Chapter 3.
Plant Biology for Rights-of-Way Vegetation Managers

Table of Contents

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Important Terms

annual
biennial
broadleaf
bulb
bulbous perennial
cambium
chlorophyll
conifer
cotyledon
creeping perennial
dicotyledon
evaporation
evergreen
fern
fibrous root
forbs
grass
hardwood
heartwood
inner bark
leaf axil
life cycle
mature
monocotyledon
nutrients
outer bark
perennial
phloem
photosynthesis
reproductive
respiration
rhizome
rosette
sapwood
sedge
seedling
seeds
simple perennial
spores
stolon
summer annual
taproot
translocation
transpiration
tuber
vascular bundle
vegetative
veins
vine
winter annual
woody plant
xylem

Although weeds are only one of several types of pests, they are the most important pest problem on rights-of-way. Therefore, it is important to have a basic understanding of plant biology, and how it influences weed management practices.

A plant is considered a weed when it is growing where it is not wanted. Some plants are considered to be weeds in rights-of-way because they interfere with the function and maintenance of the right-of-way. Weeds may obscure vision of signals, signs, crossroads, and other cars; prevent inspections; create a fire hazard; cause communication and power interruptions, provide cover for rodents; and restrict drainage in ballast, ditches, and channels. Some plants cause skin irritation and some can be poisonous to humans or animals. In addition, most states have regulations that identify certain problem plants as noxious weeds.

There are many methods of classifying plants. Most place the plants into larger groups, for example annual vs. perennial or grass vs. broadleaf. Being able to classify plants is important for the right-of-way applicator. For instance, some herbicides will kill broadleaf plants but have no effect on grasses. Selectivity of a herbicide may not apply to large categories. For example, a product may be effective on some tree species, but not all.

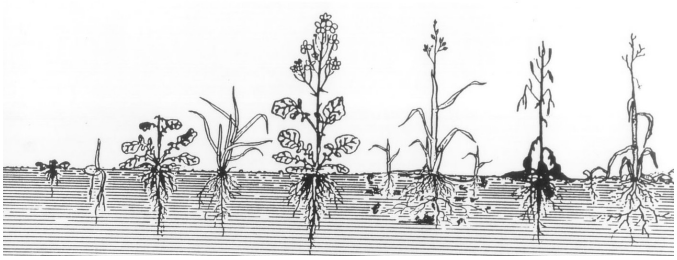

Figure 1. The four stages of weed development.

GROWTH STAGES

Nearly all plants have four stages of development (Figure 1):

-seedling
-vegetative
-reproductive
-mature (senescent)

In the **seedling** stage, seed leaves (cotyledons) may be present along with the first true leaves. At this stage, plants are small and easily controlled. In the **vegetative** stage, rapid growth of stems, roots, and foliage occurs. This corresponds with rapid uptake of water and nutrients, moving of water and nutrients throughout the plant, and the production of plant nutrients (sugars) through photosynthesis. These activities make many herbicides much more effective in controlling the plant. Flowering and seed production or fruit-set occurs in the **reproductive** stage. Growth is limited and uptake of water and nutrients is slowed. Movement (**translocation**) of water and plant food (nutrients and sugars) is directed to reproductive parts, flowers, fruits, and seeds. Movement of plant food and herbicides to the roots is reduced. In the **mature** stage, there is little or no growth. Movement of water, nutrients, and herbicides in plants is slow. At this stage, perennial plants translocate sugars to the roots for winter storage. Application of a translocated herbicide in perennials may be most effective at this time.

Plants in the seedling stage are easily controlled with herbicides because the leaf surface is easily penetrated since there is less waxy coating on the leaves and surface hairs. In addition, younger plants have their small roots near the soil surface. The small size of the plants requires less herbicide for control and there are no unsightly patches of dead weeds. As plants become larger, the leaves are more difficult to penetrate, and their roots are deeper and have more stored food. Product labels identify the best time of application when plants are at the optimum stage of growth for herbicide control.

PLANT LIFE CYCLES

Plants can be grouped by their life cycles:

Annuals (summer and winter)
Biennials
Perennials

Annuals

Annual plants have a one-year life cycle. They grow from seed, produce seed for the next generation, and mature in one year or less.

Summer Annuals

Summer annuals are plants that arise from seeds in the spring. The seeds were in the ground over the winter. They grow, produce seed, mature and die before winter. Examples include annual morningglory, barnyardgrass, crabgrass, foxtails (green, yellow and giant), kochia, lambsquarter, marijuana, partridge pea, pigweed, ragweed (common and giant), and Russian thistle.

Winter Annuals

Winter annuals grow from seeds that germinate in the fall, over-winter as young plants, set seed, mature, and die in the spring or summer. Examples include annual bluegrass, bedstraw, Carolina geranium, chickweed, downy brome, groundsel, henbit, little barley, ripgut brome, wild mustard, wild oats, wild radish, wild rye, and yellow rocket.

In milder climates the differentiation between winter and summer annuals can become less distinct. Because the root systems of annual plants do not persist from year to year, defoliating these plants usually controls them. Treating annual plants after seed set is usually not recommended. Knowing the growth habits of annuals is important in planning how and when to control them.

Figure 2. Biennial plants are a clump of leaves at the end of the first year.

Biennials

Biennials complete their life cycle within two years (Figure 2). In the first year they grow from seed, develop a root system, and a compact cluster of leaves **(rosette)** on the soil surface. In the second year, they

mature, flower, produce seed, and die. There are no grasses with a biennial life cycle. Biennial broadleaves include bull thistle, burdock, common mullein, evening primrose, musk thistle, sweetclover, teasel, wild carrot, and wild parsnip.

Control should be directed at the first-year plants. After the seedhead has been produced, which is often the most visible part of the plant, the plant begins to senesce and die. Controlling annual and biennial plants with herbicides after flowering and seed production is of little or no benefit. Mechanical cutting to reduce the height of the flower stalk may be more practical.

Perennials

Perennial plants live more than two years. Some live for many years. Most will go through the vegetative, seed production, and mature stages each year for several years. Others may grow for several years before they produce seeds. Some perennial plants, such as dandelions, die back each winter in northern climates. Others, such as shrubs and trees, may shed their leaves, but do not die back to the ground. In milder climates, some perennials can remain green year round. Most perennials grow from seed, but many also produce vegetative reproductive structures. Perennials are quite variable, but can be grouped into three broad categories based on root characteristics: simple, bulbous or tuberous, and creeping.

Simple Perennials

Simple perennials will spread by seed and root segments. These plants have persistent root systems but they do not usually spread by root segments unless broken into parts by mechanical methods. They include bluestem (big and little), broomsedge, plantain (buckhorn and broadleaf), chicory, curly dock, dandelion, goldenrod, spiderwort, vaseygrass, white heath aster, and most trees and shrubs.

Figure 3. Wild garlic reproduces vegetatively from underground bulbs.

Bulbous or Tuberous Perennials

Some perennials reproduce vegetatively from underground **bulbs** or **tubers**, as well as by seed (Figure 3). Bulbs are swollen underground leaf bases. Some examples include wild garlic and

wild onions. Tubers are swollen tips of rhizomes. They contain buds that are capable of resprouting. Examples of plants with tubers include Jerusalem artichoke, and

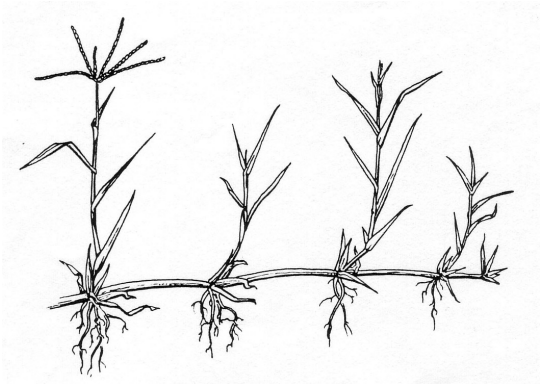

Figure 4. Aboveground stolons enable bermudagrass to spread vegetatively.

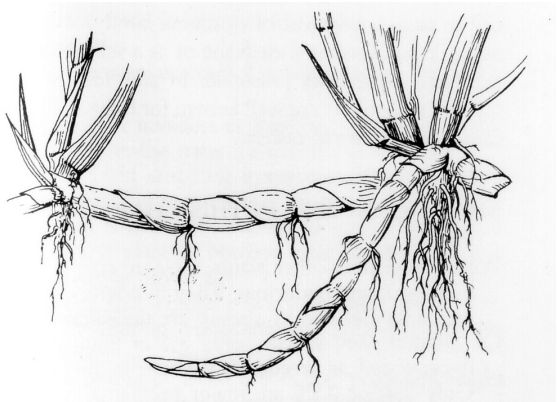

Figure 5. Some perennial plants such as Johnsongrass spreads by rhizomes.

yellow and purple nutsedge. Bulbs and tubers can be spread by soil disturbance, and can resprout when the parent plant has been controlled.

Creeping Perennials

Creeping perennials spread vegetatively from **stolons** (horizontal stems running on the soil surface usually rooting at the joints) (Figure 4), by **rhizomes** (underground horizontal stems modified for food storage and asexual reproduction) (Figure 5), or by seed. Creeping perennials usually occur as a patch that continues to enlarge each year. Roots of creeping perennials can be located off the right-of-way while the spreading stems or vines continue to reinvade the treated area. This makes the herbicide treatment appear to be ineffective. Repeated treatments with a translocated herbicide may be necessary. Examples include bermudagrass, blackberries, Canada thistle, cogongrass, common milkweed, Dalmatian toadflax, hemp dogbane, horsenettle, horsetail, Japanese knotweed, Johnsongrass, leafy spurge, multiflora rose, Phragmites (common reed), prairie cordgrass, purple loosestrife, quackgrass, red sorrel, scouringrush, St. Johnswort, yellow toadflax, field bindweed, hedge bindweed, Japanese honeysuckle, kudzu, poison ivy, trumpetcreeper, Virginia creeper, and wild grape.

Perennial plants are also best controlled while seedlings. **Mature perennials are difficult to control because their persistent roots and stems enable the plants to resprout.** Defoliating perennial plants provides only temporary growth suppression by killing the above ground plant. Herbicides that move through the plant (translocate) are most effective if applied

after rapid vegetative growth has stopped and the plant has begun to store food reserves in its roots. Having the herbicide move to the roots and underground stems is important when controlling perennial plants.

WEED CLASSIFICATION

Right-of-way pest plants can be grouped into these broad categories according to their growth form:

- grasses
- sedges
- broadleaves (forbs)
- vines
- brush and trees
- ferns and their allies

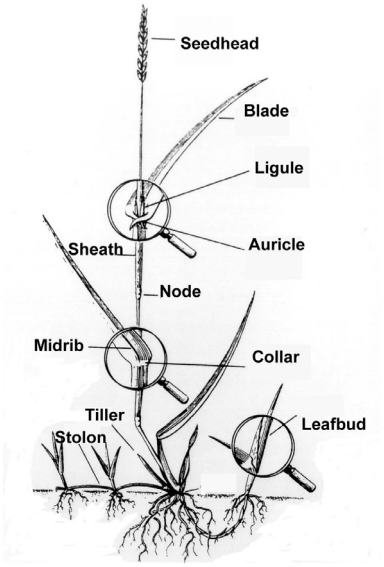

Figure 6. Parts of grass plant.

Grasses

Grasses are monocotyledons meaning there is only one cotyledon that remains unseen in the seed and there is only one leaf at germination. Grass leaves are generally narrow and upright with parallel veins. All annual grasses have fibrous root systems and many perennial grasses have rhizomes or stolons with fibrous roots attached. The growing point on seedling grass is located at or below the soil surface (Figure 6). Some grass species are annuals, including barnyardgrass, crabgrass, downy brome, foxtail, ripgut brome, and wild oats. Others are perennials such as bahiagrass, bentgrass, bermudagrass, bluegrass, bluestem, broomsedge, dallisgrass, fescue, Indian grass, Johnsongrass, quackgrass, reed canarygrass, switchgrass, vaseygrass, and wheatgrass.

Sedges

Sedges look like grasses. Most have triangular stems and three rows of leaves, but others can have round stems. Most sedges are found in wet places, but others can occur in fertile, well-drained soils. Some of the most problematic sedges, including yellow and purple nutsedge, are perennial weeds that produce rhizomes and tubers.

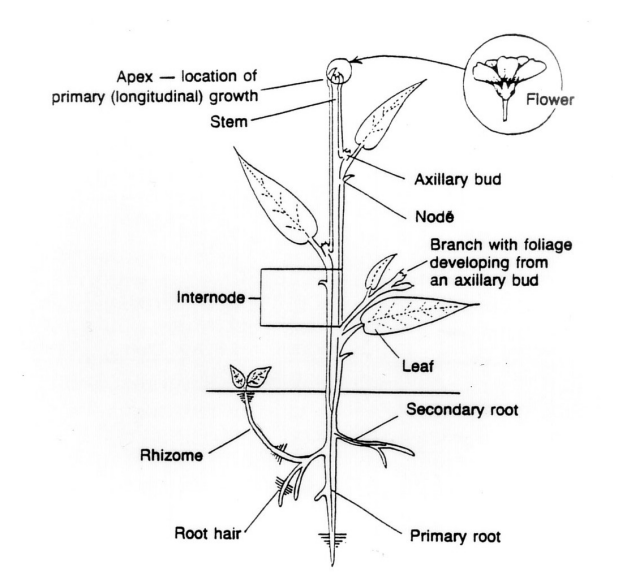

Figure 7. Parts of a broadleaf plant.

Broadleaves (Forbs)

Broadleaf seedlings have two conspicuous leaf-like structures as they emerge from the soil (dicotyledon). The leaves of these plants are generally broad with net-like veins. Broadleaves usually have a taproot and a relatively coarse root system. All actively growing broadleaf plants have exposed growing points on root tips, at the end of each stem, and in each leaf axil (Figure 7). Perennial broadleaf plants may also have growing points on stolons or other vegetative reproductive structures as well as above ground stems. Herbaceous plants do not develop persistent aboveground woody tissue. Broadleaves contain species with annual, biennial, and perennial life cycles. Examples of annuals include kochia, pigweed, ragweeds, Russian thistle, sweetclover, wild sunflower, yellow starthistle; biennials include bull thistle, common mullein, musk thistle, nodding thistle, rush skeletonweed, wild carrot, wild parsnip; and perennials include Canada thistle, many clovers, curly dock, dandelion, field bindweed, hemp dogbane, ironweed, knapweeds, leafy spurge, perennial pepperweed, plantains, purple loosestrife, tansy ragwort, and yellow toadflax.

Vines

Woody and herbaceous vines are also broadleaves with many similar characteristics. However, vines often have persistent woody stems. They invade treated weed-free areas from the surrounding untreated area; climb poles, signs, signals, guy wires, fence posts and other vegetation (Figure 8). Although some vines are annuals, including annual morningglory and wild buckwheat, most are perennials that vigorously sprout from underground vegetative reproductive structures. Examples of perennial vines include blackberry, dewberry, field bindweed, greenbrier, hedge bindweed, Japanese honeysuckle, kudzu, poison ivy, trumpetcreeper, and wild grape.

Figure 8. Woody and herbaceous vines can persist at the edge of the right-of-way.

Woody Plants

Woody plants are those that form secondary tissues from the vascular cambium (wood). These include brush, shrubs, and trees. Brush and shrubs are woody plants that have several stems and are typically less than 10 feet tall. Trees are woody plants that usually have a single stem (trunk) and are over 10 feet tall. These perennial plants may reproduce by seed or from sprouting roots. Trees consist of two broad groups: hardwoods and conifers. With few exceptions, hardwoods shed their leaves in the fall. Examples include ash, black cherry, black locust, boxelder, cottonwood, dogwoods, elms, hickories, maples, mesquite, mulberries, oaks, red alder, redbud, salt cedar, sassafras, sumac, sweetgum, tree-of-heaven, tulip poplar, wild cherry, and willows. Most conifers keep their needles year round (evergreens). The needles are actually shed after 2 - 3 years, depending on species, but there is always newer green foliage present. Examples include black spruce, Douglas-fir, eastern redcedar, hemlocks, junipers, loblolly pine, Ponderosa pine, shortleaf pine, white fir, white pine, and Virginia pine. Larch and bald cypress are also conifers, but shed their needles each fall.

Ferns and Their Allies

Figure 9. Scouringrush (*Equisetum hymale*) is an example of plants that reproduce by spores and rhizomes.

These perennial plants do not produce seed but reproduce by spores and creeping rhizomes (Figure 9). They prefer moist soils. Some examples include bracken fern, common horsetail or jointgrass, scouringrush, and swordfern.

CONDUCTING TISSUES

Two groups of tissues, the xylem and phloem, are important for the movement of herbicides, water, nutrients, sugars, and naturally occurring growth regulators in plants. **Xylem** tissue moves water and nutrients from the roots to the leaves. Typically soil-applied herbicides move upward in this tissue. **Phloem** transports manufactured plant food (sugars) from the leaves to points of active growth, including root tips, reproductive tissues and storage organs. In grasses and broadleaf forbs, these two tissue types are grouped together into **vascular bundles**, which are evident as veins (Figure 10).

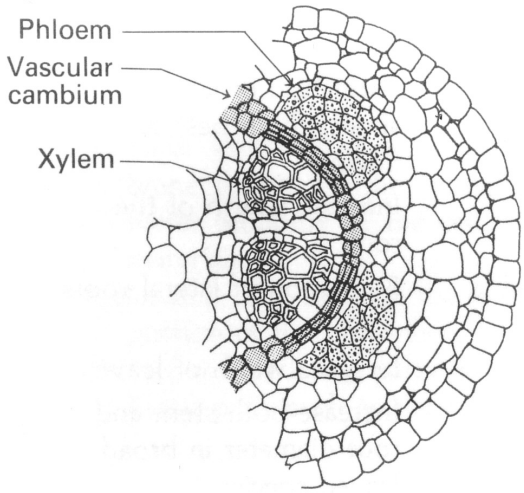

Figure 10. Conduction in herbaceous plants occurs in vascular bundles that contain the xylem and phloem tissue.

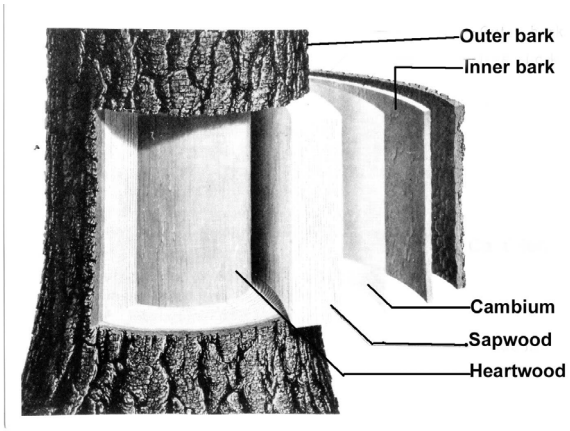

Figure 11. In woody plants xylem and phloem tissues are separated by the cambium.

In woody plants, the inner and outer bark is composed of phloem tissue (Figure 11). The wood, sapwood and heartwood, is xylem tissue. They are separated by the cambium, the living tissue responsible for tree growth. This is the part of the tree that should be treated during a fresh cut stump application. Girdling a tree by removing a ring of bark from around the trunk prevents plant food from reaching the roots. The major portion of the wood in a tree provides structural support. Living tissues are on the outer edge of the wood and on the inner edge of the bark. The rest of the bark is nonliving tissue that protects the tree from injury.

Some herbicides move only in the xylem tissue and others are translocated in both the xylem and phloem. Most soil-applied herbicides primarily move in the xylem. In contrast, most foliar-applied herbicides move primarily in the phloem. The product label will indicate where, when, and how the herbicide is to be applied to place the material in the best location for plant uptake and maximum control.

FACTORS INFLUENCING PLANT GROWTH

Water

Water carries dissolved nutrients up to the leaves and sugars (sap) to the roots. Nutrients in the soil and soil-applied herbicides must be dissolved in water and taken up by the roots of the plant. Water is also a necessary part of photosynthesis -- the manufacturing of sugar from water and carbon dioxide in the presence of green chlorophyll with sunlight as the energy source. The effects of herbicides are reduced under drought conditions, as is photosynthesis.

Rainfall must be sufficient to reach the root zone. Light rain in hot, dry weather will have little effect on soil moisture because the water quickly evaporates without reaching the plant roots. Short, heavy rains may also have little effect on soil moisture because of excessive and rapid run-off.

During drought periods, plants undergo growth stress conditions and produce thick waxy layers on the leaves. They may close their stomates (small pores in the leaf surface) and reduce their metabolic rate to protect against excessive moisture loss. Because photosynthesis and, consequently sugar production, are slowed, translocation of nutrients and herbicides will also be greatly reduced. Under these conditions, herbicides do not penetrate the leaf surfaces or move through the plant easily, so control may be reduced and their use is questionable. Plants growing in dry (arid) environments adapt to these conditions; for example, they may have small, thick leathery leaves; a thick waxy layer on the leaf surface; or the ability to grow and flower rapidly when rain occurs.

Temperature

Temperature influences all plant activities--absorption of water, transpiration (the evaporation of water from plants), respiration (plant food is used to produce energy), germination, growth, and reproduction. Temperature is one of the most important environmental factors affecting evaporation. Evaporation cools the leaf so its temperature is not as high as the surrounding air. Plant growth tends to increase when temperature rises, and it declines when temperature falls. Most plant growth occurs between 50-100° F (10-38° C). Temperature is also a factor in determining how far north and south a specific plant will grow because temperature extremes determine the length of the growing season or frost-free period.

Relative Humidity

At high relative humidity, plant leaves are more succulent, may have less of a waxy layer, and a thinner cuticle. In addition, the cuticle accumulates water. As relative humidity increases, transpiration decreases. High relative humidity and optimum temperatures usually enhance plant growth.

Liquid sprays more easily penetrate leaf surfaces as relative humidity increases. This increased penetration occurs because spray droplets do not evaporate as fast on the leaf surface. This allows more time for the herbicide to enter the leaf.

Light

Light affects photosynthesis, plant growth, and flowering. Light is the energy source that drives photosynthesis. The rate of photosynthesis increases with increased light (up to about one-third of full sunlight). Plants growing in moderate shade tend to be taller and have larger leaves than the same species growing in full sunlight. Leaves in the sun usually are thicker, smaller, with have more cuticle than plants in shade. Some plants require high light intensity. Shade intolerant plants often establish first on disturbed sites because they grow well only in a lot of sunlight. On the other hand, shade tolerant plants become established later because they have the capacity to survive and grow in the shade of other plants.

SUMMARY

Although plants come in numerous shapes and sizes, they can be grouped by a number of similarities for vegetation management purposes. All plants, including grasses, broadleaves, or woody plants, go through similar growth stages and have specific life cycles. In general, they respond similarly to environmental influences, although some plants may be more adapted to environmental extremes than others. Herbicides work best when plants are actively growing. Any conditions that make it difficult for plants to grow will reduce the effect of herbicides used to control them. Slow growth means the movement of water, nutrients, and herbicides are greatly reduced. Understanding the biology of weeds can help in planning effective management programs, regardless of whether you are trying to prevent, suppress or release them.

Chapter 3 Example Test Questions

1. What type of plants is characterized by narrow upright leaves, parallel veins running the length of the leaf, one leaf at germination, and a fibrous root system?
   A. Trees
   B. Broadleaf forbs
   C. Grasses
   D. Ferns

2. What type of plants are characterized by leaves with net-like veins, two leaves at germination, a taproot or coarse root system, buds in each leaf axil, and not woody?
   A. Trees
   B. Grasses
   C. Broadleaf forbs
   D. Ferns

3. Seedling weeds are more easily controlled because:
   A. Wax and cuticle are less thick
   B. There are generally fewer and shorter hairs
   C. They are small in size.
   D. All of the above

4. Perennial weeds are difficult to control because they have:
   A. High seed viability
   B. Thick leaf cuticle
   C. Persistent root system
   D. All of the above

5. Plants that complete their life cycle in one year are called:
   A. Winter annuals
   B. Summer annuals
   C. Biennials
   D. Both A and B

6. Perennial weeds are those that live:
   A. One year
   B. Two years
   C. More than two years
   D. None of the above

7. Plants with a two-year life cycle are called:
   A. Annuals
   B. Biennials
   C. Perennials
   D. None of the above

8. Soil applied herbicides move upward in what plant tissue?
   A. Cambium
   B. Xylem
   C. Stomata
   D. Phloem

9. The manufacturing of sugar from water and carbon dioxide in the presence of green chlorophyll with sunlight as the energy source is termed:
   A. Assimilation
   B. Respiration
   C. Transpiration
   D. Photosynthesis

10. The correct sequence of plant growth stages is:
   A. Seedling, vegetative, mature, reproductive
   B. Seedling, reproductive, vegetative, mature
   C. Seedling, mature, vegetative, reproductive
   D. Seedling, vegetative, reproductive, mature

Answers:

1.	C	3.	D	5.	D	7.	B	9.	D
2.	C	4.	C	6.	C	8.	B	10.	D

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