually result in broken branches and split trunks.

### Avoid Damage.

Much of the disappointment and frustration of winter-damaged plants can be avoided by planning ahead.

### Select Hardy Plants.

Grow plant materials that are native or are known to be winter hardy in your area.

### Select Appropriate Site.

When planting broadleaf evergreens that are known to be easily injured, such as some varieties of rhododendron, azalea, daphne, and holly, select a location on the north, northeast, or eastern side of a building or other barrier where they will be protected from prevailing winds and intense winter sun. These exposures will also delay spring growth, thus preventing injury to new growth of flowers from late spring frost. Another situation to avoid is planting hemlocks and other needle evergreens on dry soils, in full sun, and on windy sites.

### Avoid Poorly Drained Soil.

Avoid low spots that create frost pockets and sites that are likely to experience rapid fluctuations in temperature. Since heavy snow and ice can cause much damage to branches and trunks, it is important that plants be placed away from house eaves and other snow or ice collecting areas, where snow or ice is likely to fall or slide onto the plants.

### Follow Recommended Cultural Practices.

Following recommended cultural practices has been shown to be highly effective in reducing winter injury to ornamentals. Plants that are diseased or deficient in nutrients are more susceptible to winter injury than strong, healthy plants.

Avoid late summer or early fall fertilization while plants are still active, as this stimulates late fall growth which is easily killed by the cold.

Pruning by thinning is effective in reducing damage by ice and snow. Small diameter branches are encouraged which are less prone to breakage. Particularly important is the removal of any weak, narrow-angled, V-shaped crotches. Avoid late-summer pruning which stimulates new, tender growth and reduces the supply of nutrients available to the plant through the winter. Do not prune needle evergreens in late fall or sun scald will result.

Proper watering can be a critical factor in winterizing. If autumn rains have been insufficient, give plants a deep soaking that will supply water to the entire root system before the ground freezes. This practice is especially important for evergreens. Mulching is an important control for erosion and loss of water. A 2-inch layer of mulch material such as tan bark, fir bark, pine needles, wood chips, or sawdust will reduce water loss and help maintain uniform soil moisture around roots. Mulching also reduces alternate freezing and thawing of the soil which heaves some shallow-rooted plants and can cause significant winter damage.

### Protecting Against Damage.

The best protection against winter damage is to put the right plant in the right place. Special precautions can be taken to protect plants during the winter. Antidesiccant compounds are sold in many garden centers and supply catalogs. Apply in the fall and again during a January thaw when temperatures are above 50° F. Small evergreens can best be protected by using wind breaks made out of burlap, canvas, or similar materials. Wind breaks help reduce the force of the wind and also shade the plants. Windbreaks can be created by attaching materials to a frame around a plant. A complete wrapping of straw or burlap is sometimes used. Black plastic should be avoided as a material for wrapping plants. During the day it builds up heat inside, increases the extreme fluctuation between day and night temperatures, and may speed up growth of buds in the spring, making them more susceptible to a late frost. Certainly these various boxes, shields, and wrappings add nothing to the aesthetics of your winter landscape. If ornamentals require annual protection measures to this extent, it would be wise to move them to a more protected location or replace them with hardier specimens.



Collecting snow should be removed with a broom. Always sweep upward with the broom to lift snow off. When the branches are frozen and brittle, avoid disturbing them. Wait until a warmer day.

### Winter Injury.

After a particularly severe winter, many plants may show substantial injury. Damage symptoms are discolored, burned evergreen needles or leaves, dead branch tips and branches, heaved root systems, and broken branches. At winter's end, remove only those branches that are broken or so brown that they are obviously dead. Do not remove branches when scraping the outer bark reveals a green layer underneath. The extent of winter damage can best be determined after new growth starts in the spring. Wait until midsummer before pruning because even dead-looking plants may still be alive. If discoloration on narrow-leaved evergreen needles is not too severe, they may regain their green color or new foliage may be produced on the undamaged stem. Broad-leaved evergreens showing leaf damage will usually produce new leaves if branches and vegetative leaf buds have not been too severely injured. Damaged leaves may drop or be removed. Prune to remove badly damaged or broken branches, to shape plant, and to stimulate new growth.

Replant small plants with root systems partially heaved out of the ground as soon as the soil thaws. Unless the root system is small enough to be pushed easily with the fingers into the soft soil, dig the plant, retaining as much as possible of the root system within a soil ball, and replant it.

Special care should be given to plants injured by winter's cold. The dry months of July, and August can be particularly damaging as the plants are weak and often unable to survive the stress of drought. Be sure to water adequately.

### Storm-Damaged Trees.

Treatment of storm-damaged trees requires wise decisions and prompt action if the maximum in repair work is to be achieved. Repairs come in two stages: First Aid for immediate attention; and Follow-Up Work to be distributed over a period of several months to several years.

### **Decision factors:**

- Is the tree damaged beyond practical repair? If over 30 to 50 percent of the main branches or trunk are severely split, broken, or mutilated, extensive repair efforts are questionable.
- Desirability of species. Some less desirable species are: black locust, Siberian (Chinese) elm, box elder, mulberry, true poplars, silver-leaf maple, arborvitae.
- Location. If too close to power lines, building or other structures, the tree may need to be removed.
- Soundness. Extremely old, low-vigor trees might not have recovery ability.
- Special values. Rarity of species or variety, sentimental and/or historical value.
- Purpose of the tree. Does it serve a true landscape purpose or value?

### Workmanship factors:

- Remove only the branches necessary for immediate repairs. Too much removal of wood in one season can help create such problems as sunscald, weak branching habits, and soft sucker growth.
- Major tree work, such as wiring and bracing should be done by a professional arborist.
- Observe safety precautions relative to falling branches, use ladders, and avoid contact with power lines.
- Promptly remove all debris such as broken branches and prunings to help eliminate breeding grounds for insects and diseases.

### Follow-up considerations:

- Gradually prune and reshape trees for balance and general appearance over a period of 3 to 5 years.
- Control devitalizing conditions such as sucker sprouts, insects, and disease damage.
- Replacement trees, if necessary, should be carefully selected for durability, general adaptation, and mature size.

### Special Fruit Tree Treatment.

Broken limbs should be cut back to a strong side branch. When cutting terminal growth to a side branch, make the cut so it continues the line of direction of the side branch so the wound will heal quickly. If damage to fruit trees has destroyed over 50% of the bearing surface, it may be wise to remove the entire tree. Damage that exposes large areas of wood has traditionally been treated with commercial wound dressing, but current research indicates that this often slows recovery.

### Protecting and Repairing Trees During Construction

The location of a house on a lot should be carefully planned to utilize existing trees and avoid unnecessary and destructive grading. Trees of desirable species located where they may serve a useful purpose in the landscape should be protected during the construction process. Consult a person with training and experience in landscaping to help select those trees which should be saved and those which should be removed.

Plan protective measures before construction starts. If construction damage occurs, start corrective

practices as soon as damage is observed. The longer an injury is neglected, the greater will be the ultimate damage to the tree.

Trees may respond quite differently to various types of injury. Under some circumstances, death may occur soon after the tree has received apparently minor damage. In other cases, trees may grow quite satisfactorily after being subjected to severe injury. In most situations, an effort should be made to save well-located trees of young or middle age.

### **Protecting Trees During Construction.**

Trees which are not needed in the landscape planting should be eliminated before construction starts. This will provide more space for the soil from the basement, building supplies, and the movement of equipment involved in building the house.

Protect trees which are to be saved for future landscape use by placing tall, conspicuous stakes at the ends of the branches on the sides where trucks or bulldozers will be operating. As added protection, attach heavy fencing to the stakes.

### **General Corrective Practices.**

Damage to trees during construction operations usually involves impairment of the water and nutrient supply system. This is true when either the roots or top of the tree is damaged. Therefore, three corrective procedures should be applied: 1) prune back and thin out the branches to reduce water requirement; 2) irrigate as needed to maintain an adequate moisture supply in the soil, and 3) apply fertilizer to help stimulate renewed growth if the top of the tree is damaged.

Prune back the top in proportion to the severity of the root damage. In cases of serious injury, cut back and thin out the branches quite drastically.

### Bruised and Peeled Bark.

Damage to tree trunks caused by careless operation of trucks or other equipment should be assessed. If the damaged area is less than 25% of the circumference of the trunk, the wound should gradually heal over and permanent injury may be minimal. If the damage involves more than 50% of the circumference, the tree may be seriously reduced in vigor. It may lose branches and be quite unsightly. The corrective procedures of top pruning, irrigation, and fertilization should be practiced until the tree recovers or it is evident that the tree will not recover satisfactorily and should be removed.

### **Broken Branches.**

Remove tree branches which have been broken from any cause. Damage near the end of a branch can be eliminated by cutting back to a strong lateral. Cut the entire branch off close to the trunk at the "collar" when the broken area is near the base. See the Pruning chapter for more details.

### Root Damage by Trenches.

Digging of trenches for water or gas lines, or for foundations for buildings, walks, or drives may damage the root system of nearby trees. If such injury cannot be avoided, the top of the tree can be pruned back and thinned out to reduce demand for water from the remaining roots.

### **Roots Covered By Pavement.**

Roots which are covered by pavement may be deprived of air and moisture which are essential for growth. If the covered area involves only a portion along one side of the tree, satisfactory growth should continue. If the entire area around the tree is paved, the surface should be porous to allow water and air to penetrate. If brick or flagstone is used, joints should not be mortared. When pavement is nonporous, an opening should be left around the trunk of the tree. This opening should be at least 6 feet in diameter for small trees. The opening should be larger around mature trees. Roots of trees extend as much as three times beyond the spread of the branches.

#### Fertilization of Damaged Trees.

When the root system of a tree has been damaged during construction, a moderate application of fertilizer may be beneficial. Use 2 pounds of 5-10-5 formula per tree for each inch of trunk diameter measured 3 feet above the ground. Follow method of application described in section 'Fertilizing Trees and Shrubs'.

### Grading Around Trees.

A majority of the feeder roots of trees are located within a foot of the surface and typically extend several feet beyond the end of the branches. The topmost roots of trees are usually covered with about 4 inches of soil. Topsoil should not be disturbed around landscape trees during the construction operation unless absolutely necessary to change the grade.

The removal of soil around ornamental trees may damage or destroy vital feeder roots. If damage is not too severe, a layer of fertile loam may be applied over the exposed roots. The tree should recover and continue active growth.

In some situations, the grade level around the house may need to be changed and involve the addition of soil around trees. If the ground level is raised 6 inches or more, the air supply to the roots will be reduced and the tree may decline in vigor or die. Beech, most maples, poplar, hickory, walnut, and most evergreen trees are particularly susceptible to injury of this type.

Grade changes so severe as to require tree wells are to be avoided.

### Mower Wounds Can Kill Trees

Injury and infection started by lawnmower wounds can often be the most serious threat to tree health on golf courses, parks, and home lawns.

Extensive research has been conducted on the importance of wounds in tree health care. This research has led to significant adjustments in pruning, cabling, bracing, injection, and cavity treatment.

Lawnmowers cause the most severe injury during periods when tree bark is most likely to slip, in early spring during leaf emergence, and in early fall during leaf drop. If the bark slips, a large wound is produced from even minor injuries.

Most tree injuries occur when mower operators attempt to trim close to tree trunks with a power mower. This can be prevented by removal of turf around trees and replacement with mulch or by hand trimming. Care must also be used to avoid harming trees with filament-line weed-trimming machines. They can do a great deal of damage to the bark, particularly on young trees.

The site of injury is usually the root buttress, since it flares out from the trunk and gets in the path of the mower. However, injury is also common anywhere from the roots to several feet above the ground. Although large wounds are most serious, repeated small wounds can also add up to trouble.

Wounds from lawnmowers are serious enough by themselves, but the wounded tree must also protect itself from pathogens that invade the wound. These microorganisms can often attack the injured bark and invade adjacent healthy tissue, greatly enlarging the affected area. Trees can be completely girdled from microbial attack following lawnmower wounds. Decay fungi also become active on the wound surface, and structural deterioration of the woody tissues beneath the wound will often occur. Many wounded trees which are not girdled may eventually break off at the stem or root collar due to internal decay.



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# CHAPTER 14

## **Herbaceous Landscape Plants**

Edited and revised by Dr. Charles Williams, University of New Hampshire Cooperative Extension

Flower gardening is a rewarding pastime for millions of home gardeners. Flowers from herbaceous plants and bulbs provide a range of color to supplement the predominant green of lawns and other landscape plantings. The variety of foliage, shapes and sizes available add accent and contrast that can make a landscape lively and interesting. They can add depth, dimension, form, texture and fragrance to the visual environment. Flowers can also be useful outside the garden providing some culinary herbs for the table and cut flowers for fresh and preserved arrangements, etc.

Flower gardening has evolved to meet the trends and fashions of contemporary society. As with most aspects of horticulture, there is no singular or absolute best way to utilize flowers in public or private landscapes. The text of this manual essentially reviews some of the basic principles and practices involved with the selection, production, maintenance and utilization of herbaceous flowering plants.

Many of today's aspiring flower gardeners live in apartments or condominiums where space is limited. Others have a family life style that may preclude or curtail the establishment or maintenance time required for elaborate and extensive flower beds. While it is still desirable to plan for a sequence of bloom and group plants with a consideration for height and color, compromises may have to be made. If the site precludes a traditional flower border perhaps a flower "island" with taller plants in the center is in order. Flowers can be incorporated into foundation plantings, vegetable gardens, or almost any site on the property; however, small beds in the middle of lawn open space may be disruptive and add to maintenance time.

Certain home gardeners may also be interested in developing some sort of a specialty garden that reflects their interests or hobby. Others may opt for plantings that are in tune to environmental needs or ecological site requirements. Thus, there are an infinite number of combinations of: native plant or "naturalistic" gardens, butterfly or hummingbird gardens, all blue or white gardens, all rose or iris gardens, Alpine gardens, rock gardens, container gardens, seaside gardens, shady gardens, etc.

This manual chapter and the period of class instruction for Master Gardeners and other interested participants cannot begin to cover all of the details and ramifications of the broad topic of flowering herbaceous plants. Individual backgrounds, experience, and education will vary. If one is interested in particular aspects of flower gardening, a wide range of books and magazines are available on the market.

### **Planning the Flower Border**

Much of the excitement of creating an herbaceous border lies in its great flexibility of design. In form, placement, and selection of plants, the contemporary border follows few rigid rules and allows fullest expression of the gardener's taste.

The first step in planning the material for an allseason, mixed perennial border is to select key plants for line, mass, color, and dependability. Line is the silhouette or outline of a plant, mass is its shape or denseness, and dependability refers to its ability to remain attractive with a minimum of problems. Garden books and catalogues can be very useful for reference.

The most attractive flower borders are those which are located in front of a suitable background such as a fence, shrubbery, or a building. In some cases, tall flowers such as hollyhocks or sunflower may serve a dual purpose as flowers in the border and as background plants. Annual or perennial flowers of medium height may serve as background plants for a short border planting.



A general rule, unless the garden is very spacious or formal, is to avoid a ruler-straight front edge. A gentle to boldly sweeping curve, easily laid out with a garden hose, is best even along a fence, and the border can taper as it recedes from the main viewing point if an effect of distance is desired. The deeper the curve the slower the eye moves and the greater will be the visual enjoyment. A border outlined with bricks or flat stones set flush with the soil is better than a steeply cut lawn edge which must be trimmed after mowing. Even the advanced gardener finds it advantageous to plan a border to scale on graph paper. The hardest task, organizing the selection of plants, will be simplified if only two main mass forms are considered: drifts and clumps. Drifts are elongated groupings of a plant that flow through sections of the border. Clumps consist of circular groupings of a variety, or a single large plant such as a peony. The length of drifts and the diameter of clumps, as well as their heights, should be varied for best effect, and the dimensions should always be in proportion to the overall size of the border.

Establish plants in groups large enough to form masses of color or texture. As a rule, five to seven plants will create the desired effect. A large delphinium or peony will be of sufficient size to be attractive, but a random collection of different small- to medium-sized plants will present a disorganized, checkerboard appearance. Each group of flowers should have an irregular shape. These masses of color and texture should blend into a pleasing pattern of color harmony. Dwarf flowers may be used as a continuous edging or border along the front of the bed.



Flower borders may be of any depth, depending on the space available. In a small yard the bed may be only 2 or 3 feet deep. In a spacious location, the border planting may have a depth of 6 or 8 feet. If the border is quite deep, a pathway of stepping stones may be helpful as a means of working among the flowers without compacting the soil.

Tall flowers should be selected for the back part of the bed, with medium-height species in the middle, and dwarf varieties along the front as edging plants. This is very easily done because the height of most flowers is stated in catalogs. Plants along the front edge of the flower bed should be located back far enough to allow easy mowing of the lawn.

Plant height is best limited to 2/3 the depth of the border, e.g., no plants taller than 4 feet in a border 6 feet deep. Height lines should be broken up by letting some tall plants extend into the medium height groups, with a few recessed clumps or drifts leading the eye back into the border. This gives a more natural effect than a step profile. Try to vary heights, but in general, keep taller plants in the back and shorter ones toward the front.

The distance between plants in a flower border depends on the form of the individual plants and the effect which is desired in the landscape. Allow adequate space between plants. Many gardeners crowd their plants too much.

As a rule, the tall, spired-type flowers such as hollyhock, gladiolus, and tall snapdragons which are trained to a very few stems, should be planted in small clumps, to preserve their vertical effect. Bushy plants may be massed together or planted further apart, depending on the effect desired. Creeping, ground cover-type plants should be spaced just far enough apart to form a continuous mat or edging.

The enormous color range in perennials, plus their easy relocation if disharmony occurs, give the gardener great latitude in choosing and combining colors. A border in tones of the same color can be effective, or several closely related colors may be used, or the border may be made wildly exuberant with a variety of hues in one or more seasons. Hues are modifications of color such as orangish-red. The objective is a balanced composition in every season, with no section being at any time too heavily weighted with one color, and the bloom so distributed that it always makes a pleasing pattern through the bed.

Many gardening books give excellent lists of compatible colors; these plus a garden notebook and camera are invaluable for planning and revising color schemes. For real floral artistry, it is as important to consider intensity, which is the vividness of a color, as hue. For example, light tones placed near dark ones, or contrasting palest tones with the most intense, can give new interest and life to the border. Also consider location and color. Near patios, white is especially good because it shows up well in the evening or dusk hours when patios are often in use. Some colors are suitable only as dramatic accents: deep, pure red clashes with almost anything (unless softened by dark green foliage), yet properly used it confers strength and depth. White flowers and gray foliage are indispensable as separators of conflicting colors.

Red, orange, and yellow are warm colors. Blue, green, and violet are cool colors. The use of warm colors in the flower border of a small yard will give the illusion of little space. Conversely, the use of cool colors gives the impression of openness and space. In general, the smaller the area, the fewer warm colors should be used. A border planted with warm colors in front and cool colors in the back causes the front to appear closer, and the back to appear further away. This tricks the eye into believing the garden is deeper than it really is.

A gardener who becomes adept at producing constant color harmony in the border becomes more aware of the roles played by plant forms and foliage. Good foliage is obviously vital in plants with short blooming periods. Consider how much of the plant foliage will be usable and whether it is a positive or negative attribute. Some plants practically disappear when their blooming season is over (i.e., oriental poppy and bleeding heart), but others stay presentable even when not in flower. Plants with distinctive forms, color, and foliage -- airy and delicate, or strong and solid -- are wonderfully useful for creating interest. Ornamental grasses, and even handsome-foliaged vegetables like broccoli and asparagus can be used for effect.

The most logical way to choose plants is first by location, second by period of bloom, then by height and width, and finally, by color. Location takes into account environmental factors, such as the amount of sun or shade and water required. This information is easy to find in books on flowers and in catalogs.

The only restrictions on any given plant will be environmental; a lack of ability to tolerate winter or summer temperature extremes; special soil, moisture or light needs; and any limits the gardener must place on time available for maintenance.

Even in a small border, single plants of different varieties should not be used. This gives a jumbled look. Do not set in precise rows, but in groups, as plants might grow in nature. Allow enough space for each group to grow comfortably. Decide which flowers you like best, and let these be the basis of your planting. Place them in several spots, if you like, down the length of the border, but don't overdo any one plant.


Divide a flower border into bold plant groupings according to height. Background: large groups of tall plants. Foreground: shallower, wide groupings of small plants.



Selection of garden groups as to seaon of flowering and whether annual, biennial, or perennial.

The longer the border has flowers in bloom, the more you will enjoy it. Consider the months when each plant will be at its best. Do not confine yourself to material that blooms all at one time. Aim for a steady succession of color.

A last bit of advice: don't be afraid to be bold, even if it results in some mistakes. Flowers are easy to move, change, or take out altogether. There is no need to be conservative or confined. Flowers are fast growers and can be transplanted quite easily to help create the desired effect.

## Annuals

Annual flowers live only one growing season, during which they grow, flower, and produce seed, thereby completing their life cycle. Annuals must be set out or seeded every year since they don't persist. Some varieties will self-sow, or naturally reseed themselves. This may be undesirable in most flowers because the parents of this seed are unknown and hybrid characteristics will be lost. Plants will scatter everywhere instead of their designated spot. Examples are alyssum, petunia, and impatiens. Some perennials, plants that live from year to year, are classed with annuals because they are not winter-hardy and must be set out every year; begonias and geraniums are examples. Annuals have many positive features. They are versatile, sturdy, and relatively cheap. Plant breeders have produced many new and improved varieties. Annuals are easy to grow, produce instant color, and most important, they bloom for most of the growing season.

There are a few disadvantages to annuals. They must be set out as plants or sowed from seed every year, which involves some effort and expense. With some species, old flower heads should be removed on a weekly basis to ensure continuous bloom. If they are not removed, the plants will produce seed, complete their life cycle, and die. Some annuals deteriorate by late summer and need to be cut back for regrowth or replaced.

Annuals offer the gardener a chance to experiment with color, height, texture, and form. If a mistake is made, it's only for one growing season. Annuals are useful for filling in spaces until permanent plants are installed, to extend perennial beds and fill in holes where an earlier perennial is gone or the next one has yet to bloom; to cover areas where spring bulbs have bloomed and died back; and to fill planters, window boxes, and hanging baskets.

#### **Culture and Maintenance of Annuals**

#### **Site Selection**

Consider aspects of the site that affect plant growth such as light, soil characteristics, and topography. Various annuals perform well in full sun, light shade, or heavy shade. The slope of the site will affect temperature and drainage. Soil texture, drainage, fertility, and pH influence plant performance.

#### **Site Preparation**

Preparation is best done in the fall. Proper preparation of soil will enhance success in growing annuals. First, have the soil tested and adjust the pH if needed. Check and adjust drainage. To do this, dig a hole about 10 inches deep and fill with water. The next day, fill with water again and see how long it remains (should not exceed 8 hours). If drainage is poor, plan to plant in raised beds, or take the time to improve the drainage of the soil by adding organic matter. The next step is to dig the bed. Add 4 to 6 inches organic matter to heavy clay to improve soil texture. Rototill or dig to a depth of 12 inches and leave "rough" in fall. Finally, in spring, add fertilizer, spade again, and rake the surface smooth.

#### Seed Selection

If you can not find the variety of plants you need or you want to grow your own, try seeds. To get a good start toward raising vigorous plants, buy good seed packaged for the current year. Seed saved from previous years may have lost its vigor. It tends to germinate slowly and erratically and produce poor seedlings. Keep seed dry and cool until planted. If seed must be stored, place in an air-tight container, and refrigerate or place in a cool dry place. When buying seed, look for new cultivars listed as hybrids. Plants from hybrid seed are more uniform in size and more vigorous than plants of open-pollinated cultivars. They usually produce more flowers with better substance and may offer better disease resistance or insect tolerance.

#### Starting Plants Indoors

The best media for starting seeds is loose, welldrained, fine-textured, low in nutrients, and free of disease-causing fungi, bacteria, and unwanted seeds. Many soil-less commercial products meet these requirements. Fill clean containers with potting medium. Level the medium. It should be damp but not soggy. Make a shallow furrow. Sow large seed directly in the bottom of the furrow. Very small seed should be sown on the surface, without first making a furrow. Some seed should not be covered. Seed may be sown in flats following seed package directions or directly in individual peat pots or pellets, two seeds to the pot. After seed is sown, cover all furrows with a thin layer of mix or vermiculite. then water with a fine mist. You may want to place a sheet of glass or plastic over seeded containers, to keep them moist. Set them in an

area away from sunlight where the temperature is between 60 and 75 degrees F. Bottom heat is helpful.



Make shallow depressions in the medium to facilitate uniform seeding.



Sow the seeds thinly and evenly, then label each variety. By sowing in rows, the spread of some diseases is curtailed.



Cover seeds with dry verminculite and water carefully.

As soon as seeds have germinated, remove plastic sheeting and place seedlings in good light. If natural light is poor, fluorescent tubes can be used. Place seedlings 6 to 10 inches below the tubes. After the plastic is removed from the container, the new plants need watering and fertilizing, since most planting material contains little or no nutrients. Use a half-strength fertilizer solution after plants have been watered. When seedlings develop two true leaves, thin plants in individual pots or packs to one seedling per cell. Transplant those in flats to packs or other flats. spacing a few inches apart, or to individual pots. Do not start seeds too early indoors. Early germinations and growth times will vary with species. Generally, start most plants 4 to 8 weeks prior to the expected frost free outdoor planting time in your area.

#### PlantingTimes

Do not be in a rush to start seeds outdoors or to set out started plants. As a general rule, delay sowing seed of warm-weather annuals outdoors or setting out started plants until after the last frost date. Most such seeds will not germinate well in soils below 60 degrees F. If soil is too cold when seed is sown, seeds will remain dormant until soil warms, and may rot instead of germinating.

#### Sowing Seed Outdoors

Annuals seeded in the garden frequently fail to germinate properly because the surface of the soil cakes and prevents entry of water. To avoid this, sow seed in vermiculite-filled furrows. Make furrows in soil about one half inch deep. If soil is dry, water the furrow, then fill it with fine vermiculite and sprinkle with water. Then make another shallow furrow in the vermiculite and sow the seed in this furrow. Sow at the rate recommended on the package. Cover the seed with a layer of vermiculite, and using a nozzle adjusted for a fine mist, water the seeded area thoroughly. Keep the seed bed well-watered or cover with a sheet of clear plastic to prevent excess evaporation of water. Remove plastic promptly after germination starts.

#### Setting Out Transplants

By setting started plants in the garden you can have a display of flowers several weeks earlier than if you sow seeds of the plants. This is especially useful for annuals which germinate slowly or need several months to bloom. You can buy plants of these or other annuals or you can start your own. Buy only healthy plants, free of pests and diseases. Before setting out transplants, harden them off by exposing them to outside conditions during the day which will provide more light and cooler temperatures than they received inside. After the last frost date, annual plants may be set out. Dig a hole for each plant large enough to accept its root system comfortably. Lift out each plant from its flat or pack with a block of medium surrounding its roots. Put the block in a planting hole and backfill it so the plant is set at its original level. Planting in holes punched into a black plastic mulch with a bulb planter promotes early growth and reduces the need for future weeding and irrigation.



When setting out plants in peat pots, either tear off the peat pot, or at least remove the upper edges of the pot so that all of the peat pot is covered when soil is firmed around the transplant. If a lip of the peat pot is exposed above the soil level, it may produce a wick effect, pulling water away from the plant and into the air. After setting the plants, water them with a starter solution of high phosphate fertilizer which is water-soluble. Follow package directions. Provide protection against excessive sun, wind, or cold while the plants are getting settled in their new locations. Inverted pots, plastic or fabric tunnels, or cloches can be used.

#### Thinning

When most outdoor-grown annuals develop the first pair of true leaves, they should be thinned to the recommended spacing. This spacing allows plants enough light, water, nutrients, and space for them to develop fully above and below the ground. If they have been seeded in vermiculitefilled furrows, excess seedlings can be transplanted to another spot without injury. Thin the remaining plants to the recommended 8 to 12 inch spacing. An exception to the rule for thinning is sweet alyssum. This annual is particularly susceptible to damping-off. To insure a good stand of plants, sow the seed in hills and do not bother to thin the seedlings; the clump of seedlings will develop into a colorful mound.

#### Watering

Do not rely on summer rainfall to keep flower beds watered. Plan to irrigate them from the beginning. When watering, moisten the entire bed thoroughly, but do not water so heavily that the soil becomes soggy. After watering, allow the soil to dry moderately before watering again. A soaker hose is excellent for watering beds. Water from the soaker hose seeps directly into the soil without waste and without splashing leaves and flowers. The slow-moving water does not disturb the soil or reduce its capacity to absorb water. Water wands and drip systems are also good. Sprinklers are not as effective as soaker hoses. Water from sprinklers wets the flowers and foliage, making them susceptible to diseases. Structure of the soil may be destroyed by impact of water drops falling on its surface; the soil may puddle or crust, preventing free entry of water and air. The least effective method for watering is with a hand-held nozzle. Watering with a nozzle has all the objections of watering with a sprinkler. In addition, gardeners seldom are patient enough to do a thorough job of watering with a nozzle; not enough water is applied, and the water that is applied is usually poorly distributed over the bed. If you water with a sprinkler or hand-held nozzle, water in early morning so the foliage can dry quickly; this will prevent many foliar diseases from developing.

#### Mulching

Mulches help keep the soil surface from drying or crusting and aid in preventing growth of weeds. Organic mulches can add humus to the soil. Sheet plastics or fabric weed barriers used in the flower garden may be covered with a thin layer of bark or other organic mulches for a better appearance until the plants are large enough to cover it.

#### Weeding(cultivating)

After plants are set out or thinned, cultivate only to break crusts on the surface of the soil. When the plants begin to grow, stop cultivating and pull weeds by hand. As annual plants grow, feeder roots spread between the plants; cultivation is likely to injure these roots. In addition, cultivation stirs the soil and uncovers weed seeds that then germinate.

#### Deadheading (removing old flowers)

To maintain vigorous growth of some plants and assure neatness, remove spent flowers and seed pods. Flowers that respond particularly well to this practice include some ageratum, calendula, cosmos, marigold, pansy, scabiosa, and zinnia.

#### Staking

Tall-growing annuals like larkspur, or tall varieties of marigold or cosmos, may need support to protect them from strong winds and rain. Tall plants are supported by stakes of wood, bamboo, or reed large enough to hold the plants upright but not large enough to be conspicuous. Stakes should be about 6 inches shorter than the mature plant so their presence will not interfere with the beauty of the bloom. Begin staking when plants are about 1/3 their mature size. Place stakes close to the plant, but take care not to damage the root system. Secure the stems of the plants to stakes in several places with paper-covered wire or other materials that will not cut into the stem. Plants with delicate stems (like cosmos) can be supported by a framework of stakes and strings in criss-crossing patterns. Tall annuals planted in full sun, where they can develop into strong mature plants, often do not require staking.

#### Fertilizing

When preparing beds for annuals, organic or chemical fertilizer should be added according to recommendations given by soil sample analysis, or derived from observation of plants that have grown on the site. Lime may also be needed if the soil test results indicate a pH below 6.5. Use dolomitic limestone that contains both calcium and magnesium rather than hydrated lime. Ideally, lime should be added in the fall and worked into the soil so it will have time to change the pH. Fertilizer should be added in the spring so it will not leach out before plants can benefit from it.

Once annuals have germinated and begin to grow, additional fertilizers may be needed. This is especially true if certain raw organic mulches are added to a new garden area, because microorganisms decomposing the mulch take up available nitrogen. Thus a fertilizer high in nitrogen should be used in these situations. Be sure to work the fertilizer in around the plants in such a way as to avoid direct contact between the stems and the fertilizer. Apply fertilizers to damp soil and water afterward. Liquid fertilization is also an option.

#### **Controlling Insects and Diseases**

#### **Insects and Related Pests**

Do not apply an insecticide unless it is necessary to prevent damage to flowers or shrubs. Most insect pests in the garden will not cause appreciable damage if their predators and parasites are available and protected. However, if there is a pest that usually causes serious damage unless an insecticide is used, apply the insecticide as soon as the infestation appears and begins to increase.

Watch for such pests as spider mites, aphids, Japanese beetles and other beetles, lacebugs, and thrips; these are some of the insects most likely to need prompt treatment with insecticides. Do not treat for soil insects unless you find numbers of cutworms, white grubs, or wireworms when preparing the soil for planting.

When using a pesticide, be certain that both the pest and the flower are indicated on the label. Read and follow all directions for use, including precautions, shown on the label.

#### Diseases

Since annuals only grow in the garden for one season, diseases are not as serious a problem as they are for perennials. However, some wilt and root rot diseases may persist in the soil. Select varieties of plants that are resistant to disease, follow recommended practices for planting and maintaining annuals, and you will avoid most disease problems. However, there are times when weather conditions are highly favorable for diseases. If this happens, determine what disease is affecting the plants, then use a cultural control, rogue out the affected plant or, where necessary, apply an appropriate pesticide according to label directions.

Damping-off causes seeds to rot and seedlings to collapse and die. The disease is carried in soil and may be present on planting containers and tools. Soil moisture and temperature necessary for germination of seeds are also ideal for development of damping-off. Once the disease appears in a seed flat, it may travel quickly through the flat and kill all seedlings planted there. This can be prevented. Before planting, treat the seed with a fungicide, pasteurize the soil, and use sterile containers. Treat the seed by tearing off the corner of the seed packet, and through the hole in the packet, insert about as much fungicide dust as you can pick up on the tip of the small blade of a penknife. Close the hole by folding over the corner of the packet, then shake the seed thoroughly to coat it with the fungicide dust.

For best results, use a soilless mix. If you must use a soil-based mix, pasteurize it in an oven. Fill a metal tray with moist, but not wet, soil. Hold it at 180 degrees F for 30 minutes. Do not overheat. This will produce an unpleasant smell.

To avoid introducing the damping-off organisms on containers, use fiber seed flats or peat pots. These containers are sterile, inexpensive, and easily obtained from garden shops. Fiber flats are light and strong. Peat pots can be set out in the garden along with the plants they contain; roots of the plants grow through the walls of the pots. Plants grown in peat pots suffer little or no setback when they are transplanted to the garden. Larkspur and poppy, which ordinarily do not tolerate transplanting, can be grown in peat pots satisfactorily. If wooden boxes or clay flower pots are used for soil containers, clean them well. Soak clay pots in water and scrub them to remove all the white fertilizer crust from the outside. Sterilize clay pots by swabbing them with a solution of 1 part chlorine bleach to 9 parts water. Allow containers to dry thoroughly before filling them with soil. If, despite precautions, damping-off appears in seedlings, discard the containers and soil and start again.

## **Biennials**

Biennials are plants that complete their life cycle in 2 years. During the first growing season they produce leaves, usually a rosette; then in the second growing season, preceded by a cold period, they produce blooms and die. For the flower gardener, biennials present the obvious disadvantage of producing only foliage the first year and no blooms. For this reason, new varieties have been developed that produce early bloom. "Foxy" is a variety of foxglove that will bloom the first year. Biennial seeds can be sown in midsummer to produce plants that develop in the fall, forcing the plant to bloom the next year. Many gardeners maintain biennials in clumps, and encourage the plants to self-sow. At any given time, a clump contains both first and second year plants. This practice produces flowers each year, and promotes a "perennial clump of biennial plants".

## Perennials

Perennials are plants that live year after year. Trees and shrubs are perennial. Most garden flowers are herbaceous perennials. This means the tops of the plants -- the leaves, stems, and flowers die back to the ground each fall with the first frost or freeze. The roots persist through the winter and every spring, new plant tops arise. Any plant that lives through the winter is said to be hardy. Select plants suited to your particular hardiness zone, however micro climates and snow cover can alter survival.

There are advantages to perennials, the most obvious being that they do not have to be set out, like annuals, every year. Some perennials, such as delphiniums, have to be replaced every few years. Another advantage is that with careful planning, a perennial flower bed will change colors through the season, as one type of plant finishes and another variety begins to bloom. Also, since many perennials have a limited blooming period of about 2 to 3 weeks, deadheading, or removal of old blooms, is not as frequently necessary to keep them blooming. However, they do require pruning and maintenance to keep them attractive. Their relatively short bloom period is a disadvantage, but by combining them with annuals, a continuous colorful show can be provided. Many require transplanting every 3 to 5 vears.

#### Culture and Maintenance of Perennials

#### **Site Location**

You need to consider many of the same aspects of site selection for perennials as you do for annuals; sunlight (full sun to heavy shade), slope of the site (affects temperature and drainage), soil type, and the role the plants selected will play in the garden. This is especially important with perennials, as they usually are left in the site for several years. In general, it is best to plant clumps of perennials rather than one plant. Large plantings may be made if space allows. An ideal location would provide a background such as a wall or hedge against which perennials will stand out while in bloom. In island beds, perennials can provide their own background if tall ones are planted in the center and low ones toward the edges.

#### **Soil Preparation**

Preparing the soil is extremely important to perennials. Many annuals can grow and flower in poorly prepared soil, but few perennials survive more than one year if the soil is not properly prepared.

For new beds, begin preparing soil in the fall before planting time. Have the soil tested first. Results will indicate how much lime or acidifier needs to be added during preparation and how much fertilizer needs to be added in the spring. Materials to adjust pH need time to work. Before preparing new beds, check the soil to see that it is well-drained, yet has some water-holding capacity. Test for drainage as described in the section on annuals. If drainage is inadequate, dig furrows along the sides of the bed and add soil from the furrows to the bed. This raises the level of the bed above the general level of the soil. Excess water can then seep from the bed into the furrows. Raised beds may wash during heavy rains. This can be prevented by surrounding the beds with wooden or masonry walls. Since raised beds dry out more quickly than flat beds, water beds frequently during the summer. After forming the beds, spade the soil to a depth of 8 or 10 inches. Turn soil over completely, incorporating 2 to 4 inches of organic material and add lime if required. Remove debris and leave rough during the winter.

In the spring, just before planting, spade again. At this spading, add recommended levels of fertilizers. Be sure to work any phosphorous deeply into the soil, where plant roots can get it. Rake the soil surface smooth. After raking, the soil is ready for seeding or planting.

It is best to select plants with a purpose in mind, such as edging plants, accents for evergreens, masses of color, rock garden specimens, etc. With specific purposes in mind, you can choose perennials by considering their characteristics and deciding which plants best meet your requirements.

For a good display from a limited number of plants in a limited space, select named varieties. Observe the flowering times of perennials in your neighborhood. That way you will be able to choose plants that will flower together and plants that will be showy when little else is in bloom. The flowering time may vary as much as 6 weeks from year to year, but plants of the same kind and their cultivars usually flower at the same time. To obtain details on particular plants or groups of plants, consult plant societies, specialty books, nurseries which specialize in herbaceous perennials, and local botanical gardens.

Plants of many perennials can be bought at a local greenhouse or nursery. If these plants are in bloom when they are offered for sale or have picture tags, you can select the colors you want. Buy perennial plants that are compact and dark green. Plants held in warm shopping areas too long are seldom vigorous and generally have thin, pale, yellow stems and leaves. Avoid buying these plants. Buy named varieties of plants for known characteristics of disease resistance, heat and cold resistance, growth habits and colors.

Many perennials do not grow true to type if grown from seed saved from old plants. If you plant seed you have saved, many off-types of color, flower form, and plant habit are produced. Purchased seed, whether hybrid or strains, usually give uniform results. You can sow perennial seeds directly in the beds where the plants are to bloom, or you can start early plants indoors or in a cold frame and set them out in beds after the weather warms. Some perennials will bloom the first year from seed, however, most species take two years to flower.

#### **PlantingTimes**

In northern New England, it is best to plant most perennials in spring. This allows the plants to develop excellent root systems. Exceptions are peony and bearded iris, which should be planted from mid-August to mid-September. Containergrown perennials can be planted from spring through early fall, if watered well. The later in the season perennials are planted, the more likely they are to require a top mulch to survive their first winter.

#### **Planting Seed Outdoors**

Perennials seeded in the garden frequently fail to germinate properly because the surface of the soil cakes and prevents entry of water. To avoid this, sow the seed in vermiculite-filled furrows. For planting directions, see the previous section on annuals.

#### **Setting Out Plants**

Whether you buy plants from a nursery, mailorder source, or start your own indoors, set them out the same way. When the time comes to set plants out in the garden, remove them from the pots, packs, or flats. Lift out each plant with the medium surrounding its roots and set the soil block in a planting hole. If the plants are bare root, spread out the root mass and set the plant in a prepared planting hole. When setting out plants in peat pots, remove the top edge of the pot to prevent it from drying out and limiting the root development of the plant. Thoroughly moisten the pot and its contents to help the roots develop properly. Drench the soil around the planting hole with a liquid fertilizer (16-12-10 or 20-20-20 mixed 1 tablespoon per gallon of water) to stimulate root growth. Set the moistened pot in the planting hole and press the soil up around the plant. Allow plenty of space between plants, because perennials need room to develop. Perennials usually show up best when planted in clumps or groups of plants of the same variety.

#### Watering

Since herbaceous perennials grow back from the roots every year, it is important to encourage healthy, deep roots. Proper watering promotes good root development. Make sure when watering that all the roots are reached. Follow directions on watering in the section on annuals. Avoid over watering and insure adequate drainage, especially in the late winter and early spring.

#### Mulching

Any type of mulch gives an orderly look to the garden and cuts down on weeding. Mulches are very useful for maintaining uniform moisture conditions in the garden. Soil temperatures are modified by mulches to various degrees. Organic mulches keep the soil cooler in early spring. Most organic mulches should be applied after plants are well-established and when there is reasonably good soil moisture. Bark, pine needles, and shredded leaves are common organic mulches used in perennial beds. Organic mulches decompose over time, adding nutrients and organic matter to the soil. For uniform appearance, replenish the 1 to 2 inch layer every 1 to 2 years. Perennials should be top mulched during the winter months to protect them from the heaving that results from repeated freezing and thawing of the soil. However, you must be careful with winter mulching, as it can do more harm than good. Be careful not to pile mulch heavily over the crowns, as this would encourage rotting. Boughs of evergreens give ample protection but allow air circulation. Apply mulch around the plants only after the soil temperature has decreased after several killing frosts. If winter mulch is applied too early, mice may move in and eat the plants. Severe damage to the plant can result from new growth not being acclimated and frozen back. Remove winter mulch as soon as growth starts in the spring. If you don't, new growth will develop abnormally with long, gangly stems and insufficient chlorophyll.

#### Weeding

Follow weeding directions in the section on annuals. A few pre-emergent herbicides are now registered for use in perennial flowers. For most gardens, mulch plus hand weeding or cultivation provide excellent weed management.

#### Fertilizing

On most native soils, regular fertilization is necessary. However, do not fertilize perennials heavily. A light fertilization program gives a continuous supply of nutrients to produce healthy plants. Use 5-10-5 fertilizer or similar complete fertilizer. Place fertilizer in small rings around each plant in March or April. Repeat in 6 weeks. This should be enough to carry plants through the summer. Apply another treatment of fertilizer to late-blooming plants in late summer. Always water the bed after applying fertilizer. This will wash the fertilizer off the foliage and prevent burn. It will also make fertilizer available to the plants immediately. The use of lower analysis slower release organic type fertilizers is also an alternative.

#### Deadheading

After perennials have bloomed, spent flowers may be removed. This will keep the beds looking neat and will prevent plants from wasting energy setting seed. Some perennials like Delphiniums can be forced to reblossom if cut back severely after the first bloom.

#### Pinching

Some perennials and annuals respond to having the main growing point removed by developing multiple stems or more lateral branches.

#### Disbudding

To gain large blooms from certain annuals and perennials, as opposed to more numerous but smaller blooms, disbud them. In disbudding, small side buds are removed, which allows the plant to concentrate its energy to produce one or a few large blooms. Peonies and chrysanthemums are examples of plants which are often disbudded.

#### Staking

Some erect perennials are top-heavy and need staking. If plants fall over, the stem will function poorly where it has been bent. If the stem is cracked, disease organisms can penetrate the break. Stake plants when you set them out so they will grow to cover the stakes. Once staked, tall perennials can better withstand hard, driving rain and wind.

Use stakes made of any material. Select stakes that will be 6 to 12 inches shorter than the height of the grown plant. Place stakes behind the plants and sink them into the ground far enough to be firm. Loosely tie plants to the stakes, using paper covered wire, plastic, or other soft material. Tie the plant by making a double loop of the wire with, one loop around the plant and the other around the stake. Never loop the tie around both stake and plant. The plant will hang to one side and the wire may girdle the stem. Add ties as the stem lengthens.

#### **FallCare**

In the fall, after the foliage of perennials has died down, remove dead leaves, stems, and spent flowers. These materials often harbor insects and disease-causing organisms. Apply winter mulch after the temperature has dropped and the soil is frozen. Do not smother those types that retain a rosette of green foliage at their base. Many hardy perennials do not need any mulch at all.

#### **Controlling Insects and Diseases**

Proper plant selection and care reduce pest problems. Select resistant varieties. Plant perennials in conditions of light, wind, spacing, and soil textures which are suited to them. Remove spent flowers, dead leaves, and other plant litter, as these serve as a source of reinfestation. Learn the major insect and disease pests (if any) of each specific plant type grown, so that problems can be correctly diagnosed and treated as they arise.

## Asexual propagation of perennials

#### Division

Most perennials left in the same place for more than 3 years are likely to be overgrown, overcrowded, have dead or unsightly centers, and in need of basic feeding and soil amendment. The center of the clump will grow poorly, if at all, and the flowers will be sparse. The clump will deplete the fertility of the soil as the plant crowds itself. To divide mature clumps of perennials, select only vigorous side shoots from the outer part of the clump. Discard the center of the clump. Divide the plant into clumps of three to five shoots each. Be careful not to over-divide: too small a clump will not give much color the first year after replanting. Divide perennials when the plants are dormant, just before a new season of growth, or in late summer so they can become established before the ground freezes.

Stagger plant divisions so the whole garden will not be redone at the same time; good rotation will yield a display of flowers each year. Do not put all the divisions back into the same space that contained the original plant. That would place too many plants in a given area. Give extra plants to friends, plant them elsewhere in the yard, or discard them.









#### Cuttings

Many plants can be propagated from either tip or root cuttings. Generally, tip cuttings are easier to propagate than root cuttings.

To propagate most perennials, take tip cuttings from the flush of growth in June. Make tip cuttings 3 to 6 inches long. Treat the base of the cutting with a root stimulant. Leave all foliage on the cutting except the part that will be below the soil line. Insert one cutting per peat pot. Place peat pots of tip cuttings in a lightly shaded place. Cover with a sheet of clear plastic. Check regularly to make sure the cuttings do not dry out.

When cuttings do not pull easily out of the soil, they have begun to root. Make holes in the plastic sheet to increase the exposure of the cuttings to the air. This will harden the cuttings. Every few days make new holes, or enlarge the holes.

Make root cuttings of phlox, babys-breath, and oriental poppy. Dig the plants in late summer after they have bloomed. Select pencil-sized roots; cut them into 4-inch sections. Put each piece in a peat pot. Prepare a tray of peat pots as for seeds, except the soil mix should be 2 parts sand, 1 part soil, and 1 part peat moss. Water thoroughly.

## **Bulbs**

This is a term loosely used to include corms, tubers, tuberous roots, and rhizomes as well as true bulbs. This section of the chapter will refer to all of the above as bulbs. However, a true bulb is a complete or nearly complete miniature of a plant encased in fleshy modified leaves called scales which contain reserves of food. Corms are the base of a stem that becomes swollen and solid with nutrients. It has no fleshy scales. The tuber, which is an underground stem that stores food, differs from the true bulb or corm in that it has no covering of dry leaves and no basal plant from which the roots grow. Usually short, fat and rounded, it has a knobby surface with growth buds, or eyes, from which the shoots of the new plant emerge. Tuberous roots are the only ones from this group that are real roots; their food supply is kept in root tissue, not in stem or leaf tissue as in other bulbs. Rhizomes, which are sometimes called rootstocks, are thickened stems that grow horizontally, weaving their way along or below the surface of the soil and at intervals sending stems above ground.

Bulbs are broadly grouped into spring-flowering (April-May) and summer-flowering (June-September). Spring bulbs provide early color before most annuals and perennials. One of the most popular spring bulbs is tulip. These are sold by type and variety. Tulips come in all colors except blue. Some of the most common types are:

Single early:	Flower at same time as daffodils
Darwin/Darwin hybrid:	Tall, blocky flowers
Lily flowered:	Petals recurve - bell- shape
Parrot:	Twisted, ruffled petals
Double:	<b>2</b> or more rows of petals

Narcissus and daffodils are classed by length of corolla ("trumpet") in relation to perianth segments. They come in the colors of white, yellow, and peach. Many naturalize well. Hyacinths produce a large single spike of many small, fragrant flowers, and come in a complete color range. Crocus and other minor bulbs are usually grown for early bloom. They are usually short, but are the earliest-flowering bulbs in northern New England and are well suited for "naturalizing".

Selecting quality spring bulbs is very important, because the flower bud has already developed before the bulb is sold. Size is also important; look for plump, firm bulbs. Select on a basis of color, and size for intended purposes; for example, small ones for naturalizing and large ones to stand out as specimen plants.

The summer-flowering bulbs include tuberous begonia, caladium, dahlia, gladiolus, and lily.

#### **Culture and Maintenance of Bulbs**

#### Storage

Plant bulbs as soon after obtaining them as possible. In the mean time, keep them in a cool, dry place (60 to 65 degrees F). Temperatures higher than 70 degrees F will damage the flower inside spring-flowering bulbs. Rhizomes, tubers, and tuberous roots are more easily desiccated than bulbs and corms, and should be stored in peat, perlite, or vermiculite, if held for more than several days.

#### **Site Selection**

In selecting a site for planting, consider light, temperature, soil texture, and function. Most bulbs need full sun to light shade. Select a planting site that will provide at least 5 to 6 hours of direct sunlight a day. Bulbs left in the ground year after year should have 8 to 10 hours of daily sunlight for good flowering. Bulbs planted in a southern exposure near a building or wall will bloom earlier than bulbs planted in a northern exposure. Adequate drainage is an important consideration. Most bulbs and bulb-like plants will not tolerate poor drainage, and rot easily if planted in wet areas. Function must also be kept in mind. If bulbs are being used to naturalize an area, toss the bulbs then plant them where they fall to create a scattered effect.

#### **Site Preparation**

Good drainage is the most important single factor for successful bulb growing. Bulb beds should be dug when the soil is fairly dry. Wet soil packs tightly and retards plant growth. Prepare the soil 8 to 12 inches deep. Add limestone and organic matter if needed and incorporate a complete fertilizer. Use 1 pound of 5-10-10 fertilizer or similar analysis for a 5 by 10 foot area. Throughly mix the lime, fertilizer and organic matter with the soil. For individual planting holes, loosen the soil below the depth the bulb is to be planted. Add fertilizer and cover with a layer of soil (bulbs should not contact fertilizers directly). Set bulb upright in planting hole and cover.

#### **Time of Planting**

Hardy, spring-flowering bulbs are planted in early fall. Hardy, fall-flowering bulbs, such as colchicum, are planted in August or September. Tender, summer-flowering bulbs are planted in the spring after danger of frost. Lilies are best planted in late fall.



#### **Depth of Planting**

As a general rule of thumb, bulbs should be planted 2<sup>1</sup>/<sub>2</sub> to 3 times the diameter of the bulb in depth. An alternative rule is to plant large bulbs (tulips, daffodils, hyacinths) 8 to 10 inches deep, and small bulbs (scilla, crocus, grape hyacinth) 5 inches deep. It is important not to plant bulbs too shallowly, as this will encourage frost heaving. If desired, after planting mulch with a 2 to 3 inch layer of organic material such as bark chips when the ground has frozen.



#### Watering

Normal rainfall usually provides enough moisture for bulbs. But during dry weather, water plants at weekly intervals, soaking the ground thoroughly. Be especially careful not to neglect bulbs after blooming.

#### Fertilizing

After plants bloom, again fertilize them lightly with something like a 5-10-10 fertilizer. Avoid high-nitrogen fertilizer. To avoid possible burning, keep fertilizers off of the leaves. In addition to 5-10-10 fertilizer, you can use bonemeal as an extra source of phosphorus.

#### Staking

A few tall, heavy-flowered bulbs may require staking. Stake plants when they are emerging, but be careful not to damage the bulb with the stake. Avoid the need for staking by selecting lower-growing bulbs, planting them where they are shielded from the wind.

#### Deadheading

When flowers fade, cut them off to prevent seed formation. Seeds take stored food from the bulbs.

#### Moving

If leaving bulbs in place for bloom next year, do not cut the leaves after flowering until they start to wither. Green leaves produce food for plant growth next year. After leaves turn yellow, cut and destroy the stems and foliage of the plants. Dead foliage left on the ground may carry disease to new growth the next year. If moving bulbs from one place to another, or if a planting has become crowded and ceased blooming, move only after the foliage has faded. Bulbs dug and moved before foliage fades are useless.

#### **Digging and Storing**

Many summer-flowering bulbs should be dug and stored, as they are tender. This is done when the leaves on the plants turn vellow. Use a spading fork to lift the bulbs from the ground. Wash off any soil that clings to most bulbs. Spread the washed bulbs in a shaded place to dry. When dry, store them away from sunlight in a cool, dry place. Avoid temperatures below 50 or above 70 degrees F. Be sure that air circulates around stored bulbs. Never store bulbs more than two or three layers deep, as they generate heat and cause decay. Leave the soil on achimenes, begonia, canna, caladium, dahlia, and ismene bulbs. Store these bulbs in clumps on a slightly moistened layer of peat moss or sawdust in a cool place. Rinse, clean, and separate them just before planting the following year.

## **Annuals for Special Uses**

#### Annuals for Bedding

(Masses and Drifts) Wax begonia Browallia, Amathyst flower Celosia. Cockscomb Dusty miller Coleus Seed dahlia Dianthus, China pinks Heliotrope Impatiens Lobelia Marigold Nicotiana, Flowering tobacco Petunia Annual phlox Salvia Scabiosa. Pincushion flower

#### Annuals for Edging

Ageratum Sweet alyssum Wax begonia Dianthus, China pinks Daisy, Dahlberg Lobelia French marigold Myosotis, Forget-me-not Nierembergia, Cup flower Petunia Annual phlox Portulaca, Moss rose Verbena Annual vinca

#### **Annuals for Ground Covers**

Creeping Zinnia, Sanvitalia Myosotis, Forget-me-not Nasturtium Portulaca, Moss rose Sweet Alyssum Verbena Annual vinca

#### **Annuals for Foliage**

Amaranthus Basil Castor Bean Coleus Dusty Miller Kochia

#### **Annuals for Fragrance**

Sweet alyssum Dianthus, China pinks Heliotrope Nasturtium Nicotiana, Flowering tobacco Stock Petunia Annual phlox Sweet pea

#### **Annuals for Fences and Trellises**

Canary Creeper Cobaea, Cup-and-saucer vine Gourds Morning Glory Scarlet Runner Bean Sweet pea Thunbergia

#### Annuals for Low Borders

Dwarf Celosia Dwarf Bedding Dahlias French Marigold Scotch marigold Petunia Dwarf zinnia

#### **Annuals for Screen Plants**

Cleome Kochia (evergreen) Tall Marigold Tithonia, Mexican sunflower Tall Zinnia Castor bean

#### Annuals for Window Boxes, Hanging Baskets, Urns, or Tubs

Sweet alyssum Wax begonia Coleus Lobelia Nierembergia, Cup flower Cascade Petunia Thunbergia Impatiens German Ivy Fuchsia Ivy geranium

#### Annuals for the Seaside

Sweet Alyssum Dusty Miller Statice Petunia

#### Annuals for the Rock Garden

Ageratum Sweet Alyssum Wax Begonia Dwarf Celosia, Cockscomb Coleus Gazania Lobelia French Marigold Nasturtium Pansy Petunia Annual Phlox Portulaca Verbena Dwarf Zinnia

#### **Annuals for Cut Flowers**

China Asters Bells of Ireland (also dried) Carnation Celosia (also dried) **Bachelor Buttons** Pink Cosmos Cynoglossum Seed Dahlia Gaillardia, Blanket Flower Gerbera Gomphrena, Globe Amaranth (also dried) Gypsophila, Annual baby's breath Larkspur Love-in-a-Mist (also dried) Marigold Nasturtium Petunia Rudbeckia, Black-eyed Susan Blue Salvia (also dried) Scabiosa, Pincushion Flower Snapdragon Annual Statice (also dried) Tithonia, Mexican Sunflower Zinnia

## **Annuals for Special Environments**

#### Annuals Tolerant of Cool Weather

Plant after danger of heavy frost is over in the spring, except sweet peas, which should be planted just as soon as the soil is workable. Some varieties can also be sown, with risk, late in fall, just before the ground freezes, so seed will not germinate until spring.

Sweet Alvssum China Aster Bells of Ireland Calendula, Pot Marigold (can sow in fall) Annual Candytuft Annual Chrysanthemum Clarkia Cleome, Spider Flower (can sow in fall) Bachelors Buttons, Cornflower (can sow in fall) Cosmos Cynoglossum (can sow in fall) Dianthus. China pinks Didiscus, Lace Flower Dimorphotheca, African Daisy Annual Gaillardia, Blanket Flower Larkspur Lobelia Nigella, (Love-in-a-Mist) Pansv Annual Phlox Poppy, Shirley & California Salpiglossis (painted tongue) Blue Salvia Scabiosa, Pincushion Flower Snapdragon Stock Sweet Pea

#### **Tender Annuals**

Plant when all danger of frost is over in the spring.

Ageratum Garden Balsam Wax Begonia Celosia, Cockscomb Coleus Globe Amaranth Gourds Impatiens Marigold Morning Glory Nasturtium Nicotiana, Flowering tobacco Petunia Red Salvia Verbena Annual Vinca Zinnia

#### **Heat-resistant Annuals**

Celosia Cleome, Spider Flower Cosmos Four O'Clock Gaillardia. Blanket-flower Geranium Globe Amaranth Helichrysum, Strawflower Larkspur Marigold Morning Glory Nicotiana, Flowering tobacco Nierembergia, Cup Flower Petunia Annual Phlox Portulaca. Moss Rose Red Salvia Scabiosa, Pincushion Flower Sunflower Verbena Zinnia **Ornamental Pepper** 

#### **Annuals for Partial Shade**

Alyssum Aster Balsam Begonia Browallia Calendula Coleus Cornflower Impatiens Lobelia **Mvosotis** Nasturtium Nicotiana Pansv Petunia Snapdragon Torenia Wallflower

## Annuals That Tolerate Heat, Drought and Sandy Soils

Cleome Gaillardia, Blanket Flower Marigold Petunia Annual Phlox Portulaca, Moss Rose Red Salvia Sunflower Verbena Zinnia

## Annuals by Color and Height

Variety	Color of Bloom	Height (Inches)
African Daisy	white, yellow, salmon	6-12
Ageratum	blue, white, pink	4-24
Amaranthus	red, green, purple (foliage)	24-48
China Aster	yellow, pink red, blue, white, lavender	12-24
Garden Balsam	rose, purple, white	12-18
Basil, red	red-purple (foliage)	15
Browallia, Amethyst Flower	blue, violet, white	12-18
Calendula, Pot Marigold	yellow, gold	12-24
California Poppy	red to yellow	12
Cabbage, flowering	red, white, green, purple (foliage)	8-14
Annual Candytuft	pink, lilac, white	10-12
Annual Chrysanthemum	yellow, purple, orange	24-36
Castor Bean	green, maroon (foliage)	48-72
Clarkia	white, pink, red, pink & red	18
Celosia, Cockscomb	yellow, red, pink	6-36
Cornflower, Bachelor's Buttons	pink, blue, white	12-36
Coleus	variegated (foliage)	8-20
Pink Cosmos	pink, lilac, red, white	36-60
Dusty-miller	silver (foliage)	8-16
Forget-Me-Not	blue, pink	12
Four O'Clock	pink, white, yellow	24
Annual Gaillardia, Blanket Flower	yellow, red	15-24
Gloriosa Daisy	yellow, orange, red	24-30
Gomphrena, Globe Amaranth	white, pink, purple	16-24
Heliotrope	purple, white	12-24

Variety	Color of Bloom	Height (Inches)
Impatiens	red, pink, white, orange	6-24
Larkspur	blue, pink, white, purple	18-48
Lobelia	blue, violet, white	4-12
Marigold	yellow, orange to red-brown	6-48
Nicotiana	red, white, pink, green	24-36
Nigella	white, blue, violet, pink	12-15
Pansy	blue, purple, white, yellow, pink	8-12
Petunia	white, rose, purple, red, blue	e 12-18
Annual Phlox	white, rose, purple	6-10
Portulaca, Moss Rose	yellow, white, rose, orange	8
Blue Salvia	blue, white	24-36
Red Salvia	red, pink, purple	18-36
Scabiosa, Pincushion Flower	purple, pink, white	24-36
Snapdragon	white, yellow, orange, red	6-24
Annual Statice	yellow, rose, violet, white, bl	ue18-24
Strawflower	white, red, yellow	24-36
Sunflower	yellow to red-brown	12-72
Sweet Alyssum	white	3-10
Sweet Pea	orange, yellow, rose, purple, white	8+(vine)
Verbena	white, pink, blue, red	18-24
Annual Vinca	white, pink	12-18
Zinnia	red, pink, yellow, orange	6-36

## Perennials for Special Use

#### Perennials for Borders of Ponds And Streams

(Well-drained soil)

#### Sunny Locations:

Cimicifuga racemosa (Cohosh Bugbane)<sup>\*</sup> Grasses (Ornamental Grasses) Iris, in variety Myosotis scorpioides semperflorens (Dwarf Perpetual Forget-me-not) Tradescantia virginiana (Spiderwort)<sup>\*</sup> Trollius europaeus (Globeflower)

#### Semi-shady Locations:

Anemone hupenhensis or A. x hybrida (Japanese Anemone) Eupatorium purpureum (Joe-Pye-weed)

\*also do well in semi-shade

#### Perennials for Background Planting

Althaea rosea (Hollyhock) (actually biennial) Aster novae-angliae (New England Aster) Campanula persicifolia (Peach-leaved Bellflower) Cimicifuga racemosa (Cohosh Bugbane) Delphinium hybrids (Delphinium) Helenium autumnale (Sneezeweed) Rudbeckia laciniata (Goldenglow) 'hortensia' Valeriana officinalis (Common Valerian) Yucca filamentosa (Common Yucca)

#### Perennials for Edging

Achillea tomentosa (Woolly Yarrow) Ajuga reptans (Carpet Bugle) Armaria species (Thrift) Arabis caucasica (Wallcress) Aubrietia deltoidea (Purple Rockcress) Aurinia saxatilis 'Compacta' (Dwarf Goldentuft) Bellis perennis (English Daisy) Campanula carpatica (Carpanthian Bellflower) Cerastium tomentosum (Snow-in-summer) Dianthus deltoides (Maiden Pink) Dianthus plumarius (Grass Pink) Iberis sempervirens (Edging Candytuft) Papaver nudicaule (Iceland Poppy) Phlox subulata (Moss Phlox) Primula hybrids (Primrose) Sedum stoloniferum (Running Stonecrop) Veronica latifolia (Rock Speedwell) Viola, in variety (Violet)

#### Perennials for Ground Cover, Banks, and Terraces

#### Sunny Locations:

Cerastium tomentosum (Snow-in-summer) Ceratostigma plumbaginoides (Larpente Plumbago) Iberis sempervirens (Edging candytuft) Nepeta mussini (Mussini Mint) Phlox subulata (Moss Phlox) Sedum spurium (Running Stonecrop) Thymus praecox subspecies artieus (Mother-ofthyme) Veronica latifolia (Rock Speedwell) Vinca minor (Periwinkle)

#### Shady Locations:

Ajuga reptans (Bugle) Asperula odoratum (Sweet Woodruff) Convallaria majalis (Lily-of-the-valley) Hedera helix (English Ivy) Pachysandra terminalis (Japanese Pachysandra)

#### Perennials for Bold or Sub-tropical Effects

Aruncus dioicus (Spirea) Acanthus mollis (Artist's Acanthus) Dipsacus fullonum (Teasel) Echinops ritro and exaltatus (Globe Thistles) Elymus arenarius (Sea Lyme grass) Heracleum laciniatum (Cow-parsnip) Kniphofia uvaria (Torchlily, Red-hot-poker plant) Yucca filamentosa (Yucca)

#### Perennials for Naturalizing

Asclepias tuberosa (Butterfly weed) Aster (various)(Aster) Cimicifuga racemosa (Cohosh Bugbane) Convallaria majalis (Lily-of-the-valley) Hepatica (Roundlobe Hepatica) Lobelia cardinalis (Cardinal Flower) Mertensia virginica (Virginia Bluebells) Monarda didyma (Bee Balm) Physostegia virginiana (False Dragonhead, Obedience) Polemonium reptans (Creeping Polemonium) Sanguinaria canadensis (Bloodroot) Smilacina racemosa (Solomon's zig-zag, False spikenard) Solidago canadensis (Canada Goldenrod) Trillium grandiflorum (Trillium)

#### Perennials for Old-fashioned Gardens

Aconitum, in variety (Monkshood) Althaea rosea (Hollyhock) (biennial) Asters. old varieties Campanula, in variety (Bellflower) Delphinium x Belladonna (Delphinium) Dianthus barbatus (Sweet William) Dianthus plumarius (Grass or Garden Pink) Dicentra spectabilis (Bleeding-heart) Dictamnus alba (Dittany or Gas Plant) Digitalis, in variety (Foxglove) Hemerocallis lilio asphodelus (Lemon Lily) Hesperis matronalis (Sweet Rocket) Lilium candidum (Madonna Lilv) Lunaria (Honesty)(Biennial) Mertensia (Mertensia or Blue Bells) Myosotis, in variety (Forget-me-not) Paeonia officinalis types (Peony) Viola odorata (Sweet Violet)

#### **Fragrant Perennials**

Artemisia abrotanum (Southernwood) Convallaria majalis (Lily-of-the-Valley) Dianthus plumarius (Grass Pink) Dictamnus albus (Dittany or Gas Plant) Galium odoratum (Sweet woodruff) Hesperis matronalis (Sweet Rocket) Hosta plantaginea grandiflora (Funkia or Big Plantain Lily) Monarda didyma (Bee Balm) Paeonia, in variety (Peony) Phlox paniculata (Phlox) Rosa species (Heritage Roses) Valeriana officinalis (Common Valerian) Viola cornuta (Tufted Pansy, Horned violet) Viola odorata (Sweet Violet) Thymus, in variety (Thyme) Lavandula augustifolia (True Lavender)

## Perennials Having Especially Long Blooming Seasons

Anchusa azurea (Bugloss) Campanula carpatica (Tussock Bellflower) Delphinium, if cut back Heuchera sanguinea (Coral Bells) Lathyrus latifolius (Perennial Pea) Lysimachia (Gooseneck Loosestrife) Viola tricolor (Johnny-Jump-Up)

#### Perennials Suitable for Cut Flowers

Achillea millefolium (Yarrow) Anemone japonica (Japanese Anemone) Aster (various)(Aster) Chrysanthemum coccineum (Painted Lady) Delphinium hybrids (Delphinium) Dianthus barbatus (Sweet William) Dicentra (Bleeding Heart) Gaillardia x grandifolia (Blanket Flower) Gypsophila paniculata 'Flore Pleno' (Babysbreath) Heuchera sanguinea (Coral Bells) Iris (various)(Iris) Lysimachia (Gooseneck Loosestrife) Mertensia virginica (Blue Bells) Paeonia (various)(Peonv) Rudbeckia (various)(Cone Flower) Salvia azurea grandiflora (Azure Sage)

## Perennials for Special Environments

#### Perennials for Shade

Ajuga (Bugle) Anemone japonica (Japanese Anemone) Asperula (Woodruff) Convallaria majalis (Lily-of-the-Valley) Dicentra spectabilis (Bleeding-Heart) Heuchera sanguinea (Coral Bells) Hosta, in variety (Plantain Lily) Mertensia virginica (Virginia Bluebells) Phlox divaricata Primula, in variety (Primrose) Trillium grandiflorum (Trillium) Trollius europeaus (Globeflower)

#### Perennials for Semi-shade

Anchusa azurea (Bugloss) Aquilegia hybrids (Columbine) Campanula rotundifolia (Harebell) Chelone Iyonii (Pink Turtlehead) Cimicifuga racemosa (Cohosh Bugbane) Digitalis purpurea (Foxglove) Doronicum cordatum (Leopard's bane) Monarda didyma (Bee-balm) Physostegia Virginiana (False Dragonhead, Obedience) Polemonium Pulmonaria saccharata (Bethlehem Sage) Pyrethrum (Chrysanthemum coccineum, Pink Daisy)

#### Perennials for Wet Soils

Boltonia asteroides (White Boltonia) Caltha palustris (Marsh Marigold) Eupatorium purpureum (Joe-Pye-weed) Hibiscus Moscheutos (Swamp Rose-Mallow) Iris Pseudacorus (Yellowflag) Lobelia cardinalis (Cardinal Flower) Lysimachia clethroides (Clethra Loosestrife, Gooseneck Loosestrife) Miscanthus sinensis (Eulalia, Ornamental Grass) Monarda didyma (Bee-balm) Myosotis scorpioides (True Forget-me-not) Onoclea sensibilis (Sensitive Fern) Osmunda cinnamomea (Cinnamon Fern) Osmunda regalis (Royal Fern)

#### Perennials Which May Be Grown in Water

Caltha palustris (Marsh Marigold) Iris Pseudacorus (Yellowflag) Osmunda regalis (Royal Fern)

#### Perennials for Poor Soil

Achillea millefolium (Milfoil or Yarrow) Aurinia saxatilis (Goldentuft) Cerastium tomentosum (Snow-in-summer) Gypsophila paniculata (Baby's breath) Heliantlberis sempervirens (Edging Candytuft) Linaria vulgaris (Toadflax) Phlox subulata (Moss Phlox) Sedum stoloniferum (Running Sedum) Sempervivum (Roof Houseleek) Verbascum Thapsus (Mullen) Veronica rupestris (Creeping Speedwell)

#### Perennials Requiring Well-drained Soil

Arabis alpina (Alpine Rockcress) Asclepias tuberosa (Butterflyweed) Aubrietia deltoidea (Purple Rockcress) Coreopsis grandiflora (Tickseed) Dianthus barbatus (Sweet William) Digitalis purpurea (Common Foxglove) Echinops Ritro (Steel Globe Thistle) Eryngium maritmum (Sea-holly) Iris hybrids (Bearded Iris) Liatris pycnostachya (Cattail Gayfeather) Papaver nudicaule (Iceland Poppy)

#### Perennials for Dry, Sandy Soil

Achillea Ptarmica (Sneezewort) Anthemis tinctoria (Golden marguerite) Asclepias tuberosa (Butterflyweed) Aster novae-angliae (New England Aster) Coreopsis grandiflora (Tickseed) Dianthus plumarius (Grass Pink) Echinops Ritro (Steel Globe Thistle) Limonium latifolium (Statice) Papaver nudicaule (Iceland Poppy) Rudbeckla laciniata (Goldenglow) Yucca filamentosa (Common Yucca)

## **Bloom Calendar**

#### Perennials for Early Spring

Scientific Name	Common Name	Height (inches)	Color
Iberis sempervirens	Edging Candytuft	12	White
Sanguinaria canadensis	Bloodroot	8	White
Galanthus nivalis	Common Snowdro	o 6	White
Scilla siberica	Siberian Squill	6	Blue
Chionodoxa Luciliae	Glory-of-the-snow	4	Blue
Claytonia virginica	Spring beauty	4	Blue
Crocus vernus	Dutch Crocus	4	Various
Eranthis hyemalis	Winter Aconite	3	Yellow

## Perennials for Spring

Scientific Name	Common Name	<b>leight</b> inches)	Color
Aquilegia canadensis	American Columbine	18	Red- Yellow
Bergenia cardifolia	Heartleaf Saxifrage	12	Pink
Pulmonaria angustifolia	Cowslip Lungwort	12	Blue
Arabis alpina	Alpine Rock-cress	12	White
Tulipa (early)	Tulip	12	Various
Narcissus (various)	Narcissus	12	Yellow
Leucojum vernum	Spring Snowflake	12	White
Dicentra Cucullaria	Dutchman's Breeche	es 10	White
Primula hybrids	Cowslip	9	Various
Anemone Pulsatilla	Pasqueflower	9	Purple
Viola cornuta	Horned Violet	8	Various
Viola odorata	Sweet Violet	8	Violet
Muscari botryoides	Common Grape Hyacinth	8	Blue
Hyacinthus orientalis	Hyacinth	8	Various
Hepatica americana	Roundleaf Hepatica	6	Blue
Aubrietia deltoidea	Common Aubrietia	6	Purple
Trollius europaeus	Globe Flower	24	Yellow
Dicentra spectabilis	Bleedingheart	36	Pink
Iris germanica	Iris	18-36	Various
Thalictrum aquilegifolium	Columbine Meadow	rue 36	Purple
Hemerocallis	Lemon Daylily	36	Yellow
Paeonia officinalis	Common Peony	30	Various
Aquilegia chrysantha	Golden Columbine	24	Yellow
Doronicum cordatum	Caucasian Leopardbane	24	Yellow

Scientific Name	Common Name	<b>leight</b> inches)	Color
Euphorbia epithymoides	Cushion Spurge	24	Yellow
Chrysanthemum coccineum	Painted Lady	24	Various
Trollius europaeus	Common Globeflow	er 24	Yellow
Aurinia saxatilis	Goldentuft	18	Yellow
Tulipa Gesnerana	Darwin Tulip	18	Various
Gaillardia aristata	Common Peren. Gaillardia	15	Red- Orange
Brunnera macrophylla	Siberian Bugloss	12	Blue
Convallaria majalis	Lily-of-the-valley	12	White
Nepeta Mussinii	Mussini Mint	12	Blue
Phlox divaricata	Blue Phlox	12	Laven- der
Galium odoratum	Sweet Woodruff	8	Yellow
Ajuga reptans	Carpet Bugle	6	Purple
Phlox subulata	Moss Phlox	6	Pink
Primula	Primrose	6	Various
Polemonium reptans	Creeping Polemoniu	ım 6	Blue
Ranunculus repens	Creeping Buttercup	6	Yellow
Silene quadrifida	Alpine Catchfly	6	White
Cerastium tomentosum	Snow-in-summer	6	White
Veronica prostrata	Rock Speedwell	4	Blue
Pulmonaria officinalis	Pulmonuria	6-12	Purple

#### Bloom Calendar cont.

#### Perennials for Early Summer

Scientific Name	Common Name	Height (inches)	Color
Althea rosea (biennial)	Hollyhock	72	Various
Delphinium hybrids	Larkspur	24-60	Various
Digitalis purpurea	Common Foxglove	48	Purple
Anchusa azurea	Italian Bugloss	36	Blue
Lupinus polyphyllus	Washington Lupinu	ıs 36	Various
Papaver orientale	Oriental Poppy	36	Red- Pink
Hererocalis	Daylily	36	Yellow
Iris hybrids	Bearded Iris	36	Various
Paeonia officinalis	Common Peony	18-36	Pink, white
Lilium candidum	Madonna Lily	36	White
Aconitum Napellus	Aconite	24	Blue- White
Baptisia australis	Blue Wild-indigo	24	Blue
Campanula medium (biennial)	Canterbury bells	24	Blue
Chrysanthemum x superbum	Shasta Daisy	24	White
Achillea Ptarmica	Sneezewort	24	White
Lilium pumilum	Coral Lily	23	Red
Dianthus barbatus	Sweet William	18	Various
Linum perenne	Perennial Flax	18	Blue
Oenothera fruticosa	Common Sundrops	s 18	Yellow
Dianthus plumarius	Grass Pink	12	Various
Lychnis viscaria	German catchfly	12	Purple
Papaver nudicaule	Iceland Poppy	12	Various
Veronica spicata	Spike Speedwell	12	Purple
Dianthus deltoides	Maiden Pink	9	Pink
Campanula carpatica	Tussock Bellflower	8	Blue

### Perennials for Mid Summer

Scientific Name	Common Name	Height (inches)	Color
Macleaya cordata	Pink Plum Poppy	72-96	Cream
Lilium tigrinum	Tiger Lily	24-60	Orange
Cimicifuga racemosa	Cohosh Bugbane	48	White
Hemerocallis	Daylily	48	Yellow
Heliopsis helianthoides	Pitcher Heliopsis	36	Orange
Physostegia virginiana	Obedience	36	Pink
Monarda didyma	Oswego Beebalm	36	Scarlet
Echinops Ritro	Steel Globe Thistle	36	Blue
Phlox paniculata	Perennial Phlox	24	Various
Asclepias tuberosa	Butterflyweed	24	Orange
Lychnis chalcedonica	Maltese Cross	24	Scarlet
Lychnis x Haageana	Haage Campion	12	Orange- Scarlet
Heuchera sanguinea	Coralbells	18	Crimson
Veronica incana	Woolly Speedwell	12	Rosy- purple
Platycoton grandiflorus	Balloon Flower	24	Blue, white
Achillea millefolium	Common Yarrow	18	Rose, white
Astilbe x arendsii	Astilbe	24	Pinks, white

#### Bloom Calendar cont.

## Perennials for Late Summer and Early Fall

Scientific Name	Common Name	Height (inches)	Color
Eupatorium purpureum	Joe-Pye-weed	72	Purple
Lilium Henryi	Henry Lily	60-72	Orange
Artemisia vulgaris	White Mugwort	48	White
Liatris pycnostachya	Cattail Gayfeather	48	Purple
Lilium speciosum	Speciosum Lily	24-48	Pink
Solidago canadensis	Canada Goldenrod	36	Yellow
Rudbeckia fulgida	Showy Coneflower	36	Golden
Lilium superbum	American Turk's Cap Lily	24-36	Orange- Red
Veronica longifolia subsessilis	Clump Speedwell	24-36 Purple	Blue-
Liatris spicata	Spike Gayfeather	24	Purple
Limonium latifolium	Bigleaf Sea-lavend	er 20	Laven der
Colchicum autumnale	Common Autumn Crocus	3-4	Purple
Aconitum carmichaelii	Violet Monkshood	48-60	Blue
Aster novibelgii	New York Aster	36-60	Blue
Aster novae-angliae	New England Aster	36-48	Various
Helenium autumnale	Common Sneezeweed	36-48	Yellow
Echinacea purpurea	Purple Coneflower	36	Purple- Rose
Anemone x hybrida	Japanese Anemon	e 24-36	Various
Chelone Lyonii	Pink Turtlehead	24-36	Pink
Aconitum Fischeri	Azure Monkshood	24-36	Blue
Sedum spectabile	Showy Stonecrop	18	Crimson
Anemone hupehensis	Japanese Anemone	12	Rose

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# CHAPTER 15

# Landscape Design

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Landscape design can be defined as the art of organizing and enriching outdoor space through the arrangement of plants, structures, and land form in agreeable and useful relationship with the natural environment and the desired use.

Designing a landscape is an art and a science. Landscaping means creating a plan to make the best use of the space available in the most attractive way. It means shaping the land to make the most of the site's natural features and advantages. It means building such necessary structures as fences, walls, and patios. Finally, it means selecting and growing the plants that best fit the design.

The smaller the house, grounds, and budget, the greater the need for correct and complete planning, because every square foot of space and every dollar must produce maximum results. Plan for the best use of the site and minimum upkeep as well as pleasant appearance.

## Program Development and Analysis of Site and Family Needs

The first step in landscape design is to develop a specific program based upon:

- The people who will use it, their cultural needs, individual desires, and economic abilities
- The climate
- The site, its immediate surroundings, topographic and ecological conditions, and all objects, natural and man-made now existing on the site or planned for the future
- The available materials and methods of fabrication

The next step in landscape design is to conduct a site inventory and to develop a site analysis. Analyze the site in terms of what features to keep, what features to accentuate and what features to remove. Next, bring to mind what cultural, physical and emotional needs to address. Specifically analyze how the existing landscape fits in with these needs and what manipulations will be needed to develop the ultimate landscape.

## Factors Influencing Landscape Design

#### The Lot and Its Characteristics

In laying out a design, consider preserving the site's best natural resources, such as mature trees, brooks, ponds, rock outcroppings, good soil, turf, and interesting variations in the terrain. These natural elements affect the ease of construction and landscape possibilities. A careful survey of the area should be made to determine whether site conditions will be a deterrent or can be incorporated into a design plan. Examples of problems are thin, overcrowded trees which should be removed. There might be micro environmental problems on a site that requires special consideration, such as low places with poor air drainage or a spot with poor soil and water drainage.

Changes in elevation can add interest and variety to the home landscape. The character of the land, its hills, slope, and trees should help determine the basic landscape pattern. A hilly wooded lot lends itself to an informal or natural design, with large areas left in their natural state. In such a setting, it may be particularly appropriate to retain large trees. Because natural slope variations are usually an asset, excess grading of terraces or retaining walls should be avoided. If these features are necessary to facilitate construction or control water drainage, they should be designed to enhance the natural terrain.

#### **Neighborhood Sights and Sounds**

It is important to keep in mind throughout the design process the elements of the surrounding environment. These elements include both visual and audio stimuli. A basic rule to remember is: keep good elements as visual and audio "assets" and screen out the undesirable elements. Don't let your design get too complex though--often a shrub or two will provide all the screening that is necessary.

#### Climate

Climate includes light, all forms of precipitation, wind, and temperature. All these affect the way a house should be placed on a lot, how the land is used and what is planted. In planning the grounds, don't fight the climate; capitalize on its advantages. For example, orienting the long axis of the house to face between due south and S 17°W will maximize solar gain and enhance winter warming and summer cooling. In warm regions, enlarge the outdoor living area if possible. In cold regions, plant so that the winter scene is enjoyed from the inside.

Evergreens and hedges are picturesque when covered with snow. Since people respond differently to sun and shade, it is important to study the amount and location of each on the lot. Sun and shade patterns change with the seasons and vary each minute of the day. The sun is highest and shadows are shortest in the summer.

Northern exposures receive the least light, and therefore are the coolest. The east and west receive more light; western exposures are warmer than eastern because they receive afternoon light. The southern orientation receives the most light and tends to be the warmest.



Plan future shade from tree plantings with great care in order to keep sunny areas for garden, summer shade for house and terrace. Deciduous trees (those that shed their leaves) shade the house in summer and admit the sun in winter. Place trees off the corners (rather than the sides) of the house where they will accent the house but not block views and air circulation from windows. Remember that over-planting trees tends to shut out sun and air.

#### **Family Activities**

Use of the land is an important factor in landscape design. Analyze the activities of the family. For example, small children need open lawn for playing, gardeners need space for growing vegetables and flowers. Make allowances for future changes. Consider outdoor living, recreation, gardening, and household servicing.

#### **Cost-Effective Maintenance**

Decide on maintenance standards. For the person who enjoys spending many hours about the yard, landscape design may be elaborate. However, in general, the simpler the site, the less there is to maintain. A low-maintenance plan is the goal of most homeowners. This may be achieved, to a large extent, in the planning stage, by careful attention to the nature of the site. Existing trees, elevations, and the use to be made of the area should be prime considerations. Low maintenance may be achieved by adopting one or more of the following possibilities:

- Minimize lawn area. Consider using dwarf turfgrass varieties.
- Use ground covers and low maintenance perennials with natural pine, straw, barkchips, or other mulches.
- Use paving in heavily traveled areas.
- Provide mowing strips of brick or concrete to edge shrub and flower beds.
- Use fences, walls or informal hedges instead of clipped formal hedges for screening.
- Use raised flower beds and planters for easy access and lower maintenance.
- Install an underground irrigation system in areas of low rainfall.
- Keep flower beds small. Use flowering trees and shrubs for color.
- Be selective in the choice of plant materials. Some plants require much less care than others.
- Use native plant materials, as appropriate.
- Keep the design simple.
- Use mulches for weed control when possible.
- Group high water use plants in one area of the landscape to conserve time and water when irrigating.
- Use dwarf, compact and insect and disease resistant varieties.

## Definition of Areas and Design Considerations

Areas of the landscape are defined in terms of desired use: the public area, the private area, and the service and work area. The public area is the section that passersby view. The living or private area is for the family and may contain a patio, deck or porch for outdoor sitting, entertaining or dining. The service and work area should provide a place for special interests such as a garden shed or tool storage area. Well defined and adequate separation between these use areas is usually desirable to avoid conflicts, especially in terms of pedestrian and vehicular circulation.

When defining the areas of the landscape, think in terms of a series of "outside rooms", each with a floor, walls and a ceiling. This will help you to define the areas as well as help you to establish what plant material to use and where to place it.

#### Private or Outdoor Living Area

The private living area or outdoor living room has become an important part of the American home. No yard is too small to have a private sitting area where family and guests can gather. Where possible, there should be easy access from the house to the outdoor area. The ideal arrangement is to have the living room open onto a porch or terrace, and/ or have the kitchen near the outdoor dining area. The outdoor living room can be simple. An open, grassy area enclosed by a wall or shrubs enables the homeowner and guests to sit outdoors in private. A more elaborate outdoor living room can be developed by introducing a series of gardens or garden structures such as paving material, benches and planters.

The outdoor private area can serve the following functions:

Outdoor entertaining Family relaxation Recreation Outdoor eating Aesthetic enjoyment The following are guidelines to consider when planning major private areas:

**Privacy:** The area should be enclosed from public view or nearby neighbors. Properly grouped shrub borders and trees will do this. For a small area, use a fence to save space. The private area should be screened from work areas, such as clothes lines, wood piles, garden sheds, and other less pleasant views.

**Livable touch:** Furniture should be attractive, designed for outdoor use, and appropriate for the size of the landscaping. Garden accessories should be kept to a minimum and be simple and unobtrusive.

Year-round interest: If the area is visible from the house or if the area is frequented in the winter, the outdoor living area should be planned so the selection of plant material is varied and so there is interest throughout the year. For winter interest, select shrubs and trees with interesting form and texture, colorful bark, evergreen foliage, or colorful fruit. The rest of the year use flowers, shrubs, and trees to create interest. Landscape embellishments such as pools, statuary, stone steps, paving, walls, birdfeeding stands, and other architectural features will add interest to the garden. Architectural details do not change with the seasons, and they give interest and meaning to the garden throughout the year.

**Climate control:** Control of weather in the outdoor living area helps to extend the period of usefulness. Shade trees screen the area from the hot sun. Windbreaks cut down some of the wind in the fall. An awning or lattice roof can protect against inclement weather. A garden pool or fountain can convey the effect of coolness during the hot summer season.

**The terrace or sitting area:** The center of activity for a living area is often a space arranged with garden or patio furniture. It may be a porch, deck, or terrace next to the house, or the special section of the living area. This latter area might be under the shade of a large tree or in a shady corner. The sitting center may be either paved or in turf. Flagstone, brick, concrete blocks, or concrete with redwood dividers are materials commonly used for surfacing the outdoor terrace. The size of the paved terrace depends upon its expected use and the type and amount of furniture desired. An area 10 feet by 10 feet will hold four chairs and is about the minimum size for accommodating four people comfortably. Increase the size if space is desired for a picnic table. This area may also include a grill or outdoor cooking area.

**The play area:** To accommodate the special interests of small children, a play area can be a part of the outdoor living area. For very young children, a small area enclosed by a fence near the kitchen or living area may be desirable. A swing, sand box, or other equipment can be placed here. In yards with a good deal of open lawn space, there is room for croquet, badminton, or a portable wading pool. A large tree in the back yard may be ideal for a tree house. A paved driveway or parking area makes an ideal area for badminton, basketball, or shuffleboard for older children, as well as tricycling or roller skating for younger ones. Since ages of children in a family are always changing, it is necessary to make design adjustments to meet changing recreational needs.

**Enclosed Front Yard as a Private Area:** The area in front of the majority of homes has traditionally been left more or less open so the passing public can view the home. Plantings, such as hedges or a screen planting of trees and shrubs along the street in order to make the public area private, have been used to provide privacy for the front area. Privacy in the front yard may be desirable when a picture window faces the street or when the front yard is used for outdoor sitting. Where space is limited, a tall attractive fence may provide privacy and be used as an attractive background for shrubs and smaller plants.

#### Service and Work Area

When designating the service area, consider proximity to out-buildings, such as a garage. Space often needs to be provided for permanent clothes lines, garbage cans, trash burners, air-conditioner units, tool storage, wood storage, vegetable garden, compost, cutting garden, cold frame, small greenhouse, or kennel. Service facilities should not be visible from the outdoor living area or from the street. However, an exception might be an attractive greenhouse or tool storage building designed and constructed so that it blends well into the overall setting, with an interesting composition of plant material around it. Wood or wire fences, brick or masonry walls, or plant material alone or in combination are the materials most commonly used to hide or screen service areas.

#### **Public Area**

This is the area, generally in the front facing the street, that the public sees. The landscape in this area should create the illusion of spaciousness. Keep the lawn open, keep shrubs to the side and in foundation plantings. When selecting shrubs to frame the front door, consider their texture, color, size, and shape so they will enhance the total effect of welcoming guests. Tall trees in the backyard and medium-sized ones on the sides and in front will help accomplish this effect. The house is to be the focal point of the view.

Driveways should be pleasing in appearance, useful, and safe. The landscaping of many homes is spoiled by poorly designed and maintained driveways. Some driveways tend to cut up the yard unnecessarily. Parking areas and turnabouts should be provided when practical. If possible, the driveway should be hard-surfaced because it is neater and requires less maintenance than unpaved driveways. Do not plant tall shrubbery at a driveway entrance or allow vegetation to grow so tall that it obstructs the view of the abutting road in either direction.

In planning the home grounds, give careful consideration to foot traffic patterns so there will be easy access from one area to another. This traffic may be served by walkways, terraces, or open stretches of lawn. In areas of heavy use, paved surfacing material is best.

Design of the walk system to the primarily-used door will often depend on the location of the door and guest parking as well as the topography of the land. If guest parking is at the edge of the street, a straight walk is probably best if the grade is suitable. When the guest parking area is planned for the property, the walk might more logically lead from the guest parking area to the front door. Foot traffic can use the driveway.

Sometimes the topography of the land will make it desirable to have the entrance walk start at the edge of the property and curve to the front door to take advantage of a gradual grade. However, avoid curved walks that have no apparent reason for curving. For a residence, make the primary walk at least 4 feet wide. Build walks so they are safe. Avoid using materials that are rough or raised, since it is possible to trip over or catch one's heel on such materials. Design steps so they will be safe, especially in wet or icy weather. Make the treads wider and the risers shorter than the treads and risers used indoors. Install handrails where needed.



## **Elements of Design**

There are no hard and fast rules for landscaping since each design is a unique creation. However, the following list of design elements are good basic guides and should be incorporated as part of the final plan. Landscaping, as in other art forms, is based on certain elements of design, which are discussed here.

#### Scale

Scale refers to the proportion between two sets of dimensions. Knowing the eventual or mature size of a plant is critical when locating it near a building. Plants that grow too large will overwhelm and may potentially be destructive to a building. Small plantings around a large building can be similarly inappropriate. It is essential, therefore, to know the final size of a particular plant before using it in a landscape. Both the mature height and spread of a plant should be considered.

#### Balance

Balance in landscaping refers to an aesthetically pleasing integration of elements. It is a sense of one part being of equal visual weight or mass to another. There are two types of balance -- symmetrical and asymmetrical. Symmetrical balance is a formal balance. It has an axis with everything on one side duplicated or mirrored on the other side. Asymmetrical balance is balance which is achieved by using different objects to achieve equilibrium. For example, if there is a very large object on one side of a seesaw, it can be counterbalanced by using many objects of a smaller size on the other side of the seesaw or one object of equal size. In each instance, balance is achieved. This applies to landscaping when there is a large existing tree or shrub. To achieve visual equilibrium, a grouping or cluster of smaller plants is used to counterbalance the large existing plant. Balance may also be achieved through the use of color and texture.



Symmetrical Balance



Asymmetrical Balance

#### Unity

A garden with too many ideas expressed in a limited area lacks unity. Too many showy plants or too many accessories on the lawn would claim more attention than the house itself. Using too many accent plants or plants with contrasting textures, form, or color violates the principles of unity. In order to achieve unity, it is necessary to group or arrange different parts of the design to appear as a single unit. The design should be pleasantly viewed from every angle. Repetition of landscape elements, described below, can enhance unity.

#### Rhythm

Rhythm is a repetition of elements which directs the eye through the design. Rhythm results only when the elements appear in regular measures and in a definite direction. Rhythm can be expressed in color as well as form.

#### Simplicity

Every square foot of landscape does not have to have something in it. Such objects as bird baths and plastic yellow daisies are often overused in the landscape. There is a design concept expressed as "less is more." This statement is especially true regarding landscape design. Keep the landscape simple and it will look its best. Avoid cluttering the yard with unnecessary objects. This includes plant material, statuary, and miscellaneous objects. When too many extras are introduced the yard takes on a messy appearance. Use statuary or specimen plants with discretion. The simplest landscapes are often the most attractive. Remember -- create spaces, don't fill them up.

#### Accent

Accent, also referred to as dominance, focalization, or climax, is important in the total picture. Without accent, a design may be dull, static, or uninteresting. Various parts, if skillfully organized, will lead the eye towards the focal point. This may be a garden accessory, plant specimen, plant composition, or water in some form. Emphasis may also be obtained through use of contrasting texture, color, or form, or by highlighting portions of a plant composition with garden lights.



Accent



#### Repetition

#### Repetition

Do not confuse repetition in the landscape with monotony. A row of sheared hedges lined up in front and down the side of a home is not repetition; it is monotony. Repetition is something more subtle. For example, the use of curves in the landscape design. Curves may begin in bed lines in the front yard, continue in the side yard, and be picked up once more in the backyard. Alternatively, the repeated use of right angles on a grid design can successfully be used to achieve unity in the landscape. The right angles may begin in the front yard, perhaps on the sidewalk, then be used in the bed lines which go around the property, and be picked up again in the backyard. By subtly repeating such design elements as bed lines in the yard, one can achieve a continuity or flow to the entire landscape.

#### Harmony

Harmony is achieved through a pleasing arrangement of parts.



Harmony



Lack of Harmony

#### Space Dividers, Accents, and Transitions

An easy method of combining plant and architectural characteristics is the consideration of space dividers, accents, and transitions. These three elements are present in all successful landscape compositions.

Space dividers define or give privacy to spaces, create the background for outdoor living activities, and create dominance. Dividers can be made up of fences, walls, plants as hedges, or plants as borders. Space dividers must have height, must be arranged in groups that border spaces (open lawn or patio area), and must contain the most visually uniform characteristics in the composition.



**Space Dividers** 

Transitions form the connecting link between the space dividers and accents, or between the house and the land. To harmonize these elements, the transitions must be composed of characteristics that are found in both the space dividers and accents.

Accents, which should be in the minority of the composition, create interest by contrasting characteristics with the space dividers. Like sculpture, they may be displayed in two ways: 1) hidden in niches within the space dividers, or 2) standing free within the room created by the space dividers. In any design, only one of the two methods should be employed or visual confusion may result.

#### **Dominance and Contrast**

In any composition, a majority of dominant or repeated characteristics are accented by a minority of contrasting characteristics.

For a garden in which a viewer spends little time, the magnitude of contrast between the dominant characteristics and accents is very strong. Gardens of this type include entrance courts, street side foundation plantings, entrances to public buildings, or plantings seen from the highway. The magnitude of contrast refers to the degree of change between visual characteristics such as plant type, height, form, color, and texture. Generally, the ratio of dominant characteristics to contrasting features should be about 8:2 or 9:1. Also, the accents must be concentrated in one area. Gardens of this type take on a bold, architectural effect, as in many of the contemporary California gardens. The effect can be grasped and understood at a glance.

The contrast between the space dividers and the accents is created by:

- Tree types: evergreen and deciduous.
- Form: the evergreens are pyramidal as contrasted with the rounded viburnum.
- Height: the evergreens grow to at least 40 feet as contrasted with viburnums, growing to about 15 feet.

## **Drawing a Landscape Plan**

The following section provides the information necessary to draw a landscape plan that embodies the elements of good design. These steps are for those who want the fun and satisfaction of preparing their own landscape plan. They are:

- 1. Preparing the map.
- 2. Deciding how the ground area is to be used.
- 3. Placing use areas on the map.
- 4. Developing the landscape plan.
- 5. Preparing a planting plan.

Completing these steps will enable you to develop a final plan that can be implemented over several years as time and money permit.

#### Step 1 - Preparing Baseline Map.

Prepare a scale map of the home grounds and take the site inventory. Use graph paper and let one square equal so many feet, or draw to scale using a ruler or an engineer's scale.

Suggested Scale	Small Lot	Large Lot
Engineering	1 inch equals 10 feet	1 inch equals 20 feet
Architectural	1 inch equals 8 feet	1 inch equals 16 feet

The map should include the following:

- Property lines
- Undesirable features of home grounds or adjoining property
- North arrow
- Views point arrows in direction of each good view
- House, garage, other buildings
- Doors, windows, porches, and location of rooms
- Existing trees, rock outcroppings
- · Walks and driveways, if already constructed
- Contour of the land (use an arrow to show direction of surface water flow)
- Scale used
- · Location of septic tank or sewer lines
- Location of utility lines



#### Step 2 - Deciding the Ground Area.

Items listed below are most often included in the final development. Make a list that suits your individual needs.

- front lawn area or public area
- laundry area
- vegetable garden
- cooking and eating area

- garden pools
- walks
- flower beds
- outdoor living or private area
- children's play area
- small fruit
- driveway
- guest parking
- turnabouts
- garage
- other items particular to your land area

#### Step 3 - Placing Use Areas on the Map.

Place the use areas on the map. Fit them together with two considerations, traffic flow and use. How will people move from one area to another or from the house to an outside area be functional in relation to the house? Will it make use of existing features such as views or changes in the terrain? Try different combinations in relation to rooms of the house, surrounding areas, and potential views.



#### Step 4 - Develop the Landscape Plan.

Design driveways, parking areas, and walks.

Indicate where landscape elements are needed for (1) separating areas, (2) screening undesirable views, and (3) providing shade, windbreaks, beauty.

Do not attempt at this point to name the trees and shrubs, but think in terms of plant masses that will serve a purpose and help tie the various areas together into a unified plan considering design elements previously discussed.

In preparing the plan, use landscape symbols to indicate trees and shrub masses.

#### Landscape Symbols



Draw symbols to scale to represent the actual amount of space that will be involved. For example, a white pine tree at maturity will have a spread of approximately 20 feet. Make the scale diameter of the symbol in this case 20 feet.

Indicate on the map where paving, plants, and structures will be. In developing the plan, see that the proposed scheme is practical and that the following questions are addressed:

a. Is the driveway design pleasing, useful, and safe?

Have the following been provided for: safe entrance? turnabout? guest parking? Will guests use the front door?

Is the coal bin or oil tank handy to the drive way but screened from public view? Will the proposed drive be too steep?

b. Are the walks convenient? Are they of a suitable width and constructed with appro-

priate paving material?

c. Will the view be attractive from the living room?

the picture window? the porch? the dining room?

- d. Has an outdoor living area been provided, and is it adequately screened from neighbors? the service area? the buildings?
- e. Is the clothesline close to the laundry?
- f. Do all the parts fit together into a unified plan?
- g. Have a good setting, background, and privacy been provided?
- h. Are the house and major plants set back in case the highway department/local government widens the street?
- i. Will the proposed location of the septic tank and drainage fields interfere with planting needed shade trees?



#### Step 5 - General and Specific Planting Plan.

First, for each tree or shrub mass on the plan, make a set of specifications. These specifications should include:

Height - low, medium, tall

Form - spreading, upright, arching, globe

Purpose - shade, background, hedge, screen, accent, mass

Seasonal Interest - fruit, flowers, foliage

Type - evergreen, broadleaf evergreen, deciduous

Maintenance - subject to insects or plant diseases

Cultural Needs - shade, sunlight, moisture requirements

Then, select a plant or group of plants to meet the specifications. Consult garden books and nursery catalogs. Visit a local ornamental or botanical garden or nursery. Become familiar with plant material and discuss your plant with nursery staff.

Designate specific plantings on the map developed in Step 4.



#### **Planting Plan**

Planting Key	
1. Yew	11. White pine
2. Holly	12. Spirea
3. Daphne	13. Perennial border
4. Barberry	14. Weigelia
5. Azaleas	15. Flowering Quince
6. Hemlock	16. Potentilla
7. English Ivy	17. Flowering Crabapple
8. Pin Oak	18. Lilac

- 9. Hydrangea 19. Existing Maple
- 10. Viburnum

## **Selecting Plant Materials**

Well-chosen plantings are usually essential to achieving a desired landscape effect. There are hundreds of varieties of trees, shrubs, vines, groundcovers, perennials and annuals from which to choose. Remember, plants are not merely ornamental accessories. They have mass, define space in, and, consequently, contribute to the overall the garden design. When selecting plants, consider both their cultural needs and aesthetic value.

## **Cultural Characteristics**

**Hardiness:** This is the plant's ability to withstand winter and summer climatic changes, which will determine its longevity or permanence. In New Hampshire we are usually more concerned with a plant's ability to survive our long, cold winters, than with its ability to survive summer heat. Plant hardiness zone ratings are based on an area's mean minimum winter temperature. A hardiness zone map for New Hampshire has been included at the end of this chapter.

**Soil, moisture and drainage:** These are important parts of a plant's environment. Some plants respond unfavorably when a change occurs in this environment; some plants can tolerate extremely dry or wet conditions while others cannot.

**Degree of sun or shade:** This depends on where the plant is to be located in the garden. Some plants require shade, while others require full sun for best growth.

**Maintenance:** When selecting plant materials, consider the level of maintenance that may be required. Choose trees and shrubs that are generally low maintenance and tend to be disease and insect resistant. Usually a fast growing plant has a short life span and will consequently need replacing after a few years.

**Pollution and salt resistance.** Depending on the growing environment, tolerance of pollution, either atmospheric or soil or of salt, especially for street, may be an important consideration.

## **Ornamental Characteristics**

**Plant Size:** The size which a plant attains at maturity must be considered when selections are made for the landscape plan. A common mistake is selecting plants which soon become too large for their location. The drastic pruning which then becomes necessary adds to the cost of maintenance and may reduce the grace and beauty of the specimen. Overgrown plants which are left unpruned will alter the balance and accent of the design, and may partially hide the house which they are supposed to complement. The use of newer, more compact cultivars may prevent this problem, as well as contributing to lower maintenance.

The landscape picture is constantly changing because the plants which give it form and substance are continually growing. This fact presents a challenge to the landscape designer which is not found in most other artistic media.

**PlantForm:** Trees and shrubs used in landscaping develop many distinct forms. Some common forms include:

- prostrate or spreading
- round or oval
- vase
- pyramidal
- columnar

The form of mature shrubs and trees is usually more open and spreading than that of young plants. For example, the head of a young oak tree may be pyramidal in shape; during middle age the head is an irregular oval; and during old age a large, massive oak may have a spreading vase form.

Ground covers, such as turf, low-spreading shrubs, creeping plants, and prostrate vines are important materials in landscaping. The principal use of turf is for the lawn area. Other ground cover plants are commonly used on banks which are too rough or steep to mow or under trees where grass grows poorly.

Shrubs are woody plants which grow to a height of 12 to 15 feet. They may have one or several stems with foliage extending nearly to the ground. The following examples represent some of the more common forms of shrubs:

- Low spreading: junipers
- Round or Upright: many types of deciduous shrubs
- Vase: Vanhoutte spirea
- Pyramidal: arborvitae
- Columnar: junipers
Trees are woody plants which typically grow more than 15 feet tall and commonly have only one main stem or trunk, although there are many multi-stem types. The crown or leafy portion of the tree develops a typical form such as; Round or Oval: most common trees such as maple, oak and pine

- Vase: elm
- Pendulous or Weeping: willow, cherry
- Pyramidal: spruce, fir and hemlock
- Columnar: Lombardy poplar

Trees are long-lived and relatively inexpensive, given their initial cost and maintenance when compared with lawns or flower beds. In the past many builders have committed costly errors by destroying trees when establishing new residential subdivisions. Most real estate developers now appreciate the value of trees and attempt to save them when land is graded prior to construction. Regardless of our affection for trees, we must recognize they do not live forever. Decrepit, hazardous, or improperly located trees should usually be removed and replaced with new, more suitable species.

**Plant Texture:** The texture of plant materials is dependent on the size, branch structure and disposition of the foliage. Plants with large leaves which are widely spaced have coarse texture. A plant with small, closely spaced leaves has fine texture. Extremes in texture which prevent harmony in the composition should be avoided. On the other hand, some variation in texture is needed to give variety. Texture can be influenced on a seasonal basis, depending on whether the plant is deciduous or evergreen.

**Plant Color:** Although green is the basic color of most plant materials in the landscape picture. Visual variety may be enhanced by using plants with lighter or darker foliage. Also, fall foliage color may be introduced by the selection of flowering shrubs which may also produce colorful fruit. Care should be exercised in the use of particularly showy plants such as hydrangea and blue spruce. Such plants may so dominate the landscape as to destroy the balance and unity of the composition. Select colors which relate to the house exterior and other landscape elements, depending on their location and relationship.

**Other Characteristics:** Other ornamental characteristics to consider when selecting plant materials include winter habit, bark, fragrance, persistent fruit, and multi-seasonal appeal.

# Deciduous Shade and Flowering Trees

Trees are the basic element for any landscape plan. They set the stage for the entire home grounds design. The type used and their location determine to a great extent what other plantings are appropriate.

Trees are the most permanent plants we grow. Many will live and enhance the landscape for 100 or more years if they are given a chance. Because of the permanency of trees and their importance in the landscape, care must be taken to select the best species for each situation. The wrong tree or one planted in the wrong spot can actually detract from the overall landscape. Five to ten years of precious tree growing time may be lost before the mistake is realized.

# How to Choose Trees

No species or variety of tree is sufficiently superior to be called "best" without some qualifications. However, there are many excellent varieties. Choosing a variety with the characteristics that will provide the greatest satisfaction in a given situation requires careful consideration.

Most people make the mistake of selecting a particular tree and then trying to fit it into their landscape. A better approach is to decide where a tree is needed and what that tree should do in the landscape. After the desired type of tree has been determined, then it is appropriate to select a species to fulfill those requirements.

Avoid trees that are susceptible to storm damage, ones that are hosts to destructive insect and disease pests, and those that produce an over-abundance of objectionable seeds or fruits. The choice will generally depend on existing conditions at the planting site. These include room for top and root growth, soil type, subsurface drainage, and the kind of plants you will be able to grow under the tree.

A tree is a long-term investment. Therefore, start with a high quality plant. Trees at least 5 to 8 feet tall, either balled and burlapped or container grown, are usually the best buy. Difficult-totransplant species may be more easily established if you start with smaller sizes. A reputable dealer can help select the tree and will guarantee it to be alive and healthy. Most of the tree species described in the following section are commonly available in retail nurseries and garden centers. Some species have been included on the list because they are commonly available even though they may not be recommended for general landscape planting. A local nursery will probably not stock all of the species included in this list, but will generally be able to obtain a specimen for you if given enough time. If you don't have a green thumb, a nursery professional will probably plant the tree for a small additional cost.

Improved varieties are available for most of the species included in the list. The term cultivar was coined by L.H. Bailey to designate a cultivated variety. In most cases a cultivar is asexually propagated from the original selected parent material. Most of the selected cultivars are superior to the standard varieties grown from seed and are well worth the added cost needed to produce and purchase them.

Trees are often divided into three groups according to their size. Large trees generally reach a mature height of greater than 60 feet. Trees with a mature height between 30 and 60 feet make up the mediumsized group. Small trees usually grow to a height less than 30 feet. The need for small trees may often be satisfied by flowering trees.

# **Environmental Considerations**

Whether a tree lives up to its potential for health and beauty is largely dependent upon its environment: soil, water, light, and surrounding buildings and vegetation. Purchase trees on the basis of their expected behavior under the prevailing growing conditions unless these conditions can be changed significantly.

Few trees tolerate wet or very heavy soils. Very sandy or gravelly soils can cause problems for trees as well; they tend to remain too dry. Nearly all trees, however, respond favorably to deep and fertile topsoil with good internal drainage. When the soil is inhospitable, try to identify species that will tolerate that problem or add good soil in raised beds to help ensure that trees will thrive and flower well.

Flowering and fruiting as well as growth rate and density are greatly influenced by the duration and intensity of sunlight. Most flowering trees are adapted to full sunlight and perform better away from buildings or trees which cast dense shade during most of the day. Those preferring shade flower best where there is partial shade all day, especially in the afternoon.

# Availability and Adaptability

Our range of choices among trees is largely determined by their general adaptability to the area. The climatic range over which a tree will thrive is usually reflected in the species or varieties offered in local retail nurseries and garden centers.

# **Flowering Trees**

In the home landscape, flowering trees are secondary in importance to shade trees. The basic elements of framing, background, and shading are provided by shade trees, while flowering trees provide showy and unusual features with their floral beauty and seasonal interest. In addition, many flowering trees have colorful or interesting fruits which may be edible or attractive to birds.

Flowering trees must fit into the landscape. Only after deciding where they can be used most effectively should you try to select the variety to be used. If a certain type of flowering tree is desired, make the necessary changes to fit it into the landscape rather than simply placing it in the first open space.

Use relatively few flowering trees in the landscape. A small, residential property usually needs only two or three trees. Rows, large masses, and formal designs can be used more readily on estates or commercial properties.

When selecting among the many species and varieties of flowering trees available, consider:

- Size, form, and overall appearance of the tree.
- Intensity, duration, and color of the flowers and season of bloom.
- Cultural requirements, including pruning, fertilizing, and protection from insects and diseases.

Give consideration to those trees with other striking features. Some trees which do not have spectacular flowers compensate by providing brightly colored or persistent fruits, pods, fall leaf color, bark, or uniquely colored summer foliage.

Whether a tree is considered a flowering tree is often a matter of opinion. All trees produce flowers, but whether we value them for the blossoms depends on how colorful, spectacular, or unusual they are. Few large trees are noted for their flowers. While their flowers may be noticeable, large trees usually are valued more for other reasons.

Fruiting characteristics and site selection should be considered together. Soft-fruited trees and those which attract birds create periods of inconvenience when they drop fruit and create litter problems on paved surfaces such as patios, walks, driveways, or game-courts. Some native flowering trees are beautiful, hardy and adaptable to landscape conditions. They should be used wherever possible.

# **Rare and Unusual Trees**

There are many tree species that can be successfully grown in northern New England, but are rarely seen in our landscapes. Although not ordinarily recommended or readily available, these trees may be useful to carry out a specific landscape theme, to substitute for an exotic type which is not locally adapted, or may be prized for unusual form, flowers, fruits, bark, or foliage. Trees listed in this publication are reasonably reliable and most are hardy throughout the region.

Unusual forms of common tree species such as corkscrew willow, columnar or cutleaf maples, and trees with unusual foliage color are not included. Brooklyn Botanic Gardens Handbook No. 63, 1200 *Trees and Shrubs - Where to Buy* Them, is an excellent source of information on where to obtain plants that are not commonly available in nurseries and garden centers. It may be ordered from the Brooklyn Botanic Gardens, Brooklyn, New York 11225.

# **Problem Trees**

When selecting a tree to plant in the yard, it is nice to know exactly what you are getting. Many people plant a sapling, enjoy it for a few years, and then discover some serious disadvantages when the tree reaches an effective height. The following list of trees have certain disadvantages which you should be aware of before you plant them in your yard. Most are inappropriate for street tree use.

### Box Elder (Acer negundo).

This tree has weak wood, is short-lived, is susceptible to box elder bugs, and most types have poor forms.

### Silver Maple (Acer saccharinum).

One of the worst trees available because of its brittle wood and tendency to become hollow and hazardous. Its shallow surface roots can ruin sidewalks and driveways and prevent turfgrass growth underneath. Also susceptible to insects. Outlawed in some localities.

### Tree of Heaven (Ailanthus altissima).

A weed tree that sprouts up everywhere and has a disagreeable odor. It is outlawed in some cities.

# Catalpa (Catalpa sp.).

Catalpas have messy flowers and seed pods.

### Flowering Dogwood (Cornus florida).

Because of the increasingly common occurrence of dogwood anthracnose, use of this tree should be tempered. Substitute *Cornus kousa* or use disease resistant varieties as they become available.

### Ginko (Ginkgo biloba).

Do not plant the female Ginkgo as its fruits have a very offensive odor. Use male selections only.

### Black Walnut (Juglans nigra).

The tree roots produce a toxin that is harmful to certain other plants, including tomatoes. Avoid planting it near vegetable gardens.

**Mulberry** (*Morus* species). Mulberries have messy fruit.

### Sycamore (Platanus occidentalis).

Leaves and seeds from this tree are messy; it has brittle wood and surface roots. Anthracnose, a late spring blight which occurs most years, will attack it.

### Poplars (Populus species ).

These trees have brittle wood and surface root systems, but their main problem is their susceptibility to canker diseases which disfigure and usually kill them. Some also have messy flowers or send up suckers from their roots.

### Black Cherry (Prunus serotina).

Has objectionable fruit, is susceptible to insects, and is susceptible to black knot fungus.

### Black Locust (Robinia pseudoacacia).

This tree is good for fence posts and firewood, but not for landscaping. It has brittle wood, is susceptible to cankers, and over time develops into a copse of suckers.

### Problem Trees continued

### Willows (Salix species).

These trees have very brittle wood and are susceptible to canker diseases. Their roots will clog sewer and drain pipes. Some are attractive on large lots, especially near water and in wet areas.

**European Mountain Ash** (*Sorbus aucuparia*). Not for hot locations, insect and disease problems can often weaken it and cause premature death.

### American Elm (Ulmus americana).

Use only Dutch elm disease resistant varieties, as available.

### Siberian Elm (Ulmus pumila).

Its brittle wood will result in severe damage in ice storms, and its seeds and suckering habit make it a pest. Also very short-lived. Note that the Chinese elm (*Ulmus parviflora*) is often confused with the Siberian elm, but is far superior.

In the following list of recommended trees, it is as impractical to list all the superior species and varieties as it is impossible for every nursery to stock all of them. Every retailer will have some desirable varieties not listed here. On the other hand, not all dealers will have all those listed. Several trees may not be readily available in the nursery trade or may have limited uses in the landscape.

# Selected Shade and Flowering Trees

### AMUR MAPLE, Acer ginnala

The Amur maple is a small, round-headed, extremely hardy tree. Its red fall color is as brilliant as any of the maples. The winged seeds often hang on the tree after the leaves have fallen, adding interest to the tree in winter. It is one of the best of the small trees, requiring practically no attention and able to grow in a wide range of soil types. (15 to 18 ft. height; spread may equal height)

### PAPERBARK MAPLE, Acer griseum

This round-headed, rather open maple grows moderately fast while young. The bright, copper colored bark peels off in paper-like strips creating intense winter interest. The compound leaves resemble box elder and change to a russetred in the fall. Paperbark maple is best used as a lawn or specimen tree where it is visible in winter. It tolerates a wide range of soils and exposures; it may need extra water during hot summers. Best used in southern New Hampshire only. (20-30 ft. height; spread: 1/2 to equal height)

### JAPANESE MAPLE, Acer palmatum

This large shrub or small tree is planted for its interesting foliage. There are many varieties available, but the ones with red leaves and those with finely cut foliage are the most popular. Japanese maple can be grown in coastal northern New England. A rich, well-drained soil high in organic matter is needed for best growth. Japanese maple will not grow on poorly drained or dry soils. Although some varieties grow 25 feet tall, most of the varieties commonly grown as ornamentals will not get over 10 feet tall. Most of the varieties are very slow growing. (6 to 25 foot height; 6 to 25 foot spread)

### NORWAY MAPLE, Acer platanoides

Although the Norway maple is a native of Europe, it has been widely planted over the eastern United States. Most of the varieties of maple with unusual shape or foliage color have been derived from this species. They include such popular varieties as: 'Schwedler,' with purple leaves in early spring that change to dark green color; 'Crimson King,' with purple leaves that retain their color all summer; 'Columnare,' one of several varieties with a narrow, columnar habit of growth; 'Globosum', a low-growing, round-headed tree that can be crown under utility wires; and 'Summershade,' a rapidly growing, heat-resistant variety with an upright growth habit. Many other varieties of Norway maple have been selected and named. Because a name does not appear in the above list does not mean that it is not as good as the ones listed. Ask your nursery manager for advice on varieties not listed.

The dense shade and shallow root system make it almost impossible to grow anything under a Norway maple. Its yellow flowers in early spring are interesting, but not especially ornamental. It certainly has merit for planting in areas where you don't care whether or not you can grow anything in its shade. Norway maple's tend to aggressively out compete our native forest trees. To avoid future problems, use Norway maples with discretion (40 to 50 ft. height; spread may equal height)

### **RED MAPLE**, Acer rubrum

One of the first signs of spring is the flowers of the red maple. The profusion of tiny, red flowers with the background of smooth, gray bark is a beautiful sight. Red maple is also one of the first trees to change color in the fall. Some trees develop a red fall color, but many of them do not. Several improved varieties of red maple have been developed that produce outstanding fall color such as 'Red Sunset,' 'October Glory,' and 'Autumn Flame.' There are also varieties available with a narrow crown. Red maple is easy to transplant, grows rapidly and tolerates moist soils. (40 to 60 ft. height; spread may equal height)

### SUGAR MAPLE, Acer saccharum

The fire-red to yellow fall color of the sugar maple is one of the most beautiful sights in northern New England. The sap of this tree can be boiled down to produce maple syrup and sugar. Mature sugar maples show a wide variation in form but tend to have a broad, rounded head. Susceptibility to gas and smoke damage makes sugar maple less suitable for city conditions than Norway and red maples. Improved varieties of sugar maple include a dwarf, globeshaped form; a very narrow, columnar form; and a cut-leaved form. (60 to 75 ft. height; spread may be 2/3 of height)

### SILVER MAPLE, Acer saccharinum

Silver maple is a fast-growing, but relatively short-lived tree. Its brittle wood is too subject to storm damage for it to be recommended for general landscape use. The tree is also notorious for plugging sewer lines and lifting sidewalks. It should only be used where falling branches will not be a hazard and where the roots cannot interfere with sewers or sidewalks. The silvery undersides of the leaves are exposed when the wind blows; giving it some additional ornamental value. (50 to 70 ft. height; spread may be 2/3 of height)

HORSE CHESTNUT, Aesculus hippocastanum The horse chestnut is a magnificent tree in the spring when its foot-long panicles of showy flowers cover the tree, resembling candles on a Christmas tree. It is definitely not a tree for the small yard. Its coarse texture and large size make it look out of place except in a very large area. The horse chestnut has earned a bad reputation in many areas. Its branches are relatively weak and subject to storm damage. The large nuts are produced profusely. They have no economic or ornamental value and are a nuisance wherever they fall, in addition to being poisonous.

The 'Baumannii' horse chestnut, a doubleflowered variety, should be planted in preference to the standard varieties because it does not produce seed. There is also a red-flowered form available that is more showy than the standard types. (50 to 75 ft. height; 40 to 70 ft. spread)

**SERVICEBERRY**, *Amelanchier arborea* Upright in youth, and oval to spreading with age, this native plant has a slow to moderate growth rate, depending upon the site. Its mature height may exceed 40 feet in the best locations. Masses of small, white flowers in nodding clusters appear in early spring, followed by maroon-purple, edible berries which are quickly eaten by birds. The fall foliage is yellow, golden, or red. Used as a specimen or lawn tree, in border masses or in naturalistic groups, it prefers well-drained sites. It is occasionally damaged by an assortment of leaf eating insects. Many new cultivars exist. 'Princess Diana' and 'Prince Charles', both 25' tall are excellent.

### PAPER BIRCH, Betula papyrifera

This native tree is a popular landscape specimen in northern New England, either as a single trunk or as a clump. The bark becomes chalky white with age, and peels in paper-like layers. It does best in well-drained, acid, cool soil. Paper birch's graceful catkins in spring, yellow foliage in fall and white bark all year give it multi season interest. (50 to 70 ft. height; 25 to 50 spread)

### RIVER BIRCH, Betula nigra

The most interesting characteristic of the native river birch is its salmon-colored bark that peels off in paper-thin layers. The tree is noted for its ability to grow in wet soils, but it will grow in drier situations as well. The river birch has been greatly ignored in favor of the showier white birches, but it is a fine ornamental and should be planted more. It is far more resistant to insects than the white birches. 'Heritage' is a highly recommended cultivar. (40 to 70 ft. height; 40 to 60 ft. spread) Selected Shade and Flowering Trees continued

**EUROPEAN WHITE BIRCH**, *Betula pendula* The European white birch is a very graceful, but relatively short-lived tree, grown for its striking white bark. The tree is extremely susceptible to the bronze birch borer, an insect that can destroy a large specimen tree in a single season. Birch borer can be a serious problem, particularly on trees weakened by leaf miner damage. Fortunately, northern New England provides an excellent habitat, and both problems are rarely serious. (40 to 50 ft. height; spread may be 2/3 of height)

**EUROPEAN HORNBEAM**, *Carpinus betulus* Hornbeam is a slow growing, pyramidal tree while young; rounded at maturity. Light gray bark covers its smoothly ridged or flattened trunk. Delicate, elm-like leaves and a dense branching habit characterize the tree. The seeds are borne in hanging clusters of leaf-like structures. Several improved cultivars of hornbeam have been developed, of which Columnaris, a narrow, pyramidal tree with dense branches, is the most popular, being useful as a screen and plant. Hornbeam is difficult to transplant, so it should be moved while small. It is a relatively pest free tree. (40-60 ft. height; 30-40 ft. spread)

**CHINESE CHESTNUT**, *Castanea mollissima* Chinese chestnut is resistant to the destructive chestnut blight disease which has almost entirely destroyed the native American chestnut. Several government agencies have promoted planting this tree for both ornamental use and nut production. The flowers are produced in long, showy catkins in early summer; nuts, which are excellent for eating, are produced in large, prickly burs that are a nuisance in the lawn where they have fallen. Therefore, it should only be planted in areas where the burs will not be a problem. Tolerates hot, dry areas well. (40-60 ft. height; 4060 ft. spread)

KATSURA TREE, Cercidiphylum iaponicum

This is a large, rounded-to-spreading tree often with more than one trunk. The leaves, about the same size and shape as redbud leaves but with a serrate or toothed rather than smooth leaf margin, develop scarlet to yellow fall color. Katsura trees are essentially pest free. Though somewhat difficult to transplant, they make outstanding shade trees and should be more widely planted. (40-60 ft. height; variable 20-60 ft. spread)

**EASTERN REDBUD**, Cercis canadensis An understory tree native to areas south of New Hampshire, it is noted for early, abundant rosy pink flowers and graceful, upright habit. The large, heart-shaped leaves emerge as reddish purple and gradually change to a lustrous dark green. The foliage turns a mediocre yellow in the fall and usually drops quickly. Clusters of dark-brown pods may persist through fall and winter. The tree is used as a specimen, planted in masses, or naturalized at the edge of woods. It is generally hardy in central and southern New Hampshire and tolerant of a wide range of soils. Be sure to buy plants propagated from northern seed sources and avoid the frequently less hardy cultivars, which are available in white and true-pink. (10-20 ft. height; 15-20 ft. spread)

# AMERICAN YELLOWWOOD, Cladrastis kentukea (lutea)

Named for the color of its heartwood, the yellowwood is a medium-sized tree with very showy, long panicles of fragrant, white pea-like flowers in late spring. Its bright green summer foliage and often good yellow-gold fall color make it a desirable shade and specimen tree. Its thin, gray bark is similar to beech, and its lack of major pest problems makes it an excellent tree for relatively small landscapes. Prefers moist soil and full sun to partial shade. (30-50 ft. height; 40-55 ft. spread)

KOUSA DOGWOOD, *Cornus kousa* A dogwood fairly tolerant of full sun and dry, compacted soil, his tree has a rounded shape with horizontal branching, reaching about 20 feet at maturity. The Kousa dogwood flowers after it leafs out and has large, pin-wheel like, white bracts with pointed tips. In the fall, the foliage turns a variable reddish purple to scarlet. The fruit is 1/2' in diameter, reddish-pink, raspberry-like, and attractive to birds. This tree makes a beautiful small specimen in the limited parts of southern New Hampshire where it is reasonably hardy.

### CORNELIAN CHERRY, Cornus mas

Rounded with dense, ascending branches, this shrub-like but vigorous tree eventually reaches 20 feet in height. Clusters of small, yellow flowers appear before the lustrous foliage, which turns red in fall. The fruit is medium to large, maroon-red, cherry-like, edible, and attractive to birds. White- and yellow-fruited selections are available. Use as a specimen or in groups or borders. It prefers excellent soil, is hardy, and relatively pest-free.

### TURKISH FILBERT (HAZELNUT),

### Corylus colurna

Turkish filbert is a well shaped ornamental tree with a regular, pyramidal habit of growth. The rough, corky bark and heavy crop of catkins, produced in April, make this a worthwhile ornamental tree. It is especially adapted for planting in hot, dry areas. No major insect or disease problems. (40-50 ft. height; 15-40 ft. spread)

### HAWTHORN, Crataegus spp.

There are many species and varieties of hawthorn. They are valued for their profuse flowers, fruits, and picturesque growth habit. They are dense and thorny plants, with white flowers and red fruits, though exceptions to these characteristics exist. Many are native to North America. They grow well in all but the wettest and poorest soils and are used as specimens, naturalized at the edge of woods, or in large formal plantings. The fruit is highly attractive to birds. Hawthorn is subject to borers, cedar-hawthorn rust, fire blight, and leaf-eating insects. It is somewhat difficult to transplant. Annual maintenance is beneficial. Winter King hawthorn (C. Viridis 'Winter King') and the Washington hawthorn (C. phaenopurum) are two of the most outstanding hawthorns for landscape use.

**RUSSIAN OLIVE**, *Elaeagnus angustifolia* The unique silver or grey foliage of Russian-olive is its most striking feature. The flowers are inconspicuous but very fragrant. The brown, shredded bark of its crooked trunk may be very picturesque. Russian-olive will grow in many types of soil, but it is especially adapted to hot, dry areas. Several diseases, including verticillium, can be devastating. It will grow in places where few other trees will survive, and its salt tolerance make it a good seaside tree. (12 to 15 ft. height; spread may equal height)

**EUROPEAN BEECH**, *Fagus sylvatica* The European beech is a better adapted landscape specimen than the native American beech. The dark green, glossy foliage and smooth, light gray bark make it a very handsome tree. Many unusual cultivars have been selected from this species. They include cultivars with unusual form, variable leaf shape, or unusual colored foliage. Beech is difficult to establish. (50-60 ft. height; 35-45 ft. spread)

### WHITE ASH, Fraxinus americana

White ash does not grow as fast as green ash, but it will eventually become a larger tree. It develops a purple fall color that is rather unique. White ash has the same borer problems as green ash. The new seedless varieties of white ash such as 'Rose Hill' or 'Autumn Purple' should be planted in preference to the standard varieties. (50 to 80 ft. height; spread may equal height)

### **GREEN ASH**, Fraxinus pennsylvanica

Green ash is a vigorous tree while young. It develops a broad crown at maturity. The leaves turn a bright-yellow in fall but do not remain on the tree long enough to be effective. It is drought resistant and will grow on a wide variety of soil types. A borer insect can be a serious pest of green ash while it is becoming established. Seedlings of green ash can be a problem in flower beds and untended areas; it is advisable to plant the new seedless varieties such as 'Marshall's Seedless' instead of the standard ones. (50 to 60 ft. height; spread may be 1/2 of height)

### GINKGO, Ginkgo biloba

Geological evidence indicates that the ginkgo has been growing on the earth for 150 million years. Although it is one of the most primitive trees known, it is one of the best adapted to city conditions. The ginkgo has no known insect or disease pests and, hence, never needs spraying. The interesting fan-shaped leaves of the ginkgo turn a clear yellow in fall. Only grafted nonfruiting (male) varieties should be planted; the round, plum-like fruits of the female trees have an obnoxious odor. Ginkgo will eventually become a large tree, but it is slow growing and will take at least 50 years to develop. (50 to 80 ft. height; 30 to 40 ft. spread)

### HONEY LOCUST,

*Gleditsia triacanthos* var. *inermis* Native honey locust trees are best known for their long, stiff, branched thorns that are a constant hazard. They also produce long, flat seed pods that may be a nuisance. The improved thornless (var. *Inermis*) and usually podless varieties of honey locust, such as 'Sunburst', 'Shademaster', 'Skyline', and 'Majestic' are some of the best for landscape use. Their lacy foliage gives a loose, open shade that is ideal for patios and shade-loving plants. In the fall, the small leaflets filter into the grass as they fall and require little raking. (30 to 70 ft. height; spread may equal height) Selected Shade and Flowering Trees continued

**GOLDENRAINTREE**, *Koelreuteria paniculata* The large, conspicuous, yellow flower clusters of the goldenraintree are produced in late June when few other trees are in bloom. The flowers are followed by showy, bladder-like fruit that hangs like clusters of small Chinese lanterns until late in the fall. It will grow in a wide variety of soils and has no serious insect or disease pests. However, it is a relatively short-lived tree, and is relatively hardy only in southern New Hampshire. (30 to 40 ft. height; spread may equal height).

**GOLDENCHAIN TREE**, *Labumum x watereri* Goldenchain tree is a striking sight in mid-spring when it is covered with foot-long, pendulous clusters of bright yellow flowers. It is a vaseshaped tree that grows fairly rapidly. The goldenchain tree grows best during cool, moist summers. (12-15 ft. height; 9-12 ft. spread)

### SWEET GUM, Liquidambar styraciflua

The glossy, green, star-shaped leaves of the sweet gum are one of its most ornamental features, especially when they take on fall colors of yellow, orange, red, and purple. Where it is given room to develop, few trees will approach it in symmetrical beauty. The interesting ball-shaped fruit hangs on the tree long after the leaves have fallen; they are a nuisance in the lawn when they finally fall. An additional ornamental feature is the winged or corky bark projections that develop along the branches. Unfortunately, thin acid soils and low temperatures limit the use of Sweet Gum in northern New England. (30 to 50 ft. height; 20 to 30 ft. spread)

### TULIPTREE, Liriodendron tulipifera

The native tuliptree needs a deep, fertile, moist soil to develop properly. It is often difficult to transplant, but once established it will grow rapidly and develop into a large tree. It is too large for the average-sized yard and should be planted only where it has ample growing space. Pale-yellow, tulip-shaped flowers are produced in May. After the fruit breaks open in the fall to release its seed, a tulip-shaped portion of the fruit remains on the tree to add interest during the winter. The tuliptree has few serious insect or disease problems. Tuliptree is not hardy in the mountainous areas of northern New England. (70 to 90 ft. height; 35 to 50 ft. spread)

### AMUR MAACKIA, Maackia amurenis

Maackia is moderately fast growing, developing a rounded head at maturity. Its major interest is the small, white, late summer flowers that are arranged in branched clusters 4 to 6 inches long, although its bronze-colored bark can add winter landscape interest. It is widely adapted and can be easily grown. No major pest problems have been reported. (20-30 ft. height; 20-30 ft. spread)

**LOEBNER MAGNOLIA**, *Magnolia x loebneri* This tree is a 30 foot rounded tree that produces spectacular white or pink flowers in early spring. 'Leonard Messel' (pink-tinged flowers) and 'Merrill' are both outstanding. They prefer rich, moist, well-drained soil, full sun, and protection from winter wind. They are not hardy in northern New England.

### STAR MAGNOLIA, Magnolia stellata

One of the hardiest magnolias, the star magnolia forms a dense, mounded, large shrub or small tree reaching 20 feet. The large, white, star-like flowers appear in early April before the foliage emerges, even on young plants. This trouble-free magnolia has effective, dark green foliage that turns to a nondescript leathery brown in the fall. Winter exposes an attractive smooth gray bark. Best used as a specimen or in small groups.

### CRABAPPLE, Malus spp.

Crabapples are among the most popular flowering trees. Not only are they splendid in bloom but also versatile in tree form and growth habit. Some are also prized for their attractive or persistent fruits, which attract birds. There are more than 200 named varieties of crabapple.

The choice to use crabapples in the landscape should be accompanied by a willingness to attend to their maintenance if their full value as ornamentals is to be realized. Pruning is necessary to maintain the proper growth habit. Apple scab, cedar apple rust, and fire blight can be serious diseases of crab apples which require some control; try to use disease-resistant cultivars. Powdery mildew can be a fall disease problem, and cankers may develop where equipment makes wounds in the trunk. Chewing and scale insects, borers, and even mice (in weedy or brushy areas) will sometimes attack the tree. To avoid the need to control diseases, choose from the many superior resistant cultivars available.

The following cultivars have been selected as among the best, based on their disease resistance and ornamental characteristics.

'Adams' has single pink flowers and 5/8" red persistent fruit. It is very disease resistant, has a dense round habit and reaches 24' height.

'Dolgo' has pink buds that turn into white flowers. Its  $1 \frac{1}{4}$  red-purple fruit is good for jelly. It reaches 40' in height.

'Donald Wyman' has single pink buds turning to white flowers. Its bright red 3/8" fruit persist into winter. It is disease resistant and reaches 20 in height and 25' in spread.

'Mary Potter', with pink buds, single white flowers, and  $\frac{1}{2}$ " red fruit, reaches 10-15' in height and 15-20' in width. It is disease resistant.

'Red Jewel' reaches 15' in height and 12' in width. It produces an abundance of white flowers and small red fruit.

'Sentinel' has pale pink flowers and small fruit. Its somewhat upright, columnar habit make it useful in narrow spaces.

'Sugar Tyme' has pink buds, white flowers and persistant  $\frac{1}{2}$ ' red fruit. It reaches 18' in height and is disease resistant.

*Malus floribunda* — The pink buds change to fragrant, white flowers which produce small, yellow and red fruit. This variety has a rounded growth habit and reaches 30 feet in height. It is moderately disease susceptible.

'Jackii' — Single, white, very fragrant flowers are followed by tiny, persistent, bright-red fruit on this upright variety which reaches a compact 20 feet.

'Katherine' — The double, light-pink flowers fade to white and produce medium-sized, dull-red fruit. This variety has a loose, open growth habit that reaches 20 feet and exhibits good disease resistance.

'Liset' — This variety has the deepest-red flowers of all the crabs and begins flowering at an early age. It has medium sized, bright-red fruit. The new foliage is purple, but changes to green during the growing season. A rounded, densely branched growth habit is characteristic. The tree grows to 15 feet and is slightly disease-susceptible.

'Pink Spires' — Light-pink flowers give way to medium, purplish red fruit on this variety. The medium to upright growth habit reaches 20 feet. It is moderately susceptible to scab. 'Red Jade' — Clusters of small, single, white flowers are most prolific in alternate years. The medium, bright-red fruit persists into winter and attracts birds. This variety has a characteristic, weeping growth habit that reaches 15 feet. The tree is moderately disease-susceptible.

*Malus sargentii* — Clusters of small, fragrant, white flowers produce the little, dark-red, persistent fruits on this variety, one of the smallest crabs. Its low, mounded, dense growth habit reaches only 8 feet. It is slightly susceptible to disease. A dwarf Sargent type that is outstanding for the shrub border is 'Tina', which reaches only 5' in height.

*Malus sieboldii* var. *zumi* 'Calocarpa' — The pink buds open into fragrant, white flowers (best in alternate years) on this variety. The small, red fruit attracts birds well into the winter. This tree has a dense, pyramidal growth habit and reaches 25 feet. 'Spring Snow' is a 25' tall, rounded tree that produces a spectacular show of white flowers. Because it is sterile, it is appropriate for places where fruits are undesirable.

### BLACK GUM, Nyssa sylvatica

The scarlet to orange fall color of the native black gum is one of the most brilliant of any tree species. It is a dense, pyramidal tree with lustrous, dark green, leathery leaves. It is a difficult tree to transplant and like most hard-to-transplant trees, smaller sizes have a better chance of surviving after they are moved. At the present time, black gum is difficult to find in many nurseries, but it should become more commonly available as more people get to know its merits. It is a slow-growing, pest-free tree. (30 to 50 ft. height; 20 to 35 ft. spread)

AMUR CORKTREE, *Phellodendron amurense* Corktree is a slow growing, spreading tree. Its massive branches and deeply furrowed, cork-like bark make the tree interesting in winter. Inconspicuous, small, white flowers are produced in early summer. They are followed by clusters of berries that change from glossy green to black. The foliage, which is somewhat coarse, drops soon after turning yellow in the fall. Corktree is best used as a specimen or lawn tree. It is easily transplanted and tolerates a wide range of soils and exposures. It has no serious insect or disease problems. (30-45 ft. height; 30-45 ft. spread)

### Selected Shade and Flowering Trees continued

### AMERICAN PLANETREE/SYCAMORE,

### Platanus occidentalis

The most striking feature of the sycamore is the flaking bark that peels off to reveal a lighter colored bark underneath. Sycamore is considered a dirty tree; it is continuously dropping bark that needs to be picked up. A twig blight that temporarily disfigures the foliage attacks sycamore almost every spring. It will seldom kill the tree, but it certainly reduces its value as an ornamental. Sycamore is a fast-growing tree that will reach an immense size. It is too large for the average home grounds and should not be used as a street tree due to roots that heave sidewalks and a tall crown that interferes with overhead power lines. It needs a deep, rich soil to develop properly. (75 to 100 ft. height; spread may exceed height). If a sycamore-type tree is desired, London Planetree (*P. x acerifolia*) is a better choice than the native American species. It is resistant to the twig blight and does not reach as large a size.

### FLOWERING CHERRY, Prunus spp.

Among the many flowering cherries, only a few are good landscape specimens. They serve as specimens, accents, borders, or in groups. Most are slow growing. They respond well to good soil or soil improvement and tend to decline in vigor on poor or heavy soils. Cherries will not tolerate wet soils. The fruits of most flowering cherries are hardly considered ornamental but are very attractive to birds. Attention must be given to pruning, fertilization, and borer control.

Double-Flowered Mazzard Cherry — This dense, pyramidal tree grows to 40 feet and is hardy. The double, white flowers last for 7-10 days, and the medium-sized, edible fruit is attractive to birds.

Higan Cherry — A dense, rounded tree, this variety reaches 30 feet in height. The light-pink flowers may be single or double and produce small, black, inconspicuous fruits. A pendulous, weeping variety is the most popular.

'Kwanzan' Cherry — The hardiest and most reliable form of Oriental Cherry, this variety has double, pink flowers and an upright growth habit that stays under 30 feet.

Sargent Cherry (*P. sargentii*) — One of the largest and hardiest of the cherries, this medium-sized shade tree reaches 40 feet and features showy, deep pink blooms followed by lustrous green foliage. The round headed crown sports bronze to reddish fall foliage, and the trunk has a polished, chestnut brown bark. A narrow, columnar variety, 'Columnaris,' is also available. Sargent Cherry is one of the better *Prunus* species for New Hampshire where the choice of cherries is often limited.

### FLOWERING PLUM, Prunus spp.

The most popular plums are those which have reddish-purple foliage. Trees are rounded to upright, densely branching, with double or single flowers. The varieties with brightly colored foliage include 'Newport' and 'Thundercloud.' 'Atropurpurea' and 'Nigra' (Black Myrobalan Plum) have darker foliage colors. Fruit, when present, is edible but not ornamental. The plums require regular maintenance—pruning, fertilization, and occasional spraying—to maintain vigor. Sunscald is often destructive to unshaded or unprotected trunks, and many insects can cause problems. Dark leaved plums should be used sparingly in the landscape.

### CALLERY PEAR, Pyrus calleryana

This species grows to 30 feet and is native to China. It is fast growing and pyramidal when young, but with age, becomes upright or rounded. Before the foliage appears, the branches are laden with fragrant, white flowers. The glossy foliage becomes orange to scarlet to deep crimson in fall. It is an excellent lawn, specimen, or street tree. Avoid using it in narrow areas, if possible. It is tolerant of all but wet or very poor soils and is somewhat resistant to fire blight. The smaller sizes are best for transplanting. Good cultivars to consider for different forms include 'Aristocrat,' 'Whitehouse,' 'Capitol,' 'Chanticleer,' and 'Redspire.' Avoid planting the cultivar 'Bradford' due to graft incompatibility and severe splitting.

### WHITE OAK, Quercus alba

A mature white oak is one of the most majestic trees. They are rounded in outline with thick, sturdy, horizontal branches. The native white oak is slower-growing and more difficult to transplant than most other oaks. However, it is not as susceptible to insects and diseases, and it grows on a wider range of soil types. It is a difficult species to transplant and is best moved only in the spring. (100 ft. height; 50 to 80 ft. spread)

### RED OAK, Quercus rubra

Red Oak is one of the fastest-growing oaks. It develops into a large, broad, round-topped tree with a deep-red fall color. It withstands city conditions, has a clean habit of growth, and makes one of the best street and shade trees. (65 to 75 ft. height; 40 to 50 ft. spread)

### PIN OAK, Quercus palustris

The branching habit of the native pin oak is truly unique. The upper branches are ascending, the middle ones horizontal, and the lower ones drooping. This makes the pin oak a generally poor choice as a shade or street tree. One exception is the cultivar 'Sovereign' cultivar; whose lower branches do not droop. However, 'Sovereign' is no longer recommended due to graft incompatibility. As the drooping lower branches are removed to allow for traffic beneath the tree, the horizontal branches begin to droop; some branches always seem to be interfering with traffic. Pin oak should be planted where it has room to assume its natural shape. It will grow poorly in soil with a high pH - the leaves will turn yellow due in part to iron chlorosis, and extensive soil treatment will be necessary to return the tree to a healthy condition. (60 to 70 ft. height; 25 to 40 ft. spread)

JAPANESE PAGODATREE, Sophora japonica This tree gets its common name from the fact that it was planted around Buddhist temples in the Orient. It is also known as the scholar tree or simply as Sophora. Its large clusters of pea-like flowers are relatively showy and appear in midsummer after most other trees have already flowered a forming a creamy carpet under the tree as they fall. A good tree for city conditions and poor soils, it could be considered messy since its petals, fruits, leaves, and pods drop at different times. (50 to 75 ft. height; spread may equal height)

KOREAN MOUNTAIN ASH, Sorbus alnifolia Generally superior to its commonly planted European cousin, this medium-sized, pyramidal to broad-oval shade tree offers white flowers and glossy green, beech-like foliage which turns yellow, orange and golden brown in the fall. The persistent brilliant red fruits offer food for birds and add to the fall foliage display. A better park than street tree, this plant is definitely one of the best mountainash.

### EUROPEAN MOUNTAINASH,

### Sorbus aucuparia

Upright when young and spreading at maturity, this vigorous, rapidly growing tree reaches 45 feet on the best sites. Flat clusters of fragrant, white flowers appear in late spring and clusters of small, orange-red berries, attractive to birds, in the fall. The loose, compound foliage turns reddish in fall. The tree is best used as a specimen. It is subject to sunscald, borers, and fire blight. Varieties available include cutleaf, weeping, upright, and yellow-fruited types. Mountainash, being best adapted to cooler climates, performs well in northern New England.

### **JAPANESE STEWARTIA**

(Stewartia pseudocamellia).

Not well known or widely available, this small to medium-sized upright oval tree is possibly one of the best small trees for the garden. Surprisingly hardy, the showy white flowers are accented by orange anthers and occur over a three week period in July. The dark green leaves may turn yellow to dark reddish purple in the fall. The bark is first rate for winter effect, developing a mottled, peeling character.

JAPANESE TREE LILAC, *Syringa reticulata* The Japanese tree lilac is a tough, adaptable, small tree with rounded to spreading growth habit. It is noted for its large, showy, creamy white clusters of flowers which appear in mid-June, about four to six weeks after common lilac has bloomed. The dark green foliage which may turn a translucent yellow in the fall is not overwhelming, but is generally superior to most lilacs. The shiny, reddish brown, cherry-like bark develops on the trunk and larger branches, adding interest in winter. It tolerates a wide range of growing conditions. (20-30 ft. height; 15-25 ft. spread)

**BALD CYPRESS**, *Taxodium distichum* This fast-growing, pyramidal tree becomes rounded with age. The light-green, fernlike leaves turn a rust color before they are shed in the fall. This tree has relatively few insect or disease problems and will grow on a wide variety of soil types and moisture conditions. It is especially suited to wet or swampy conditions and is hardy to south New Hampshire only. (50 to 70 ft. height; 20 to 30 ft. spread)

### Selected Shade and Flowering Trees continued

### LINDEN, Tilia spp.

The lindens are some of the best shade trees. Their small flowers which are produced in early summer, are not especially ornamental, but are highly fragrant. The small, round seed is bon on an interesting leafy bract that hangs on the tree well into the winter. Of the seven species of linden grown in this country, the littleleaf linden *(Tilia cordata)* is the most commonly available and best-suited for home situations. The leaves remain green on the tree long after other trees have shed. Lindens have few insect or disease pests.

Two improved cultivars of littleleaf linden are 'Greenspire,' a straight-trunked tree that rapidly grows into a narrow, oval form, and 'Chancellor,' with a narrow, compact, upright form. (60 to 70 ft. height; spread may be 1/2 to 2/3 of height)

### SILVER LINDEN, Tilia tomentosa

This is a beautiful specimen tree that tolerates heat and drought better than other lindens. The upper leaf surface is dark green, but the undersides are densely covered with hairs, which give them a silver color. When the leaves are blown in the wind, the silver under surfaces can be seen, giving a beautiful effect. This tree should not be planted in areas where there is a large amount of dust or soot present as it will collect on the hairy leaves and make them unsightly. Flowers of this species have been reported to be poisonous to bees. (50-70 ft. height; 25-40 ft. spread)

### LACEBARK ELM, Ulmus parviflora

A superior landscape elm, not to be confused with the inferior Siberian elm (U. pumila). Small, dark green leaves that may turn yellow in fall. Profuse clusters of small samaras (winged dry fruit) present in the fall. Magnificent mottled, somewhat exfoliating bark in light gray, green, orange, and brown. Very environmentally durable plant with high resistance to Dutch elm disease and elm leaf beetle. (40-60 ft. height; 40 ft. spread) JAPANESE ZELKOVA, Zelkova serrata Zelkova is a fast-growing, vase-shaped to spreading tree. Its leaves resemble those of the elm; it is a close relative, but unlike the elms, it has smooth, gray bark. Young Zelkova trees are often crooked and need corrective pruning to develop into a desirable tree. Zelkova is susceptible to several pests that attack elm trees, but it is relatively resistant to Dutch Elm Disease. (50 to 80 ft. height; 50 to 80 ft. spread)

# Conifers

Conifers, or cone bearing plants, generally have narrow-leaved or needle-type evergreen foliage. Noted for the attractiveness of their evergreen foliage, conifers are available in a variety of sizes, shapes, and colors. The deciduous conifers are an unusual group of trees. Their foliage is needle-like, similar to narrow leaved evergreens, but it is shed in the fall of the year. Two examples include the larches and dawn redwood.

Conifers range in size from prostrate plants, growing only a few inches tall, to large trees. Shapes include flat ground covers; horizontal spreaders; upright, pyramidal forms; and even weeping and contorted forms. Foliage color ranges from a gold and cream variegation to all shades of green, gray-green, and blue-green.

The most common causes of damage or death of needled evergreens are poorly drained soil, planting too deeply, and winter drying. Most are easily killed by water standing around their roots; therefore, they should be planted in well-drained soil. A raised bed may be the solution for planting on excessively wet sites.

Winter drying can be a problem with nearly all evergreens. The foliage may be damaged when cold or frozen soils make it difficult for roots to replace moisture as fast as it is lost by the foliage. If the summer or fall has been dry, thoroughly soak the area around the plants in October, so the plants go into the winter with an adequate moisture supply. Less winter-hardy evergreens should be planted in areas protected from winter sun and wind to prevent damage and ensure their survival.

Evergreens are sold either balled-and-burlapped or in containers. The burlap may be left on the ball for planting unless it is treated or plastic, in which case it should be slit in several places. Loosen the burlap from around the trunk and tuck it under the sides of the ball. Be careful to remove any string or wire wrapped around the plant. Remove metal or plastic containers before planting.

Fertilizing at planting time with a liquid, fertilizer can help with plant establishment. Established plants that have good color and are making satisfactory growth usually don't need additional fertilizer. However, if fertilizer is required, low rates are recommended.

# Dwarf and Slow-Growing Conifers

Contemporary, residential landscapes frequently require the use of low maintenance plants which must fit within the scale of small suburban environments. Dwarf conifers can be effectively used in such small scale landscapes to add diversity of form, texture, and coloration. Since the dwarf conifers are evergreen, these features are manifested throughout the year and tend to dominate the winter scene.

# Landscape Use

The wide diversity of plant growth habits enables one to use dwarf conifers effectively in foundation plantings, in shrub borders, or as patio plants. The particularly interesting shapes and growth characteristics of many dwarf conifers serve as ideal accent or focal points, and caution should be exercised not to overuse species with exceptionally strong features. In rock gardens or in landscapes with an alpine theme, dwarf conifers are unexcelled. Textures vary from coarse to very fine, and colors range from yellowish-green through all shades of green, all the way to pale-blue.

# Culture

As a general rule, the dwarf and slow-growing conifers are adaptable to a wide range of soil conditions. Most are fairly drought tolerant, extremely cold hardy, and relatively insensitive to soil fertility. However, optimal growth is obtained when plants are grown in well-drained, moist soils of medium fertility. Since most plants are purchased container-grown, the root ball should be gently loosened around the outside during planting, with special care being taken to avoid planting the root system below the original level. Established plants would be fertilized in the spring with a general purpose tree and shrub fertilizer (such as a 10-6-4 analysis or equivalent) at 1 to 2 pounds per 100 square feet. Pruning is not generally required to maintain the size or form of the plant. Dwarf conifers are notably insect and disease free, although spider mites might present problems on the dense-foliaged types if left uncontrolled. Mulching prevents weed infestations, eliminates the necessity for mowing close to the plant (thereby reducing the potential for mechanical damage), and serves to highlight the plant's exceptional features.

One good example of a dwarf conifer is *Picea abies* 'Nidiformis,' the birdnest spruce. This plant may attain a height of 4 feet and a width of 5 to 6 feet. It is globose in shape, often somewhat depressed in the top, reminding one of a bird's nest. The foliage is a good, dark-green color of medium to fine texture. Birdnest spruce is best used in foundation or border plantings, or in a container.

### FIR, Abies species

The flat needles of firs leave a round but flat scar when they fall from the twig. The cones of firs are borne in an erect position, while those of most other conifers hang downward. Concolor fir, described below, is the most common one grown as a landscape plant.

### BALSAM FIR, Abies balsamea

The native balsam fir is a popular Christmas tree because of its fragrant needles. It is not a good plant for the refined landscape, and its use should be limited to native plantings.

### **CONCOLOR/WHITE FIR**, *Abies concolor*

The concolor fir is similar to blue spruce in foliage color and general form, but has a softer look and is less stiff. Because of its greater insect and disease resistance, it may be preferable to blue spruce. White fir tolerates city conditions, and is fairly resistant to heat and drought. (30 to 50 ft. height; 15 to 30 ft. spread)

### VEITCH FIR, Abies veitchii

The needles of this stiffly pyramidal evergreen are a dark green above and a whitish color below. This is one of the hardiest of the firs. It is a relatively slow-growing tree with horizontal branches. Veitch fir prefers moist, acid soils. (5075 ft. height; 25-35 ft. spread)

**FALSE CYPRESS**, *Chamaecyparus* spp. Chamaecyparis, or false cypress, is a variable evergreen. Both tree and shrub forms are available in a wide variety of foliage colors. The foliage is similar to that of *Thuja*, but has white lines on the undersides. Falsecypress is adapted to a cool, moist climate and tends to be scorched and discolored by drought and drying winter winds. Falsecypress comprise a group of slow growing, dense, pyramidal evergreens with a wide variety of foliage colors and textures. Many cultivars of Hinoki Falsecypress (C. obtusa) are available. 'Erecta" forms a slender column, "Filicoides" has twisting frond-like foliage and "Gracilis" is a slender tree with weeping branchlets. The varieties of Sawara falsecypress (C. pisifera) offer great diversity in foliage and tree form. (40-75 ft. height; 10-20 ft. spread)

### JUNIPER, Juniperus spp.

Junipers have sharp, pointed, needle and scale-like foliage. Their fruit is a fleshy, blue berry. The sexes are separate, and only female plants produce berries. Junipers are adaptable, and hence commonly grown evergreens. They withstand dry, poor soils better than other evergreens. Junipers need full sun for best development. None of the junipers will grow on wet, poorly drained soil or heavy shade.

There are hundreds of varieties of juniper from which to choose; they come in all sizes and shapes. The color varies from yellow-green to green, blue-green, gray-green, or silver. Because so many varieties of juniper have been grown, many of the names have become confused. For landscape purposes we can divide them into three major groups: prostrate, spreading, and upright.

The prostrate (creeping) junipers are low growing plants used primarily as ground covers. They seldom grow over 18 inches high and will spread over a large area. The foliage of many prostrate junipers changes color in winter. Some examples include: *J. horizontalis, J. procumbens* 

Spreading junipers can be divided into two groups. The first group has a horizontal growth habit which gives the plant a flat-topped appearance. Branches on the second group have an arching pattern of growth that makes a more vase-shaped plant. Most spreading junipers retain the same foliage color year round. Examples include: *J. chinensis* and *J. sabina*.

Most upright junipers are actually tree types which are grown as shrubs. Unless they are heavily sheared, they will quickly outgrow their intended use. To develop their natural beauty, they need to be planted where they have plenty of room to grow. The foliage color of most upright junipers does not change with the seasons. Examples include: *J. scopulorum* and *J. virginiana.*  One newer cultivar for New Hampshire gardens is listed below:

**Blue Star Juniper** (*Juniperus squamata* 'Blue Star').

A brilliant blue green, this tough little shrub is well adapted for sunny, well-drained areas. Maturing at a height of about  $2\frac{1}{2}$  feet by about 4 feet in width, 'Blue Star' is a compact juniper that is ideal for foundation planting.

### EUROPEAN LARCH, Larix decidua

The spring needles of the European Larch are fresh apple-green and soft. They turn deeper green in summer and spectacular golden yellow in fall before deciduating. A large tree (75 feet tall, 30 feet wide), it prefers sunny locations, in moist to wet acid soil. *Larix kaempferi*, the Japanese Larch, has more graceful, pendulous branches, and is a better landscape specimen. Both are related to *Larix laricina*, our native tamarack.

### DAWN REDWOOD,

### Metasequoia glyptostroboides

Dawn redwood was believed to be extinct until 1941 when a Chinese botanist discovered it growing in a remote valley of central China. Three years later a botanical expedition obtained seeds from these and distributed them to botanical gardens and arboreta throughout the world. It is a fast-growing, pyramidal tree with a tendency to grow late in the season which results in some twig dieback. The loose, feathery, needlelike foliage drops quickly in the fall. Deep, welldrained, moist soils are preferred. Avoid planting in frost pockets. No serious pests are known. (70-100 ft. height; 25 ft. spread)

### SPRUCE, Picea species

The needle-like foliage of the spruces has four angles when seen in cross section; the needles are not flat as with most conifers that produce their needles singly. Spruces can be recognized by the persistent leaf bases that remain on the twigs after the needles have fallen.

Spruces are native to cool climates and are excellent landscape plants for northern New England. They should be planted only in well-drained soils. Young trees with dense foliage and a symmetrical growth habit are the most attractive. The four spruces described in the following section are the ones most commonly available in the nursery trade.

### NORWAY SPRUCE, Picea abies

Because Norway spruce is one of the fastest growing of all the spruces, it is perhaps overplanted. As the tree grows older, the side branches become horizontal with a slight upturn at the tip. Secondary branches hang downward from the main branches, giving the tree a graceful appearance. The large cones (4 to 6 inches long), largest of any of the spruces, are an added attraction. (40 to 60 ft. height; 25 to 30 ft. spread)

### **BLACK HILLS SPRUCE,**

### Picea glauca 'Densata'

Black Hills spruce, a slow-growing, compact variety of the native white spruce, is one of the hardiest of the spruces. Its dense, green to bluish-green foliage is its most ornamental characteristic. Its mature size of 20-25 feet makes it useful in the small landscape.

### DWARF ALBERTA SPRUCE,

### Picea glauca 'Conica'

The dwarf Alberta spruce is slow growing, coneshaped tree which seldom needs pruning. The bright-green, dense foliage makes it attractive. Although capable of growing larger, Its maximum size seldom exceeds 12 feet. Alberta spruce is often used a novelty specimen plant and also as a container plant.

### SERBIAN SPRUCE, Picea omorika

A great choice for a limited space, this densely narrow evergreen is noted for its distinctive fishhook branching and refined habit. Although fairly adaptable as to site, this spruce does best on deep, well drained—yet moist—soils with winter protection from strong winds. (50-60 ft. height; 20-25 ft. spread)

### COLORADO BLUE SPRUCE,

### Picea pungens var. glauca

The Colorado blue spruce is a very strong accent plant due to its stiff growth habit and unusual color, it stands out wherever it is planted. Placing this tree in a landscape is difficult because it is so dominant. It is best used as a single specimen for accent. A blue spruce grows slower than green types and usually commands a higher price. (90 to 135 ft. height; 20 to 30 ft. spread)

### PINE, Pinus species

The pines can be easily distinguished from other evergreens because their leaves are produced in bundles of two, three, or five needles. Pines are used for screens, windbreaks and mass plantings, or are planted as specimen trees. They need full sunlight to develop properly.

Many species of pine can be grown in northern New England. The five species described in the following section are the ones most commonly grown as ornamentals. Four of these species grow to be large trees; mugo pine is a shrub.

### BRISTLECONE PINE, Pinus aristata

One of the oldest living plants in the world, living specimen bristlecone pines growing in Arizona and Nevada are over 4,000 years old. it is becoming popular in landscape plantings primarily because of its dense, short needles and its picturesque growth habit. Probably never destined to be a mainstream commodity, this surprisingly hardy and tough plant can make a picturesque, bonsai-like focal point for a private patio or meditative garden. It is very slow growing and endures a hot, dry exposure, but does not tolerate shade. (8-20 ft. height; spread: irregular)

### LACEBARK PINE, Pinus bungeana

Lacebark pine is a relatively slow growing tree and often develops with more than one trunk. The needles are about 3 inches long and are grouped three to a bundle. Needles are retained on the tree several years longer than on most pines, making the tree especially dense. The bark peels off the trunk and branches in irregular patches, producing a beautiful mottled effect. (30-50 ft. height; 20-35 ft. spread)

### SWISS STONE PINE, Pinus cembra

This is a slow-growing pine with a dense, pyramidal habit of growth. It is very similar to white pine in foliage color and texture. It will grow on a wide variety of soils and exposures. (30-40 ft. height, 15-25 ft. spread)

### JAPANESE RED PINE, Pinus densiflora

A picturesque tree with a distinct, flat-topped growth habit, often used for bonsai. The cones are produced in dense clusters. Orange-red bark is interesting throughout the year. A dwarf, flattopped cultivar, Tanyosho pine, is commonly grown as a shrub. It will grow to about 6 feet in height. (40-60 ft. height; 40-60 ft. spread)

### WHITE PINE, Pinus strobus

The delicate, soft, light bluish-green foliage of the native white pine makes it an attractive evergreen tree. It is one of the few commonly grown five-needled pine. Easily transplanted and fast growing, it will become a large tree and needs adequate room to develop properly.

On favorable sites, white pine sometimes grows too fast to retain its dense foliage. This can be avoided by pruning the tree to increase its density. However, in pruning white pine, note that needles are not produced evenly along the stem but are clustered near the tip. When the tip is cut back, some needles must be left on the remaining portion or the twig will die back to last year's growth. White pine is sensitive to air pollution and road salt and is not a good choice for planting in city conditions. (50 to 80 ft. height; 20 to 40 ft. spread)

### AUSTRIAN PINE, Pinus nigra

The long, stiff needles of Austrian pine are produced in bundles of two. They are a deep, dark-green color, which makes the plant excellent for use as a background for small trees with colorful flowers or ornamental fruit. Austrian pine develops into a large tree and needs adequate room for growth. It is relatively resistant to air pollutants and will grow on a wide range of soil types. (50 to 60 ft. height; 20 to 40 ft. spread)

JAPANESE BLACK PINE, *Pinus thunbergiana* Japanese black pine produces its stiff, dark green, 3 to 5 inch long needles in bundles of two. Its large, grayish-white terminal buds help distinguish it from most other pines. Popularity of Japanese black pine has increased during the past few years, primarily because of its informal growth habit. This irregular growth habit makes it a good accent or specimen plant for use in informal landscapes, but it is not well-suited for mass plantings. Salt tolerant; spreading, compact forms are valued in the shrub border. (20 to 80 ft. height; spread 20 to 40 ft.)

### SCOTCH PINE, Pinus sylvestris

Scotch pines, commonly grown for Christmas trees, can be recognized by their short, twisted needles that are produced in bundles of two. Young scotch pines have a symmetrical, pyramidal shape but develop an open growth habit as they mature. Mature specimens develop a reddish-orange, flaking bark on upper branches. (30 to 60 ft. height; 30 to 40 ft. spread)

### MUGO PINE, Pinus mugo

Sometimes called Swiss mountain pine, mugo pine is an excellent, small, evergreen shrub with a dense, rounded growth habit. Plants of mugo pine show a wide variation in shape and vigor. The compact types such as the variety *P. mugo mugo* are the most desirable. Because of its variability, it is more desirable when grown as a single plant rather than in masses. Pruning may be necessary to maintain a desirable growth habit. (15 to 20 ft. height; 30 to 40 ft. spread)

**UMBRELLA PINE**, *Sciadopitys verticillata* Although not a true pine, the Umbrella pine is a very slow growing (perhaps one-half foot per year), dense evergreen with large, lustrous, flattened needles arranged in whorls around the stems. It is best used as a specimen because of its unique beauty and dense pyramidal shape. Avoid hot, dry locations and maintain a constant mulch under the plant. Little other maintenance is required. Best for southern New Hampshire landscapes. (20-30 ft. height; 15-20 ft. spread)

### HEMLOCK, Tsuga species

Hemlock can be recognized by its short, flat needles with narrow, white stripes on the underside. Its small cones are only about 1/2 inch long.

**CANADA HEMLOCK**, *Tsuga canadensis* Hemlock is one of the most graceful and beautiful of the native needled evergreen trees, but it needs moist, well-drained soil to develop properly. It prefers partial shade and should be protected from the wind. It is easy to transplant but requires a good soil. Hemlock will withstand close shearing and is one of the better needled evergreens for growing as a hedge. (40 to 70 ft. height; 25 to 35 ft. spread)

**CAROLINA HEMLOCK**, *Tsuga caroliniana* Less well known than our native Canadian hemlock, this somewhat less graceful tree is more tolerant of city conditions. More compact, deeper green, and slower growing than our native species, this evergreen is offered as an alternative to, but not as a substitute for, our Canadian hemlock.

### YEW, Taxus sp.

Yews' fleshy, red fruit; ability to grow in shade; and lack of serious insect or disease pests also contribute to their popularity.

The sexes are separate in yews. Male flowers are produced on one plant and the female flowers on another. Only female plants produce the attractive berries, but both sexes need to be present to ensure fruit production. One male plant is generally sufficient to pollinate six to eight female plants. The seed within the female fruit is poisonous, as are most other parts of the plant.

Yews prefer a shaded or partially shaded planting site with a moist-not wet— well-drained soil. Direct sunlight and strong winds may injure the foliage in winter as will the summer heat.

Among the yews grown as ornamentals, the Japanese yew (*Taxus cuspidata*) and the intermediate yew (*Taxus x media*), are the most common forms. *Taxus canadensis*, the Canada yew, is the hardiest. Although not as dark green as the others, it should be considered in northern New England as well as *Taxus cuspidata* 'Nana', a slow growing form that is greatly resistant to winter burn.

The many varieties of yew can be divided into three major groups: upright, globe-shaped, and spreading. Upright yews are usually less than half as wide as they are tall. Globe-shaped or rounded ones have about the same width and height. Spreading yews are two to three times as wide as they are tall. (English - 35 to 60 ft. height; 15 to 25 ft. spread. Japanese - 10 to 40 ft. height; equal spread)

One variety, described below, is especially well adapted for residential landscapes throughout New Hampshire.

**Taunton Yew**, *Taxus* x *media* 'Tauntonii' A smaller, more compact *Taxus* that grows to a height of about 3½ feet and a width of 6-8 feet, it is extremely resistant to winter burn and responds well to regular clipping. **EASTERN ARBORVITAE**, *Thuja occidentalis* Also called American arborvitae or white cedar, is native throughout the northern half of eastern North America, especially in moist areas. This plant has long been established in American gardens, and according to some, is overused by building contractors. Arborvitae propagates readily from cuttings, is relatively easy to produce in a short time, and is relatively inexpensive, thus it is a favorite of building contractors.

At maturity, arborvitae are usually dense, pyramidal, 40 to 50 foot trees, but cultivars range from dwarf to rounded or globe shapes, with foliage colors of yellow, blue, and various shades of green. Arborvitae are small, evergreen trees and shrubs with needle-like juvenile leaves and scale-like mature foliage and branchlets flattened in one plane. Branches are erect and spreading with thin, scaly bark. Its seed is produced in small cones. It is an easily propagated, fast-growing plant. (40 to 60 ft. height; 10 to 15 ft. spread)

# **Deciduous Shrubs**

Deciduous shrubs, those that lose their leaves in fall, give seasonal color and texture changes to the landscape. The flowers, foliage, fruit, and bark provide color and landscape interest. A properly selected group of shrubs will give interest to the landscape throughout the year.

Deciduous shrubs usually tolerate difficult growing conditions better than most other ornamentals. Many grow rapidly and may require some annual pruning. Cutting older, heavier shoots back to ground level is one accepted practice for multistemmed shrubs, especially if the plant is overgrown. One third to one fourth of the stems should be removed each year. Many deciduous shrubs have few serious insect or disease problems. Aphids or mites are occasional problems, but they are relatively easy to control.

Many deciduous shrubs are sold bare root while some must be balled and burlapped or container-grown to be successfully transplanted. Bare root plants are planted in the spring before growth starts. Balled and burlapped and container shrubs may be planted almost anytime if properly cared for.

The species and varieties described in the following section are hardy and most commonly grown. The expected maximum height and width of each shrub are listed after the common name.

# **Selected Deciduous Shrubs**

JAPANESE BARBERRY, *Berberis thunbergii* Barberry is a rugged plant that adapts to many situations. It has been widely used as a hedge or barrier plant because of its thorny twigs. It is an easy plant to prune and can be clipped into tight hedges. The small, yellow flowers are not especially showy but the bright-red berries are attractive in the fall. Barberry leaves normally have a good, red fall color. The variety *atropurpurea* has red foliage throughout the growing season. "Crimson Pygmy," a dwarf red-leaved cultivar, is also available. (3 to 6 foot height; 4 to 7 foot spread)

### BEAUTYBUSH, Kolkwitzia amabilis

A tall, vigorous, upright shrub with an arching branching habit, the plant is covered with pink flowers in May or June. The brown, bristly seeds of beautybush are also interesting. This shrub is easy to grow and requires little attention if it is given enough room to develop. (6 to 15 foot height; 4 to 8 foot spread)

**RED CHOKEBERRY**, *Aronia arbutifolia* A dependable shrub on almost any soil, it produces small white to reddish flowers in late May. Chokeberry is planted primarily for the bright-red berries that are produced in late summer. There is also a Black chokeberry, *Aronia melanocarpa*. (6 to 10 foot height; 3 to 5 foot spread)

### DWARF FLOWERING ALMOND,

### Prunus glandulosa

Flowering almond is a small, delicate shrub. Its branches are covered with small flowers in early May. The flowers may be pink or white, single or double. This shrub makes a nice accent plant in a foundation planting. (4 to 5 foot height; 3 to 4 foot spread)

### PURPLELEAF SAND CHERRY,

### Prunus x cistena

This small shrub is valued for its purple-colored foliage which persists throughout the growing season. It produces small, pinkish flowers in May and small, colorful cherries in fall. (7 to 10 foot height; 5 to 8 foot spread)

### SPREADING COTONEASTER,

### Cotoneaster divaricatus

An interesting plant, spreading cotoneaster has an upright growth habit and arching, spreading branches. Red berries cover the branches during early fall adding considerable interest to the landscape. Cotoneaster is susceptible to fire blight disease and is occasionally attacked by spider mites. (5 to 6 foot height; 6 to 8 foot spread)

### SLENDER DEUTZIA, Deutzia gracilis

Deutzias are a group of shrubs grown for the showy, white or pinkish flowers produced in May. Slender deutzia is desirable because of its small size and slender, graceful, arching, growth habit. This plant is useful in a large shrub border, but is limited in use due to its ratty appearance when not in flower. (2 to 6 foot height; 3 to 4 foot spread)

### **REDOSIER DOGWOOD,**

#### Cornus sericea (stolonifera)

Redosier is a shrub-type dogwood adaptable to most soils but does best in moist situations. It spreads by underground stems and increases in diameter as new stems arise from the ground. It does not have interesting flowers or fruit but is grown primarily for its colorful stems. Both red-stemmed and yellow-stemmed varieties are available. A dwarf cultivar, 'Kelseyi,' seldom grows over 2 feet high and is useful as a ground cover in large areas. This is an excellent wetland plant. (7 to 9 foot height; 10 to 12 foot spread)

### WINGED EUONYMUS, Euonymus alatus

Winged euonymus, a large shrub, can be used as a hedge because its neat, uniform appearance requires little or no pruning. Twigs of this shrub have corky ridges and are especially interesting in winter after catching a soft snow. This plant has excellent, scarlet color in the fall. The compact variety, *E. alatus* 'Compactus,' grows to only 4 feet tall and is more commonly planted than the standard variety, but is not hardy in the mountainous parts of northern New England. Euonymus must be transplanted with earth around its roots. Once established, they require little care. (15 to 20 foot height; 15 to 20 foot spread)

**BORDER FORSYTHIA**, *Forsythia x intermedia* The profuse, yellow flowers of forsythia are considered by many people to be the first sure sign of spring. They are easily grown on almost any soil but prefer full sun. There are many cultivars of forsythia available, including some dwarf forms. Cultivars of Border forsythia, such as 'Beatrix Farrand', 'Karl Sax' and 'Lynwood' perform well in coastal areas. Further north, their flower buds survive winter infrequently, and hybrids like 'Vermont Sun', 'Meadowlark' and 'Northern Sun' should be planted. (8 to 10 foot height; 10 to 12 foot spread)

### EUROPEAN FLY HONEYSUCKLE,

### Lonicera xylosteum

This is one of the few honeysuckles refined enough to be used in the landscape. The gray-green foliage forms a mound 8-10 feet tall and 8-10 feet wide. It produces white flowers in spring and red fruit in midsummer. Two cultivars, 'Claveyi' and 'Emerald Mound', are more compact, have bluish foliage, and are excellent hedge plants. AMUR HONEYSUCKLE, Lonicera maackii Amur honeysuckle is the largest and fastest growing of all the shrub honeysuckles. Fragrant, white flowers are produced in late May. Bright-red berries remain on the plant from September to November. Amur honeysuckle holds its leaves late in the fall, and it is not unusual for the plant to have green leaves and red berries at Thanksgiving time. Amur honeysuckle makes a fast growing screen, but it needs plenty of room to develop. (8 to 15 foot height; 8 to 12 foot spread)

# **HYDRANGEA**, *Hydrangea arborescens* 'Annabelle'

This hydrangea is a small shrub that produces large, white flower clusters almost 6 inches in diameter. It is usually killed back to the ground in winter. Hydrangea does not require any special soil but prefers a light shade location. (3 to 5 foot height; 3 to 6 foot spread)

### COMMON LILAC, Syringa vulgaris.

Lilac is one of the best known and most commonly planted of all the flowering shrubs. It is grown primarily for its late spring flowers. Of the hundreds of varieties of lilacs that have been named, the so-called French hybrids are among the most popular. They are dense, upright shrubs that can be grown almost anywhere. Lilac flowers range in color from white to pink to lilac to bluish to purple. Both single- and double-flowered forms are commonly available. The flowers of most varieties are very fragrant.

Proper pruning is necessary to keep the plants attractive and to promote heavy flower production. After the plant becomes established, about one third of the old stems should be removed each year. Older lilac stems may be attacked by borers, and powdery mildew is a common summer disease. Proper pruning helps to minimize this problem. (8 to 12 foot height; 6 to 15 foot spread) Another good lilac is Syringa patula 'Miss Kim'. It reaches 3-4 feet in height and produces blue flowers a bit later than most lilacs.

### LATE LILAC, Syringa villosa

This very hardy lilac produces lilac to white flowers a bit later than most lilacs. It reaches 10 feet in height and width, and is a good addition to the shrub border.

# **SWEET MOCKORANGE**, *Philadelphus* coronarius

Mockorange is a vigorous, upright shrub grown primarily for its white flowers which are borne in late spring. There are many varieties of mockorange from which to choose. Some varieties produce very fragrant flowers while others are not fragrant. Both single- and double-flowered varieties are available, and flower size varies from  $\frac{1}{2}$  inch to almost  $2\frac{1}{2}$ inches in diameter. Some varieties never get over 4 feet in height while others may grow to 12 feet.

Mockorange has no serious insect or disease problems. Removal of a few older stems from the base each year will keep the plants vigorous and flowering. They have little ornamental value other than their flowers, and easily out grow their space if not pruned regularly. (4 to 12 foot height; 4 to 12 foot spread)

### PRIVET, Ligustrum spp.

Privets are automatically considered hedge plants because they have been so widely grown for this purpose. Unsheared specimens produce pyramidal clusters of small, white flowers followed by similar clusters of black berries. Fruit remains on the plant most of the winter and provides considerable food for birds.

Privets are vigorous plants that will adapt to most types of soil, under most conditions. There are several varieties of privet available. They range from 4 to 12 feet in height. Some of the more popular varieties include:

'Amur' - one of the hardiest varieties.

'Regel' - a low cultivar with almost horizontal branches.

'Golden Vicary' - with bright-yellow foliage throughout the growing season.

### ROSEGOLD PUSSY WILLOW, Salix gracilistyla

GOAT WILLOW, Salix caprea

BLACK PUSSY WILLOW, Salix melanostachys

**PURPLEOSIER WILLOW**, Salix purpurea Pussy willow is grown for its interesting and attractive catkins (flowers). The sexes in willow are separate with the male having large, gray, fluffy catkins with bright-yellow stamens. The female flower is not as attractive. The catkins on pussy willow appear in very early spring. It is an easily transplanted, vigorous shrub. However, it has many problems and needs to be kept vigorously growing to look attractive. Pussy willow has been overplanted in many areas. Purple osier willow is the hardiest of those listed. (Rosegold Pussy Willow 6 to 10 foot height, 6 to 10 foot spread; Goat Willow 15 to 25 foot height, 12 to 15 foot spread; Black Pussy Willow 6 to 10 foot height, 6 to 10 foot spread; Purpleosier Willow 8 to 10 foot height, 6 to 8 foot spread)

### FLOWERING QUINCE,

Chaenomeles speciosa

Quince shrubs usually have deep-red flowers. However, new varieties with white, pink, and various shades of red flower colors are now available. Lustrous, green foliage appears soon after the flowers have opened. The large, yellow-green, apple-like fruits are not particularly attractive but can be used to make jellies. The Japanese quince (*C. japonica*), a smaller plant only 3 feet high, is similar to flowering quince. (6 to 10 foot height; 6 to 12 foot spread)

**ROSE-OF-SHARON**, *Hibiscus syriacus* 

A large shrub, Rose-of-Sharon flowers in August, a time when few other shrubs are in bloom. Flowers may be single or double and range in color from white to pink to red to violet, with all the variations in between. Unless the older portions of the plant are pruned out regularly, the flowers will become smaller. If handled properly, the plant is bushy enough to be used as a hedge or screen. It is hardy in coastal northern New England. (6 to 12 foot height; 6 to 10 foot spread)

### SMOKEBUSH, Cotinus coggygria

The plumose, fruiting panicles of smokebush are attractive for several weeks in summer. The foliage is blue-green throughout the growing season. This shrub is often used as an accent point in the landscape because of the showy panicles. The yellow to orange autumn color is also attractive. Smokebush will grow in any soil and any location in the garden. Insects and disease are of little concern. The cultivar 'Purpureus' has purple leaves and fruiting panicles that are much showier than the species. (15 foot height).

### SPIRAEA, Spiraea spp.

Spiraeas are as easy to grow as any group of flowering shrubs. They adapt to a wide range of soil types. A good deal of sunshine is required for flowering, but they will grow in moderate shade. Most spiraeas have white flowers, but there are a few with pink or red flowers. They range in height from  $1 \frac{1}{2}$  to 7 feet. Vanhoutte spiraea is the most well known, and still popular because of its heavy set of white flowers and graceful, arching growth habit. Bridalwreath spiraea is attractive with its double, white flowers; lustrous, green foliage; and orange fall color. 'Anthony Waterer' is the most popular small spiraea, around 2 feet high. The red flowers of this species are borne in large 5 to 6 inch clusters. Many new, white-flowered, dwarf cultivars are being used as foundation plants. Spiraeas are relatively free of insect or disease pests. Occasionally a heavy spring infestation of aphids will occur.  $(1\frac{1}{2}$  to 12 foot height;  $1\frac{1}{2}$  to 12 foot spread)

### STAGHORN SUMAC, Rhus typhina

Sumacs are easily grown shrubs and do particularly well in a dry soil. The staghorn sumac can eventually become a rather large shrub, perhaps 35 feet high; however, as a multiple-stemmed plant, it seldom reaches that height. There are plants with male flowers only, female flowers only, or plants with both male and female flowers. Female flowers develop into bright-red fruit spikelets in fall and are quite interesting. The brilliant, red fall color of sumac foliage is outstanding. Staghorn Sumac has fuzzy twigs from which it derived its common name. The plant can be used as a mass planting, but in modern landscapes it is often used as a specimen because of its interesting growth habit. Attractive, cutleaf cultivars are available. Sumacs have no serious insect or disease problems. Though related to poison ivy, it is not a poisonous plant. (15 to 25 foot height; 15 to 30 foot spread)

### BUCKTHORN, Rhamnus frangula

Buckthorn was developed and is used almost solely as a hedge. A columnar cultivar will spread only about 4 feet wide and maintains its shape with little or no pruning. The foliage is a dense, dark, lustrous green. It is densely twiggy and stiff, but is useful where a columnar tall hedge is needed. (10 to 12 foot height; 8 to 12 foot spread)

### VIBURNUM, Viburnum spp.

As a group of shrubs, viburnums have much to offer. They have beautiful spring flowers; attractive summer foliage; excellent fall color; and attractive, bright-colored fruits in fall and winter. The fruits may be red, yellow, blue, or black and in a given species may change color several times as they mature. In some species the flowers are quite fragrant, adding materially to their value as ornamental plants. Viburnums are usually sold balled and burlapped or in containers. (2 to 30 foot height; 2 to 30 foot spread).

### HOBBLEBUSH (Viburnum alnifolium).

Despite being a native plant best used for naturalizing, hobblebush does have several ornamental qualities of merit. The large, white, flat topped flower clusters are a one of the showiest of any native woody plant. The clean green foliage emerges becoming an effective deep red to maroon in the fall. This leggy, and somewhat open, plant appears to be hobbling around on its knees and elbows and is best used when faced with greenery or a stone wall. Hobblebush does best in light shade on the edge of moist, deciduous woods.

### KOREANSPICE VIBURNUM, V. carlesii

A small shrub growing to 6 feet, the flower buds are pink, opening to white flowers that are quite fragrant. The cultivar 'Compactum' is a preferred selection that matures at about 3 ½ feet and is attractive year round. Like the species, the early, semi-snowball type white flower clusters are pink in bud and are very pleasantly fragrant. The attractive green foliage turns a more consistent red to maroon bronze in the fall than the species and then drops to reveal a clean winter habit.

### WITHEROD VIBURNUM (Viburnum

cassinoides).

Another native viburnum, this plant fits in well with our natural New Hampshire landscape. The creamy white flower clusters produce a fruiting display that passes through a sequential ripening process, changing in color from green to nearly white and then to pink, rose, blue, and finally becoming black, Often all stages are present together on the same fruiting cluster. As unusual as this trait is, the fruits are quickly enjoyed by birds. Foliage is a shiny rich green followed by a brilliant and dependable red. Like most viburnums, its clean winter habit is an asset in the winter landscape. **ARROWWOOD VIBURNUM**, *V. dentatum* A large shrub, 6 to 16 feet, arrowwood will grow in sun or shade and is adaptable to any soil. Arrowwood is a rapid grower and may have good, glossy, yellow to red fall color.

**WAYFARINGTREE VIBURNUM**, *V. lantana* Another large shrub, 10 to 15 foot, this viburnum is especially good for dry soil situations. The fall color is a good red; the fruit changes from red to black and provides a source of food for birds.

### BLACKHAW VIBURNUM, V. prunifolium

A large shrub, 12 to 15 feet in height, can grow 20 to 30 feet high. During May this shrub is covered with white flowers in flat clusters, later followed by blue-black berries that are among the largest fruits in the viburnums. Blackhaw has an excellent, shining, red fall color.

### DOUBLEFILE VIBURNUM,

#### V. plicatum tomentosum

A medium-sized shrub, up to 9 feet high. During May this plant has creamy-white flowers borne in flat clusters followed by bright-red berries in fall. The fall color is a consistent reddish purple. The plant's most interesting features are its horizontal branching and wide-spreading growth habit. This interesting form gives the plant added interest in the landscape.

Other important landscape viburnums include the Burkwood viburnum (*V. x burkwoodii* and cultivars) and American cranberrybush viburnum (*V. triloba*).

### WEIGELA, Weigela florida

Most of the weigelas available in the nursery trade are hybrids developed to produce superior flowers. The funnel-shaped flowers are borne in clusters of three to five. They range in color from white to deep red. The stems are usually covered with flowers for a short period of time in the spring. Weigela is easy to grow and has no serious insect or disease problems. (6 to 9 foot height; 9 to 12 foot spread)

### WINTERBERRY, llex verticillata

Winterberry is grown primarily for its bright-red berries that appear while the leaves are still green and remain on the plant long after the leaves have fallen. The inconspicuous flowers are borne on separate plants; some plants have all male flowers and others have all female flowers. Only female plants produce the berries, but both sexes need to be present to ensure fruit production. One male plant is enough to pollinate six to eight females. Winterberry will grow in any good garden soil. Many cultivars, including 'Red Sprite' with superior winter fruit are available. (6 to 10 foot height; 6 to 10 foot spread)

# **Broad-Leaved Evergreens**

Among the most highly prized landscape plants are broad-leaved evergreens. They are the true aristocrats of our gardens. However, many of them require special attention if they are to develop into attractive, long-lived plants.

Wide fluctuations in temperature, prolonged dry periods, drying winds, and bright sunshine are not ideal conditions for most broad-leaved evergreens. Good soil preparation and a carefully selected location will help ensure the success of these plants. However, the year-round beauty and special effect that they give to the landscape make them well worth the extra care needed to grow them.

The broad-leaved evergreens are valued chiefly for their evergreen foliage, but many of them possess other desirable ornamental traits. They are generally clean plants, dropping few leaves at any one time. They offer a range of foliage colors and textures for landscape interest.

Broad-leaved evergreens prefer a rich, well-drained, slightly acid soil. Increasing organic matter content and improving drainage can modify an existing poor soil to one in which they will grow successfully.

Locate those broad-leaved evergreens subject to winter injury in areas where they receive protection from the wind and afternoon sun, especially in winter. North and east sides of buildings are ideal. Wind and sun protection provided by fences or large plants will also help prevent injury. Protection from the hot summer sun of southern and western exposures, may be needed.

Broad-leaved evergreens are best fertilized in the spring. Summer or fall fertilization may induce late season growth that is highly susceptible to winter injury. Winter scorch of foliage can also develop if plants dry out during the winter. To prevent this, water plants in late summer and fall if rainfall has been deficient.

Plant size is also important for the winter hardiness of some species. A small, young plant may be easily killed while the same species may be quite hardy when larger-sized plants are used. Poor culture, attacks by insects or disease, or any other factor that weakens a plant makes it more subject to winter injury.

# Selected Broad-leaved Evergreens

The plants described in the following section are generally hardy in all parts of the state. When broad-leaved evergreens are planted and located properly, they can add year-round interest to the landscape and provide a pleasant contrast to needle-leaved evergreens in both winter and summer.

### AZALEA AND RHODODENDRON,

### Rhododendron spp.

The plants commonly called azaleas and those called rhododendron belong to the botanical genus, Rhododendron. It is the largest group of woody ornamental plants. Over 4,000 species, varieties, and hybrids have been recognized. Most azaleas are deciduous, and most rhododendrons are evergreen. Both require acid, moist, organic soils, cool temperatures, high humidity, and protection from harsh winter winds. They are valued for their very colorful flowers in the spring and summer, and the evergreen types are additionally valued for the foliage color they add to the winter landscape. New cultivars of azaleas and rhododendron are added to nursery lists every year. Check with a local nursery for those best adapted to your location.

Selection and Culture of Azaleas and Rhododendrons

Although all azaleas and rhododendrons belong to the genus *Rhododendron* by plant taxonomists, the name azalea" is commonly used for North American deciduous species and many evergreen hybrid types. Generally "Rhododendron" is used for those species that have large, evergreen, leathery leaves and flowers distinctly clustered in terminal groups. When a sharp division cannot be made, it is always correct to call any of them rhododendrons. Whatever name is used, the culture required for all these plants is very similar. The same cultural practices as described below may also be applied to blueberries, pieris, heather, holly, and other ericaceous plants that prefer acid, organic soils.

### Location

Most azaleas and rhododendrons are at their best in fairly mild, humid climates. Selecting a good site is very important, as is selecting good quality plants. A site sloping to the north or east is usually best, because it is protected from drying south and west winds. Thus, plants are less subjected to rapid temperature changes in late fall or early spring. Always plant azaleas and rhododendrons where they get protection from strong winds. Buildings and slopes provide good barriers. Evergreen shrubs or trees such as pine, juniper, or spruce planted to the south or west of rhododendrons protect them and make good backgrounds for showing off the flowers. Plants not given protection from the wind often develop leaf scorch or splitting of the bark on the stems. Avoid siting at the corners of buildings where wind tends to be stronger and on southwest building faces where late winter sun and heat can promote foliar damage.

### Light

Filtered sunlight is ideal for many rhododendrons, but morning sunlight with shade after 1 p.m. may be satisfactory and desirable. Plants may survive continuous shade if trees have branches pruned high. Protection from afternoon sun may also be given by fences, shrubbery, or screens. Some deciduous azaleas are less sensitive to sun, and should be used if the location receives full afternoon sun. Many smallleaved types may not only thrive, but prefer full sun. However, in full sun delicate flower colors will bleach quickly even though the plants may grow well,

### Drainage

Because the delicate roots of azaleas and rhododendrons are easily destroyed, excellent drainage is important. To test drainage, dig a hole six inches deep in the bed and fill it with water. If the water has not drained from the hole in four hours, install drainage tile to carry away excess water, or build raised beds.

### **Starting the Bed**

Planting azaleas and rhododendrons in groups rather than individually permits more efficient use of prepared soil. Don't place the bed close to shallow rooted trees such as maple, ash, or elm. Feeder roots rapidly move into improved soil and compete for water and plant food. For best results, dig out the bed to loosen the soil. Plants should be spaced 3 to 4 feet apart, and at least 18 inches from the edge of the bed.

### **Soil Considerations**

Proper placement alone is not enough. Azaleas and rhododendrons must have soil that is prepared carefully and thoroughly. Roots of azaleas and rhododendrons are very delicate and unable to penetrate heavy or rocky soils.

Azaleas and rhododendrons required an acid soil. Most of them thrive best at a soil pH between 4.5 and 6.0. Many northern New England soils have a native acid reaction. However, alluvial or river bottom soils may have a more alkaline reaction and need to be made more acid to grow azaleas and rhododendrons well. Soils previously limed heavily for a lawn or garden may need the pH lowered. Mortar or similar building materials mixed into the soil close to foundations may increase pH. When the pH is unknown, it can be determined by conducting a soil test.

If the pH is too high, the soil may be made more acid by incorporating agricultural sulfur, aluminum sulfate, or iron sulfate into the soil at an appropriate rate. Although a soil test is the best way to determine the amount required, in general, about two to three pounds of agricultural sulfur per 100 square feet will lower the pH one unit, depending on soil texture and organic matter content. This rate should be multiplied by 6.9 for aluminum sulfate and by 9.0 for iron sulfate. Raising soil pH by the addition of liming agents, such as ground limestone, is rarely necessary for rhododendron and azaleas.

The best soil in which to grow azaleas is good quality, loamy topsoil which contains plenty of organic matter. In areas with heavy clay or excess sand, good quality topsoil can be added or used to replace the poorer soil only if the entire soil area is treated that way. Amendments should not be added just in individual planting holes because water movement will be impeded. If topsoil is added to the planting bed, be sure to check the pH and make any adjustments that may be necessary.

### Mulch

Most azaleas and rhododendrons are shallow rooted and need a mulch to conserve moisture around the roots, to minimize winter injury, and to prevent injury from cultivation. Coarse materials such as partly decomposed oak leaves or pine needles are ideal. Oak shavings, hardwood chips, and aged sawdust or peat moss mixed with coarser materials may also be used satisfactorily. A two to three inch depth of mulch is satisfactory. Avoid piling up mulch too close to the base of the plant stem. As the old mulch decomposes, add new mulch. Given the abundance of materials, late fall can be a good time to apply additional mulch.

### Fertilization

After planting, an application of liquid fertilizer formulated for acid-loving plants may aid in establishment Follow the directions on the package. In subsequent years, a granular fertilizer for acid-loving plants may be broadcast evenly around plants, as required. Use only those products specially formulated for rhododendrons and azaleas and follow directions. Rhododendrons and azaleas grow well naturally at relatively low nutrient levels and little additional fertilizer is required. Ideally, fertilizing should be done in April or May; don't apply fertilize after July 1. Late summer fertilization may force out tender fall growth or delay hardening off of new growth and may result in increased winter damage.

### **Maintaining The Planting**

Rhododendrons and azaleas require little care once they are properly established. Mulch will keep down weeds and conserve moisture. Cultivation should be done carefully, it at all, because the shallow, fine roots are easily damaged.

### Watering

Although rhododendrons have been killed by over watering, more often that not newer plantings often suffer from a lack of water. The shallow fibrous root system of rhododendrons and azaleas makes them susceptible to drought. As a general rule, one inch of water, either from rainfall or artificial irrigation, should be available per week during the growing season.

### Pruning

Usually there is little need to prune azaleas and rhododendrons. If growth becomes excessive, reduce the size can be kept in check with light, periodic pruning after bloom. Amazingly, many types will break bud readily from old wood and respond well to heavy pruning, if necessary.

Azaleas sometimes branch poorly and form a loose, open shrub. The plants' form can be improved by pinching out the soft, new shoots of vigorous growing plants. Do not pinch after July because flower buds will not have time to develop for the following year.

### Winter Protection

In New Hampshire, winter damage to evergreen rhododendrons and azaleas is a common problem. To avoid winter damage, proper siting is important. As a general rule, avoid site exposed to winter wind and sun. Most damage shows up as split bark, dried leaves, or dead or damaged flower buds. If hardy types are selected and proper locations are chosen, little or no winter protection is needed. If existing varieties show winter damage, provide some protection. It is normal for leaves to curl and droop on cold days.

Discarded Christmas trees may be used to protect plants. Branches can be anchored in the ground to shield the rhododendron from wind and sun. Screens may be built of burlap or other materials to provide shade and windbreak. Temporary fences made of lath or snow fencing are effective in providing necessary windbreak and light shade.

Protection must remain loose and airy throughout the winter. Small plants should not be covered with large mounds of leaves. Masses of leaves may begin to decay and smother the plant beneath them. Leaves may be pulled up around the stems in late fall but should not cover the entire plant.

Also, several types of aerosol, anti-transpirants may be applied to evergreen foliage to protect it from winter time water loss. As a rule, these materials should be applied when the temperature is no lower than 40°F. Often these materials are not effective throughout an entire winter, and may need to be reapplied during a January thaw. The practice of using anti-transpirants can be expensive and time consuming. However, for newly planted rhododendrons, anti-transpirants can be very effective in minimizing winter injury.

### Problems Sunscald, scorch

Large-leaved evergreen rhododendrons are sometimes subject to sunscald during winter. This is most likely to happen if the plant did not receive ample moisture before freezing in fall. The exposed portions of the leaf (usually the central portion when the leaf was curled) may become brown. This browning may also appear on the edges of some leaves. To prevent scorch, plants should be well watered in the fall if rainfall has been sparse, protected from drying winds, mulched well, and given some shade. **Iron Chlorosis** 

If leaves turn yellow in the sections between the veins, but the veins remain green, iron deficiency may be the cause. If the entire leaf turns yellow with some browning, other problems are suggested, for example, calcium deficiency. Chlorosis may also result from soil that is not acid enough, poor drainage, nematodes, or other conditions that cause root or stem injury. Iron chlorosis can usually be temporarily controlled by spraying the foliage with an iron (ferrous) sulfate solution, chelated iron, or a liquid fertilizer formulated for acid-loving plants. Conditions leading to chlorosis, such as poor drainage or alkaline soil, must also be corrected. In acid soils, iron chlorosis rarely occurs.

### **Insects and Diseases**

There are several insects and diseases that commonly bother azaleas and rhododendrons. The most common insect problems are root weevils, azalea bark scale and rhododendron borer. The most common diseases are Phytophthora root and crown rot, Ovulinia petal blight and fungal leaf spots.

### **Stem Bark Splitting**

This problem results from rapid temperature changes and freezing. The bark above ground splits and may peel off. The stems do not usually heal, and the branch dies above the injury. Death may not occur for one or two years. Winter protection may help, but generally the best remedy is to plant reliably hardy varieties or prune out affected branches of injured plants. When checking a reference for hardiness of a particular rhododendron or azalea, keep in mind that northern New England has cold winters, which stress plants and may predispose them to other problems.

Evergreen Rhododendron Varieties There are many beautiful rhododendrons. However, many are not reliably cold hardy in New Hampshire. Generally more varieties may be grown in the milder climate of the coast. The following selected varieties are some of the most reliable.

Of the many hybrids available, those derived from *Rhododendron catawbiense*, called Catawba hybrids, have the greatest hardiness. New varieties may be superior to those listed, but establishing their true adaptability takes many years. The collector may be willing to take risks with tender plants, but the beginner should always select varieties well adapted to the local growing environment.

'Album Elegans'- Soft lilac fading to white, late flowering, a R. maximum hybrid.

'America' - Dark red with a ball-shaped flower cluster. Broad, bushy plant.

'Atrosanguineum'- Red with purple markings. Hardy.

'Boule de Neige'- White, early. Slow growing, but develops into a compact, large plant.

'Boursault' - Compact grower, buds purple, turning rosy-lilac.

Catawbiense Album - White flowers in round trusses. Narrow leaves, tall, vigorous.

'English Roseum'- Lilac pink, large foliage,

vigorous upright growth.

'Everestianum' - Purplish-pink with green markings. Hardy.

'Ignatius Sargent' - Purplish red with brown markings.

'Lord Roberts' - Medium height, red flowers with black blotch.

'Mrs. Chas S. Sargent' - Deep rose spotted with yellow. Cold hardy.

'Nova Zembla'- Red flowers similar to 'America.' Cold and heat tolerant.

'P.J.M.'- Early flowering, purple, dark foliage. This is a reliable rhododendron for central and northern New Hampshire. Many of the newer introductions have been selected for improved flower color.

'Purple Splendor'- Very deep violet purple with darker blotch.

'Ramapo'- Small, violet blue flowers. Low, spreading plant. Tolerates sun and shade.

'Roseum Elegans' - Lavender-pink with green markings. Endures temperature extremes. Good for the beginner.

### Deciduous Rhododendron Varieties

Deciduous azaleas and rhododendrons are fairly cold hardy and provide a mass of color in spring as well as often providing effective fall foliage, ranging from shades of yellow to oranges and reds. Different species vary widely in hardiness, however. Normally, those found in nurseries will be the ones best suited to the area. Choose only vigorous plants of good varieties. Beginners should choose some of the old standards and later try some of the newer introductions.

Flame Azalea (R. calendulaceum) - The showiest of the deciduous American azaleas, retaining their flowers for nearly two weeks. Available in yellows, apricot, salmon, pinks, oranges, and reds. Excellent for mass planting and to create naturalistic plantings. For central and southern New Hampshire only.

Exbury (Knap Hill) Hybrids - A very popular group due to their showiness and hardiness. Available in pastel shades ranging from cream, through pink to yellow and orange.

Mollis Hybrids (R. x kosteranum) - slightly more tender and smaller than Exbury, but much varietal variation. Colors mainly in yellow, apricot, orange, red. Cornell Pink Rhododendron (*Rhododendron mucronulatum* 'Cornell Pink'). One of the first rhododendrons to bloom, its true pink flowers held on naked stems are a welcome harbinger of spring. This medium-sized, compact shrub is nearly rounded in outline and has soft green summer foliage which changes to shades of yellow and bronzy crimson in the fall. Winter habit is clean and neat.

Northern Lights Hybrid Azaleas (*Rhododendron* 'Northern Lights') - Hardy to nearly -40° F, this group of deciduous rhododendrons blooms early in a variety of colors. Flowering in white, yellow, orange, rosy pink, or lilac, these plants are medium-sized and compact. Reported to not be especially resistant to powdery mildew, attention to site selection and cultural conditions-good air circulation, low humidity, and proper sanitation—is important. However, this group of especially hardy shrubs might be a good choice where the selection of rhododendrons is limited.

Royal Azalea (R. schlippenbachii) - An azalea hardy in coastal areas with large, fragrant, rosepink flowers. Foliage has good autumn color although may sometimes be burned by late summer heat.

### BOXWOOD, Buxus spp.

Boxwood has been a popular, broad-leaved evergreen for many years, and very old specimens can be found. Boxwoods make excellent specimen plants or hedges. They can be easily pruned to any desired shape. Of the available boxwood types, the Korean or littleleaf box is most hardy and easily grown. The leaves tend to lose color in winter; in shade, winter discoloring is less severe. Because boxwood foliage is desicated every winter, its use is limited to moist, protected coastal regions. (3 to 4 foot height; 3 to 4 foot spread)

### DROOPING LEUCOTHOE,

Leucothoe fontanesiana

A slow-growing plant with spreading, arching branches and lustrous, dark-green leaves, it produces fragrant, bell-shaped flowers in early spring. It needs shade for best growth and is most suitable beneath large evergreens. It is related to pieris and requires the same growing conditions. Best used in southern New Hampshire (3 to 6 foot height; 3 to 6 foot spread)

### WINTERCREEPER EUONYMUS,

### Euonymus fortunei

Most varieties of wintercreeper euonymus are vines or groundcovers. Sarcoxie's euonymus, developed at Sarcoxie, Missouri, is an erect form that makes an excellent, broad-leaved, evergreen shrub. It grows in full sun but will retain its green winter color better when grown in shade. Many cultivars exist with different leaf colors and variegation patterns. Euonymus scale, a white-covered scale insect, may attack the stem and leaves of euonymus. It is not hardy in mountainous areas of northern New England. Winter damage is common. (4 inches to 4 foot height; indefinite spread)

### JAPANESE HOLLY, llex crenata

Most Japanese hollies produce small, spineless leaves and black fruit. They are popular, small, compact, evergreen shrubs further south, but are limited to coastal areas of northern New England.

### **INKBERRY**, *llex glabra*

The inkberry, a black-fruited holly native to eastern North America, is not as showy an ornamental as the other hollies, but it is one of the most hardy of the group and makes a good hedge or screen. Leaf size, shape, and glossiness vary considerably. The selection 'Compacta' should be used in the landscape. Occasional pruning will keep the plant from developing a loose, open type of growth. (6 to 8 foot height; 8 to 10 foot spread)

### AMERICAN HOLLY, Ilex opaca

The spiny, evergreen leaves and bright-red berries of American holly are familiar to most people. It is native and is slow-growing, eventually developing into a small tree.

The sexes of holly are on separate plants. Some plants produce only male flowers and others produce only female flowers. Only the female plants produce berries, but both sexes must be present to ensure fruiting. One male plant is enough to pollinate the flowers of six to eight female plants. Acid soils high in organic matter and with good drainage are essential for growing hollies. Limited to use in southern New Hampshire only. (40 to 50 foot height; 18 to 40 foot spread) JAPANESE PIERIS, Pieris japonica

Formerly called andromeda, pieris is an attractive, broad-leaved evergreen. The new foliage is bronze in color in spring, soon turning a lustrous medium-green. The flowers, borne in April, are creamy-white and hang in long, drooping clusters. The plant needs protection from winter sun and wind to prevent leaf scorch and flower bud damage. A light, well-drained, acid soil high in organic matter will produce the best plants. It is hardy in coastal areas, but suffers foliage desiccation in winter in many parts of northern New England. (9 to 12 foot height; 6 to 8 foot spread)

### **OREGON GRAPEHOLLY,**

### Mahonia aquifolium

Oregon grapeholly is a fairly coarse, stiff shrub that reaches 3-6 feet. In April, the plant is covered with bright-yellow flowers. In the summer, the bluish-black, grape-like fruits develop. The foliage is dark, lustrous, and holly-like. In winter, the leaves turn a bronze-purple color. This shrub is usually semi-evergreen and much of the foliage dies in the winter. Protection from winter sun and wind will help it remain more attractive. It is useful in coastal areas of northern New England, but suffers winter leaf desiccation. (3 to 9 foot height; 3 to 5 foot spread)

### PYRACANTHA/FIRETHORN,

### Pyracantha coccinea

Pyracantha is an evergreen to semi-evergreen shrub. It produces showy, small, white flowers in the spring, but the clusters of bright-orange berries produced in the fall, hanging on the plant until mid-winter, are its main attraction. Pyracantha can be grown as an individual specimen plant, hedge, or barrier. It can be trained flat against a wall or on a trellis to look like a vine or espalier. It normally grows 6 to 7 feet tall and can spread to almost twice as wide, so ample space must be given for the plant to develop fully. Dwarf varieties are available for smaller areas, as are varieties with brighter-red fruit. Pyracantha is one of the few plants that seems to do best on poor soil. Good soil and high fertility produce rampant growth susceptible to disease (fire blight) and low in berry production. The plant has several insect problems to watch for, including lacebug and spider mite. It is best grown in coastal areas, and often suffers leaf desiccation. (2 to 10 foot height; 2 to 10 foot spread)

### MOUNTAIN LAUREL, Kalmia latifolia

This beautiful shrub, with buds and flowers in many pink, rose, and red colors, is one of the prettiest shrubs available for both sun and shade locations. A moist, well-drained, acid soil is necessary. It suffers winter desiccation in all but coastal areas. (3 to 15 foot height; 3 to 15 foot spread)

### NORTHERN BAYBERRY,

#### Myrica pennsylvanica

Bayberry is grown for its aromatic, semi-evergreen leaves and its waxy, gray berries. Because of their fragrance, the berries are frequently used in making candles. The sexes of bayberry are usually separate so both male and female plants need to be planted together to ensure production of the ornamental berries. Bayberry grows vigorously on good soil but will generally fruit more heavily when grown on poor soil. It is a fine ornamental, for its foliage as well as its fruit. It is very salt tolerant. (5 to 12 foot height; 5 to 10 foot spread)

# **Ornamental Vines**

Vines serve many useful landscaping purposes. Where space is limited, vines may be used as dividers or barriers. They can screen unsightly views or provide privacy for the patio or porch. The monotony of a long fence or blank wall may be broken with vines. They can soften harsh structural lines and blend the structure with other plantings. On steep banks and in other areas where grass is difficult to establish and maintain, vines may be used as ground covers. They can be established on trellises against buildings to provide shade, thereby improving energy efficiency for cooling.

Selection of a suitable vine depends on its intended use, location, soil adaptability, and type of support. Dense, coarse foliage is desirable if a screen is needed. A fine-textured, slow-growing vine should be selected to add pattern and interest to a stone or brick wall. A decorative vine should possess desirable flowers, fruit, or foliage for seasonal interest.

### Types

Vines can be classified according to their method of climbing: by tendrils, twining, or clinging. The kind of support required is determined by the growth habit of the vine selected.

Tendrils are slim, flexible, leafless stem appendages that wrap themselves about anything they contact. The grape is probably the best known vine which climbs by means of tendrils. Twining vines, such as bittersweet and clematis, wind their stems around any available support. Clinging vines climb by means of either tendrils with disk-like adhesive tips that attach themselves to any surface, such as Boston Ivy, or by means of small aerial rootlets along the stems that attach themselves into crevices of a rough-textured surface, such as Wintercreeper euonymus or climbing hydrangea.

### Vine Supports

Twining and tendril-type vines climb best on wires, trellises, and arbors. They can be grown on solid vertical surfaces only if proper supports are provided. Although clinging vines can be used on brick or masonry walls, they can erode cement between bricks and weaken the wall. They should never be used on walls of frame buildings as their method of climbing, can cause damage. These vines cling so closely to the wall that moisture is likely to collect under them and cause the wood to rot. Grow clinging vines on trellises far enough from the siding of wood structures to allow free air circulation behind the vines. The trellis should be movable to permit painting the siding without damaging the vine. Clinging vines are particularly valuable on concrete exposures such as along highways or commercial buildings.

Vine supports should be constructed with sturdy, durable materials. Wire, tubing, or wood may be used to make suitable support. Copper or aluminum wire or tubing is preferred over other metals, because these materials will not rust. Use pressuretreated wood or treat wood with a preservative that is not toxic to plants to make it last longer.

## Culture

Plant bare-rooted vines in the spring before new growth starts. Plants growing in containers may be planted to early summer. Young vines should be trained to provide the desired growth pattern. New stems may need to be fastened into position by tying with a soft cloth. Some vines grow rampant and appear overgrown unless severely pruned at frequent intervals. Only when a naturalistic effect is desired, and there is adequate space, should vines be allowed to grow freely. Vines may develop sparse foliage low on the trellis and develop a mass of foliage at the top. To prevent this, pinch back the terminal growth of the stems as they develop. Pinching forces lower branching and more uniform distribution of foliage on the trellis. Vines growing poorly should be fertilized in early spring or late fall according to soil test recommendations.

## **Selected Vines**

### BITTERSWEET, Celastrus spp.

Two types of bittersweet commonly grown for ornamental use in the garden are: American bittersweet, *C. scandens*, a native plant, and Oriental bittersweet, *C. orbiculata.* The American bittersweet is a vigorous vine that grows 10 to 20 feet tall and climbs by means of twining stems. It will thrive in almost any soil or exposure except a wet, boggy situation. Bittersweet is planted for its attractive fruit, a favorite for dried arrangements. Reddish-yellow fruit capsules split open in early autumn to expose red-orange berries. The fruits are grouped in terminal clusters which make them conspicuous both before and after the leaves fall.

Bittersweet produces male and female flowers on separate plants. Male and female plants must be grown to ensure fruit set. Male plants are more vigorous growers and usually must be pruned harder than female plants to prevent the berry producing plants from being crowded out. One male plant should be used for each five female plants. Bittersweet is not easily transplanted due to the spreading root system; therefore, small, young plants should be used. Plants grow rapidly once established and can become a serious pest if not pruned back to keep them under control. The vines should not be permitted to climb trees or shrubs, as they have the ability to choke them out. Bittersweet occasionally may be infested with euonymus scale, but has few other insect or disease pests.

**BOSTON IVY**, *Parthenocissus tricuspidata* Boston ivy is one of the best vines for covering structures or supports quickly. It is a fastgrowing, close-clinging vine which climbs by means of adhesive disks that have the potential to damage masonry walls and buildings. The vine is tolerant of many soil types and grows in full sunlight or in shade. Boston ivy grows to a height of 50 to 60 feet. Its bright-green leaves stand out and overlap on long stalks. Leaves turn rich tones of scarlet, orange, or purple in the fall. The new growth in spring is reddish-bronze.

The flowers are inconspicuous but attract a large number of bees. Fruit is fairly showy in the fall after the leaves are gone. The bluish-black berries are attached to the vine in grape-like clusters and persist after the leaves have fallen. The vine is well-adapted to city conditions. When given free rein, the vine will cover windows, doors, or anything in its path; it needs annual pruning. Easily transplanted; start with 2-year plants.

### CLEMATIS, Clematis spp.

Clematis are among the most decorative and spectacular of all the flowering vines. A wide range of color and flower shape may be found in the many varieties and species offered for sale. The large-flowered clematis hybrids are the most widely used. These hybrids are deciduous vines that climb by twining stems, which act as tendrils. They attain a height of 8 to 10 feet. Flowering time varies according to variety but may be from late spring until frost. The Sweet Autumn Clematis, Clematis dioscoreifolia robusta (C. paniculata), is a more vigorous species that grows to 20 or 30 feet. It is an easy vine to grow and is popular for the masses of fragrant, white flowers produced in late August and September. Clematis prefer a light, loamy, well-drained soil with a pH between 6.5 and 7. Lime should be added if soil pH is below pH 6.5. They require constant soil moisture. Clematis grow well in full sun or partial shade. Preferably, the foliage should be exposed to full sun and the soil kept cool and shaded by low ground-cover plants or mulch. Vines grow well on the east side of a wall, but not on the north. Protection from strong winds is also desirable. Proper pruning time depends upon variety. Those which bloom on previous year's wood should be pruned immediately after flowering. Many types grown in northern New England bloom on growth made during the current year and should be pruned in early spring before new growth appears.

When planting, the crown of the plant should be set at ground level and mulched. Support, such as a bamboo stake, must be provided immediately to prevent breakage of the brittle stems. A light lattice trellis is one of the best supports for clematis. The landscape uses of clematis are many. They are excellent accent vines when trained on arbors, light wires, or delicate trellises but are also effective when allowed to trail over rocks, stone walls, or fences.

### ENGLISH IVY, Hedera helix

English ivy is a handsome evergreen vine, climbing by attaching itself to rough surfaces by very short aerial rootlets. It may attain a height of 20 to 50 feet further south, but in northern New England it generally winter kills on branch tips, a process which prevents it from reaching maximum size. The rich, leathery, dark, shiny leaves hold their color all winter if protected from winter sun and wind. North or east facing walls are the most satisfactory locations. English ivy prefers a shady location with a fairly moist soil, well-supplied with organic matter.

Flowers are only produced on old vines that have reached a mature condition. They are greenish and small, followed by ½ inch, blue-black fruit in large clusters that persist for several months. The landscape uses of English ivy are many, both indoors and outdoors. As a ground cover in the shade or under trees and shrubs, it is an excellent broad-leafed evergreen. On vertical, flat surfaces, interesting patterns are formed during its first few years of growth. It is not suitable for covering walls with a southern exposure because of the intense summer heat and winter sun. 'Baltica' and 'Bulgaria' English Ivy are a hardier varieties recommended for use in New Hampshire.

### HONEYSUCKLE, Lonicera spp.

A few climbing honeysuckles are suitable for landscape use in northern New England. Most frequently found are the Hall's Japanese Honeysuckle, L. japonica 'Halliana,' Goldflame Honeysuckle, L. heckrottii, and Trumpet Honeysuckle, L. sempervirens. Hall's Japanese honeysuckle is a semi-evergreen vine with wiry stems. It climbs 20 to 30 feet by twining, or forms a ground cover by rooting at the joints. It is a rampant vine that easily grows out of bounds and becomes a pest unless carefully controlled. Flowers open white and turn pale yellow. They are produced from June to September. Black berries produced in the fall are of little ornamental value. It should not be placed where it can climb on other plants or trees. It needs annual pruning to keep it in bounds. Goldflame Honey suckle is the best of the climbing honeysuckles. Pink buds open to yellow, and then age to pink, from early to midsummer. It climbs 10 to 20 feet.

The Trumpet Honeysuckle is a loose-growing vine with twining stems and semi-evergreen, bluish-green leaves. Scarlet trumpet-shaped flowers are produced from May to August at the ends of the branches. Red fruits attract the birds in early fall. It will grow 15 to 20 feet high.

The climbing honeysuckles are among the easiest plants to grow in the garden. They will thrive either in sun or shade. Although they perform best in good, well-drained garden soil, they will tolerate poor soils. However, they do not tolerate wet, boggy conditions. Honeysuckles stand severe pruning and can be cut back to 6 to 8 inches if they have grown out of bounds or need rejuvenation. Although a few insects and diseases may attack honeysuckles, they usually are not serious problems.

### CHINA FLEECE VINE/SILVER-LACE VINE,

### Polygonum aubertii

This vine, sometimes called a silver-lace vine, produces clusters of small, white to greenishwhite flowers in August and September, which turn pinkish at maturity and remain effective for a long time. The dense foliage is bright-green. The vine is a rank grower and can be used for a quick screen. Once established, it may grow as much as 20 feet in a single season. It will require severe pruning each spring to keep it within bounds, and can become a nuisance. It is adaptable to many soil types and is suitable for city conditions. It needs a sunny location.

### TRUMPET CREEPER/TRUMPET VINE,

### Campsis radicans

Common trumpet creeper is a deciduous, robust vine that climbs by both aerial rootlets and twining stems. Growing to a height of 25 to 30 feet, this vine is useful for rustic effects on fence posts, walls, poles, or rock work. Brilliant orange and scarlet, 2 to 3 ½ inches long, the trumpetshaped flowers are very showy from July through September. The dark-green leaves present a bold, tropical appearance. Long, cigarlike fruits on bright-tan stems may be considered decorative during the winter months. Common trumpet-creeper grows well in partial shade. However, a full-sun exposure is required for maximum flower production. It will tolerate both wet and dry soils.

Additional support is sometimes required for this vigorous vine. Tying the heavy branches to a sturdy support and thinning the vine in early spring will prevent strong winds from tearing it down. Pinch back the tips during the growing season to eliminate excessive top growth and promote bushiness. Common trumpet-creeper transplants readily. It is a prolific seed producer and may become a pest if not kept under control. A hybrid variety, 'Madame Galen,' has larger, more showy flowers than the common type. Color is salmon-red rather than orange-scarlet.

### VIRGINIA CREEPER/WOODBINE,

### Parthenocissus quinquefolia

Virginia creeper is a native, deciduous vine which climbs by tendrils with adhesive disks that adhere to brick, stone, or tree trunks. It grows 30 to 50 feet tall and has a loose, open growth pattern. The leaves of Virginia creeper are fiveparted and stand out on slender, drooping side branches. They open purplish in the spring, remain a dull, deep green throughout the summer, and turn brilliant scarlet or crimson before dropping in the fall. It is one of the first of all woody plants to display fall color. Inconspicuous, greenish flowers develop into clusters of bluish black, pea-sized berries in September and October. The berries either fall before winter or are eaten by birds after the leaves drop.

Virginia creeper will grow in a variety of soils and is considered to be a very drought-resistant plant. Thriving either in a sun or shade exposure, Virginia creeper is valued for producing a pleasing pattern on large blank walls, for covering rustic structures, and for covering ground or bank in rocky areas.

### WINTERCREEPER EUONYMUS,

### Euonymus fortunei

Wintercreeper euonymus is a handsome, evergreen vine growing to 15 to 20 feet. This shrubby vine climbs by means of aerial rootlets. It attaches to any upright support or roots on the soil surface to form a near mat. The species seldom flowers or produces fruit. However, several varieties available are valued for their pink capsuled fruits which split open to expose orange seeds. The rich, dark-green, leathery leaves of some types turn a bronzy-green in the fall.

Wintercreepers grow slowly in the shade but prefer protection from the winter sun to prevent desiccation. The plant is tolerant to many soil conditions but prefers soil that is moist and well supplied with organic matter. Wintercreepers are useful for training against walls, as ground covers, and for climbing over low walls and on tree trunks. The vine may be allowed to completely cover a wall or may be thinned out to give a tailored tracery. Varieties of varying leaf form and fruiting ability are available. Growth habits and cultural requirements of these are essentially the same. Euonymus scale is their most serious pest. This plant often winterburns and dies back from winter damage.

JAPANESE WISTERIA, Wisteria floribunda The wisterias are vigorous, twining vines that grow to 25 or 30 feet. These vines are most valued for their long, pendant clusters of violet-blue flowers. Varieties are available which produce flowers of varying colors (from white to pink to deep reddish and bluish-violet). Bean-like, velvety pods remain after the leaves fall, but are not particularly ornamental. All wisterias will bloom, but some vines take as long as 7 to 15 years to produce their first flowers. Excessive nitrogen fertilizer may stimulate leaf and stem growth at the expense of flower production. The following practices may help induce flowering: (1) an application of superphosphate in early spring, (2) severe pruning of the new growth in late spring or early summer, and (3) root pruning by cutting some of the roots with a spade a few feet from the trunk in late fall. Grafted plants or plants that have flowered in the nursery are recommended to ensure earlier bloom.

Wisterias are excellent vines for training on stoutly constructed arbors and pergolas but are

hardy only in the milder areas of northern New England. They are best when trained horizontally on a wire or structure 10 to 20 feet above the ground. The vines are excellent for use on open-structured roofs over patios and terraces.

Japanese wisteria is a rapid-growing vine. It climbs by stems twining from right to left. A twisted, heavy main stem or trunk several inches in diameter is often developed. The shiny, bright-green leaves turn yellow in autumn. The fragrant, pea-like flowers are arranged in clusters 8 to 36 inches long. The flowers open gradually from base to tip of the cluster when the leaves appear. The flower clusters are longer but more open than those of the Chinese wisteria, which is not hardy in the north.

### CLIMBING HYDRANGEA,

*Hydrangea anomla* subsp. *petiolaris* An excellent landscape vine with very showy, flat-topped flower clusters in summer; glossy, dark-green leaves; and exfoliating winter bark, it is slow to establish but once well-rooted grows rapidly with clinging roots that will attach to structures and supports. It may grow 60 to 80 feet, so use a sturdy support. It is generally hardy in central and southern New Hampshire.

**DUTCHMAN'S PIPE**, *Aristolochia durior* This vigorous vine graces many New England porches with its 4-10 inch dark green, heart-shaped leaves and unusual yellowish flowers. It grows 10-20 feet in a single season and tolerates any moist, well-drained soil in a sunny or partly shaded location.

# Groundcovers

Groundcovers are low-growing plants that spread quickly to form a dense cover. They add beauty to the landscape and at the same time help prevent soil erosion. Many types of plants, including shrubs, vines, and perennials, can be used as excellent groundcovers.

Grass is the best known groundcover, but grass is not suited to all locations. Other groundcover plants should be used where grass is difficult to grow or maintain. Unlike grass, most groundcovers cannot be walked on. They can be used effectively to reduce maintenance work and to put the finishing touch on any landscaping project.

### Location

Ground covers can be found to fit many conditions, but they are used most frequently for the following locations:

- Steep banks or slopes
- Shady areas under trees and next to buildings
- Underplanting in shrub borders and beds
- Where tree roots grow close to the surface
- and prevent grass from growing.
- Very wet or very dry locations

When planted under trees, ground covers reduce the possibility of mower damage to the base of the tree. Some ground covers may be used to protect the roots of shallow-rooted trees. They shade the soil and keep it from drying out rapidly. Some ground covers don't require as much moisture and nutrients as grass. Therefore, they are in less competition with trees and shrubs.

### Selection

Selection of a suitable plant for ground cover depends on the area where it will be grown. Some ground cover plants prefer partial shade; others thrive in deep shade or full sun; and a few grow well in either sun or shade. The selected ground cover plants listed here grow well in a wide variety of soil types. Some, however, prefer moist soil, while others need dry or well drained soil. Select types best suited to the conditions existing where the ground cover is needed. From these selected types, choose one that ornamentally blends best with surrounding plantings.

# Culture

A well-prepared planting bed is necessary to develop a dense, healthy ground cover planting. The soil should be worked to a depth of 6 to 8 inches. Take care to eliminate perennial weeds and grass that might compete with the ground cover during establishment. Organic materials such as peat moss, leaf mold, compost, or well rotted manure lighten clay soils and improve the water-holding capacity of sandy soils. Eight to ten bushels of organic materials per 100 square feet incorporated to a depth of 6 to 8 inches may be necessary in very poor or heavy soils. If you need to add a soil amendment, add it to the entire planting bed, not just to individual planting holes.

A soil test provides the best guidance for fertilizer usage. Mix the fertilizer into the soil to a depth of 6 to 8 inches. Most ground cover plants can be planted from spring to midsummer, but spring is preferred. The arrangement and spacing of plants in the planting bed depends on the growth characteristics of the plant.

Space plants so they will develop a uniformly covered area in a relatively short period of time. Plant in staggered rows, not straight lines, in both directions to get faster coverage.

Plants that spread rapidly may be spaced much wider than slowly spreading types. Spacing also depends on funds available and how quickly a complete cover is wanted. Spacings from 6 inches to 2 feet are most frequently used. If plants are spaced 4 inches apart, 100 plants will cover about 11 square feet.

Watering, weeding, mulching, and feeding will be the main requirements of the new ground cover planting. Water during dry periods. An occasional thorough soil soaking is better than frequent light watering. Occasional hand weeding with a minimum disturbance of the soil may be necessary. A 1 to 2 inch mulch layer of leaf mold, compost, or similar organic material will conserve soil moisture and reduce weed growth.

# **Selected Groundcovers**

## AJUGA/CARPET BUGLEWEED, Ajuga

### reptans

Ajuga is a good ground cover, forming a dense carpet of foliage over the soil. This semi-evergreen plant grows rapidly by producing mats of foliage in rosettes. Runners develop from the mother plants, take root and produce new plants. The foliage grows about 4 inches high with upright clusters of blue flowers reaching 6 to 8 inches. The plant flowers in early May to mid-June. Ajuga will flourish in almost any soil with good drainage. It grows best in sun or light to medium shade.

The foliage is deep-green in color and partly evergreen, turning brown after severe freezing weather. Bronze and variegated varieties are also available. The extensive root system prevents soil erosion. If established plants are set 12 to 15 inches apart in the spring, they will cover the soil in one growing season. Do not set the plants too deep. The crown should never be covered. In the spring or early fall, rooted "runner plants" can be dug from established plantings and replanted elsewhere.

**CREEPING JUNIPER**, *Juniperus horizontalis* Although not the only juniper species commonly used as a groundcover, creeping juniper is an excellent, woody, evergreen plant cover that grows 1 to 2 feet tall depending on the variety. It is a vigorous grower capable of covering a large area. The leaves are needle-shaped and green or blue-green in color. The foliage frequently turns a purple or slate color in the winter.

Creeping juniper withstands hot, dry situations, prefers full sun and excellent drainage, and grows well on slopes and banks. The plants may be improved by clipping the ends of main branches for two or three seasons after planting to induce a dense branching system. Plants should be spaced 2 to 4 feet apart. Some common varieties are listed below:

Andorra juniper (*J. h.* 'Plumosa') is a flat-topped variety with a compact habit of growth, reaching a height of approximately 18 inches. The foliage is a light grey-green, becoming a purplish-plum color in the winter.

'Bar Harbor' is a low, vigorous-growing plant usually no more than 8 inches tall. The foliage is grey-green in summer, turning a slate color in winter. 'Wiltoni' (Blue Rug) grows flat on the ground. The foliage is an outstanding blue color which is retained all winter.

### MOSS PINK, Phlox subulata

Creeping phlox is commonly used as a rock garden plant but forms an effective ground cover on poor, bare soils where there is little competition. It forms a dense mat of moss-like foliage, which is covered in spring with masses of flowers in either pink, purple, or white. In rocky areas, it will persist in the existing soil and drape itself over the stones. It is a plant for full sun and relatively dry soils. As plants age, they may tend to develop occasional dead spots. Periodic division to fill such spots may be necessary. In coastal areas the plants are evergreen, but where winters are cold and plants are exposed, browning may occur.

### CROWN VETCH, Coronilla varia

Crown vetch is a perennial legume sometimes used to cover dry, steep, rocky slopes. The plant grows 1 to 2 feet tall and bears small pink flowers from July to September. The plant spreads by underground stems, and one plant can cover an area up to 6 feet in diameter. It tolerates shade but thrives in full sun. The foliage dies to the ground by December. Crown vetch is most valued for its ability to prevent soil erosion. It is often used for this purpose on highway slopes. The plant is suited for covering large areas and is too vigorous and invasive for small sections of the landscape.

The plant is propagated either from crowns or by seed. Crowns planted 2 feet apart will provide coverage in about 2 years. One crown per square foot is recommended for quick cover. It can be seeded further south with good results, but in northern New England crowns produce quicker effect.

### ENGLISH IVY, Hedera helix

English ivy is an evergreen, creeping vine forming a dense mat of dark-green foliage 6 to 8 inches tall. The plant grows best in shade or semi-shaded locations. It is most useful on north and east facing banks, under trees where grass will not grow, or under planted between shrubs. If exposed to full sun or sweeping winds, the foliage "burns" in the winter. Although it can be planted 1 foot apart for cover in 1 year, it is more economical to transplant growing plants from pots or flats in the spring at a spacing of 18 to 24 inches. Vines may grow about 3 feet the first season. When used next to buildings or walls, English ivy will climb, clinging by means of aerial rootlets. This may be an asset or fault depending upon the situation and personal preference. Its aerial roots have the ability to damage mortar between benches. 'Baltica' and 'Bulgaria' English ivy are hardy selections recommended for coastal and northern New England.

### HALL'S JAPANESE HONEYSUCKLE,

Lonicera japonica 'Halliana' Hall's honeysuckle is a branched, dense, semi-evergreen, woody vine which covers the ground and roots at the nodes. It is best used on large banks or other difficult situations where large areas must be covered. The plant is too vigorous and rangy for small areas. It should never be planted near trees or shrubs as it will climb them and eventually choke them out. The dark-green leaves appear early in the spring, turn bronze in the fall, and usually hang on most of the winter.

The fragrant flowers are white, turning a pale yellow with age. The plant flowers continuously in midsummer. The plant grows slowly until well established, then very robustly, attaining a height of 18 to 24 inches. It does well in sun or partial shade. The plant is tolerant of all soil conditions, including very dry soils.

### HOSTA/PLANTAIN LILY, Hosta spp.

For partially shaded areas, hostas make effective ground covers. They appear most often in perennial borders as accent plants or edgings, but their large leaves provide a lush covering for the soil. Hosta species vary in size and foliage color. Some have deep-green, yellow-green, blue-green, or grey-green foliage while others are edged or variegated with white or cream. Hostas may also produce lily-shaped flowers in white or lavender. Flower stems may be 6 to 24 inches tall, and plants range from dwarf (3 to 4 inches) to tall (2 feet) forms.

As a ground cover, hostas are best where the soil remains slightly moist. Excessively dry soil may cause the foliage to burn around the margins or partially die back. In full sun, leaf color is pale and leaf die-back may be more severe, especially during dry periods. In winter the foliage of hostas dies back leaving the ground exposed. However, new foliage develops quickly in spring and lasts well into the fall.

### PACHYSANDRA/JAPANESE SPURGE,

### Pachysandra terminalis

Pachysandra is a popular ground cover suitable for shady landscape situations. This evergreen plant spreads by underground stems and attains a height of 1 foot. The foliage is tinged purple in spring, becoming bright-green in summer and yellow-green in winter. Clusters of tiny, off-white blossoms appear above the leaves in May, but they have little ornamental value.

The plant is adapted to full or partial shade. When planted in full sun, growth is poor. It is one of the few plants that will grow under evergreens and in dense shade. The evergreen leaves commonly "burn" and turn brown in exposed places during the winter. Established plants are usually planted 1 foot apart in the spring. Clipping the tips of vigorous growing shoots in the spring will induce the plant to become more dense. The plants should not be cut all the way to the ground. The plant prefers a moist, highly organic, well-drained soil for best establishment. A planting of this ground cover is usually a uniform height throughout.

### COMMON PERIWINKLE/MYRTLE/VINCA,

### Vinca minor

Periwinkle or myrtle is an excellent, evergreen ground cover with dark-green foliage and purple, blue, or white flowers, depending on the variety. It blooms in April-May. The plant grows about 6 inches tall, spreading in all directions by sending out long trailing and rooting shoots which make new plants. It prefers shade. The foliage color is richer in mid shade, but more flowers are produced in light shade.

This ground cover is most commonly used for under planting trees and shrubs, on shaded slopes, or on the north side of buildings. Rooted cuttings or established plants are normally spaced from 12 to 18 inches apart. At a 6-inch spacing, a complete cover will be produced in 1 year. Plant in the spring in areas with severe winters. Spring flowering bulbs interplanted with periwinkle will lend color and interest to the ground cover planting. Daffodils are particularly well-suited since they bloom with periwinkle and do not require frequent division.

### PURPLELEAF WINTERCREEPER,

### Euonymus fortunei coloratus

Purpleleaf Wintercreeper is an excellent evergreen plant for covering relatively large areas, banks, slopes, and shaded areas under trees. The plant sends out prostrate stems which root where they contact moist soil. It will cling to vertical walls and surfaces it contacts and has the potential to do some damage. When established, this ground cover forms a loose, somewhat irregular network of stems to a height of 8 to 12 inches. Its deep-rooting habit makes it a good soil binder.

The medium-green evergreen foliage turns purplish-red in early fall, retaining this color throughout the winter. The plant does not produce flowers or fruit. Established plants are usually planted in the spring at a distance of 18 to 24 inches apart. One plant per square yard will make a cover in two or three growing seasons. Some pruning of upright shoots helps to keep the ground cover lower and more compact. The plant grows well in full sun or shade. It is suitable for most of northern New England, but winter kills in the far north or on sites exposed to winter wind and sun. In addition to the purpleleaf variety, there are numerous cultivars of wintercreeper that make excellent groundcovers.

### YUCCA, Yucca filamentosa

Yucca is a rugged plant able to take almost any situation. The plant is normally around 2 feet high with all the leaves arising from a central point at ground level in a rosette fashion. The leaves are long, pointed and rigid. In summer the plant produces a flower stalk about 4 feet high with a large head of pendulous, creamy-white flowers. Yucca is used as an accent plant and is frequently used in modern ground plantings. The plant is suited best to hot dry situations.

### **RUSSIAN ARBORVITAE,**

Microbiota decussata

This 12" tall evergreen groundcover resembles eastern white cedar in texture. With time, it can spread to a diameter of 12 to 15 feet. It performs best in full sun to partial shade, and moist well-drained soil. It is green in summer and purplish in winter.
### SEDUM/STONECROP, Sedum spp.

Over 300 species and 500 cultivars of sedums exist, ranging from tiny mats only a few inches high to plants 2 feet high. They are used as mass ground covers, in rock gardens, on slopes, between stepping stones, and even in containers. Most of the sedums are spreading or creeping plants that will root from broken branches or fallen leaves. Related to the cacti, their thick, waxy, generally evergreen leaves mean that they do not require large amounts of water. Most sedums are very drought tolerant, and will rot if kept too moist or if air circulation is poor. They are best used in full sun, where they produce flowers ranging from tiny yellow-green stars to large masses of small, pink to wine-colored flowers. Foliage color will also vary, from various shades of green to blues and bronzes.

### **ORNAMENTAL GRASSES**, numerous genera,

### species, and cultivars

The group of ground covers increasing most rapidly in popularity at present is the ornamental grasses. With heights ranging from under 1 foot (blue fescue) to over 5 feet (zebra grass), the ornamental grasses will generally have a member that can fit any landscape situation. Often used strictly as ground covers and for erosion control on slopes, ornamental grasses also make outstanding specimen plants when used as individual plants in the landscape. In addition to a wide range of heights and spread, there is tremendous variation in leaf size and color. Leaf colors range from pale greens to bright power blues and blood reds, with many types of both vertical and horizontal stripe patterns.

Most of the ornamental grasses require full sun and will produce a wide variety of flowers, ranging from small, bottlebrush arrangements to large, showy plumes. Flower colors range from pale yellows and pinks to deep maroons. Many of the flower spikes persist well into the winter giving added landscape interest, though the leaf clumps will generally die to the ground and regrow each spring.

Additional ground covers to consider include bearberry, hypericum, candytuft, goutweed, santolina, ferns, many plants often classified as perennials (such as daylilies), and various woody shrubs (Japanese holly, cotoneasters, *etc.*)

## List of Plants for Specific Purposes

### **Trees Resistant to Gypsy Moth**

### Species rarely fed upon:

ash	Fraxinus species
red cedar	Juniperus virginiana
honey locust	Gleditsia triacanthos
sycamore	Platanus occidentalis
tulip tree	Liriodendron tuplifera
white cedar	Thuja occidentalis
black walnut	Juglans nigra
black locust	Robinia pseudoacacia

#### Species fed upon when other foliage is gone:

hickory	Carya species	
black gum	Nyssa sylvatica	
hornbeam	Carpinus caroliniana	
red maple	Acer rubrum	
Norway maple	Acer platanoides	
sassafras	Sassafras albidum	
beech	Fagus grandifolia	

#### Thorned and prickly plants useful as barriers:

barberry	Berberis species
hawthorn	Crataegus species
flowering quince	Chaenomeles species
roses	Rosa species
red cedar	Juniperus virginiana
holly	Liex species
mahonia	Mahonia species

### **Plants to Attract Wildlife**

Birds and other animals seek food, shelter, water,and safe areas for reproduction. The plants listed help meet these requirements.

### Trees:

beech	Fagus species
oak	Quercus species
pine	Pinus species
red cedar	Juniperus virginiana
ash	Fraxinus species
birch	Betula species
cherry	Prunus species
dogwood	Cornus species
blackgum	Nyssa sylvatica
hickory	Carya species
holly	<i>llex</i> species
magnolia	Magnolia species
maple	Acer species
persimmon	Diospyros virginiana
tulip tree	Liriodendron tulipifera
service berry	Amelanchier species
sassafras	Sassafras albidum
crabapple	Malus species

### Shrubs:

sumac	Rhus species
spice bush	Lindera benzoin
viburnum	Viburnum species
yew	Taxus species
elderberry	Sambucus species
rhododendron	Rhododendron species
hawthorn	Crataegus species
Russian olive	Elaeagnus angustifolius
Oregon grape holly	Mahonia species
pyracantha	Pyracantha species

### Vines and other plants:

lackberry	
aspberry	
eaberry	
artridge berry	
oneysuckle	
/irginia creeper	
ittersweet	
okeberry	
lueberry	

## Plants Tolerant of Dry, Poor Soil

Get the plants listed here off to a good start by preparing the soil they are to be planted in and by watering until they are established.

### Trees:

graybirch	Betula populifolia
hackberry	Celtis occidentalis
junipers	Juniperus species
golden rain tree	Koelreutaria paniculata
osage orange	Maclura pomifera
Virginia pine	Pinus virginiana
red pine	Pinus resinosa
chestnut oak	Quercus prinus
locust	Robinia pseudoacacia
sassafras	Sassafras albidum

### Shrubs:

amur maple	Acer ginnala
Japanese barberry	Berberis thunbergii
quince	Chaenomeles species
smoketree	Cotinus coggygria
broom	Cytisus species
Russian olive	Elaeagnus angustifolia
witch hazel	Hamamelis virginiana
St. Johnswort	Hypericum species
privet	Ligustrum species
buckthorn	Rhamnus species
sumac	Rhus species

### Groundcovers:

yarrow	Achillea species
sweet William	Dianthus species
daylilies	Hemerocallis species
cinquefoil	Potentilla species
creeping phlox	Phlox subulata
St. Johnswort	Hypericum species

### **Plants Tolerant of Shade**

The degree of shade tolerance varies from plant to plant. Most will do well with some sun, especially those that flower.

### Trees:

red bud	Cercis canadensis
arborvitae	Thuja occidentalis
hemlock	Tsuga species

### Shrubs:

abelia	Abelia species
alders	Alnus species
chokeberry	Aronia species
aucuba	Aucuba japonica
barberry	Berberis species
Hinoki cypress	Chamaecyparis species
hollies	llex species
mountain laurel	Kalmia latifolia
leocothoe	Leucothoe fontanesiana
mahonia	Mahonia species
heavenly bamboo	Nandina domestica
pieris	Pieris species
rhododendron	Rhododendron species
yew	Taxus species
viburnum	Viburnum species

### Ground covers:

spurge	Pachysandra terminalis
periwinkle	Vinca minor
bugle weed	Ajuga species
lily-of-the-valley	Convallaria majalis
ferns	several
daylilies	Hemerocallis species
plantain lily	Hosta species
Virginia bluebells	Mertensia virgnica
primrose	Primula species
violets	Viola species

### **Plants Tolerant of Salt**

autumn olive	Elaeagnus angustifolia
honey locust	Gleditsia triacanthos
mulberry	Morus species
black locust	Robinia pseudoacacia
buffalo berry	Shepherdia argentea
tamarix	Tamarix gallica
white oak	Quercus alba
red oak	Quercus borealis
English oak	Quercus robur
white willow	Salix alba

### Plants with Colorful Autumn Foliage

### Shrubs:

Botanical Name	Common Name	Color	
		Range	Height
Acer ginnala	Amur Maple	Scarlet	8 feet
Cornus alba 'sibirica'	Siberian Dogwood	Red	9 feet
Euonymus alatus	Winged Euonymus	Scarlet	7 feet
Nandina domestica	Nandina	Scarlet	6 feet
Rhus aromatica	Fragrant Sumac	Yellow -scarlet	4 feet
Rhus copallina	Shining Sumac	Scarlet	25 feet
Rhus glabra	Smooth Sumac	Bright red	25 feet
Rhus typhina	Staghorn Sumac	Red	30 feet
Rosa rugosa	Rugosa Rose	Red -yellow	6 feet
Vaccinium species	Blueberries	Scarlet	3-25 feet
Viburnum species	Arrowwood	Red to burgandy	6-20 feet

### Trees:

Botanical Name	Common Name	Color	
		Range	Height
Acer saccharum	Sugar Maple	Red-yellow	Tall
Acer rubrum	Red or Swamp Maple	Red	Tall
Amelanchier laeois <i>virginicus</i>	<i>Chionanthus</i> Fringetree	Yellow	Medium
Cornus mas	Cornelian Cherry	Red	Small
Cornus kousa	Japanese Dogwood	Bronze to rec	d Small
Crataegus phaenopyrum	Washington Hawthorn	Scarlet /orange	Medium
Ginkgo biloba	Ginkgo	Yellow	Tall
Liquidambar styraciflua	Sweet Gum	Scarlet	Tall
Oxydendrum arboreum	Sourwood or Sorrel Tree	Scarlet	Medium
Pyrus calleryana 'Bradford'	Bradford Pear	Dark red	Medium
Quercus rubra	Red Oak	Red	Tall
Quercus coccinea	Scarlet Oak	Scarlet	Tall
Sassafras albidum	Sassafras	Orange /scarlet	Medium

### **Plants with Attractive Fruit**

### Shrubs:

Botanical Name	Common Name	Fruit Color	Season	Height	
Aronia arbutifolia	Red Chokeberry	Red	Fall	8 feet	
Berberis thunbergii	Japanese Barberry	Red	Fall-Winter	5 feet	
Callicarpa japonica	Japanese Beautyberry	Purple	Fall	6 feet	
Cotoneaster species	Cotoneaster	Red	Fall	1-15 feet	
Elaeagnus multiflora	Cherry Elaeagnus	Red	Mid Spring	9 feet	
Euonymus alatus	Winged Euonymus	Scarlet	Fall	7 feet	
llex verticillata	Winterberry	Red	Fall-Winter	7 feet	
Ligustrum lucidum	Evergreen privet	Blue-black	Fall-Winter	10 feet	
Lonicera species	Bush Honeysuckle	Red	Spring-Fall	8-15 feet	
Mahonia aquifolium	Oregon Holly Grape	Bluish-black	Spring	6 feet	
Nandina domestica	Nandina	Red & white	Fall-Winter	6 feet	
Pyracantha coccinea lalandei	Pyracantha or Firethorn	Orange	Fall-Winter	6-20 feet	
Rhus glabra	Smooth Sumac	Scarlet	Fall-Winter	15-20 feet	
Rhus typhina	Staghorn Sumac	Crimson	Fall-Winter	15 feet	
Rosa species	Rose	Red	Fall	6 feet	
Symphoricarpos albus	Snowberry	White	Fall	3 feet	
Viburnum dilatatum	Linden Viburnum	Red	Fall	10 feet	
Viburnum opulus Viburnum	European Cranberry b	ush	Red	Fall-Winter	10 feet

### Trees

Botanical Name	Common Name	Fruit Color	Season	Height
Acer ginnala	Amur Maple	Red	Summer	20 feet
Crataegus species	Hawthorn	Red	Fall	15-30 feet
llex opaca	American Holly	Red	Fall-Winter	45 feet(marginal)
Juniperus virginiana	Red Cedar	Bluish	Fall-Winter	75 feet
Liquidambar styraciflua	Sweet Gum	Brown	Fall	100 feet
Malus species	Crab Apple	Red to yellow	Fall	20-40 feet
Melia azedarach	Chinaberry	Yellow	Fall-Winter	40 feet
Oxydendrum arboreum	Sourwood or Sorrel Tree	Grayish	Fall-Winter	75 feet
Sorbus species	Mountain Ash	Red	Fall	30 feet
Evergreens with cones		Brown	Fall-Winter	75-100 feet

### Vines

Botanical Name	Common Name	Fruit Color	Season	Height
Ampelopsis brevipedunculata	Porcelain Ampelopsis	Lilac-blue	Fall	25 feet
Celastrus scandens	American Bittersweet	Yellow-red	Fall-Winter	30 feet
Euonymus fortunei	Wintercreeper	Orange	Fall	30 feet

### New Hampshire Plant Hardiness Zone Map

Average Winter Minimum Temperatures

U.S. Dept. of Agriculture		Arnolo	dArboretum
Zone	Degrees (F)	Zone	Degrees (F)
3A	-35 to -40	3	-20 to -35
3B	-30 to -35	4	-10 to -20
4A	-25 to -30	5	-5 to -10
4B	-20 to -25	6	-5 to -5
5A	-15 to -20		
5B	-10 to -15		
6A	-5 to -10		
6B	-0 to -5		

Adapted from the latest U.S.D.A. hardiness range map by Charles H. Williams, UNH Extension Specialist-Ornamentals. 1991



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# CHAPTER 17

# **Composting Processes**

Taken from the 1993 King County, WA Master Recycler Composter Training Manual Edited and revised by Nancy E. Adams, University of New Hampshire Cooperative Extension

In this chapter we will examine the potential for recycling organic debris through natural processes of decomposition. This includes the biological processes that transform organic materials into compost, the uses for compost, and the benefits of compost for soils and plant growth. We will focus on composting of yard debris and food scraps.

## Introduction to Composting

Yard debris and food "wastes" are valuable resources. They are also the most economical and practical materials suited for composting, because they are large, easily separated parts of our waste stream. We will look at home composting options as well as centralized composting operations.

Terms introduced in this chapter include:

- Organic wastes
- Carbon:Nitrogen ratio
- Vermicompost
- Holding unit
- Turning unit
- Mulch
- Fertilizer
- Soil amendment
- Compost
- Humus
- Bacteria
- Soil structure
- Soil aggregates
- Micronutrients
- Macronutrients
- Grasscycling



## What is "Organic"?

Anything that is alive or was once alive is "organic." All plants and animals, and anything made from plants or animals, is organic. Any wastes generated by plants and animals, or remaining after we use products made from a plant or an animal, are also organic. Organic products are an important part of our economy and of our lives. Some of the common organic materials that we use and dispose of daily are listed in *Figure 1.* 

As *Figure 1* illustrates, organic materials account for much of what we consume and throw away every day. Paper products alone make up over one third of our waste. Yard debris comprises an estimated 17 percent of our garbage, and food wastes another 7 percent. Due to the sheer volume of organic wastes produced, the way that we choose to handle these materials is one of the most important waste management decisions that we face today.

Figure 1.

### **Common Organic Materials**

**Food** — Fruits, vegetables, grains, eggs, dairy products, meat, and fish.

**Clothing and Furnishings** — Cotton, wool, burlap, leather, feathers, and down.

**Building Materials** — Lumber, plywood, and other wood-based materials.

**Paper Products** — Paper, newsprint, cardboard, and tissues

**By-products** — Food processing wastes, sawdust, blood, bones, and fur.

Animal Wastes — Manure, sewage, and hair.

**Yard Debris** — Grass clippings, leaves, prunings, fallen branches, and trees.

# Decomposition: a Problem and a Solution

Organic materials have many different qualities and uses, but all organic materials have a common trait which sets them apart from other waste materials: organic wastes naturally break down into a rich, soil-like material called compost. Decomposition is inevitable. When organic wastes are separated from trash and allowed to decompose with an adequate air supply, they can be turned into a valuable soil amendment which helps plants grow better, protects soil from erosion, and conserves other resources.

In some situations, particularly landfills, decomposition can create serious problems. When buried, organic materials decompose in the absence of air, or anaerobically, and produce methane gas. This can create a problem if the methane gas migrates into nearby buildings, creating a danger of explosion. As rain or groundwater percolates through a landfill, weak acids are produced by decaying organic matter. As these acids wash through the landfill they react with other trash, creating a potentially toxic leachate which can contaminate groundwater, lakes, and streams.

# Landfilling and Burning of Leaf & Yard Waste

### NH RSA 266:3 VI

Beginning July 1, 1993, NH RSA 266:3 VI takes effect. It states that "no leaf or yard waste shall be disposed in a solid waste landfill or incinerator including any waste to energy facility. This paragraph shall not apply to municipalities organized under RSA 53-A, RSA 53-B, or 1986, 139, if application of the paragraph would cause the municipality to violate or incur penalties under legal obligations existing on the effective date of the paragraph. Any generator or transporter who violates this paragraph shall be subject to the penalties and enforcement provisions of RSA 149-M:12."

**266.4 Effective Date.** This act shall take effect January 1, 1993.

(Approved May 18, 1992)

(Effective Date January 1, 1993).

# Composting: Nature's Recycling System

The natural processes of decomposition are the basis for recycling systems for many types of organic materials. Some of the organic waste composting systems currently being promoted as solutions to our solid waste problems include:

- Backyard composting of yard debris and food scraps.
- Mulching organic wastes to protect soil from erosion and help establish new plantings on disturbed lands.
- Centralized composting of yard debris, such as local curbside collection.
- Mixed waste composting of soiled paper, food wastes, and other organic materials.
- Co-composting of sewage sludge with sawdust or shredded yard debris.

Each of these composting systems has advantages and disadvantages. Which system is preferred for a given situation depends on the convenience and availability of transportation and markets, and the volume and type of organic waste to be handled, whether the waste generators involved are large or small, concentrated or dispersed. Yet all of these systems operate on the same biological principles which are described in the following sections.

# **Compost Flora and Fauna**

### Bacteria: Powerhouse of the Compost Pile

The most numerous organisms in a compost pile are bacteria. Too small to be seen individually, the effects of bacterial activity are easy to detect. Bacteria generate the heat associated with composting, and perform the primary breakdown of organic materials, setting the stage for larger decomposers to continue the job.

Bacteria don't have to be added to compost.

They are present virtually everywhere, and enter the compost pile with every single bit of added organic matter. Initially, their numbers may be modest, but given the proper conditions (proper moisture, air, a favorable balance of carbon



Bacteria

and nitrogen, and lots of surface area to work on) bacteria can reproduce at a remarkable rate.

Bacteria are unicellular micro-organisms which reproduce by division: simply growing a wall through the middle of their cells and dividing into two. Then they do it again and two cells become four, then four cells become eight, and so on. This might not be as impressive if it didn't happen so fast. One gram of the common bacteria *Escherichia coli* would become a pound in three hours, and a mass the size of the earth in one and a half days if sufficient food and proper conditions were available.

Many types of bacteria are at work in the compost pile. Each type thrives on special conditions and different types of organic materials. Even at temperatures below freezing some bacteria can be at work on organic matter. These psychrophilic bacteria (a grouping of bacterial species that includes all those working in the lowest temperature range) do their best work at about 55  $^{\circ}$ F, but they are able to carry on right down to 0  $^{\circ}$  F. As these bacteria eat away at organic wastes, they give off a small amount of heat. If conditions are right for them to grow and reproduce rapidly, this heat will be sufficient to set the stage for the next group of bacteria, the "mesophilic," or middle-temperaturerange, bacteria.

Like us, mesophilic bacteria thrive at temperatures from 70 to 90 °F, and just survive from 40 to 70°F, or from 90 to 110°F. In many compost piles, these efficient mid-range bacteria do most of the work. However, given optimal conditions, they may produce enough heat to kick in the real hot shots, the "thermophilic," or heat-loving, bacteria.

Thermophilic bacteria work fast, in a temperature range of 104 to 200 °F. Unless the compost pile is turned at strategic times or new materials are added to the pile, the bacteria will work for only four to seven days until their activity peaks and the pile cools down below their optimum range. But what activity in those four to seven days! In that short time, they turn green, gold, and tan organic material into a uniform deep brown. If the pile is turned to let more air in, the thermophilic bacteria will feast for another four to seven days. (Large compost piles with a volume of several yards or more can retain enough heat to keep thermophilic bacteria alive for several weeks or longer).

In all of this work, the bacteria are not alone though at first they are the most active decomposers. Other microbes, fungi, and a host of invertebrates take part in the composting process. Some are active in the heating cycle, but most organisms prefer the cooler temperatures of slow compost piles or proliferate only when hot piles start to stabilize at lower temperatures.

### **Nonmicrobial Composters**

A compost pile is a real zoo. Besides the many types of bacteria, a multitude of larger organisms, many of them feeding on the spent bacteria and their byproducts, add diversity to the compost pile. The following is just a sampling of some of the more common organisms in this diverse group. (Much of this information about nonmicrobial composters is quoted from Dr. Daniel L. Dindal's slide show, *The DecomposerFoodWeb*).

Actinomycetes are a type of primary decomposer common in the early stages of the decomposition of the pile. Actino-

mycetes produce greyish cobwebby growths throughout compost that give the pile a pleasing, earthy smell similar to a rotting log. They are fre-



**Fungi** also perform primary decomposition in the compost pile. Fungi send out thin mycelial fiber-like roots, far from their spore-forming

reproductive structures. The most common of the reproductive structures are mushrooms that sometimes pop up on a cool pile. Though they are major decomposers in the

compost pile, fungal decomposition is not as efficient as bacterial decay. The growth of fungi, even more than bacteria, is greatly restricted by cold temperatures. Since they have no chlorophyll, fungi must obtain their food from plants and animals. Parasitic fungi exist on living plants or animals. Most fungi are saprophytic, living on decayed vegetable and animal remains.

**Nematodes,** or roundworms, are the most abundant invertebrates in the soil. Typically less than 1 millimeter in length, they prey on bacteria, protozoa, fungal

spores, and each other. Though

there are pest forms of nematodes, most of those found in soil and compost are beneficial.





Fermentation mites, also called mold mites, are

transparent-bodied creatures

that feed primarily on yeasts in fermenting masses or organic debris. Literally thousands of these mites can develop into a seething mass over a ferment-



ing surface. Their presence in a compost pile is a good sign.

Springtails, along with nematodes and mites,

share the numerical dominance among soil invertebrates. They feed principally on fungi, although they also eat nematodes and small bits of organic



detritus. They are a major population controlling factor on fungi.

**Wolf spiders** are truly "wolves" of the soil and compost microcommunities. They don't build webs, but merely run freely hunting their prey. Depending on the size of the spider, their prey can include all sizes of arthropods, invertebrate animals with jointed legs and segmented bodies.

Centipedes are found frequently in soil and

compost microcommunities. They prey on almost any type of soil invertebrate near their size or slightly larger.



Sow bugs feed on rotting woody materials and

highly durable leaf tissues, such as the veins comprised of woody xylem tubes. Sow bugs that roll up like an armadillo are known as pill bugs or roly polys.



Ground beetles have many representatives

lurking through litter and soil spaces. Most of them feed on other organisms, but some feed on seeds and other vegetable matter.



Redworms play an important part in breaking

down organic materials and in forming finished compost. As worms process organic materials, they coat their wastes with a mucus film that binds small



a mucus film that binds small particles together into stable aggregates and helps to prevent nutrients from leaching out with rainwater. These stable aggregates give soil a loose and well-draining structure.

# Unwanted Guests: Pests of the Compost Pile

Given a comfortable or nourishing environment, pest species will be attracted to the action in the composting pile. Common pests in compost systems include house and fruit flies, rodents, raccoons, and domestic animals such as cats and dogs. Rats are probably the least-wanted guests of all. In a hospitable environment with plenty of food, their numbers increase quickly and they may become transmitters of disease. Although pests may take residence in any compost pile, they are especially attracted to the same high-quality foods that humans and our pets like to eat. So it is important to keep kitchen scraps, including vegetable and fruit scraps, meat, fish, dairy products, grains, and pet food out of yard debris compost piles. Safe methods for composting many food wastes will be discussed in this chapter.

# **Basic Compost Farming**

Put a pile of leaves, an old cotton rag, or a freshly cut board out in the environment, and decomposition is bound to occur. How long the process takes depends on a number of factors: the makeup of the materials, the amount of surface area exposed, the availability of moisture and air, and the presence of insulating materials around the decomposing object.

It is useful to think of composting as growing microorganisms. Just as a farmer keeps in mind the basics of fertility, cultivation, irrigation, and the season when growing a crop; a good composter focuses on the materials being composted, their preparation, and their moisture content to ensure a healthy compost crop. Fortunately, as composters we can do much more to control the conditions in a compost pile than a farmer can do to control the weather.

Understanding how to create the ideal composting conditions described here will allow you to make compost quickly and help you to diagnose and solve other peoples' composting problems. But remember that provided sufficient time, perfectly good compost can be made without the preparations described here.





### Materials: "Greens" and "Browns"

All living organisms need relatively large amounts of the element carbon (C) and smaller amounts of nitrogen (N). The balance of these elements in a material is called the carbon-to-nitrogen ratio (C:N). This ratio is an important factor determining how easily bacteria are able to decompose an organic material. The microorganisms in compost use carbon for energy and nitrogen for protein synthesis, just as we use carbohydrates for energy and protein to build and repair our bodies. The optimal proportion of these two elements used by the bacteria averages about 30 parts carbon to 1 part nitrogen. Given a steady diet at this 30:1 ratio, bacteria can decompose organic material very quickly (*see Figure 2*).

It helps to think of materials high in nitrogen as "greens," and woody, carbon-rich materials as "browns." There is often a visual correlation between high nitrogen content in green plant material, and high carbon content in brown materials. *Figure 3* lists the C:N ratios for several common organic wastes.

As the chart illustrates, most materials available for composting don't have the ideal carbon to nitrogen ratio. One way to speed-up composting is to combine nitrogen-rich "green" materials (such as grass clippings) with carbonaceous "brown" materials (such as autumn leaves) to create a mix having a 30:1 carbon-to-nitrogen ratio. This works best on a weight, rather than volume, basis. For instance, a mixture of one-half brown tree leaves (40:1 ratio) could be used with one-half fresh, green grass clippings (20:1 ratio) to make a pile with the ideal 30:1 ratio. The C:N ratios listed in *Figure 3* are only guidelines. For instance, brown grass clippings from an unwatered lawn will have far less nitrogen content than green clippings from an abundantly fertilized lawn. Similarly, the leaves from different types of trees vary in the C:N balance. There are also some confusing exceptions to green-nitrogen, browncarbon correlations. For instance, evergreen leaves are low in nitrogen, and brown-colored animal manures are often high in nitrogen.

The best way to become familiar with C:N balancing is to try to be specific about it for a while, then relax into an intuitive assessment of what a pile needs. Think like a chef varying the ingredients for a recipe. Be curious, write down the type and quantity of materials used, and take note of the temperature your pile reaches and the quality of the finished compost. After a while, the process becomes as intuitive as cooking.

Figure 3.

Average Carbon:Nitrogen Ratios					
Food scraps	15:1				
Grass clippings	19:1	Greens			
Rotted manure	25:1				
	30:1	Ideal			
Corn stalks	60:1				
Leaves	40 - 80:1				
Straw	80:1				
Paper	170:1	Browns			
Sawdust, wood chips	500:1				

### Surface Area

A melting block of ice provides a good analogy for how surface area affects the speed of decomposition. A large block of ice melts slowly, but when it is broken into smaller pieces the surface area increases, and the ice melts more quickly.

Similarly, when large, coarse, or woody organic materials are chopped or shredded into smaller pieces, the composting process speeds up *(see Figure 4)*. With more surface area exposed, bacteria have greater access to easily available food, so they can reproduce and grow quicker, producing more heat. While breaking organic materials into smaller pieces speeds up the decomposition process, it isn't essential in order to compost them. In some instances, such as when using organic wastes as mulches, slow decomposition is advantageous. The less surface area that is available on a mulch, the slower it decomposes and the longer it will continue to control weeds, slow evaporation, and stop soil compaction and erosion.

#### Figure 4.





### **Moisture and Aeration**

All compost organisms need a certain amount of water and air to survive. The amounts of air and water in a compost pile form a delicate balance that must be maintained for rapid decomposition to take place. Too much air circulating in the pile can make the pile too dry for bacteria to function. At less than 40 percent moisture, the bacteria are slowed by the lack of water. At greater than 80 percent moisture, there is not enough air for "aerobic" decomposition to continue. Anaerobic bacteria, which thrive in the absence of oxygen, can take over the pile. Anaerobic decomposition is slow and can produce unhealthy by-products, including an odor similar to rotten eggs.

Optimal moisture levels for composting occur when materials are about as moist as a wrung-out sponge. It should be obviously moist to the touch, but yield no liquid when squeezed. This level of moisture provides organisms with a thin film of water on materials, while still allowing air into their surroundings.

If a compost pile is too wet, it should be turned (pulled apart and restacked) to allow air back into the pile and loosen up the materials for better drainage. Mixing materials of different sizes and textures also helps to provide a well-drained and well-aerated compost pile. *Figure 5* shows the effect of turning. If an undecomposed pile of yard debris becomes dry it needs to be pulled apart and watered as it is restacked. Watering an intact pile from above is not effective as dry organic materials often shed water. Dry materials must be gradually wetted and mixed until they glisten with moisture. Prolonged exposure to winter rains can effectively soak a dry compost pile. It is best to cover a pile once materials are uniformly moist to retain moisture and to prevent the pile from becoming anaerobic.

### Compost should be about as moist as a wrung-out sponge. It should be obviously moist to touch, but yield no liquid when squeezed.

## Figure 5.





### Volume

For fast, efficient composting, a compost pile must be large enough to hold heat and moisture, and small enough to admit air to the center. As a rule of thumb, compost piles need to be a minimum size of 3 ft. by 3 ft. by 3 ft. (1 cubic yard).

A smaller pile will dry out easily, and cannot retain the heat required for quick composting. However, by insulating the sides of smaller piles, higher temperatures and moisture can be maintained.

The upper size limits for a compost pile are about 5 ft. by 5 ft. by any length. Larger piles must be turned frequently or have "ventilation stacks" placed throughout the pile to allow air into the interior to prevent anaerobic conditions from forming. *Figure 7* shows the effect pile volume can have on decomposition.

### **Time and Temperature**

The hotter the pile, the faster the composting process. As we've seen, temperature is dependent on how we manage our microorganism farm. A home compost pile built with proper consideration of carbon to nitrogen ratios, surface area, volume, moisture, and aeration, can produce stabilized compost in as little as three weeks. A commercial composting operation, which thoroughly shreds materials and turns or aerates piles, may require six to 12 weeks to produce finished compost. The smaller particle sizes and increased pile volumes of larger systems reduce aeration in the interior of piles, slowing down the process. With less attention to the details of materials used and the environment provided for them, a cooler, slower pile can be built. Low-maintenance methods of composting will still create an excellent compost, but may take six months to two years to yield finished compost.

# **Compost Benefits and Uses**

Whether a compost pile is quick and hot or slow and cool, when the decomposer organisms have completed their work, the contents of the pile have been transformed into an entirely new material. Most of the wastes that made up the pile are no longer recognizable in the finished compost — with the exception of some persistent, woody parts. What remains is dark, loose, crumbly material that resembles rich soil. The volume of the finished compost has been reduced because of biochemical breakdown and water respiration to about 30 to 50 percent of what went into the pile. The compost is now ready to use for growing new plants, and begin the cycle over again.

## **Beneficial Properties of Compost**

Compost will improve the quality of almost any soil. The main benefit is to improve the "structure" of the soil. The structure of a soil determines its ability to drain well, store adequate moisture, and meet the many needs of healthy plants. Although compost provides important nutrients, it is not a substitute for fertilizers. More important than the nutrients supplied by compost is its ability to make existing nutrients more easily available to plants.

### Soil Structure

The value of compost as a soil amendment is suggested by its appearance. Even a casual observation of soil amended with compost shows that it is made up of many round, irregular "aggregates." Aggregates are groups of particles loosely bound together by the secretions of worms and compost bacteria. If these aggregates are rubbed between a finger and thumb, they break down into smaller aggregates. In between and within the aggregates themselves are many small air channels like the empty spaces left in a jar of marbles. A well-structured soil with lots of small aggregates stays loose and easy to cultivate. The channels that aggregates create through the soil allow plant roots and moisture to penetrate easily. The smaller pores within the aggregates loosely hold moisture until a plant needs it. The larger pore spaces between the aggregates allow excess water to drain out and air to circulate and warm the soil.

By encouraging the formation of aggregates, compost improves the structure of every type of soil: silt, sand, or clay. In loose sandy soils, compost helps to bind unconsolidated particles together to retain water and nutrients that would normally wash right through. Added to a clay or silt soil, compost breaks up the small tightly bound particles and forms larger aggregations, which allow water to drain and air to penetrate.

Figure 8.	
pH Levels of	Soil
Material	рН
Recycled yard debris compost	5.5 – 7.5
Sphagnum peat moss	3.5
Douglas fir bark	3.6 – 3.8

### **Nutrient Content**

Dark, loose compost *looks* like it should be rich in nutrients. Indeed, compost contains a variety of the basic nutrients that plants require for healthy growth. Of special importance are the micronutrients present in compost, such as iron, manganese, copper, and zinc. They are only needed in small doses, like vitamins in our diet, but without them plants have difficulty extracting nutrients from other foods. Micronutrients are often absent from commercial fertilizers, so compost is an essential dietary supplement in any soil.

Compost also contains small amounts of the macronutrients that plants need in larger doses. Macronutrients include nitrogen, phosphorous, potassium, calcium, and magnesium. These nutrients are usually applied in measured amounts through commercial fertilizers and lime. The three numbers listed on fertilizer bags (e.g., 10-10-10) refer to the percentage of the three primary macronutrients nitrogen, phosphorous, and potassium (N-P-K) available in the fertilizer. Although compost generally contains small amounts of the these macronutrients, they are typically present in forms that are not readily available to plants. When applied in four to six inch layers, compost may provide significant amounts of these nutrients. However, due to the variability and slow release of major nutrients, compost is considered a supplement to fertilization with more reliable nutrient sources.

### **Nutrient Storage and Availability**

To understand how compost is able to store nutrients and make them available when needed by plants requires a closer look. When viewing compost through a microscope that enlarges things 1,000 times, individual compost particles resemble the aggregates that are observed with the unaided eye. Like the aggregates, individual particles of compost contain many porous channels. Just as the channels in the aggregates provide space to store water, these spaces in the compost particles provide spaces to store nutrients.

The sides of the channels provide vast surfaces inside the particles where individual ions of minerals and fertilizers can cling. These ions are given up to plant roots as the plants require them. Thus, compost is able to store nutrients that might otherwise wash through a sandy soil or be locked up in the tight spaces of a clay soil.

The ions clinging to the surfaces of our compost particles tend to be those that give soil a "neutral" pH. A measure of soil acidity or alkalinity is its pH. The acidity or alkalinity of a soil affects the availability of nutrients to plants. Most important plant nutrients are relatively easily available to plants at a pH range of 5.5 to 7.5. At pH levels above this range (alkaline) or below this range (acid), essential nutrients become chemically bound in the soil and are unavailable to plants. Recycled yard debris compost typically has a pH range of 5.5 to 7.5. When mixed into soil, this compost will help keep the pH at optimum levels for nutrient availability. The pH levels of some common soil amendments are compared in *Figure 8.* 

### **Beneficial Soil Life**

Taking a step back from the microscopic view, another beneficial characteristic of compost is evident. The presence of redworms, centipedes, sow bugs, and others shows that compost is a healthy, living material. The presence of decomposer organisms means that there is still some organic material being slowly broken down which is releasing nutrients. They are also indicators of a balanced soil ecology, which includes organisms that keep diseases and pests in check. Many experiments have shown that the rich soil life in compost helps to control diseases and pests that might otherwise overrun a more sterile soil lacking natural checks against their spread.

### **Compost Uses**

Compost is a much needed resource. It is not only useful to the home gardener, but is essential to the restoration of landscapes where topsoil has been removed or destroyed during construction or mining operations. Compost is increasingly being applied to agricultural and forest lands depleted of their organic matter. The most common use of compost today is probably in topsoil mixes used in the landscape industry.

Compost is typically applied in three ways:

- 1. To mulch or "top dress" planted areas
- 2. To amend soil prior to planting
- 3. To amend potting mixes

### Mulching

Gardeners and landscapers use mulches and top dressings over the surface of the soil to suppress weeds, keep plant roots cool and moist, conserve water, maintain a loose and porous surface, and prevent soil from eroding or compacting. Compost serves all of these purposes and also gives plantings an attractive, natural appearance. Compost can be used to mulch around flower and vegetable plants, shrubs, trees, and ground covers.

To prepare any area for mulching, first clear away any visible grass or weeds that might grow up through the mulch. Make sure to remove the roots of any weedy plants which spread vegetatively, such as quack grass, ivy, and buttercup. Different types of plants benefit from varying application rates and grades of mulch. Recommended uses of compost as mulch and top dressings are shown in Figure 9.

#### Figure 9.

### Using Compost as Mulch On flower and vegetable beds:

Screen or pick through compost to remove large, woody materials. They are less attractive, and will compete for nitrogen if mixed into the soil.

Apply ½ to 1 inch of compost over the entire bed, or place in rings around each plant extending as far as the outermost leaves. Always keep mulches a few inches away from the base of the plant to prevent damage by pests and disease.

### On lawns:

Use screened commercial compost, or sift homemade compost through a ½ inch or finer mesh. Mix with an equal amount of sand or sandy soil.

Spread compost / sand mix in 1/4 to ½ inch layers after thatching or coring, and before reseeding.

### On trees and shrubs:

Remove sod from around trees and shrubs as far as branches spread. If this is impractical, remove sod in a circle a minimum of 4 feet in diameter around plants.

Use coarse compost or material left after sifting. Remove only the largest branches and rocks.

### For erosion control:

Spread coarse compost, or materials left after sifting, in 2 to 4 inch deep layers over entire planting area or in rings extending to the drip line.

Mulch exposed slopes or erosion prone areas with 2 to 4 inches of coarse compost.

## Soil Amendment

Compost can be used to enrich garden soils before planting annuals, ground covers, shrubs, and trees. Many commercial topsoil mixes contain composted yard debris or sewage sludge as a major component, along with sand, sandy soil removed from construction sites, peat moss, and ground bark.

Amend soils by mixing compost or topsoil mixes thoroughly with existing soil. If a rich compost or topsoil mix is laid on top of the existing soil without mixing, the zone where they meet can become a barrier to penetration by roots and water. In this condition, plantings often develop shallow roots and eventually blow over or suffer from lack of water and nutrients. Recommended applications for different situations are shown in *Figure 10.* 

### Figure 10.

### **Using Compost as Soil Amendment**

# In flower and vegetable beds and ground covers:

Dig or till base soil to a minimum 8 to 10 inch depth.

Mix 3 to 4 inches of compost through the entire depth. For poor soils, mix an additional 3 inches of compost into the top 3 inches of amended soil. In established gardens, mix 2 to 4 inches of compost into top 6 to 10 inches of soil each year before planting.

### **Planting lawns:**

Till base soil to 6 inch depth.

Mix 4 inches of fine textured compost into the loosened base soil.

### Planting trees and shrubs:

Dig or till base soil to a minimum 8 to 10 inch depth throughout planting area, or an area 2 to 5 times the width of the root ball of individual specimens.

Mix 3 to 4 inches of compost through the entire depth. For poor soils, mix an additional 3 inches of compost into the amended topsoil. Do not use compost at the bottom of individual planting holes or to fill the holes. Mulch the surface with wood chips or coarse compost.

## **Potting and Seedling Mixes**

Sifted compost can be used to make a rich, loose potting soil for patio planters, house plants, or for starting seedlings in flats. Compost can be used to enrich purchased potting mixes or to make your own mixes.

Plants growing in containers are entirely reliant on the water and nutrients that are provided in the potting mix. Compost is excellent for container growing mixes because it stores moisture effectively and provides a variety of nutrients not typically supplied in commercial fertilizers or soil-free potting mixes. However, because of the limits of the container, it is essential to amend compost-based potting mixes with a "complete" fertilizer to provide an adequate supply of macronutrients (N-P-K). Simple "recipes" for making your own compost mixes are shown in *Figure 11*.

### Figure 11.

### Using compost in potting mixes

For starting and growing seedlings in flats or small containers:

Sift compost through a 1/2 inch or finer mesh.

Mix 2 parts sifted compost, 1 part coarse sand and 1 part Sphagnum peat moss. Add ½ cup of lime for each bushel (8 gallons) of mix. Use liquid fertilizers when true leaves emerge.

# For growing transplants and plants in larger containers:

Sift compost through 1 inch mesh or remove larger particles by hand.

Mix 2 parts compost; 1 part ground bark, Perlite or pumice; 1 part coarse sand and 1 part loamy soil or peat moss. Add ½ cup of lime and ½ cup of 10-10-10 fertilizer for each bushel (8 gallons) of mix. (An organic fertilizer alternative can be made from ½ cup blood or cottonseed meal, 1 cup of rock phosphate, and ½ cup of kelp meal.)

# Managing Organic Materials at Home

With an understanding of the value of finished compost and the biological processes that transform organic materials, it is easy to see why people would want to compost organic materials at home. Home composting not only provides a free soil amendment, but also reduces the cost of garbage collection and landfilling. Composting at home is a winning proposition.

Many of the common organic materials identified earlier are materials we generate at home and are candidates for home composting. These include yard debris, kitchen scraps, sawdust, soiled paper and cardboard, hair, pet wastes, and natural fiber fabrics. However, just because a waste *could* be composted at home does not mean that it *should* be. Some of these organic materials, including many yard clippings, are better managed by not producing them in the first place. Others, such as meat and other animal or fatty food wastes, invite so many problems that we are better off putting them into the trash.

Part of your role as a Master Gardener may be to help people decide which approaches are most appropriate for their unique situation. The decision depends on what materials are available, how much time and effort a person is willing to spend, the space available, costs, aesthetic considerations, and what options are available. To guide these decisions you must be familiar with the entire range of home composting methods and the types of materials and maintenance styles best suited to each of these systems.

The first step in selecting a management strategy for organic materials generated at home is to understand what options are available. When we apply solid waste management priorities to organic materials, we create the following hierarchy of options:

- 1. **Reduction** Landscaping strategies and practices that reduce the amount of yard debris.
- 2. **Reuse** Composting of materials for reuse onsite.
- 3. **Recycling** Collection of organic materials for processing and marketing by centralized composting facilities.

The following sections examine the specific practices involved in each of these options.

### **Source Reduction**

Source reduction principles should be applied to purchases of organic products as they are to any other. But how can we be selective about the wastes that come out of our yards and gardens? When autumn comes we cannot decide that the leaves won't fall. And we can't very well selectively cut the grass, can we?

In fact, we can choose to reduce organic materials generated at home. The choices are fewer than the multitude of choices we can make at the supermarket, but the process is the same and the results can be just as impressive.

### **Determine Needs**

There are three main questions that we can ask ourselves about how we generate yard debris to determine if we "need" to be producing so much waste.

- 1. *How do you use your yard?* These uses affect the amount of space devoted to high-maintenance/ high-waste-producing components, such as lawn and annual flower beds, as opposed to low-maintenance plantings or paved areas.
- 2. Is the level of maintenance you provide essential for plant health and the reasonable appearance of the yard? Yard debris can be reduced by less pruning, mowing, watering, and fertilization without sacrificing appearance and health.
- 3. Are there materials that can be put to use at home that are currently being disposed?

### **Identify Alternatives**

A number of steps can be taken to reduce the amount of organic wastes generated in our landscapes. The alternatives range from simple changes in maintenance procedures to complete re-landscaping of yards to create self-sustaining composting systems. Several source reduction options are described here, starting with the simplest and moving to more involved strategies.

### Grasscycling

Grass clippings are the largest single component of landscape waste in most yards. Yet it is actually healthier for the lawn to leave the clippings on the lawn than to remove them. Letting the clippings remain on the ground returns nutrients to the lawn, adds organic matter to rejuvenate the soil, conserves moisture, and saves time and money on bagging. Grasscycling does not contribute to build-up of "thatch," which is an accumulation of dead roots and stems.

It helps to have a lawn mower that is designed to "mulch" grass clippings back into the turf. Mulching mowers, now widely available, recirculate the clippings through the blades, chopping them into tiny pieces and blowing them down into the grass. Reel-type mowers are also effective at cutting the clippings small enough so that they are not conspicuous when left on the lawn. Other mowers may be adapted by modifying the outlet spout to direct clippings down rather than out.

During periods of fast growth and wet weather, grasscycling may require more frequent cuttings, to avoid heavy deposits of clippings. But without bagging the clippings, each mowing can take half the time.

### Mulching

Many common yard clippings make excellent mulches or soft "paving" for paths and play areas. Grass clippings, leaves, and pine needles are all suitable for mulching landscapes. Wood chips from pruning and removing trees are a natural looking substitute for "Beauty Bark." This material can often be obtained for free by calling a tree service.

Yard debris mulches can be applied following the same methods described for using compost as mulch *(see Figure 9).* Mulch annual flower and vegetable gardens with nonwoody materials that break down quickly and can be tilled under without competing with plants for nitrogen. If woody materials, such as sawdust or wood chips, are used in an annual garden they must be pulled aside before tilling, or they must be balanced by adding a high-nitrogen fertilizer such as blood meal when tilling them in.

Trees and shrubs can be mulched with one-half to one inch layers of grass clippings, or with two to four inch layers of wood chips, twigs or pine needles. Avoid making thick layers of fine green materials, as they can mat down, becoming anaerobic and acting as impenetrable barriers to air and water.

### **Selective Fertilization and Watering**

Selective use of fertilizers and water, applied at the correct time in proper amounts, actually makes lawns healthier and more tolerant of stress, and produces less waste. Lawns should be fertilized in spring and early autumn to encourage strong root development. For more information on lawn fertilization, see the chapter on lawns in this handbook.

### **Turn In Crop Wastes**

At harvest time, chop or till crop wastes from annual vegetable and flower gardens into the soil. Spring crops will decompose quickly if cut when they are still succulent, or you can add nitrogen fertilizer to speed decomposition. Fall crop wastes can be turned in or left cut roughly on the surface to protect soil from erosion and compaction, then tilled in with fertilizers a few weeks before spring planting.

### **Alternatives to Lawns**

Reducing the size of one's lawn can produce less debris and conserve fertilizer, water, labor, and other resources. Many low-maintenance ground covers can be used to replace grass in low-traffic areas. In many cases, ground covers will be healthier and more attractive than lawns grown in less than optimum conditions, and they certainly require less work to stay attractive. Many low, spreading shrubs also provide interesting alternatives to lawns.

Areas used heavily as paths or play areas can be replaced by wood chips. To create a low-maintenance, long-lasting path or play area, remove the sod and lay down two or three overlapping layers of corrugated cardboard to suppress weed growth. Cover the cardboard with four to six inches of chip; it will compact as it is walked on.

### **Natural Landscapes**

Many people are replacing high-maintenance lawns and shrubs with more natural-looking wooded areas (with native and other understory plantings and shade-loving ground covers) or wildflower meadows. An initial thick layer of wood chip or other yard debris will help create the woodland look and reduce watering, weeding, and other maintenance. These woodlands also provide areas to reduce grass clippings, leaves, needles, and other trimmings by using them as mulches. Meadow areas (probably away from the street or borders with neighbors) can be seeded with wildflowers and pasture grasses with attractive seed heads. These meadows are attractive when left unwatered and unmowed, or only mowed once each summer after flowering.

### Selection

Sometimes major changes in the layout of a garden or maintenance plan are not possible. In these cases, it is important to carefully select landscaping practices to reduce waste. Here are some general criteria to use in selecting yard debris management options.

- 1. Reduce or reuse as many materials as possible at home (or on-site at public facilities). On-site reuse or composting is the most efficient land-scape waste management option.
- 2. Use organic materials diverted from other sites whenever possible to meet landscape needs. Consider trading unwanted plants or plant divisions with neighbors and friends. Always try to reuse wastes, such as wood chips and animal manures, before purchasing new materials that would provide the same service.
- 3. Buy compost and mulch products made from recycled yard debris whenever possible for potting mixes, soil amendments, and other garden needs.

## Reusing Organic Materials: Home Composting

Composting at home is an easy way to reuse yard debris. Home composting methods range from "no work" techniques that require maintenance once or twice a year, to active turning methods that are maintained weekly. Composting systems can be categorized by the type of materials they process: yard debris, food wastes, or pet wastes. In addition to considering the materials to be composted, the composting method chosen depends on how much space is available, the time and effort that the composter is willing to spend, and how quickly the compost is desired. The following sections review common home composting systems and discuss their advantages and drawbacks. Figure 12 lists the brochures available from New Hampshire to help people choose and use a home composting system.

### **Composting Yard Debris**

Yard debris can be composted in simple holding units where it will sit undisturbed for slow decomposition, or in turning bins, which produce finished compost in as little as a month. Not all yard debris is appropriate for home composting. *Figure 13* lists the types of debris considered appropriate for home composting and materials to avoid. **Holding Units** are simply bins used to keep decomposing materials in an organized way while they break down. Using a holding unit is the easiest way to compost. It requires no turning or other labor, except for placing the debris into the bin as it is generated.

Non-woody materials, such as grass clippings, crop wastes, garden weeds, and leaves, work best in these systems. Decomposition can take from six months to two years. The process can be reduced to just a few months by chopping or shredding wastes, mixing green and brown materials, and maintaining proper moisture.

Since materials are added continuously, they decompose in stages. Generally, the more finished compost is located inside and at the bottom of the pile, while partially decomposed materials are near the top. Once or twice a year, remove the finished compost and return the undecomposed materials to the holding bin.

Some examples of holding units include circles of snow fencing or stiff hardware cloth (not poultry wire), old wooden pallets lashed together, and stacked cinder blocks. There are also a variety of commercially available bins made from wood, molded plastic, or metal.

Figure 12.

### **NH Composting Brochures**

UNH Cooperative Extension offers a number of brochures and workbooks about composting. **Titles include:** 

*Backyard Composting* (a flyer prepared with the NH Governor's Recycling Program especially for backyard composters. Cost: Free)

*Composting: Wastes to Resources* (designed for adult volunteers, leaders, camp counselors, and teachers who want to set up composting projects with youth. Cost: \$8.00)

*Composting to Reduce the Waste Stream* (a guide to small scale food and yard waste composting. Cost \$7.00)

*Municipal Leaf & Yard Waste Composting* (a planning guide for New Hampshire communities. Cost: Free. Contact: Governor's Recycling Program; 271-1098)

**Turning Units** are typically a series of bins used for building and turning hot, fast compost piles or for slowly accumulating debris in cool piles that are turned occasionally for aeration. Barrels or drums are also used as turning units, mounted either vertically or horizontally for easy turning. Turning units allow wastes to be conveniently mixed for aeration on a regular basis. This speeds composting by providing bacteria with the air they need to break down materials. Given the proper mix and preparation of materials, turning piles will also generate the heat required to kill weed seeds, insect pests, and plant diseases.

Turning units can be expensive to buy or build, and hot composting requires substantial effort (see *Figure 15*). However, the effort and expense is rewarded with high-quality compost produced in short periods of time.

Hot composting must be done in batches using enough material to fill a 3 ft. by 3 ft. by 3 ft. bin, or about two-thirds of a barrel composter. Materials should be chopped, moistened, layered, and mixed as described in *Figure 16.* Hot piles should be monitored and turned after temperatures peak and begin to fall. Compost prepared in this way can be ready for use in three to four weeks.

Composting in rotating barrel units requires the same attention to balancing of carbon and nitrogen, chopping, and moisture control. If the materials are properly prepared and the barrel is rotated every two to four days, compost can be ready to use in two to three weeks.

Figure 13. Composting Materials

### Yard Debris Acceptable for Home Composting

**Grass clippings**: Our most common organic waste at home.

**Yard Trimmings**: Old plants, wilted flowers, small prunings from shrubs and trees.

**Leaves**: Deciduous leaves are ideal for composting. Evergreen leaves are slow to decompose and may need to be shredded before composting.

**Weeds**: Weeds make fine compost, if seed heads, rhizomes, and other vegetative reproducing parts are kept out.

**Plant-derived food scraps**: Vegetable and fruit waste can be composted with yard debris in a properly prepared hot compost pile or worm bin.

**Wood chip**: Wood chip is a product resulting from tree trimming. Tree services will gladly leave some from work in your neighborhood.

**Sawdust**: Sawdust from unpainted, untreated wood without glues (i.e., no plywood) can be composted in worm bins or in yard debris piles in small amounts.

**Cardboard and paper**: Soiled cardboard and paper are not acceptable for recycling, but they can be torn up and composted with yard debris, or used under wood chip paths to suppress weeds.

### Organic Materials That Should Not Be Composted At Home

Everything that was once alive will compost, but not everything belongs in your compost pile. Some materials that create problems and should be kept out of home compost systems include:

Plants infected with a disease or a severe insect attack: Insect eggs and disease spores can be preserved or the insects themselves could survive in most home compost piles (examples are apple scab, aphids, and tent caterpillars). These materials should be composted in large commercial systems which uniformly reach high, pasteurizing temperatures.

lvy, succulents, and certain pernicious

weeds: Plants which spread by rhizomes; such as Morning glory, Buttercups, Quack grass, and Comfrey may not be killed even in a well built hot pile in a home compost system. They can choke out other plants when compost is used in the garden. These plants should be composted in large commercial systems which uniformly reach high, pasteurizing temperatures.

**Cat and dog manures**: Even though you find these in your yard, they are not yard wastes. Pet wastes can contain pathogens harmful to people. These wastes should be buried in ornamental areas of the garden, or flushed down the toilet.

**Waxy leaves**: The waxy leaves of plants such as Rhododendron, English Laurel, and Pine needles break down very slowly. Try composting small amounts of these mixed with other materials, or shred them for use as mulch. Large amounts of these leaves should be composted in large commercial systems which uniformly reach high temperatures and involve mechanical shredding processes.



Figure 15.

**Compost Turning Units** 



Wood slat three-bin turning system



Cinder block and wood turning unit.



Rotating barrel composting unit



Chapter 17 Composting Processes

### **Building a Hot Compost Pile**

Hot compost piles are the only effective way to compost food and yard wastes together without pest problems. They can also kill plant diseases and weed seeds and will produce compost in a short period of time. Unfortunately, many home compost piles, even when built carefully, do not attain the high temperatures needed to kill diseases and pests uniformly throughout the pile. Diseased or insect-infested plant materials are best composted in large commercial operations where high temperatures are uniformly produced throughout the compost pile.

### To Build a Hot Compost Pile:

- 1. Gather enough green and brown materials to make at least a 3 ft. by 3 ft. by 3 ft. pile (1 cubic yard) and to approximate a 30:1 carbon to nitrogen balance.
- 2. Shred or chop coarse and woody materials to increase their surface area. Semi-woody yard wastes like corn stalks can be cut up with a pair of pruners, or chopped with a machete or square point spade on a block of wood. Even some pounding with the back of a hatchet will create entry ways for decomposer organisms. A wide range of shredders and chippers are available for yard debris, or a rotary lawn mower can be used to shred leaves on a hard surface such as a driveway.
- 3. Start building the pile with a 4 to 6 inch base of the coarser, brown wastes (small branches, corn stalks, straw) to help air circulate from below. Moisten each layer.
- 4. Add a 4 to 6 inch layer of nitrogen materials. If the greens are not very fresh, sprinkle a small amount of blood meal or cottonseed meal, high nitrogen fertilizer such as ammonium sulfate, vegetative food scraps, or poultry manure over this layer. Food wastes may make up a part of this layer. Highnitrogen materials such as fresh grass clippings or vegetative food wastes should be used in thinner layers. Moisten and mix the green and brown layers together, so bacteria can feed on both layers simultaneously.

- 5. Continue alternating and mixing layers of green and brown materials, adding water and extra nitrogen-rich materials as needed, until the bin is full.
- 6. Close the lid or cover the pile, and wait.
- **7.** Monitor the temperature of the interior of the pile on a regular basis. It should peak between 120 to 160°F in 4 to 7 days.
- 8. When the temperature begins to decrease, turn the pile. Take materials from the outer edges and top of the pile and place them at the base and middle of the new pile; those from the middle should be on the outside edges and top of the new pile.
- 9. Continue monitoring the temperature in the pile.
- **10. About one week later, turn the pile again after the temperature of the pile peaks.** After another week the compost should be finished.



Turning a compost pile

### **Composting Sod and Weeds**

Weeds that spread through roots or rhizomes and sod stripped from a lawn require special, covered compost piles. The roots of these plants — including Quack Grass, Buttercup, and Morning Glory — will sprout and spread through compost piles unless light is completely excluded. Small volumes of these weeds can be composted in any system that effectively excludes light and prevents their spread into soil. A covered garbage can or extra thick black plastic bag can be used as a "weed holding pile." To compost large quantities of stripped sod, simply pile the fresh cut sod, (roots up/grass down), in a square or rectangle up to three feet high. Make sure each layer is thoroughly wet, and cover the entire pile (including the sides) with black plastic or a tarp. Sod piles may take one to three years to completely decompose. Decomposition of sod piles can be shortened to as little as six months by sprinkling each layer with a high-nitrogen fertilizer, such as cottonseed meal or ammonium sulfate.

Do not put flowers and seed heads of any weeds into sod piles or any other home compost system. Weed seeds can only be killed by the high uniform temperatures of a large compost pile.

### **Composting Food Scraps**

Although non-fatty food scraps can be composted with yard debris in properly maintained hot piles, it is difficult for most people to maintain the conditions required for successful hot piles. Improperly composted food wastes can attract pests, create unpleasant odors, and make the compost unhealthy to handle. As Master Gardeners, encourage people to practice two other methods for safely composting food scraps:

- 1. To incorporate them into the soil where they will decompose and fertilize established or future plantings,
- 2. To compost them in worm bins which produce rich "castings" and use the castings as a mulch or soil amendment.

*Figure 17* lists the types of food scraps appropriate for home composting and those that are inappropriate.

**Soil Incorporation.** This is the simplest method for composting kitchen scraps. Dig a hole one foot deep. Chop and mix the food wastes into the soil, then cover with at least eight inches of additional soil. Depending on soil temperature, the supply of microorganisms in the soil, and the carbon content of the wastes, decomposition will occur in one month to one year.

Food waste burial can be done randomly in fallow areas of the garden, or in an organized system. One such system is to bury scraps in holes dug around the drip line of trees or shrubs.

An English system, known as "pit and trench" composting *(Figure 18)* maintains a three-season rotation of soil incorporation and crop growth.

The garden includes three rows: a trench in which to bury food wastes, a row for growing crops, and a third row to use as a path. In the next season, the fertile soil of the former compost trench is used to grow crops, the former crop row is left fallow and used as a path, and the compacted path is loosened and dug as a new trench to bury food wastes. After a third season of rotation, the cycle starts over again. This form of composting keeps the garden perpetually fertile with little organizational effort.

#### Figure 17.

Compostable Foo	d Wastes
<u>Can Be Used</u>	Cannot Be Used
Can Be Used Apples Apple peels Cabbage Carrots Celery Coffee grounds, filters Egg shells Grapefruit Lettuce Onion peel Orange peel Pears Pineapple Botatoes	Cannot Be Used Butter Bones Cheese Chicken Fish scraps Lard Mayonnaise Meat scraps Milk Peanut butter Sour cream Vegetable oil Yogurt
Pumpkin shells Squash Tea leaves and bags Tomatoes Turnip leaves	

### Figure 18.

### **Pit and Trench Composting**



### Worm Composting

Worm composting systems use "redworms" (not earthworms) to compost food scraps. Redworms can be purchased, found in leaf or manure piles, or taken from another worm bin. Worm bins are usually wood boxes with tightly fitting lids that provide redworms with a dark and moist environment, while excluding rodents and other pests. (*See Figure 19*) Surface area is more important than depth in sizing a worm system; generally, one square foot of surface is required for every pound of food waste to be composted per week. Drainage must be provided by drilling small holes in the bottom of the bin.

The worms live in moist "bedding" made from shredded newsprint, corrugated cardboard, sawdust, fall leaves, or other high-cellulose materials. Scraps are buried in this bedding, and the worms turn the food wastes and bedding into a highquality soil amendment suitable for use on house plants, vegetable seedlings, and flowers. With a basic understanding of worms, these vermicomposting systems are simple to maintain.

Two or three times a year, when most of the contents of the bin have become dark "worm castings," the compost may be harvested. The finished compost will be greatly reduced in volume from that of the original materials, and should only fill one half or less of the bin. The compost may be harvested by moving it all to one side of the bin and adding fresh bedding to the empty side. Then you begin burying food waste in the new bedding. The worms will finish decomposing the old bedding and then migrate to the fresh bedding and food scraps, allowing the finished compost to be harvested.

Worm bins are fun and interesting. Mary Appelhof's book *Worms Eat My Garbage* is the best single source of information about these "living" garbage disposals.

Figure 19.

Worm Composting Bin



Figure 20.

### **Composting Criteria**

### Materials

Types of organic materials to be composted.

### Cost

Amount of money required to buy or build a particular system.

### Labor

Amount of time and energy needed to maintain the compost system.

### Aesthetics

Types of materials and construction that are attractive and fit into a particular backyard. Also, how neatly the system organizes the compost.

### Efficiency

Amount of time and space required to make compost, and the desired quality and quantity of the finished product.

### Pest Control

How well pests are excluded.

# CHAPTER 18

# Who are the Master Gardeners?

Edited and revised by Holly Young, UNH Cooperative Extension and Judith Lonergan, formerly with UNH Cooperative Extension

The purpose of this section is to explain why the Master Gardener Program was created, what Master Gardeners do, and how they are a part of Cooperative Extension . This section also explains many of the tasks Master Gardeners perform, and suggests ways you can improve your telephone, writing, and public presentation skills.

# The Cooperative Extension System

In all states where the program exists, Master Gardeners are trained and supervised by Cooperative Extension (CE). In fact, Cooperative Extension created the Master Gardener Program. When you work as a Master Gardener, you are acting as a representative of CE. In New Hampshire, Master Gardeners are covered by the University of New Hampshire's general comprehensive liability policy. Transportation is excluded from this policy. For more information, contact your county educator.

So, what is Cooperative Extension?

# Genesis of the Cooperative Extension System

The CE grew out of the U.S. Congress' concern for the education of the average citizen. Prior to the Civil War, very few college courses addressed the problems of citizens who made their livelihood from agriculture. In 1862, however, Congress passed the Morrill Act, which provided for a university in every state which would educate citizens in agricultural and mechanical fields. These colleges are known today as "Land-Grant Universities."

Congress soon realized that to be effective, the educational function of land-grant universities must be supplemented with a research capability. Consequently, it passed the Hatch Act in 1887. This act provided for the establishment of facilities where colleges could conduct research into agricultural, mechanical, and related problems faced by rural citizenry. Finally, in order to spread the benefits of the landgrant universities into even the most rural and remote parts of each state, Congress passed the Smith Lever Act of 1914. This act provided for the establishment of the Cooperative Extension Service. As a result of the Smith Lever Act, there are now Extension offices in every county which serve to "extend" to the public the information which has been developed on the campuses and research stations of the land-grant universities. In fact, Extension agents are considered members of the university faculties, since their role is primarily educational.

# Organization of Cooperative Extension

As a Master Gardener, the vast majority of your contacts with the CE will be through your local Extension Educator and office. This is because local educators determine, within a set of state guidelines, how to teach and administer the Master Gardener Program in their individual Extension unit. Each Extension office in New Hampshire conducts programs in Agriculture (including horticulture), Forestry and Wildlife, Family, Community and Youth (the 4-H program). Master Gardeners generally fall within the Agriculture educator's sphere of responsibility, but many have used their horticultural skills to conduct programs in cooperation with other areas. In addition to administrative and program development assistance, the land-grant universities provide technical support to the local Extension office. This is essential, since no Extension Educator can know the answers to every question posed by the public. Consequently, universities employ experts, called Extension Specialists, in specific areas such as horticulture, soils, turf, tree diseases, insect problems, etc. Local Extension offices and their Master Gardeners often contact these Specialists for answers to difficult questions.

### **Volunteers in Extension**

Volunteer workers are one of the most important and unique aspects of Cooperative Extension. This is in keeping with Extension's philosophy that active citizen participation in planning and implementation ensures program success. As a Master Gardener, you will join this family of volunteers.

Each Extension office has an Advisory Council made up of local citizens and civic leaders who provide feedback and direction. Many Extension Educators ask Master Gardeners to serve on these boards. Other educators ask Master Gardeners to act as program coordinators who perform much of the administration of local Master Gardener activities.

# Creation of the Master Gardener Program

The Master Gardener Program was created by Extension to meet an enormous increase in requests from home gardeners for horticultural information. This increase derives primarily from the urban and transient nature of modern American life.

Fifty years ago, an Extension educator dealt with the questions of a few hundred farm families. In many regions, however, land that once constituted a single farm now encompasses several subdivisions, increasing the number of families an Extension office must serve by the hundreds. In addition, many of these new families are recent arrivals, and are unfamiliar with the grasses, shrubs, trees, diseases, etc, which comprise the micro environment of their new urban or suburban home. They often call their local Extension office for advice on what to plant and how to care for it. Consequently, the Master Gardener Program was created in 1972 in the state of Washington. Since then it has spread to 48 states. Master Gardeners have become a vital part of Extension's ability to provide consumers with up-to-date, reliable knowledge so they can enjoy and protect the value of horticulture around their homes. Master Gardening has also become a fun and useful volunteer activity which has given its participants a sense of community spirit, accomplishment, and intellectual stimulation.

# Your Responsibilities as a Master Gardener

When you enter the Master Gardener Program, you enter into a contract. In essence, you agree that in return for the training you receive, you will volunteer an equal number of hours back to Extension. Failure to complete this obligation means that you are not entitled to participate in Master Gardener activities. Upon completion of your training, you have one year to complete the agreed-upon volunteer service commitment, or "payback" time.

After you complete your payback time, you may choose to continue with the Master Gardener Program. Numerous people have worked as Master Gardeners for years and contributed substantial amounts of time to Extension--sometimes hundreds of hours! To be considered an "active" Master Gardener, however, you must agree to volunteer a minimum number of hours annually. This requirement varies from unit to unit, so ask your Extension Educator what pertains in your local program. If you choose not to continue in the program, you may not, thereafter, represent yourself as a Master Gardener.

Your Extension Educator determines what may be counted as work time and what may be counted as contributed time. The distinction between the two types of time allows local units some autonomy while ensuring one standard for any comparison of the total amount of time Master Gardeners put in around the state.

As an example, imagine that a Master Gardener agrees to talk to a local garden club about growing herbs. The Master Gardener spends one hour researching and preparing his or her speech. The Master Gardener decides to bake the herbs into cookies for the audience's appreciation; this takes one hour. The Master Gardener spends a half hour commuting to and from the talk location, and one hour giving the talk. This is a total of three and half hours of work as a Master Gardener. It is possible that the Extension educator may decide that baking the cookies was a nice gesture, but can't be counted as work time. In that case, this Master Gardener could count two and half hours work time and one hour contributed time.

Volunteer work is usually done within the geographical area served by the Extension unit office conducting the training. Master Gardeners can make special arrangements with their Extension educators, however, to participate in activities outside of their unit. Some Master Gardeners are retired and have a great degree of flexibility as when they can volunteer. Other Master Gardeners who are still working can make arrangements with their educators to volunteer in the evening or on weekends. Some volunteers perform tasks that can be done after-hours, such as research, writing, telephone-calling, and record-keeping.

### **Time Sheets**

Time sheets are used to keep track of the hours of time you volunteer as a Master Gardener. (Time sheets are available from your county educator.) Turn these in on a regular basis, as determined by your local county educator. Most educators will appoint a Master Gardener to keep track of these and tally your hours. Don't be lax in reporting your time; you deserve recognition for your efforts!

Time sheets are an important part of the Master Gardener Program. Not only do they allow Extension to reward volunteers for their hard work, but they are also valuable for program evaluation. The time sheets provide a record of the many ways Master Gardeners serve the public. Local and state governments, which fund Extension, are very interested in how effectively Extension uses tax revenues. Consequently, detailed time sheets benefit both the Master Gardener Program and its clients.

### Use of the title "Master Gardener"

The title *Master Gardener* should be used only by individuals trained in a Cooperative Extension program. The title is valid only when used by an active Master Gardener who is participating in a

program approved by an Extension educator. When an individual ceases to be active in the Master Gardener program, their designation as a Master Gardener ceases.

Master Gardeners should not display credentials or give the appearance of being a Master Gardener at a place of business unless that place has been designated as a site for Extension education. The title "Master Gardener" should not be used in a manner which implies Cooperative Extension endorsement of any product or place of business.

The title *Master Gardener* should be used only when doing unpaid volunteer work for Extension. When experienced Master Gardeners speak before groups on horticultural subjects, they may accept unsolicited reimbursements (such as reimbursements for expenses) or gifts. It is inappropriate, however, to seek speaking engagements for pay while participating in an authorized Extension activity and using the title *Master Gardener*.

### **Pesticide Recommendations**

UNH Cooperative Extension promotes an Integrated Pest Management approach to yard and garden problems. Master Gardeners know that the use of chemicals in the garden is usually a last resort. An experienced Master Gardener may suggest a non-chemical treatment if the cultural problem is one which is not specifically covered by Extension recommendations. N.H. Master Gardeners may not recommend chemical controls without approval from their county educator.

Even with approval from local Extension Educators, Master Gardeners must be very careful about chemical recommendations because the registration and use of pesticides are governed by the United States Environmental Protection Agency and the state Department of Agriculture. Under the amended Federal Insecticide, Fungicide, and Rodenticide Act (Federal Environmental Control Act of 1972), it is illegal to use a pesticide on a crop unless the crop is listed on the label. The given rate of application on the label may not be exceeded. Fines and other penalties vary according to the laws broken.

# **Master Gardener Positions**

Over the years the program has existed, the activities of Master Gardeners around the country have broadened considerably. When the program began, Master Gardeners mostly answered telephone requests for gardening information. They also staffed plant clinics and information booths. In many areas of the country, these tasks are still vital to Extension. In recent years, however, creative Master Gardeners and Extension educators have recognized that the talents which citizens bring to the Master Gardener program can be utilized in a variety of horticultural activities.

Some examples of activities N.H. Master Gardeners have participated in are listed below. Note that not all of these activities involve the examination or discussion of plants. All do, however, help Extension provide horticultural information to the public. If you think of an activity which uses your special talents, discuss this with your educator. He or she might agree it would be a good way for you to contribute to the Master Gardener Program and to Extension.

- Created and maintained demonstration gardens.
- Gardened with the elderly and handicapped.
- Worked at county fairs and plant clinics.
- Conducted a garden project for low income youth with Expanded Food Nutrition Education Program.
- Acted as liaison for Extension office in a residential area by answering gardening questions and taking soil samples.
- Wrote gardening articles for local newspapers.
- Conducted school gardening programs.
- Gave talks to groups interested in horticulture.
- Presented 4-H demonstrations.
- Instructed other Master Gardeners.
- Appeared as guests on televised gardening programs.
- Participated in on-site lawn and garden clinics.
- Worked in trial gardens at research station.
- Conducted garden tours.
- Planned and implemented public relations projects.

- Worked on special events projects.
- Planned and completed community beautification projects.
- Compiled plant lists for specific areas.
- Photographed Master Gardener activities.
- Developed educational fact sheets.
- Worked in the university soil testing lab.
- Created and maintained historic garden restorations.
- Maintained office reference library.
- Designed brochures.
- Solicited seed and plant donations for various projects.
- Designed and maintained community and school landscapes.
- Assisted with vegetable gardening project at county farm.
- Contributed to the preparation of the Master Gardener Handbook.
- Produced slide programs.
- Volunteered as 4-H leaders.
- Served on Extension Advisory Council.
- Served as a judge at county fairs.

## Communicating

As a Master Gardener, you will work with all sorts of people. These people will come to you with questions and problems about horticulture. To fully understand the client's problem and suggest a solution, you must be able to communicate effectively. This can be a challenge, since the object of discussion, the client's garden or plant, is often not present, and you must deduce the problem from a verbal description of the trouble.

Effective communication is not just a matter of speaking clearly and listening closely. As you listen to a client's description of his or her ailing indoor plant, you are trying to understand a situation that you have not experienced. It is very easy to leave out details when we describe something that is familiar. The client may not know that the color of the leaf edges or the proximity of heating ducts to the plant are important clues to the plant's problem. You can improve communication by asking questions. By thinking of all the possible symptoms and conditions that might match up with the described ailing plant, you can pose questions that should yield enough information to find the solution. It is a good idea to summarize your findings and present them to the client. Don't be afraid to say something like, "I am going to describe, in my own words, the condition of your plant as I understand it. Stop me if I have it wrong." After all, we are not talking books -- we're all merely human and what we mean and what we say are not always the same. Being human, we have ways of interpreting meaning from voice changes, gestures, facial expressions, and general body language, as well as words. The important point is to express our own understanding so the client can compare it with his or her knowledge of the situation.

There is a stumbling block to communication other than incomplete information from the client -- the Master Gardener's horticultural expertise. This can be a problem in at least two ways. The Master Gardener can know so much about a topic that he or she does not bother to listen to everything the client has to say. Or, the problem may be identified and possible solutions discovered, but the Master Gardener cannot describe necessary procedures in terms the client understands. Germination, propagation, and fertilization are all very nice terms, but they are quite useless if they draw blank looks. There is nothing wrong with basic, down-to-earth terms like grow, dig, and water -- go ahead and use them.

Although some people dispute this statement, no one knows everything. As a Master Gardener you know a great deal about horticulture, but remember that one of the most important things you know is how to find answers. In your work at plant clinics or at the Extension office phone, you will have access to excellent resource material. If your client's problem is too complex to readily solve with your knowledge and the aid of the resource material, take the person's name, address, and phone number and then find the time to answer the question thoroughly or see that it is answered by the Extension educator or a specialist.

# **Using the Telephone**

When working with clients by telephone, communication can be even more difficult because there are no visual clues to meaning. Listen carefully and ask many questions. Be sure to familiarize yourself with the office procedure for telephone use. Your Extension educator or someone on the staff should be able to provide you with such information as what to say when answering the phone and how to log calls.

Every time you make or receive a telephone call as a Master Gardener, you are representing Cooperative Extension. The impression you create can be a lasting one and may determine whether or not the person you are speaking with will continue to turn to Extension for assistance.

When the telephone rings, answer promptly -- quick service helps build a reputation of efficiency. Identify yourself -- it helps personalize the call and gets the conversation off to a good start. Be friendly by being a good listener so the caller will not have to repeat what is said. Be considerate by not carrying on two conversations at once. Callers should not be made to feel they are competing with people in the office for your attention.

Sound as good as you are. Show that you are wide awake and ready to help the person on the line. Use simple, straightforward language. Avoid technical terms and slang. Speak directly into the telephone, pronouncing words clearly. Talk at a moderate rate and volume, but vary the tone of your voice.

When you must leave the line to obtain information for the caller, it's courteous to ask, "Will you wait? Or shall I call you back?" If the person chooses to stay on the line, use the hold button (if your telephone has one) or lay the receiver down gently. Should it take longer than you expected to gather material, return to the line every 30 seconds or so to assure the caller you're working on the request. When you have the information, thank the caller for waiting. Transfer a call only when necessary, but if you must, explain why you're connecting the caller with someone else. Be sure the caller wants to be transferred. If he/she does not, offer to have someone call back. When answering for someone else, be tactful. Comments such as "He hasn't come in yet" or "She's just stepped out for coffee" can give the wrong impression. It's better to say "Mr. Jones is away from his desk right now. May I ask him to call you?" When you take a message, be sure to write down the name, time, date, and telephone number. Don't hesitate to ask the individual to spell his/her name or repeat the number.

You will occasionally speak with a caller who may be having a bad day and takes it out on you. Remain calm and don't take the comments personally. As long as you are trying, in a courteous manner, to help a caller, you are doing your job. Retain your sense of humor and give the caller your sincere attention.

Because people are calling you for information, you need to know how to utilize Extension publications on horticulture. Printed material is recognized as a means of saving the time of county staff members and specialists. However, publications should not be treated as free products. Find out what the office's policy is on publications and how conservative you need to be in their distribution. Ordering and distribution of Extension publications is now computerized and supplies can be obtained quickly.

## Writing Tips

Master Gardeners have plenty of opportunity to use writing skills. Some Master Gardeners help produce publications for local gardening needs, others prepare scripts for slide sets, and some write newsletters and columns for the local newspaper.

Organization and simplicity will help you achieve a well-written product. A great deal of time and crumpled paper can be saved by starting with a clearly defined purpose and outline. An easy way to understand the purpose of your writing is to create the title. A good title tells, in a few words, what the subject of the work is. "All about Grapes" indicates a great deal of material is going to be covered: history, varieties, culture, and uses of the fruit. If you are only writing about the culture or the pruning, say so. Do not mislead the audience. Once the title is written, you know how you should limit the topic and what should be covered. The roughest outline is better than none, and its bare-bones structure makes it easy to see the logic of the work you are about to create. It is much easier to repair holes in the logic at the outline stage than later,

when hard-won paragraphs or even pages may have to be removed. It's a lot like pruning -- easier done when there are no leaves on the tree. Make an outline after the topic has been captured in a title.

After the title and outline are complete, the writing can proceed. Address each topic on the outline, and soon the job will be finished. Remember the idea of a topic sentence for each paragraph. Explain each topic on the outline and back up what you say with information from professionals. If you really get stuck, examine the idea you are trying to express. Perhaps there is nothing more to say about it than the sentence that is already there. Perhaps it is irrelevant or misplaced in the outline. If all else fails, put the work aside and go find a garden to play in. A change of scenery and a little time away from the words can do wonders for clearing the head. When you come back to the work, the problem may be perfectly clear and the solution obvious.

Simplicity is essential to clear writing. Even though vague phrases invade business letters, news writing, television, and radio, there is no need to promote the trend. For instance, "We would like for you to stop by our office" can be replaced with "Please come into our office." The same message is conveyed with greater clarity using half as many words. If you find yourself struggling over a choice of words, try telling someone what you want to say. As you say it, listen to yourself, because you are probably using the words you need to write the same explanation. Avoid slang, jargon, and flowery or obscure vocabulary. You won't go wrong with the simplest English words used correctly. The goal of good writing is to communicate, not to confuse.

An interesting sentence carries a strong verb and few adjectives. If you must shorten a piece of writing, you can sacrifice adjectives and gain simplicity along with space. Articles (a, an, the) are often unnecessary. Some languages do not have articles at all; we can probably do without some of ours.

Perhaps the most common misunderstanding about writing is that it is easy. While it is true some people are more adept at writing than others, those who write well usually admit it takes work. Just as good gardeners must get their hands dirty, good writers spend hours rewriting and use dictionaries and grammar books constantly. They are not looking up words you've never heard of either. They check the actual meaning of "cultivate" or whether or not there is a hyphen in "damping-off." Make sure there is a good dictionary in the office and **use** it. Sometimes new publications need to be produced or existing ones adapted for local conditions. If the educator you are working with decides you can develop new materials for distribution, check office files for old publications and/or write the appropriate specialist. Some already available materials may only need slight modification. Remember that proper letterheads and policy statements are necessary on all materials sent out via franking privileges. After the publication is complete, send a copy to the appropriate specialist so that they can be shared with other units.

When producing new materials from old, be certain not to infringe upon a copyright. Most Extension materials are not copyrighted and may be used for Extension purposes. If you want to use copyrighted material or even parts of that material (this includes art work) written permission must be obtained from the publisher and often from the author or artist as well.

# **Public Presentations**

Because Cooperative Extension provides information and educates the community, you will have plenty of opportunity to appear before the public in your capacity as a Master Gardener, if you so desire. Not only do Master Gardeners meet the public at plant clinics but many Master Gardeners become so knowledgeable about a specific horticultural interest that they are invited to give talks to clubs and groups. This is a wonderful way to help Extension, as educators are often in demand for such talks. Educators and Master Gardeners are also called upon to provide workshops, demonstrations, and tours.

Most public presentations have four components: title, introduction, body, and summary. The title should be short, descriptive, and interest-catching, but most of all, it should tell what the subject is. The introduction tells the audience who you are and elaborates on the goal/content of the talk. This part of the presentation is often the key to success or failure as it sets the tone for the remainder of the program and should hook the interest of the audience.

The body of the presentation contains the substance and should satisfy the curiosity that brought the audience to the presentation. Use research-supported information and cite references whenever possible. The summary states the major points of the presentation in a logical sequence without details. This part should be short and clear. Following a presentation, be prepared to answer questions. Repeat questions for the audience when they are difficult to hear or understand, then answer them.

Public presentations take preparation to be successful. Don't be fooled by a casual delivery. Many people who appear to be relaxed and able to effortlessly speak before groups have actually spent many hours achieving this effect by preparing and practicing. To plan a presentation consider:

- Who the audience is
- Their general knowledge of the subject
- How technical the subject is
- Timeliness
- Appropriateness
- Purpose
- Materials
- Length of presentation.

After collecting materials, studying, and reviewing notes, Rehearse. Observe these points carefully during rehearsal:

- Are charts, graphs, and posters easy to see and read?
- Can the audience hear the speaker from anywhere in the room?
- Are the materials used in the demonstration arranged so they are accessible and easy to reach without fumbling and delay?
- Does the speaker make unnecessary apologies? Avoid saying "This is the first time I've done this" or "I'm not used to speaking before groups." Do the best job you can. The audience doesn't expect you to be perfect, and you are probably much better than you think.
- If you are giving a demonstration with another person, are the delivery and action coordinated or does one team member do so much the other's participation seems unnecessary?

If you are preparing an exhibit for public presentation here are some basic concepts to keep in mind when planning and setting it up:

- Choose one idea which can be explained in a simple, catchy statement. Use few printed words.
- Have a single center of interest to which the eye is drawn.
- Develop the story completely using as few items as possible. Clutter is not good for an exhibit.
- Create a design which is orderly, interesting, and artistic.
- Attract attention with movement, color, light, sound, or a clever title and attractive design, but not with all of these.
- Make sure that charts, posters, and other visuals are attractive, neat, clean, and easily read.
- Judge exhibit by asking if it attracts attention, arouses interest, conveys a message, is well-constructed for a neat and orderly appearance.
- Select people to tend exhibits who are wellinformed, can meet the public easily, and create a favorable impression.

Advertising public presentations is very important. Too often, well-prepared programs fail to reach a large audience for lack of adequate advertising. Word of mouth is not sufficient. Public events can be announced in newsletters, newspaper feature articles or regular columns, paid advertisements, radio or television public service announcements, and on posters displayed in appropriate locations. Sometimes it is helpful to find a local sponsor, such as a shopping center, a bank, or the chamber of commerce, to assist in financing and advertising an event. Be certain all arrangements with sponsors are clearly defined and responsibilities are agreed upon ahead of time. These arrangements must be approved by your county educator. When advertising outdoor events, such as garden tours or community garden walk-throughs, where no indoor facilities are available, include an alternative time and date in case of bad weather.

Preregistration can serve as an indicator of expected attendance. Some educators report good response for workshops that require pre-payment of minimal fees to cover costs of materials. Participants appear to be more motivated and interested after making a financial commitment. Slides may be available for use in public presentations through your Extension office.

If no slide sets are available for your use and there is adequate time for the project, you may want to produce a slide set. (Check with your county educator prior to beginning the project .) Begin with the same principles basic to good writing and speaking: clarify the subject and identify the audience.

It is best to plan the show and write the script before taking pictures. Illustrations and photographs should relate directly to the script. Decide what should be illustrated and prepare a list of objects and scenes to be photographed. Plan to shoot more pictures than you need and be ready to shoot retakes. Professional photographers often fill the wastebasket with rejects before finding the masterpiece we see published. Avoid complicated slides that show too much.

When presenting a slide program avoid phrases such as "This is a slide of ..." "Here we see. . ." "Now we're looking at. . ." "Next we have. . ." "This picture you're watching. . . ." Instead, talk about what is in the picture. Do not leave a scene on the screen too long, but never for less than 5 seconds. Slides shown longer than 1 minute tend to warp. Each time the topic changes in the script, the new subject should be identified immediately. Do not let the audience sit and wonder why they are suddenly looking at a wheelbarrow when just a second ago you were discussing beans. Do not lead up to the point, begin with the point and then explain it. Do not ask the viewer to recall a prior slide. If you want the audience to see the same slide twice, at different times in the program, provide two slides.

Be sure to view the slides before the talk so that you can be familiar with the equipment and to check for upside-down and reversed slides. Familiarize yourself with the script before the presentation. Reading the script to the audience yields a monotonous delivery that can be very dull. Answer some questions as they arise but avoid straying far from the topic.

Videotapes are now available for many topics, as well.

# **Radio and Television**

Extension educators have been presenting educational radio and television programs for many years. If you have an interest or experience in this area, you might want to volunteer to do a program or to work on the production of a program. Before producing a radio or television program, remember that while you will reach a large audience with one presentation, you will also increase demand for information from the Extension office as new people become aware of its existence. Always check with your county educator before committing to a mass media presentation.

First, let's look at radio program production. Before approaching a radio station with your ideas, consider the identity of the audience you want to reach. What is their age, sex, marital status? Are they renters or homeowners? What time of day are they likely to listen to the radio for information? Radio stations know who their listeners are and what they like. Find the best station for your information by matching your audience with the radio station they are most likely to hear.

Maximum impact can be obtained by a different program each day in the same time slot. People can then habitually tune in to find out what gardening tips you are offering. Plan a message approximately 30 seconds to 2 minutes in length. Longer messages cause listeners to lose interest.

After identifying the audience and preparing the program, make arrangements to meet with the program director at the station you have chosen. Take one or two sample programs with you. Some stations prefer to use their own personnel to prerecord messages from a script you have prepared. Others choose to have you record the message using their facilities. Beware of the live call-in or talk show format. These can lead to drawn out and uninteresting rambling sessions and can put the person with the answers on the spot if the question is unclear or controversial. Plan to record 1 or 2 weeks' worth of programs at each visit to the studio.

Whatever the format, the message should be clear and concise.

- Use common English and simple sentence structure.
- Keep stories or examples to a minimum, using them only to emphasize or clarify a point.

- Short (30 seconds to 3 minutes) time slots should address only one topic.
- Radio presentations are usually one-way conversations and are most effective when delivered in a somewhat conversational manner. Ad-libbing from a carefully prepared set of notes comes across better than reading from a script.
- Speak clearly, emphasizing important points. Avoid talking fast. Practice!
- Even in a short message, main points and especially control recommendations need to be repeated or else summarized at the end.
- Provide a means for obtaining additional information. This may increase the office work load, but it also increases the audience you are reaching. However, it is not a good idea to offer specific publications on the radio. The demand may exceed the supply and the station is often picked up in other counties or states.

Television broadcasts need to be well-prepared in advance, as do radio programs. However, the added visual dimension of the medium must be taken into consideration. Be certain the material you present is best for television, i.e., it can be made visually informative or entertaining. Demonstrations are good for television. Interviews can be done on radio. Television is good when visual examples are useful: healthy versus diseased plants, characteristic markings on insects, variety of color or petal shape in flowers. Find out ahead of time if the station can and will use your slides, films, or video tapes.

Before you get to the studio:

- Outline the material in a script. It does not have to be a word-for-word account, but should be in logical order and contain all the points you want to make.
- Approach script writing as a story telling experience. Tell an interesting and informative story.
- As always, use simple English words correctly. Avoid slang and jargon.
- Scripts should be like public presentations made in person, with a title, introduction, body, and summary.
- Use only the visuals that help tell the story and eliminate the others.

- Use 35 mm slides for visuals, not snapshots.
- Evaluate art work and visual props. You should be able to determine the main topic from 6 feet. Use photographs at least 8 by 10 inches in size when possible.
- Avoid detail in graphs and charts. Keep it simple.
- Mark on the script where slides/graphics should appear; be ready to make changes for the director.
- Leave sufficient time to have slides and other graphics processed.
- Prepare parts of the demonstration ahead of time if necessary.
- Obtain necessary approval and clearances for use of films and slides.
- Remember that color contrast may not be clear on black and white television sets. Use light and dark shades for good contrast.
- Rehearse in front of a mirror: check timing, eliminate any bad habits (head bobbing, frowning, fidgeting).
- Watch out for bad verbal habits (using too many ah's, um's, or ok's) and eliminate them.

A relaxed appearance is best, so wear appropriate but comfortable clothing. A brand-new outfit is not the best idea; you may find yourself uncomfortable and begin to adjust your clothing or look unhappy. Avoid white, plaids, bright colors, shiny fabrics, and bold patterns. Noisy or shiny jewelry can distract viewers from the material you are presenting. A fresh hairstyle or cut can look unnatural. Ask the television station personnel for additional tips on dress and makeup. Don't feel embarrassed about this admitted concern for your appearance. Television is a visual medium and the way you look is an important part of a successful production.

When you get to the studio, go over the script with the director. Decide on cues and positions and make a final check to be certain your slides and graphics are in order. A quick run-through will reveal any upside-down or backward images.

During the filming, speak in a natural tone. Relax. Imagine you are talking to a person just a few feet away. Maintain eye contact with the camera, unless advised otherwise. If you make an error, correct it naturally and without fuss. Just as in live presentations, don't apologize. Tell the viewers of other ways to obtain information on your subject. Most of all, enjoy the experience.

# The Master Gardener as Manager

Master Gardener volunteers make it possible for Extension educators to reach more people with horticulture programs than would be possible without them. This expansion of program services makes the educator more efficient, but increases responsibility. That is why it is important that Master Gardeners manage their own program. While the Extension educator continues to head the program, a Master Gardener volunteer can act as coordinator of the activities performed by volunteers. In some units there are several coordinators, each one responsible for a different geographic area or a different program need.

After the Master Gardener program becomes established in an area, volunteer coordinators can help strengthen the program by participating in the program's planning and goal-setting. By meeting and working with the Extension educator responsible for the program, you can help determine the needs of the community for horticultural information and the Master Gardener projects that would meet those needs. It is important at goal-setting time to determine how the program's success will be measured. Master Gardeners need to keep records of their work; the volunteer coordinator is in a good position to explain the importance of this to the other volunteers and to see that accurate records are kept.

If you have management skills or think you could become a good manager, express your interest so you can be considered for the position of coordinator. Some mental signals that might mean you are manager material: are you the one with the suggestions on how to schedule the plant clinics, staff the jobs that need doing, match workers, outline the tasks to be completed in order to accomplish the job?

The Master Gardener program needs a volunteer coordinator from the beginning. At the first training session, you may find yourself selected to help with the lecturer's audio-visual equipment or to help corral the students after a break. Coordinators begin with small jobs like this and take on more complicated tasks as the program progresses. Veteran Master Gardeners are often involved in decisionmaking concerning new projects, advanced training, and screening of new Master Gardeners.
## **Work Evaluation**

You, the Master Gardener, and your local Extension educator should plan to evaluate your performance of volunteer tasks and in return, the adequacy of support from the Extension Office. The purpose of this is to ensure your satisfaction with volunteer work and to determine whether the tasks you perform are worthwhile for you, the community, and Extension.

As a volunteer you should expect the following from Extension employees for whom you work:

- Concise explanation of jobs and opportunities for volunteer service.
- Staff guidance and support in accomplishment of tasks.
- Maintenance of records of task accomplishments.
- · Recognition of outstanding accomplishments.
- Integration of Master Gardener volunteers as full partners in the accomplishment of Extension's mission to the citizens of the community.
- Continuous Master Gardener training opportunities.
- Periodic evaluation of Master Gardener performance.

Extension, in turn, expects the following from you:

- Assistance in developing meaningful jobs and opportunities for Master Gardeners.
- Timely notice of needs and support from the Extension Staff for required tasks.
- Reporting of tasks accomplished, number of hours involved, and task evaluation at specified reporting time.
- Acting as an equal partner in the Extension team in a manner that reflects credit upon you and the Cooperative Extension.
- Recruitment of additional individuals for future Master Gardener training.
- Participation in periodic conferences with an Extension educator to evaluate task(s) performed and Extension's support of Master Gardener tasks.

## The Master Gardener Paycheck

As you know, volunteers are not paid with money, but we hope that the gratitude of your fellow paid workers in the Extension office and the district and state staff will help you feel that your work is appreciated. Certainly the number of citizens who come to you with plant problems will indicate that you and your knowledge are needed.

As you do your job, you will probably begin to notice some of the pay that volunteers traditionally enjoy. You are, after all, a Master Gardener, and your horticultural and communication skills qualify you to do some interesting work. Your sense of accomplishment and pride in a job well done are assets that only you can collect.

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