MAINTENANCE GUIDEBOOK IV
LANDSCAPE AND GENERAL GROUNDS MAINTENANCE

CHAPTER ONE - LAWN CARE

SECTION A GENERAL

1. INTRODUCTION

The continuous planting, maintenance, and replacement of plants is essential to maintaining a high-quality environment at housing developments. Over time, landscape development should provide a sense of permanence and a regional context for each development. Landscaping should harmoniously blend the built-up area with the natural environment. It should also visually reinforce the road network, screen unsightly views or elements, and buffer incompatible land uses.

This guidebook presents information for effective, economical, and practical landscape and grounds care to help public housing agencies and Indian Housing Authorities, jointly referred to as HAs, maintain their developments. This is not intended to limit or restrict HAs' initiatives in programming or developing practices compatible with their environments. The guidebook deals with specific landscape problems most frequently encountered at housing developments. For additional assistance, HAs should contact HUD Maintenance Engineering staff.

Field Office HUD Facilities-Management Engineers have a variety of experience in landscape maintenance in the areas that they cover, and HAs are encouraged to ask for their assistance. In addition, other sources of information may be obtained from County or State Cooperative Extension Service Agents, Soil Conservation Service staff, university agriculture departments, and city parks department agronomists or horticulturists.

Lawn-care technical assistance available from such sources includes:

- Preparation of soil bed;
- Formulation and application of fertilizers for initial, annual, and interim feeding of turf grass.
- Weed infestation, recognition, and control;
- Fungus encroachment, recognition, and control;
- Insect invasion, recognition, and chemical control;
- Types and mixtures of seed for the area.

2. SITE PLANNING

Attractive lawns and effective lawn maintenance usually go hand-in-hand with good site planning. The placement of play grounds, parking areas, trash receptacles, and pedestrian paths, for example, directly affects the amount and quality of lawn areas.

3. RESIDENT COOPERATION AND MAINTENANCE

Good lawn maintenance requires the cooperation of residents, including children. The extent and kind of cooperation differ greatly depending on whether residents undertake the actual care of lawn areas or the HA's staff does the maintenance. Residents' participation in landscaping and grounds maintenance normally results in better upkeep of an HA's developments compared to developments without residents' participation. In both cases, however, cooperation is imperative. HAs should ensure that residents and their guests do not damage landscaping, and that they maintain good appearance of the grounds at all times.

In developments where the HA's staff maintain the lawns, the basic responsibility for securing residents' cooperation lies with the management. Nevertheless, the Maintenance Superintendent, or other designated staff, and the grounds crew have an important role to play in securing resident cooperation. Groundskeepers should conduct their business professionally and be friendly with all residents.

Where residents maintain the lawns, HAs should provide technical assistance to help them become knowledgeable about landscape-maintenance practices, and should inspect their completed work. Assistance may include landscape and grounds-maintenance instructions distributed to residents at appropriate times of the year. These instructions should include both regular and seasonal landscape-maintenance activities. Management should also help residents in organizing gardening clubs, and meetings where maintenance work and problems are discussed. In addition, the management should coordinate its grounds-maintenance-related purchases of supplies and equipment for residents' use.

Some of the HA's most valuable assistance to residents can be provided by maintenance persons in the form of day-to-day, over-the-fence, neighborly advice on fertilizing, mowing, raking, seeding, watering, reseeding, and treatment of lawn diseases. People do not learn gardening or lawn care in meetings, or from distributed materials alone, and such advice helps them to learn how to care for their lawns. The grounds staff will also be responsible for reporting negligent and destructive activities to management for appropriate action.

4. PREVENTIVE MAINTENANCE

To control erosion and maintain healthy turf, preventive maintenance can be best conducted by, but is not limited to, the following:

- Analysis of soil conditions through sampling and testing;
- Selection of appropriate grass, seeds, and other plant materials to achieve natural cultural conditions for the given region; to reduce infestation of weeds, encroachment of fungus, and invasion of insects;
- Proper lawn care, including fertilizing, seeding, mowing, and watering;
- General cleanliness of grounds, timely attention to aeration, raking, top-dressing, weeding, and the proper preparation of bare spots for reseeding;
- Most desirable frequency and mowing height recommended for the particular type of turf and for a given shade and/or sun environment for each season;
- Resistance of grasses to both drought and excess of rainfall or water in a particular area;
- Need for adequate equipment, tools, and their care;
- Controlling foot traffic and other activities resulting in damage to lawns;
- Residents' cooperation.

No list of needed equipment is provided, since the requirements for each HA will differ. Caution against over-purchasing when starting out is recommended. It is best to let need and experience determine the purchasing program.

SECTION B SEED SELECTION

1. GENERAL

The best lawns are most readily established through the utilization of high-quality seeds or other planting material adapted to the climate and soil. Single species of grasses are planted more often in the south than in other parts of the country. Mixtures of grasses are commonly planted throughout the central and northern latitudes of the United States.

In choosing a single grass or a mixture of grasses, the HA may consult the local County Cooperative Extension Agent, the State Extension Agent, the Soil Conservation Service, the State Agricultural Experiment Station, a seed dealer, or a nursery representative.

Federal and state seed laws have been enacted to protect the public. The laws require that seed mixtures be accurately labeled as to kind, variety, purity, and germination. When selecting single or mixed grass seed, the analysis tags on the seed containers should be examined before purchasing. Read the grass-seed analysis labels for exclusion of undesirable turf species such as redtop, timothy,

meadow fescue, orchard grass, clovers, and tall oat grass.

Grass seed should be selected on the following basis:

- Seed will germinate and mature to a desirable type that does not winter-kill or die out annually and does not require constant annual reseeding.
- Mixtures must be adaptable to the area and compatible with each other in texture, leaf size, growth characteristics, and maintenance requirements.
- A bluegrass mixture should contain grasses having a purity of 85% or more and a germination rate of 75% or better, based on tests not more than six months old.
- A fescue grass mixture should contain grasses having a purity of 95% or more and a germination rate of 85% or better, based on tests not more than six months old.
- When seeding individual species, particularly Merino Kentucky Bluegrass and Pennlawn creeping red fescue, only certified grass should be planted.
- Do not purchase or use inexpensive grass-seed mixtures containing high percentages of temporary or other undesirable grasses.
- Do not purchase or use grass-seed mixtures or individual grass species if:
    - The percentage of weed seed exceeds 0.5%;
    - The percentage of inert matter (such as chaff and stems) contained in the mixture or single species exceeds 0.5%;
    - The percentage of other grass seed exceeds 4.0%.

Certain prominent strains of desirable grasses will not thrive unless planted in soils and climatic environments suitable to their growth. For example, bluegrass and fescue are not adapted to the southern California area because their traffic wear resistance is reduced by climatic conditions. The plants are weakened, in part by drought, to a level beyond their capacity to revive and manufacture life-sustaining food.

Neither redtop nor timothy is adapted to the two-inch mowing height recommended for mixtures of the more desirable cool-season grasses. Unless redtop seed is certified to 92% purity or better, it may contain yarrow seed of the same size, which makes it difficult to screen out. The yarrow weed has a large bulbous root system and a fern-like top growth. It is a tough competitor against lawn grasses, but can be eradicated with the proper lawn weed killer.

2. SELECTION BY GEOGRAPHIC AREAS

For practical purposes, the desirable permanent grasses for each of the following eight regions has been selected according to their most suitable application to a given climatic environment. They are grouped into eight regions of the United States and Puerto Rico, as shown in Figure 1-1.

a. Regions

Region 1 - Cold and Humid: This is the cool-season region that includes the northeastern United States, where there are abundant rainfall and acid soils. Upright growing grasses (Kentucky bluegrass, fine fescue, and bent grass) are adapted to this area. These grasses achieve their best growth during the cool weather of spring and fall, when temperatures are below 80 degrees F. Schedule cultural practices to take advantage of these cooler seasons. The most favorable time to establish a lawn, or to renovate an existing lawn using these grasses, is during late August or early September. During the fall season, temperatures are moderate, rainfall is plentiful, and there is less weed competition.

Region 2 - Cold Winters and Summer Rains (Midwest): Summers in this region are warm and humid, and cool-season grasses, such as those grown in Region 1, predominate. Some zoysia-grass lawns, however, can be found in the southern portion of this region.

Region 3 - Cold and Arid (Great Plains States): In the Great Plains, where rainfall is limited, grasses such as buffalo grass, blue grama grass, and wheat grass are of greatest value under favorable conditions. They are low growing and are highly drought-resistant. Buffalo grass turns a light straw color when growth stops. The other two turn brown when growth stops during dry periods. All become active again when moisture and temperature conditions improve. Cool-season grasses are used where they can be watered.

Region 4 - Cool and Humid (Pacific Northwest): This region in noted for ample rain and typically acid soil. Cool-season grasses well adapted to this area include bent grass, blue grass, fine fescue, and rye grass. These grasses will stay green year round.

Region 5 - Variable: This region, running across the entire country, is where there is an overlap of the warm-season and cool-season grasses. Both types of grass grow in this area, so review species selection with local agronomists. Tall fescue and zoysia grass are most commonly used in this region.

Region 6 - Hot and Dry (Southwest): Generally, the rainfall is low and temperatures are high in this region. Lawns consist primarily of Bermuda grass with some St. Augustine grass and zoysia grass. Under irrigation, the common and improved varieties of Bermuda grass are perhaps the best lawn grasses for the irrigated section of this region. Establishment and management practices are similar to those described for these grasses in other regions. In the northern areas, buffalo grass is sometimes used for areas of low maintenance.

Region 7 - Southern Hot and Humid: Several grasses are adapted for lawns in this region. They vary considerably in their management requirements, growth habits, and adaptability to environmental conditions, but each has a place in the total lawn program. The most desirable species for this area include Bermuda, St. Augustine, zoysia, and centipede grasses. Warm-season grasses are more variable in their nutrient requirements than cool-season grasses. Late spring or early summer is the ideal time to establish these lawns.

Region 8 - Tropical (Southeast): This region consists primarily of the Gulf Coast states, which have a tropical climate and rainfall as high as 70 to 80 inches annually. The most frequently used grasses are centipede, Bermuda, bahia, and St. Augustine. Zoysia grass also grows well in most areas of this region.

b. Grass Species

Bent Grasses (Astoria, Colonial, and Highland): Bent-grass lawns are well adapted to western Oregon and Washington. These lawns are very attractive but require close management, including mowing to the recommended height, ample watering, heavy fertilization, and treatments with fungicides, herbicides, and insecticides. Because of their aggressiveness, bent grasses are not recommended in mixtures with bluegrass and fescue. The bent grass soon takes over, and the lawn must then be managed for bent grass.

Bahia Grasses (Paraguay, Pensacola, Argentine, Seaside, and Wilmington Varieties): Bahia grass lacks many characteristics of the better lawn grasses. However, it is desirable for use on open areas, vacant plots, and roadside shoulders, where ease and low establishment and maintenance costs are important. Its use for lawns is limited by two bad characteristics: it forms a coarse open turf, and it produces an abundance of seed heads, which makes mowing difficult except with a rotary-type mower. Bahia grass is adapted to a wide range of soil conditions and is tolerant of shade.

Bermuda Grasses: In addition to common Bermuda grass, there are several species of improved strains of Bermuda grass desirable for use on athletic fields, playgrounds, and lawns. They are more widely adapted to the southern portion of the United States than the other grasses. For example, in the southwestern area, Tifgreen, Santa Ana, and Texturf 10 have performed well. In the south and southeast, Everglade No. 1, Ormond, Tiflawn, and Tiftan 57 have proven satisfactory. They will grow in most soils if the area is well drained, adequately fertilized, and the soil Ph is not too low. They do not, however, produce a satisfactory turf in shaded areas.

The improved Bermuda grasses are the finest of southern grasses in both texture and quality, but

they require a high level of maintenance. Although they should be watered during dry periods, they require less water than other southern turf-grass species. At the end of the growing season, it is a good practice to cut the lawn top growth by mowing to a height of 1-1/4 inches to stimulate growth and color pickup after winter dormancy. As the weather becomes hotter, raise the cutting height progressively to two inches before the fall dormant period.

Blue Grama Grass: This grass is well suited to the drier areas of the Great Plains section. Like buffalo grass, it is low growing, and while its growth is the bunch type, it will produce a dense tufted sod when heavily seeded. It has lower wear resistance than buffalo grass but is very practical in mixtures with two parts of it to one part of buffalo grass. Seed at a rate of 1.0-1.5 pounds per 1,000 square feet.

Buffalo Grass: This low-growing grass forms a dense, fine-leaved, grayish-green foliage. It is drought resistant, and prefers well-drained heavy soils. It is adapted to the western and southern sections of this region, where water for irrigation is limited or unavailable. It is grown by planting four-inch squares, four-by-six-inch rectangles, or blocks of sod 1.5 to three feet on center. Plant in warm weather from April through June. Start lawns from prepared or treated seed by planting at a rate of 1.0-1.5 pounds per 1,000 square feet in May and June. Plant untreated seed in the fall so winter ground moisture will soften the seed for spring germination.

Carpet Grass: This grass grows well in low, moist, relatively acidic soils. Start carpet grass lawns either by transplanting or from seed (3-4 pounds per 1,000 square feet) in the spring or summer. Mowing to a height of two inches may be difficult during the summer period because of the formation of seed spikes. It is also useful for erosion control on slopes. It is free from insect pests and disease, and will do well with limited fertilization.

Centipede Grass: This is best suited to low-maintenance lawns. Centipede grass can be established from seed or by transplanting. It is easy to maintain and is resistant to most diseases. This grass is adapted to southern areas that have high rainfall and few prolonged cold periods. Centipede grass will grow in heavy soils and is outstanding among the low maintenance grasses. However, its unattractive brown winter color and susceptibility to pests and drought detract from the virtue of its low maintenance.

St. Augustine Grass: This grass requires a moderate level of maintenance. St. Augustine grass varieties Bitter Blue Floritam and Floratine are widely used throughout the lower south. They make a thick, dense growth and are adapted to sandy loams, but will also do well on other soils. St. Augustine grass is among the coarsest of southern grasses, but produces a succulent growth that is easy to mow.

Tall Fescue (Festuca elatior arundinacea): This coarse grass, an unsightly pest when it invades or is planted with other finer lawn grasses, may help solve lawn problems in areas of the United States where neither northern nor southern grasses grow especially well. It is a cool-season grass with medium-to-coarse texture. It will stay green year round and has good drought tolerance. Newer cultivators include Alta, Clemfine, Jaguar, and Rebel.

Wheat Grass: The Crested and Western varieties are widely adapted and thrive in most soils of the central and northern Great Plains. Use these two varieties individually or in a 50/50 mixture at a rate of 1-2 pounds of seed, applied either in the fall or spring. These grasses respond best to good fertile soil and, with adequate moisture, will produce a good lawn turf. They tolerate long periods of drought and are resistant to heavy traffic when mowed to the recommended height. Wheat grass will not survive close mowing under drought conditions.

The Crested variety is a bunch-grass type, but when seeded heavily, will form a dense turf. It makes most of its growth in spring and fall, and turns brown as it becomes semi-dormant in the summer.

The Western variety forms an open turf from underground stems. It is useful for embankments, slopes, and channels, and will form a dense sod if fertilized and a desirable moisture level is maintained.

Zoysia Grasses: These hybrid grasses are used to a limited extent. Popular varieties of the species are manila grass (zoysia matrella), Meyer zoysia, and Emerald zoysia, a hybrid. Zoysia grasses are equal, if not superior, to St. Augustine grass in their tolerance to cold. They survive traffic well and are good grasses for shady areas. Their major drawback is slow establishment, since they require at least two years to form a dense turf. This time can be shortened by heavy and frequent fertilization, followed by a thorough watering.

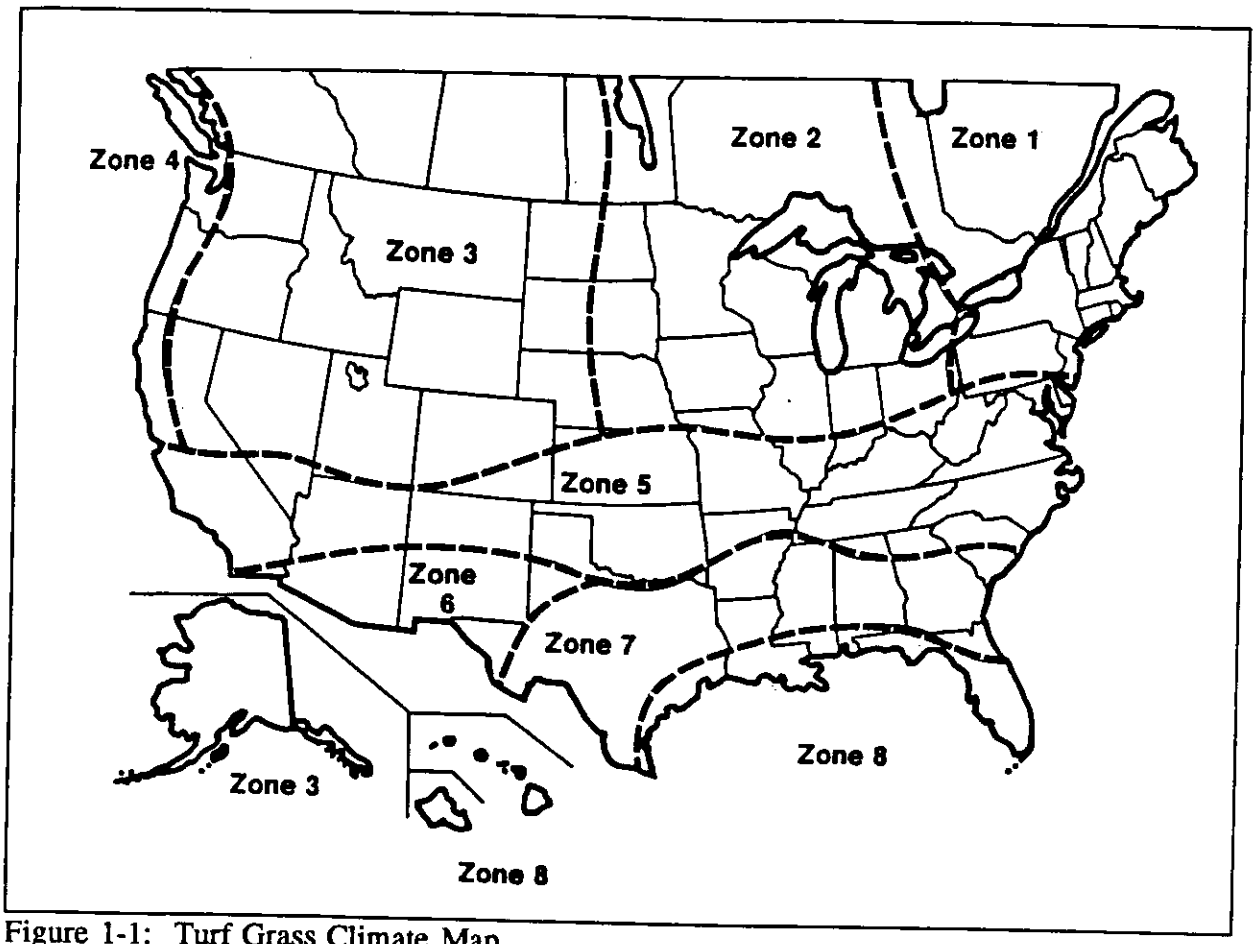


Figure 1-1: Turf Grass Climate Map

SECTION C FERTILIZATION

1. SOIL SAMPLING AND TESTING

Soil sampling and testing are the foundation of a good fertilization program. To find out the chemical properties present in various types of soils, it is necessary to take soil samples. Soil tests should be done between once a year and once every three years, in the spring. Ranges for acceptable test results are as follows:

pH range	5.8-7.0
Organic matter	1.5-3.0%
Magnesium - Mg	35 pounds/acre
Phosphorous - P	100 pounds/acre
Potassium - K	85 pounds/acre
Soluble salts	not to exceed 500 ppm

The reliability of soil testing depends on the method used for taking soil samples. Grass gets most of its nourishment from the top four inches of soil. One method of taking soil samples is as follows:

- Make a four-inch deep vertical cut in the turf, then lay back the surface.
- Use a small garden trowel and take a slice of soil 1-2 inches thick from the face of the cut.
- Take 12 to 25 individual samples from the area to be planted.
- Thoroughly mix the individual samples together in a clean pail or other container.
- Soils with wide variations in physical characteristics should be sampled independently, not mixed.
- Submit at least a one-quart container of the sample to the laboratory for testing.

Test results are usually available about one month from the time of mailing the samples. Soil test results should be considered an estimate of nutrient availability and pH balance within the soil. It is the base to which additional nutrients are to be added.

Soil-testing services for determining the degree of acidity or alkalinity, also the chemical analysis for Nitrogen (N), Phosphate(P_2O_5) or Phosphorus (P) and Potash or Potassium (K) determination, are available from the following sources at no cost or for a small fee:

- County Cooperative Extension offices;
- State agricultural experiment stations;
- Soil Conservation Service offices;
- Agronomy departments at various universities.

Industrial consulting or supply houses frequently offer customer-courtesy or commercial soil-testing services.

Soil-testing kits for the chemical analysis of pH, N, P, and K, are available commercially at a reasonable price. Chemicals used in soil-testing deteriorate with age and must be replaced every year. When test kits are used with care following the instructions, a reliable indication of plant food elements and soil reaction is obtained.

If soil-testing is not practical, a local seedsman, nurseryman, or farmer can advise whether the area in question has acid or alkaline soils. As a rule, the presence of ground mold and mosses is a sign of soil acidity.

2. LIME

Some soils are "sour" (acid) and others are "sweet" (alkaline), so called because of their respective positions below or above 7.0, the neutral point on the pH scale. While grasses will grow in soil pH ranging from 5.0 to 7.5, better turf grasses prefer a range between 6.0 and 6.5, or slightly acid on the pH scale. With a few exceptions, grasses of poorer quality grow in either "sour" soil (ranging from 5.0 to 6.0), or in the slightly higher pH soil range of 6.8 to 7.5. The soil's acidity or alkalinity (pH) is normally controlled by spreading dolomitic lime. The use of ground limestone, with its characteristic

trace elements, is preferred to maintain a soil reaction slightly below the pH neutral point. This tends to keep grasses green longer in the fall, ward off the encroachment of snow mold disease, increase drought resistance, and improve resistance to brown patch and dollar-spot disease.

Lime can be applied any time during the year, but fall is preferable because rainfall and freezing and thawing action move the lime and minerals slowly down into the soil, where they are absorbed by plant roots. This promotes the strong root growth and development necessary for the grass to produce hardy dense turf. The correct amount of lime in the soil helps other chemicals perform their function. Further, the activity of many soil-dwelling insects, and some larvae populations, will be retarded as the pH of the soil approaches 7.0. Dolomitic limestone is desirable because it contains calcium and magnesium. However, it is not available in all areas of the country. Ground oyster shells are also excellent because they contain many trace elements. They are reasonably priced and available in coastal areas.

When excess lime is applied, the leaves of plants sometimes turn yellow and become veined and mottled, an early sign of nutrient starvation. This condition resembles calcium or nitrogen deficiency. However, too much calcium (lime) locks up both iron and manganese needed by plants to produce chlorophyll and manufacture plant starches.

The type of nitrogen fertilizer used determines the amount of lime necessary to neutralize the acid-producing effect of fertilizer. For example, each pound of Nitrogen (N) in ammonia-sulphate fertilizer, applied per 1,000 square feet, requires five pounds of ground limestone. The use of hydrated and burnt lime is not recommended, since it usually burns the lawn. Except for ammonia nitrate, most nitrogen fertilizers require about two pounds of limestone per pound of nitrogen per 1,000 square feet of lawn area.

Alkaline soils are more likely to be found in regions having limited rainfall. Acid soils develop in regions where the annual rainfall exceeds 20 inches. Frequent and heavy artificial watering not coordinated with natural rainfall also contributes to increased soil acidity. Large amounts of water move down through the soil, and in draining off, dissolve and leach out the basic chemicals from the soil. A growing lawn also removes these basic chemicals from the soil, and intensifies the soil acidity. An adequate program for replacement can be initiated through soil-testing, followed by selection and application of proper fertilizers and lime.

The following table is for determining the quantity of limestone required for specific soil reaction.

pH Existing		pH Desired	Pounds of Lime per 100 square feet
6.0	to	6.5	46
5.5	to	6.5	47-92
5.0	to	6.5	93-138

3. NITROGEN

Nitrogen, the growth-producing nutrient for plants, should be supplied at a constant and uniform rate to keep grass growing and maintain a healthy plant condition. An adequate supply results in dark green foliage and active vegetative growth. However, an oversupply of nitrogen causes too-rapid plant growth, less firm tissues, and weakening of the plant so that it is less resistant to disease, infection, and injury. Excess nitrogen applied at flowering time causes the plant to retard flower and seed formation and to resume active vegetative growth.

The available nitrogen is only a very small fraction of the total soil nitrogen content. Most nitrogen is tied up in decomposing organic matter and is released in inadequate amounts to turf grass. Therefore, supplemental applications of nitrogen are necessary. Heavy-textured, clayey, and organic-content soils tend to reserve and release more nitrogen to plants. Because the available nitrogen content in soils is already in solution, it is subject to severe leaching losses and dilution from torrential rains, and from irrigation due to excessive watering. The lighter the texture of the soil, the more pronounced is the effect of the leaching action.

Nitrogen is necessary for the bacterial breakdown of plant residues in the soil. Clippings and shredded leaves contribute food for bacterial growth and nitrogen demands. By contrast, soils that are excessively acid or depleted in organic matter are inherently poor suppliers of nitrogen. Nitrogen is available from organic sources such as compost, humus, leaf mold, manures, and other materials. The activity of soil bacteria is greatest when the soil pH value is on the slightly acid side of the scale, between 6.0 and 6.8 pH. In highly acid or alkaline soils, there is very little breakdown of organic nitrogen by soil bacteria. This causes plants to be starved for nourishment, even when large quantities of organic nitrogen are applied.

Adequate quantities of phosphorus and potash are also necessary to promote good root growth and leaf development. However, the growth response of turf grass to nitrogen (N) far exceeds any response due to either phosphorus (P) or potassium (K).

4. PHOSPHATES

Phosphate compounds are needed by all plants, especially plants that produce flowers, seeds, and grain. These compounds promote germination of seed and contribute to general plant health. Phosphate materials include organic phosphates, super-phosphates, and ammonia phosphates. Common sources of organic phosphates are bone meal, sewage sludge, and vegetable meals.

Phosphate, incorrectly called phosphorus, gives little trouble when the soil pH is between 5.0 and 7.3. Above 7.3 pH, the phosphorus locks up with calcium to form an insoluble calcium phosphate compound. When the pH drops below 5.0, the phosphorus is locked up and unusable by plants.

5. POTASSIUM

The principal sources of potassium are muriate of potash and sulphate of potash, which are completely soluble in water. Other potash carriers are potassium nitrate, cottonseed hulls, hardwood ashes, and tobacco stems. Muriate of potash is the common source of potassium in mixed fertilizers, although the sulphate form is preferable where chloride is a problem, for example, in tobacco fertilizers. Potash is an important food element in the formation and transportation of starch, sugar, and other carbohydrates within the plants. An adequate application of potassium to the soil causes plants to produce disease-resistant, stiff, healthy stems, and improves root growth.

Potash, incorrectly called potassium, gives little trouble until the soil pH rises above 8.0. A deficiency of potash, termed potash hunger, results in rust or yellow leaf blight. It also creates a favorable environment for fusarium wilt and for root knot nematodes to develop. Excessive application of nitrogen (N), or phosphorus (P), or both, often accentuates rust infestation.

Overliming, or a scarcity of sodium (N_2), which is a substitute for potash, also increases the rust tendency, as does a lack of humus in the soil or improper surface drainage.

6. SECONDARY ELEMENTS (CALCIUM, SULPHUR, AND MAGNESIUM)

Calcium is supplied by limestone that, as discussed above, is used to control soil acidity. Secondary sources of calcium are most phosphatic materials and certain nitrogen materials, for example, calcium cyanamide. Gypsum ($CaSO_4$) is ordinarily used as the major source of sulfur. It makes up roughly one quarter of all super-phosphates. Some sulfur is found in mono-ammonium phosphate. Sulfur is also present as potassium sulfate in certain special fertilizers.

Dolomite limestone has a high magnesium content. It is a preferred source of agricultural lime, since

it maintains a proper balance between calcium and magnesium. It is sometimes used as a filler in mixed fertilizers.

Magnesium sulfate (Epsom salt) may be used for quick correction of magnesium deficiency. Magnesium is also sometimes added as potassium magnesium sulphate.

7. MINOR ELEMENTS

Copper, zinc, iron, manganese, and boron are required by plants in small quantities. Use them with extreme caution, since excess applications may be severely toxic. Animal manures and many natural organic fertilizers contain these trace elements. Copper, zinc, iron, and manganese are usually applied as a sulphate. Recently, however, chelated compounds and insoluble "fritted forms" of these elements have become available.

8. QUICK-ACTING FERTILIZERS

Commercial-grade fertilizers containing soluble nitrogen, which is readily available to plants, speed up grass growth. The rapid growth exhausts the nutrient supply quickly. To obtain a steady, uniform growth rate and maintain a healthy stand of turf, four or more minimum-rate applications are necessary. If the yearly total nutrient requirements of the turf grass were applied in two applications, or even one, the grass would probably be "burned." Following this would be a short period of accelerated leaf growth, producing a lush, rich, dense turf that is highly susceptible to disease. This would be followed by "no growth."

Should the "no growth" stage occur during a period of warm days and cool humid nights, the overstimulated grass would lack vigor, due to the lush condition and lack of nutrients. The grass will then become vulnerable to attack by several types of fungi and insects. Under such conditions, many supposedly good lawns fade away in late May or early June. They become pocked with bare spots where weed seeds near the soil surface germinate, develop to maturity, and begin crowding out other desirable and still-surviving grass. Weeds drop seeds during July and August that could germinate the following spring, thereby tending to perpetuate the weed-growth cycle.

9. SLOW-ACTING FERTILIZERS

Natural organic and synthetic organic-nitrogen fertilizers are not water-soluble. They depend upon certain soil bacteria and fungi to break down the chemical materials for plant growth. They do not "burn" grass because the bacteria make the nutrients available to the plants. Another reason that natural organic fertilizers do not burn is that they have a low nutrient value. Due to production, freight,

and handling costs, these fertilizers are more expensive.

Synthetic organic-nitrogen fertilizers are increasingly popular despite their initial higher price. Because of their much higher chemical content, the transportation and application labor costs are low. They do not burn and they contain valuable trace elements. They only need to be applied twice a year, spring and fall, since the nitrogen becomes available slowly over the entire growing season. However, in the case of Kentucky Blue and Red fescue grasses, three annual applications are needed for optimum results—one-third in early spring, one-sixth in early summer, and one-half in early fall. Although the initial cost of this fertilizer is high, its use is desirable.

The ideal fertilizer mixture would be one containing about 70-75% of slow-release synthetic organic-nitrogen, with the balance comprising readily available nitrogen combined with adequate quantities of phosphate and potash. This type of fertilizer mixture will yield excellent quality turf, with two to three applications per year.

The actual weight of a nutrient in any bag of fertilizer is found by multiplying the total bag weight by the percentage grade figures for each of the elements contained in the bag. For example, a 50-pound bag of 10-6-4 fertilizer will contain the following quantities:

50 x 0.10 = 5 pounds of nitrogen (N)

50 x 0.06 = 3 pounds of phosphate

50 x 0.04 = 2 pounds of potash

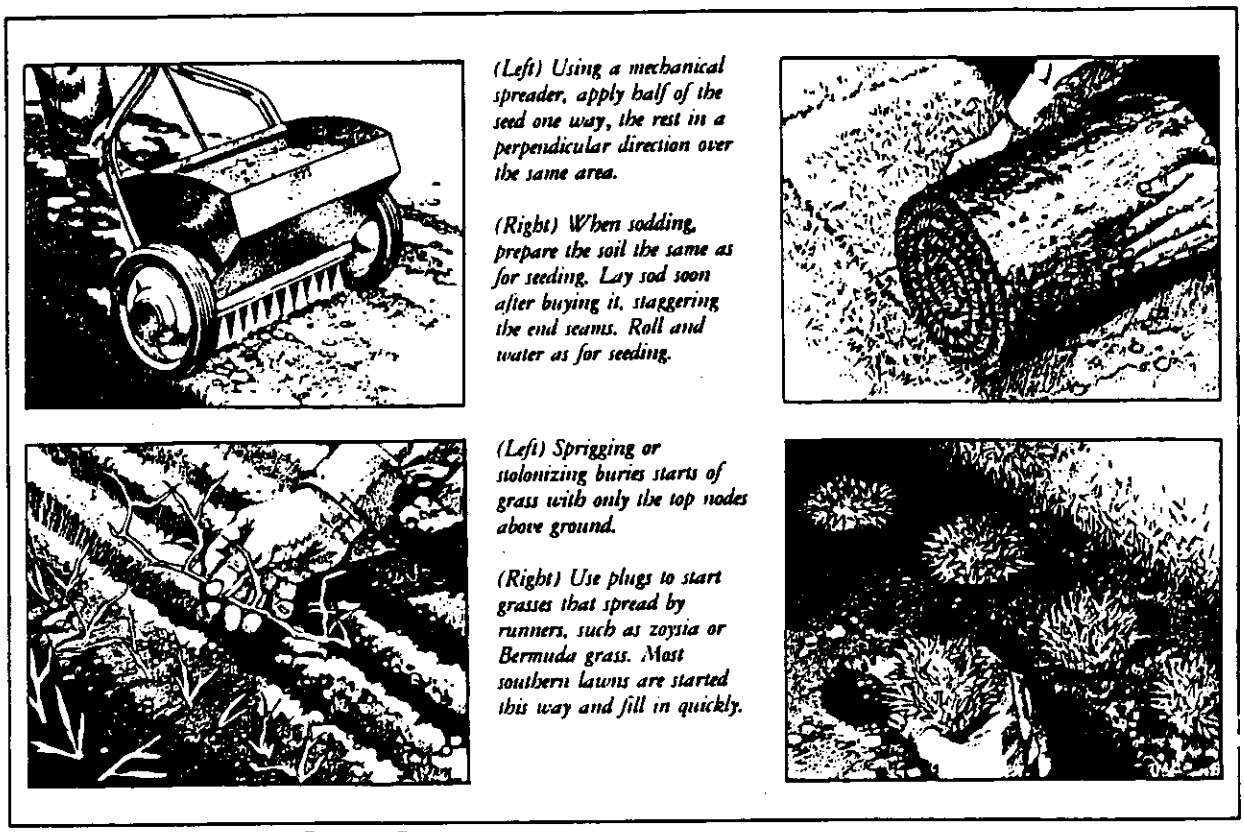
SECTION D ESTABLISHING AND MAINTAINING TURF-GRASS

1. STARTING A NEW LAWN

Once soil tests have been completed, prepare the site for the application of seed or sod. The preparation of the seed bed determines the long-term success of the lawn being planted. See Figure 1-2 for ways to start a lawn.

Remove Debris and Establish Rough Grade: The planting bed should first be cleared of debris such as sticks, stones, and other items. Once the seed bed has been cleared, fill low areas with topsoil. Fine grade the site for a gradual slope between fixed points, such as sidewalks and building foundations. Refer to the following section on drainage for more specific guidelines regarding grading.

Correct Drainage: The initial site preparation of the lawn determines how well the area will drain. The ground should slope gently and gradually so that excess rain water is carried away from the site.



(Left) Using a mechanical spreader, apply half of the seed one way, the rest in a perpendicular direction over the same area.

(Right) When sodding, prepare the soil the same as for seeding. Lay sod soon after buying it, staggering the end seams. Roll and water as for seeding.

(Left) Sprigging or stolonizing buries starts of grass with only the top nodes above ground.

(Right) Use plugs to start grasses that spread by runners, such as zoysia or Bermuda grass. Most southern lawns are started this way and fill in quickly.

Figure 1-2: Ways to Start a Lawn

There should be no low spots in the lawn to collect and hold water. It may be necessary to install an underground drainage system where natural site drainage is inadequate. Prevent water from draining toward the foundations of structures. The grade at foundations should be set so there is at least a two percent slope away from all structures. Drainage swales should be designed to look natural while maintaining their function as routes for moving water. Avoid placing swales where they will drain over sidewalks and planting beds that could be damaged by moving water.

Trees are sensitive to the amount of water they receive. Adding or removing more than three inches of soil around the drip edge, which would affect the water supply to the tree, should be avoided. A "tree well" should be built to maintain the grade around the tree to be preserved.

Condition Soil: Soil amendments should be added, as indicated by soil tests, after the site has been graded. For areas planted after new construction, the topsoil removed from the site before construction should be replaced. Spread half the topsoil over the site and till it in. This will create a transition zone between the underlying soil and the new soil.

The best way to improve the quality of the turf is to incorporate organic matter into the seed bed. Compost, peat moss, and leaves all help to get the lawn off to a good start. Organic matter opens the structure of clay soils and helps retain moisture in sandy soils. The organic matter should not be

mixed too deeply. Keep it within the top six inches of the soil where the grass roots will benefit most. Amend soil acidity at this time. Refer to Section C, Fertilization, for more information.

Add Nutrients: Lawn fertilizer containing nitrogen and phosphorus should be incorporated into the seed bed along with organic matter. These soil amendments will encourage the new lawn grass to thicken quickly.

Roll and Water: Rolling the seed bed with a water-filled roller will reveal any soft spots that might later sink and cause depressions. It also creates a uniform planting depth for seeds, improves the soil contact of seeds or sod, and reduces dustiness. The area should be watered well after rolling to settle the soil.

Sow Grass Seed: Grass seed can be sown with the same equipment used for spreading fertilizer. In small areas, spread the seed by hand or with a small hand spreader. Whatever the method used, divide the seed into two lots with one half spread in one direction and the other at a right angle to the first. Use of this crisscross pattern will avoid spotty coverage.

To be sure the seed is embedded into the soil, the area should be lightly hand-raked after sowing, or dragged with a brush or mat. Small seeds should be covered with soil 1/8 to 1/4 inch in depth and large seeds covered 1/4 to 3/8 inch deep. Firm the seeded area by rolling with a light roller to press the seed into the soil.

Seeding can be improved by following the rolling operation with an application of mulch. Use a light covering of weed-free hay or straw to hold moisture in the soil and to prevent washing of the seed. The type of mulch used depends on the region of the country, but straw and peat moss are most commonly used. The mulch also prevents the soil surface from crusting over, a condition caused by the repeated sequence of rainfall followed by sun and wind. This results in no seedling growth because the crusted soil surface excludes soil moisture and air, and ultimately ends in a barren eroded area. One 60-80 pound bale of weed-free hay or straw mulch will adequately cover about 1,000 square feet of soil. During this growth period, the mulch will protect the tender seedlings from being trampled underfoot by random transient traffic and children at play. Mulching also prevents birds from eating the grass seed before germination.

On terraced areas or on sloping banks, cheesecloth, open-mesh sacking, or commercial mulching cloth staked in place will help to hold soil moisture and seeds in place during germination and growth. The grass will grow through the mulching mat, which should be left in place to rot. The mat should not be removed if the grass has protruded through it, or the grass and roots will be torn from the soil.

Proper watering is the most critical factor in establishing a new lawn from seed. New seedlings should be kept moist until they are well established. Once seeds have begun to germinate, they must not be permitted to dry out, or they will die. On the other hand, take care to prevent soil moisture buildup to saturation levels because excess moisture creates a favorable environment for the development of a fungus disease called "damping off," which kills the seeds. Thoroughly soak the lawn to a 6-inch depth after sowing, then water frequently, preferably in the early morning, to keep the top surface moist.

Lay Sod: Sod is used to cover sloping surfaces which are subject to erosion, or where the applicable grass seed is not available or does not produce plants that are true to type. The latter grasses, including zoysia, improved strains of Bermuda, St. Augustine, centipede, creeping bent, and velvet bent, must be planted by vegetative methods, such as spot or plug sodding, sprigging, or stolonizing.

To sod, prepare and fertilize the area in the same manner as for seeding. Firm planting bed with a roller after final hand-raking. Lay sod pieces as brick are laid, fitting them together as tightly as possible. After the first strip has been laid, a wide board should be placed on the sodded strip. One worker can kneel on this board and move it forward as the sodding continues. This will eliminate tearing the sod or tramping and gouging holes in the prepared soil bed.

Sod laid on slopes and terraces should be held in place by driving small stakes about every two to three feet on center, through the sod into the ground, so the tops of the stakes are flush with the grass. A strong twine can then be run from stake to stake crossing and crisscrossing to hold the sod firmly in place. Remove the stakes and twine after the sod has become established, to allow mowing. However, if mowing is not required, they may remain in place to deteriorate.

After sod is laid, tamp it lightly and top dress with a small amount of topsoil. Work top dressing into the small cracks between the sod strips using a broom or the back of a wooden rake. Sod must lie flat. Wherever there are hollows beneath the sod, the sod will dry out and eventually die.

Sod should be kept moist until well established. During the first year, light applications of nitrogenous fertilizer (ammonia sulphate, ammonia nitrate, or urea) every two to four weeks, during the growing season, will help establish the lawn.

Sprigging or Stolonizing: Sprigging or stolonizing is the planting of individual plants, runners, cuttings, or stolons at spaced intervals. Sprigs or runners are obtained by tearing apart or shredding established sod. The spacing should be governed by rate of spread of the grass, how soon coverage is desired, and the amount of planting material available. Bermuda grasses spread more rapidly than the zoysias. Sprigs or runners may be planted end-to-end in rows rather than at spaced intervals.

Large Bermuda grass areas may be established by spreading shredded stolons with a manure spreader and discing lightly to firm them into the soil. This method requires 90-120 bushels of stolons per acre. Creeping bentgrass and velvet bentgrass can be stolonized by spreading shredded stolons at a rate of 10 bushels per 1,000 square feet and top dressing with topsoil to a depth of 1/4 inch, and rolling to firm the stolons into the top dressing.

2. TOP DRESSING

Poor soil texture contributes to soil compaction, which retards root growth. The soil condition should be improved by applying top dressing in low areas where water collects and the turf can be damaged by ice forming. Top-dressing material may be composed of very loose pliable top soil, preferably excess soil removed from the site. This may be improved by adding concrete sand or a well-sifted compost of organic material. Washed concrete sand, according to specifications established by the American Society of Testing Materials, makes an excellent material for top-dressing a lawn. It is also good for mixing with composted materials, humus, or topsoil before top-dressing a lawn. Finer textured sands must not be used for top-dressing or in the preparation of soil beds. When used in larger quantities, this sand will reduce soil porosity and cause the soil to become compacted. For best results, all top-dressing should be chemically treated before application to kill insects, disease, and weeds.

Usually, top-dressing should be applied at more than 1/8-inch or 1/4-inch in depth where between 0.4 and 0.8 cubic yards of material will be required per each 1,000 square feet of lawn area.

3. RAKING AND ROLLING

In the fall, when the soil is firm and reasonably dry, rake grass vigorously with a steel or mechanical rake to clean up debris and thatch accumulation. In the spring, grass should be raked lightly with a twig or leaf rake to remove thatch, twigs, and dead leaves. A manual or powered leaf sweeper can also be used.

Rolling a lawn in the spring is a practical way to restore the surface to near its original level. It also improves conditions for mowing by pushing down bunches of grass that have been heaved up by winter freezing and thawing. This procedure is recommended only when the lawn is uneven and difficult to mow. Rolling should be done when the ground is frost-free and has begun to dry, but is still moist. A light roller should be adequate.

4. WATERING

The need for, and frequency of, watering is dictated by the type of soil, turf, temperature, humidity, and other weather conditions. A water supply of about 30 inches per year or more is necessary for the establishment of a good turf. This may be from rainfall or a combination of rainfall and irrigation. Artificial watering may be done by fixed or movable sprinklers. Lawns should be watered when indicated by their color, lack of resilience to foot printing, or wilting. The need for watering can also be determined by taking a sample core, cut out of turf and soil, 2-1/2 inches deep, with a 4-1/2 inch long tapered hollow-tine sampling tool having a 1/2-inch diameter cutting edge opening.

When soil moisture becomes low, it should be watered to a depth of 4-6 inches. Artificial watering should be done slowly, to enable the soil to absorb the water without surface runoff. The moisture should extend to the depth of the root zone to encourage deeper rooting. The top two inches of the soil may be allowed to become dry before the next watering. Watering is best done in the early morning to avoid water loss due to higher evaporation during the day. This also minimizes fungus attacks when the days are hot and nights are cool.

Clayey soils require less frequent watering, but in larger amounts to wet the soil to about a six-inch depth. Apply water slowly so it will not run off faster than can be absorbed by the soil. Sandy soils require more frequent watering, usually applied in lesser amounts, to wet the soil to about a four-inch depth. This is two inches less than on clayey soils because the porous soil does not retain the surplus water for as long as clayey soils.

Generally, except in arid regions, properly maintained bluegrass or fescue lawn will not be killed off by normal dry weather. Such turf should not be watered until the blades of grass start to wilt. Do not water lawns lightly at frequent intervals since this will cause shallow root growth, sparse turf, and stimulate the growth of weeds.

Chemically treated water is not as good as natural precipitation, well water, or another natural source. Some seasonal variations in watering requirements are listed below:

- It is desirable to develop a healthy deep-rooted grass by summertime. This permits longer intervals between watering and allows the soil surface to dry out. This shuts off the water supply needed by weeds, particularly crabgrass, for germination and root growth.
- Controlled watering is desirable in the early-spring following a dry winter. This helps the development of a good root system because grasses establish most of their root growth at this time. When the top 2-3 inches of surface soil dry out, it's time to water.
- In warmer climates, Bermuda grass needs water during the dormant season to remain resilient. Watering of dormant warm-season grasses in the winter months also has the advantage of

encouraging the growth of cool-season grasses, which keeps otherwise drab lawns green.

- Lawn care resulting in a soft succulent turf with shallow roots should be avoided since, during daytime high humidity and cool nights, the turf becomes susceptible to fungus attack. Thus, it is necessary to adjust watering to natural rainfall.
- Control of watering is essential, particularly with cool-season grasses, because their growth is retarded during periods of high temperature. Constant watering uses available nutrients at a faster rate, and will result in a rapid increase in weed growth and a loss of turf grass.
- As trees mature, their shade kills Bermuda grass. After the grass weakens and disappears, bare spots will spoil the look of the lawn. Correction can be made by reseeding thinning lawns with shade-tolerant cool-season grasses. Such areas should be watered regularly to remain green year round.
- Lawns will have different water needs as trees and shrubs mature. Turf watering and fertilizer requirements increase with increasing competition of extending roots from trees and shrubs. Sometimes, the selection of grass species may need to be altered, or other forms of ground covers are used. In other cases, where nothing grows, paving may be necessary. (See barren areas resulting from foot traffic.)
- In areas where natural precipitation is limited and soils become excessively dry, fall-season watering is desirable to prevent the turf from drying out.
- Something to remember is that excessive watering produces more weeds.

5. MOWING EQUIPMENT

a. General

Lawn mowers are generally of the following types: hammer knife, reel, rotary, or sickle bar. They may be the hand-pushed or self-propelled reel, hammer knife, rotary, or sickle bar with power unit; self-propelled gang-reel riding unit; tractor-drawn with hammer knife, reel, rotary, or sickle-type cutting units.

A new mower type is the mulching mower, which "mulches" the cut blade of grass into small pieces which can be left on the surface of the lawn rather than raked or bagged. This process returns the nutrients available in the cut grass to the soil much more quickly than they would be if the grass were composted and then spread over the lawn. Many stores now offer conversion kits for nonmulching mowers.

Mowing equipment should be selected on the basis of the predominate turf grass, the size of the lawn, its roughness, the unevenness of terrain, and weather conditions. Certain makes of mower cannot be adjusted to cut at 2-inch or 2-1/2 inch heights. Do not purchase any mower that cannot

be adjusted to cut at two inches or higher.

Reel or rotary mowers: These are practical for all lawn grasses. Bent, Bermuda, centipede, and other low-growing grasses form a dense mat close to the ground and can be cut lower. Therefore, the reel type is generally preferred. Grasses not cut below two inches on level ground may be cut with a rotary type because its lifting action aids in giving a uniform cut.

Reel mowers are probably the best type for general and resident use on limited areas at housing developments. When motor-driven, they can cut 3-4 acres per day, and the hand-operated reel type cuts 3/4 to 1 acre per day. Received straight from the factory, this type of mower is generally set to cut lower than is desirable for best grass development. But they can be easily adjusted to cut as high as two or more inches by lowering the roller. Hand mowers provided for use by residents should be set in the maintenance shop so that the adjustment cannot be changed by anyone who wants to "shave" the lawn.

Rotary mowers: The horizontal whirling knife, or rotary-disk mower, is well adapted to cutting grass to any height desired. It is most useful on flat surfaces and gentle slopes, but is not satisfactory on terraced banks or steep slopes. Its advantage over the reel mower is that the horizontally whirling blade creates a suction by which prostrate grass stems are lifted up and cut off. It will also cut wiry seed stems off weeds, preventing the spread of weeds and aiding their gradual elimination from lawns. It is recommended that this type of mower be equipped with a bag for catching clippings; otherwise the mowers throw out the cuttings in bunches, which lie on the lawn and smother the newly cut grass.

Sickle-bar: The sickle-bar type of mower is useful for rough areas that need mowing only three or four times a year. It is also practical for trimming around trees, buildings, fences, and mowing steep banks. When used on a steep slope, any standard sickle-bar power mower may be equipped with a bicycle wheel attached to give balance to the unit.

Hammer knife: The hammer-knife mower functions by revolving horizontally swinging blades pivoted on vertically swinging arms.

b. Safety Precautions

All lawn mowers should be used with caution. They should never be field-cleaned of debris unless the power and propelling units are completely stopped and the machine blocked or braked so that it cannot roll. When cleaning reel and sickle-bar mowers, the operator should take care not to cut fingers with sharp blades and cutter bars.

It is strongly recommended that spark plug wires be disconnected before moving, storing, or working on hand-propelled or power-operated mowers.

Leather-sole shoes become very slick on very dry or very moist turf. Rubber overshoes with metal golf cleats fastened to the soles are good protection against slipping. Their wear is recommended when using hand-steered, small power unit mowers on dry or moist turf, particularly on slopes.

On steep slopes, hand-steered power-unit mowers should be handled by two operators, one to operate the mower and the other to hold on to one end of the rope tied to the mower. The rope operator stays on the top of the slope walking parallel to the machine operator and releases the rope as the mower moves down the slope. The rope operator is on level ground and can keep a firm hold on the rope. This makes it less likely that the machine will get away from him or her.

6. MOWING

a. General

One common reason for turf failure is cutting the grass too close to the ground, which prevents grass from spreading out and developing into a dense turf. The grass' root development is related to its top growth. To remain healthy and resistant to disease and weed invasion, it must produce, through minimum blade height and surface, enough plant foods for vigorous root development. Low clipping starves the roots, causing them to become shallow.

Also, the turf will thin out and be baked during hot summer temperatures, leaving room for the invasion of low-growing weeds. Low mowing permits sunlight to warm the ground, helping crabgrass seedlings to germinate in late May and June. Grass should not be permitted to grow too high and then cut back so that bleached stems are evident. This is a shock to the plant, which could then be injured by the hot sun. It is also necessary to remove the clippings to avoid smothering the grass with them.

A two-inch mowing height is recommended for all turf grasses to ensure a densely tufted sod, tolerance for long periods of drought, and resistance to heavy traffic. This height also retards the germination of weed seeds lying near the soil surface.

b. Mowing Frequency

Frequency of mowing can be determined by the rate of growth. This depends on the amount of rainfall or watering, the natural fertility of the soil, soil pH, amount of added fertilizer, the temperature, and other seasonal factors and growing characteristics of the various grass species. No specific rule on mowing frequency can be established, given the number of variables. Mowing should be done when the grass needs it—that is, when cool-season grasses are no higher than three inches and warm-season grasses are no higher than two inches. During seasons of drought or retarded growth, mowing should probably be suspended entirely. Cutting grass higher than three inches may raise subsoil moisture to the level of grass roots.

Mowing should be done often enough so that the short clippings can be left on the ground to decompose. This is beneficial to the turf, because clippings under an inch long serve as mulch to the roots and return plant food elements to the soil. Longer clippings tend to mat on top of the grass instead of dropping between the blades to the ground, which smothers the plants. When dried out, long cuttings become an unsightly litter, holding an excessive amount of moisture, and thus weakening the grass. When conditions of humidity and temperature are right, fungi can encroach on the weakened lawn.

c. Exceptions

The following are three possible exceptions to the "Rule of Mowing High":

- Grasses that can tolerate close cutting in full sun or light shade are the warm-season grasses, such as Bermuda, centipede, carpet, St. Augustine, and zoysia grasses. These warm-season grasses are best maintained at a height of two inches.
- If the lawn is infested with crabgrass that has started producing seed heads, it is necessary to mow closer and use a grass catcher to remove as many low-lying seed heads as possible. This also applies to other weeds which spread over the grass and shade out the sunlight. A crabgrass rake is very effective for removing these plants.
- A third exception is the renovation of an old lawn composed of weeds and wild grasses, where high cutting will be of little value. Before reseeding, the lawn should be mowed close to cut down existing weeds. This will permit the growth of new grass unrestricted by a stand

of tall weeds and old grasses. It will also expose thin spots and help remove thatch before scarification of the soil, so the seed can be planted in a proper soil environment.

d. Preventing Mowing Injury to Trees and Shrubs

Trees and shrubs in lawn areas are damaged by mowers bumping against the base of the tree trunk or the stems of the bushes. When possible, treat the damaged area by applying a tree-dressing compound, thereby saving the tree from tissue drying or possible infection by wood-rotting fungi, bacteria, and invasion by insects at the wound area. If tree-dressing compound is not available, the scar area may be coated with shellac or paint and, when dry, painted over with an emulsified asphalt. Eliminate this type of mower injury by maintaining a mulched area of about 12 to 18 inches in diameter around all plantings. This practice is particularly desirable around newly planted trees and shrubs.

7. AERATION

Aeration consists of punching holes and removing soil cores to allow for lateral expansion of the compacted soil into these holes. This loosens the soil beneath the grass without disturbing or damaging the turf surface and root structure. Proper aeration of grass reduces maintenance costs resulting from labor and materials, fertilizer, seed, sod, sprigs, and artificial watering, which would be wasted due to runoff on compacted soils. Also, the turf will be denser, stronger, and better able to withstand traffic. Further, it is less susceptible to disease and more hardy through periods of drought. In summary, aeration will do the following:

- Make the soil porous through vertical penetration, permitting air, moisture, and fertilizer to reach the grass roots.
- Increase turf growth and density, particularly if plant food is spread and the area dragged while soil cavities are still open.
- Help in preparation of a good seed bed while improving existing turf.

Aeration exposes the ground so it can readily absorb surface water, resulting in less runoff and erosion. When done before fertilization, aeration improves the effectiveness of fertilization. After fertilizing, the turf area should be dragged, raked, or brushed to smooth off any unevenness resulting from the aeration process. This moves the fertilizer from the turf into the soil and grass root system.

Equally useful is a heavy rain or extended mechanical watering with chemical fertilizer. For ordinary lawns, where soil compaction is moderate, combining aeration with feeding two or three times a year

should be satisfactory. For dense, heavy soil, perform both operations more frequently. This will encourage the grass roots to grow deeper down into the soil and to produce a more drought-resistant turf. Aeration of soil before preparing a seed bed in existing turf will increases the yield of seedling plants. Soil brought to the surface forms a light top-dressing to cover the seed. When sprigging a lawn using plugs of grass, the stolons may be planted in the holes made by the aerator.

HAs with 10 or more acres of ground area should consider using aerators that have a width between 16 and 24 inches. One aerator type is the power spike, which can cover up to 20,000 square feet per hour. However, spike aerators are not recommended because they tend to further compact the already compacted soil. Instead of a spike aerator, use a rotating drum aerator, with either 1/4-inch, 3/8-inch, or 1/2-inch diameter hollow tines, for removing clean-cut plugs up to 3-1/2 inches long. The ground must contain moisture to a depth of about four inches for the machine to work without putting unnecessary strain on its working parts. The 1/4- and 3/8-inch tines may be used any time to relieve compaction and matting, which prevents free water percolation. This machine will core uniformly spaced holes on about six-inch centers in an area of 8,000 to 10,000 square feet per hour, and will aerate about 1.4 to 1.8 acres per day.

Rotating-drum aerators may be rented from tool- and equipment-rental companies. They will often deliver the machine to and from the HA and demonstrate its use.

The hollow-tined fork or hand aerator is an inexpensive and practical tool for smaller developments. However, it is also an ideal tool for larger developments, for handling small areas where traffic has been heavy and compaction severe. It is also good for problem areas not considered large enough to require the renting of a machine.

The hand aerator has two tapered hollow tines set small-end down and about six inches apart on either end of a metal bar fastened to an inverted U handle. The tines are pushed into the soil by stepping down on the tine-holder bar. Two cores of earth, up to three inches long, pop up and out of each hollow tine and fall onto the lawn with repeated operation of the aerator.

For easiest operation, the hand aerator should be used in the spring or fall. At this time, the soil is beginning to firm up after long rainy periods during which moisture has penetrated deep into the soil, making it readily workable. If the earth is too soft, the tines will merely push holes in the ground. Under ideal soil conditions, one worker could aerate about 1,000 to 2,000 square feet of ground area per hour. The area will be covered with holes every six square inches and a core of earth for top-dressing or for filling low spots will be laying beside each hole.

SECTION E LAWN REPAIR

1. EXISTING LAWNS

a. Small Repairs/Patching

Over time, it is inevitable that a section of lawn, whether weedy, damaged, or dead, will need replacing. Replace the damaged section by reseeding, replugging, or with a piece of sod. Always patch an existing lawn with the grass species. Bring the underlying soil level to proper grade and use the same method for starting a new lawn as described in Section D, Establishing and Maintaining Turf-Grass. Follow the same watering guidelines as for new lawns.

b. Large-Area Rehabilitation

The renovation of an existing lawn is similar to the preparation of a new lawn. Undesirable grasses and weeds should be removed first. This can be done either mechanically or chemically. The mechanical method involves tilling up the existing lawn and raking out the debris. The chemical method uses herbicide to kill all existing plant material in the lawn. A pre-emergence weed control is not recommended for this method since it may affect future lawn-seed germination. Once the lawn is dead, it is necessary to remove as much thatch as possible. A vertical cutter is most effective for removing thatch and maximizing contact between seed and soil. Another method is to mow the lawn at the lowest setting and then vigorously rake the area with a steel rake to remove loose debris from the planting area.

Existing lawns are improved by frequent aeration. Aeration is recommended before lawn rehabilitation as it improves soil quality and provides ideal space for seed germination.

Soil testing, as described in Section C, should be done and appropriate soil improvements made. Seed should be sown, or sod laid, as described in Section D. Most importantly, a good watering program should be followed.

c. Shaded Areas

Few lawns will grow in heavily shaded areas. Too much shade will cause grass to become thin, weak, and gradually die out. However, there are options for dealing with shady areas. Areas with high open shade are likely to benefit from the use of a shade-tolerant grass species. Even within

a grass type, certain cultivars are more likely to take shade better than others. In some situations, it may just be impossible to grow a healthy lawn. Shade-tolerant shrubs and ground covers are the best choice for these areas. The plant lists in Chapters Two, Three, Four, and Five include plant varieties that are both shade-tolerant and require little maintenance.

Another method is to bring more light into a shaded lawn. This can be done by selectively pruning trees to allow more light to reach the turf. A significant portion of a tree can usually be trimmed without drastically changing its appearance or affecting its health. When considering planting trees in lawn areas, select species that cast a filtered shade.

SECTION F WEEDS

1. GENERAL

Webster's dictionary defines a weed as any plant growing in cultivated ground to the detriment of a crop or to the disfigurement of the place. However, weeds may be useful under special conditions or in specific areas, such as for controlling soil erosion. Weed seeds are transported by birds and wind, and most soil contains dormant seeds that germinate when temperature, moisture, and mowing conditions are favorable. They can reduce a healthy stand of turf by competing with and depriving it of the water, light, and the soil nutrients needed to sustain it.

Weeds become a factor after grasses lose aggressiveness and vigor, and in addition, may serve as host for turf-grass diseases. They frequently provide a haven for vermin and for the overwintering of plant and turf-attacking insects and diseases. One or a combination of the following conditions encourages weed infestation:

- Poor soil type and density;
- Nutrient starvation;
- Lack of water;
- Over-fertilization;
- Over-watering;
- Inadequate drainage;
- Soil compaction;
- Improper mowing;
- Insect damage (surface and sub-surface types);
- Disease damage;
- Extreme fluctuations in temperature and natural moisture and/or precipitation.

These factors retard both root development and top growth, affect turf color, density, and texture, and impede recovery from injury.

A turf-grass management program should include the planting of permanent grasses and their maintenance through good soil sampling, testing, liming, fertilizing, mowing, and watering practices. Chemical treatment for weeds should be considered only as a last-choice effort.

2. CHARACTERISTICS

Various weed seeds remain dormant in the soil for years and germinate when brought to the surface by cultivating, and when other conditions are favorable. Weeds are capable of growing to maturity and setting vast numbers of seed within the short span of 30-60 days. When unchecked, their rapid growth enables them to readily overtake and stop turf growth. Certain weeds have extensive root systems and continue to grow new shoots repeatedly, even when the top growth has been destroyed. Clover is a good example of this.

Weeds that are common in turf-grass environments are usually low-growing, prostrate, vine-like forms of undesirable plants. Low mowing, to eradicate weeds, should not be resorted to, since it will also destroy desirable lawn grasses. Weeds may be classed as herbaceous or woody. Most plants regarded as weeds are herbs that are either annuals, biennials, or perennials.

a. Annuals

Annual herbaceous plants complete their life cycles in one growing season by germinating from seed in the spring or summer, producing seed, and dying in the same year. The seeds of winter annuals germinate in the fall of one growing season. The plants live over winter, produce seed, and die in the spring of the year following germination.

b. Biennials

Biennials live two years, developing a cluster of leaves fanning out and around the main shoots at ground level during the first year, and a storage root that helps the plant survive the first year's winter. During the second year, leaves, flowers, and seed develop, after which the plant dies.

c. Perennials

Roots and stems of perennials live indefinitely, but their tops die each year and new stems and leaves develop the following year.

3. IDENTIFICATION AND CONTROL

The common names of weeds vary so that a weed may be known by different names in different locations. Conversely, several different weeds may be known by the same common name. See Figure 1-3 for illustrations of the most common weed species in lawns.

Most chemical companies producing herbicides publish information on their products, including illustrations and descriptions of the more common weed varieties. They also include recommendations for mixing herbicide proportions and their correct application. Such information is usually available upon request.

Except for crabgrass, no attempt will be made to explain the identification of all weeds. For those interested in learning to identify and control weeds, the following two books are recommended:

- *Weeds of the North Central States*, Circular No. 718, Agriculture Experiment Station, University of Illinois, Urbana, Illinois 61801, 260 pages.
- *Weed Identification and Control* by Duane Isely, Iowa State University Press, Ames, Iowa 50010, 400 pages.

a. Crabgrass

Crabgrass is a summer annual that develops from seeds produced during the previous year that remained near the soil surface. Seeds germinate during the warm moist days in late spring and develop to unsightly prominence during July and August, crowding out the desired grasses.

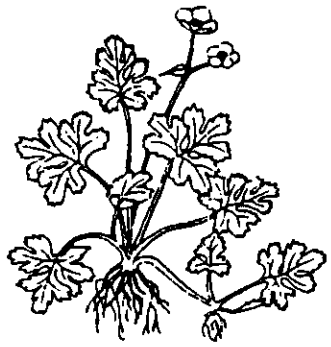
Control and Eradication: Even during periods of warm late-spring weather, crabgrass seeds will not germinate when the moisture content of the soil is low. This plant thrives during hot summer weather. It develops sturdy roots and a top growth that spread out aggressively with a total span of 1-2 feet. In late summer, crabgrass turns purple, then brown, and finally dies, dropping an abundance of seeds from which new plants develop the following year.

The reappearance of crabgrass, year after year, is only possible when a given lawn area

Black Medic, *Medicago lupulina*

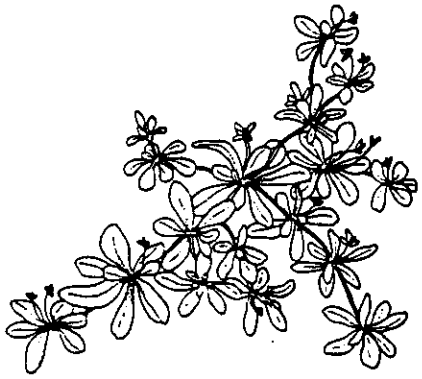
Low growing with hairy stems and yellowish flowers in summer. Healthy turf will choke out or use postmergence herbicide in early spring and in fall.

Creeping Buttercup, *Ranunculus repens*



A perennial with trailing stems and yellow flowers. Dig out individual plants or use postemergence herbicide in spring.

Carpetweed, *Aizoaceae family*

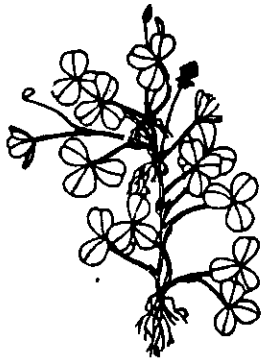


Common weed with narrow stems, small leaves, and tiny white flowers. Healthy turf will choke out or use postemergence herbicide in early spring or in fall.

Common Chickweed, *Stellaria media*

An annual with creeping stems that root easily. Dig out individual plants or use postemergence herbicide in spring.

White Clover, *Trifoliium repens*



A persistent perennial with white blooms. Dig out immediately or use postemergence herbicide for large areas.

Common Crabgrass, *Digitaria sanguinalis*

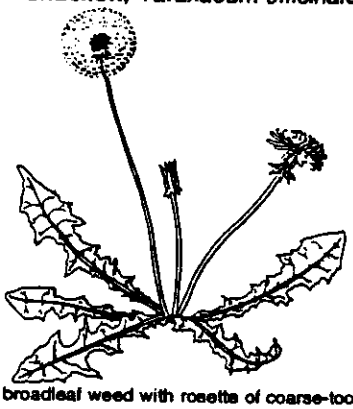
An annual bunchgrass that likes moisture and sun. Healthy turf will choke out or use postemergence herbicide in early spring.

Figure 1-3: Weed Identification & Control ©Meridith Corp., *Better Homes & Gardens New Garden Book*

Dallis Grass, *Paspalum dilatatum*

Narrow leaf perennial bunchgrass that grows fast in low, wet areas. Dig out indivdiual plants or apply a postemergence herbicide.

Dandelion, *Taraxacum officinale*



Common broadleaf weed with rosette of coarse-toothed, long leaves. Dig out entire taproot or used in the fall.

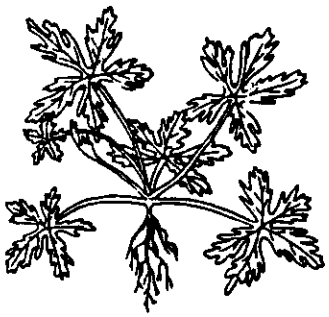
Curly Dock, *Rumex crispus*

Crinkly-edged rosette of leaes with 2-3 foot spikes of yellowish-white flowers. Dig out individual plants or apply postemergence herbicide over larger area.

Wild Garlic, *Allium canadense*

A perennial weed early to emerge in spring with fragrant leaves. Apply postemergence herbicide in late fall and early spring.

Wild Geranium
Geranium masculatum



A pink-flowered annual that prefers dry, sandy, soils. Control with a postemergence herbicide for large area.

Hawkweed (Devil's Paintbrush)
Hieracium aurantiacum

A perennial with hairy, basil leaves forming dense patches. Prefers moist, cool soil. Remove by hand if few or use postemergence herbicide in spring or fall.

Figure 1-3: Weed Identification & Control

Heal-All, *Prunella vulgaris*

Creeping perennial with gangly stems and purple or pink flower spikes. Healthy grass will choke out or use postemergence herbicide.

Ground Ivy, *Glechoma hederacea*

A creeping perennial that thrives in damp, shaded areas. Pull out individual plants or use postemergence herbicide in spring.

Knotweed, *Polygonum aviculare*

Annual weeds with wiry stems and small bluish-green leaves. Difficult to remove because of taproot. Use a postemergence herbicide.

Lamb's Quarters, *Chenopodium album*

Common annual weed with fuzzy gray leaves. Pull out by hand or use postemergence herbicide for large areas.

Nimblewill, *Muhlenbergia schreberi*

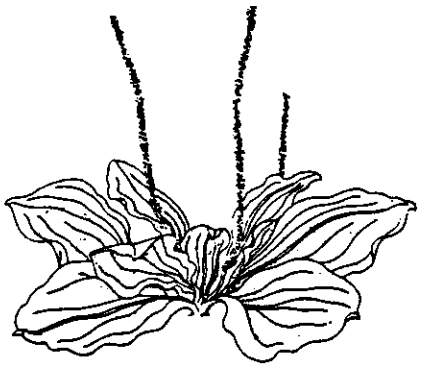
A creeping perennial with long, narrow, grayish-green leaves. Pull during growing season. Difficult to remove. Spot treat individual plants with postemergence herbicide.

Nut Grass, *Cyperus esculentus*

A perennial seed in moist sandy soils. Control is difficult because of tubers. Treat individual plants with a glyphosate herbicide.

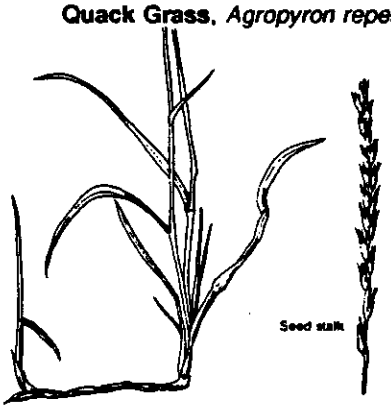
Figure 1-3: Weed Identification & Control ©Meridith Corp., *Better Homes & Gardens New Garden Book*

Plantain, *Plantago major*



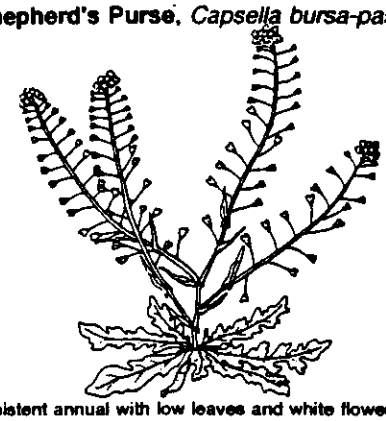
A perennial with a rosette of broad leaves and tall, slender stalks with pencil-shaped flowers. Dig out individual plants or use postemergence herbicide in early spring or fall.

Quack Grass, *Agropyron repens*



A hardy, spreading perennial bunchgrass with dense root structure. Impossible to eradicate without killing lawngrasses too. Dig out by hand to control.

Shepherd's Purse, *Capsella bursa-pastoris*

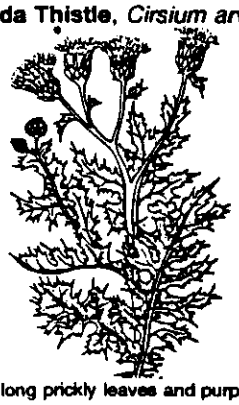


A persistent annual with low leaves and white flowers. Pull individual plants by hand or use a postemergence herbicide for large areas.

Sheep Sorrel, *Rumex acetosella*

A perennial forming a matlike growth wherever soils nd drainage are poor. Use a postemergence control in early sprig and early fall.

Canada Thistle, *Cirsium arvense*



A perennial with long prickly leaves and purple flowers on tall stems. Likes clay soils. Like dandelion, must remove root to kill. Use a postemergence herbicide for larger infestation.

Common Yarrow, *Achiellea millefolium*

A creeping perennial with finely divided soft leaves that grows in poor soil. Dig weed out by hand or control with postemergence herbicide for larger areas.

Figure 1-3: Weed Identification & Control ©Meridith Corp., *Better Homes & Gardens New Garden Book*

comprises a thin stand of grass, the direct result of poor soil conditions. Much can be done through proper and timely application of fertilizer and soil aeration. The control of crabgrass is a slow process, and to be successful, should be carried out over several years. One method is to prevent seed infestation of the soil. This is done by cross-raking of the lawn just before mowing to bring immature seed heads within reach of cutting blades. When seed heads have matured, a grass catcher should be used on the mower and the cuttings burned or dumped, but not composted. A special crabgrass rake can be used effectively to pull the mature plants from the soil. It is also useful for removing other tough low-spreading weeds.

Weed-seed germination, and the growth of new crabgrass seedlings, can be retarded by shade from fescue and bluegrass, if they are maintained no shorter than two inches. This gives enough shade to shield the soil surface from the warming rays of the sun.

Crabgrass is not tolerant of shade; therefore, heavily infested areas of new crabgrass can be covered with black garden paper or lightweight roofing felt for seven to ten days. This is a sufficiently long time to completely kill young crabgrass. The desirable grasses, such as fescue and bluegrass, will be somewhat discolored and retarded from the covering, but will revive.

There are two categories of chemical control for crabgrass. Pre-emergence application, which destroys the crabgrass seed before germination, and post-emergence, which destroys the growing plant after seed germination. Some pre-emergence chemicals that have given 75 percent or more control of crabgrass are DCPA, oxadiazon, and siduron. With a good stand of grass, pre-emergence herbicides should be applied in March and early April or 30 days before weed-seed germination is expected. The residual effect of these chemicals continues to destroy germinating crabgrass seed for many weeks. The application of chemicals for crabgrass control generally produces better results where the soils are slightly to moderately acid. If seeding is necessary to fill in barren areas, it is better to apply post-emergence control around mid-June, or when the crabgrass plants are seen. In this manner, desirable grasses will not be killed.

Post-emergence chemicals, such as CAMA, MSMA, and MAMA can be used with good results. In all cases, the manufacturers' directions should be carefully followed. Take care not to apply a crabgrass killer that will injure the desirable turf grasses growing in the application area.

In addition, there are also herbicides that may be used for killing other weeds and undesirable grasses in lawns. Chemical names for post-emergence herbicides include cacodylic acid, CAMA, MAMA, Dalapon, Dicamba, Glyphosae, 2,4-D, and 2,4-DP. These chemicals should be present

in herbicides, which will not damage desirable lawn grasses if used correctly. Herbicides should be selected with care because some may damage grass temporarily, or even permanently kill desirable turf.

Herbicides are prepared in granular, powder, and liquid forms. The weed-killing strength is stated on container labels, either as a percentage of active ingredient or as pounds per gallon acid equivalent. Apply all herbicides **only** according to instructions on container labels. Do not overdose, since this may damage the desirable turf temporarily, or permanently, and add to the cost of the application.

For best results, apply herbicide sprays only when:

- No rain is expected, at least on the application day;
- Little or no wind is blowing to avoid damage to desirable plants;
- The temperature is close to 70 degrees F, or between 70 and 85 degrees F.

Small, sparsely populated weed growths may be removed by hand weeder successfully. Do not attempt to pull weeds by hand as roots left behind usually regenerate the foliage.

SECTION G DISEASES

1. GENERAL

More than 100 different diseases have been found on turf grass. However, to date only about 10 to 15 of them are known to damage the turf. Some of the approximately 90 others are reported on turf with greater frequency, and are probably responsible for more damage than is generally realized. It has frequently been found that two or more fungi will be present in a given disease attack.

Only those fungi that get their nutrients from a living host are true disease organisms. Such organisms cause leaf spot, fading-out, brown patch, rust, grease spot, dollar spot, and snow mold. Many of these are known to persist in organic refuse. Mushrooms and slime mold in lawns are examples of fungi that are not true disease organisms. Although they do not attack turf grasses directly, they are recognized as disease organisms. Any condition that may tend to harm grass will make it vulnerable to disease attack. Thus, the presence of a disease increases its susceptibility to attack by another disease.

Diseases are more likely to occur in lawns which have been improperly established or maintained. The following conditions contribute to poor turf, and ultimately to disease attack: improper selection

of grass mixtures and species, buried debris, compacted soils, improper watering, improper mowing, insect injury, pesticide injury, fertilizer burn, and hydrated-lime burn. Additional causes are foot traffic, children playing on immature and/or wet lawns, delivery trucks and automobiles driving over lawns or parked on them, and other abuse.

2. IDENTIFICATION AND CONTROL

Some lawn diseases can be controlled by using chemicals called fungicides, of which many kinds are available. **All fungicides are poisonous!** On the issue of exposure of workers to pesticides, OSHA defers to the EPA, which enforces pesticide-use laws under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). (OSHA regulations 29 CFR 1910.1200 Scope B.5.A.) See EPA guidelines in Appendix A for more information. Follow directions and precautions noted on the container. Some commercial fungicides with the same brand names are prepackaged at different strengths for entirely different uses. This difference is frequently identified by key letters following the brand name. Order the brand name with the exact key letter affixed to obtain the strengths and mixture instructions for the fungus being treated. Effective fungicides for control of turf-grass diseases include anilazine, benomyl, captan, and iprodioine.

Lawn injury from other causes is frequently mistaken for disease symptoms. These include burning with chemical fertilizers, chemical weed killers, drought, dog and insect damage, or fungi damage in combination with other symptoms. Refer to Figure 1-4 for illustrations of the most common diseases found in turf grass.

a. **Brown Patch:** Brown patch is a fungus disease that attacks practically all kinds of turf grasses, causing them to turn brown during the summer months. Attacks of brown patch usually come during periods of hot humid weather, when grass is in a weakened condition and when daytime temperatures drop from 80 degrees F to 60-70 degrees F at night, and dew or fog develops. The attacked area has irregularly shaped brown patches or spots from about one inch to several feet in diameter. Part of the grass within the circle frequently escapes injury.

   The disease is worse in turf areas that are over-fertilized, causing the grass blades to become soft from excess tissue juices and fertilization. This problem can be overcome by using slow release organic nitrogen fertilizer. Application of slow-release nitrogen in the spring, in sufficient quantities (2-4 pounds per 1,000 square feet), should sustain the turf through the hot summer weather. This eliminates the need for intermediate and late-summer feedings. It generally takes two years for this kind of program to become effective.

Brown patch may be controlled by avoiding over stimulation with nitrogen fertilizer, particularly the quick-acting commercial variety, and by applications of mercurial fungicides. Commercial fungicides should include anilazine, chlorothalonil, benomyl, fenarimol, and triadimefon. Follow the directions and precautions on the label. Fungicides should be sprayed on grass blades and not watered into the soil. Fungicides can be made more effective by the addition of iron sulphate, or its concentrate called iron chelate, in the spray. If the grass is not dead, beneficial results should be seen within a few days, and the treatment can be repeated at 7-14 day intervals, as needed.

b. **Dollar Spot:** This fungus disease is characterized by the size of the turf injury spots, ranging from 3 to 12 inches in diameter, giving the affected area a straw-colored appearance. It is prevalent in spring and fall during periods of warm humid days and cool nights. The most susceptible grasses are Kentucky Bluegrass, Bermuda, St. Augustine, bahia, fescue, redtop, and zoysia.

   Cultural practices that minimize dollar spot include using larger amounts of nitrogen, soil aeration, and thatch removal. Chemicals for treatment include anilazine, benomyl, fenarimol, and triadimefon.

c. **Damping Off:** Damping off occurs when seedling turf areas are dotted with dead patches, from one to several inches in diameter. The young grass turns black, then withers and turns brown. Sometimes this fungus kills the young sprouts before they emerge from the ground, making it appear that the seed did not germinate. It is also responsible for spotty growth of new lawns, so that some patches show no grass while other areas have a good stand. Factors favoring this condition are over stimulation by fertilizer and too much surface and ground water. All turf grasses are affected by this disease. For control, see Curvularia.

d. **Leaf Spot:** This fungus disease, also known as melting out, causes small reddish-brown to purple-black spots on leaves, which enlarge and spread across the leaves, the center becomes yellowish in color. It is particularly aggressive on fescue and all bluegrass, except Merino. Damage can be minimized by cutting not less than two inches high, employing an adequate amount of fertilizer but avoiding over stimulation with nitrogen, and using mixed planting of several grasses. For control, see Curvularia.

e. **Curvularia or Fading Out:** This fungus disease is frequently termed "fading out" because of indefinite symptoms. A blighted area with no distinct outline may encircle many patches of healthy

turf, which frequently remain unaffected. It appears during the hot summer months following the springtime diseases of leaf spot and melting out. At first, the affected lawn appears to be drying out, even with adequate moisture. The green grass then fades out becoming yellow, and eventually dies.

Curvularia, leaf spot, and melting-out diseases may be controlled, partially or completely, either before the disease starts, or at the early stages, by coating the blades of grass with fungicides that contain one of the following chemicals: benomyl, iprodione, thiophanates, fenarimol, chloheximide, or triadimefon.

f. **Red Thread:** This disease attacks weak, slow-growing cool-season grasses. Also known as pink patch, it is common in the northwest region. The grass blades become stuck together with bright pink threads of fungi. Raise fertility levels, and, if it continues, the soil Ph should be checked and adjusted to the 6-7 range. Use fungicides containing anilazine, chlorothalonil, iprodione, or triadimefon if the improved cultural practices fail to cure the problem.

g. **Pythium Blight:** The two most destructive lawn diseases caused by pythium fungi are grease spot and cottony blight. Grease spot occurs in several parts of the country on a variety of grasses. Cottony blight occurs mainly on rye grasses in the south.

Pythium diseases occur in humid areas, and the fungi are destructive at or above 70 degrees F, especially on poorly drained soils. These diseases are most common on newly established turf, but if conditions are favorable, they occur on established lawns. Diseased areas vary from a few inches to several feet in diameter, appearing in streaks as though the fungus had spread from mowing or from water flow following heavy rains. The injury is detectable in early morning as a circular or irregular-shaped spot or group of spots about 1-3 inches in diameter. They are surrounded by blackened grass blades covered with white or gray mildew. Diseased leaves become water soaked, mat together, and appear slimy. The darkened grass blades soon wither and become reddish-brown, particularly if the weather is sunny and windy. Grass is usually killed in 24 hours, and it lies flat on the ground rather than remaining upright like grass affected by brown patch disease. New grass does not grow back into the diseased area until properly treated.

Avoid watering practices that keep the foliage and ground wet for long periods. Avoid excessive watering during warm weather. Aeration should be done on an annual basis and seeding delayed until fall, when cool, dry weather generally checks the disease. Chemicals give best results when

disease first appears. Two fungicides known to give satisfactory results are propanocarb and chloroneb.

h. **Snow Mold:** This fungus disease is commonly found in the northern part of the United States during the late fall, winter, and early spring. The fungus thrives under cool, moist conditions of melting snow, and the disease appears as a white cottony growth in the turf. As the blades of grass die, they turn brown and sometimes mat together. It is more severe when the soil acidity is below 6.0.

Preventive turf-grass cultural practices that prevent the disease are:

- Grade terrain for adequate drainage;
- Rake leaves and other debris in fall to help dry lawn rapidly in the spring;
- Apply last nitrogen feeding in late summer;
- Apply fungicides during winter to lawns infested the previous year to aid in preventing disease recurrence.

i. **Summer Patch:** Summer Patch, formerly called fusarium blight, is a turf-grass disease that occurs during hot, dry, and windy weather. This disease first shows up as light-green areas, either circular or crescent-shaped, at first about two inches to one foot in diameter. Within days they enlarge to two feet or more. As the disease advances, the grass color fades to a dull tan and finally to a reddish-brown color. A characteristic, called "frog eye," occurs when a healthy-appearing patch of grass is partially or completely surrounded by a ring of dead grass. Several controls for this disease include benomyl, fenarimol, iprodione, thiophanates, and triadimefon.

j. **Slime Mold:** This is a group of grass-covering fungi characterized by a dusty, bluish-gray, black, or yellow mass. It feeds on dead organic matter. It is not parasitic on grass, but does present an unsightly appearance.

Slime molds occur during wet weather, but they disappear rapidly when the moisture dries up. The large masses can be easily broken up by sweeping with a broom or by spraying with a strong stream of water. If slime mold persists during prolonged damp weather, apply a garden fungicide at minimum strength to the affected areas.

k. **Copper Spot:** This disease appears on grass leaves as small reddish spots which, as they enlarge, become darker red and eventually blight the entire leaf. The disease patches range from one to three inches in diameter and give a copper color to the grass. The patches are not

characterized by the same distinct straw-colored appearance and circular patterns as dollar spot; however, both fungi sometimes affect a lawn area simultaneously. The control is the same as for dollar spot.

l. **Mosses:** Mosses never develop in a healthy lawn. They result from any one, or a combination of factors, such as lack of soil fertility, high soil acidity, poor soil drainage, soil compaction, insufficient light, and improper watering. An established moss bed can be removed from the lawn by any of the following methods, all of which are surface treatments only.

- Spray with a copper sulfate solution mixed at a rate of five ounces of copper sulfate to four gallons of water per 1,000 square feet of lawn area. Do not allow the chemical to soak into the soil.
- Vigorously hand rake the affected area.
- Apply concentrated amounts of ammonia sulfate when moss is moist.

m. **Algae:** Algae are fresh water plants that grow in moist areas under trees and are sometimes mistaken for moss. Algae can be eliminated by spraying the area with a solution comprising a mixture of one teaspoon copper sulfate in eight gallons of water. Algae, like moss, will return if any of the causal factors are permitted to get out of control.

n. **Rust:** Rust fungi attack many lawn grasses, but are more serious on Merino Kentucky Bluegrass than on other grasses. Common Kentucky Bluegrass is less susceptible to rust than Merino, but it is more susceptible to the more destructive leaf spot. Rust has been reported on Merino from Canada to Oklahoma and from Rhode Island to California.

Heavy dew encourages rust development, which generally occurs during the dormant period of late summer and lingers until frost. Yellow-orange or red-brown powdery spots develop on leaves and stems. If a light-colored cloth is rubbed across the affected leaves, the rust-colored spores will stick to the cloth to produce a yellow or orange stain.

Lawns containing pure stands of Merino Kentucky Bluegrass are especially susceptible to attack by rust fungi. Damage is less severe if Merino is mixed with common Kentucky Bluegrass or with creeping red fescue.

Several chemicals are effective in the control of rust on Merino Kentucky Bluegrass and other grasses. However, it may take several applications to eradicate rust or prevent infection of new growth. The chemicals anilazine, chlorothalonil, and cycloheximide tend to retard the growth on

Merino for about a week. It is recommended that iron chelate be added to the mixture, at the rate of 1/2 ounce per 1,000 square feet of area being sprayed. The iron concentrate will correct for iron chlorosis of the grass and increase the effectiveness of the fungicide.

o. **Mushrooms:** Several kinds of mushrooms grow in lawns. Mushrooms vary in size, shape, and habit of growth, and may grow individually, in clumps, or in circles. Mushrooms usually develop from buried organic matter, like pieces of construction lumber, logs, or tree stumps. Although they are usually harmless to grasses, they are objectionable because their fruiting bodies occur repeatedly and present an unsightly appearance in the lawn. Mushrooms develop following prolonged wet weather, and frequently disappear when the soil begins to dry, or when the grass is mowed.

   The easiest method of eliminating mushrooms is to dig up the buried items responsible for their development. If this is impractical, punch holes in the ground using an iron bar. Space the holes 6-8 inches apart and make them 6-8 inches deep, then drench the soil by pouring a fungicide solution into the holes.

p. **Fairy Rings:** Fairy rings are a type of mushroom which develop during spring and fall. They occur in dark green grass in circles, or arcs, surrounding areas of light-colored or dead grass. Unless the fungus is controlled, the ring enlarges each year and leaves alternate bands of green and discolored grasses.

   The fungus that causes fairy rings spreads in concentric circles from 5 to 24 inches, depending upon soil conditions, temperature, moisture, and fertility. Fairy rings seldom occur in lawns that are properly and adequately fertilized. The fungus is usually several inches below the surface. It forms a dense layer of mycelial threads that break down soil organic matter at the outer edge of the ring.

   Practices that minimize the effects of fairy rings include applying increased nitrogen, aerating the rings to improve water penetration, and digging up the entire area of the ring and replacing it with fresh soil and replanting grass. This disease is difficult to eliminate with chemical methods.

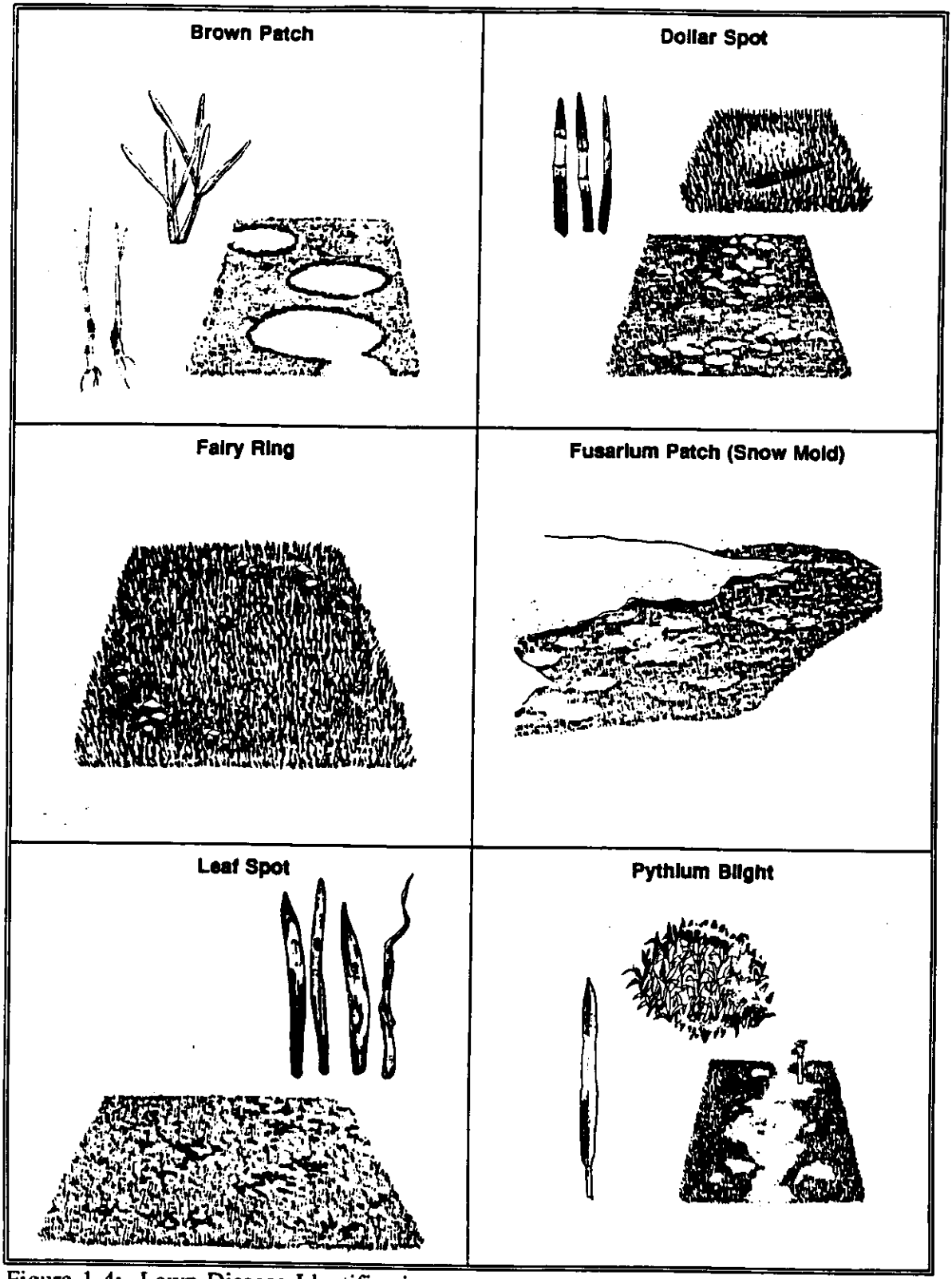


Figure 1-4: Lawn Disease Identification

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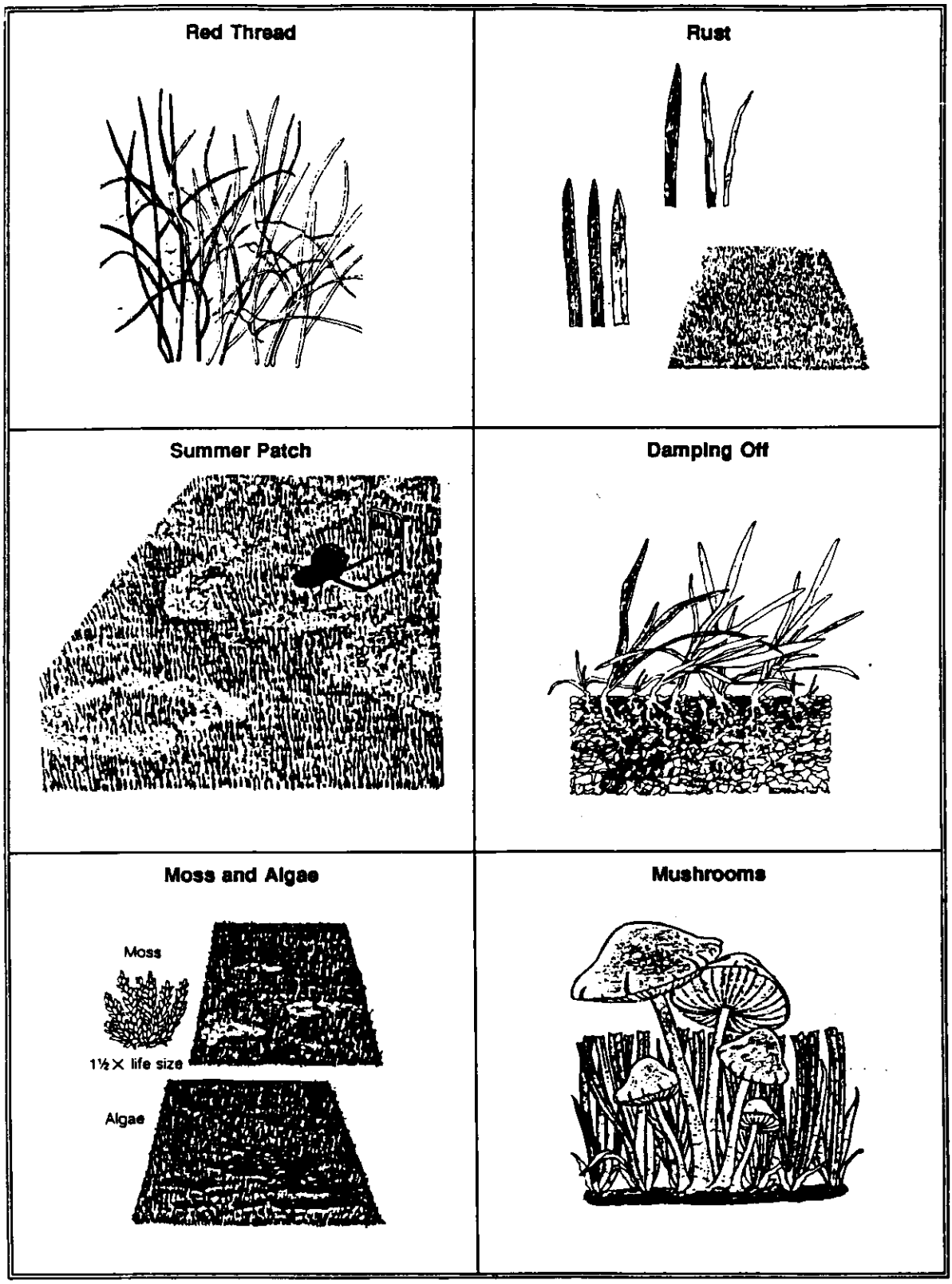

Figure 1-4: Lawn Disease Identification

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SECTION H INSECT DAMAGE

1. GENERAL

Turf grass is subject to attack from insects and insect-like pests, which cause it to turn brown and die. These pests can be grouped as follows:

- Soil and root-infesting insects, including Japanese, Oriental, and Asiatic grubs; white-fringed beetles; masked, rose, and European chafers; mole crickets; wireworms; billbugs; and ants.
- Leaf- and stem-damaging insects, including sod webworms, armyworms, cutworms, lucerne moth, fiery skipper, grasshoppers, and leaf bugs.
- Plant juice-sucking insects, including chinch bugs, aphids, leaf hoppers, mites, scales, and ground pearls.

2. IDENTIFICATION AND CONTROL

This section deals with insect identification and cites a few easy inspection techniques that may reveal the extent of insect infestation. See Figure 1-5 for illustrations of the most common insects affecting lawns. Various insecticides for insect control are also included. Specific rates of application and application timing should be according to manufacturers' instructions. See related EPA/OSHA requirements in Appendix A.

a. Soil and Root Insects

Grubs: There are many species of beetles whose larvae, or grubs, attack the roots of grasses during the grub's underground development. They are whitish to grayish and, except for the larvae of the green June beetle, lie in a curled position.

Grub populations are best evaluated in the spring, after the soil has been warmed, and again in the fall, before cold weather. Grounds maintenance personnel have two opportunities each year to learn the severity of insect infestation and the progress being made in eradicating this pest. This can best be done by cutting three sides of a strip of sod one foot square and 2-3 inches deep. Lay back the sod using the uncut side as a hinge, and knock the grubs from the exposed grass roots and soil using a trowel or blade. Taking samples at random throughout the lawn gives a good picture for evaluation. Six or more grubs per square foot indicate the need for an eradication program.

Chemical control of grubs must consider that the insects are deep in the soil and that repeated heavy watering with the insecticide is necessary to control the pests. Remove thatch before any chemical treatment, and use an insecticide containing chlorpyrifos, diazinon, isofenphos, or trichlorfon.

Chinch Bugs: The primary symptom of a chinch-bug infestation is the appearance of large yellow circular patches in the lawn. St. Augustine grass is the most vulnerable, although Kentucky bluegrass and creeping bentgrass are also affected.

An adult chinch bug is about 1/6-inch long, black, with white markings. The immature, or nymph forms cause most of the damage. They are one-half the size of a pinhead at birth, bright red with a white band across the back, and increase in size and darkness with each of four molts.

Chinch bugs may be detected by using a tin can with both ends removed. One end of the can is pushed into the ground in a yellowed patch of the damaged turf, and the cylinder is filled with water. If chinch bugs are present, they will float to the surface after a few minutes. They congregate in grass that is just beginning to turn yellow, not in lawn that is already dead or actively growing.

It is easiest to control chinch bugs by selecting grass species, such as "Floratam" St. Augustine, that are resistant to them. Chemical control can be done by using insecticides containing chlorpyrifos, diazinon, isofenphos, NPD, or propoxur.

Sod Webworms: Sod webworms live in the grass root system and chew off grass blades just above the thatch line during the night. Most of the damage occurs from spring to midsummer. Visible symptoms of webworms are dead patches of grass 1 to 2 inches in diameter. Both blue and bent grasses are susceptible to webworm damage. Thatch removal will make the lawn less desirable for sod webworms. Chemicals for control include carbaryl, chlorpyrifos, diazinon, acephate, isophenphos, NPD, propoxur, and trichlorfon.

Billbugs: Billbugs feed upon fibrous grass roots of turf throughout the United States. Adults are various-colored beetles, 1/5-inch to 3/4-inch long, with long snouts or bills, at the tip of which are strong jaws. With these jaws, adults burrow into grass stems for food and for depositing their eggs. The small larvae have soft white bodies and hard yellow-to-brown heads. Dead sections of grass will easily lift from the soil, although leaves are also fed upon. Kentucky bluegrass is most often damaged in the northern regions, whereas Bermuda and zoysia grasses are attacked

in the southern regions. For chemical control, use an insecticide containing diazinon, propoxur, or carbaryl.

Ants: Most ants are small, 1/10-inch to 1/2-inch long, ranging in color from yellow to black. They are frequent inhabitants of lawns throughout the country. Argentine and pavement ants are found in lawns in the southeast and Atlantic Coast States, respectively. Their ant hills and underground nests smother or destroy the roots of surrounding turf. The southern fire ant is spreading northward from the Gulf Coast States, where it forms loose mounds in grassed areas. Texas leaf-cutting ants, found in Texas and Louisiana, damage turf by establishing unusually deep underground nests, made of cut plant leaves.

Ants do not feed on and destroy turf. Their damage is the result of nest mounds they make, which eventually cover and smother the grass. Chemicals used for the control of ant populations include chlorpyrifos, carbaryl, and diazinon.

Mole Crickets: Mole crickets, which are relatives of grasshoppers, are approximately 1-1/2 inches long. They feed on grass roots and cause irregular streaks of brown and wilted grass. They are found in southern regions in warm-season grasses such as bahia, Bermuda, centipede, and St. Augustine grass. Grass damaged by mole crickets pulls up easily, and the insects can be seen if the ground is bare.

The most common form of control is use of a mole-cricket bait containing propoxur. In the spring, diazinon can be used about a week after signs of mole-cricket activity appear.

b. Leaf- and Stem-Damaging Insects

Sod Webworm (species): Sod webworms occur throughout the United States. Adult moths of the webworms are 1/2-inch to 1-inch long and yellowish brown to dirty gray in color. They hide in the grass during the day, coming out in late afternoon or evening. Webworms are about 3/4-inch long, light brown, and covered with fine hairs. They build short, silk-lined tunnels in the ground to feed on the grass, often dragging bits of the blades into their burrows. Sod webworms prefer new lawns. Ragged brown patches in the turf are the first signs of damage; however, in heavy infestation, large areas of turf may be completely killed. Most of the common species have several generations per year.

Thatch removal makes lawn less desirable for sod webworms. Chemicals for the control of these

insects include carbaryl, chlorpyrifos, diazinon, acephate, isophenphos, NPD, propoxur, and trichlorfon.

Armyworm (species): Two of this group are the most destructive to turf, the armyworm and the fall armyworm. The armyworm adult is pale brown with a single white dot in the center of each forewing. The forewing of the fall armyworm adult is dark gray and mottled, while the hind wing is grayish white. Both have a 1-1/2 inch wing spread. The caterpillars resemble each other more closely, having a basic tan-to-green color with three yellowish-white hairlines running end to end down the back. Armyworms hide in the soil by day and feed on the stems and then the leaves of grasses at night. Fall armyworms do not leave the grass plants in order to hide. When these species are numerous, they may devour plants to the ground, causing circular bare areas in the turf.

Thatch removal will make the lawn less desirable for sod webworms. Several chemicals for the control of these insects include carbaryl, chlorpyrifos, diazinon, or acephate.

Cutworms: Cutworms have worldwide distribution. Certain species are found primarily in southern states and others in northern climates. There are many species of cutworm responsible for turf damage. The adults are moths of medium size with a wingspread from one to two inches. They are usually multicolored, of dull hues such as brown, gray, or dirty-white and are nocturnal in habit. Larvae are nearly two inches long and are smooth greenish, brownish, or dirty-white caterpillars. Some species remain in the soil and feed upon roots and underground parts of stems, others cut grass off at the soil line, and still others devour the blades. Damage is done at night, leaving small, elongated, or irregular closely cropped brown spots in the turf.

Thatch removal makes lawn less desirable for cutworms. Chemicals for the control of these insects include carbaryl, chlorpyrifos, diazinon, or acephate.

Fiery Skipper: The larvae of the fiery skipper feed on the leaves of grasses, but attack bent grass most severely. Early infestation is indicated by isolated, round bare spots, one to two inches in diameter. The spots may become numerous enough to destroy most of the lawn. The adults are small yellowish-brown butterflies.

Thatch removal will make the lawn less desirable for sod fiery skippers. Chemicals for the control of these insects include carbaryl and diazinon.

Grasshoppers: Grasshoppers do not feed on a well-kept lawn, except when they are very numerous and forage is scarce. They usually migrate to lawns from cropland or wasteland. Control measures in lawns are seldom necessary.

c. Plant Juice-Sucking Insects

Chinch Bugs: See **Soil and Root Insects**, for identification and control information.

Leafhoppers: There are several species of leafhoppers that feed upon and cause injury to grass. They are less than 1/5-inch long, and may be green, yellow, or light tan. Both nymphs and adults suck plant juices, and, especially in dry, hot weather, may cause extensive off-color in lawns, appearing as gray to light brownish-yellow spots. Insecticides for the treatment of leafhoppers should contain acephate or diazinon.

Mites: Mites are spiders, but are included here because they are responsible for serious damage to grasses under some circumstances. They are smaller than a pinhead, red to dark brown, and have eight legs when mature. Damaged grasses become pale and sickly looking and may reveal minute specks on the leaves under closer inspection. Severely damaged lawns become so thin that weeds will eventually take over. Mites are usually kept in check by other insects or predators, but insecticides containing diazinon or dicofon can be used for control.

Ground Pearls: The female adult secretes a white, waxy sac, in which it places about 100 pinkish-white eggs. Ground pearls cause serious damage to Bermuda grass in the south and southwest and to centipede grass in the south. Attacked grasses turn brown in the summer and show irregular dead spots in the fall. No chemical is presently used to control ground pearls.

Nematodes: Plant parasitic nematodes are tiny worm-like creatures that live in the soil. The adult varies in size from 1/16-inch to 1/6-inch in length. It is reported that they are next to arthropods in the damage and overall destruction they cause. Symptoms of their damage include loss of plant leaf color and vigor, and stunted, deformed, and rotted plant roots.

There are two main types of root nematodes, those which feed on plant roots while in the soil, and those which burrow into the plant roots to feed. If nematode infestation is suspected, soil samples should be tested by a County Extension Agent. If treatment is indicated, it should be done by a commercial firm, since there are thousands of kinds of nematodes.

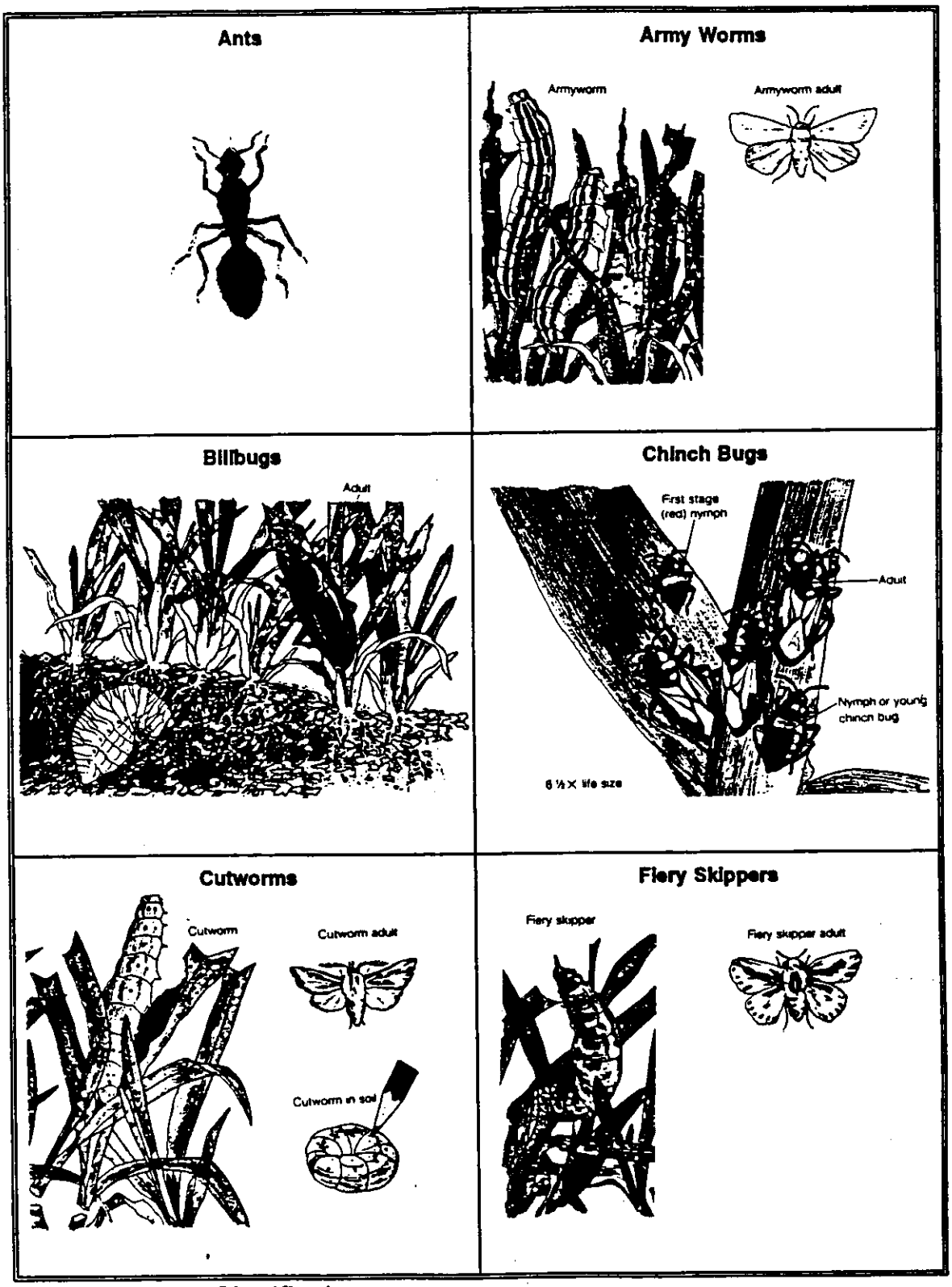

Figure 1-5: Insect Identification

Figure 1-5: Insect Identification

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SECTION I IRRIGATION

1. SYSTEM DESCRIPTION

Irrigation systems are generally below-ground and fully automated. All lawns should be irrigated as often as necessary to maintain healthy growing conditions. Irrigation systems should be kept in proper working condition through adjustment, repair, and cleaning on a regular basis.

a. Routine Maintenance

Sprinkler heads should be continually inspected and repaired to maintain full coverage. Adjust spray heads as necessary to minimize overspray on buildings, sidewalks, or other unlandscaped areas. Lateral lines can be flushed out after removing the last sprinkler head or two at each end of the lateral. Repairs to the system should be made with originally specified materials or suitable substitutes. Automatic controllers should be set for seasonal water requirements.

b. Winterization

Isolation valves should be provided for ease of maintenance, and are necessary for the winterization of a looped mainline system. Irrigation systems should be drained and winterized prior to the ground's freezing.

END OF CHAPTER ONE