TURF MANAGEMENT

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A lawn is an important part of the urban and rural landscape. A well-trimmed, dense, uniform lawn adds beauty, recreational space and value to a landscape, as well as practical and environmental benefits such as reduced runoff, area cooling, trapping of sediment and pollutants, improved soil aeration, improved water quality through infiltration, reduced wind-blown dust, and soil erosion. Lawns provide an environment for microorganisms which can break down pesticides. Lawns also reduce noise, air temperature and glare, as well as provide a backdrop for other landscape elements. Proper lawn installation and maintenance reduces the amount of work and problems that can be associated with a quality lawn.

Grass Plant Structure and Growth

Leaves, stems, and roots all originate from the crown, which is a very tightly compressed growing point located near the base of the plant just below or at the soil line. Growth types of grasses include:

Bunch-type Grasses – Bunch Grasses spread primarily or entirely by tillers and these tillers form small dense clumps. Bunch Grasses include perennial ryegrass, tall fescue, hard fescue and chewings fescue.

Stoloniferous Grasses – Stoloniferous Grasses spread by above-ground stems called stolons, and form a relatively loose mat of horizontally growing aerial shoots. Creeping bentgrass is a Stoloniferous Grass.

Rhizomatous Grasses – Rhizomatous Grasses spread by below-ground stems called rhizomes, which form dense, uniform lawns with upright shoots. Kentucky bluegrass is a Rhizomatous Grass.

Turfgrasses adapted to the northern United States are called **cool season grasses**. They have growth peaks in the cooler spring and fall months. Southern turfgrasses are called warm season grasses and their growth peaks during the hot summer months. In late fall, leaf and sheath production of cool season grasses ends and shoot formation begins. These new shoots are rough and course and will produce flowers the following spring. After flowering, the grass shoot dies along with its associated roots. However, there is little detectable difference in the lawn since dead shoots are continually replaced with new plants. Lawns may simply appear a bit thinner by late June or early July. Growth begins again in late July or Early August and the process starts over.

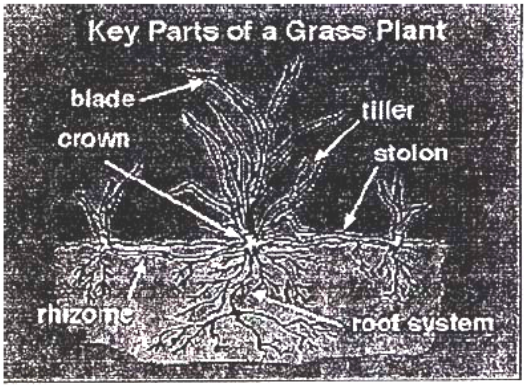

Figure 1. Anatomical structures of a grass plant.

Selecting Grasses

Several species of grasses are suitable for lawns in Minnesota. They include Kentucky bluegrass, the fine fescue grasses, and perennial ryegrass, all of which are described below.

Kentucky Bluegrass – Kentucky bluegrass is the most important grass for lawns in the Midwestern region and it is a major component of most lawns. Kentucky bluegrass produces a beautiful, dense turf of soft-leaved plants that spread and fill in bare or damaged areas quickly. Kentucky bluegrass is the most important cool-season grass for lawns in North America. It is adapted to a wide range of environmental conditions, but does best in soils of moderate to high fertility with a pH of six to eight. It tolerates moderate mowing heights, full-sun to light shade conditions, as well as slight to moderate traffic.

Many varieties of Kentucky bluegrass have been developed, each having different characteristics in terms of aggressiveness, tolerance to low mowing, resistance to diseases, shade tolerance, and level of management required. Kentucky bluegrass forms a beautiful, dense, soft turf and spreads vigorously by rhizomes or underground stems. It mows cleanly and easily. It grows poorly in shade and goes dormant during dry periods of the year. Kentucky bluegrass is slow to germinate and establish.

Common Kentucky bluegrass and varieties with similar characteristics, typically require a mowing height of two to three inches, need less fertilizer, and are more drought tolerant than the improved, aggressive varieties of Kentucky bluegrass. Consequently, they are suitable for low maintenance lawns. Named Kentucky bluegrass varieties which are particularly well-suited to low maintenance situations are Aquilla, Newport, Park, South Dakota Certified and Kenblue.

The improved, aggressive varieties of Kentucky bluegrass form a more dense turf and fill in damaged areas faster, require higher levels of fertility, are typically more disease resistant, require more thatch control, and are more likely to require irrigation during the summer. Kentucky bluegrass varieties better suited for higher maintenance include Wildwood, Liberator, Absolute, Midnight and Princeton.

Fine Fescue Grasses – Creeping red fescue, chewings fescue, and hard fescue are fescue grasses particularly well suited to shady lawns and lawns with very sandy soil, and lawns without irrigation. They have excellent shade tolerance and are well adapted to droughty, sandy soils and to low maintenance. They mix well with Kentucky bluegrass and are adapted to low maintenance lawns. Growth of fine Fescue grasses can be bunchy due to minimal spreading ability. They also have poor recuperative ability. They are adapted to low fertility levels, however they are prone to thatch build-up and high temperature injury. The fine fescues have narrow, tough leaf blades that are not easily crushed and will rarely stain clothes, but they are difficult to mow in a pure stand. For seeding a home lawn, a mixture of fine fescues and Kentucky bluegrasses is usually preferable to using fine fescues alone. Varieties that have performed well in regional trials include Shadow II, ForenTine and Jasper.

Perennial Ryegrass – Perennial Ryegrass germinates and becomes established quickly and vigorously. Perennial ryegrass is a cool-season, medium-textured, and wear-tolerant grass particularly well adapted to high traffic areas. Because the plants tolerate considerable wear damage, perennial ryegrass is often used on athletic fields and park areas. Perennial ryegrass is more difficult to mow cleanly than Kentucky bluegrass and it is adapted only to high maintenance conditions.

Perennial ryegrass is a bunch-type grass that does not spread rapidly. Consequently, if a perennial ryegrass turf is allowed to thin out due to low maintenance, the turf becomes very bunchy and of poor quality. For home lawns, perennial ryegrass mixes well with the Kentucky bluegrasses and this helps reduce bunchiness, improves mowing quality, and gives more disease tolerance to the lawn.

Perennial ryegrass is not as tolerant of cold climates as either Kentucky bluegrass or the fine fescue grasses. For Minnesota, choosing varieties with improved cold tolerance is critical. Varieties currently available which have shown good performance in the Midwest include Secretariat, Premier II, Monterey, Lin Drive and Omega 3.

Annual (Italian) Ryegrass, Buffalo Grass, Creeping Bentgrass, Turf-type Tall Fescue, and Zoysia Grass are not recommended for lawns in Minnesota.

A mixture of 60 to 70 percent Kentucky bluegrass and 30 to 40 percent fine fescue grass is suitable for most sunny lawns. A mixture of 60 percent fine fescue grass and 40 percent Kentucky bluegrass is best for most shady lawns. For high traffic lawns with high maintenance practices, a mixture of 60 percent Kentucky bluegrass and 40 percent perennial ryegrass may be best. Mixtures of all three species are common at 50 percent Kentucky bluegrass, 40 percent fine fescue and ten percent perennial ryegrass.

No more than five to ten percent of a grass seed mixture should be annual ryegrass. High percentages of this grass are commonly found in inexpensive mixtures that give unsatisfactory results. Annual ryegrass is a soft, short-lived grass that germinates rapidly and is useful only in some locations where temporary and rapid cover is required.

Lawn Soil Preparation

When starting a new lawn, two zones of soil: topsoil and subsoil, must be prepared. Topsoil is the area where the majority of grass roots are found and is

usually four to six inches in depth. It is the primary area of root development and growth. The subsoil is soil below the root zone. The most important property of the subsoil is good drainage. It should be loose and graded before applying topsoil. Never roll or pack the subsoil. The subsoil grade should parallel the finished surface grade.

Good topsoil is difficult to obtain. At construction sites, the existing topsoil should be stockpiled during the construction process, and then returned in a uniform layer over the subsoil. If the existing topsoil is too sandy, add one to two inches of course fibrous peat and till it in to a depth of four to six inches to promote establishing and maintaining the turf. If the topsoil contains too much clay, add one to two inches of course sand and till it in to a depth of four to six inches. Coarse fibrous peat may partially improve a heavy clay soil, but if it is too fine, it will worsen the situation. Peat will increase the cation exchange capacity and the water-holding capacity of sandy soils.

When applying the topsoil, first apply about two inches of topsoil and mix it with the subsoil. Then apply topsoil to a minimum depth of four inches, or preferably to a depth of six to eight inches. The finished grade should drop at least one foot in 100 feet away from the house or in the direction of desired surface water flow so that any surface runoff will flow away from the house. Use a cultipacker drawn across the finished surface to make a good seedbed.

Before seeding, test the soil for nutrient status and pH. Instructions for soil testing can be arranged through the county extension service. The soil test report includes data on soil pH, percent organic matter and ppm of nitrogen, phosphorus, and potassium. It also includes recommendations on how to correct any deficiencies.

Phosphorus and potassium fertilizer should be incorporated into the top four to six inches of soil before seeding since these elements are relatively immobile in most soils. Base the application rates of phosphorus and potassium on soil tests. Nitrogen fertilizer, at a rate of 0.5 lb. N/1000 ft^2, should be mixed into the soil along with the seed or tilled in just before planting to a depth of one-half to one inch. An additional 0.5 lb. N/1000 ft^2 should be applied two weeks after seedling emergence and watered in.

Seeding a Lawn

The best time to seed a lawn in Minnesota is between August 15 and September 10 because that is when most grasses normally germinate in nature. Most annual weeds do not germinate after August 15. A lawn seeded during this period of late summer can become established before winter and will start growing in the spring before weeds start to germinate. The second best time to seed is early spring as soon as the ground can be cultivated.

It is necessary to purchase the best seed possible, as poor quality seed rarely results in a well-established lawn. Determine the quality of the seed by reading the label which should provide all the information listed below and as shown in Figure 2.

Purity – Purity represents the percents by weight of pure grass seed, crop seed, weed seed, and inert ingredients in the package. Purchase seed with the highest purity percentage of grass seed possible.

Germination – Germination is the percent by weight of pure grass seeds that are viable. Purchase seed with the highest germination percentage possible.

Crop – Crop includes the percent by weight of seeds normally grown as agricultural crops, including hay. This percentage should be low as possible.

Weeds – Weeds refer to the percent by weight of all seeds in the package that are not listed as pure seed or crop seed. This percentage should be as low as possible.

Noxious Weeds – Noxious weeds are listed as the number of noxious weeds per pound. Noxious weeds are very difficult to control. Always purchase grass seed with no noxious weeds.

Inert Materials – Inert materials indicate empty seed hulls and other particles that will not grow. This percentage should be as low as possible.

When seeding, divide the seed into two equal lots and sow it in two directions. Most mechanical seeders have built-in cultipackers which leave about ten percent of the seed showing. If a mechanical seeder is not used, roll the seedbed lightly to firm seed into the soil. Irrigate lightly after seeding. Refer to Table 1 for recommended grass seeding rates per 1000 ft^2 of lawn.

It is best to water newly seeded areas two or three times per day for ten to 20 minutes at a time. Never allow the seedbed to dry out once it has been watered,

but do not allow the soil go into the night in a wet condition. As seedlings develop, apply water in longer periods, in greater quantities and less often until the grass is well-developed.

Will-Grow Seed Company Turf Town, Oregon Lot No. 1234-B. Test Date: 09/2006		
Pure seed	**Variety**	**Germination**
44%	Arctic Creeping Red Fescue	85%
31%	Blue Ribbon Kentucky Bluegrass	80%
9%	Wilson Chewings Fescue	85%
12%	Gopher Perennial Ryegrass	90%
1.56%	Crop	
2.11%	Inert Matter	
0.33%	Weeds	
Noxious Weed Seeds: 25 Canadian thistle seeds per pound.		

Figure 2. Sample label for a grass seed mixture.

Table 1. Seeding rates per 1000 ft^2 of lawn.

Grass Variety	Pounds/1000 ft^2
Kentucky Bluegrass	2-3
Fine Fescue	4-5
Kentucky Bluegrass/ Fine Fescue Mix	3-4
Kentucky Bluegrass/Perennial Ryegrass Mix	3-4
Kentucky Bluegrass/Fine Fescue/Perennial Ryegrass	3-5

When grass blades reach a height of three to four inches, mow the new lawn to a height of three inches. Mow only with a sharp mower. After several mowings, the cutting height can gradually be reduced to the desired mowing height of two to three inches for an established lawn.

Seeding costs less than sodding and, if successful, provides a great feeling of accomplishment. It ordinarily takes six to 12 weeks to establish a healthy lawn from seed, but it usually takes almost a full growing season before the lawn can be considered well-established and ready for extensive traffic.

Sodding a Lawn

Sodding costs more than seeding, but it results in an "instant" lawn. The real advantage is that customers need not face the problems and time involved in turf establishment as the sod grower and landscape installer does that for them. The grass from sod should be freshly mowed and weed free. In most situations, either peat or upland mineral soil sod is satisfactory. Sodding can be done soon after growth starts in the spring and can continue until October.

Soil preparation is often neglected in sodding a lawn. A sodded lawn requires the same soil preparation as a seeded lawn. Areas to be sodded should have phosphorus and potassium tilled into the soil according to soil test recommendations for that soil. An application of one-half pound nitrogen per 1000 ft^2 may be applied to newly sodded turf. Sufficient water is critical. When sodding must be done during hot, dry periods, irrigation equipment capable of keeping the sod continuously moist is required. The actual laying of the sod should be accomplished in accordance with the following procedures.

1. Lay sod as soon as possible upon receipt of the sod. Avoid leaving it stacked and rolled for more than one or two days.

2. Stagger the joints and fit the pieces as closely together as possible. Always lay sod across a slope. Use short wooden pegs, spaced one foot apart, to anchor sod on a slope.

3. Soak the sodded area immediately after laying it and water it daily, unless it rains, until the sod is firmly rooted into the soil. This takes two to three weeks.

4. After establishment, treat the sodded area as any established lawn.

Fertilization

Normally three nutrients or essential elements are most important in fertilizing a lawn: nitrogen (N), phosphorus (P), and potassium (K). Although many other elements are necessary for proper plant growth, most, except these three, are usually provided in sufficient quantities by natural soil processes.

Adequate nitrogen causes the plants to develop a dark green color and to grow vigorously. The amount of nitrogen required by a lawn varies with maintenance practices. A lawn, which is kept growing vigorously

during the summer with irrigation, requires more nitrogen than a non-irrigated lawn. Some nitrogen in the soil is present as part of the organic matter and becomes available for use by plants as organic matter is decomposed by soil micro-organisms. Decomposition of lawn clippings, plant roots, and other organic materials provide this nitrogen for use by plants. The amount of nitrogen provided by these natural soil processes is generally not adequate to maintain the vigorous growth desired in most lawns throughout the growing season; consequently, supplemental nitrogen-containing fertilizer is usually required.

Before the nitrogen in organic matter can be taken up by plant roots, the organic matter must be broken down so that nitrogen is in the form of ammonium (NH_4^+) or nitrate (NO_3^-) ions. In most soils, the ammonium form is quickly converted to the nitrate form. This nitrate form is not tightly held on the soil particles and is soluble in soil water. Consequently, in sandy soils with excessive rain or irrigation, nitrates can move in the water to depths below the root zone. In clay soils with excessive rain, nitrates can also be leached below the root zone, or it can be converted to a gas and be lost to the atmosphere.

Since nitrogen applied at excessive rates can burn grass plants and cause other problems, it is best to apply moderate amounts of fertilizer on a regular basis rather than large amounts infrequently. If soluble or quickly available forms of nitrogen are used, no more than one pound of N/1000 ft^2 should be applied in one application. At this rate, a low maintenance lawn will require one or two applications of fertilizer in late August or late October to early November (Figure 3). For higher maintenance lawns, two to three applications of one pound of N/1000 ft^2 each are required to maintain constant growth (Figure 4). If three applications are made, apply in mid-May, late August and mid-October. Always irrigate immediately following fertilizer application. This prevents burning of the leaf blade under moist conditions and it decreases the chance of runoff from heavy rains.

Specific nitrogen fertilizer recommendations for lawns are based on soil organic matter content and lawn management practices. Turf on high organic matter soils requires less nitrogen than turf on low organic matter soils. Irrigated lawns grow more vigorously and do not go dormant in mid-summer, so they require more nitrogen fertilizer than non-irrigated lawns. Leaving clippings on the lawn recycles nutrients and reduces nitrogen fertilizer requirements by about one pound of N/1000 ft^2 per year, compared to lawns where clippings are removed.

Most lawn fertilizer should be applied in the late summer and fall period. Fertilizing in the fall rather than the spring leads to a lengthened period of green in the fall, early spring green-up, higher levels of energy reserves in the plants in spring and summer, and most importantly, increased tolerance of summer stresses such as disease. Fertilizer should not be applied to frozen ground.

Nitrogen – Nitrogen fertilizers can be broadly grouped into quickly available or soluble materials, and slowly available or slow release materials. The quickly available fertilizers are water soluble and the nitrogen is readily available to the plants. The use of soluble fertilizers results is a sudden flush of growth and a rapid depletion of the available nitrogen. Thus, it will be necessary to make frequent light applications of these materials to obtain uniform growth over a long period of time and to prevent possible burning.

Slowly available nitrogen materials depend on soil temperature, microbes or moisture to gradually decompose the materials and transform the original compounds into nitrogen forms available to plants. These forms release nitrogen to the plant over a longer period of time. High temperatures and adequate moisture accelerate the breakdown of these materials, and the supply of nitrogen to the plant is more rapid. Low temperatures or dry soil minimize the release of nitrogen to the plants.

Phosphorus – Phosphorus is important in stimulating early root growth and promoting early plant vigor. Phosphorus moves very little in the soil as most of it is bound tightly to soil particles. Soils naturally high in phosphorus normally provide sufficient phosphorus for vigorous lawn growth for many years without adding phosphorus in fertilizers.

Three important reasons why a phosphorus-deficient soil should be corrected prior to seeding are as follows:

1. Phosphorus moves very little in the soil, therefore, phosphorus should be mixed throughout the root zone. This is relatively easy prior to seeding, but more difficult after establishment.

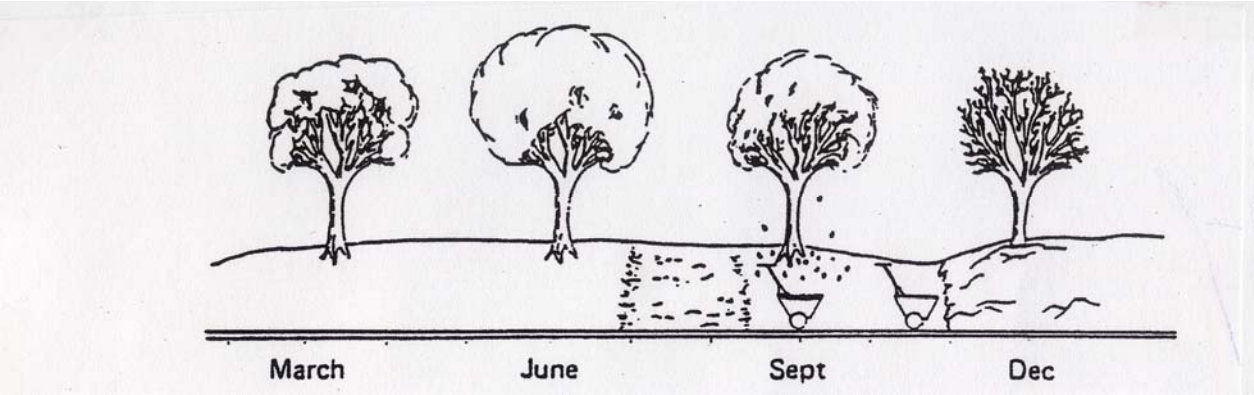

Figure 3. At a rate of one pound of N/1000 ft^2, a low maintenance lawn will require one or two applications of fertilizer in late August and perhaps late October or early November.

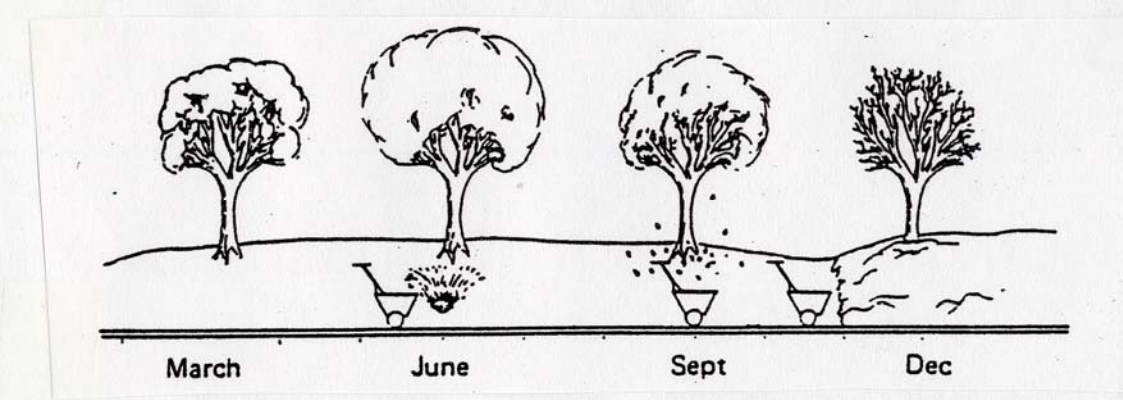

Figure 4. For high maintenance lawns, two or three applications of one pound of N/1000 ft^2 each are required to maintain constant growth. If three applications are made, apply in mid-May, late August and late October.

2. Phosphorus is required for root growth. New seedling plants with newly developing root systems will be adversely affected by lack of phosphorus.

3. Mixing phosphorus into the soil rather than applying it to the surface reduces the chance for phosphorus to move into lakes and streams. If incorporated into the soil, fully developed turfgrass root systems can absorb phosphorus from a much larger volume of soil and therefore, reduce plant deficiencies.

New phosphorus regulations exist in Minnesota. Spilling or spreading of fertilizer on impervious surfaces is prohibited. Lawn fertilizer must contain no phosphorus throughout the state. Phosphorus can be used on a **new lawn seeding without a soil test or it can be used on established lawns if a need is shown by a soil test.**

Potassium – Potassium is important in the synthesis of some plant components and in the regulation of many physiological processes. Potassium deficiencies in lawns can lead to increased incidence of turfgrass diseases and reduced tolerance to environmental stress.

Potassium is held on the surfaces of soil particles and does not move readily in most soils, however, it can gradually move out of the root zone in very sandy soils. Where soils are high in native potassium, supplemental potassium fertilization may be unnecessary, however, where soils are low in native potassium, supplemental applications are very important. Soil tests are essential to determine the potassium level of a soil and to develop a potassium fertility program.

The label on lawn fertilizer bags lists the nitrogen, phosphorus, and potassium contents as a series of three numbers called the fertilizer analysis. A 20-5-10 fertilizer contains 20% nitrogen, phosphorus equivalent to five percent $P_2 0_5$, and potassium equivalent to ten percent $K_2 0$. The proper analysis to use depends on the soil test. For a soil high in phosphorus and potassium, a fertilizer analysis of 34-0-0 or 45-0-0 would be suitable, while a soil with low phosphorus or potassium would require a fertilizer such as 18-18-8 or 15-25-10.

The release characteristics of a fertilizer and its burn potential determine the amount that can be applied in a single application. Fertilizers with quick-release sources of nitrogen or potassium can burn plants if applied at high rates. In addition, applying too much nitrogen in one application is inefficient since the nitrogen not used by the plant can leach through the soil and out of the root zone. Consequently, quick-release forms of nitrogen should always be applied at a rate of one pound of N/1000 ft^2 or less in any one application. Since slow-release nitrogen is released gradually over a longer period of time, higher rates can be applied to the turf. Generally, however, rates higher than two pounds of N/1000 ft^2 in a single application are not recommended even when slow-release fertilizers are used.

The area to be covered by a given weight of fertilizer using a desired rate of nitrogen application rate can be determined from the following equation:

$$\frac{\text{weight of fertilizer x \%N in fertilizer (fraction)}}{\text{rate of application}} = \text{area covered by given weight}$$

For example, when applying fertilizer at a rate of one pound of N/1000 ft^2 with a 20 lb. bag of a fertilizer having an analysis of 23-3-6, wherein the fertilizer is 23% N:

$$\frac{20 \text{ lbs. x } 0.23}{1 \text{ lb. N/1000 ft}^2} = 4600 \text{ ft}^2$$

This 20 pounds of fertilizer should be used to cover 4600 ft^2 of lawn area. If the lawn area is less than 4600 ft^2, then only a portion of the bag is needed to supply one pound of N/1000 ft^2. If the lawn area is 2500 ft^2, then 11 pounds of fertilizer should be applied as calculated below:

$$\frac{20 \text{ lbs.}}{4600 \text{ ft}^2} : \frac{X}{2500 \text{ ft}^2} = 11 \text{ lbs}$$

$(4600X = 20 \times 2500;\ X = 50{,}000/4600;\ X = 11)$

When fertilizing lawns, particularly with quick-release nutrients, it is important to consider the weather and turfgrass conditions to achieve maximum effectiveness of the applied fertilizer. Ideal conditions include a cool day with a good rainfall or irrigation immediately following the fertilizer application to wash the fertilizer off the leaves and into the soil. As the temperature increases, the potential for damaging the leaves through fertilizer burn increases; consequently, care must be taken by applying a lower rate of fertilizer,

using slow-release forms, or washing fertilizer off the leaves immediately after application. Unless absolutely essential, fertilizer application using quick-release nutrients should be avoided when temperatures are greater than 85°F.

Fertilizer Spreaders – Many fertilizer spreaders are available that make fertilizer application easy and accurate. Two types of spreaders for granular materials are available including a drop spreader and a rotary spreader. Drop spreaders distribute the fertilizer directly below the hopper in a well-defined pattern. Rotary spreaders throw the fertilizer material out beyond the spreader in several directions and are satisfactory for most lawns. Although rotary spreaders give a less precise distribution, they are much faster and are less apt to leave a striped pattern on the lawn where areas were missed. With either type of spreader it is a good practice to fertilize one-half the desired application rate in one direction, then the second-half perpendicular to that direction.

Fertilizer spreaders will apply different materials at different rates. A spreader should be calibrated for each individual's pace and for the fertilizer used. To calibrate a spreader with a given fertilizer, adjust the spreader setting to a selected level, weigh out a known amount of fertilizer, spread that amount of fertilizer and measure the ground area covered in the process. It may be convenient to do this on a sheet of plastic or a hard surface so the fertilizer used in the calibration process can be recovered. To calibrate according to pounds of nitrogen/1000 ft^2, make the following calculation:

$$\frac{\text{lbs. of fertilizer} \times \text{\%N in fertilizer (fraction)}}{\text{ft}^2 \text{ of area covered}} = \text{lbs. N/ft}^2$$

then: $\text{lbs. N/ft}^2 \times 1000 = \text{lbs. N/1000 ft}^2$

For example, if the spreader is set at eight, and 0.6 pounds of fertilizer covers an area of 100 ft^2, and the fertilizer has an analysis of 23-3-3 wherein the fertilizer is 23% N:

$$\frac{0.6 \text{ lb. fertilizer}}{100 \text{ ft}^2 \text{ area}} \times \frac{0.23 \text{ lb. N}}{\text{lb fertilizer}} = 0.0014 \text{ lb. N/ft}^2$$

then: $\frac{0.0014 \text{ lb N}}{1 \text{ ft}^2} \times 1000 = 1.4 \text{ lb. N/1000 ft}^2$

This spreader at a setting of 8 applies this fertilizer at the rate of 1.4 lbs. N/1000 ft^2. Next, make the same measurement at several spreader settings. Then develop a chart for that fertilizer that gives the rate of nitrogen application at various spreader settings. Settings can then be made for any desired application rate. Realize that different fertilizers would have different calibration curves. Manufacturers of lawn fertilizers often recommend a setting for specific fertilizer spreaders.

Mowing

Mowing at two to three inches and on a proper schedule helps maintain a dense, smooth, uniform turf, and reduces the competitiveness of many weeds. High-maintenance lawns which are growing vigorously can be mowed at a lower height than low maintenance lawns. High maintenance lawns can be mowed at two inches while low maintenance lawns will do best when mowed at three inches.

The mowing schedule should be determined by how fast the grass is growing rather than by a routine weekly or ten-day schedule. Lawns should be mowed frequently enough so that no more than one-third of the vertical height is removed with each mowing. This helps the plant maintain sufficient leaf area for quick recovery and continued growth. This rule means that if the mowing height is two inches, mowing should be scheduled again before the lawn is three inches tall. This mowing schedule should be maintained into the fall as long as the grass continues to grow. The lawn should go into the winter at the height it has been maintained during the growing season. The last mowing in Minnesota is often late October or even early November.

A reel or rotary mower is adequate for a home lawn as long as it is sharp and well-adjusted. A rotary mower is simple and versatile, but can be very dangerous. Safety precautions in the owner's manual should be strictly followed. Always pick up sticks, stones, wire, and other debris before mowing. With any mower, attention given to routine sharpening, engine maintenance and safety will add years to the operation of the mower as well as insure a better quality cut for the lawn.

For most lawns there is no need to remove the clippings from the lawn as long as they are small enough to work down into the grass. In fact, leaving the clippings on the lawn has positive benefits because they gradually decompose and reduce the need for fertilizer. Clippings that are too long remain on top of

the plants and can pack down totally covering the growing plants. These clippings should be raked off to allow the growing plants to continue growth.

Irrigation

Minnesota's climate, along with the natural ability of many turfgrass plants to survive dry periods, makes irrigation of lawns optional in some cases. Low maintenance lawns typically receive no irrigation in Minnesota. During the spring and fall periods, natural precipitation is generally adequate to cause excellent growth and color. However, during the summer when rainfall is often insufficient for plant growth, the lawn may turn brown and go dormant. Most cool-season grasses survive hot, dry periods during summer. Going dormant is how the crown remains alive, but leaf and shoot growth stops, causing the turf to turn brown. Healthy crowns can withstand dormancy; however, not all grasses can go without irrigation during dormancy. Perennial ryegrasses and most improved Kentucky bluegrass varieties will require some irrigation to keep the crowns alive. Turf growing on compacted soils is very vulnerable to hot, dry weather. Shallow roots and excessive thatch are common in these lawns, and provide little protection from injury during these hot, dry periods. If lawns are dormant due to a hot, dry period, avoid heavy play and traffic on these lawns. Also apply one-quarter to one-half inch of water every two to three weeks to keep the crowns alive. Apply water more frequently on sandy soils or during very hot weather. High nighttime temperatures, such as 70°F to 80°F cause northern cool season grasses to deplete their carbohydrate energy reserves rapidly. Extended periods at these temperatures can cause serious, permanent turf losses. Aerify compacted soils in spring or fall to improve drought tolerance and provide some irrigation during dormancy. Most turf plants, however, do not die unless soil temperature becomes very high. After a normal dry period, new growth begins again once adequate rainfall is received. In order to promote vigorous growth and green color, even during dry periods, high-maintenance lawns are generally irrigated so the turf always has adequate water.

If irrigation is practiced, it should be scheduled so that one to one and one-half inches of water is applied to the turfgrass each week during summer periods. Any rainfall received during the week would reduce the irrigation required that week. To measure the amount and distribution of water from a particular irrigation system, place straight-sided cans at various locations on the lawn during a normal irrigation, then measure the depth of water in the cans after a given period of irrigation run time.

If the lawn is healthy, water the lawn heavily and then let the soil dry out between irrigations. This helps develop deep root systems and plant tolerance to stress conditions. Where the lawn has been recently established from seeding or sodding, or where the lawn is affected with patch disease symptoms, frequent watering is necessary to keep the lawn alive and lessen stress symptoms.

Water lawns from four to eight a.m. During this time, less water is lost to evaporation, the grass dries off quickly once the sun comes up, and early morning winds are usually lighter so water distribution is improved. City water demands are usually less at this time as well. Midday watering, although good for the plants since it cools them and reduces heat stress, is not as efficient because some water evaporates before getting into the soil. Higher winds can also blow the water onto hard surfaces instead of the turf. Avoid watering at night. Plants that go into the night wet will remain wet for an extended period of time. This allows diseases to enter the plants and encourages accelerated disease growth.

Aerification

An aerifier is a machine which removes plugs of soil from the lawn leaving holes about one-half inch in diameter and up to three inches deep. The cores of soil are typically left on the soil surface to gradually break down and filter back into the turf. Aerification has several distinct advantages in a turfgrass situation including relieving soil compaction, increasing water, oxygen and fertilizer infiltration into the soil, and helping to control the development of thatch.

Aerification is particularly helpful where the soil is compacted as a result of poor soil preparation before lawn establishment, or from considerable foot traffic on the lawn. Compacted soils result in shallow-rooted lawns particularly susceptible to disease, insect, and environmental stresses. It also causes inefficient watering as irrigation water runs off the surface to lower areas rather than infiltrating into the soil.

Aerification is best done in cool weather during late summer from August 20 to September 20. By aerifying during that period of time, the lawn recovers quickly and is completely re-established by winter.

Thatch Control

Thatch is an accumulation of tightly meshed dead and living stems and roots that build up between the zone of green vegetation and the soil surface. A thatch accumulation of less than one-half inch is usually not detrimental to the lawn, but if more than one-half inch accumulates, problems may occur. Factors that contribute to excessive thatch include:

1. Acidic soils with pH below six, which reduces earthworm, insect and microorganism activity.

2. Compacted soils with restricted oxygen levels which impair activity of decomposing organisms.

3. Excessive nitrogen or irrigation that stimulates shoot growth.

4. Infrequent mowing or excessively high mowing height.

A shallow root system may develop due to excessive thatch. Increased disease and insect attack, increased scalping from mowing, dry spots in the lawn, and reduced tolerance to environmental stresses may also occur. Thatch develops when the rate of organic matter accumulation exceeds the decomposition rate. Cultural or environmental factors that stimulate growth or impair thatch decomposition will increase the probability of thatch accumulation.

High maintenance lawns may require thatch control treatments annually due to vigorous growth, while low maintenance lawns may never develop an excessive amount of thatch. Control measures should be based on the presence of thatch rather than as a routine treatment. The need for thatch control can be determined by cutting a small pie-shaped cross-section in the turf, lifting it, and examining the extent of thatch build-up. If the depth exceeds one-half inch, steps should be taken to reduce it and prevent further accumulation.

Aerification is an effective way to increase thatch decomposition and reduce thatch build-up. Aerification increases the rate at which water and oxygen can move into soils thus creating a better environment for the thatch-decomposing organisms. As the soil cores brought to the surface in aerification gradually break down and work back into the thatch, decomposition of thatch by microorganisms is increased.

A preventative biological control of thatch is an active earthworm population in the lawn. Microorganisms, fungi, insects, and earthworms are responsible for thatch decomposition. Therefore, improve their habitat by maintaining a soil pH between six and seven, by maintaining moist thatch and soil, and by aerification. Do not use soil insecticides or fungicides unnecessarily. Use them only when needed to control specific, identified pest problems as the pesticides can reduce beneficial microorganism, insect, and earthworm populations.

A vertical mower, sometimes called a power rake, can be used to remove thatch when an excessive amount exists in a lawn. A vertical mower has blades or tines that produce a slicing action into the turf perpendicular to the soil surface. The amount of thatch removed by vertical mowing depends on the depth to which the blades penetrate into the turf and soil, the weight of the machine, and the size of the power unit. Depending on the vertical mower used and the amount of thatch to be removed, it may be necessary to go over the lawn several times for adequate thatch reduction. The large quantity of organic material brought to the surface during vertical mowing should be removed from the lawn. This material can be easily composted or used as a garden mulch.

Vertical mowing damages and thins many of the living plants, therefore time the vertical mowing so that at least 30 days of favorable temperature and moisture follow the operation. In Minnesota, a late summer or early fall vertical mowing is preferred to spring in order to minimize weed invasion. For quick recovery, the lawn should be actively growing and should be irrigated soon after vertical mowing.

Vertical mowing is also an excellent way of preparing an old or damaged lawn for over-seeding into the existing grass. The vertical mower must be set deep enough to bring soil to the surface. Soil at the surface during seeding greatly improves germination of over-seeded grasses.

Weed Control

Proper lawn maintenance should be the most important weed control practice used on a lawn. A thick, densely growing lawn keeps weed invasion to a minimal level; consequently, proper fertilizing, mowing, watering, aerification, and thatch control should be the first line of defense against weeds. Herbicides kill existing weeds or prevent expected weeds from coming up. They should be used after proper lawn maintenance practices have been established, not before. In this

way they can be used occasionally to treat weed problems rather than used on a routine basis.

To control broadleaf weeds such as dandelion, plantain, clover, or creeping Charlie; selective post-emergent herbicides can be used. These chemicals kill certain plants such as broadleaf weeds, without damaging the grass plants. They should be applied when the weeds are young and actively growing. Care must be taken so that the herbicide does not drift to desirable broadleaved plants such as flowers, shrubs, vegetables, or trees as they will also be killed or damaged.

Most effective control of annual grass weeds such as crabgrass and foxtail is achieved with pre-emergent herbicides. These chemicals kill plants just after the seed germinates. To be effective, the herbicide must be on the soil when the weed seeds germinate. In Minnesota, pre-emergent herbicides for control of crabgrass should be applied by May 15 in a normal year. Do not wait until the weed problem exists to apply a pre-emergent herbicide; the best method is to apply the herbicide to areas of the lawn which had a crabgrass or foxtail problem the previous year.

Control of most perennial grass weeds such as quackgrass or tall fescue with chemicals can only be achieved by using nonselective post-emergent herbicides. These chemicals kill all plants onto which they are applied, including the desirable grass plants. Consequently, they are only applied to spots of weed invasion with required reseeding of the area.

Before using a herbicide, carefully read the label to determine:

1. Whether or not the desired turfgrass is tolerant of the chemical.

2. Whether or not the weeds require a pre-emergent or post-emergent herbicide; this is critical to deciding when and what to apply.

3. Which weeds it controls and which plants are not affected.

4 Environmental conditions under which it should or should not be applied.

5. The rate and method of application.

6. Any safety precautions associated with its use.

Disease Control

Lawn grasses may be seriously damaged by diseases; however, with proper fertilization, watering, mowing, and aerification, most lawns will recover. Good lawn care is the best preventive measure for lawn diseases. Disease prevention practices on lawns include the following practices:

1. Grow grasses adapted to the client's area and level of management.

2. Apply fertilizer according to local recommendations and based on a soil test.

3. Irrigate when it is needed, but avoid keeping the grass wet for long periods.

4. Mow frequently at the recommended height for the grass type and use.

5. Maintain thatch layer at less than one-half inch.

6. Thin or prune trees and shrubs to allow air movement and light penetration.

7. Improve drainage and reduce compaction by aerification.

The following describes common Minnesota turfgrass diseases and how to control them.

Snow Mold – Snow Mold is visible when the snow melts in the spring. Diseased grass is covered with white, pink, or dirty-gray mycelium. The affected grass is bleached and sometimes killed, usually in a circular pattern. This symptom is most common in wet, shaded areas where snow accumulates and is slow to melt. Infection begins in the fall under the wet snow and may continue through winter until spring. Fungal growth stops when the surface freezes or dries. Snow mold damage can be minimized on lawns by keeping the turf surface free of a heavy grass or leaf mat going into the winter. Therefore, mow the grass until it goes dormant and rake leaves off the lawn so that the surface can dry quickly. Brushing or sweeping the mycelium off in the spring can also reduce damage.

Leaf Spot and Melting Out – Leaf Spot symptoms begin as a dark-brown or purple spot on the leaves in the fall or spring and may result in the sudden dying of whole plants in the summer. In cool, wet periods, the leaf tissue is killed and the sheath and crown may be invaded. Then during dry periods, large or small

irregularly shaped areas of the lawn die suddenly. Management of leaf spot and melting out is facilitated by raising the cutting height, watering, and fertilizing to meet the needs of the grass plants. Excess water and nutrients can increase grass disease problems. If leaf spot and melting out is a problem, over-seeding with resistant cultivars will reduce the damage. Chemical treatment requires application in cool, wet growing conditions early in disease development. If melting out symptoms are already present, treatment results will be poor.

Powdery Mildew – Powdery Mildew appears as a white dust on the leaves. It is common in cool, shaded areas of the lawn in fall and spring. Mildew often thins turf areas in dense shade under trees or on the north side of buildings. Improving light penetration, mowing frequently, and increasing air movement reduces mildew. Over-seed with shade-tolerant and powdery mildew-resistant cultivars.

Dollar Spot – Dollar Spot symptoms are round, bleached, circular areas four to six inches in diameter. In severe cases, the spots may grow together, forming large irregular areas. Symptoms are more severe when dew formation is common and grass is growing slowly such as warm days and cool nights. Water and fertilize the turf to stimulate growth.

Fusarium blight – The disease symptoms formerly labeled "Fusarium Blight" are now known to be a complex of similar appearing diseases including Necrotic Ring Spot, Rhizoctonia, Yellow Patch, Summer Patch and Brown Patch. These diseases are most serious on well-maintained new lawns. First, a circular area of red-colored, straw-colored, and normal leaves occur. As the patch becomes older, the center may be green with straw- and red-colored blades around the outer portion of the ring. Plants are weakened and are very susceptible to summer heat and drought. The roots are covered with dark strands of the fungus mycelium, and crowns of affected plants are dark brown. Yellow Patch develops under wet conditions and is often present on newly laid sod on heavy soils. Damage is more severe in lawns with heavy thatch on compacted soil. Thatch often is decomposed in patch areas producing a sunken appearance. Brown Patch most often is a ring of dark, water soaked appearing grass that fades and dries to light brown. Thatch reduction treatments such as aerification and power raking are required to improve root growth. Irrigate to prevent wilt, but do not keep the turf surface excessively wet.

Fairy Ring – Fairy Ring appears as a ring of fast-growing, dark green grass, often surrounded by a ring of thin or dead grass. After rains or watering, mushrooms may develop in the dark green ring. Fairy rings are caused by several soil-inhabiting fungi. Growth usually starts at a central point, and the fungus grows outward equally in all directions, developing a circle. Fairy rings are difficult to control. The most satisfactory treatment is to mask the rings by irrigating with a root feeder attachment and injecting water twelve inches deep into the soil within the rings of dead grass. This treatment in conjunction with aerification and adequate fertilization will hide the symptom. Mushrooms can be broken up with a rake or lawn mower.

Slime Mold – Slime Mold symptoms appear following heavy rains or irrigation periods. Small colored or white slimy beads develop on the grass, and upon drying they form a powdery mass. Slime molds do not damage grass, but they are unsightly. They soon disappear, or the deposits can be removed with a rake or a forceful spray from a garden hose.

Rust – Rust appears as orange to reddish-brown spots on grass blades. This rusty material rubs off on fingers and shoes and may be a problem in August or September. A heavy infection can cause grass blades to turn yellow and die. Rust is rarely a problem where proper fertilization, watering, and mowing are practiced. Grass varieties resistant to rust are available.

Moss and algae are simple plants usually found in densely shaded and moist lawn areas. Improving soil drainage and increasing air circulation and light penetration often prevent this problem. If grass does not receive adequate light, replace with shade tolerant ground covers or specifically selected shade tolerant grass varieties.

Refer to the chapter on Disease Management for additional information on turf diseases and the control of turf diseases.

Insect Management

Insect management involves a thoughtful process of detection, identification, and evaluation. It is important to remember that complete elimination of insects is impractical, therefore, try to manage the insect population at a level that does little damage to the lawn. In fact, damage control, and not insect control, is the ultimate goal. Lawn damage varies with

grass condition, the insect species, and its population level. Vigorous lawns can withstand greater pest numbers than severely weakened ones. Therefore, proper watering and fertilization can help prevent damage. Fortunately, lawn insects do not often present major problems in Minnesota.

The mere presence of an insect may not be a problem, since not every insect is a pest. Even if the insect is a pest, it may not be present in large enough numbers to cause a problem; consequently, it is essential to know what insect is present, what population levels cause damage, the stage or stages and time of year when it is most susceptible to control, and the best methods to regulate the populations. Insects on lawns should be controlled when they cause damage, not simply because they exist. It is not beneficial to apply an insecticide to sub-threshold populations of turf pests. Unnecessary insecticide applications may create several problems, including pest problems and thatch build-up. Pesticides may also destroy beneficial insects such as big-eyed bugs, which prey on chinch bugs.

Detecting the presence of an insect is the first step in good lawn insect control. Be sure to examine an area of grass that contains living as well as damaged grass plants. The most serious lawn insects feed on living plants and are not found in dead areas. Insects found in completely dead patches generally are not responsible for the damage.

If the lawn looks wilted and water-starved, a root-feeding insect may be involved. Peel the sod back, examine the roots, and look for any root-feeding pests. Some insects hide in the thatch and then feed on the grass blades. Damage from this type of feeding appears as brown patches when the blades are clipped off. One must search in the thatch to find the insect. Other insects live on the leaf blades and withdraw the plant's sap. Close examination of the grass blade will reveal this type of pest. There are a few very common insects or insect relatives that live in grass, but do not cause direct feeding damage.

Once detected, the insect should be identified. Identification of turfgrass insect pests is the most critical step in proper insect management. An excellent reference book with color plates is **Turfgrass Insects of the United States and Canada**, by H. Tashiro, Cornell University Press, 1987. The following information can help in identifying the most common lawn insects. The insects are listed below according to where they are found.

Root Feeders**:**

White Grubs – White grubs are the larvae of the common May beetles or June bugs that fly to lights in the spring. The adults lay eggs in spring and summer. The damaging grubs are whitish with brown heads. They feed on the roots of the grass, and heavy infestation will loosen sod so that it can be rolled back with a minimum of resistance. The grubs are usually found curled in a "C" shape. Population levels of three to ten grubs per square foot can be expected to produce noticeable damage. Therefore, control is justified when a random check of the lawn shows this level.

The most common grub species in Minnesota feed on the roots for three years before they reach the adult stage. The first year, grubs are up to one-half inch long and produce little damage. The second year, the grubs range from one half to three-quarter inch in length, and damage becomes more apparent. This is the best time to control the grubs since damage usually is not extensive and chemicals will effectively control the grubs. The third year, the grubs grow to one inch or more and damage becomes very apparent, particularly in hot, dry weather. Unfortunately, control is not effective at this time since damage is generally extensive and the large grubs are difficult to kill.

The best method of control is to examine the lawn at least once a year and treat with a labeled insecticide when three to ten one-half-inch grubs are found per square foot. Getting the insecticide into the root zone is important in successful grub control. This is best done by wetting the lawn the previous evening, applying the recommended insecticide, and immediately watering thoroughly. Treatment is generally effective throughout the growing season except in the fall, as the grubs move down into the soil for winter. Irrigation will mitigate grub damage. Grub infested lawns have weakened root systems making the grass vulnerable to water stress. Frequent irrigation of grub infested turf can be an alternative or supplement to insecticide treatment.

Bluegrass Billbugs – Adult Bluegrass Billbugs are long-snouted, one quarter inch, gray to black beetles with a strongly tapered abdomen. They can be found walking on hard surfaces in early spring prior to depositing eggs in grass stems. The plump, legless white larvae that hatch first, feed on stems and then on available roots. Infested lawns have off-colored,

irregularly shaped areas that turn yellow and finally turn brown in late July. Highly infested sod will peel back, but with more resistance than that found for white grubs. However, these areas can contain individual plants that offer little resistance when pulled. Adult Billbugs are best controlled in May as the females are laying eggs. Application of an insecticide is suggested about ten days after adults are sighted. Billbugs, like white grubs, also can be controlled when the larvae are feeding on the roots, preferably in June or early July. About ten larvae per square foot are considered sufficient to cause noticeable damage. Treatment is not suggested in late July or August, as the larvae complete their feeding and move one to two inches into the soil to pupate.

Blade Feeders:
Sod Webworm – Sod Webworm is the most common blade-feeding lawn pest in Minnesota. The adults frequently are called lawn moths. They are light-colored moths or "millers" that make short, erratic, darting flights. They fold their wings back closely against their bodies when resting. This gives them a very narrow appearance.

The moths lay eggs in the lawn. The worms hatch from these eggs and begin to feed at night on the grass leaves. Some species damage plant crowns or roots as well as leaves. During the day the worms hide in silk-lined tunnels or burrows at or slightly below the soil surface. When fully grown, the worms are a dirty white to light brown with darker spots and are about 3/4 inch long.

Close visual examination of the thatch will detect the Sod Webworm. Flooding the area with soapy water will force the worms to the surface, where they can be counted. A population of 15 worms per square yard may damage turf seriously. Examinations should be made in June and again in early August, since sod webworms have two generations a year. The lawn should be well-watered a day or so before applying an insecticide; then delay further watering for at least three days after treatment.

Aphids and Leafhoppers – Aphids and Leafhoppers are small insects that suck the sap from exposed leaf blades. Established lawns are seldom damaged, however, new lawns can suffer from feeding by these sap-sucking insects. Control is suggested for new lawns only.

Greenbugs – Greenbugs are aphids that can damage established lawns. The insects are small and yellow to green, and can be found by sweeping a hand over suspected areas. Greenbugs are carried into Minnesota on southerly winds, so they can show up overnight. Damage is almost always to areas of the lawn shaded by trees or shrubs. Only bluegrass is attacked. Control is important when greenbug populations are first seen.

Chinch Bugs – Chinch Bugs can cause serious problems in lawns when conditions are warm and dry. Their damage is most frequently observed in July in central Michigan and in late summer or early fall in southern Michigan. Cinch Bug damage is often attributed to some other agent. They are rare in Minnesota, but when present they become evident in August. The presence of irregularly shaped yellow patches, two to three feet in diameter, which turn brown and then die, is characteristic of Chinch Bug injury. Clumps of clover and other non-grass weeds may survive in these areas. Plant damage results not only from withdrawal of sap, but Chinch Bug saliva contains substances toxic to the plant and the puncture wounds often block plant conducting vessels.

False Chinch Bugs – False Chinch Bugs are about one quarter inch long, brown, and generally found in dead areas of the lawn. Control is not recommended since they do not cause damage.

Ants – Ants are to be expected in lawns. Their preference for nesting in areas of sparse vegetation can lead one to think that the ants are the cause of the poor lawn development. This is not true. Ants do not feed on plants and, therefore, propose no threat to lawns. Ant control is not justified on the basis of protecting the lawn.

Earthworms – Earthworms are beneficial and should be tolerated whenever possible. However, large populations can cause lumpiness, and in extreme cases, reduce the value of the lawn for recreation. Vertical mowing can help reduce the lumpiness and also the amount of feed available for night crawler development.

Refer to the chapter on Insect Management for additional information on insects and control of insects in turf.

Turf Renovation
Weedy and diseased turf can deteriorate to the point of little or no recovery, or the existing turf can become incompatible with the site. In both of these instances,

turf should be renovated. Renovation of turf ranges from thatch removal, to introducing new seed into an existing lawn, or to starting over with a new lawn. Lawns should be renovated if 40 to 50 percent of the lawn is dead or has very sparse growth. The lawn should also be renovated if it is soft, spongy and responds poorly to irrigation and fertilization, as this indicates excessive thatch of three quarter of an inch or more. If weed cover 40 to 50 percent of the lawn and insufficient turf exists to fill in the bare areas once the weeds are removed, the lawn should be renovated.

The preferred time to renovate a lawn is from mid-August to early September. The second best time for renovation is usually early spring just as the turf is beginning to turn green and grow. If the whole lawn needs to be redone, start over with new seed or sod. All the procedures described above for seeding, sodding and maintenance of turf also apply to the renovation process.