Master Gardener
PUBLISHED BY UNIVERSITY OF MISSOURI EXTENSION extension.missouri.edu

Managing Lawns and Turfgrass

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It takes some time and effort to develop a lawn with the right mixture of turfgrass species and varieties for your landscape and situation, but it is worth the investment to achieve results that are attractive, durable and easy to maintain. Important questions to ask are: How will the area will be used, and what level of maintenance will it receive? What are your expectations for your yard? What are the different levels of shade in your landscape? What are your climate and soils?

Managing a lawn involves decisions about frequency of mowing, fertilization and watering, and whether you plan to use crabgrass preventers or products to control turfgrass diseases and insects. You will also want to evaluate any historical information you have about disease and insect occurrences. If you take the time to consider these factors in advance, it will help you select the best species or mixture of species for your situation.

Species and cultivar selection

The key to a quality lawn is to select turfgrass species and varieties that will grow best in your region. Finding those varieties that will offer good quality, color, density and disease resistance will make lawn care easier.

The following information on available turfgrass species and varieties will help you select species well adapted for specific situations. There are hundreds of commercially available varieties for most turfgrass species, but not all will ever be available for sale by any single seed company, garden center or nursery. Local seed companies align themselves with specific national seed growers, which limits the number of varieties they sell.

In addition to providing many of the premium seed varieties, seed suppliers can provide useful information for selecting species and varieties that perform best in particular situations. Many of the major seed companies have their own Web sites that offer information plus contacts and retail sources where you can purchase their products. Web sites will often sell small quantities, which they will deliver directly to your door, a convenience to consider.

The difficulty can be finding the varieties you read about. One approach to finding what you want is to list the varieties recommended for your area or with the desired characteristics, and then cross-reference to what you find available.

Lawn topics inside

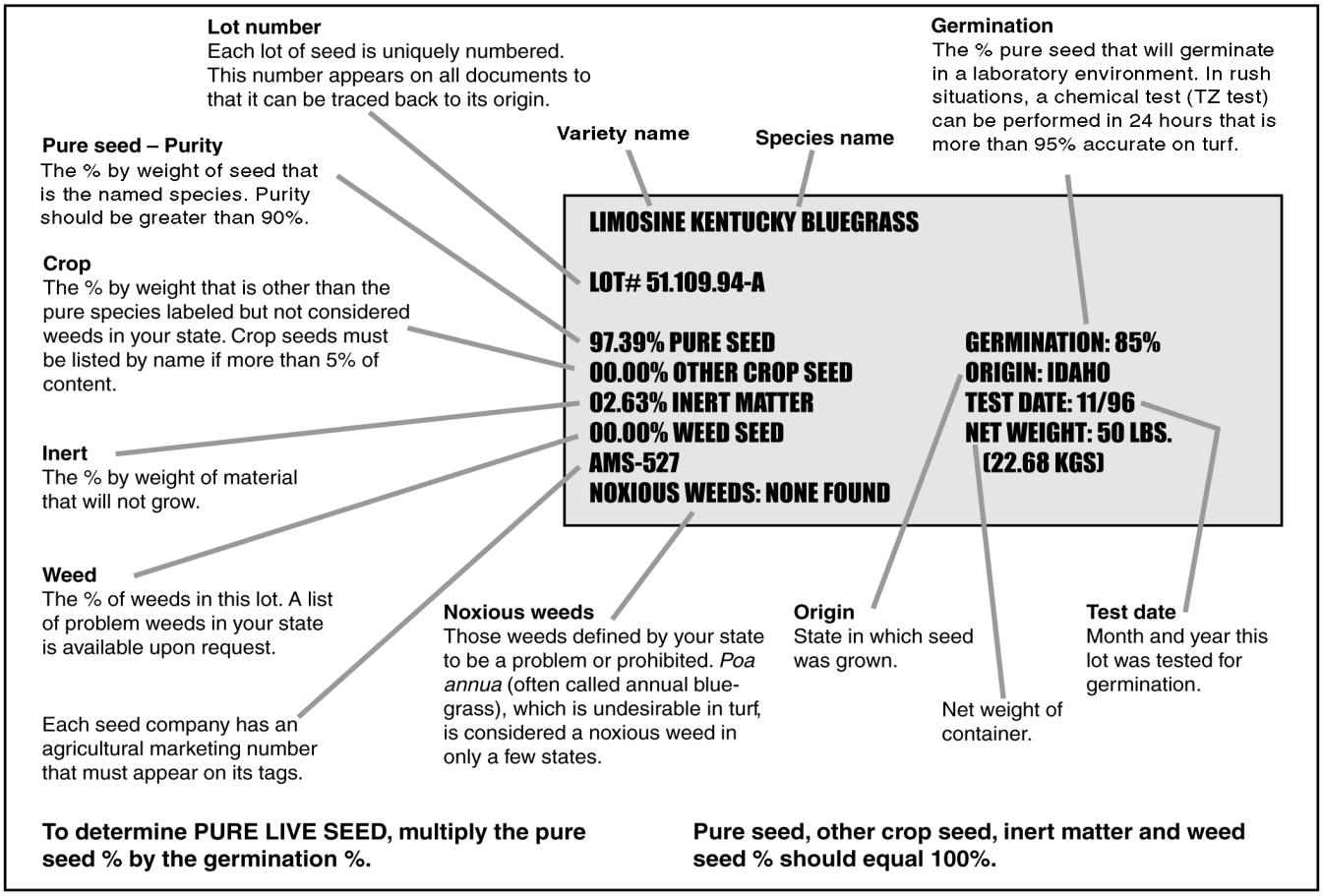

Figure 1. Seed labels.
Seed bags carry a printed tag with important information, including species, variety name, purity, germination, weed seed and noxious weed seed, and testing date. The species and variety names can be cross-referenced to local recommendations for those that grow best in your area. As long as purity and germination are acceptable, the next vital information is the weed list. The best products will have 0 percent listed for weeds and noxious weeds. Avoid products with large amounts (greater than 0.2 percent) of annual bluegrass (*Poa annua*) and rough bluegrass (*Poa trivialis*); patches of these weeds will decline during the summer creating unsightly spots in your lawn.

Before you buy, read the information on the seed label to make sure you know what you are purchasing (Figure 1).

Species and cultivar identification

Various plant parts can identify each turfgrass species. The primary plant parts used include the leaf blade, leaf tips, collars, ligules, auricles and roots (Figure 2). Knowing the various shapes and sizes of different species and the characteristic presence or absence of key plant parts will help you to identify turfgrass species.

First it is necessary to distinguish between cool-season and warm-season grasses. Plants that have rhizomes (below-soil surface runners) or stolons (surface runners) are warm-season plants. While some cool-season plants (many bluegrasses, a few turf-type fescues) have small rhizomes, none have stolons. Once a plant is known as a cool-season or warm-season species, further identification can be made.

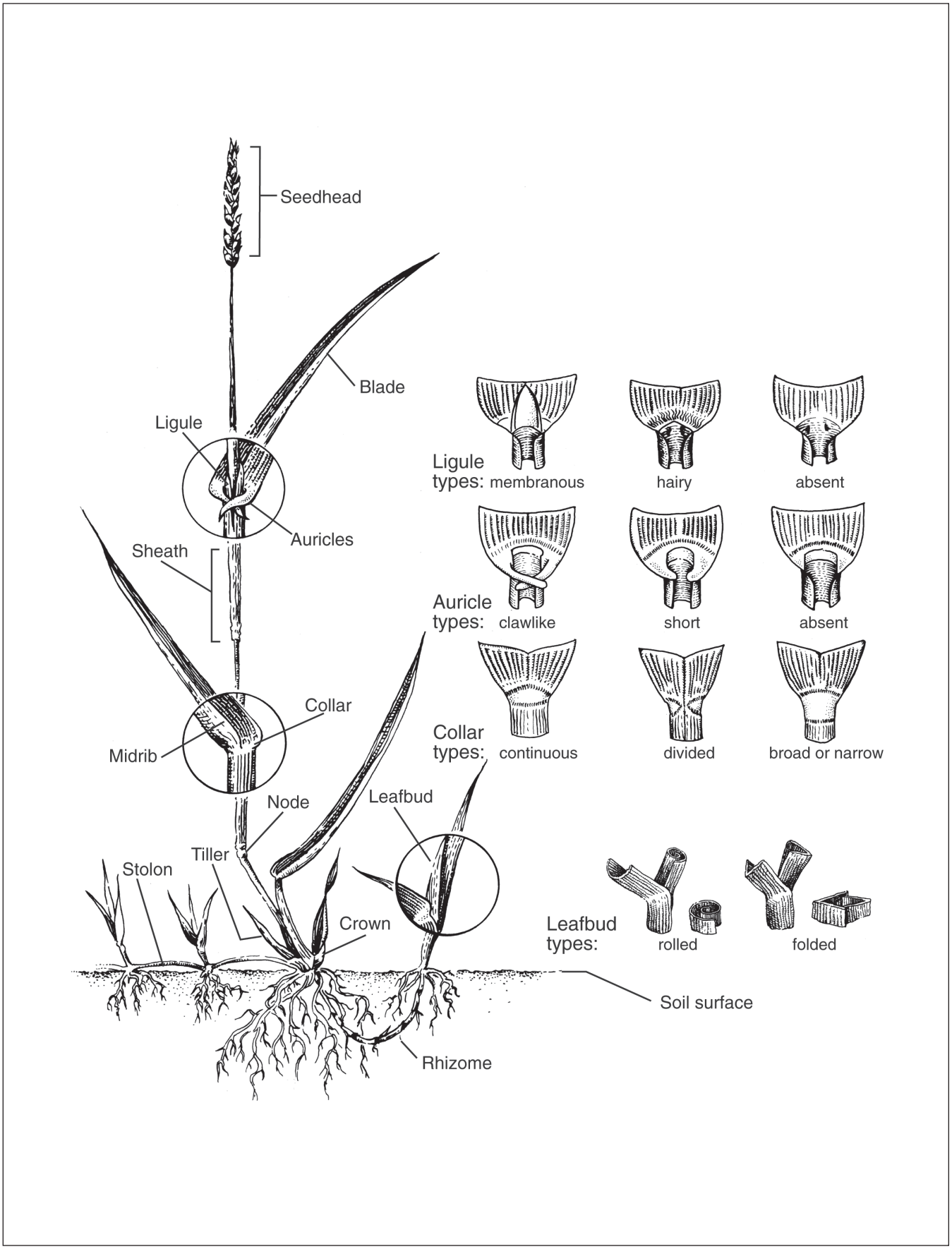

Figure 2. Turfgrass identification.

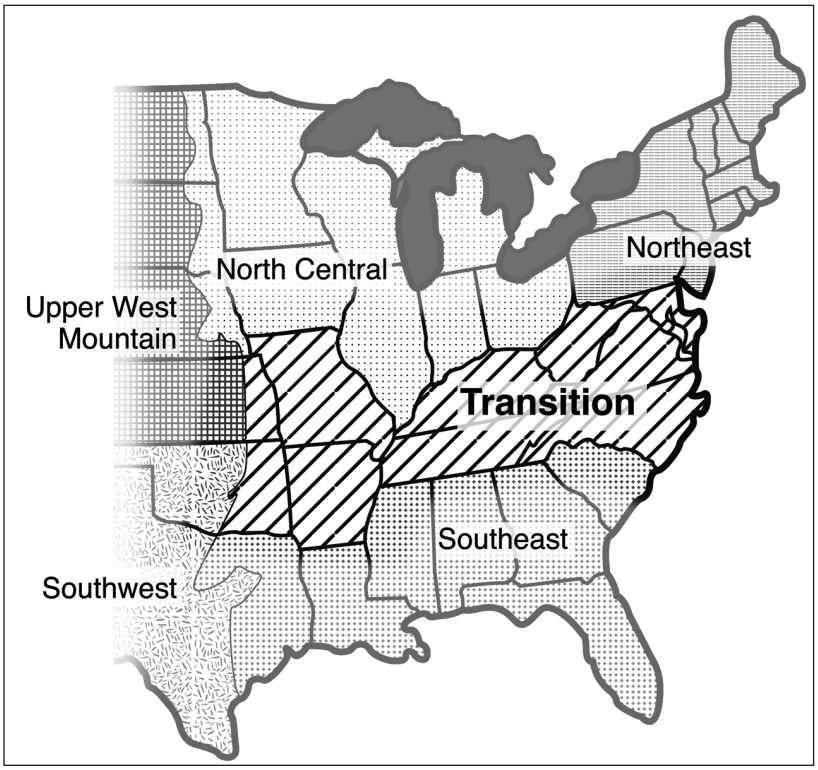

Figure 3. The Transition Zone.
Within this turf management region, neither warm- nor cool-season grass species are completely adapted — from *Turf Management in the Transition Zone* by John Dunn and Kenneth Diesburg.

Cool-season turfgrasses

Cool-season species are characterized as C_3 plants, which means the first product of the photosynthesis process is a compound containing three carbon atoms. Cool-season grasses grow best in the spring and fall when air temperatures range between 60 and 75 degrees F. The best root growth occurs when soil temperatures range between 50 and 65 degrees F. The growing season for cool-season grasses ranges between the months of March and November. However, these grasses do not grow well in the hot summer months. The cool-season grasses include turf-type tall fescue, Kentucky bluegrass, perennial ryegrass, fine fescue and bentgrass. Bentgrasses are used in high-maintenance golf courses and will not be discussed here.

Turf-type tall fescue *(Festuca arundinacea* Shreb.*)*

Suggested seeding rate: 7-9 lb. per 1,000 sq. ft.
Mowing height: 3 to 4 inches
1 to 2 mowings per week

Tall fescue has been a favorite for nonirrigated turfgrass in the Transition Zone (Figure 3) since the release of 'Kentucky 31' in 1943. Tall fescue forms a deep root system in sandy soil or clay and tolerates a wide range of soil pH. It grows well in moderate shade as well as open, sunny locations. The species is second to no other cool-season grass for tolerance of summer heat and drought.

Some managers prefer to mix tall fescue with Kentucky bluegrass. Such mixtures of two or more compatible species often show better turf quality than a single species because one of them will be more resistant to prevailing diseases or other stresses that come over time. For example, research has shown that in some years, diseases such as Rhizoctonia brown patch infects tall fescue without affecting Kentucky bluegrass. At other times, dollar spot severely affect Kentucky bluegrass while tall fescue has resistance.

To mix species, a blend of two or three improved tall fescues combined with a blend of two or three Kentucky bluegrasses is suggested. Use a ratio of 9:1 fescue to bluegrass blend by seed volume. Avoid using the more aggressive Kentucky bluegrass cultivars, which may be too competitive with tall fescue.

Seed distributors often sell turf-type fescue blends that combine several different tall fescue cultivars or bluegrass. These blends are ideal for home lawn use and are generally less expensive than buying single varieties.

Use of the forage-type tall fescues is not recommended, as this type of tall fescue, although persistent, results in lower lawn quality than turf-type cultivars. Its use should be restricted to roadsides and other low-profile turf sites. If used, the seeding rate should be increased to 10 pounds of seed per 1,000 square feet.

A milestone in the development of tall fescue occurred with the release of 'Rebel' tall fescue in 1979. Rebel's leaf texture was finer, about two-thirds the width of a Kentucky 31 tall fescue leaf. Rebel also spreads more aggressively when producing tillers, which means that only one-third to one-half as much seed is needed to establish turf.

In recent years numerous turf-type tall fescues have appeared on the commercial seed market. Some are so-called dwarf varieties, with a slower vertical growth rate than other turf-type tall fescue cultivars. Dwarfs often require fewer mowings than some of the other tall fescue cultivars, but they may also be slower to recover from disease and injury.

Turf-type tall fescue

Advantages	Disadvantages
+ establishes faster than bluegrass	- brown patch is generally a problem
+ deeply rooted for drought tolerance	- can appear clumpy
+ better wear tolerance	- tougher leaf tissue to mow
+ few insect problems	- may require more frequent mowing
+ turf types possess nice texture and color	
+ does moderately well in shade	
+ may contain endophytes	

The availability of many new tall fescue cultivars provides fresh options for cool-season turf in the Transition Zone. Several of these varieties offer resistance to some of the common turf diseases, especially to dollar spot and summer patch. Therefore selecting the more resistant varieties will improve turf quality. The new varieties generally will still require fungicides for the control of brown patch.

Turf-type tall fescues can appear a deep emerald green with a slightly coarser texture than bluegrasses. The sheath of the plant at the crown appears pinkish. Tall fescues can appear clumpy and have severe thinning. The leaves have a rolled vernation with expanded leaves showing prominent evenly spaced veins and rough leaf edges. The sheath is round, smooth and split. Ligules are blunt to absent and may have hairs on the margins. Auricles are indistinct and blunt.

Kentucky bluegrass *(Poa pratensis L.)*

Suggested seeding rate: 2-3 lb. per 1,000 sq. ft.
Mowing height: 2.5 to 3.5 inches
1 to 2 mowings per week

Kentucky bluegrass is well adapted to a moderate climate with average daily summer temperatures below 90 degrees F, soil pH of 6.0 to 7.0, and adequate moisture. Bluegrasses are less drought tolerant than tall fescue. They become increasingly difficult to maintain as summer temperatures approach and exceed 90 degrees F. Careful irrigation is required to maintain quality Kentucky bluegrass turf in hot, dry summers. For these reasons, as recommended in the previous section, mixtures of bluegrass with other grasses such as turf-type tall fescues (10 percent bluegrass, 90 percent fescue) combine the advantages of each species to mask their respective weaknesses.

As a group, the Kentucky bluegrasses adapt best to open, sunny areas in fall and spring. During hot summers, bluegrass often does best in areas that receive afternoon shade. Turfgrass breeders have managed to incorporate a moderate degree of shade tolerance in several newer cultivars, partly because these have improved resistance to powdery mildew.

Unfortunately, most common Kentucky bluegrass types are weakened at some point by unfavorable environmental conditions or diseases such as leaf spot disease. However, turfgrass breeding programs have developed improved cultivars, such as 'Merion,' named for the Philadelphia golf course where it was discovered. Merion was a big

Kentucky bluegrass

Advantages	Disadvantages
+ good sod-forming grass	- aggressive varieties form thatch
+ high recovery potential and rate	- disease prone (leaf spot, dollar spot, summer patch)
+ soft, easily mowed leaves	- poor to fair shade tolerance
+ high quality (color & density)	- more frequent insect problems (grubs and cutworms)
+ excellent cold tolerance	- fair heat tolerance
+ good drought resistance (can go dormant to survive long period without water)	- higher nitrogen requirement
	- may require more frequent irrigation

Endophytes

Endophytes are fungal organisms that live symbiotically within the cells of the grass plant. They create a bitter-tasting toxin that repels most insects and kills many of those that continue to feed. Many cultivars of cool-season grasses contain endophyte, especially tall fescues and perennial ryegasses. Natural cultivars of bluegrass that contain endophyte have not been found. Endophytes remain in the foliage portion of the plant and do not normally provide protection from root-feeding insects such as white grubs. Endophytes reproduce with the plant and remain active for as long as the plant lives.

improvement over common Kentucky bluegrass, but in spite of its resistance to leaf spot disease, it is still highly susceptible to other diseases such as stripe smut and summer patch.

Other bluegrass cultivars like 'Flyking' and 'Pennstar' offered further improvements, but vulnerability to summer diseases still discouraged their use in the Transition Zone, especially for high traffic areas and closely mowed golf course fairways, tees and sports fields. Newer cultivars have good resistance to brown patch disease, but they are still susceptible to dollar spot, leaf spot and summer patch so selecting bluegrass varieties that offer some resistance to these diseases is a practical first step in lawn establishment.

Blends of Kentucky bluegrasses look rich with dark, blue-green colors that make them aesthetically pleasing. Bluegrasses do develop tillers and small rhizomes, which allow bluegrasses to recover better than tall fescues from thinning or other problems. The leaves have a folded vernation (V-shape), which is smooth on top with a translucent midvein. The leaf tips are boat-shaped and look much like the end of a canoe. The collars are considered medium in height and the auricles are absent. The ligule is short and blunt. The sheath is round, smooth and split.

Perennial ryegrass (*Lolium perenne* L.)

Suggested seeding rate: 6-8 lb. per 1,000 sq. ft.
Should not be seeded alone
Mowing height: 2.5 to 3.5 inches
1 to 2 mowings per week

Unfortunately, many seed mixtures and blends available to homeowners at local garden centers contain large amounts of ryegrass (both annual and perennial). Though ryegrasses tend to germinate quickly, which can help them establish quickly, they are also susceptible to disease and generally have not been toleratant of high summer temperatures. Current breeding work, using germplasm from southern states, should lead to new cultivars with better summer qualities than those currently available, but until this happens, the best use of perennial ryegrass in the Transition Zone is for sports fields where rapid establishment is needed and funds are available for periodic fungicide use.

Perennial ryegrasses have not been popular in the Transition Zone where extreme summer temperatures and humidity create an ideal environment for Rhizoctonia brown patch, dollar spot and other warm weather diseases. 'Manhattan,' 'Pennfine,' and several succeeding ryegrass cultivars showed better disease resistance than common types, which usually decline after one or two summers until little remains of the original turf. New generations of perennial ryegrass also offer improved heat tolerance. Most of these ryegrasses are deep rooted and and will recover rapidly from drought stress when soil moisture is replenished and temperatures moderate.

Perennial ryegrass

Advantages	Disadvantages
+ quick germination and establishment	- poor recuperative ability
+ good wear tolerance	- tougher leaf blade dulls mowers
+ good color and density (spring and fall)	- disease prone
+ does not form thatch	- poor shade tolerance
+ compatible with bluegrass	- poor freezing tolerance
+ may contain endophytes	- high fertility needed
	- poor drought tolerance
	- fair heat tolerance

'Manhattan' and 'Pennfine' and other ryegrasses have been widely used in seed mixtures with Kentucky bluegrass and other cool-season grasses because of their quick germination and other qualities mentioned earlier. Athletic field managers depend upon them for rapid germination (5 to 10 days) to fill worn areas in turf cover

after games. In lawns, they persist better than most Kentucky bluegrasses on wet, lower pH, infertile soils.

Manhattan-type perennial ryegrasses are characterized by tough leaf tissue consisting of thick-walled cells that helps the ryegrass tolerate traffic. This also makes it tougher to mow. A sharp mower is needed for perennial ryegrass turf to prevent fraying of leaf tips that produces an unsightly brown cast. Pennfine-type perennial ryegrasses have somewhat softer leaves that are easier to mow.

Perennial ryegrasses have deep emerald colors that are aesthetically pleasing, particularly in the spring and fall. Leaf blades have a folded vernation that appears fine in texture and tapers to a sharp point. The backsides of the leaf blades are glossy, which can lead to a distinct striping effect as sometimes noticed on athletic fields. Collars are distinct and divided. Auricles are small and clawlike. Ligules are small and membranous, blunted to pointed structures. The sheath is usually compressed and smooth and appears reddish at the base of plants. Perennial ryegrasses do not produce rhizomes.

Fine leaf fescue *(Festuca* spp.*)*

Suggested seeding rate: 5 lb. per 1,000 sq. ft.
Should not be seeded alone
Mowing height: 3 to 4 inches
1 mowing per week

Fine leaf fescues are often used in lawn seed mixtures with Kentucky bluegrass or ryegrasses. Rapid germination allows them to provide early cover that prevents soil erosion and retards weed competition, while Kentucky bluegrass develops at a slower pace. Fine fescues grow best in dry, shady lawn areas that have slightly acid soils, conditions which discourage growth of Kentucky bluegrass. Proper management of fine leaf fescues in a shady environment includes high mowing with little fertilizer and water.

Fine leaf fescue

Advantages	Disadvantages
+ quick establishment	- poor to moderate wear tolerance
+ very fine leaf texture	- poor to moderate recuperative ability
+ high density	- can develop thatch
+ tolerates low fertility	- difficult to mow
+ tolerates poor soil conditions	- NOT heat tolerant
+ drought resistant	- susceptible to diseases
+ good shade tolerance	
+ good cold tolerance	

When irrigated, fine leaf fescues will adapt to open, sunny areas in mild coastal climates and to dry southwestern climates. They will not persist in areas where warm, humid summers provide optimum conditions for diseases like leaf spot, dollar spot, brown patch and summer patch.

Fine leaf fescues have pointed and bristle-like leaf blades that are dark green. Collars are usually narrow, but broad in Chewings. Auricles are absent. Ligules are membranous and short. The sheaths are usually round, but flattened in Chewings.

The primary species of fine leaf fescues used for turf are briefly described below.

Chewings fescue — one of the quickest of the fine fescues to establish turf. Its aggressiveness makes it a better companion grass for perennial ryegrass than for Kentucky bluegrass. It adapts to closer mowing than other fine fescues. This grass is moderately susceptible to dollar spot, but has better resistance to red thread than other fine leaf fescues.

Turfgrass Information

There are many resources available to help you select turfgrass species and varieties suited for your region, and for your own lawn with its unique growing conditions.

Good sources of information include turfgrass specialists, MU guides (a list is provided at the end of this publication), garden centers and Web sites.

Good information on selecting varieties can also be found through the National Turfgrass Evaluation Program. NTEP provides data tables for all turfgrass species based on a number of different characteristics, including quality, density, color, disease resistance and wear resistance, ranked from best to worst, and averaged nationally and by location. See NTEP's Web site, *ntep.org.*

Slender creeping red fescue — spreads by short, fine rhizomes. This fescue establishes rapidly to produce a dense turf, but is highly susceptible to red thread disease.

Strong spreading, creeping red fescue — produces rhizomes that are coarser than those of the other fine spreading fescues, which may aid in drought tolerance. Leaf texture is somewhat coarser than that of other fine fescues. Spreading fescue is similar in color and compatible in seed mixtures with Kentucky bluegrass. Disadvantages of spreading fescue include intolerance of close mowing and a high susceptibility to disease in warm, humid summers.

Hard fescue — adapts to shaded areas, but is also adapted to sunny, hot, dry locations with infertile soils. Hard fescues have slower establishment and leaf growth and better tolerance to summer stress than other fine fescues, with Chewings fescue being the second most tolerant. Tolerance of dollar spot and red thread disease is generally best among the fine fescues.

Sheep fescue — has a lower rate of vertical growth than either Chewings or hard fescue. Sheep fescue has good tolerance of cold and drought. Some new cultivars have good resistance to red thread and dollar spot.

Warm-season turfgrasses

Warm-season species are characterized as C_4 plants, with the first product of the photosynthesis process producing a compound that contains four carbon atoms. Warm-season grasses grow best in the summer, from May through September, when air temperatures range from 80 to 95 degrees F. Best root growth occurs when soil root temperatures are from 75 to 85 degrees F.

Zoysiagrass (*Zoysia japonica* L.)

Suggested seeding rate: 1-2 lb. per 1,000 sq. ft. in late May to late June
Suggested sprigging rate: 8-10 bushels per 1,000 sq. ft. in late May to late June
Suggested plugging rate: 2-inch plugs planted on one-foot centers in late May to late June
Mowing height: 1½ to 2 inches, best at 1 inch
1 mowing per week (taller height), 2 mowings per week (short height)

Zoysia japonica originated in the western Pacific area. It is the species to which 'Meyer' zoysiagrass belongs. Meyer has good heat and drought tolerance, and is more winter hardy than bermudagrass, the other principal warm-season grass grown in the Midwest. Excellent summer qualities made Meyer a logical choice in the 1960s by golf course superintendents who considered it a good alternative to Kentucky bluegrass for Transition Zone summers.

In addition to its good summer qualities, Meyer's tough leaf tissue is an added advantage for use on high-traffic areas such as golf course fairways and tees. Its mature turf is dense and tends to exclude most weeds. A high quality lawn can be maintained with 1 to 2 pounds of nitrogen per 1,000 square feet per year. Research plots have been maintained with as little as 1 pound of nitrogen in eight years. Higher annual rates of nitrogen are sometimes used to speed recovery of the slow-growing zoysia from damage. Meyer zoysia is dormant about six months from fall to spring in the Transition Zone. However, many homeowners find the gold-brown color to be compatible with late fall-winter landscapes.

Meyer zoysia lawns and golf course fairways are susceptible to occasional winter injury. Damage is

Zoysiagrass

Advantages	Disadvantages
+ excellent heat tolerance	- straw-colored, winter dormancy
+ excellent drought tolerance	- first green-up in late April
+ excellent weed competition	- poor shade tolerance (needs 6-8 hours sun)
+ excellent sod formation	- slow wear recovery
+ low fertility required	- potential winter damage
+ tough leaves, dense growth	- can develop thatch

usually confined to poorly drained areas and corrective measures should be taken to improve soil drainage in those locations. Damage may also occur where close-mowed zoysiagrass turf grows on heavy-clay ridges with exposure to heat and drying winds in summer and severe wind chills in winter.

Another type of problem, large brown patch of zoysia, appears most often during cooler spring and fall weather. Patches range from a few inches to several feet in diameter and continue to expand in the same location over successive years. An orange band may form on the active border of the patch. Rhizoctonia species have been implicated in this disease, which is difficult to control with fungicides. Fortunately, this disease does not kill the plant's growing points (stems and roots), and zoysia will usually recover and fill-in during active summer growth.

Two important species, *Zoysia tenuifolia* Willd. ex Trin., and *Zoysia matrella* (L.) Merr., with few exceptions, are best adapted south of the Transition Zone. Several improved seeded-type and vegetative-type zoysias are currently being tested and some of these or newer zoysiagrasses may eventually replace Meyer. Winter hardiness of these zoysias must first be proven in the Transition Zone.

The terminal buds of zoysiagrass are rolled and pointed like a pencil point. The leaf blades are short and pointed with scattered hairs. Leaves extend off the shoot at a 90-degree angle. The collars are indistinct to broad with hairs at the margins. The auricles are absent, while the ligules have short fringes of hairs. The sheath is round and smooth, with hairs at the top of the split. Zoysia has both rhizomes and stolons.

Bermudagrass *(Cynodon* spp.*)*

Suggested seeding rate: 1-2 lb. per 1,000 sq. ft. in late May to mid-July
Suggested sprigging rate: 8-12 bushels per 1,000 sq. ft. in late May to mid-July
Mowing height: 1.5 to 2 inches, best at 1 inch
1 mowing per week (taller height), 2 or 3 mowings per week (short height)

Bermudagrass is not recommended for ***lawn*** turf in the Transition Zone. It is an invasive, aggressive spreader that does not recognize borders. Once established, it is difficult to eradicate. In southern areas of the Transition Zone, many lawns are contaminated with common bermudagrass to the point that eradication is impossible. When that is the case, it is easier to fertilize and mow, than to attempt control.

Bermudagrass

Advantages	Disadvantages
+ good cold hardy cultivars	- prone to spring dead spot disease
+ quick growth and recovery	- invasive to flower beds and cool-season turf
+ seeded and vegetative cultivars	- difficult to eradicate
+ excellent fine textures and density	- straw colored during winter dormancy
+ good dark green color	- can develop thatch
+ excellent sod formation	- poor shade tolerance
+ excellent heat tolerance	- requires high fertility for good quality
+ excellent drought tolerance	

Bermudagrass' heat and drought tolerance are superior to Meyer zoysiagrass, the principal Midwest zoysia. It requires just a little more fertilizer for optimum growth than zoysiagrass. The big question for bermudagrass' use in the Midwest is winter hardiness. In that respect, it is inferior to Meyer zoysiagrass. Turf managers should expect moderate to severe bermudagrass winter injury at least one or two times every 10 years in the Transition Zone. On the other hand, bermudagrass will recover from injury more rapidly than Meyer zoysiagrass because of its aggressiveness. Natural enemies of the southern bermudagrasses include nematodes, mites and mole crickets.

Cultivated variety

"Cultivar" is a term now used in place of variety. It means cultivated variety and differentiates a plant from a botanical, or natural, variety.

Despite its drawbacks, bermudagrass has long been popular, especially in the southern United States. Homeowners discovered that bermudagrass would make a good southern lawn grass even if it was coarse and its cold hardiness unpredictable. Early golf course superintendents appreciated its heat and drought tolerance, which meant bermudagrass required little or no irrigation during the summer. Density of the established hybrid bermudagrasses helps to exclude weeds. However, the finest quality turf requires generous fertilization (at least one pound of nitrogen per 1,000 square feet per actively growing month) and ample water plus close, frequent mowing.

'Westwood' bermudagrass, discovered on a fairway in St. Louis in the 1960s, probably originated as a mutation of an earlier 'U-3' plant, but with superior cold hardiness. Spring dead spot disease does not seem to be an extensive, recurring problem in Westwood. Westwood has been used on golf courses and athletic fields from southern Indiana and Illinois through the southern half of Missouri.

The bermudagrass cultivars 'Midway,' 'Midiron,' 'Midlawn' and 'Midfield' are all intermediate in cold hardiness and texture between coarse, cold-hardy Midwestern strains and the finer, less hardy African bermudagrass, *C. transvaalensis.* Several cultivars 'Yukon,' 'Riviera' and 'Patriot' have been recently released and will be gaining ground in the athletic field market.

The terminal bud of bermudagrass is mostly folded and flat. The leaf blade is flat and sharply pointed and may have some hairs. Leaves extend off the shoot at a 45-degree angle. The collar is narrow with hairs on the edge. Auricles are absent, while the ligule contains fringes of hair, like zoysia. The sheath is slightly flat and sometimes hairy. Bermudagrass has both rhizomes and stolons.

Buffalograss (Buchloe dactyloides [Nutt.] Engelm.)

Suggested seeding rate: 1 to 3 lb. per 1,000 sq. ft.
Suggested plugging rate: 2-inch plugs on one-foot centers
Mowing height: 2.5 to 4 inches
1 mowing every 1 to 2 weeks, depending on use (can be left unmowed)

Buffalograss is known for its endurance in the dry western plains. It is a fine-textured grass that spreads by stolons. It is best used in low-maintenance areas such as golf course roughs, roadsides, parks and low-maintenance lawns. Buffalograss can survive on as little as 1 inch of water during an entire summer. For this reason, it has been a logical choice in the plains states by turf managers faced with the challenge of maintaining rough areas without irrigation.

Buffalograss

Advantages	Disadvantages
+ excellent heat tolerance	- straw-colored, winter dormancy
+ excellent drought tolerance	- poor to fair shade tolerance
+ excellent cold tolerance	- poor wear tolerance
+ can form sod (requires longer growth and netting	- slower growing
+ a native species	- poor density, more weeds
+ can be established from seed, plugs or sod	- can have winter annual broadleaf weeds
+ excellent for rough, low maintenance areas	- off green color
+ unmowed, 6-8 inch maximum height	

Buffalograss grows best in sunny locations where rainfall ranges from about 12 to 24 inches annually, but it will become dormant during extended periods of dry weather. A soil pH of 6.5 to 7.0 is close to optimum, but buffalograss will adapt to alkaline soils where the pH exceeds 8.0.

An unusual characteristic of this species is the occurrence of male and female flowers on separate reproductive stems. Seedheads of male plants grow

on stems 6 to 8 inches tall. Seed of female plants are found in 'burs' low in the turfgrass canopy that makes harvesting seed difficult and raises its cost.

Buffalograss should be seeded (with burs), plugged or sodded in late May to late June after soils have warmed. Rake burs (each contains 3 to 5 seeds) into soil, then roll to ensure good bur-to-soil contact. Sod and sod pieces should be lightly top-dressed with nitrogen until they are well established. Irrigate seed and sod during establishment to prevent drought stress. Buffalograss is not competitive during establishment. Therefore, careful use of herbicides will decrease weed competition and improve the establishment rate. Irrigate only enough to retain green color during droughts. Excessive moisture will encourage weed and disease pressure.

The terminal bud of buffalograss is rolled with leaf blades being short, pointed and noticeably hairy. The collar is broad, the auricles are absent and the ligule is a fringe of hairs. The sheath is round, smooth and split. The plant is grayish green and has stolons only.

Lawn and turfgrass fertilization

Soil testing is the starting point of any lawn fertilization program. A soil test is recommended each time you establish new seed, which provides an opportunity to get the pH checked as well as macronutrients such as phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg). After establishment, soils should be tested every two or three years to keep an eye on pH levels as well as other nutrients.

The optimal pH range for growing turfgrasses is 6.0 to 7.0. Most Missouri soils are slightly acidic and in the range of 5.0 to 7.0. A balanced availability of plant nutrients is found in the pH range of 6.0 to 7.0. An even better range for your soil pH is 6.5 to 6.8. You will notice how important pH can be when soils are on the acid side of the scale. Many nutrients are tied up and unavailable to the plant as pH dips to around 5.0 to 5.5. When this happens, turfgrasses look stunted, chlorotic (yellow) and do not respond to additional fertilizer applications.

Liming soil with a pH of less than 6.0 will easily and effectively raise soil pH to the desired level. Calcium carbonate ($CaCO_3$) is the best liming material; it neutralizes hydrogen (H^+) ions in the soil solution and can replace H^+ on the cation exchange sites of the soil. Through this process, the pH of acidic soils is increased into a range more suitable for plant growth. However, liming materials can burn turfgrasses, especially during higher summer temperatures. Lime should be applied during the cooler days of spring and fall. Since it is difficult to get lime into the rootzone of a mature turf, the ideal time to add lime is at the time of establishment, when it can be tilled into the soil before the grass is seeded.

Many testing labs will make a recommendation on their soil test report for the proper amount of lime to add, but there is a simple way that you can calculate the amount of lime needed. Take the neutralizable acidity (N.A.) number and multiply it by 25 to equal the number of pounds of lime to add per 1,000 square feet. As a rule, lime should not be applied to actively growing grass in amounts that exceed 50 lb./1,000 sq. ft. per application. For a new lawn, it is acceptable to till in the entire amount required.

Use a soil probe or small trowel to sample your soil at a 4-inch depth. Pull 10 to 15 samples randomly from each lawn area. Remove any plant tissue or thatch. Mix these samples in a ***plastic*** bucket, then pull a representative 1-pint sample from this to send to the lab. Sample problem areas separately. The University of Missouri Soil and Plant Testing Lab will do these tests and give liming and fertilizer recommendations for a nominal fee. Contact your local extension center to submit a soil sample.

Complete fertilizers

Most fertilizers bought by homeowners contain, in addition to nitrogen (N), varying amount of phosphorus (P — shown on the analysis label as P_2O_5), varying amounts of potassium (K — shown on the analysis label as K_2O) and perhaps iron (Fe) or sulfur (S). The fertilizer composition of these products is usually in a quick-release form. Meaning that they release all their nutrients at once, which creates a huge flush of growth followed by a tapering growth decline over 2 to 3 weeks. It generally will not create any problems to use these products annually, however if soil test are showing high levels of P and K; then it is not necessary to add more P and K. In this situation a good nitrogen fertilizer alone would be sufficient.

Nitrogen

The goal of nitrogen (N) fertilization is to apply the right amount at the right time to promote consistent growth. Maintaining a darker, longer lasting color and allowing the turfgrass to recuperate from damage is a key to a healthy lawn. Nitrogen fertilizer does make grass grow and is directly related to the frequency homeowners should mow their lawn — another factor in the fertilizer equation.

Feed turfgrasses when they are actively growing (Table 1). Cool-season grasses should be fed primarily in the fall, with some fertilizer applications made in spring. Many spring applications are applied with a form of fertilizer that also contains preemergent herbicides (crabgrass preventers) to control annual grassy weeds. Warm-season grasses should be fed after initial green-up in the spring. They can be given N fertilizer during each month of active growth (May through August for nitrogen only, with potassium applications in September).

Late-season nitrogen fertilization, sometimes referred to as late-fall fertilization, has been used by turf managers for years. This type of fertility program involves applying much of the season's nitrogen during the late season months of August through October or November (depending upon location). It is important that late-season fertilization not be confused with dormant or winter fertilization. The latter method implies that fertilizer applications are made after the turf has lost most of its color during late

Calculating how much fertilizer to apply

The first of the three numbers on a fertilizer bag is the percent nitrogen (by weight), the second is percent P_2O_5 (not actual P) and the third number is percent K_2O (not actual K).

Percent nitrogen refers to the concentration of nitrogen in the fertilizer source. Natural organic sources are typically low in nitrogen concentration, while synthetic nitrogen sources are higher. Knowledge of this number allows you to calculate how much fertilizer to apply based on specific rates of nitrogen being applied per 1,000 square feet. For example, if you want to apply 1 pound of nitrogen per 1,000 square feet of lawn area, you must apply Ringers organic fertilizer (9 percent N) at a rate of 11 pounds of fertilizer per 1,000 square feet (the result of 1 ÷ .09). Knowing the basis for this simple calculation allows you to apply the proper amount of nitrogen per 1,000 square feet regardless of the type of fertilizer or nitrogen type.

Example

Apply 1 pound of nitrogen (N) per 1,000 square feet with a 24-4-12 fertilizer.

Take 1 pound of N divided by the percent N in the product, which will equal the pounds of fertilizer to apply per 1,000 square feet.

$$\frac{\text{1 lb. of nitrogen needed}}{\text{0.24 (\%)}} = \text{4.16 lb. of fertilizer per 1,000 sq. ft.}$$

In the same way, fertilizer applications can be calculated based on the amount of phosphorus (P) or potassium (K) needed per 1,000 square feet. Divide the number of pounds you need per 1,000 square feet by the percent of P or K (decimal form) to equal pounds of fertilizer required per 1,000 square feet.

Table 1. Nitrogen application scheduling

	September	October	November	March to April
Standard cool-season	1.0 [1]	1.0	1.0	0.5-1.0 [2]
Low-maintenance cool-season	1.0		1.0	0.5-1.0
	May	**June**	**July**	**August**
Standard warm-season	0.50	0.50	0.50	0.50
Low-maintenance warm-season	0.50		0.50	

Notes:

1. All rates are in pounds of nitrogen (N) per 1,000 square feet.
2. The spring application may be made with a combination crabgrass preventer.

fall or winter and is not actively growing. This differs notably from the late season concept, which requires that nitrogen be applied before the turf loses its green color in the fall. Late-season fertilization has become popular because of agronomic and aesthetic advantages that include: better fall and winter color; earlier spring green-up; increased shoot density; improved root growth in the fall, winter and spring; and enhanced storage of energy reserves (carbohydrates) within the plant.

It is important that the nitrogen source used for fall application should be a type that does not depend heavily on microbial activity to cause the nitrogen to release. This means that fertilizers containing urea, sulfur-coated urea (SCU), IBDU, shorter-chain methylene ureas and ammonium sulfate are ideal N sources for late-season applications. Although SCU and IBDU are referred to as controlled-release fertilizers, the rate at which nitrogen is released from these fertilizers mainly depends on soil moisture, not on the degree of microbial activity. The use of microbe-dependent N sources for late-season applications may not elicit the desired fall/winter color response because they do not provide enough available nitrogen for plant uptake in low temperatures. However, these slow-release N sources would be ideal for spring and summer use. Examples of these would be natural organic nitrogen sources and fertilizers consisting mostly of longer-chain methylene-ureas (low in cold-water soluble N). Research has shown that natural organic fertilizers, such as Bradfield, Milorganite, Sustane, Ringer, Nature's and Organica, perform well in home lawn fertilization programs. A product like Organica, a corn gluten-based fertilizer, can also provide some preemergent activity for annual grass and broadleaf weed control.

Phosphorus

Phosphorus (P) is a major component for energy transfer in the plant. It is also required for good seedling growth and development, which makes it vitally important during establishment of new seed. Phosphorus also promotes good root development. Adequate levels of P on a soil test report should fall around 25 to 35 pounds per acre. Soil test recommendations for phosphorus are based on P_2O_5 (the form in a fertilizer product).

Do not apply more than 2.5 pounds of P per 1,000 square feet to established lawns at one time. To calculate the actual amount of phosphorus in P_2O_5, multiply the amount of fertilizer needed by 0.44. There are several good sources of P fertilizers, including super phosphate (0-18-0), triple superphosphate (0-45-0), monoammonium phosphate (11-48-0), and diammonium phosphate (18-46-0).

Potassium

Potassium (K) is another major component for plant growth. It enhances root growth, enhances disease resistance, improves heat tolerance, improves drought tolerance and increases cold tolerance. Adequate levels of K should fall between 200 and 400 pounds per acre. Soil test recommendations for potassium are based on its form as K_2O.

Do not apply more than 1.5 pounds of K per 1,000 square feet to established lawns at one time. To calculate the actual amount of potassium in K_2O, multiply the amount of fertilizer needed by 0.83. Potassium sulfate (0-0-50), often referred to as SOP, is an excllent source.

Winterizer fertilizers

Fertilizers with higher percentages of potassium or phosphorus, in addition to nitrogen, are often called "winterizer" fertilizers. Our preference is to have the percentages of nitrogen and potassium equal, which is often hard to find unless you purchase a commercial grade fertilizer.

Potassium enhances cold hardiness in turfgrasses by helping plants to "harden off". This means the plant releases excess water from its cells in preparation for winter. Water expands when frozen, causing plant cells to burst under high water content or succulent growth. This is not as important with cool-season grasses, but it is vital with warm-season grasses, such as zoysiagrass and bermudagrass.

Warm-season grasses should not receive nitrogen applications into the fall. Final applications of nitrogen for warm-season grasses should be made in late August. While zoysiagrass and bermudagrass are still growing in September, applications of potassium during the month will help these grasses harden-off for the coming winter months and increase winter survival. One or two applications of 1 pound of potassium per 1,000 square feet can be applied during the month of September on a 14- to 21-day interval. If soil test reports indicate high to very high potassium levels, additional potassium from a winterizer is not needed.

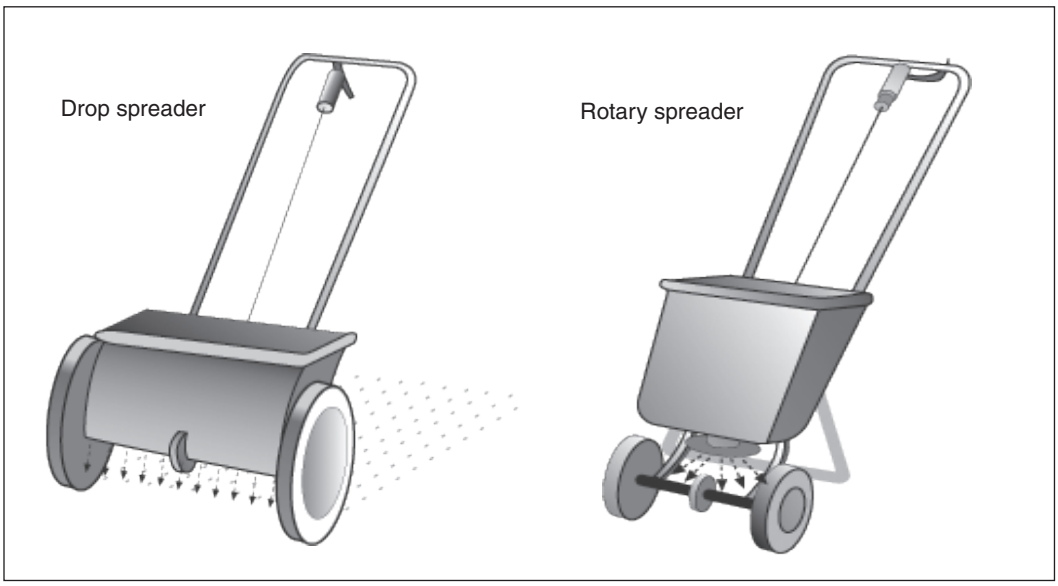

Figure 4. Fertilizer spreaders.
Two common types of fertilizer spreaders that are practical for home lawn use are drop spreaders (left) and rotary spreaders (right).

Lawn establishment and renovation

Establishment of turfgrass brings beauty to any landscape. When preparing an area for turf, do not hurry the process. Mistakes made at this time will be evident later, and will cost extra in time and labor. A beautiful turf depends on many factors, including initial soil preparation.

Fall seeding of cool-season turfgrasses

Summer heat and humidity through July and August causes many people to wonder why even to try to maintain cool-season grasses such as Kentucky bluegrass and turf-type tall fescue in home lawns. Yet even in a difficult year, the aesthetics of cool-season grasses can inspire the annual rituals of renovation and over-seeding. Turfgrass brings beauty and value to any landscape and the success of a beautiful turf depends on many factors.

Late summer or early fall is the optimum time of the year to establish cool-season turfgrasses. Labor Day weekend is usually an excellent time to start seeding preparations. Successful turfgrass establishment include several steps.

First, perform a soil fertility test to obtain fertilizer recommendations. Knowing which nutrients are sufficient and which ones are needed will determine optimum fertilizer needs. The pH of the soil is also important to know and a pH range of 6.5 to 6.8 is excellent for turf establishment. A pH range of 6 to 7 is acceptable. Any lime requirements to raise pH will be specified on the soil test results. Having this information before seeding can save you time and money when trying to establish turfgrasses. Starter fertilizers (e.g., 10-24-18, 6-24-24, 13-13-13) are usually recommended at a rate of 1 pound of nitrogen per 1,000 square feet at time of seeding, but again this depends on soil test results.

Preparation of the site includes the removal of any debris such as rocks and a visual inspection to make sure the grade or slope of your landscape will provide adequate surface drainage. Holes from rock removal or low water holding pockets need to be filled in to ensure proper drainage. Poorly drained areas are detrimental to maintaining healthy turf. Site preparation should also include broadleaf weed control if infestations are high. Perennial broadleaf weeds such as dandelion and plantain should be controlled at this time of the year. Trimec, Weed-B-Gon or Weed-B-Gone MAX are excellent over-the-counter products available to homeowners. Labels for these products usually recommend a three-week interval between spraying and seeding, therefore start early if you first need to control broadleaf weeds.

If you choose to renovate your lawn to a different turf species (bluegrass to fescue or vice versa) or you just wish to start over, an application of a nonselective herbicide (Roundup, Finale or an equivalent product) is needed to kill the old turf and any weeds. Start earlier in August when taking out an old lawn to give more time for the products to work. Always try to time your actual seeding for Labor Day weekend or the first week of September. Nonselective herbicides can be purchased at any home and garden center; be sure to follow the label for application instructions. In seven to 10 days a second application may be necessary to control any areas missed in the initial application. If your old lawn is totally brown, then soil preparation and reseeding can take place seven days after the final herbicide application.

If your lawn only requires over-seeding to fill in thinned areas or small spots from summer disease or drought, then a nonselective herbicide is not required, and seeding can proceed.

When seeding, it is important to have good seed to soil contact to improve germination. If you choose to renovate with a nonselective herbicide, you have the option to till the soil and create a fine seedbed. To prevent erosion, cover the tilled soil with straw at a rate of one bale per 1,000 square feet. The best method of planting seed is with a slit-seeder, a piece of equipment that plants the seed about one-fourth inch deep. This gives better seed germination and reduces the chance that seed will wash away in a heavy rain. Other methods to ensure good seed/soil contact include using a power rake or vertical slicer. Either of these work up the top half-inch of soil and can be used for complete or partial renovations. Such equipment can usually be rented at a local rental or hardware store for a nominal fee.

General steps to establish turfgrass

1. Obtain a soil fertility test and fertilizer recommendations.
2. Rough grade.
3. Apply lime if needed.
4. Apply fertilizer as recommended by soil test.
5. Apply organic amendments if needed.
6. Till materials listed above into top 4-6 inches of soil.
7. Perform finish grading.
8. Apply starter fertilizer and work into top inch of soil.
9. Apply seed.
10. Rake or drag to cover seed lightly.
11. Roll lightly.
12. Mulch.
13. Water.
14. Mow.
15. Control weeds.

Seeding rates for Kentucky bluegrass should be about 2 to 3 pounds per 1,000 square feet. Turf-type tall fescues can be seeded around 7 to 9 pounds per 1,000 square feet. Seed applications following tillage, power raking or vertical slicing should be raked in lightly to help cover the seed with soil at a shallow depth (about one-fourth inch). It is always best to seed half rates of seed in two directions to improve stand density.

The final step to a successful lawn renovation is proper watering. The first two weeks following seeding is the most critical. Until seeds germinate and start to put down roots, they can easily wash away. You should keep the soil surface moist, not wet. Do not let the seed dry out once it starts to germinate. On warm, windy days with lower humidity, it may require several light waterings a day to keep the surface moist. Always avoid puddles and runoff.

In a successful renovation, seedling turfgrass should be up and growing in 10 to 14 days. If your renovation takes place in the first half of September, you will be mowing your new lawn once or twice in late fall. One month after you notice new seedlings, apply additional fertilizer (use a good, complete fertilizer, such as 24-4-12 at a rate of 1 pound of nitrogen per 1,000 square feet). Recommended fall seeding programs for cool-season grasses can start Labor Day weekend with seeding still possible until October 15.

Early spring seeding of turfgrasses

Spring seeding techniques vary depending on which month your spring seeding occurs. The old remedy of seeding before a snowfall does have some credibility if done at the right time of late winter or early spring. This procedure will work from late January through February if there is an excellent chance of getting the seed down to the soil surface. Melting snow will mud-in the seed just enough to achieve germination. Although this is not usually the best procedure, germination rates should be high enough to improve a thinned stand of turfgrass.

A second option is to broadcast seed (half rate, two directions) on mostly bare soil that may have been tilled or loosened the previous fall. This can be done through February when weather conditions are still likely to include a series of freezing and thawing periods. Freezing and thawing of bare soil develops small, ice-forming peaks and ridges in the soil surface that create cracks and crevices where the seed can fall and eventually be covered with soil. Germination rates for this type of seeding is good. It also allows seed to establish early, which offers some competition against summer annual grasses and broadleaves.

Normal spring seeding practices after the final thaw can involve two procedures. The first includes complete tillage of the area being seeded. This requires drier conditions to work the soil. Overseeding on freshly tilled, graded soil offers a perfect seedbed and only requires minor raking or dragging to work the seed into the soil. With this procedure, germination rates should be as complete as the seed label specifies. Straw may be needed to help hold the soil and serve as a little mulch until germination begins. One bale of straw per 1,000 square feet is recommended on freshly tilled soil.

If you want to avoid the need for complete tillage in spring, another spring seeding option is to use a power-seeder or slit-seeder. These can be used for complete renovation jobs or for partial renovations on thinned out areas of your lawn. These seeders plant seed into a powder seedbed or into shallow furrows on 3-inch centers. They should achieve good seed to soil contact, which is the most effective way to get complete seed germination. These procedures generally do not require the use of straw.

Keep in mind that spring seeding will not allow the use of many preemergent herbicides (crabgrass preventers) for annual grass control, however there are two that are available. Tupersan (siduron) can be applied at any time seed is planted, but it is best with applications during the last week of March through the first two weeks of April. It is the only preemergent herbicide to controll annual grassy weeds that can be applied the same day as seeding.

Dimension (dithiopyr) is a product that can be used for annual grass control (crabgrass, foxtails, etc.) after a new stand of grass has had two mowings. Grass seed planted early (March 1) could possibly receive two mowings by mid-April, thus allowing for an application of Dimension at that time. Many other preemergent products require the grass to be well established before their use.

Both preemergent products (Tupersan and Dimension) need to be watered in with about one-half inch of water. Before germination, water conservatively if periodic spring rains keep the soil moist. The first two weeks are the most critical. Always prevent puddles and runoff. Watering can be reduced once the seed begins to germinate and root.

Sodding cool-season turfgrasses

The soil should be prepared as indicated above (rocks and debris removed, to desirable grade, powdery on the surface). A good starter fertilizer (e.g., 10-24-18) should be applied before laying the sod at a rate of 1 pound of nitrogen per 1,000 square feet. Soil should be slightly moist when sod is laid. Irrigate the newly sodded lawn heavily on the first watering to soak through the sod and wet the top 1 to 2 inches of the soil. This can be easily checked by pulling back a piece of sod and observing. Water frequently enough to keep the sod moist — do not keep the sod and soil saturated. You should be able to walk on the sod without sinking in or making foot-marks. Sod transplanted to a well-prepared soil should begin to knit horizontally with adjacent pieces and root down within 1 to 2 weeks. This depends on the thickness of the sod and weather conditions. Overwatering and underwatering are usually the primary reasons for sod failure.

Establishing warm-season turfgrasses

Many improved varieties of zoysia, bermuda and buffalograss are now available as seed. Seeding rates should range from 1 to 2 pounds per 1,000 square feet for zoysia and bermuda, and 1 to 3 pounds per 1,000 square feet for buffalograss.

Warm-season grasses can be established from sprigs, which are pieces of torn sod that usually contain stolons with up to four nodes. Sprigs can be planted by broadcasting them over loose soil followed by a light disking or tillage to partially cover them with soil. A portion of each sprig should remain exposed after planting. Mechanical spriggers are available, by contract, from sod installers. The sprigger slits the soil open, plant the sprig and cover the sprig with a small amount of soil. In either case, the sprig should produce roots and creeping stems from each planted node. Sprigs can be purchased as sod and then shredded, or often can be purchased by the bushel. One square yard of sod makes one bushel of sprigs. Plant 8-10 bushels of sprigs evenly distributed per 1,000 square feet.

You can also use plugs to establish arm-season grasses. Plugs are usually 1 to 2 inches in diameter with 1 to 2 inches of soil attached. They should be fitted tightly into prepared holes and tamped firmly into place. Plugs are generally placed 6 to 12 inches apart. This spacing will usually fill in within one growing season if planted by June 1.

Preparation to establish warm-season turfgrass

1. Control any existing weeds (broadleaves and grasses) early in the spring, especially if a broadleaf herbicide is needed for perennial broadleaf weeds. Three to four weeks is required between applying a broadleaf herbicide and planting warm-season grasses. Nonselective herbicides can be used closer to planting (at least 7 days). If desirable grasses exist, use of a nonselective herbicide is not recommended. Newly emerging crabgrass can be controlled with MSMA, 14 days before planting.
2. Time warm-season grass planting for early June to optimize air and soil temperatures. Warm-season grasses can be seeded, sprigged or plugged until July 15. Sod can be laid until August 1.
3. Remove all rocks and debris, fill in holes and set grade to desired elevations.
4. Add lime, if needed, and fertilize with 1 pound of nitrogen per 1,000 square feet using a good starter fertilizer (e.g., 10-24-18). Apply before any tillage.
5. Loosen hard soils and prepare a seedbed by intensively coring, spiking or slicing the surface. Light rototilling may be desirable if establishing a new lawn.
6. Plant seed, sprigs, plugs or sod of desired warm-season grass. Zoysiagrass seed requires light to germinate, so ***do not cover*** with soil. Press the seed into the soil surface with a light roller.
7. Water frequently to encourage germination and rapid coverage. Keep moist, but prevent puddles and runoff.
8. Begin mowing as soon as possible (usually around 1.5 inches) to force horizontal growth.

Note: Ronstar (oxadiazon) is the ***ONLY*** preemergent herbicide that can be applied to bermudagrass ***sprigs*** for crabgrass control.

Managing thatch and compaction

Thatch is a tight, brown, spongy organic layer of both living and dead grass roots and stems that accumulate above the soil surface. Interactions between environmental and soil conditions and management practices (turf species, fertilization, mowing and irrigation), influence the rate and extent of thatch accumulation. Thatch tends to be a problem in Kentucky bluegrass, fine fescues and zoysiagrass lawns. Thatch is rarely a problem in tall fescue. Grass clippings do not contribute to thatch accumulation and should be returned to the lawn during mowing to recycle the nutrients contained in them.

Take measures to slow thatch accumulation when the thatch layer is thicker than one-half inch (easily measured by removing a small plug of turf that includes a portion of the underlying soil). The thickness of the thatch layer can increase quickly beyond this point, which makes it more difficult to control later. As the thatch layer thickens, it becomes the main rooting medium for the grass. This predisposes turf to drought stress and winter injury and increases the possibility for weed, disease and insect problems. Also, fertilizers and other lawn-care products applied to a thatch layer work less efficiently.

Power raking and dethatching

This method of thatch removal has been used for years. Light (shallow) power raking can be beneficial if done frequently enough. However, deep power raking of a very thatchy lawn can be damaging, and the practice often removes a substantial portion of living tissue. Used properly, power raking of wet, matted turf can help to speed spring green-up of turf by encouraging air movement into the root zone and enhancing turf warming. Dethatching in the spring should be completed before applying preemergence herbicides for annual grass control in cool-season grasses. Fall is a better time to dethatch cool-season grasses. Warm-season grasses should be dethatched when grasses are actively growing (by June). The thatch and organic material gathered after power raking should be composted before it is used as a mulch or soil amendment to kill any living grass plants that might be present.

Core cultivation

Core cultivation or aerating is the recommended technique to manage thatch. It is more beneficial than power raking because it helps to improve the root zone by relieving soil compaction while simultaneously helping to control thatch accumulation. Core aeration also allows air, water and nutrients to more efficiently enter the root zone. Soil compaction, in fact, is one of the contributing factors to thatch accumulation. Plugs of thatch and soil 2 to 3 inches long (longer is better) are removed by the aerating machine and deposited on the lawn surface. A single aeration using a machine equipped with half-inch tines on 2-inch centers will remove about 10 percent of the thatch from the lawn in one pass.

Methods to deal with the cores left on the lawn vary. It is best to break up the plugs and work the soil back into the canopy or thatch layer of the sod. However, rainfall and time will disintegrate the plugs. Depending on the soil type, core disintegration may take only a few days or several weeks. The mingling of soil and thatch that results hastens the decomposition of the remaining thatch. The little tufts of thatch and turf can also be collected and composted. Irrigation helps to wash the soil from the cores, and dragging with pieces of chain-link fencing or an old metal doormat can speed the process. Running over the cores with a power rake or dethatcher also does a good job of breaking cores. Running over the cores with a rotary mower can be effective, but it will quickly dull the blades.

Core aerification can be done in spring and fall for cool-season grasses. It is usually done in June for warm-season grasses.

Proper mowing key to healthy lawns

Turfgrass plants mowed shorter than their optimal height of cut are generally under more stress and are more susceptible to weeds, diseases and insects. Optimal cutting heights for cool-season grasses, such as blends of turf-type tall fescues, should range from 3 to 4 inches. Warm-season grasses, such as zoysia, should range between 2 to 3 inches.

The current recommendation is to select the tallest acceptable mowing height for your species of grass and maintain that height during the entire season. This provides benefits throughout the season — competition against weeds as well as reduced summer stress. However, seasonal variation in mowing height was once thought to be highly beneficial, and some still hold this view. Mowing cool-season grasses a little taller in summer months can have benefits through summer stress periods (deeper roots, better cooling effect). Taller grasses will conserve moisture, which reduces irrigation requirements. Cool-season grasses mowed a little taller in the spring and fall also compete more successfully against weeds (up to 80 percent control of annual weeds).

Mowing creates wounds through which fungi can enter and infect the plant. Leaf cuts made by a sharp mower blade are cleaner and heal faster than the tearing and shredding caused by a dull mower blade. A dull mower blade inflicts more and bigger wounds that increase potential for infection from diseases. Observe leaf tips in your lawn or grass clippings collected on your mower deck immediately after a mowing to see the quality of cut. Use this as an indicator of when to sharpen mower blades. Having a spare, sharp mower blade allows you to switch blades when needed and prevents delays in mowing when it is time to get your mower blade sharpened.

During hot summer months it is best to mow later in the day to minimize additional stresses on your grass. It is also best to change direction of mowing each time you mow.

Frequency of mowing should be determined by the "one-third rule" of mowing. Make sure that no more than one-third of the leaf growth is removed during a single mowing. During the spring and fall, cool-season grasses can be mowed every 5 to 6 days when properly fertilized.

A word of caution about using weed trimmers. Rotary line trimmers typically scalp turfgrasses when edging along sidewalks, curbs and driveways. This actually *promotes* weeds. Best edging practices include using a power edger or line trimmer (rotated) with a vertical blade to prevent scalping turfgrasses.

Handling clippings

Clippings should be uniformly distributed rather than deposited in clumps. Mowing the lawn when the grass is dry and using a properly sharpened mower blade will spread clippings evenly. If some areas produce excess clippings, simply mulch those in with a second pass of the mower.

Many homeowners believe grass clippings need to be removed for a healthy, vigorous lawn, but this is not usually recommended. By following the steps in the "Don't Bag It" lawn care program (see box on this page), you can have a beautiful lawn without collecting the grass clippings. Returning them to the soil can greatly enhance fertility (as much as 30 percent nitrogen and 50 percent potassium). Grass clippings also contribute to the organic matter levels of your soil, which improves its water and nutrient holding capacity.

When to bag clippings

- When rain delays mowing.
- When you want to make compost (avoid using chemically treated grass clippings in compost).
- When preparing for aeration and over-seeding in late summer to early fall.

Quick facts about watering

- Lawns in the Transition Zone may require as much as 1 to 1.5 inches of water per week from irrigation or rainfall during summer to remain green and actively growing.
- When managed properly, tall fescue requires 25 percent less water and zoysia grass requires 50 percent less water than Kentucky bluegrass to maintain a green, actively growing lawn in this region.
- Turfgrasses in the Midwest rank as follows in resistance to leaf wilting and browning during summer dry periods — bermuda, zoysia, tall fescue, Kentucky bluegrass, and perennial ryegrass.
- Taller grass has deeper roots and less tendency to wilt.
- Deeper roots draw moisture from a larger volume of soil and therefore require less supplemental irrigation.

Irrigation

As much as 80 percent of the water used around a home during the summer is for outside uses. Watering the lawn is usually the main outside water use. During dry summers, local water authorities may cut off water for outside use or only allow watering on certain days; such measures may be necessary and effective to reduce water consumption and relieve the strain on water supplies. To avoid severe loss of turf and to be prepared to conserve water if necessary, homeowners should manage their lawns each year in anticipation of water restrictions.

The following information offers cultural ideas that will reduce the need to irrigate your lawn, while still improving its appearance and its competitiveness.

Read your lawn to know when to water

Purple-blue wilting leaves or leaves that are folded or rolled lengthwise along the blade are signs that lawns should be thoroughly watered if grasses are to remain green and actively growing. If footprints show up in a lawn several hours after it is walked on, you have another sign of insufficient water. Leaves with plenty of water quickly return to their rigid upright shape, while leaves that lack water will remain trampled for a period of time.

If high temperatures and dry conditions continue without rain or irrigation, the aboveground portion of grasses will turn entirely brown and die. Grasses are said to be dormant during this browned-out stage because the lower portion of the plant usually remains alive but not growing. Summer dormancy of grasses is a mechanism that helps a lawn survive, but it does not guarantee that a lawn will fully recover from a browned-out stage. Thorough watering will bring the lawn out of dormancy, and new growth will resume from the belowground base (crown) of grass plants.

Dormant lawns should receive at least 1 inch of water every two or three weeks during summer to prevent complete turf loss. Grasses may not show a noticeable greening, but that amount of irrigation should be sufficient to hydrate the lower plant portions and increase recovery when adequate moisture is available.

Wet wilt is another type of wilt to look for. Wet wilt occurs when the soil is obviously wet, but the root system is not able to keep pace with the water demands from the atmosphere. The curling of leaves from wet wilt looks much like wilt caused by lack of soil moisture. Waterlogged lawns that have a shallow root system are susceptible to wet wilt. Do not add more water when lawns are wilting, yet soil moisture appears adequate. It will only aggravate the problem by starving the root zone of oxygen.

Select a watering system

Soils in the Transition Zone often have low water infiltration rates. Automatic controllers can be set to supply several short cycles so that the total amount of water desired is supplied without runoff.

The most common type of watering occurs with hose-end sprinklers. Some studies have shown that the average homeowner applies more than twice the amount of water that is required for turf growth when using hose-end sprinklers.

There are several types of hose-end sprinklers. Select one that best fits your size and shape of lawn and then operate it efficiently. All hose-end sprinklers can be attached to inexpensive timers that can be used to shut off unattended sprinklers and avoid over-irrigation.

Watering by hand may be needed in some problem areas to postpone the need to irrigate the entire lawn. Some areas of a lawn usually wilt before others. These "hot spots" may be caused by hard soils that take up water

slowly. They often occur on slopes, southern exposures and warmer areas next to drives and walks. Lawns that have unusual shapes also may require some hand watering to avoid unnecessary irrigation of paved surfaces, mulched beds and buildings. Soaker hoses that have a narrow pattern and supply water at a slow rate can be useful in these areas.

Table 2. Approximate lawn water requirements

Lawn type	Green turf [1] inches of water per week	Dormant turf [2] inches of water per week
Perennial ryegrass	1.5	1.0
Kentucky bluegrass	1.2	0.7
Tall fescue	0.8	0.5
Zoysia or bermuda	0.5	0.2
Buffalograss	0.50	0.2

Notes:

1. Lawn remains green and growing.
2. Lawn may turn brown but will not die.

Know how much water

Once you have decided on the best sprinkler for your lawn's size and shape, you must decide how long to operate the sprinkler. This is best achieved by knowing how many inches of water your system puts out in a given amount of time. To calculate, place shallow, straight-sided containers (tuna or vegetable cans work well) or rain gauges in a grid pattern around the sprinkler. Operate the sprinklers (use overlapping patterns where needed) for a given amount of time and measure the amount of water captured. Measure the depth of water in the cans with a ruler or read directly from the rain gauges. Then simply determine what the output of your sprinkler system is per 15, 20, 30 or 60 minutes. You need to have some idea how many minutes it takes to apply one-fourth or one-half inch of water.

The utility water meter connected to your home can also be used to check how effectively water is being applied. It accurately measures water in cubic feet or gallons. When no other water is being used in the home, water a known area for a set amount of time and use these conversion factors to determine your water application rate:

- 624 gallons (83.3 cubic feet) of water are required to apply 1 inch of water on 1,000 square feet of lawn.
- 7.48 gallons = one cubic foot of water.

Heavy soils, as found in much of Missouri and the Midwest, will take in only about one-fourth to one-half inch of water per hour. If your sprinkler system delivers more than that amount, rotate it to a different location after each one-fourth to one-half inch of water has been applied. Then repeat the process until the full amount of water desired has been applied (Table 2).

Keep the application schedule flexible and irrigate based on observations of soil moisture or wilting of plants. A screwdriver, pocketknife or soil probe pushed into the ground in several locations can be used to quickly assess soil moisture. The screwdriver will easily penetrate to the soil depth that has received sufficient water. The screwdriver test can also be used to determine where and when irrigation is needed.

Once the decision has been made to irrigate, use these recommendations to guide irrigation scheduling and the amount of water to supply. A basic rule of thumb for irrigation is to, "Apply at one time only that amount of water that the soil can absorb in one hour, always avoiding puddles and runoff."

Identify best time of day to water

Early morning is the best time to water a lawn (4 to 8 a.m.). During this time, water pressure is highest and disruption of the water pattern from wind is low. Cooler morning temperatures reduce water loss from evaporation. Watering early also has the advantage of reducing the chance of turf diseases that require extended periods of leaf moisture from dew and guttation fluids.

Watering tip

Rotary sprinklers that are set to deliver a half or quarter sprinkler pattern will discharge two or four times the amount of water on a given area. Operate rotary sprinklers with half patterns for one-half the amount of time and sprinklers with quarter patterns for one-fourth the amount of time.

("Guttation" refers to the physiological process in leaves where water or cell sap is forced out upon plant surfaces.)

Avoid irrigation during midday (higher temperatures), during late evening (extends leaf wetness period promoting disease), and during windy conditions (water patterns fluctuate).

Water new lawns with care

Newly seeded or sodded lawns require special attention with irrigation. Newly seeded lawns should be watered daily and may need as many as four to five light waterings in a single day. Watering with a light mist is best for establishing new lawns. Keep the seedbed moist, but not saturated, to a depth of 1 to 2 inches until germination occurs (green cast to lawn and seedlings are one-fourth to one-half inch tall). The first 7 to 10 days are critical for good seed germination. Once seedling growth is noticeable, you can reduce watering. Seedlings of a new lawn must not be stressed to the point of wilt. Continue with light applications of water — one-eighth to one-fourth inch — one to four times daily.

Applying straw (one bale per 1,000 square feet) to a freshly tilled area at the time of seeding will help shade the ground and prevent rapid drying of the soil surface. Straw also will reduce seedling damage from the force of large sprinkler drops.

Newly sodded lawns require watering one or two times a day. Begin irrigation immediately after laying sod. Plan your sodding operation so that a section of laid sod can be watered immediately while other areas are being sodded.

Sod should be watered so that the sod strip is moist as well as the top inch of soil below the sod. The first irrigation will take about 1 to 1 1/2 inches of water to completely wet the sod. After watering, lift up pieces of sod at several locations to determine if it has been adequately irrigated. Continue to lightly water one to two times a day to prevent wilting and to ensure moist soil just below the sod layer.

Components of an IPM program

1. Identifying the problem – of both pests and any naturally occurring enemies.
2. Monitoring and recordkeeping – populations of pests and natural enemies must be regularly monitored over time, allowing one to determine how season, weather, cultural programs, etc., influence populations and resulting levels of pest-related injury.
3. Determining an injury threshold – level of pest population that correlates with sufficient aesthetic or economic injury to warrant implementation of pest management practices.
4. Establishing an action threshold – determine the pest population that accurately predicts injurious pest levels that are likely to occur unless pest management strategies are implemented immediately.
5. Selecting a strategy – for each pest, choose a mix of tactics that will be effective, but least disruptive to beneficial insect populations and least hazardous to humans, animals and the surrounding environment.
6. Evaluating success – constantly evaluate the success of pest management strategies.

Possible treatment strategies

- Select pest resistant/tolerant grass species or cultivars.
- Modify habitat: reduce attractiveness to pest or enhance attractiveness to beneficials.
- Modify human behavior: improve cultural and management practices, and alter attitudes and expectations regarding aesthetics or playability.
- Implement physical controls: trapping, manual picking and barriers.
- Use biopesticides: natural enemies or pathogens (introduction or reintroduction).
- Use chemical controls: pheromones, juvenile hormones, naturally occurring toxins and synthetic poisons.

Managing Common Turfgrass Pests: Weeds, Diseases, Insects and Moles

As sod becomes established and roots penetrate and grow, gradually reduce the frequency of watering and amounts applied. After sod has been mowed two or three times, follow regular watering practices outlined earlier.

Whatever pest problem you are having, there are five basic steps to effective pest management:

1. Properly identify the key pest and the damage it may cause.
2. Monitor pest populations regularly.
3. Determine the potential for economic loss from the pest.
4. Select the proper pest control tactic, such as cultural, biological or chemical.
5. Evaluate the control measure used.

Integrated pest management for lawns

A popular and positive trend in turf management, from both professionals and homeowners, is an interest in plant health care and reduced pesticide use. The degree of interest ranges from those who would prefer to use strictly organic or natural pest management practices, to others who would opt for a combination of improved cultural practices and chemical approaches. In either case, there is a decided interest in the use of biopesticides (host-specific natural enemies, such as predators or pathogens), pest-resistant species and varieties, pheromones and other attractants that lure or confuse pests, hormones that prevent pest development, and naturally occurring chemicals that kill pests or suppress their activity. A pest-management approach that embraces all of these alternatives is known as Integrated Pest Management or IPM.

Weeds

A weed is simply a plant out of place. Any plant that disrupts the desired aesthetic quality, performance or functionality of a turf area is a weed. Weeds are opportunistic and can become a problem under several situations, including improper management (mowing height and frequency, fertilization, irrigation), soil disturbance, thinned areas due to traffic, diseases, insects and poor seed establishment.

A turfgrass weed control program involves any practice that will prevent weed development in a turf or shift factors favoring weed development to the point that turf growth and health are favored instead.

The primary step in any pest-management program is proper identification. Proper weed identification is necessary before a decision can be made about control. It is possible that a simple change in a cultural practice could prevent a weed problem or at least decrease population levels below economic or aesthetically disruptive levels. However, in some situations, the use of chemical pesticides may still be needed.

When caring for your lawn and trying to keep it weed-free, "the best defense is a good offense." Weeds are opportunistic and invade weakened lawns, thus the best weapon to fight weeds is a dense, healthy stand of grass. Good management practices give lawns a fighting chance against weeds. These include planting the appropriate grass for a particular location, reseeding bare areas in the fall, proper fertilization, and correct mowing and watering. Mowing height influences competition against weeds such as

IPM considers options

Integrated Pest Management involves the selection, integration and use of pest-management techniques based on predicted economic, aesthetic, sociological and ecological consequences. IPM seeks to maximize the use of biological and naturally occurring pest-management tools.

The IPM concept does not prohibit use of chemical-based pesticides. Rather, it considers their use as one of many options available in a pest management program.

Elimination of a particular pest is rarely the goal of a true IPM program. Instead, management programs attempt to keep pest populations below levels that have been previously determined to cause intolerable damage — economically, aesthetically, ecologically and sociologically.

Control weeds early

One general rule of thumb is to control weeds when they are small and to avoid blanket pesticide applications. When targeting only a few weeds, they can easily be hand-pulled or spot treated with a good ready-to-use (RTU) product.

crabgrass, since taller turfgrass shades sunlight from weed seeds. Watering practices in the spring should be limited for better "deep-soaking" to maintain a drier surface. Frequent light sprinklings with the warming temperatures of spring encourage weed seed germination.

If you decide to use weed-control products, read the label directions carefully. Do not overapply, either by excessive overlapping or applying more product than recommended to a specific area. Applying too much product can damage turfgrass roots and cause unnecessary waste. Try to avoid routine, blanket applications of combination products to control just a few weeds. In this situation, spot treatment or hand pulling is a better option. Determine the effective application width of your rotary spreader and space out each spreader pass to ensure uniform coverage with minimal overlap. It is also recommended to apply one-half of the rate required in two directions. This allows better distribution of the particles and avoids striping.

Do not spread crabgrass preventer or "Weed and Feed" products into flower or garden beds; they will injure new plantings. The fertilizer used in these products is usually designed to provide 1 pound of nitrogen per 1,000 square feet. This is more than enough nitrogen for good spring or fall growth.

Control of annual grassy weeds

Crabgrass is the primary weed problem homeowners face each year. A summer annual, crabgrass is a coarse-textured grass that germinates in the spring and grows well throughout the summer's heat. Its wide leaf blades, heat tolerance and prostrate growth habit make it an eyesore in lawns and it smothers nearby bluegrass or fescue. During the summer, crabgrass will produce seedheads even at low mowing heights. Crabgrass is killed by the first hard frost in the fall, which causes its seedheads to drop. In the spring, the new crabgrass seedlings emerge around the previous year's plant. To avoid this, re-seed the open space during the fall with a desired grass and apply a preemergent to kill germinating crabgrass seedlings.

Preemergent products are so-named because they must be in place before crabgrass seedlings and other annual grassy weeds (goosegrass, foxtails, barnyardgrass and fall panicum) begin to emerge. As a general rule, crabgrass starts to germinate when daily high temperatures begin to reach 70 degrees F or above. In southern areas of the Transition Zone, this may occur as early as mid-March. Farther north, this may not be until late March or early April. Highest crabgrass emergence begins to occur as daily high temperatures reach 80 degrees F. The general rule is that for areas south of I-70 application should be made by March 15; for areas north of I-70 application should be made by April 15. A natural guide, specific to each year's fluctuating weather patterns, is to have your preemergent in place before the yellow blooms of Forsythia have all dropped.

Preemergent products will not kill crabgrass that has already emerged. A preemergent barrier must be present at the soil surface to kill the crabgrass seedling when its first root contacts the soil. Therefore, the preemergent must be applied at the right time and watered into the soil surface either by light irrigation or rainfall. Many effective products are available, almost all of which are combinations of fertilizer with the preemergent herbicide (or crabgrass preventer) in the same bag. These combinations are an effective way to fertilize a lawn and control crabgrass with one application. Both need to be watered in to be effective. Corn gluten-based organic fertilizers are also an excellent choice for control of many annual weeds. Corn gluten-based products will provide 60 to 70 percent control of annual weeds.

Control of perennial grassy weeds

Control of annual grassy weeds is relatively easy due to proper cultural practices and use of preemergent products. Controlling perennial grassy

weeds is a different story. Unfortunately, there are only two classes of selective herbicides to control perennial grassy weeds in turf and they have highly specific uses. The sulfonyl-ureas are designed to control tall fescue, ryegrasses (annual and perennial) and annual bluegrass in Kentucky bluegrass, bermudagrass and zoysiagrass. Another product (fluazifop-p-butyl) controls bermudagrass in tall fescue and zoysiagrass. These herbicides provide excellent control of these specific weeds in these specific grasses, but they have no effect on many troublesome perennial grassy weeds growing in other turfgrasses.

Weeds, such as quackgrass, nimblewill, dallisgrass, johnsongrass, bermudagrass (common and hybrids) and zoysiagrass do not have selective herbicides available to control them. Nonselective herbicides (Roundup, Finale, etc.) are the only way to stop further invasion of these perennial weeds. The use of these products will make brown spots in your desirable turfgrass, but reseeding or re-sodding can repair these areas.

Control of broadleaf weeds

Broadleaf weeds, in general, are easy to control thanks to the methods and large number of products available. Most of the products available for control of broadleaf weeds are systemic herbicides, which means that they move or translocate through the entire plant for a more effective control. Most products are classified as post-emergence; they are applied after the weeds emerge. One exception, Gallery (isoxaben) is the only product designed as a preemergent product for broadleaves. Its primary use is to control winter annual broadleaf weeds (common chickweed, henbit, shepherd's-purse, etc.) and summer annual broadleaf weeds (spurge, purslane, knotweed, etc.).

Some of the preemergent products you use for crabgrass prevention will also control many summer annual broadleaf weeds (carpetweed, purslane, knotweed, pigweed and spurge). Other broadleaf weed problems in the spring can be controlled with one of many three-way type broadleaf herbicides (2,4-D, MCPP and dicamba). Best spring control is achieved when applications are made in mid-May. Controlling broadleaf weeds at this time will not only include the annual broadleaves, but many of the perennials and the few biennials that emerge from seed.

Perennial broadleaf weeds (dandelion, plantains, oxalis, clovers, curly dock, etc.) are more easily controlled in September. Perennial broadleaf weeds have large taproots that store carbohydrates late in the summer to prepare for the long winter. This translocation process makes it easier to move systemic broadleaf herbicides into their roots, which helps provide the most efficient control of perennial broadleaf weeds.

Biennial broadleaf weeds (mallow, prickly lettuce, yellow rocket and thistles) do not exist in large numbers, but they can be difficult to control. Biennials have two-year growth cycles. The first year is vegetative development when small rosettes are formed. The second year, flowering occurs when a tall flower stalk develops and seed is produced. The best time to control biennials is in the first year of vegetative growth when most of the plant's energy is moving downward into the root system. The same systemic broadleaf herbicides used for perennial broadleaf control will also work here.

"Weed and feed" combinations of fertilizer and broadleaf weed control herbicides such as 2,4-D often fail to effectively control target dandelions and other broadleaf weeds because of poor herbicide contact and uptake by the weed. The problem is usually one of placement. To kill the dandelion, the herbicide must be taken up by the foliage. Most granules will bounce off leaf surfaces down to the soil surface, and root uptake of 2,4-D is poor. These products perform better when applied to wet leaf tissue as with a heavy dew in the morning. Many product labels recommend this practice.

Control of miscellaneous perennial weeds

Some miscellaneous perennial weeds include wild garlic (onion), star-of-Bethlehem and yellow nutsedge. Each is unique.

Wild garlic and onion have slender leaves with a heavy, waxy cuticle layer. They develop from bulbs and return every year. The best control for these are ester formulations of 2,4-D with dicamba. Many of the three-way broadleaf herbicides described previously will control these weeds.

Star-of-Bethlehem is another bulb type plant in the lily family. It emerges and flowers in the spring and can be controlled with several broadleaf herbicides.

Yellow nutsedge can be identified by a triangular shaped stem at the soil surface. It grows from seed and underground nutlets and usually grows in thinned-out areas of low-lying turf that hold water. Eliminating wet areas and maintaining a dense lawn will reduce yellow nutsedge infestations.

Diseases

Three requirements lead to development of turfgrass diseases. They include a susceptible host plant (turfgrass), a causal agent (pathogen/fungus) and a favorable environment (weather conditions). Think of each requirement as one side of a triangle. All three corners must be present for a turfgrass disease to develop (Figure 4).

Selecting disease resistant varieties of turfgrass species is the foremost best step to reduce potential disease problems. Using good turfgrass management practices that lead to a healthy plant is the second. Managing plant growth and carefully selecting the appropriate varieties for your conditions come next.

Knowing some information about what diseases favor — especially any that have historically been at that site — can give the homeowner a heads-up on prevention. A couple of examples include: Dollar spot is a disease that favors lower fertility, primarily infects bluegrass and ryegrass, and likes 80-degree days with moderate humidity and nighttime temperatures in the 60s that produce heavy morning dews. Brown patch favors high nitrogen in turfgrasses, primarily infects fescues, ryegrass and bentgrass, and likes 90-degree days with high humidity and nighttime temperatures above 70 degrees.

This information would help you decide how to change management/cultural practices to favor your lawn and not the disease. It will also help you decide the best possible time to apply fungicides to prevent diseases (preventive approach), for example, applying fungicide early to avoid an infection. The other approach is to manage your lawn the best you can and apply fungicide on an as-needed basis (curative approach).

The following is a list of the more common turfgrass diseases in the Transition Zone.

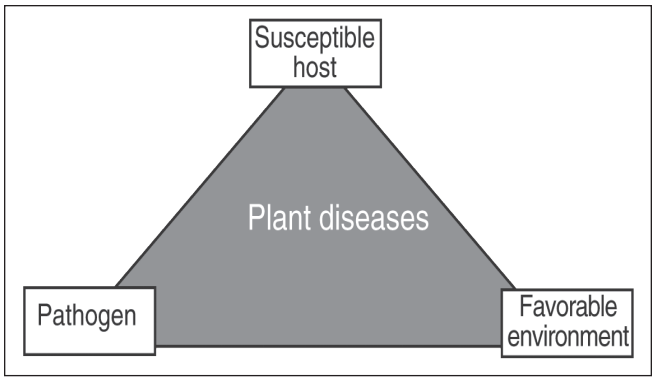

Figure 5. Plant disease occurrence triangle.

Cold weather diseases

Pink snow mold (*Fusarium nivale*). This snow mold is nonspecific to all turfgrasses. It does not require snow cover. Pink snow mold can be lethal and is found primarily on golf courses.

Gray snow mold (*Typhula* spp.). This disease is nonspecific to all turfgrasses. It requires snow cover and is promoted by wet conditions, poor drainage and high nitrogen.

Cool weather diseases

Red thread (*Laetisaria fuciforme*). Red thread affects ryegrass and fine fescues with low nitrogen under cool, wet conditions. It rarely causes permanent damage.

Powdery mildew (*Erysiphe graminis*). Powdery mildew affects primarily bluegrass when nights are damp, humid and cool, and days are mild and cloudy. It usually occurs on shaded, poorly drained soils.

Fairy rings (*Marasmius* spp., *Psalliota* spp.). These usually appear in spring and summer as rings or arcs of dark green grass with or without mushrooms. Some rings may appear dead. Sizes vary from a few inches to several feet in diameter.

Warm weather diseases

Dollar spot (*Sclerotinia homeocarpa*). This disease affects bluegrass, ryegrass and fine fescues. It is a low nitrogen disease promoted by temporary drought, and warm days with cool nights and heavy dew. It is often lethal to low-cut turf.

Leaf spot (*Helminthosporium* spp.). Leaf spot affects bluegrass, ryegrass, fine fescues and tall fescues. It is promoted by excessively high or low nitrogen, improper mowing, and alternating wet and dry cycles. It may progress to melting-out during the summer. Some leaf spot is a natural spring occurrence on bluegrass.

Hot weather diseases

Rust (*Puccinia graminis*). Rust affects bluegrass, ryegrass and fescues. It appears in warm to hot, dry periods when grasses are growing slowly or not at all. It is promoted by low fertility. It is favored when plants are under moderate soil moisture stress and receiving heavy morning dews and frequent light rains.

Pythium (*Pythium* spp.). This disease primarily affects ryegrass and can affect bluegrass and fescues. It appears during periods of extreme high heat and water-logged conditions, usually after thunderstorms followed by immediate sunshine and heat.

Brown patch (*Rhizontonia solani*). Brown patch affects tall fescue, ryegrass and fine fescues. It is promoted by high levels of nitrogen, and it is favored by hot, humid, wet weather. It can be lethal on low-cut turf.

Summer patch (*Magnaporthe poae*). This affects primarily bluegrass and some fine fescues. It is promoted by excess nitrogen and develops following high temperatures and heavy rainfall in July and August. Summer patch becomes active in the soil in the spring, but symptoms do not appear until late summer when grasses are under stress. It commonly occurs on slopes with a southern exposure, where it creates dead rings of grass that have a "frog eye" appearance.

Insects

Insects are one of the most populous forms of animal life on earth. However, only a small number of insects are a potential threat to turfgrass at some point in their life cycle. Turfgrass insects can be somewhat cyclical, and population levels depend on a number of factors, including weather, suitable food sources, desirable habitat and predators.

A healthy, growing plant is the best defense against turfgrass pests. Many plants become more susceptible to pests if they are stressed. Following good turf management practices with mowing, proper watering, fertility, aeration, thatch control and overall sanitation (leaf litter, mulches and other debris) produces good, healthy, dense turf that is pest-resistant.

Turfgrass damage is usually not observed until the numbers of an insect species reach a threshold level. Insects may always be present but not always at damaging levels. For example, a homeowner would not need to treat if only one or two white grubs should be found while doing yard work. However, if the homeowner peels back dead sod and finds more than five white grubs per square foot, then treatment is called for.

Turfgrass pests cannot be controlled over long periods of time solely through the use of pesticides. A properly designed integrated pest-management system will not only maintain control of existing pests but will also help prevent reoccurrence of these pests and the possibility of new outbreaks. Plan for possible pest problems before you plant. Keep records of problems in your lawn and talk to neighbors about pest problems they have experienced.

The following is a list of the more common turfgrass insect pests in Missouri.

Subsurface feeding insects

White grubs. White grubs are the primary insect problem many homeowners face annually. Damage is usually noticed in late July to early August. Damage from the previous year's generation can occur in mid-May. Small or large patches of dead or dying grass will have roots pruned so that sod can be pulled up or rolled back like a loose carpet. Numerous C-shaped, whitish larvae with brown heads will lie in the upper soil directly below the dead sod. Animals, such as skunks or birds digging for grubs, can cause additional related turfgrass damage. Adults are scarab beetles, including billbugs, black turfgrass ataenius beetle, green June beetle, Japanese beetle, masked chafer and May/June beetle. Identification of white grub species can be made by: time of the year the grub is present, size of the grub and raster patterns on the grub's abdomen.

Black turfgrass ataenius grubs. Early damage from these grubs appears as a wilted spot in the turf. Heavy infestations will kill the turf in irregular patches. Grubs (one-fourth inch length) primarily feed on the roots of annual bluegrass and Kentucky bluegrass. Black turfgrass ataenius has two generations per year (May and August). Use insecticide in April or May to control overwintering, egg-laying adults.

Bluegrass billbug. Damaged by billbugs can be confused with drought, disease, chinch bugs or white grubs. Billbug injury creates spotty, dead turf patches that are easily pulled up with the stems breaking off at the crown. The stems are hollowed out or filled with a light brown frass. The best time to control billbugs is in May, to kill overwintering adults before they lay eggs.

Green June beetle. The feeding activity of these grubs rarely causes severe turf damage. Rather, the damage to a lawn generally is mechanical. The grubs burrow in and out of the turf, which produces mounds. These beetles are attracted to soils with high organic content; the decaying organic matter is the primary food for the grubs.

Japanese beetle. These beetles are now considered a threat in Missouri, where they have been found in most counties of the state. Adult beetles are known to feed on approximately 400 ornamental host plants. Grubs feed on roots of turfgrasses causing a wilting appearance and gradual thinning. Dead turf sod can be rolled back under heavy infestations. Adult beetles can damage leaves of both turf and ornamentals. White grubs should be treated in the first or second instar during July and August.

May/June beetle. The earliest symptoms of white grubs feeding on turfgrass roots is a gradual thinning and weakening of the stand. Damage may progress from sudden wilting of the grass, even with adequate moisture, to small patches of dead grass that easily peel back. These beetles have a three-year life cycle. Adult beetles can damage trees and ornamentals. White grubs should be treated during late July to early August to control any newly hatched larvae. However, during the second year of the grub's life cycle, treatments can be made from April through September.

Masked chafer. Turfgrass infested with this species exhibits the typical symptoms of white-grub damage: wilting, irregular dead patches of turf. This beetle has a one-year life cycle. Treat grubs about four weeks after the adult

beetles start to emerge, when egg deposits begin to hatch in late July to early August.

Surface feeding insects

Armyworms. Young larvae begin to feed on tender foliage. Feeding injury by the first two instars causes skeletonized foliage. The third through sixth instars consume all of the plant. When populations are high, feeding produces circular bare areas in turf. Treatments should be applied mid- to late-day, just before nighttime feeding. This insect has several generations per year.

Chinch bugs. The chinch bug feeds by sucking sap from grass stem and foliage. They tend to favor shaded areas first. Damage starts as small, yellow or brown discolored areas that expand in size as the insect population increases. Generally, control measures are needed during the summer generation only. Best control results when the entire lawn is treated.

Cutworms. Cutworm caterpillars feed at night and shear grass blades close to the ground in a circular pattern around their burrows. This feeding produces brown, one- to two-inch-diameter spots. Light infestations can be controlled by predators (birds) and parasites. Females lay eggs on leaf tips in the spring. Mowing with a bagger at the right time can reduce populations 80 to 90 percent. Caterpillars feed at night, so surface treatments should be applied mid- to late afternoon and allowed to dry.

Sod webworm. The appearance of irregular brown spots in the lawn is the first indication. Grass blades will be chewed off at, or just above, the soil surface. Fresh clippings and green fecal pellets are also present. Larvae live in silken-lined tubes in the thatch layer, so look for pencil-size holes in the thatch. Larvae feed at night, so surface treatments should be made in the early morning or late afternoon and allowed to dry.

Moles

While most people have never seen a mole, they are aware of the damage that moles cause to lawns and flowerbeds. Most individuals think moles feed primarily on the roots of plants, causing the plant to die. The truth is, moles' feeding on plant material is limited. Instead, they create air pockets around roots and flower bulbs that cause them to dry out and die.

The eastern mole (*Scalopus aquaticus*) lives most of its life underground and is highly specialized for a subterranean way of life. The mole is a small, sturdy animal, 5.5 to 8 inches long, with a somewhat cylindrical body and elongated head. It is grayish-brown on the back to pale or more brown on the belly. Its velvety fur often has a silvery sheen. Occasionally bright orange or cinnamon-yellow markings will occur. A fleshy snout serves as a highly sensitive organ of touch and smell to seek out numerous food sources. Tiny eyes are concealed in fur and covered by fused eyelids; sight is limited to distinguishing light from dark. The greatly enlarged front feet are normally held with the soles vertical and pointing outward. They possess well-developed claws that have a specialized bone attached to the wrist to aid in digging.

Moles construct networks of tunnels at the soil surface (Figure 5). Many of these are built after rains when the mole is in search of new food sources and are usually not reused. Digging of surface tunnels normally proceeds at a rate of 1 foot per minute. Moles also create mounds, called molehills, of soil by pushing up soil as they develop deeper permanent tunnels and nesting cavities.

Moles tend to feed and rest on two-hour cycles, 24 hours a day. Animal foods constitute about 85

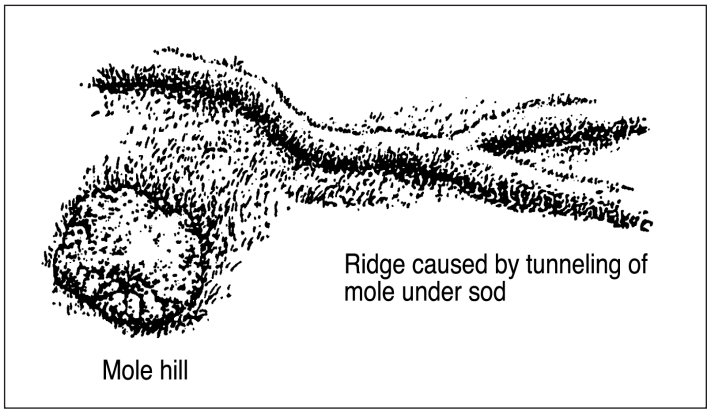

Figure 6. Mole signs.

More on moles

For more information on moles, read *The Wild Mammals of Missouri* by Charles W. Schwartz and Elizabeth R. Schwartz, the source for the descriptive information in this section.

percent of their diet. This primarily includes earthworms (their main source of water) and grubs, however millipedes, centipedes, spiders, sow bugs, snails and slugs are taken in considerable amounts. Moles are insatiable eaters and can consume 70 to 80 percent of their body weight daily. Moles generally move up or down within the soil profile to follow food sources such as earthworms, which move with soil moisture. That is why you do not see much mole activity during a droughty summer, but with spring and fall rains, activity abounds.

Mating occurs in the spring with a single annual litter of two- to five young produced in March, April or early May. High infestations consist of two to three moles per acre.

Controlling and trapping moles requires a little time and patience. There are a number of home remedies to control or repel moles, including human hair, Juicy Fruit gum, poison peanuts, mothballs, flooding tunnels with a garden hose and water (flooding creates a moist environment favorable for earthworms), a hose connected to a car exhaust and finally, pets (some dogs and cats can be effective). Ultimately, though, success controlling moles is likely to depend on locating active runways and properly placing baits or traps.

Control products

Mole-control products are available to homeowners and can be purchased at local nurseries or garden centers. Most products tend to work as repellants with castor bean oil as the active ingredient. Many have been tested on the Eastern mole and appear effective on that species, which is our predominant species. These products need to be sprayed (garden hose-end applicator) or applied as granules (through a spreader) at regular intervals to maintain a barrier that repels these mammals. The repellant type products are marketed as natural and safe, but information about effectiveness is mixed. Mole-Med was one of the earliest repellants with castor bean oil as the active ingredient (its name may have changed to Chase due to new ownership) available in liquid and granular form. Other repellants include Scoot Mole, Shotgun Mole & Gopher Repellant, Mole Max, Mole-Out, Whole Control, Schultz Garden Safe Mole Repellant. Formulations vary with each. These products will generally treat 5,000 to 10,000 square feet and last one to three months.

Two other products, Kaput Mole Control (Lesco) and Moletox Baited Gel (Bonide), are water-based gels containing warfarin as the active ingredient and flavored like the mole's primary food, earthworms. It is best to locate the active runways as you would for trapping (see below) before placing the bait. Both are packaged in syringe-type applicators that inject bait into the tunnels. Both claim excellent control.

The latest mole bait registered is Talpirid by Bell Laboratories, a bromethalin-based product that actually looks, feels and tastes (so they say) like earthworms. Each "worm" contains a lethal dose of bromethalin. It is the only mole bait that has submitted efficacy studies to the U.S. Environmental Protection Agency. A more affordable generic of this product is available as Motomco Mole Killer. Both claim 98 percent effectiveness.

There are also some poisonous granular baits of a different class than the previous baits mentioned. These include Moletox II and Mole-Nots, both of which are cracked corn baits laced with 2 percent zinc phosphide. One teaspoon of material will treat an active tunnel. While some results indicate excellent control with these products, keep in mind that moles do not prefer grains in their diet. For the same reason, poison peanuts are not likely to be effective, since most of their diet consists of earthworms and insects. While much more affordable, they are not as effective.

Another granular bait is Mole Patrol Bait. Mole Patrol is a ready-to-use, pelletized bait that is highly palatable to the moles, with unique attractants.

This product contains chlorophacinone, an anticoagulant historically used by the rodenticide industry. Some studies indicate 100 percent control of moles.

Controlling earthworms is **not** recommended since they are considered a beneficial organism that aerates the soil and breaks down organic materials. The application of soil insecticides for controlling grubs will also control earthworms to some degree, sometimes causing moles to move out. This approach to mole control can present hazards to the environment and can be expensive. There are ***no*** pesticides registered for killing beneficial earthworms ***and this should not be attempted***.

Trapping

If you have a mole actively building mounds, there really is not much you can do unless you catch them in the act and move quickly with a spade or shovel. Your success, however, is still likely to be limited.

Trapping can be effective, however, if you can see evidence of a network of shallow runways used for feeding. First, with a small stick or broom handle, poke holes in various runways over the entire network. Come back two hours later and inspect these holes. Find the tunnels with the holes plugged back up. This indicates which runways are active feeding tunnels at that time. These are the tunnels where you will want to set your traps. The key in trapping is to locate the active runways. Second, select one of these tunnel to set your trap.

There are several types of traps. Simply follow the instructions of the manufacturer to set the trap (Figure 6). The Nash trap (wire hoop type) and the Victor Out O' Sight trap (scissors type) both work, but seem to be more difficult to set.

The Victor Harpoon or gig-type trap has had the highest success rate among traps tested at the MU Turfgrass Research Center. To set, push down a four-inch swath of the runway with your foot. Before setting the harpoon, push the trap into the soil with the gigs over the runway and move up and down several times to reduce the friction of the soil against the gigs. This will ensure a quick and decisive thrust of the harpoon. While the trap is in the soil, pull the harpoon up and lock it in position with the trigger pan (flat

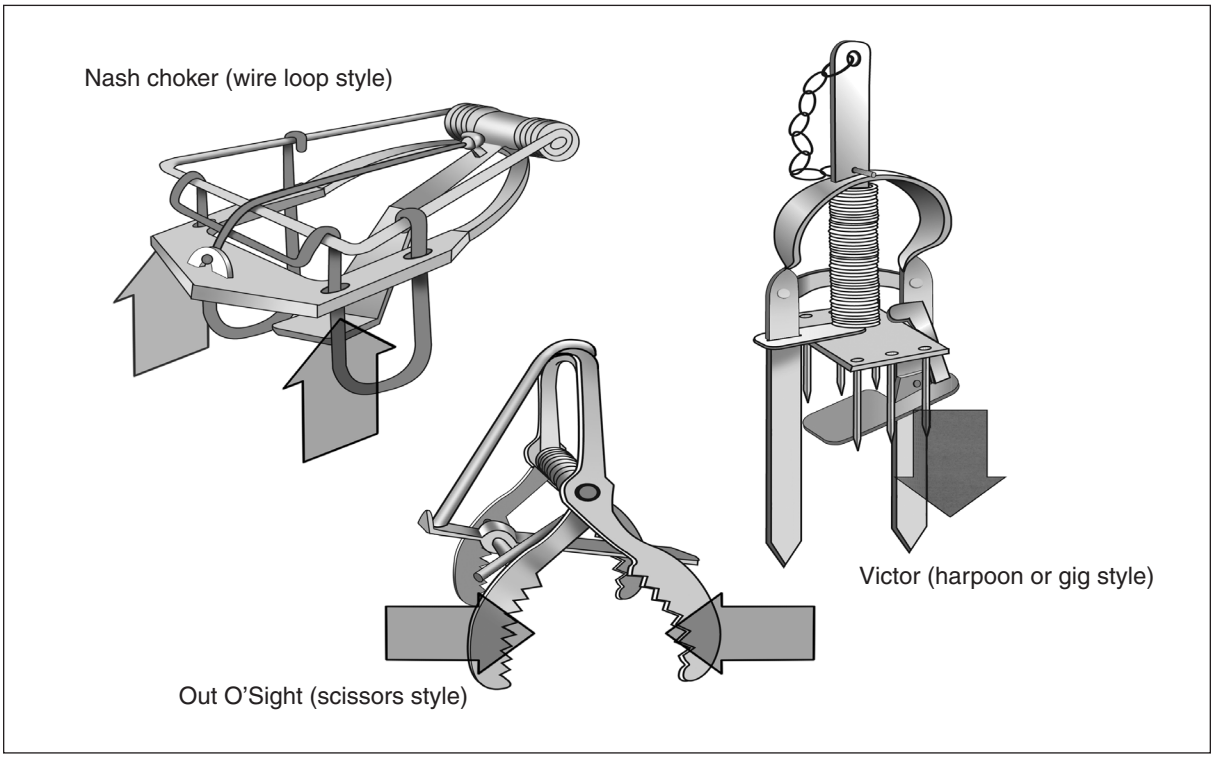

Figure 7. Types of mole traps.

plate) slightly touching the depressed runway. Your trap is set. After the trap is set, poke a hole in the runway on each side of the trap one foot away, then wait a couple of hours or until you notice the trap has been sprung. At that time, look at the holes on each side of the trap. If one hole is plugged with the trap sprung, then you have more than likely caught the mole on that side and you need to be prepared with a spade in hand to retrieve the trap. If both holes are plugged with the trap sprung, then the mole more than likely made it through the trap. In this case, simply reset the trap on the same runway or over another active runway. To prevent injury to pets, place a five-gallon bucket over harpoon traps with a rock or brick on top.

For further information

If you have questions that this publication or other references do not answer, contact your local extension center.

MU publications at *extension.missouri.edu/explore/*

Lawn Establishment

G6700 *Cool-Season Grasses: Lawn Establishment and Renovation*
G6705 *Cool-Season Grasses: Lawn Maintenance Calendar*
G6706 *Establishment and Care of Zoysiagrass Lawns*
G6708 *Thatch: Enemy of Lawns*
G6720 *Home Lawn Watering Guide*
G6725 *Grasses in Shade: Establishing and Maintaining Lawns in Low Light*
G6730 *Establishment and Care of Buffalograss Lawns*
G6749 *Natural Lawn Care*
G6770 *Bermudagrass for Athletic Fields*
G6772 *Cool-Season Grass Cultivars for Athletic Fields*
G6954 *Soil Testing for Lawns*

Mowing

G6959 *Don't Bag It Lawn Care: How to Recycle Your Grass Clippings, Leaves and Branches*
G6956 *Making and Using Compost*
G6958 *Grass Clippings, Compost and Mulch: Questions and Answers*

Pest Control

G6750 *Home Lawn Weed Control*
G6751 *Calibrating Sprayers and Spreaders for Athletic Fields and Golf Courses*
G6756 *Turfgrass Disease Control*
G7200 *White Grubs in the Lawn*
G9440 *Controlling Nuisance Moles*
IPM1009 *Turfgrass and Weeds*
IPM1020 *Turfgrass and Insects*
IPM 1029 *Identification and Management of Turfgrass Diseases*

Related reading and Web sites

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Dunn, John, and Kenneth Diesburg. 2004. *Turf Management in the Transition Zone*. Hoboken, N.J.: Wiley & Sons.

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National Turfgrass Evaluation Program (NTEP) at *ntep.org*

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