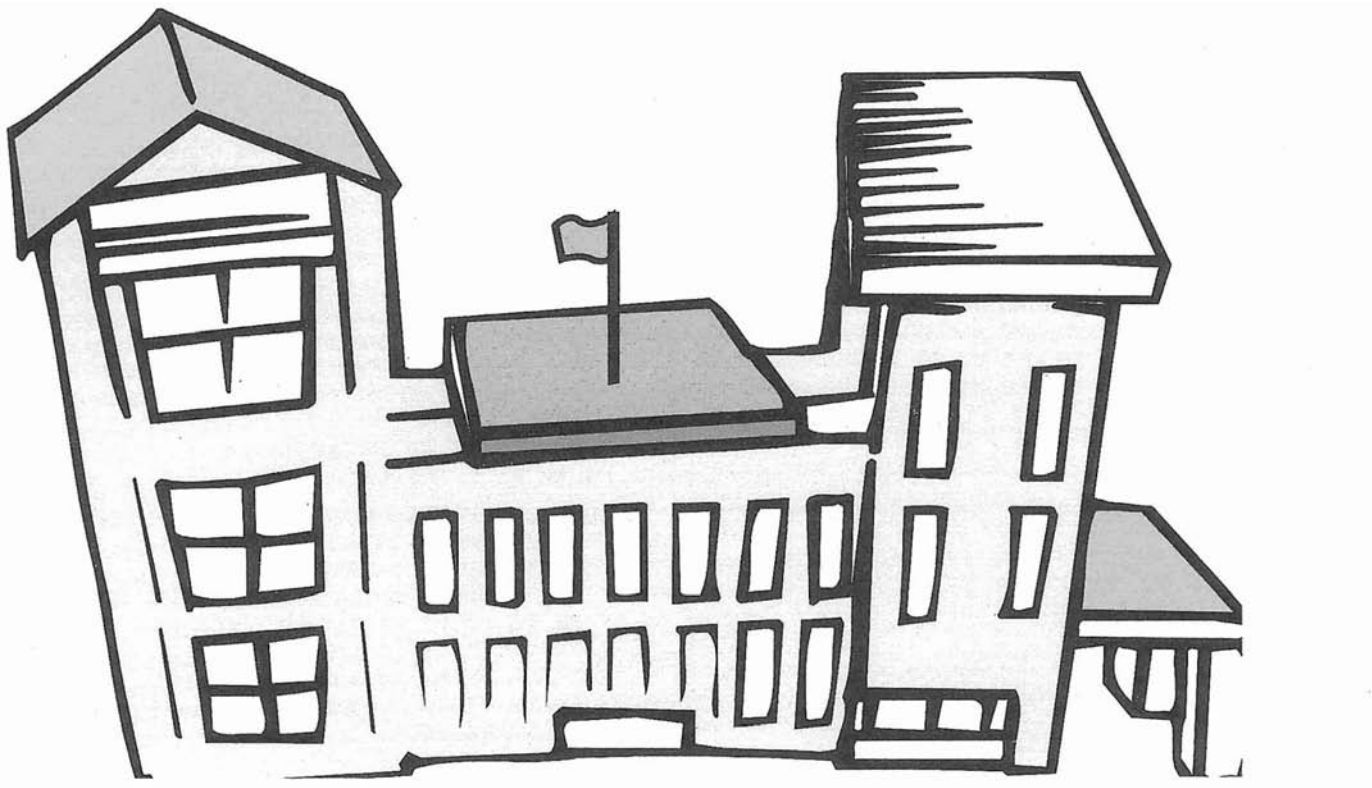
Integrated Pest Management In Schools

IPM for School Lawns, Athletic Fields, and Weeds on School Grounds



University of Maryland, College Park | Maryland Department of Agriculture

MARYLAND COOPERATIVE EXTENSION
UNIVERSITY OF MARYLAND COLLEGE PARK-EASTERN SHORE

ERRATA SHEET
AND
IMPORTANT NOTICE CONCERNING
IPM TRAINING MANUALS AND INFORMATION SHEETS

BACKGROUND

Legislation was enacted in 1997 mandating that Maryland Public Schools (Grades K-12) develop and implement Integrated Pest Management (IPM) plans for managing pests in public schools. The legislation also mandated schools to develop and implement methods for providing notification to parents and or guardians, as well as, school staff of pesticide use in school buildings. In 1999, this legislation was expanded to require public schools to develop and implement IPM plans and notification of pesticide use on school grounds.

In an effort to assist schools in the initial development and implementation of IPM plans and notification and posting formats, the Maryland Department of Agriculture (MDA) produced several manuals and contracted with the University of Maryland to write four additional manuals. These documents were intended for use by the schools for information and guidance. The documents were never intended to supplant the IPM and notification law and regulations but rather to facilitate implementation of the law. However, there are statements in these documents that incorrectly state the requirements of the law. The Department does not have the funds to republish the manuals and therefore has disseminated this errata sheet to all public school systems in Maryland to ensure that all schools are complying with the law.

Please note that the IPM in School manuals contain additional statements or information other than the examples listed below that do not uniformly incorporate and provide detail of the statutory mandate of Maryland's IPM and notification of pesticide use in public school buildings or on school grounds law and regulations. Therefore, if you are reading these manuals for training/guidance purposes or when performing pest control services, make sure you adhere to the definition of Integrated Pest Management found in Maryland's Integrated Pest Management and Notification of Pesticide Use in a Public School Building or on School Grounds law and regulations. For more information or questions, please contact the Maryland Department of Agriculture's Pesticide Regulation Section at 410-841-5710

ERRATA SHEET

PLEASE NOTE AND BE AWARE OF THE FOLLOWING:

1. The IPM in Schools manuals produced by MDA and the University of Maryland contain statements that incorrectly state that IPM is an alternative to pesticide application. An example of such a statement can be found in the Preface of the *Integrated Pest Management in Schools: IPM Training Manual,* where it states "Integrated Pest Management (IPM) is an alternative to pesticide use." This statement is incorrect. IPM **is not an alternative** in Maryland's Public Schools (Grades K-12); **it is the required method** of pest control under Maryland's IPM- in-Schools law and regulations."

2. The IPM in Schools manuals produced by MDA and the University of Maryland contain statements that fail to uniformly affirm the statutory mandate that pesticides be used only when "nontoxic options are unreasonable or have been exhausted." Examples of statements that fail to affirm the statutory mandate can be found 1) on page 6 of the manual entitled *Guidelines for Integrated Pest Management in Schools,* where it states "Pesticides are a component of an IPM program…" 2) on App. A, page 7 on the manual entitled *Contracting Guidelines for IPM Services in Maryland Public Schools* where it states "A broad definition of IPM is a pest control program that… incorporates different methods of pest control such as…and pesticides, when warranted…" and 3) in same manual on p. 17 where it states that "Pesticides play a limited, but important role in and IPM program." These statements do not reflect the statutory mandate that pesticides may be used only when nontoxic options are unreasonable or have been exhausted. In fact implementing an IPM program with a proper focus on pest prevention may result in a pest management program that does not include the use of any pesticides.

3. The IPM in Schools manuals produced by MDA and the University of Maryland contain some language that fails to provide the correct notice requirements mandated by the IPM-in-Schools law and regulations. An example of such a statement can be found on page 8 of the manuals entitled *Guideline for Integrated Pest Management (IPM) in Schools,* which states "A voluntary registry of individuals with medical problems or conditions who could be adversely affected by exposure to pesticides shall be maintained at the school health or administrative offices, as well as by the contact person." **Prior notification is not a voluntary option for schools, nor is it limited to individuals with medical problems or conditions.** Both the law and regulations regarding IPM and Notification in public schools buildings and on school grounds **mandate notification** to all parents, guardians and school staff for elementary schools. Middle and High schools may choose to either notify all parents, guardians and staff members or establish a list of parents, guardians and staff members who wish to be notified of pesticide use. The law requires that all parents, guardians and staff be informed of the notification list so they can opt-in.

4. The IPM in Schools manuals produced by MDA and the University of Maryland contain confusing statements regarding a school's legal obligations. An example of such a statement can be found on page 4 of the manual entitled *Contracting Guidelines for IPM Services in Maryland Public Schools.* The statement reads "In addition, the Governor's Pesticide Advisory Council has issued the following policy statement regarding IPM in schools…" This statement references a Council that no longer exists and a policy that is not in law or regulation

IPM for School Lawns, Athletic Fields, and Weeds on School Grounds

Edited by Tawna Mertz, Scientific Writer and Editor; Paula Shrewsbury and Michael Raupp, Entomology Department, University of Maryland; and Ed Crow, Entomologist, Pesticide Regulation Section, Maryland Department of Agriculture.

Maryland Cooperative Extension
University of Maryland
College Park, Maryland, 20742

Maryland Department of Agriculture
Pesticide Regulation Section
50 Harry S. Truman Parkway
Annapolis, MD 21401
Telephone: 410-841-5710
Fax: 410-841-2765
Internet: http://www.mda.state.md.us

Funding was provided in part by the U.S. Environmental Protection Agency (EPA) and the Maryland Department of Agriculture (MDA). This document does not necessarily reflect the opinions of the U.S. EPA.

Acknowledgments

Additional thanks go to the University of Maryland, Cooperative Extension Service and the Home and Garden Information Center (HGIC) and the many authors who have developed fact sheets and made them available through HGIC. Several fact sheets have been modified and are incorporated into this manual. Other references used in the preparation of this manual include IPM in Schools Chapter 18, IPM For Weeds On School Grounds, USEPA Document #909-B-97-001 by the Bio-Integral Resource Center, P.O. Box 7414, Berkeley, CA 94707, March 1997, the IPM Workbook for New York State Schools by S. Stauffer, R. Ferrentino, C. Koplinka – Loehr, and K. Sharpe, Cornell Cooperative Extension Community IPM Program, IPM for Pennsylvania Schools: A How to Manual, Pennsylvania Integrated Pest Management Program, Pest Management Guidelines for Howard County Schools, and the University of Wisconsin – Madison, Turfgrass Disease Diagnostic Laboratory Website at http://www.plantpath.wisc.edu/tddl/tddl/tddl.htm.

What is IPM?

The Maryland Department of Agriculture regulation on Integrated Pest Management and Notification of Pesticide Use in a Public School Building or on School Grounds (Title 15, Subtitle 05, Chapter 02, Agriculture Article, Annotated Code of Maryland) defines Integrated Pest Management (IPM) as:

"A managed pest control program in which methods are integrated and used to keep pests from causing economic, health related, or aesthetic injury through the utilization of site or pest inspections, pest population monitoring, evaluating the need for control, and use of one or more pest control methods including sanitation, structural repair, nonchemical methods, and, when nontoxic options are unreasonable or have been exhausted, pesticides, in order to minimize the use of pesticides and minimize the risk to human health and the environment associated with pesticide applications. "

Managing pests through an IPM program requires a basic understanding of pest biology and behavior to select effective methods of control. The most basic aspect of any pest control program understanding what a pest is. A pest is any living organism (animal, plant, or microorganism) that interferes with or threatens human, animal or plant health, property, or the environment. Pests have basic needs for air, food, moisture, warmth, and harborage. Landscapes are commonly constructed and maintained in ways that provide these needs and create environments that encourage pests to stay and multiply.

Many individuals are under the false assumption that IPM represents a nonchemical approach to pest management. In fact, IPM programs integrate both nonchemical and chemically based methods of pest control. In the long run, this integrated approach is more effective and less risky for school occupants than traditional pest management approaches that rely only on the use of chemicals. IPM employs a combination of tactics that include structural modifications, sanitation, inspections and monitoring, use of traps, and the judicious use of pesticides when necessary. Long-term control of pests is achieved by using the best available technical information about the pest and its interactions with its surroundings.

Table of Contents

Introduction

In schools, lawns often cover several acres and serve important roles as athletic fields, picnic lunch sites, outdoor classrooms, and general recreational areas for the community at large. Heavy use of lawns and athletic fields causes stress that predisposes grass to attack by a variety of weeds, insect pests, pathogens, and vertebrates such as moles. As a result, most pesticides used on school grounds are applied to lawns.

Because the bodies of children are often in direct contact with the grass, use of pesticides on lawns increasingly concerns parents and health professionals. On the other hand, coaches and school administrators are under pressure to ensure quality turf for use by students and by community athletic leagues. This is not just for aesthetic purposes; well-maintained turf provides a safe playing surface for athletes. In addition, the competence of landscape maintenance staff is often judged by the aesthetic appearance of the lawns that surround schools. Child health and safety often conflict when pests damage school lawns and athletic fields and pesticide applications are considered.

Lawn IPM starts with the selection of appropriate turfgrass varieties. Next, the grass must be established correctly or existing lawns and athletic fields may need renovation. Finally, turf should be maintained in ways that optimize growth of grasses and minimize conditions favorable to insect pests, weeds, or pathogens.

PAGE

INTENTIONALLY

LEFT

BLANK

Selection of Turfgrass

Selecting the Appropriate Turfgrass to Meet Site Needs

Selecting an appropriate turfgrass cultivar and buying quality seed are important steps in the IPM process. During the last decade, numerous new turfgrass cultivars have been developed and released by turfgrass seed breeders. Many of these cultivars are adapted to the environmental conditions that prevail in other regions of the country and are not adapted to the difficult environmental conditions that occur in the transition zone, which includes Maryland and Virginia. To identify cultivars that perform well in this region, extensive cultivar trials have been conducted at the University of Maryland and Virginia Polytechnic Institute & State University as part of the National Turfgrass Evaluation Program (headquartered at Beltsville, MD).

Use of recommended cultivars can result in a turfgrass stand of higher quality and density, greater stress tolerance, lower nutrient requirements, less water usage, fewer pest problems and thus reduced pesticide use. There has been extensive interest in recent years regarding turfgrass species that have reduced nutrient requirements, especially reduced nitrogen needs. The two recommended turfgrass species with the lowest nitrogen requirements are the fine fescues and zoysiagrass; turf-type tall fescue has intermediate requirements. Although Kentucky bluegrass and Bermudagrass generally have the highest nitrogen requirements, research has identified several Kentucky bluegrass cultivars that provide fair quality under reduced nitrogen fertility and other maintenance inputs.

Much of the seed available at retail stores is not the improved type recommended by turf specialists. However, many hardware stores and nurseries carry at least some of the recommended cultivars. The improved cultivars often cost more than twice as much as the lowest priced seed, but the quality is much better. In addition to buying improved seed cultivars, be sure the seed is certified. Compare seed labels and know the differences between products, such as the amount of weed seed and other seed, and the date the seed germination rate was tested. Using certified seed will help reduce problems with weeds. Also varieties containing endophytes may increase tolerance to drought and reduce pest problems.

In addition, when purchasing sod it should also be certified. Maryland has a certified sod program that is administered by the Maryland Department of Agriculture. Specifying certified sod guarantees that the sod will contain cultivars that are currently recommended by researchers in Maryland and Virginia, will have been seeded in recommended percentages, and will be of high quality (free of insects, weeds, and diseases).

Many seeding specifications (for municipalities, counties, state and governmental agencies, landscape architects, and professional organizations) state that cultivars used for turfgrass must be selected from *Turfgrass Recommendations for Certified Sod and Professional Seed Mixtures in Maryland,* Agronomy Mimeo #77 (Prepared by: Dr. Thomas R. Turner, Turfgrass Specialist, Mr. David Funk and Mr. John Krouse, Research Assistants, Department of Agronomy, University of Maryland). Turfgrass types and their characteristics, recommended seed mixtures, and the cultivars recommended for these mixtures are listed below (adapted from Agronomy Mimeo #77).

Selection of Turfgrass

4

Turfgrass Types and Their Characteristics

Turf-type tall fescue. Turf-type tall fescue is the most highly recommended turf grass for Maryland. It has few pest and disease problems and tolerates heavy traffic, heat and drought. It grows best in full sun or moderate shade and has moderate nitrogen requirements. Cultivars can be seeded individually or as a blend of several varieties of tall fescue. Overseeding turf when needed will help keep weeds out and maintain quality
and safety.

Zoysiagrass. Zoysiagrass also has few problems. It is a warm season grass and is green in the summer but turns light brown and dormant from mid-October to mid-May. Zoysiagrass is often planted as plugs or sprigs, but seed is available. Zoysiagrass needs full sun, has low nitrogen requirements, and is very low-maintenance once established. For more details see Agronomy mimeo # 69, planting and establishment of Zoysiagrass).

Fine fescue. Fine fescues have very narrow blades. They are a low maintenance, tolerate shade and low fertility, and require less mowing. However, they do not tolerate poorly drained soil or heavy traffic and high heat or humidity may cause the grass to become dormant. There are several varieties of fine fescue. Creeping red fescue is good for shady, low-maintenance sites. Chewing fescue and hard fescue do well in sunny or shady, low-maintenance locations.

Kentucky bluegrass. Popular for its deep color and fine blade, Kentucky bluegrass is cold tolerant and moderately wear-and heat-tolerant. However, it will not grow in heavily shaded areas. Kentucky bluegrass requires higher amounts of water and nitrogen fertilizer than other cool season grasses and are considered to be a high maintenance turf.

Perennial ryegrass. Because it germinates rapidly, perennial ryegrass is often selected to quickly establish a lawn or fill in bare spots. It is very tolerant of traffic, but often damaged by cold temperatures. Ryegrass recovers slowly from damage, therefore, it may require frequent reseeding.

Bermudagrass. Bermudagrass is most often used as a turf grass in the south and less often in the north because it is very sensitive to freezing temperatures. It tolerates heavy traffic and responds well to management, forming a dense, fine-textured turf. However, it has no shade-tolerance. Only a few varieties are recommended for Maryland.

Recommended Seeding Mixtures for Various Site Conditions

Full sun sites. For full sun areas that will receive irrigation and intensive management, a mixture of Kentucky bluegrass (85–100%) and perennial ryegrass (0–15%) is recommended. A minimum of three bluegrass cultivars should be selected, with each ranging from a minimum of 10% to a maximum of 35% of the mixture by weight. Perennial ryegrass may be added where rapid establishment is necessary for erosion control. No more than 15% of a perennial ryegrass cultivar should be used, as it will predominate if seeded at a higher percentage. For full sun areas where lower maintenance is desired, consider a mixture of chewing and hard fescues.

Full sun to moderate shade sites. Two different types of seed mixtures may be selected for sites that have both full sun and shade. Tall fescue turf will tolerate a wider range of management inputs. Turf-type tall fescue (100%) as a single cultivar or a blend of turf-type tall fescue cultivars may be used. A Kentucky bluegrass/fine fescue turf will generally require higher maintenance for the survival of the Kentucky bluegrass in the sun, but reduced maintenance is recommended for the maximum survival of the creeping red fescue in the shade. A mixture of Kentucky bluegrass (80–90%) and creeping red fescue (10–20%) with a minimum of three bluegrass cultivars should

be selected, ranging from a minimum of 10% to a maximum of 35% of the mixture by weight. One creeping red fescue cultivar should be selected. More than 20% creeping red fescue may cause a dominance of this species during establishment.

Shady sites. Sites that are partial to full shade often receive minimal management (no irrigation, low fertility). One of the recommended fine fescues may be selected (100% of one cultivar). Neither blending cultivars nor mixing of fine fescue species have been studied extensively in Maryland and Virginia for compatibility. Limited research does not indicate any advantage to either. The fine fescues include hard fescue, chewing fescue, creeping red fescue, and sheep fescue. Creeping red fescue and slender creeping fescue should be considered only for shady sites and not for sunny, low-maintenance sites.

Recommended Turfgrass Cultivars

Listed below are recommendations for producers of certified sod. These recommendations represent results of scientific evaluations of varieties for Kentucky bluegrass, turf-type tall fescue, fine fescue, Bermudagrass, and zoysiagrass that have performed well in trials in Maryland and Virginia over a period of several years. While these recommendations are designed primarily for producers of certified sod, their use should ensure high quality turf in school settings as well. In all of the tables that follow, cultivars followed by a numerical notation in parentheses (1), (2), (3), or (4) may be removed from these lists in subsequent years for the following reasons:

(1) may be removed from the list due to declining field performance relative to other cultivars

(2) may be removed from the list due to declining seed quality

(3) may be removed from the list due to non-availability of certified seed

(4) may be removed from the list due to the lack of current testing data relative to other cultivars. The cultivar will be removed from the list if it is not included in the next available cultivar trial.

Cultivars listed in italic are considered promising but have only been tested in Maryland or Virginia for a few years, or may be difficult to find due to limited seed availability.

Zoysiagrass Sod

Only twelve cultivars are currently recommended in Maryland for certified sod production due to potential winter hardiness problems of other cultivars. The group listed as vegetative cultivars can only be obtained as sod, plugs, or sprigs. The group listed as seeded may be obtained as seed as well as in vegetative forms.

Vegetative Cultivars

Belair (4), Cavalier, *Marquis,* Meyer, Omni (4), *Sunburst.*

Seeded Cultivars

J – 14, J – 36, J – 37, Zenith, *Zen 400, Zen 500.*

Bermudagrass Sod

Only six cultivars are currently suggested for use in Maryland for certified sod production due to potential winter hardiness problems of other cultivars.

Midfield, Midiron, Midlawn, Quicksand, Tufcote, Vamont.

Kentucky Bluegrass Sod

A minimum of 3 Kentucky bluegrass cultivars must be chosen, with each cultivar ranging from a minimum of 10% to a maximum of 35% of the mixture's weight. At least 65% of the mixture must be from cultivars listed in Category I. No more than 35% of the mixture may be comprised of promising cultivars.

Category I: Recommended Kentucky Bluegrass Cultivars (65–100% of the mixture).

Absolute, Allure, Alpine (4), America, Apollo, Arcadia, Ascot, Aspen (4), Award, *Barirus, Baronie,* Blacksburg, Blackstone, Bluechip, *Brilliant,* Caliber, Cannon (4), Challenger, *Champagne,* Chateau (2), Chicago, Classic, *Compact, Connie, Coventry,* Eagleton (4), Eclipse, *Envicta, Explorer,* Fairfax (4), Freedom (4), Georgetown (4), Glade, Gnome (4), Goldrush, *Haga,* Impact, Jefferson, Julia, Kelly, Liberator, Liberty (4), Limousine, Livingston, Lofts 17574, Marquis, Merit (4), Midnight, Monopoly (4), Moonlight, Nottingham (4), Nuglade, Odyssey, Opti – Green (4), *Platini,* Preakness (4), Princeton 105, Quantum Leap, Rambo, Rugby II, *Serene, Showcase, SR 2000, SR 2109,* Total Eclipse, Touchdown (4), Unique, Viva (4), Washington (4).

Category II Special Use Kentucky bluegrass cultivars (0–35% of the mixture).

For shade tolerance:

America, Ascot, *Brilliant, Champagne,* Chateau (2), Compact, *Coventry,* Liberator, Moonlight, Nuglade, Princeton 105, Quantum Leap, *Showcase, SR 2000,* Unique.

For low maintenance tolerance:

Barirus, Baron, Caliber, Eagleton, Freedom (4), *Haga,* Livingston (4), Merit (4), Midnight, Monopoly (4), NUSTAR (4), Washington (4).

Turf-Type Tall Fescue Sod

Turf-type tall fescue cultivars may be seeded individually or in blends. The following Kentucky bluegrass cultivars may be mixed with turf-type tall fescue to enhance sod strength during harvesting (may be 0–10% of the seed mixture): Abbey, Baron, Cheri, Nassau, Nustar, Ram I, Shamrock, Wildwood, and all cultivars from Category I Kentucky bluegrasses except Touchdown.

Alamo E, Apache II, Arid (3), Avanti (4), Axiom, Bandana, Barlexus (4), *Barrington,* Bonanza (4), Bonanza II (4), Bonsai 2000, Bravo (2), *Bulldawg,* Chapel Hill, Chieftain II (4), Chinook, *Cochise II, Comstock,* Coyote, Crossfire II, Crossfire (4), Debutante, *Dominion,* Duke (4), Duster, Eldarado (4), *Empress,* Falcon II, Finelawn Petite, Gazelle 1, Genesis, Good – En, Grande (4), Guardian (4), Heritage (4), Hounddog 54, Jaguar 3, Lancer (4), Leprechaun, Marksman (1), *Masterpiece,* Micro DD, Millennium, Minimustang (3,4), Montauk (3,4), Mustang II (3), *Olympic Gold,* Olympic II (3,4), *Oncue,* Palisades (3,4), Pixie (4), Pixie E+, Plantation, Pyramid (4), Rebel 2000, Rebel 3D (4), Rebel III (4), Rebel Jr (4), Rebel Sentry, *Red Coat,* Regiment, Rembrant, Renegade, Reserve, Safari (2), *Scorpio,* Shenandoah, Shenandoah II, Southern Choice, SR 82004, SR 82101, SR83004, Stetson (4), Tarheel, *TF6,* Titan 2, Tomahawk (4), Trailblazer II (4), Tulsa (1), *Twilight II,* Virtue, Watchdog, Wildcat (2,4), Wolfpack, WPEZE, *Wyatt.*

Fine Fesque Sod

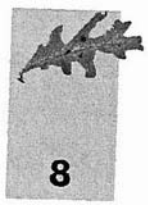
The following fine fescue cultivars may be used for the production of certified sod. No one cultivar may be more than 40% of the seed mixture by weight. Hard fescue must be 40–95% of the mixture. Chewings, sheep, and creeping red fescue may be 0–40% of the mixture. Promising cultivars may not comprise more than 40% of the mixture. Kentucky bluegrass must be 5–40% of the

mixture by weight and selected from those eligible for mixing with tall fescue (see above). H = hard fescue C = chewings fescue ; S = sheep fescue CR = creeping red fescue.

Aurora (H), Banner II (C), Bighorn (S – H), Bridgeport (C), Brigade (H), Brittany (C), Discovery (H), Ecostar (H), Flyer II (C – R), Jamestown II (C), K – 2 (C), MX 86 (S), Nordic (H), Osprey (H), Pamela (H), *Quattro (S),* Reliant II (H), *Sandpaper (C), Scaldis (H),* Shademaster II (C – R), Shadow II (C), Spartan 2 (H), SR 4100 (C), Tiffany (C), Treasure (C), Victory (C).

Perennial Ryegrass:

Accent, Achiever, Affinity, ASP400, Assure, Blazer III, Brightstar (3), Brightstar II, Buccaneer*, Caddy Shack, Calypso, *Catalina,* Cutter, Derby Supreme, Divine, *Edge,* Elf, Esquire, Head Start, Image, Laredo (2), Majesty, Manhattan 3, Monterey, Morning Star, Omega (3), Palmer III (2), Panther, *Passport,* Pennant II, Precision, Prelude III (3), Premier II, Prizm, Quickstart, R.22, Saturn II, Secretariat, Sonata, SR 4010, SR4200, SR 4400, Top Gun, Top Hat (3), Wind Star.



Establishment and Renovation of Turfgrass

Starting New Lawns from Seed

Adapted from Agronomy mimeo # 67

Prepared by Thomas R. Turner, Ph.D.,Turfgrass Specialist Department of Natural Resource Sciences & Landscape Architecture, University of Maryland

Late summer and early fall (August 20 through October 15) is the ideal time in Maryland for the establishment of cool season grasses such as turf-type tall fescue, fine fescue, and Kentucky bluegrass. If you cannot irrigate or if water restrictions are in effect, seeding between September 15 and October 15 may be preferable to take advantage of cooler temperatures and greater likelihood of rainfall. Seeding later than October 15 presents problems with the winter survival of turfgrass seedlings and with competition from winter annual broadleaf weeds. Seeding in the spring can present problems with competition from summer annual grass weeds such as crabgrass, and reduced survival of young turfgrass plants when summer heat and drought begins.

In addition to seeding at the proper time, effort should focus on proper soil preparation, careful selection of quality seed or sod, proper care during the first two months of establishment is essential to obtaining a healthy, dense turfgrass stand that is resistant to weed encroachment and other problems. By following basic management guidelines, the chances for establishing attractive lawns and athletic fields with reduced pest problems will be enhanced greatly.

Steps to Starting a New Lawn from Seed

1. Assess the situation. While planning school lawn renovation, consider converting any excess lawn area to groundcover, perennials, shrubs, or trees. This can reduce maintenance and add interest to the school's landscape. Check for these problems areas planned for lawns and athletic fields:

- Poor drainage
- Deep shade
- Low fertility
- Improper pH
- Compaction of soil
- Erosion

2. Test Soil. Results of a soil test taken within the past 3 years will provide adequate information for renovation. If you have not tested your soil recently, call the **Home and Garden Information Center at 1-800-342-2507 or your local county Maryland Cooperative Extension office** for a test kit.

3. Select a grass variety. See Turfgrass Cultivar Recommendations for Maryland listed previously. Calculate the square footage of the renovation area to determine how much seed you will need. Seeding rate depends on the type of grass and is usually indicated on the seed label.

4. Eliminate existing vegetation. It is important to eliminate existing vegetation, such as weeds and other grasses, which will compete with your newly seeded lawn. Existing vegetation can be eliminated through cultivation with tillers and rakes. When these and other nonchemical, nontoxic options are unreasonable or have been exhausted, herbicide applications may be considered. When using an herbicide, be sure to follow the label directions and do not spray or allow spray drift to contact any desirable plants. Reduced risk herbicides should be the first choice, but may require multiple applications. Adhere to notification requirements for the use of pesticides (herbicides) on school grounds.

5. Prepare the Soil. Prepare the soil by tilling to a depth of 3-5". Debris such as stones and woody roots should be removed. Soil composition and texture may be improved at this time with the addition of amendments such as organic matter. Apply lime and fertilizer following soil test recommendations. If soil test results are unavailable, apply a starter fertilizer, following the instructions listed earlier in this section under Nutrient recommendations. Starter fertilizers have a relatively high percentage of phosphorus (the second number) compared to other major nutrients. Look for analysis numbers on the package such as 5-10-5 or 8-16-8 (see the section below on lawn fertilizers for an explanation of these numbers). Soil pH should be between 6.0 and 7.0. Poor fertility or improper pH will reduce the likelihood of successful establishment so always try to obtain a soil test. The surface should be leveled and raked.

6. Seed. Spread half the seed in a north-south direction and the remaining seed in an east-west direction. This will insure complete, even coverage. Good seed contact with the soil is essential for germination and growth of the seedlings. Lightly rake the area to work the seed into the soil. For even better seed contact, roll the area. A light covering of weed-free straw will reduce moisture loss and increase the survival rate of the seedlings.

Irrigating New Lawns

One of the most critical factors for successful establishment of new turfgrass seedings is maintaining adequate soil moisture until the turf is well established. Without moisture, germination and early seedling survival will be poor and may result in complete failure of the stand. Because the root system of young seedlings is shallow and not developed extensively, maintaining moisture in the upper inch of the soil is especially important.

The most likely times of the year to experience problems with excessive drying out of the soil surface are late spring and summer. Rapid drying of the soil surface may occur with windy days, low humidity, high temperatures, sandy soils that retain little moisture, and compacted soils that inhibit water infiltration into the soil. A combination of these factors can result in rapid turf loss during drought.

From the time of seeding and for several weeks thereafter, the soil surface should be kept moist. When drying conditions exist, several light watering 0/16 to 114 inch water) a day may be needed to remote seed and germination and keep seedlings that have just emerged from dying. As the seedlings develop and their root systems increase, the surface may be allowed to dry out, but the root zone must still be kept moist. This may mean less frequent, but longer duration of irrigation.

Avoid watering past the point at which the water starts to puddle or to run off the site. This point will occur sooner on clay soils and compacted soils than on sandy soils. Also, in the late spring and the summer, avoid watering during the night. Several seedling diseases that can kill entire stands of young grass are substantially worse when leaf blades remain wet throughout the night.

As the turf stand continues to develop to the point where mowing is required, the need for irrigation decreases. The soil at this point should be firm enough to allow the use of a mower without its sinking into the turf. If the soil is too wet when the new turfgrass stand is first mowed, ruts may be created or grass plants may be pulled out.

Care must also be taken to not stop watering turfgrass mixtures too soon. Species that are quick to germinate and grow rapidly, such as perennial ryegrass and tall fescue, will establish faster than slower germinating and growing grasses, such as Kentucky bluegrass. However, seed is often sold that contains several types of grass. If a seed mixture contains both quick and slow establishing types of grass, care must be taken to maintain adequate moisture until the slower growing grass is well established.

For areas where irrigation is impractical or impossible, it is essential that a weed-free mulch, such as straw, be used to reduce loss of soil moisture. Even with mulch, however, loss of some seedling turf should be expected during adverse environmental conditions if no water is applied. A subsequent overseeding of thin areas may then be necessary. Although not usually a problem, excess water from either rainfall or irrigation also can lead to problems. The most common problems encountered are soil erosion, ponding of water that leads to suffocation or scalding of young grass, and disease problems in the late spring or summer months.

A few tips for successful turf establishment:

- ***Keep seedbed moist until turf has been mowed***
- ***Watch seedbed moisture carefully on days with low humidity, on windy days, and on sandy soils***
- ***Mow new grass for the first time when it is not more than 1/3 higher than the height it will be maintained.***

Mowing New Lawns

Poor mowing practices are a primary cause for the decline of lawns and athletic fields, and are just as important for a young lawn as for an established lawn. The basic practices are virtually the same. First, it is especially important that a sharp blade be used so that sensitive seedlings are not shredded or pulled out. Second, do not mow if the air temperatures are over 90° F. It can cause damage to seedlings. Third, mow the new turf when the grass is no more than ½ higher than the height you plan to cut. Thus, if the mower is set for 2 inches, mow the grass before it gets no higher than about 3 inches. Do not mow the grass too short. Low mowing heights will allow many weeds to get a foothold in a young grass stand. Grasses, such as turf-type tall fescue, fine fescue, and Kentucky bluegrass, should be mowed no lower than 2 inches, and preferably 2 to 3 inches. Finally, do not mow unless the soil is sufficiently firm to support the mower.

Fertilizing new lawns

Nutrient recommendations

Nutrient management recommendations recently developed by the State of Maryland will help guide school districts and other public facilities with fertilizing lawns, trees and shrubs. The Maryland Water Quality Improvement Act (WQIA) of 1998, requires the following. Grounds managers applying nutrients (fertilizer) to sites larger than 10 acres, or smaller sites that, cumulatively, are 10 acres or more, or to any amount of state-owned land must follow University of Maryland Cooperative Extension recommendations, conduct soil tests, and keep records of fertilizer applications for three years.

Soil tests should be conducted prior to seeding, so that the proper amounts of limestone and fertilizer can be applied to the seedbed. If recommendations are followed, no additional fertilizer should be needed for 1 to 2 months after seeding. At this point, normal maintenance fertilizer recommendations can be followed as described later in the **Maintenance section** of this document. However, if no fertilizer was applied prior to seeding, apply 10 pounds of a 10-10-10 fertilizer per 1000 sq. feet as soon as possible. After that application, wait 1 to 2 months, and then follow recommendations in **Maintenance Section** of this document, which details nutrient management guidelines for Maryland state property and commercially managed turf grass.

Fertilizers and the environment

It's important to fertilize with care. Over-fertilization contributes to water pollution in the Chesapeake Bay region and throughout the United States. When water runs off the land it carries soil, nutrients and other pollutants with it. Nutrients, like nitrogen and phosphorus, fuel algae growth in the Chesapeake Bay and rivers, streams, and lakes. Excessive algae growth, along with sediments, clouds the water and prevents the growth of important underwater Bay grasses. In addition, when algae die they decay. Decaying plants use up oxygen that fish need to survive. Because warm water holds less oxygen than cold water, summer oxygen levels in the waterways, bays and lakes may drop so low that fish can't live. Furthermore, numerous studies show that many insect and mite pests perform better on fertilized plants.

Weed Control in New Lawns

Weed control in newly seeded turf may become necessary if competition is severe. Under some conditions, weeds are so aggressive that the grass never has a chance to establish and the area will have to be reseeded. Weeds are more likely to be a problem in spring seedings and mid to late fall seedings. Tall fescue clumps in Kentucky bluegrass lawns, as well as clumps or patches of orchardgrass, Bermudagrass, nimblewill and quackgrass are among the most common perennial grass weeds in Maryland. Other perennial weed grasses in lawns and athletic fields include creeping bentgrass, redtop, timothy, roughstalk bluegrass and smooth paspalum (sometimes called dalligrass). Broad leaf weed problems in newly established turf include dandelion, clover, plantain, dead nettle, purslane, henbit, oxalis, wild clover, wild violet, wild garlic/onion, chickweed, and black medic.

If weeds are so extensive that hand pulling is not practical, use of herbicides may be warranted. Generally, it is most feasible to apply broadleaf weed herbicides after new turf has been mowed 2 to 3 times. Control of annual grasses is more difficult. Herbicides labeled for these uses change frequently. It is best to consult the following weed control publications for information on products

that may be used on young lawns: University of MD Agronomy Mimeo # 79 - "Broadleaf Weed Control in Established Lawns" and University of MD Agronomy Mimeo # 85 - "Herbicides for Crabgrass and Goosegrass Control in Turf."

Renovating Existing Lawns and Athletic Fields

Adapted from Home & Garden mimeo 37, Lawn Renovation
By: Peter J. Ricciuti, Faculty Extension Assistant, University of Maryland

Unless a new school is under construction, few schools will have the resources to create new lawns and athletic fields. Most schools will be renovating older turf areas. In particular, athletic fields may need frequent renovation due to their high use. A thin and weedy turf can sometimes be rescued with improved cultural care, but if the athletic field is less than 50% desirable turf, complete renovation may be needed. Renovation involves eliminating existing grass and weeds and planting a high quality turfgrass. The best time for lawn renovation is late summer or early fall. School athletic fields are most used during late summer and fall and adjustments will have to be made for work to occur around sports schedules. Spring-seeded grass often suffers from the heat and drought of summer. Fall-seeded grass has time to become established before the onset of summer extremes and weed competition.

Steps to Complete Renovation

1. Assess the situation. While planning school lawn renovation, consider converting any excess lawn area to groundcover, perennials, shrubs, or trees. This can reduce maintenance and add interest to the school's landscape. Check for these problems on lawns and athletic fields:

- Poor drainage
- Deep shade
- Low fertility
- Improper pH
- Compaction of soil
- Erosion

2. Test Soil. Results of a soil test taken within the past 3 years will provide adequate information for renovation. If you have not tested your soil recently, call the Home and Garden InfOlmation Center at 1-800-342-2507 or your local county Maryland Cooperative Extension office for a test kit.

3. Select a grass variety. See Turfgrass Cultivar Recommendations for Maryland listed earlier in this document. Calculate the square footage of the renovation area to determine how much seed you will need. Seeding rate depends on the type of grass and is usually indicated on the seed label.

4. Eliminate existing vegetation. It is important to eliminate existing vegetation, such as weeds and other grasses, which will compete with your newly seeded lawn. Existing vegetation can be eliminated through cultivation with tillers and rakes. When these and other nonchemical, nontoxic options are unreasonable or have been exhausted, herbicide application may be considered. When using an herbicide, be sure to follow label directions and do not spray or allow spray drift to contact any desirable plants. Reduced risk herbicides should be the first choice, but may require multiple applications. Adhere to notification requirements for the use of pesticides (herbicides) on school grounds.

high. Other reduced risk herbicides may be used but may require multiple applications and may be less effective at killing weeds.

5. Remove thatch. Thatch is a layer of dead stems and roots of grass plants that builds up in a lawn. If a thick thatch layer is present, it must be removed before seeding. A dethatching rake works fine for small areas. For large areas, it is practical to use a motorized dethatcher, preferably a vertical mower (also called a verticutter). This is similar to a lawn mower but is designed to cut down through the thatch layer with rows of knives. A vertical mower may be rented from rental shops and some hardware stores. To create a seedbed for the new grass, adjust the vertical mower to cut through the turf and thatch and into the soil ¼ to ½ inch. Several passes will be necessary for complete thatch removal. If you use a vertical mower, the thatch will often be chopped finely enough to leave in place. Otherwise, rake up the thatch and clippings. Avoid removing soil from the renovation area.

Core aeration benefits lawns by loosening compacted soil. It also dethatches, but not as completely as vertical mowing. Several passes may be needed for thick thatch layers. The small holes left by an aerator provide good sites for seed germination. There are many types of aerators but the best type removes small cylinders of soil and deposits them on the surface rather than simply making holes in the ground. Dethatching and core aeration ensurers seed-to-soil contact and should improve establishment of turf.

6. Prepare the Soil. Apply lime and fertilizer following soil test recommendations. If soil test results are unavailable, apply a starter fertilizer, following the instructions listed earlier in this section under Nutrient recommendations. Starter fertilizers have a relatively high percentage of phosphorus (the second number) compared to other major nutrients. Look for analysis numbers on the package such as 5-10-5 or 8-16-8 (see the section below on lawn fertilizers for an explanation of these numbers). Soil pH should be between 6.0 and 7.0. Poor fertility or improper pH will reduce the likelihood of successful renovation so always tried to obtain a soil test.

If dethatching was done with a vertical mower, spread the fertilizer and/or lime directly on top of the furrows without raking.

7. Seed. Spread half the seed in a north-south direction and the remaining seed in an east-west direction. This will insure complete, even coverage. Good seed contact with the soil is essential for germination and growth of the seedlings. Lightly rake the area to work the seed into the soil. For even better seed contact, roll the area. A light covering of weed-free straw will reduce moisture loss and increase the survival rate of the seedlings.

8. Water. Keep the seed moist during germination. If rain is insufficient, water lightly and regularly until the grass germinates, then reduce the frequency of watering, but apply it more deeply until the grass is established.

Overseeding existing lawns

Overseeding can revive marginal turf or convert it to an improved grass variety. The new grass will eventually take over, but complete conversion may require overseeding each fall for 2 or 3 years. Test your soil and begin to correct any of the cultural problems discussed in step 1, listed above. Then follow these steps:

- Mow the lawn short (about 1 inch)
- Vigorously rake out grass clippings and thatch
- Remove as many weeds as possible, either by digging or spot treatment with glyphosate or similar herbicide.

- Sow the seed at ½ the normal seeding rate.
- After seeding, rake the area lightly.
- Water thoroughly to a depth of 4 to 6 inches. Then keep the seedbed moist until the seedlings appear.
- Do not mow until the new grass reaches its normal mowing height. (About 3 inches for most grasses)

Note: If you plan to overseed a large area, it is best to use a vertical mower and run it through the existing grass. The vertical mower will create a good seedbed.

16

Maintenance of Turfgrass

Soil Testing

Poor soil conditions can cause turf problems. A soil test provides the pH, nutrient content, and texture of your soil. The pH reading indicates soil acidity or alkalinity. The best pH levels for healthy grass range from 6.0 to 6.5. Most frequently, pH is too low and the soil needs an application of limestone. Recommendations from a soil test will indicate how to reach the proper pH level. Results are given for soil phosphorus and potassium. Most turf grasses also need some nitrogen, but it is difficult to test for this nutrient. Have your soil tested every 3 to 5 years. Call the Home & Garden Information Center at 1-800-342-2507 or your county Cooperative Extension Service Office to receive the test materials and more information.

Fertilizers

Fertilizer packages are labeled with three numbers such as 20-10-10 that indicate the percentage by weight of the three nutrients most essential to plants. The order is always nitrogen (N), phosphate ($P_2 0_5$), and potash ($K_2 0$). Nitrogen promotes overall grass shoot growth. Phosphate supplies phosphorus, which promotes strong root growth. Potash supplies potassium and helps grass withstand stresses, such as a drought or disease. Most turf grasses need to have some nitrogen added annually to ensure proper growth and resistance to pests. If soil testing indicates adequate levels of phosphorus and potassium, use a fertilizer that has a low percentage of these two nutrients. Too much fertilizer, and fertilizer applied at the wrong time can harm your lawn. Excess fertilizer causes rapid, lush growth that is more susceptible to diseases and more attractive to pests

Slow-Release Nitrogen

The nitrogen in fertilizer can be in a water-soluble or a water insoluble form. Slow release nitrogen sources are fertilizers that have 40% or more of their nitrogen as water insoluble (WIN). Water insoluble sources provide nitrogen over a longer period than soluble sources. The result is more uniform plant growth, less chance of injury to the grass, and less potential for nitrate leaching. Among your choices of slow release nitrogen sources are:

- Materials made from manure, sewage sludge, or composted plant or animal products. The nitrogen content of these materials ranges from very low to around 10%.
- Sulfur coated urea-14–38% Nitrogen
- Resin coated urea-24–35% Nitrogen
- IBDU-30–31% Nitrogen
- Ureaformaldehyde and Methylene ureas 20–38% Nitrogen

Determining the % of WIN (Water Insoluble Nitrogen)

A fertilizer label may supply the following information:

- 20-10-10
- Guaranteed analysis
- Total nitrogen 20%
- 8% Water insoluble nitrogen
- Available phosphates 10%
- Water soluble potash 10%

To calculate the % of WIN, divide the percent of water in-soluble nitrogen by the percent of total nitrogen and multiply by 100. In this case the result is 8% divided by 20% x 100 = 40%. This fertilizer contains 40% WIN.

Fertilizer Guidelines

Adapted from Agronomy mimeo 115, *Nutrient Management Guidelines for State Property and Commercially Managed Turfgrass*

By Thomas R. Turner, Ph.D., Department of Natural Resource Sciences and Landscape Architecture, University of Maryland

Nutrient management laws passed by the Maryland Legislature in 1998 require the University of Maryland nutrient management guidelines to be followed on state property and commercially managed turf grass sites larger than 10 acres. Research shows that nutrient loss from properly managed turfgrass sites is very small. However, certain types of improper nitrogen applications on specific types of sites can result in excessive nitrate (NO_3) leaching. This problem is very specific and occurs under the following conditions:

Very high rates of nitrogen are applied using soluble NO_3-N-containing fertilizers, such as ammonium nitrate (NH_4NO_3).

The fertilizer was applied to dormant turf, such as Bermuda grass during the winter.

Soils are predominately sand.

Design has high water tables.

The current nitrogen recommendations are dependent on a variety of factors, such as turf grass species and cultivars, age of turf, soil type, management practices (i.e. irrigation, clipping removal, and pest control programs), weather conditions, use of area, length of growing season, and the need for recovery from pest damage, adverse environmental conditions, or traffic. Three major factors must be considered when developing a nitrogen fertilization plan for large turfgrass sites:

What type of nitrogen should be applied?

How much nitrogen needs to be applied annually?

When should nitrogen be applied?

Rates of Nitrogen Application

The maximum amount of nitrogen that should be applied in one application is dependent primarily on the amount of soluble nitrogen in the fertilizer. No more than 1.0 lb. soluble N/1000 ft.^{2} should be made in any single application. For a fertilizer that contains 50% of soluble nitrogen and 50% in a slow-release (water insoluble) form, no more than 2.0 lbs. total N/1000 ft.^{2} should be

Nitrogen Recommendations for Commercially Maintained Turfgrass on Large Sites		
	Total nitrogen annually (lbs. N/1000 ft.²) Years 1–2	Total nitrogen annually (lbs. N/1000 ft.²) Subsequent years
Cool season grasses		
Kentucky bluegrass	3.0–4.5	3.0–4.0
Turf-type tall fescue	3.0–4.0	2.0–3.0
Fine fescue	1.0–3.0	0–2.0
Warm season grasses		
Bermudagrass	3.0–4.0	3.0–4.0
Zoysiagrass	1.0–3.0	0–2.0

applied in any single application. This results in the application of 1.0 lb. soluble N/1000 ft.². Some fertilizers contain most of their nitrogen and a slow-release form. For these fertilizers, applying 1.0 lb. soluble N/1000 ft.² would result in extremely high total nitrogen rates. For example, a natural organic fertilizer contains 10% of its nitrogen in a soluble form and 90% in slow-release form. Applying 1.0 lb. soluble N using this fertilizer would result in a total nitrogen rate of 10 lbs. N/1000 ft.², which is well in excess of the recommended annual rates of nitrogen for typical turfgrass. Thus, for slow-release fertilizers containing little soluble nitrogen, the maximum amount applied in one application should not exceed total annual nitrogen requirements. The table above lists nitrogen requirements for maintaining established stands of common turfgrass species grown in Maryland.

Numerous factors influence whether moderate adjustments to these rates are needed. If the site receives little use, it does not need higher growth rates to recover from traffic, so lower nitrogen rates may be possible. Other ways to reduce total nitrogen requirements include:

- Return clippings to the site during mowing.
- The use of iron.
- Increasing the height of mowing.
- Careful selection of cultivars when seeding, overseeding or sodding.

Several factors may warrant moderate increases in annual rates. These include:

- Heavily used sites.
- Sites that are mowed lower than typically recommended due to use requirements.
- Sites that have been damaged by adverse environmental conditions or pests.

Recommended Periods for Nitrogen Fertilization of Large Turf Areas

	Recommended Periods	Periods to Avoid
Warm season grasses	One month before dormancy breaks* through September 1	September 1 through one month before dormancy breaks During severe or prolonged drought
Cool season grasses	One month before top growth starts** through early June	Mid-June through mid-August
	Late August through six weeks after first killing frost	When turf is dormant due to heat, drought or cold

*Dormancy generally breaks in mid-April in Central Maryland (later in Western Maryland and earlier on the Eastern Shore of Maryland)
** Top growth generally begins in late March in Central Maryland

- Sites where pesticide use is not economically feasible or not permitted. Somewhat higher nitrogen rates can be important for minimizing several pest problems, particularly weeds and diseases.

Timing of Nitrogen Applications

The primary potential for nitrogen loss from turfgrass sites is when excessive rates of nitrogen, particularly NO_3-N, are applied to turf that is not actively growing. Most of the annual fertilizer requirement should be applied during periods of active shoot (leaf blades, rhizomes, stolons) and/or root growth. See the table below for recommended fertilization times

The primary growth period for warm season grasses (zoysiagrass, Bermudagrass, buffalograss) is from mid-spring, after dormancy has broken, through mid-fall, when the first killing frost is experienced. nitrogen applications to warm season grasses should be restricted to these periods. However, fertilizer that contains primarily NH_4-N can be applied up to a month before dormancy is broken in the spring, so that nitrogen is available for plant uptake when growth begins. Applications after September 1 are not recommended, due to the possible enhancement of winterkill, particularly with Bermudagrass. However, if Bermudagrass has been over seeded with the cold season species, such as perennial rye grass, up to 1.0 lb. N/1000 ft.^{2} may be applied after September 1 to enhance performance.

Cool season grasses have a longer growth period. They can grow virtually any time during the year, if moisture and temperature conditions are right. Prime growth periods are typically from late winter through early summer, and from late summer through early winter. Research shows that ⅔ to ¾ of the total annual nitrogen should be applied during the late summer through early winter growth period to maximize cool season turf grass performance and quality.

Under extended hot and dry periods during mid-summer, cool season grasses may experience a period of dormancy until rainfall occurs. Nitrogen fertilizer should not be applied at this time. If

irrigation is available or if rainfall is adequate throughout the summer, little dormancy will occur and nitrogen uptake of cool season grasses will continue. Although not generally needed, applications of ¼ to ½ lb. N/1000 ft.^{2} can be made if growth is not adequate to meet use demands.

During the winter months, although top growth may have virtually ceased, root growth and nitrogen uptake may still occur if the ground is not frozen, particularly with Kentucky bluegrass. Applications of nitrogen during this time can enhance rich growth and performance of turf. Early fertilization when the ground is firm also may be necessary on lawns and athletic fields that tend to be excessively wet each spring. For most situations, however, mid-winter applications are not necessary and the guidelines listed in the table above should be followed.

If mid-winter application is necessary, there is minimal risk of runoff for leaching of nitrogen if the following guidelines are met:

- No more than ½–1.0 lb. N/1000 ft.^{2} should be applied.
- Fertilizers containing significant amounts of NO_3-N should not be used.
- Application should not be made to frozen ground if significant rainfall is in the immediate forecast.

Phosphorus and Potassium

Phosphorus (P) is critical for the establishment of turfgrass. Inadequate soil phosphorus will result in very poor seeding vigor, slow establishment of grass, and a stand with very poor density and root growth. Exposed soil due to low density can lead to erosion problems. Weed encroachment also can be a problem due to the lack of competition from the thin turfgrass stand. It is essential that sufficient phosphorus be added to the soil at the time of seeding, if soil tests show levels are low. Phosphorus is not as critical in mature turfgrass stands, but deficiencies can result in poor spring green-up, reduced vigor, reduced density, and reduce drought-tolerance. Light applications of phosphorus generally are sufficient to overcome deficiencies in mature turf.

Potassium (K) is not as critical as nitrogen or phosphorus during initial turf establishment. However, potassium plays an important role in mature turf regarding rhizome production and tolerances to heat, drought and cold. Sufficient potassium is needed to ensure that quality turf will be obtained during and after summer and/or winter stresses. Severe deficiencies of potassium will result in thin, chlorotic, and unvigorous turf.

Phosphorus and Potassium Recommendations for Maintenance of Large Turf Sites Based on Soil Test Results from University of Maryland
(lbs./1000 ft.2)

Soil Test Category	Low	Medium	Optimum-excessive
Phosphorus (P_2O_2)	2.0	1.0	0
Potassium (K_2O)	2.0–4.0	1.0–2.0	0–1.0

Currently, nitrogen application recommendations cannot be obtained from soil tests, but recommendations for application of potassium and phosphorus can be obtained from them. The school grounds staff or a commercial turf maintenance company should test lawns and athletic fields within a year of the initiation of site management. Until the first soil test is taken, not more than 1.0 lb P_2O_5 and 2.0 lb K_2O per 1000 ft.^{2} should be applied for maintenance of turf. After the initial soil test, subsequent sampling every 3–4 years generally is sufficient to monitor soil potassium and phosphorus levels.

Sites having different soil types, different uses or management histories, or substantially different fertility levels as determined by previous soil tests should be sampled separately. Conversely, sites with similar soil types, uses and management histories, or fertility levels may be lumped together into one sample. For example, a single sample may be sufficient for an athletic field complex that has had similar management over a period of time and has a relatively uniform soil type.

Soil pH

Maintaining soil pH in an optimum range is important for maximizing the efficiency of nutrient use, and can be important for reducing weed and disease problems. Turfgrass can withstand a rather broad range of soil pH, but 5.8–6.2 is generally considered ideal. Wide deviations from this range can result in reduced phosphorus and micronutrient availability, and can interfere with soil nitrogen metabolism and availability. Depending on turfgrass species, problems in turf may start to occur at soil pH above 7.8 and below 5.4. To maximize efficiency of nutrient availability and use, soil tests should be taken as recommended previously for soil phosphorus and potassium, as well as soil pH.

Recommended limestone applications to achieve the soil pH of about 6.4 are shown below. If diseases such as summer patch of Kentucky bluegrass or spring dead spot of Bermudagrass are of concern, maintaining lower soil pH (5.4–5.7) may be desirable, and reduced amounts or even no limestone should be applied. Limestone should be applied approximately one month or more before fertilizer applications, to minimize the potential for volatilization loss of applied nitrogen.

The information presented within this publication for nitrogen, phosphorus, potassium, and limestone applications is meant only as a guideline. Although these recommendations should result in satisfactory turfgrass maintenance in most situations, there are many factors that could impact weather modifications of these recommendations or warranted for a specific site.

Grass cycling

Adapted from Home and Garden mimeo # 63. *IPM Series: Turf.*

By Peter Ricciuti, Faculty Extension Assistant, David Clement, and Mary Kay Malinoski Regional Specialists, Home and Garden Information Center, University of Maryland Cooperative Extension, Ellicott City, MD

Leave grass clippings on the lawn. It is a way to recycle nutrients. If you leave clippings on the lawn for 2 years or longer you may be able to reduce the amount of nitrogen fertilizer required by 25% more. Grass clippings left on the lawn do not cause excessive thatch buildup, however, if a heavy thatch layer is present, the clippings will decompose more slowly and may increase thatch buildup.

Thatch

Thatch is the intermingled layer of living and dead stems, leaves and roots that exist between the soil and green vegetation. A thin thatch layer (¼–½ inch) provides some benefits such as surface cushioning, increased wear tolerance, and temperature moderation. Excessive thatch (1 inch or more) can

Limestone Recommendations for Establishment[1,2] of Turfgrass (pounds per acre)						
Soil pH	**Loamy sands**	**Sandy loams**	***Coastal Plain* Loams**	***Coastal Plain* Silt loams and silty clay loams**	***Piedmont and Mountain* Loams**	***Piedmont and Mountain* Silt loams and silty clay loams**
6.4	0	0	0	0	0	0
6.3	0	0	0	0	1090	1305
6.2	0	0	1090	1090	1525	2180
6.1	0	1090	1305	1525	1960	2830
6.0	870	1525	1740	1960	2395	3700
5.9	1090	1740	2180	2395	2830	4355
5.8	1305	2180	2395	2830	3485	5010
5.7	1525	2395	2830	3265	3920	5880
5.6	1740	2615	3265	3700	4355	6535
5.5	1960	3050	3700	4140	4790	7185
5.4	2180	3265	4140	4355	5445	7840
5.3	2395	3700	4355	4790	5880	8710
5.2	2615	3920	4575	5225	6315	8710
5.1	2830	4140	5010	5665	6750	8710
5.0	3050	4575	5445	6100	7185	8710
4.9	3265	4790	5880	6315	7625	8710
4.8	3485	5010	6100	6750	8275	8710
4.7	3700	5445	6535	7185	8710	8710
4.6	3920	5665	6750	7625	8710	8710
4.5	4140	6100	7185	8060	8710	8710

1 These rates are for limestone that is tilled into the soil to a 4–6 inch depth. Use maintenance rates if not tilled-in.
2 Divide the above rates by 2 to obtain maintenance limestone recommendations for turfgrass.
Note: Do not apply more than 2000 lbs./acre for any one maintenance application to turfgrass.
Note 2: Divide the listed rate by 43.5 to obtain rate and lbs./1000 ft.^{2}.

Mowing Guide

	Spring and Summer	Fall and Winter
Tall fescue	2½ –3½ inches	2½ inches
Perennial ryegrass	2½–3	2–2½
Kentucky bluegrass	2½–3	2–2½
Fine fescue	2½–3½	2½
Bermudagrass	½–1	½–1½
Zoysiagrass	½–1	½–1½

cause a variety of lawn problems. Fescues and perennial ryegrass produce thatch slowly, but zoysia, Bermuda, and bluegrass tend to be heavy thatch producers. Excessive thatch may:

- Prevent water and air from reaching the soil and root zone, thus reducing the turf's tolerance to drought and temperature extremes.
- Provide a protective home for insect pests (billbugs, chinch bugs and sod webworm larvae) and disease fungi.
- Prevent certain insecticides and herbicides from penetrating to the soil level, making them ineffective.
- Interfere with overseeding.

Thatch Removal. A vertical mower (cuts down through the thatch layer with rows of teeth) or core aerator can mechanically remove thatch. As with aerating, a good time to dethatch is when the grass is growing vigorously and will have time to recover. Another way to decrease the thatch level is to make the soil more hospitable to microorganisms that decompose organic debris. This can be done by adding lime if soil is too acidic, encouraging earthworm activity, and aerating the soil. Be aware that many insecticides and fungicides are lethal to earthworms. Improper cultural practices such as light, frequent watering and over fertilizing can increase the rate of thatch buildup.

Mowing

Low and infrequent mowing may be the major cause of lawn deterioration. It is best to remove no more than ⅓ of the grass blade each time you mow. For example, to maintain a 3-inch height, do

not let the grass get much taller than 4 inches. Mowing to the proper height can reduce weed problems by much as 50 to 80%. Unless you have bluegrass, it is safe to let an established lawn go dormant during dry periods. Dormancy is a survival mechanism and your lawn will usually recover when rainfall returns.

Watering

Once you have an established lawn, water only when needed rather than on a schedule. Water if the grass develops a blue-gray color or if walking on it leaves footprints. Water slowly to allow water penetration and to prevent runoff. Wet the soil to a 4–6 inch depth. You can check the depth with a screwdriver. Early morning watering allows the grass to dry before night and reduces the chance for disease. Shallow and infrequent watering, or watering in the evening, can damage your lawn.

Soil Compaction

Compacted soil may result in poor rooting and reduced vigor. Clay soil, construction, or heavy foot traffic can lead to compaction. Poor drainage is an indication of compaction. Also, some weeds do well in compacted soil and their presence may indicate a problem. They include, annual bluegrass, broadleaf plantain, goosegrass, knotweed and spurge. Core aeration can help. It should be done when the grass is growing vigorously. Choose an aerator that removes small cylinders of soil. Tine or spike devices that merely puncture the soil do not work as effectively.


26

Integrated Pest Management of Turf Grass

Establishing Priorities

Adapted from *IPM for Schools: A How-To Manual.* US EPA, Pest Management Guidelines for Howard County Schools, and the University of Wisconsin – Madison, Turfgrass Disease Diagnostic Laboratory Website at http://www.plantpath.wisc.edu/tddl/tddl/tddl.htm.

No school system will have adequate budgetary resources to manage all turf or landscape areas with equal inputs of time and money. Nor do all management areas require the same amount of care. For example, athletic fields in football stadiums must provide a very high quality turf to avoid injury to young athletes. By contrast, turf areas used for recreational purposes such as picnics or recreational play require less attention and are less expensive to maintain. Many schools have found it useful to establish management priorities for turf and landscape areas based on their use patterns, safety requirements, and aesthetic value. By establishing management priorities, areas may be assigned to levels or categories that differ in the type and intensity of maintenance activities implemented. These levels help guide management decisions and reconcile safety and quality needs with budgetary allocations. An example of a three level priority scheme implemented by the Howard County, MD Public School system is as follows.

Level A Athletic Fields

Definition-These are prime athletic fields, high school stadium and Bermuda playing fields. Level A athletic fields are typically reserved for games. These fields should have dense turf (> 90% cover), good drainage, and irrigation. The soil type may be either sand based or native soil. The field must provide a uniformly smooth surface and have an appropriate turf that will sustain a high level of traffic. Annual events on these fields should be limited. Grounds services managers have authority to cancel events in case of inclement weather to prevent major and costly repairs to these fields. A dedicated field manager with turf management education and/or experience with proper training is considered vital to allow proper decisions and implementation of management strategies on a day-to-day basis.

Primary cultural practices include regular mowing, fertilization and irrigation. Secondary cultural practices include routine aeration, topdressing, and overseeding or sodding to replace worn areas. Use of chemicals to control or manage weed, disease, and insect pests is allowed as a function of the overall integrated pest management program which stresses ideal turf management as a means to limit the extent of damage from pests.

IPM Action Points

- **Mowing-** Mow with enough frequency to adhere to the "1/3 rule" which states

that one third or less of the leaf tissue is removed at any one mowing. Mowing height should be 1–2 inches for soccer fields and 2–3 inches for football fields.

- **Irrigation-** Irrigate sufficiently-to provide approximately one inch of water to the turf each week with rainfall amounts included. For example, if ¼ inch of rain falls one week, supply ¾ inch through irrigation.
- **Fertilization-** Apply a minimum of four pounds of nitrogen per thousand square feet annually to low use fields with light to medium traffic. Higher use fields may require six or more pounds of nitrogen per thousand square feet. Do not apply more than 1 lb. nitrogen/1000 ft^2 at any one time.
- **Aerification-** Perform aerification as needed to minimize compaction. Aerification can be performed at up to two to three week intervals during the growing season, although one aerification in spring and one in autumn may be sufficient.
- **Topdressing-** Topdressing consists of regular applications of soil and sand, ranging from 1/16–¼ inch layers each time.
- **Overseeding-** Overseed thin areas in which the turf density provides less than 90–95% coverage as needed.

Level B Athletic Field

Definition- Level B athletic fields include baseball, softball, and multipurpose fields. These are often low to medium budget high school game fields and many of the junior high/middle school fields. These fields have moderate to good turf (> 70% cover) with up to 30% of the surface covered by weeds but no more than 10% bare ground. The soil type is native soil. Surface drainage generally provides all the drainage; native soil and lack of tiling preclude internal drainage. The field must provide a uniformly smooth surface (no major ruts, rapid divot repair, etc.) and an appropriate turf, which will sustain a high level of traffic. No limits are placed on the number of events the turf will support, but good management practices should be used to prevent unnecessary damage (e.g., rotation of practice areas, proper mowing and fertilizing, etc.).

Primary cultural practices for Level B athletic fields include regular mowing and fertilization. Irrigation is used only for restoration or establishment. Secondary cultural practices include occasional aeration, topdressing, and overseeding or sodding to replace worn areas. Use of chemicals to control or manage weed and insect pests is allowed as part of an overall integrated pest management program.

IPM Action Points

- **Mowing-** Mow the turf at a 2–3 inch height at least once weekly. If possible, comply with the "1/3 rule."
- **Irrigation-** Irrigation will only be used to restore damaged turf areas.
- **Fertilization-** Apply a minimum of four pounds of nitrogen per thousand square feet annually to low use fields with light to medium traffic. Higher use fields may require six or more pounds of nitrogen per thousand square feet. Do not apply more than 1 lb. N/1000 ft^2 at any one time.
- **Aerification-** Aerification should be performed once in spring and once in autumn.
- **Topdressing-** Topdressing should be concentrated in the center and other problem wear areas in the field.

- **Overseeding-** Thin areas in which the turf density provides less than 70% coverage should be over seeded as needed.

Level C Athletic Fields

Definition- Level C athletic fields include elementary fields and practice areas at middle schools. These fields have poor to moderate turf with 50% or more of the surface covered by weeds. A fair portion of the fields may be bare ground but this should be kept to no more than 10% bare ground for safety reasons. The soil type is native soil. Surface drainage generally provides all of the drainage. Native soil and lack of tiling preclude internal drainage. The field should have a relatively smooth surface (no major ruts, rapid divot repair, etc.) for safety reasons. No limits are placed on the number of events the turf will support, but common sense should be used to prevent unnecessary damage (e.g., rotation of practice areas, regular mowing). Primary cultural practices for Level C athletic fields include regular mowing and fertilization. Irrigation is used only for restoration or establishment. Secondary cultural practices may, but are not likely to, include overseeding or sodding to replace worn areas. Pesticides to control weeds, diseases or insects will generally not be used.

IPM Action Points

- **Mowing-** Mow the turf at a 2–3-inch height at least at 7 to 10-day intervals. If possible, comply with the "1/3 rule."
- **Irrigation-** Irrigation will only be used to restore damaged turf areas.
- **Fertilization-** Fertilization rates will vary from 0 to 2 pounds of nitrogen annually per 1000 square feet.
- **Aerification-** Aerification will likely never be aerified, although an aerification program should be considered if better turf performance is desired.
- **Topdressing-** Level C fields will not be top-dressed.
- **Overseeding-** Level C fields generally will not be over seeded. Large, bare areas may need to be over seeded.

Detecting and Monitoring Pests

Established lawns and playing fields will develop problems with insects, diseases, and weeds. The use of pest resistant varieties that are properly maintained will help to reduce the number and severity of pest problems. However, when problems arise, an integrated approach to managing problems is the best one. A critical feature of turf IPM is a carefully planned monitoring program. Monitoring entails making regular inspections of the lawn to gather and record site-specific information on which to base pest control decisions. Monitoring enables pest managers to do the following:

- Identify the pest(s).
- Identify any natural enemies of the pest(s).
- Apply preventive methods to reduce the occurrence of pest problems.
- Determine if any treatment is needed.
- Determine where, when, and what kind of treatments are needed.
- Evaluate and fine-tune treatments as the pest management program continues over the seasons. Tools used to monitor lawns and athletic fields are below.

Tools Used to Monitor Lawns and Athletic Fields

The following tools are useful for monitoring lawns. They can be carried in a sturdy bag designed to transport baseball equipment (available at most sporting goods stores). The soil probe with its extension fits snugly in the bottom pocket designed for baseball bats, and everything else fits into an upper zippered area.

- ***soil probe***
- ***pH meter***
- ***soil thermometer***
- ***10-power hand lens (magnifying glass)***
- ***watering can and bottle of detergent***
- ***plastic bags for collecting specimens***
- ***clip board and forms for recording data***
- ***a ball of twine or clothesline for taking transects***
- ***a small hand trowel and knife***
- ***camera***
- ***field guides for identifying pests and natural enemies***
- ***pheromone traps for cutworms, sod webworms, etc.***

Gathering Background Data on the Site

The first step in a monitoring program is to map all lawn areas, noting locations of existing pest problems or conditions that can produce pest problems (bare spots, broken sprinkler heads, etc.). Identify the turf grasses in each area and record the maintenance history of the turf and current horticultural practices. Soil should be tested at representative sites to assess fertility status and requirements. If any pests are present, be sure to get an accurate identification. Many unnecessary pesticide applications can be traced to mistaken identification of pests.

Next, give each major section of turf an identifying number and prepare a monitoring form for recording on-going maintenance activities and information about pests and their management in each section of lawn. You will need to compile an inventory of existing lawn maintenance equipment. In addition to mowers, are there aerators, de-thatchers, and fertilizer spreaders that can handle organic materials? Is there a spring-tooth harrow or drag chain for removing weeds from infields and running tracks? These are useful tools in nonchemical turf management. Inspect the condition of the equipment. Are mower blades kept sharp? Can mowing height be adjusted easily? Does the equipment have flotation tires to reduce soil compaction? Prepare a list of equipment that is needed so it can be worked into the budget process.

Developing Pest Tolerance Levels

Most turf can tolerate some pest presence without compromising appearance or function. The challenge for the pest manager is to determine how much damage is tolerable and when action is needed to keep pest damage within tolerable levels. Competing interests of aesthetics and safety must be taken into account when deciding whether or not treatments are warranted. It is good practice to involve representatives of these interest groups in setting pest tolerance levels for lawn areas.

Work with your school district's IPM Coordinator, school Contact Person, pest management services and maintenance personnel, athletic directors, and other interested parties to develop pest tolerance levels for lawns and athletic fields at each school site. By involving members of the school and community with setting treatment guidelines, confrontations can be minimized and broad support developed for the IPM program. Tolerance levels will differ, depending on location and uses of the turf. For example, tolerance for pest presence on lawns at the front of the school in

public view may be lower than tolerance on playing fields behind school buildings.

Tolerance levels may also differ depending on the particular pest. For example, tolerance for damage by pest insects or pathogens that can kill large areas of turf, leaving bare soil, may be lower than tolerance for weeds that displace grasses but nevertheless continue to cover soil and serve as a playing surface.

Pest levels can be quantified in a number of ways. Table 2, Transect Method for Monitoring Weeds in a Lawn, describes a method for quantifying the amount of weeds growing in a lawn. This permits expression of tolerance levels by percentage of weeds, for example, "up to 25% weed growth is tolerable on the back lawn at the elementary school; only 10% is tolerable on the football field at the high school."

A spade is used to cut three sides of a 1-foot square of grass. The grass is carefully folded back, using the uncut edge as a hinge. Dirt from the roots is removed, and the number of exposed grubs counted. Then the grass can be folded back into place, tamped, and watered in.

Tolerance for insect damage can be correlated with numbers of insects present and amount of visible damage. For example, white grubs can be monitored by examining several areas of soil underneath the grass. A spade is used to cut three sides of a I-foot square of grass. The grass is carefully folded back, using the uncut edge as a hinge. Dirt from the roots is removed, and the number of exposed grubs counted. Then the grass can be folded back into place, tamped, and watered in. In well-managed lawns, up to 10 grubs per square foot can be present without causing any appreciable damage to the turf. In stressed or poorly managed lawns, however, 10 grubs per square foot might seriously damage the grass. By setting tolerance levels, pest managers and grounds keepers can gear their management efforts to keeping pest populations within tolerable levels, and apply treatments only if, when, and where necessary.

Intervening to Reduce Pests

Adapted from *Integrated Pest Management In Schools: IPM Training Manual For Grounds Maintenance.* Maryland Cooperative Extension Bulletin 358.

The decision to implement a control action is guided by several qualitative factors. These include the density and damage potential of the pest, the use of the turf, the presence of biological control agents, the availability of alternative control tactics, climactic factors, and the management guidelines and policies established by the school. Monitoring should have determined the pest's identity and levels of damage. Action may be warranted if an action threshold has been determined and in the upcoming season, the pest is anticipated to occur at a density requiring a control action. In evaluating the need for control, you must investigate the use of cultural, biological, mechanical, and physical methods first. If these options are unreasonable or have been exhausted, herbicide application may be considered. In some cases the use of a single intervention tactic such as a pre-emergence herbicide may greatly reduce the need for multiple applications of post-emergence herbicides later. Careful selection should be made of the most appropriate tactics to reduce or keep pests populations below the damage threshold, after which active measures should stop.

Table 1: Diagnosing Common Turf Problems and Their Control

REMINDER – When a determination is made that an action is necessary to control a pest, you must investigate the use of cultural, biological, mechanical, and physical methods first. Only when these options are unreasonable or have been exhausted can a pesticide application be considered.

Symptoms	Possible Causes	Control/Comments
1. Problems with the general appearance of the lawn		
Rings or arcs of dead or green grass, mushrooms may be present.	**Fairy rings.** Rings or arcs of dead or green grass bordered by zones of darker green grass. More common on droughty sites or poorly nourished turf. Occurs on all turf cultivars.	Aerate turf frequently, maintain adequate nitrogen fertility and adequate water during dry spells.
Circular, straw-colored patches.	**Summer patch.** Circular patches that range from 3-12 inches in diameter. This disease occurs in bluegrass and fine fescue lawns 2 years or older, July through September.	Avoid excess nitrogen, especially in spring. Use slow-release nitrogen sources. Increase mowing height; avoid light, frequent watering, and reduce thatch build-up. Apply a registered fungicide as a preventative when conditions indicate and when soil temperatures reach 650 F or a curative application when soil temperatures are 75-950 F.
Irregular brown patches with white moths flying over the turf ..	**Sad webworm.** Brown caterpillars may be found at the base of the blades and in the thatch. Active from June through July.	Reseed with grasses with high levels of endophyte, such as tall fescue; or spray with Bt insecticide.
Localized yellow or brown areas.	**Cinch bugs.** Tiny black insects with shiny white wings, found on crowns and stems. Damage usually occurs in sunny, well-drained locations.	Reseed with grasses with high levels of endophyte, such as tall fescue. Often controlled by natural predators, such as big-eyed bugs.
Straw-color patches surrounded by a ring of dark green turf.	**Dog urine.** May resemble some diseases. May kill the crown tissue.	Heavy irrigation will promote recovery of spots.
Banded streaks or irregular patterns.	**Fertilizer or chemical injury.** Grass may be stimulated at the margins. May kill the crown tissue.	Calibrate spreaders and sprayers for uniform and accurate applications of materials.

Integrated Pest Management of *Turfgrass*

REMINDER – When a determination is made that an action is necessary to control a pest, you must investigate the use of cultural, biological, mechanical, and physical methods first. When these options are unreasonable or have been exhausted, a pesticide application may be considered.

Black or dark spots or patches on lawn.	**Oil or gasoline damage.** Possibly from leaking lawn mower.	Severe oil leak or spill requires removal of affected soil. Small gasoline leaks or spills volatilize quickly. Soil should be replaced if saturated.
Large yellow area near pool	**Chlorine damage** from pool water.	Leach chlorine through soil with water. Replant.
Grass over high spots looks scalped.	**Mower injury.** Crowns of plants exposed.	Adjust terrain, raise mower blade or change mowing direction.
Shredded blade tips.	**Dull mower blade injury.** Tips appear gray and then turned to hand.	Sharpen mower blades.
Patches of dead or dormant grass.	**Buried debris, insect injury or thick thatch.**	Often follows a dry spell. Check for causes.
Pale green to golden yellow turf.	**Chlorosis.** Iron or nitrogen deficiency. Yellow streaks may form parallel to leave things.	Maintain adequate fertilizer levels.
Black are greenish crust on soil.	**Algae growth.** On bare soil or in thin turf. Occurs in poorly drained or compacted areas, usually more severe in shade.	Increase drainage and establish a thicker stand of turf. Aerate compacted areas and increased sunlight in shaded areas.
Small green plants growing within turf.	**Moss.** On bare soil or in thin turf. Occurs in poorly drained or compacted areas, usually more severe in shade.	Increase drainage and establish a thicker stand of turf. Aerate compacted areas and increased sunlight in shaded areas.
Turf appears dry and bluish green in color.	**Drought.** Footprints remain after walking on turf. Grasses wilt.	Irrigate turf.

REMINDER – When a determination is made that an action is necessary to control a pest, you must investigate the use of cultural, biological, mechanical, and physical methods first. Only when these options are unreasonable or have been exhausted can a pesticide application be considered.

2. Problems on individual leaf blades		
Leaf spots.	**Helminthosporium leaf spot.** Fungal leaf spots with tan centers. Lesions are round or elongated. Turf thins out. Common in wet spring weather and affects primarily bluegrass and ryegrass.	Avoid drought stress and light or frequent watering. Reduced thatch build-up and avoid spring fertilization with soluble nitrogen sources. Reseed with improved turf cultivars. Fungicides are not generally warranted.
	Dollar spot. Leaf lesions with a dark border and hourglass-shaped spots. Disease affects all turfgrass varieties. Common in late spring on turf under low fertility.	Avoid drought stress. Prevent thatch build-up and soil compaction. Maintain adequate nitrogen fertility and reseed with improved turf cultivars. Treat with fungicide if warranted.
	Brown patch. Elongated fungal lesions with chocolate-brown margins. Entire leaves may turn brown and thinning may occur. Occurs in mid-summer, especially on tall fescue, during warm and hot, humid weather with high soil temperatures and nitrogen levels.	Tall fescue turf maintained at proper mowing height and fertility will recover in the fall. Avoid high nitrogen levels. Fungicides are not generally warranted.
Pink/reddish color on leaf blades.	**Red thread.** Red, thread-like growths extending beyond leaf blades. Disease appears in patches and occurs in spring and fall on fine fescue and perennial ryegrass cultivars with slow growth. Low fertility and high moisture may also contribute.	Maintain adequate nitrogen fertility levels. Fungicides are not generally warranted.
Gray to black streaks in leaf blades.	**Striped smut.** Leaves split into ribbons and curl. Disease appears in irregular patches and infects primarily bluegrass in spring and fall.	Avoid drought stress and excessive thatch. Reseed with improved turf cultivars.
Blades covered with red, orange or yellow powdery material.	**Rust diseases.** Turf may appear yellow or reddish from a distance. Occurs primarily on bluegrass, ryegrass and zoysia with slow growth. Low fertility may also contribute.	Maintain adequate nitrogen fertility levels and reseed with improved turf cultivars. Fungicides are not generally warranted.
Blade covered with white coating.	**Powdery mildew.** White coating typically occurs in shady areas in the fall on bluegrass.	Reduce shade and improve air movement. Avoid excessive nitrogen and drought stress. Increase mowing height and reseed with improved and disease-resistant cultivars. Fungicides are not generally warranted.

REMINDER – When a determination is made that an action is necessary to control a pest, you must investigate the use of cultural, biological, mechanical, and physical methods first. Only when these options are unreasonable or have been exhausted can a pesticide application be considered.

Blades covered with black sooty-like material.	**Sooty mold.** Not harmful. It is easily wiped off or removed. Blades remain green underneath. Occurs primarily in spring or fall after rain.	Wash off sooty material with a hose or remove material by mowing.
Circular patches, 1-6" diameter, pinkish or reddish-brown matted leaves.	**Pink snow mold.** Generally appear at snowmelt or in the presence of plenty of surface moisture during cool-cold overcast periods, especially during the late fall through spring.	Avoid lush growth entering winter. Mow grass until growth has stopped. Apply fungicide as curative if necessary.
Circular patches, 6-36" diameter, matted leaves with a grayish color.	**Gray snow mold.** Generally appear at snowmelt or in the presence of plenty of surface moisture during cool-cold overcast periods, especially during the late winter through spring.	Avoid lush growth entering winter. Mow grass until growth has stopped. Apply fungicide as curative if necessary.
Circular spots of, 1-3" diameter, leaves are abrasion or water-soaked.	**Pythium blight.** Mycelium is present during early-morning hours. Leaves are rapidly blighted and entire plants die in 24 hours. Dead plants are brown or red-brown in color and matted; July-early September. Perennial ryegrass is especially vulnerable during hot and humid weather and in poorly drained sites.	Seedlings of all species planted during warm and humid periods are susceptible. Improve drainage and avoid high levels of nitrogen. Apply fungicide if necessary.
Turf comes up easily, obvious lack of roots.	**White grubs.** Turf can sometimes be rolled up like a carpet. C-shaped grubs found in the soil from June through September. Can be severe on bluegrass, ryegrass and fine fescues.	Reseed the lawn in the fall with a tolerant turf species, such as tall fescue or zoysia.
Turf blades can be pulled easily from sod.	**Billbugs.** Light tan, sawdust-like material (frass) in areas of heavy feeding. Small, legless grubs found near crowns and roots from June through August.	Water and fertilize grass to stimulate regrowth. Reseed with an endophyte-containing tall fescue. If necessary, use a registered insecticide April through mid-May.

REMINDER – When a determination is made that an action is necessary to control a pest, you must investigate the use of cultural, biological, mechanical, and physical methods first. Only when these options are unreasonable or have been exhausted can a pesticide application be considered.

3. Other occurrences

Small, fuzzy bees that nest in loose soil.	**Grounds bees.**	No control necessary. Not aggressive. Males have no stinger. They establish a mating territory and only appear threatening. They are only around for a few weeks.
Large, black wasp with yellow markings on the abdomen; hover above the lawn; non-aggressive; nest in loose soil.	**Cicada killers.** Feed on cicadas.	Control generally not necessary.
5/8-inch long, blue-black wasp, yellow stripe on each side of abdomen; fly over long during the day.	**Scoliid wasps.** Not aggressive.	Parasites of white grubs. Do not attack people. Control not necessary. Adults often seen visiting goldenrod flowers in late summer.
Trails of raised soil running along surface of the lawn.	**Moles.** Tunnel belowground, feed on grubs, beetles, and other insects. Help aerate soil.	May need to control grab the population. Moles may be trapped.
1-2" diameter holes in ground. 1-2" runways may be visible on surface.	**Voles.** (Also called meadow mice)	Move mulch away from base of trees. Pile mulch no more than 1-inch deep. Keep lawn mowed.
Cone-shaped holes in ground. Turf may be pulled up in patches.	**Skunks.** Feed on grubs in lawn.	Control grub population. Use hardware cloth to keep skunks from living under buildings.

Adapted from:
1. Ricciuti, P., D. Clement, and M.K. Malinoski. 1999. *IPM Series: Turf.* Home and Garden Mimeo # 63. University of Maryland Cooperative Extension, College Park, MD.
2. Dernoeden, P.H. *Diagnosing Common Lawn Diseases.* Agronomy Mimeo # 84. University of Maryland Cooperative Extension, College Park, MD.
3. University of Wisconsin - Madison, Turfgrass Disease Diagnostic Laboratory at http://www.plantpath.wisc.edu/tddl/tddl/tddl.htm .

Evaluating Pest Management Practices

When actions are taken to reduce pest presence, monitoring data should be used to evaluate the effectiveness of the treatment. Did pest numbers go down sufficiently to prevent intolerable damage? Were treatments cost-effective? Is the problem likely to recur? Can conditions causing chronic pest problems be altered or removed? If not, can other ground covers better suited to conditions at the site replace the lawn?

Diagnosing Problems in Turfgrass

To help determine common turf grass problems see the section called *Diagnosing Common Turfgrass Problems.* above. Further information on identifying and managing problems is found in sections of *Key Insect Pests of Turfgrass, Diseases of Turfgrass, and Weeds of Turfgrass* below.

Key Insect Pests of Turfgrass

Prepared by Paula Shrewsbury, Ph.D., Extension Specialist in Ornamental and Turf IPM, Dept. of Entomology, University of Maryland

White Grub Complex (subsurface pests / feed on roots):

Japanese Beetle

Damage Symptoms

- Adults feed on over 300 species of ornamental plants causing skeletonization of the foliage; active during the day; preferred host plants include roses, linden, grape, and others.
- Grubs (immature stage) feed on roots of many plants, especially turfgrass, at the soil/ thatch interface.
- Symptoms include an overall wilted or drought stressed appearance to the turf; turf may feel spongy underfoot; heavy infestations result in turf death (turf can be "rolled up" like a carpet).
- Damage is most severe August through September.

Biology

- One generation per year; overwinter as larvae (grubs) in soil.
- Adults active mid-June through July; eggs laid in soil (upper 2"); eggs require moisture to develop.
- Grubs active from early to mid August into the fall and again in April and May.

Monitoring

- Visually monitor adults, especially on preferred host plants (ex. linden, grape, roses).
- Grubs should be monitored by using a sod spade to cut 3 sides of 1' x 1' area (approx. 4" deep); pull sod back and count number of grubs present; remove grubs to identify species by their rastor pattern; look for any naturally occurring biological controls (ex. fungal pathogens, milky spore, nematodes); cup cutters may also be used to monitor grubs-they cover 1/10 of a square foot (multiply by 10 to get number of grubs per square foot); monitor several locations to obtain a better estimate of the grub population; sample in a zig-zag pattern across turf;

concentrate monitoring for grubs in areas where turf is irrigated (in dry years) and near preferred host plants of adults.

- Adults prefer to lay eggs in *moist* soils in open sunny areas; in dry years populations should be highest in low lying, moister areas and this is where monitoring should be concentrated.
- Skunk and raccoon damage is an indicator that grubs are present (not always so monitor to be sure).
- Grub damage thresholds vary depending on a number of factors such as time of year, irrigation practices, turf variety, and age of turf (action threshold for unstressed turf = greater than 10 grubs per sq. foot).

Control Strategies

- Chemical controls, when warranted, should be applied around mid-August to target early instar grubs; chemicals should be watered in with at least 0.25" of water (moves chemical down to thatch / soil interface and draws grubs up into upper soil profile); spot treatments should be applied based on monitoring and previous seasons records.
- Milky disease (bacterium) is slow acting and usually remains in grub populations for several years; should only be used on low value turf; commercial product is only active against Japanese beetle grubs.
- Naturally occurring parasites (tachinid flies and Tiphia wasps) and predators (ground beetles, rove beetles, ants) can suppress grub populations; conserve these beneficials.

Oriental Beetle

Damage Symptoms

- Adults cause little damage; they are rarely seen and are known to feed on flowers of roses, hollyhocks, phlox, dahlias, and petunias.
- Grubs are a serious pest of turf grass and containerized nursery stock.
- Symptoms are the same as those caused by Japanese beetle grubs.

Biology

- Similar to Japanese beetle; Oriental beetle grubs often co-occur with Japanese beetle grubs in the soil.

Monitoring

- A pheromone has recently been developed for the adult male beetle and should soon be commercially available.
- Same as for Japanese beetle.

Control Strategies ***REMINDER** – ***When a determination is made that an action is necessary to control a pest, you must investigate the use of cultural, biological, mechanical, and physical methods first. When these options are unreasonable or have been exhausted, a pesticide application may be considered.***

- Chemical controls, when warranted, should be applied around mid-August to target early instar grubs; chemicals should be watered in with at least 0.25" of water (moves chemical down to thatch / soil interface and draws grubs up into upper soil profile); spot treatments should be applied based on monitoring and previous seasons records.

Masked Chafers (Northern and Southern)

Damage Symptoms

- Adults do not feed.
- Grubs feed on turfgrass roots and organic matter.
- Symptoms are similar to those caused by Japanese beetle grubs.

Biology

- Same as Japanese beetles, except adults are nocturnal.

Monitoring

- Adults can be monitored with black light traps.
- Grubs can be monitored by the same method as Japanese beetle grubs; also focus in turf areas near lights (adults are attracted to lights at night).
- Action thresholds:
- Stressed turf = 8-10 grubs per sq. foot.
- Vigorous turf = 20 grubs per sq. foot.

Control Strategies ***REMINDER** – **When a determination is made that an action is necessary to control a pest, you must investigate the use of cultural, biological, mechanical, and physical methods first. When these options are unreasonable or have been exhausted, a pesticide application may be considered.***

- Chemical controls, when warranted, should be applied around mid-August to target early instar grubs; chemicals should be watered in with at least 0.25" of water (moves chemical down to thatch / soil interface and draws grubs up into upper soil profile).
- Spot treatments should be applied based on monitoring and previous seasons records.
- Tall fescues and creeping bentgrass are more tolerant of damage than Kentucky bluegrass.

Green June Beetle

Damage Symptoms

- Adults feed on thin-skinned ripening fruits (ex. grapes, peaches).
- Grubs feed on roots, crowns, and decaying organic matter in thatch and root zones lawns top dressed with organic materials attract green June beetles.
- Grubs injure turf by tunneling (young grubs) and burrowing (older grubs) in soil which disrupts the surface soil, loosens roots, thins thatch, and turf wilts and dies; burrowing of older grubs leave soil mounds in turf.
- Damage allows weed encroachment into the turf.
- Damage most severe in late July to mid-August.

Biology

- Adults active mid-June through July; mid-July adult males swarm over turf looking for females to mate.
- Eggs laid in sunny, thatchy turf or recently manured turf.
- Grubs active late April to early June and late summer through November; active at night and third instar grubs crawl on their backs, burrow in the soil, and can migrate 40 to 65'.

Monitoring

- Visual monitoring for adult activity (mid-day in sunny areas of turf), soil mounds, tunneling in turf, and large exit holes in ground.

Control Strategies

- Chemical controls, when warranted, should be applied in August before mounds appear.
- Avoid applying organic fertilizers and other organic matter to the turf.
- Kentucky bluegrass tends to recover quicker from damage with new growth from underground stems.
- Overseed damaged turf in the fall to reduce weed encroachment.
- Digger wasps are a common parasite.
- Naturally occurring fungal pathogens attack green June beetles .

White Grub Complex Control Strategies

Control Strategies ***REMINDER** – **When a determination is made that an action is necessary to control a pest, you must investigate the use of cultural, biological, mechanical, and physical methods first. When these options are unreasonable or have been exhausted, a pesticide application may be considered.***

Cultural Controls

- Host plant selection:
- Do not plant roses, lindens, or grapes where Japanese beetles may be a problem.
- Do not plant peaches or other thin-skinned fruits where green June beetles may be a problem.
- Fine and tall fescues are not as severely damaged by grubs as are Kentucky bluegrass and perennial ryegrass.
- Water management:
- Irrigated turf can tolerate more damage from grub feeding than non-irrigated turf.
- However, remember irrigated turf is more attractive to adult females to lay their eggs.

Biological Controls

- Naturally occurring beneficials:
- Many natural enemies of turf insects exist in nature such as ants, ground beetles, rove beetles, big-eyed bugs, digger wasps, *Tiphia* wasps, spiders, and others; try to conserve beneficials.
- Commercially available biological controls:
- These include microbials such as insect killing fungi, nematodes, and bacteria.
- Entomopathogenic nematodes *(Steinernema* spp. and *Heterorhabditis* sp.):
- Microscopic round worms that kill several species of insects.
- Nematodes (several species) are commercially available for grub control, however, have not been widely used for several reasons.
- When using these nematodes for insect control remember:
- Match the right nematode species to the right insect pest.
- Purchase them from a reliable source.
- Use nematodes as soon as you receive them.

- Apply at recommended rate (1 billion / acre).
- Do not let them sit in the spray tank or in your vehicle where they can overheat.
- Apply when temperatures are between 50 and 90^{Q} F.
- Water soil pre-and post-nematode application and keep soil moist for several days following treatment (nematodes require moisture).
- Nematodes are sensitive to UV light so avoid exposure of nematodes to full sunlight (apply on a cloudy, rainy day).
- The most effective nematodes for control of white grubs are *Steinernema glaseri* and *Heterorhabditis bacteriophora* (cruiser species).
- Fungal pathogens:
- Almost all turfgrass insect pests, including white grubs, are susceptible to naturally occurring fungal pathogens such as *Beauvaria bassiana* and *Metarhizium anisopliae.*
- *Beauvaria bassiana* is now commercially available (Naturalis-T by Troy Biosciences) and labeled for many turf insect pests (at this time I have not seen data to suggest effective control of grubs).

Chemical Controls ***REMINDER** – **<u>When a determination is made that an action is necessary to control a pest, you must investigate the use of cultural, biological, mechanical, and physical methods first. When these options are unreasonable or have been exhausted, a pesticide application may be considered.</u>***

- Turf areas should be watered prior to and following (at least 0.25") chemical applications to move chemicals down to the soil/thatch interface where grubs are feeding and draw the grubs up higher in the soil profile.
- Most controls work best on smaller grubs than larger grubs (target mid-August when grubs are small).
- Merit (imidacloprid) is a systemic insecticide that has a relatively wide window of opportunity for applications to target small grubs (does not work well once grubs have become 3rd instars). It has been shown to give very good control against fall feeding grubs when applied between early April and mid-August. This means decisions on its use are being made prior to having knowledge of the likelihood that the pest population is damaging. Be aware that indiscriminate use of this product can quickly lead to problems (ex. insect resistance and pest outbreaks).
- Mach 2 (halofenizide) is a new insecticide. It is an insect growth regulator (IGR) and kills grubs by disrupting their normal development. Mach 2 has a relatively wide window of opportunity for applications to target small grubs (does not work well once grubs have become 3rd instars).
- Studies indicate Dylox gives better control of larger (3rd instar) grubs than other chemicals tested.

Black Turfgrass Ataenus (subsurface *pests-feed* on *roots)*

Damage Control

- Major pest of golf course fairways, greens, tees, and collars; wilting and gradual thinning; turf is stunted and lifts readily because of damaged roots; larvae (grubs) feed on roots.

Biology

- Adults and white grubs (larvae) are small (approx. ~" shiny black adults); two generations per year; overwinter as adults in soil surface or under leaf litter along fairways or under trees in wooded areas; masses of adults begin to migrate in late March; eggs laid in soil in early May to mid June; grubs are active in upper soil/lower thatch layer in June and early July; prefers compacted, decaying, moist thatch and soils high in organic matter; second generation grubs active late July to early August.

Monitoring

- Feeds on annual and Kentucky bluegrass and bentgrass so monitor these grass types; adults active during warmest part of day and fly over greens and fairways; monitor grubs by taking soil samples (2" depth) with a cup cutter; action thresholds vary; unstressed turf = 30 to 50 per sq. foot.

Control Strategies

Biological Control:

- Population declines have been associated with a milky disease (different bacteria than the Milky spore disease that attacks Japanese beetle grubs).

Chemical Control: ***REMINDER** – **When a determination is made that an action is necessary to control a pest, you must investigate the use of cultural, biological, mechanical, and physical methods first. When these options are unreasonable or have been exhausted, a pesticide application may be considered.***

- Chemical controls to target adults in thatch (before they lay eggs around mid-April); first generation larvae are active when van houtte spirea are in full bloom.

Sod *Webworm (surface / thatch pests-feed* on *stems* and *leaves)*

Damage Symptoms

- Adults do not cause damage.
- Small larvae (caterpillars) chew leaves and stems; larger larvae cut off the grass blades just above the thatch line and pull blades into their silk tunnels and eat them; they can consume large amounts of green foliage; larvae feed at night; injury appears as small brown patches of closely cut grass (looks like mower scalping) and patches run together and form large, irregular brown patches.
- Birds feeding on larvae result in holes in the turf.
- Damage is most severe in August and September.

Biology

- Adults are nocturnal and are active from May to early October; fly in a zig-zag pattern.
- Larvae are also nocturnal, found in the turf thatch, spin silk and web leaves and soil particles together to form tunnels; pupate in cocoon at the end of the silk tunnel.
- Over winter in the soil as larvae; 2 to 3 generations per year.

Monitoring

- Newer lawns are preferred, sunny locations are preferred.
- Adults are best monitored with black light traps (expect active larvae about 2 weeks after peak adult flight; in the evening shine headlights over lawn and

walk across lawn to disturb adult moths; look for zig-zag flying adults.

- Larvae can be monitored by visually searching the thatch layer for silk tunnels and frass.
- Irritant flush can be poured over a section of lawn (3 x 3') to force larvae to the surface to make monitoring easier; irritant flush can be made up of 1-2 tsp of liquid soap per gallon of water.
- Action threshold = 15 caterpillars / square yard.

Control Strategies

Cultural Control:

- Turf recovery from web worm damage varies.
- Warm season grasses tend to recover from spring and early summer damage, but not late summer damage when web worm populations have increased and grass growth has slowed.
- Bluegrass recovers better than fine fescues or perennial ryegrass.
- Fertilize and water to increase vigor. •

Raise mowing height.

Biological Control:

- Bacillus thuringiensis
- *Bt varieties kurstaki* and *aizawai* are commercially available and are effective against caterpillar pests such as sod webworms and cutworms; only effective against small caterpillars.
- Select endophyte resistant turf varieties:
- Turfgrass varieties containing endophytes have enhanced resistance to webworms; endophytes are a fungus present in the turf plant that repels and kills several insect feeding turf pests; they are not harmful to turf.
- Entomopathogenic nematodes *(Steinemema carpocapsae)* are commercially available:
- Native predators (ants, ground beetles, predatory flies, wasps, big-eyed bugs, and birds) and fungal pathogens.

Chemical Control: ***REMINDER** – **When a determination is made that an action is necessary to control a pest, you must investigate the use of cultural, biological, mechanical, and physical methods first. When these options are unreasonable or have been exhausted, a pesticide applicationmay be considered.***

- Chemical controls, when warranted, should be applied late in the afternoon since larvae are nocturnal; turf should be mowed prior to application and then not mowed for 24 to 48 hours following application.
- "Conserve" is a new "biorational" product; It is a by-product of a soil bacterium and gives good control of caterpillar pests of turf and ornamentals; it also controls sawflies, leaf beetles, and thrips.

Cutworms (surface / thatch pests-feed on stems and leaves)

Damage Symptoms

- Problem on close-cut bentgrass turf of golf course greens and tees.
- Feed on grass blades (chewing) and expose thatch resulting in circular spots of brown dead grass or depressed spots (especially around larval burrows).

Biology

- Overwinter as larvae or pupae; two to four generations per year.
- Larvae dig a burrow in the ground or thatch (or use an aeration hole) for shelter during the day; larvae are nocturnal and emerge at night to clip off grass blades and shoots.

Monitoring

- Black light traps for adults; use irritant flushes to expose larvae; 3-8 larvae per square yard may require treatment; bird feeding also indicates cutworms are present.

Control Strategies

Cultural/Mechanical Control:

- Remove and destroy grass clippings that contain eggs of the cutworms; hand remove cutworms from greens in early morning.

Biological Control:

- Resistant turf varieties with endophytes; *Bacillus thuringiensis* against first and second instars; entomopathogenic nematodes *(S. carpocapsae)* can be used, water in after application.

Chemical Control: ***REMINDER** – **When a determination is made that an action is necessary to control a pest, you must investigate the use of cultural, biological, mechanical, and physical methods first. When these options are unreasonable or have been exhausted, a pesticide application may be considered.***

- If chemical controls are use apply late in the day and do not water for two to three days after application.
- "Conserve" is a new "biorational" product. It is a byproduct of a soil bacterium and gives good control of caterpillar pests of turf and ornamentals; it also controls sawflies, leaf beetles, and thrips.

Chinch Bugs (surface / thatch pests-feed* on *stems and leaves) Damage symptoms

- Suck sap from crowns and stems of grass and inject a toxin into the plant.
- Patches of turf gradually yellow and then turn brown and die; turf does not recover; can kill entire lawns; resembles drought injury or sun-scald.
- Hot, droughty summers increase chinch bug populations.
- Prefers turf with thick thatch in full sunlight; damage is most severe August and September.

Biology

- Found near soil surface at the edges of brown patches.
- Two generations per year; overwinter as adults; adults active spring to late summer.
- Nymphs active mid-summer to fall.

Monitoring

- Monitor early in the season to catch populations when they are small.
- Monitor at the edge of brown patches where populations should be active.
- Visually monitor or use the floatation method (coffee can) to determine if nymphs and adults are active; especially in sunny areas.

- Thresholds of 15 to 20 insects per sq. foot (or 8-10 per 9" diam. coffee can) can cause significant damage.

Control Strategies

Cultural Controls:

- Irrigate, fertilize, overseed, and reduce thatch.

Biological Controls:

- Select endophyte resistant turf varieties-turfgrass varieties containing endophytes have enhanced resistance to chinchbugs; endophytes are a fungus present in the turf plant that repels and kills several insect feeding turf pests; they do not harm the turfgrass.
- Cool, wet springs promote growth of a fungal pathogen *(Beauveria* sp.), which can reduce chinch bug populations; this is commercially available as Naturalis-T.
- Naturally occurring populations of big-eyed bugs and predatory mites help to suppress populations.

Chemical Controls: ***REMINDER** – **When a determination is made that an action is necessary to control a pest, you must investigate the use of cultural, biological, mechanical, and physical methods first. When these options are unreasonable or have been exhausted, a pesticide application may be considered.***

- Chemical controls, when warranted, should be applied when chinch bugs reach damaging levels as indicated by monitoring (usually around early May and again in late July); spot treatments.

Blllbugs (surface / thatch pests-burrow into stems)

Damage Symptoms

- Individual stems of grass are killed first by larvae boring into grass stems and eventually larger clumps (resemble dollar spot) and then irregularly shaped tan or brown patches appear in turf that may resemble fertilizer bum; areas of green and yellow turf; turf appears wilted; tufts of discolored turf pull up easily.
- Most damaging to Kentucky bluegrass.

Biology

- Four species found in New Jersey (Uneven billbug, Little billbug, Bluegrass billbug, and Hunting bill bug).
- One generation per year.
- Over winter as adults in turf and surrounding areas.
- Adults active April to October.
- Larvae active May to September.
- Adults feed on grass stems and burrow into the soil.
- Young larvae tunnel into stems (compacted frass in stem) and exit through the crowns larger larvae drop down to soil and feed externally on the crowns and roots.

Monitoring

- Adults should be monitored visually or with pitfall traps; monitor around hot locations like turf along driveways and sidewalks where adults commonly walk.
- Tug on turf in browned areas; if it breaks off easily and stems are filled with fine sawdust like frass then it is billbug damage.

- Degree-day (DD) accumulations can be use to predict activity time of different life stages.

Control Strategies

Cultural Control:

Fertilize and irrigate to mask damage symptoms; Kentucky bluegrass is the preferred host followed by perennial ryegrass.

- Resistant varieties of bluegrass are available (Touchdown, Merion, Nugget, Adelphi, Baron, Cheri, Newport).

Biological Control:

- Select endophyte resistant turf varieties-turfgrass varieties containing endophytes have enhanced resistance to billbugs; endophytes are a fungus present in the turf plant that repels and kills several insect feeding turf pests.
- Cool, wet springs promote growth of a fungal pathogen *(Beauveria* sp.), which can reduce billbug populations; this is commercially available as Naturalis- T.
- Entomopathogenic nematodes *(Steinernema sp.* and *Heterorhabditis sp.)* are commercially available.

Chemical Control: ***REMINDER** – **When a determination is made that an action is necessary to control a pest, you must investigate the use of cultural, biological, mechanical, and physical methods first. When these options are unreasonable or have been exhausted, a pesticide application may be considered.***

- Chemicals, when warranted, should be applied in April to mid-May to target adults before they lay eggs; larvae may be controlled by applying Merit (imidacloprid) or Mach2 (halofenozide) when adults begin to become active.

Annual Bluegrass Weevil (Hyperodes sp.) *(surface / thatch pests-burrow into stems)*

Damage

- Damage short-cut annual bluegrass (less than 0.75 inch); turf wilts and then turns straw colored; damage first appears along edge of fairways near woods or perimeters of greens and tees; damage apparent in late Mayor early June and again in late July or early August; will also feed on clover, plantain, and dandelions.

Biology

- Two generations per year; adults overwinter in leaf litter of white pines near fairways; in the spring (when Forsythias are almost in full bloom) adults migrate to fairways, greens, and tees.
- Eggs are laid between leaf sheaths (when white flowering dogwoods are in full bract); first and second instar larvae remain inside the plant tissue; late instar larvae move to the exterior of the plant and feed on the crowns.

Monitoring

- Monitor for migrating adults in spring visually or with black light traps; cut turf core with cup cutter, break up soil and thatch, place in lukewal111 water and adults and larvae will float to top (5-10 minutes); action threshold of 30 to 50 larvae per sq. foot (3-5 per cup cutter core).

Control Strategies

Cultural Control:

- Provide adequate irrigation; raise mowing height if possible; do not plant white pines near greens; reduce presence of annual bluegrass

Integrated Pest Management of *Turfgrass*

Chemical Control: ***REMINDER** – **When a determination is made that an action is necessary to control a pest, you must investigate the use of cultural, biological, mechanical, and physical methods first. When these options are unreasonable or have been exhausted, a pesticide application may be considered.***

- If chemical control is warranted spring applications (between forsythia and dogwood bloom) should be applied to target adults before they lay eggs (bifenthrin - Talstar, cyfluthrin - Tempo, deltamethrin - DeltaGard, lambda-cyhalothirin Scimitar); a second application may be necessary in July for second generation adults; larvae may be controlled by applying Merit (imidacloprid) or Mach 2 (halofenozide) when adults begin to become active.

Excellent pictures of weeds and their management can be found at the University of Maryland's Home and Garden Information Center website at www.agnr.umd.edu/users/hgic.

Key Diseases of Turfgrass

Adapted from Agronomy Mimeo 84, *Diagnosing Common Lawn Diseases* and Agronomy Mimeo 80, Maryland *Turfgrass Disease Control Recommendations.* By Peter H. Dernoeden, Ph. D., Extension Turfgrass Specialist, University of Maryland.

Diseases can seriously damage turfgrass plants and impair the appearance of turf. Promoting vigorous growth through sound cultural practices greatly aids in minimizing disease injury. Frequently, however, environmental stress, traffic, or poor management weakens plants, predisposing them to invasion by fungal pathogens. When disease symptoms appear, turfgrass managers must make a rapid and accurate diagnosis of the disorder. The prudent manager also attempts to determine those cultural factors, which may have contributed to disease severity. The most common cultural abuses that aggravate turf diseases include: close mowing, poor drainage, excessive thatch, light and frequent irrigation, inadequate or excessive nitrogen fertility, shade and traffic. A good case in point is summer patch, which is particularly damaging when turf is mown too closely, given light and frequent irrigations, and fertilized with excessive amounts of nitrogen.

Despite hard work and good management, disease frequently becomes a serious problem. This normally occurs when environmental conditions favor disease development, but not plant growth and vigor. For example, snow molds, Pythium blight, and brown patch are damaging when unfavorable temperatures stress plants and impair their growth and recuperative capacity. In these situations, fungicides are generally recommended in conjunction with cultural practices that promote turf vigor.

Most turfgrass diseases are caused by pathogenic fungi that invade the leaves, stems or roots of plants, causing various symptoms such as leaf spots, root rots or death of entire plants. Sometimes these fungi produce visible structures such as mushrooms, white powdery mildew or a fluffy, moldy growth. These fungi are normally present in most lawns, but disease only occurs when environmental factors favor growth of the pathogen and increase the susceptibility of the grass host. This relationship between the environment, host, and pathogen are the key factors in disease causation and control. Turfgrass management practices alter the environment and therefore have a major impact on disease development. These management factors include mowing, irrigation, fertilization, thatch control, traffic, and soil pH and soil compaction. Ultimately, use of disease resistant cultivars and sound cultural practices will provide the most efficient means of discouraging disease. See earlier sections for cultivar recommendations for Maryland. Some common diseases and their management are described below.

Fairy rings

- Rings or arcs of dead or green grass bordered by zones of darker green grass. Rings or arcs of dead or green grass, mushrooms may be present.
- More common on droughty sites or poorly nourished turf.
- Occurs on all turf cultivars.
- Aerate turf frequently.
- Maintain adequate nitrogen fertility and adequate water during dry spells.

Summer patch

- Circular, straw-colored patches that range from 3–12 inches in diameter.
- This disease occurs in bluegrass and fine fescue lawns 2 years or older, July through September.
- Avoid excess nitrogen, especially in spring.
- Use slow-release nitrogen sources.
- Increase mowing height.
- Avoid light, frequent watering.
- Reduce thatch build-up.

Helminthosporium leaf spot

- Fungal leaf spots with tan centers.
- Lesions are round or elongated.
- Turf thins out.
- Common in wet spring weather and affects primarily bluegrass and ryegrass.
- Avoid drought stress and light or frequent watering.
- Reduced thatch build-up and avoid spring fertilization with soluble nitrogen sources.
- Reseed with improved turf cultivars.

Dollar spot

- Leaf lesions with a dark border and hourglass-shaped spots.
- Disease affects all turfgrass varieties.
- Common in late spring on turf under low fertility.
- Avoid drought stress.
- Prevent thatch build-up and soil compaction.
- Maintain adequate nitrogen fertility
- Reseed with improved turf cultivars.
- Treat with registered fungicide if necessary.

Brown patch

- Elongated fungal lesions with chocolate-brown margins.
- Entire leaves may turn brown and thinning may occur.
- Occurs in mid-summer, especially on tall fescue.

- Tall fescue turf maintained at proper mowing height and fertility rates will recover in the fall.
- Avoid high nitrogen levels.

Red thread

- Pink/reddish color on leaf blades.
- Red, thread-like growths extending beyond leaf blades.
- Disease appears in patches and occurs in spring and fall on fine fescue and perennial ryegrass species.
- Maintain adequate nitrogen fertility levels.

Striped smut

- Gray to black streaks in leaf blades.
- Leaves split into ribbons and curl.
- Disease appears in irregular patches and infects primarily bluegrass in spring and fall.
- Avoid drought stress and excessive thatch.
- Reseed with improved turf cultivars.

Rust diseases

- Blades covered with red, orange or yellow powdery material.
- Turf may appear yellow or reddish from a distance.
- Occurs primarily on bluegrass, ryegrass and zoysia.
- Maintain adequate nitrogen fertility levels.
- Reseed with improved turf cultivars.

Powdery mildew

- Blade covered with white coating.
- White coating typically occurs in shady areas in the fall on bluegrass.
- Reduce shade and improve air movement.
- Avoid excessive nitrogen and drought stress.
- Increase mowing height and reseed with improved and disease-resistant cultivars.

Pink snow mold

- Circular patches, 1–6" diameter, pinkish or reddish-brown matted leaves.
- Generally appear at snowmelt or in the presence of plenty of surface moisture during cool-cold overcast periods, especially during the late fall through spring.
- Avoid lush growth entering winter.
- Mow until growth has stopped.
- Apply fungicide as curative if necessary.

Gray snow mold

- Circular patches, 6–36" diameter, matted leaves with a grayish color.
- Generally appear at snowmelt or in the presence of plenty of surface moisture dur-

ing cool-cold overcast periods, especially during the late winter through spring.

- Avoid lush growth entering winter.
- Mow until growth has stopped.
- Apply fungicide as curative if necessary.

Pythium blight

- Circular spots of, 1–3" diameter, leaves are abrasion or water-soaked.
- Mycelium is present during early-morning hours.
- Leaves are rapidly blighted and entire plants die in 24 hours.
- Dead plants are brown or red-brown in color and matted; July–early September.
- Perennial ryegrass is especially vulnerable during hot and humid weather and in poorly drained sites.
- Seedlings of all species planted during warm and humid periods are susceptible.
- Improve soil drainage.
- Avoid planting during hot, humid weather.
- Reseed with improved and disease-resistant cultivars.
- Apply fungicide as curative if necessary.

Key Weeds in Turfgrass

Adapted from: *IPM in Schools* Chapter 18, *IPM For Weeds On School Grounds.* USEPA Document #909-B-97-001 by the Bio-Integral Resource Center, P.O. Box 7414, Berkeley, CA 94707, March 1997. Other references used in the preparation of this section include the IPM Workbook for New York State Schools by S. Stauffer, R. Ferrentino, C. Koplinka – Loehr, and K. Sharpe, Cornell Cooperative Extension Community IPM Program and IPM for Pennsylvania Schools: A How to Manual, Pennsylvania Integrated Pest Management Program.

A "weed" is commonly defined as a plant growing in a place where it is not wanted. Plants can be unwanted because they compete with desired species, because they cause harm to people or structures, or because their appearance or odor is offensive. The designation "weed" can be quite subjective; for instance, the dandelion can be considered a weed in one setting and a wildflower or culinary herb in another.

On school grounds, there is usually consensus on the weedy nature of certain plant species such as thistles, docks, crabgrass, and poison oak or ivy that spring up where they are not wanted. These species have common characteristics that enable them to "take over" when conditions are right. By understanding conditions suited to weed growth, landscapes can be designed and maintained in ways that minimize such conditions, and the need for herbicides can be reduced or eliminated. The goal is to encourage desirable plants to out-compete weeds in habitats where plant growth is acceptable (shrub beds, turf areas, tree wells, student gardens), and to remove conditions conducive to weeds in areas where vegetation is not wanted (in pavement cracks, on running tracks, under fences). A review of basic principles of weed biology and ecology will help identify conditions that promote weed growth and suggest methods for encouraging competitive desirable vegetation and discouraging weeds.

A healthy, dense turf competes well against weeds. Therefore, proper mowing, fertilizing, and soil conditioning should be the first line of defense. Presence of certain weeds can indicate cultural problems. For example, crabgrass and chickweed thrive in lawns that are mowed too low. Some weeds will appear in even the most carefully managed lawn. Digging or pulling can solve minor problems. If weeds overwhelm the

lawn despite good cultural practices, consult the Home and Garden Information Center for advice regarding chemical control. Several products are available for either spot treatment or as preventative control.

Identification and Biology of Weeds

Weeds can be found among both broadleaf plants and grasses. Like all plants, weeds are classified within three general categories according to the duration of their life cycle and their methods of reproduction.

- **Annuals** - These are the most common weeds; they live one year and reproduce by seed. These plants have a rapid life cycle that enables them to germinate, shoot up, blossom, set seed, and die within the space of a few weeks or months. Their rapid life cycle allows them to thrive on a minimum of nutrients and water. An example of an annual weed found in Maryland lawns particularly newly established ones is common purslane.
- **Biennials** - These weeds live two years, and reproduce both vegetatively and by seed. Wild carrot is an example of a biennial weed common in Maryland.
- **Perennials** - These weeds live more than two years. Although perennials produce seeds, their main means of reproduction is usually vegetative, for example, by forming new plants from bulbs or corms, or by producing new top growth from buds located on underground stems (rhizomes). Well known perennial weeds include dandelions, clover, and nutsedge.

Weed Habitats

Weeds tend to grow in places where the soil is bare or disturbed:

- areas that have been cultivated (shrub and flower beds, etc.)
- trampled or close-mowed lawns
- unpaved play areas and paths
- sports fields
- fence lines
- graded roadsides
- cracks in sidewalks or other pavement
- areas where the same herbicide has been used repeatedly and plants tolerant to that material have established

Weedy areas found on school grounds tend to be hot, dry, sunny habitats—often with low nutrient levels and soil moisture. Certain plants such as thistles, knotweeds, plantains, barnyard and crab grasses have evolved to take advantage of these conditions. As they grow, die, and decompose, the soil is stabilized, erosion is reduced, and the soil environment becomes more moist and fertile. Under these improved conditions, plant species with less-weedy characteristics will eventually displace the weeds. Thus a meadow left undisturbed may eventually become a forest.

Detection and Monitoring

The purpose of monitoring is to determine if, when, where, and why weeds are growing or posing a problem, and to assign priorities for habitat change and least-toxic weed suppression. Weed monitoring should be done at several times during the year. In spring turf areas should be monitored to detect broadleaf weeds or winter annuals that escaped control the previous year. Determine if control is necessary and act to reduce problems later. Beginning in early summer look regularly

for summer annuals like crabgrass, oxalis, and spurge and control these weeds while they are still small. In late summer and early fall look for young winter annuals that have just germinated, summer annuals and perennials that have escaped control. One method for keeping track of weed densities is called the transect method. This method is described below.

The Transect Method for Monitoring Weeds in a Lawn

1. **At the beginning and at the end of the season, establish three parallel transect lines along the length of the field. Use the center of the field and two imaginary lines on either side.**

Note: Three transects will give sufficient data to indicate percentage weed cover in the total turf area. If time is limited, information recorded from one transect across a representative area of turf (e.g., down the center of the field) may give sufficient indication of weed trends for management purposes.

2. **Calculate the number of paces you will walk between samples.**
   a. **Measure the length of one of your transect lines in feet (e.g., 360 ft).**
   b. **Measure the length of the pace of the person doing the transect. To do this, slowly walk a known length (e.g., 20 ft), count the number of paces it takes to cover this distance (e.g., 10 paces), and divide the distance by the number of paces (20 ft divided by 10 paces = 2 ft per pace) This figure represents the average length of the pace.**
   c. **Divide the length of the field by the length of the pace (360 ft divided by 2 ft per pace = 180 paces). This establishes the number of paces it takes to walk the transect.**
   d. **Divide the number of paces by the number of samples to be recorded (a minimum of 20 samples is recommended): 180 paces divided by 20 samples = 9 paces per sample. Thus, in this example, a sample will be taken every 9th pace along the transect.**
3. **Stretch lines of string along the three transect lines, laying the string directly on the ground.**
4. **Beginning at one end of the first transect, walk the calculated number of paces (9 paces in the above example), stop and look at a 3 x 3 inch area (this is about the circumference of a softball or the lid to a 1 lb coffee can) immediately in front of your toe. If this area contains part or all of a weed, check the 'yes' box on the first line under 'Transect A' on the monitoring form (below). If you know the identity of the weed, write it down.**

If the toe sample area contains grass, check the 'no' box on the monitoring form. If 25% or more of the toe area sample is bare soil, check the box marked 'bare.' If less than 25% is bare, but a weed is present, check 'yes.' Continue pacing the transect line and marking the monitoring form. Repeat along the two other transect lines.

5. **To calculate the average percentage of weeds, total the number of boxes marked 'yes' in each column and multiply by 100. Divide this number by the total boxes in all columns. The resulting figure represents average percent weed cover in the turf. Do the same calculation with the boxes representing bare ground. This will indicate percent area that will become weedy if not seeded to grass.**
6. **By collecting data from the transects at the beginning and end of each season, the turf manager can spot emerging problem areas. For example, if several boxes in succession are marked 'yes' indicating weed presence, a closer look at this area on the transect is warranted. Usually such 'clumping' of weed growth indicates exceptionally heavy wear on the turf, although structural problems such as severely compacted soil, a broken irrigation line, inoperative sprinkler head, scalping of the turf due to uneven grade, etc.,**

also may be indicated. By monitoring the turf area from season to season, the manager can tell if weed populations are rising, falling, or remaining relatively stable. This information will indicate whether or not current turf management practices are keeping weeds at or below the agreed-upon tolerance level. If weed populations are rising, changes in management practices are indicated.Mapping Weed Habitats

The first step in monitoring is to map areas where weeds are growing. This need not be a detailed, time-consuming process—a rough map will do. For areas to monitor see the list under "Weed Habitats," above.

Weed Monitoring Form for Turf

Location of turf **Date**

Data collected by **Length of pace**

Distance between sampling points on transact

(For example, every nine paces)

Number of transects **Length of transects**

Sketch of location of transects

	Transect A				Transect B				Transect C			
	Yes	No	Bare	Weed I.D.	Yes	No	Bare	Weed I.D.	Yes	No	Bare	Weed I.D.
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												

Identifying Weed Species

It is important to accurately identify the most common weed species on your school grounds in order to determine appropriate management methods. Knowing the scientific name of the weed makes it much easier to obtain information from research professionals and the scientific literature. Assistance is avail-able from Cooperative Extension Service literature and personnel, or pictorial weed guides. Excellent pictures of weeds and their management can be found at the University of Maryland's Home and Garden Information Center website at www.agnr.umd.edu/users/hgic. Weed samples can be preserved by encasing weed samples in plastic shrink-wrap on index cards. This simple method results in a portable, easy-to-use weed reference.

Learn about the growing conditions required by the weed as well as its growth characteristics and methods of reproduction. Weeds can be indicators of soil conditions that need to be changed to discourage weed growth. For example, yellow nutsedge (*Cyperus esculentus*) indicates excessive water perhaps due to a broken irrigation pipe or valve. Conversely, prostrate knotweed (*Polygonum aviculare*) indicates dry, compacted soil requiring aeration and addition of organic matter. By changing the conditions indicated by the weed, these unwanted plants can be discouraged from growing.

Record Keeping

It is important to record the time of year a particular weed species appears, its abundance, and its impact on the landscape. This information will help determine

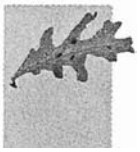
- which weeds and how many of each can be tolerated in a specific area without the weeds impairing the function of the landscape or its aesthetic appeal
- whether or not management strategies are effective
- whether weed populations are rising, falling, or staying about the same from year to year
- whether new species of weeds are becoming a problem (this often happens as a result of weed control efforts) Without this information, it is impossible to determine the long-term effectiveness of management methods.

Establishing Weed Tolerance Levels

School landscape maintenance budgets rarely stretch far enough to suppress all weeds, even if that were desirable. Aesthetic standards should be adjusted to take this into account. Assigning tolerance levels helps prioritize budget allocations, facilitate long-term plans, and provide justification for weed management action—or lack of action.

Identify areas where weeds pose potential health or safety hazards or threaten damage to facilities, and distinguish these locations from those where weeds are considered aesthetic problems alone. For example, poison oak or ivy can cause severe skin rashes and itching, and weeds growing in playing fields can reduce the cushioning ability of turf and increase the chances of sport injury. Weeds in running tracks can pose tripping hazards. Weeds may also provide harborage to other insect, disease, and vertebrate pests such as rodents that may enter schools or damage other plants in the landscape. Assign low tolerance levels to weeds in such areas, and place high priority on their management. On the other hand, assign higher tolerance levels to weeds growing in shrub beds or along fence lines and lower priority for management.

Since most weed tolerance levels are subjective, one way to establish them is to invite a representative group (e.g., the school principal, coach, landscape maintenance supervisor, PTA officer,



teacher, student, and parent) to tour the school grounds and decide where weed levels are acceptable and where they are not. It is important that this group reach consensus on overall weed management objectives for various school sites, and that weed tolerance and action levels derive from this agreement. Weed tolerance levels can be re-evaluated on an annual basis.

Long-Term Weed Management Plans

Long-term plans should focus on making changes to the habitat to permanently exclude weeds in areas where weed tolerance levels are low. In some cases this may require augmented budget allocations. By developing plans, budget needs can be spread over several years.

Evaluation of Weed Management Programs

The availability of herbicides has often helped perpetuate poor landscape designs and inappropriate maintenance practices because herbicides could be used to compensate for them. By gathering monitoring data, the underlying causes of weed presence can be pinpointed. The data can be used to change design specifications for landscapes, sport fields, playgrounds, and pavement to avoid encouraging weeds.

The long-term costs, risks, and benefits of various weed management approaches should also be evaluated. A one-time cost to install concrete or asphalt mow strips under backstops and fence lines and thereby permanently remove weed habitat may be less costly in the long run than repeated herbicide use that may pose a potential health risk, resulting in lawsuits and poor public relations.

Management Options

Horticultural Controls

This approach involves manipulating plant selection, planting techniques, and cultural practices so that desired vegetation grows so densely and vigorously that weeds are crowded out. Planting beds can be rototilled and irrigated to force weed seeds to germinate. As soon as sprouted weeds appear as a "green fuzz" on top of the soil, they can be killed by a second cultivation with the tiller set at 1 inch. Shallow cultivation prevents weed seeds from being moved to the top 2 inches of soil—the germination range. This will reduce weed growth while ornamental plants are becoming established.

Plant Selection

In shrub beds, you can include groundcovers with rapid, spreading growth habits that can outcompete weeds.

Competitive Interplanting

When new plants are installed weeds often colonize spaces between individual plants before the ornamentals can spread and shade them out. These weed habitats can be eliminated by overseeding newly planted areas with fast-growing annual flowers such as sweet alyssum (*Lobularia maritima*), farewell-to-spring (*Clarkia amoena*), and scarlet flax (*Linum grandiflorum var. rubrum*).

Mulching

Mulches are primarily used to exclude light from the soil, thus limiting weed seed germination. Mulches can be composed of organic materials (compost, wood chips, shredded bark, etc.), stones or gravel, or synthetic landscape fabric. Landscape fabric is preferred over black plastic, because it allows air and water to move through the soil to benefit ornamental plant roots, but excludes light

Selective Use of Low Toxicity Herbicides.

Tim Rhay, IPM specialist with the Eugene, Oregon Public Works Department, manages the city's parks and sports fields within an IPM framework. His approach has been adopted by a number of local schools as well. When herbicides are needed, he selects materials that have relatively low toxicity and are compatible with spot-treatment. In discussing his infield/bare-soil weed management program (see also Physical Controls), he writes,
"The integrated methodology developed in Eugene . . . will both provide quality infield surfaces and reduce the resource requirement for doing so. In particular, the need for herbicide application will be dramatically reduced. Some spot treatment may be necessary to deal with noxious perennial plants that do not respond to cultivation. In some cases, a comprehensive treatment may be needed to gain initial control of an area. In some climate zones, treatment may be needed only at the infield/outfield interface, to prevent opportunistic vegetation from creeping into the bare soil area. When such treatment is required, consider low-toxicity granular preemergence materials which can be soil-incorporated during the dormant season, after the field is taken out of play. For post emergence work, newly available fatty acid-based herbicides [i.e., herbicidal soaps] may be useful for some types of vegetation. Others may require the use of foliar-applied, translocated materials such as glyphosate. Consult local regulatory and reference sources before choosing herbicide materials." (Rhay 1994)

at the soil surface to thwart weeds.

To be effective, mulches should be applied immediately after plants are installed. Bark or compost mulches should be 3 to 4 inches deep to exclude light. If landscape fabric is used, it should be covered with an inch or two of bark, stones, etc. to improve the aesthetic appearance of the planting area and reduce degradation of the fabric by sunlight. Landscape fabric can last for years if properly maintained.

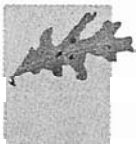
Physical Controls

Hand-pulling, cultivation, and use of string trimmers and mowers are very effective weed control techniques. If labor is in short supply, make good use of parent and student volunteers, community service groups, and youth groups. Classrooms can adopt a flower bed or a section of the school yard to maintain and beautify. If students are involved in grounds maintenance, they will be more careful of the plants and take pride in a clean, well-maintained school yard.

Weeds on baseball infields, running tracks, and other bare soil areas can be suppressed by periodic shallow cultivation with a tractor-mounted rotary harrow, also called a rotary hoe or power rake (Rhay 1994). Drag chains may also be used but are labor intensive. Physical removal of weeds may also damage playing surfaces such as infields and necessitate repair. In areas with heavy clay soils, this method can be combined with addition of sawdust to reduce the crusting and puddling characteristics of these soils.

Eliminate Weed Habitat

Creating a "mow strip" under and immediately adjacent to fence lines can solve a common weed problem. When fences surround paved playing surfaces such as basketball courts, the steel fence posts can be installed directly into the paving material, 8 to 12 inches to the inside of the paving edge. The paving prevents weeds from growing under or adjacent to the fence, and provides a paved strip



for the wheel of a mower that can keep adjacent grass trimmed. The strip also provides access for use of string trimmers when shrub beds abut the fence line.

Weeds can be reduced along fence lines by pouring a 16-inch wide concrete or asphalt strip to cover the soil under and beside the fence. This retrofit can be performed in stages over several years as budgets permit. The one-time paving cost will produce many years of savings in weed control. Use asphalt or cement crack filler to fill cracks in paved areas where weeds are a problem.

Flaming

Flamers are used by a growing number of parks and school districts to treat weeds in pavement cracks, under picnic tables and benches, along fence lines, etc. This technique utilizes a small gas- or propane-fired torch to sear the tops of young weeds. The heat raises the temperature of the sap in the plant cells, the cell walls rupture, and the weed wilts and dies. Flaming is most effective on young annual and perennial weeds in the seedling (4-to 5-leaf) stage, because at that point the fragile root system is killed along with the top growth. Grasses are difficult to kill by flaming because a protective sheath covers their growing tips.

Keep the torch about 6 inches above the vegetation and pass it slowly over the plants. Hold the flamer over each plant briefly so the plant is heated but not actually burned. The leaves may lose their usual green color, but there may not be any evidence of wilting, let alone plant death, for several to many hours. Leaves that have been heated sufficiently to burst cell walls will feel very soft to the touch and may turn a purplish color.

The use of flamers has inherent risks of injury to technicians and property. Adequate training and protective clothing must be provided if flamers are used. Care must be taken to ensure that flames do not damage property and that flames do not contact flammable materials or liquids.

Soil Solarization

This technique uses a covering of clear plastic to raise soil temperatures high enough to destroy weeds and their seeds may be used to prepare areas for small beds. It is generally not used for large areas. For solarization to be effective, daytime temperatures should average 85°F or more, so it should be done during the hottest and sunniest time of the year. Solarization can kill annual or perennial weeds as well as soil pathogens and nematodes. Even tough Bermudagrass can be killed with this method. Solarization can also be used to destroy weed seeds and other soil pests in rototilled beds scheduled for new plantings.

To solarize a section of soil, do the following:

- Mow any existing vegetation to the ground.
- Cultivate to incorporate the vegetation into the soil.
- Provide a smooth surface by raking the soil so it is level.
- Encourage weed seeds to germinate by irrigating the soil 1 to 2 weeks before covering it.
- Irrigate again just before laying down the plastic.
- Use UV-stabilized plastic 2 to 4 mils thick.
- Anchor the tarp by burying its edges in a small soil trench around the area to be solarized.
- In the Southwest, wait 3 to 4 weeks before removing the plastic, and 6 to 9 weeks anywhere else.

Chemical Controls

When nonchemical weed management methods are not sufficient to solve weed problems, herbicides are available for integration into the program. There are many herbicides on the market. For information on the efficacy and hazards of various herbicides and on how to select an appropriate product for your situation, consult your local cooperative extension service. A discussion on the use of herbicides is presented below.

Whenever possible, apply herbicides as spot-treatments to the target weeds. For example, a tool called a "rope wick applicator" can be used to wipe a small amount of herbicide on a single plant or patch of weeds. This reduces human exposure and helps to protect non-target vegetation and beneficial soil organisms that can be damaged or killed by herbicide residues. Wick applicators are available as hand-held versions or as attachments to small tractors and riding mowers.

When applying herbicides, use a colorant to mark the treated area. This will not only insure even coverage, but will help passersby see and avoid the treated area. Do not allow children to play or lie on the treated area—rope it off and post a sign.

Herbicides must be used in accordance with their EPA-approved label directions. Applicators must be certified or registered to apply herbicides and should always wear protective gear during applications. All labels and Material Safety Data Sheets (MSDS) for the pesticide products authorized for use in the IPM program should be maintained on file. Never apply these materials where they might wash into the storm drains, sanitary sewer, creeks, ponds, or other water sources.

Perennial Grass Weed Control

Adapted from Agronomy Mimeo 73, *Perennial Grass Weeds and Their Control in Turf.*
Prepared by Peter H. Dernoeden, Extension Turfgrass Specialist

Perennial grasses growing out of place in lawns, golf courses, highway medians, etc. can be extremely difficult to selectively control in turfgrasses. Tall fescue clumps in Kentucky bluegrass lawns as well as clumps or patches of orchardgrass, Bermudagrass, nimblewill and quackgrass are among the most common perennial grass weeds in Maryland. Other perennial weed grasses in lawns and sports turfs include creeping bentgrass, redtop, timothy, roughstalk bluegrass and smooth paspalum (sometimes called dallisgrass).

Those grasses that spread by above ground stems or runners (stolons) or below ground stems (rhizomes) include creeping bentgrass, roughstalk bluegrass, Bermudagrass, quackgrass and nimblewill. Bermudagrass spreads rapidly by stolons and rhizomes. Creeping bentgrass, roughstalk bluegrass and nimblewill spread by stolons and seed. Quackgrass spreads by rhizomes and seed. Tall fescue, redtop, smooth paspalum, orchardgrass, and timothy spread by seed, and are called bunchgrasses because they generally do not produce either stolons or rhizomes. Bunchgrasses can be removed by digging, but stolon and rhizome spreading grasses are not controlled effectively in this manner. Furthermore, rototilling living plants that spread by stolons or rhizomes will actually encourage their spread.

Creeping bentgrass, Bermudagrass and tall fescue are cultivated and considered desirable grasses in certain situations. Creeping bentgrass is used on golf course greens, fairways and tees in Maryland. Bermudagrass, especially the cultivars *'Tufcote'*, *'Midiron'*, and *'Vamont'*, are used as sports turfs in southern and lower Eastern Shore counties of Maryland. Tall fescue is used extensively for many situations ranging from home lawns to highway medians. Creeping bentgrass and Bermudagrass are typically grown in monostands, and are not intentionally mixed with other species.

Weeds to look for include:

- When tall fescue is mixed with predominantly Kentucky bluegrass stands (i.e. 50% Kentucky bluegrass), it will eventually develop a clumpy growth habit, which is considered objectionable by most people.
- Creeping bentgrass growing in Kentucky bluegrass, tall fescue or perennial ryegrass gives turf a patchy appearance.
- Bermudagrass, quackgrass, smooth paspalum and nimblewill are among the most objectionable of all perennial grass weeds.
- Bermudagrass, nimblewill, and smooth paspalum are warm-season grasses that develop a brown or dead appearance during their winter dormancy periods, which ranges from late October to late May in Maryland. Common Bermudagrass grows very rapidly during summer and spreads into flower beds, gardens, patios, driveways, and sidewalks, as well as golf course fairways and putting greens.
- Quackgrass also spreads rapidly, and quackgrass, common Bermudagrass and smooth paspalum produce coarse-textured and open (i.e. low density) stands.
- Smooth paspalum produces conspicuous clumps in all turfgrasses, but is most commonly found in golf course roughs.
- Orchardgrass also is a clumping bunchgrass that is a common contaminant in tall fescue seed, especially the cultivar '*Kentucky-31*'.
- Timothy and redtop are less common in lawns, but they were used as components of highway seed mixes in the past.
- Roughstalk bluegrass seed is a serious contaminant of seed and is very difficult to control when it is accidentally introduced in new seedings of Kentucky bluegrass lawns, and perennial ryegrass and creeping bentgrass grown on golf courses.
- Annual bluegrass is a prolific seed producer, but tends to be a short-lived weed in lawns, but can persist throughout wet summers.
- Annual bluegrass is a persistent weed when grown on intensively managed and well irrigated turf sites such as golf courses.

Methods of Control

As previously noted, bunchgrasses can be removed by digging. However, most bunchgrasses cannot be controlled with herbicides that selectively kill weeds, while leaving the desirable turfgrass uninjured. Complete Bermudagrass control is rarely achieved with any selective herbicide. In most situations, a nonselective herbicide such as glyphosate or glufosinate is recommended for perennial grass weed control. Non-selective herbicides kill or injure all green plant tissues contacted and therefore they should be used with extreme caution.

Control of Broadleaf Weeds

Adapted from Agronomy Mimeo 79, Broadleaf Weed Control in Established Lawns.
Prepared by P.H. Dernoeden, Extension Turf Specialist

The presence of broad leaf weeds in school lawns and athletic fields mar the appearance of turf. More importantly, they compete with the desired turfgrass for water, nutrients and light. Lack of

control of these weeds often results in a deterioration of the turfgrass stand as the number of weeds increase. This can lead to bare patches under weed leaves, which may pose safety hazards to athletes. Control of weeds is not by itself enough because a weed problem is often symptomatic of a more basic cultural or soil problem. If these problems persist, weeds also will be a continuous problem. Thus, weed control not only includes removal of existing weeds, but also taking corrective management measures for the factors causing the poor lawn so that weeds will not become a recurring problem.

Cultural Control of Broadleaf Weeds

The numbers and types of weeds found in lawns are greatly influenced by management and cultural practices. For example, close mowing and too little nitrogen favor white clover. Close mowing also favors weeds such as carpetweed, spurge, plantains, and dandelion. Poorly drained areas favor weeds such as ground ivy and chickweed, while compacted sites favor knotweed.

Correcting improper management practices so that a dense, vigorous turf develops is the best and most lasting method for broadleaf weed control. Of particular importance are proper fertilization, mowing, and watering, mentioned earlier in this document. Although chemical control of most weeds may be possible with the proper use of a labeled herbicide, weeds will become a recurring problem if poor management and cultural practices are continued. A few broadleaf weed species cannot be controlled satisfactorily by herbicides and non-chemical choices of control are preferred on school grounds, so proper management is necessary to reduce the opportunity for their establishment and spread. Once large numbers of weeds have been controlled, vigilant digging or hand-pulling young weeds as they emerge can effectively keep lawns free of broadleaf weeds for long periods.

Glossary

A

Action Threshold (Action Level). The number of pests or level of pest damage that triggers a control action. For an explanation of action thresholds see Maryland Department of Agriculture, Action Thresholds and School IPM Programs. Pesticide Regulation Section, Annapolis, MD. 10 pp. Available at http://gnv.ifas.ufl.edu/~schoolipm/tp.htm

Active Ingredient. The chemical or chemicals in a pesticide responsible for killing or repelling a pest. Active ingredients are listed as part of the Ingredient Statement on all pesticide labels.

Aeration. The exchange of gases that occurs between the atmosphere and soil. Also, the process of amending soil to facilitate gas exchange.

Aerobic Conditions. The condition when water is not fully occupying the pore spaces and atmospheric gases can exchange with soil gases.

Anaerobic Conditions. No-oxygen conditions that occur when pore spaces are filled with water and no gas exchange occurs between soil and the atmosphere.

Anti-Microbial Pesticide. A pesticide used for control of microbial pests, including viruses, bacteria, algae, nematodes and protozoa, or for the purpose of disinfecting or sanitizing. Anti-microbials do not include fungicides used on plants.

B

Bait. A food or other substance used to attract a pest to a pesticide or trap.

Balled-and-burlapped Stock. Tree stock with roots encased in a ball of soil that is wrapped in a fabric burlap, cloth, or wire.

Bare-root Stock. Plant material with bare roots packed in moisture-holding peat or moss.

Basal Pruning. The removal of stems at ground level from shrubs.

Beneficial Insectary Plants. Plant species that attract beneficial insects, like the ladybugs or parasitic wasps.

Biological Control. Control of pests using predators, parasites, and disease-causing organisms. Biological controls may be naturally occurring or introduced.

Biostimulant. Commercially prepared formulation containing nutrients and/or biological products or organisms, usually added to soil at the time of transplanting to stimulate root growth and plant establishment.

Botanical Pesticide. A pesticide produced from plant-based chemicals. Examples include nicotine, pyrethrins, and strychnine.

Brand Name. The name or designation of a specific pesticide product or device made by a manufacturer or formulator.

Broadcast. A pesticide application method of applying a pesticide over an entire area.

C

Caliper. The diameter of the tree, usually measured at 6 or 12 inches above the ground.

Certified Applicator. In individual that demonstrates a higher level of competence of pesticide use by meeting criteria established by the Maryland Department of Agriculture (MDA). A certified applicator must pass examinations administered by MDA.

Chemical Control. The use of a pesticide to reduce pest populations or activity.

Chemical Name. The scientific name of the active ingredient(s) found in a formulated product. The chemical name is derived from the chemical structure of the active ingredient.

Common Name. A name given to a pesticide active ingredient by a recognized committee on pesticide nomenclature. Many pesticides are known by a number of trade or brand names, but the active ingredient has only one recognized common name.

Companion Planting. Planting a diversity of plants that, when grown together, will reduce problems with the pests or environmental conditions.

Container Stock. Plant material that comes in a container with soil.

Crack and Crevice Treatment. A pesticide application method in which small quantities of pesticides are placed precisely into cracks, crevices, and other small openings where pests hide.

Cultural Control. A pest control method that involves changing human habits and practices such as sanitation, work practices, and garbage pickups schedules. This also includes altering landscape design, installation, and maintenance of grounds to reduce pest activity and damage.

D

DBH (diameter at breast height). Diameter of the tree at 4 feet. above the ground.

Degree-day Accumulations. Degree-days are the number of degrees above a threshold or base temperature that occur in a 24-hour period. Degree-day accumulations are the sum of these degree-days over a period of time, usually an entire season, beginning when temperatures first go above the threshold temperature.

E

Environmental Protection Agency (EPA). The federal agency responsible for ensuring the protection of humans and the environment from the potential adverse effects of pesticides.

EPA Registration Number. A number assigned to a pesticide product when the product is registered for use by the EPA. The number must appear on the all labels for a particular product.

Exotic Plants. Non-native plants introduced into an area. Invasive exotics can aggressively take over native plants, shutting out the more beneficial species.

F

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The federal law and its amendments that regulate pesticide registration and use.

Formulation. The pesticide product as purchased, containing a mixture of one or more active ingredients, carriers (inert ingredients), and other additives that make it easy to store, dilute and apply.

H

Habitat modification. The alteration of landscape design and management practices or structural modifications that reduce or prevent pest problems.

Harborage. The hiding places or protected areas where pests live, such as cracks and crevices.

Heading Back. Pruning that involves cutting a growing or one-year-old shoot back to the stub.

I

Inert Ingredients. Materials in a pesticide formulation that do not have anti-pest activity. Ingredient Statement. The part of a pesticide label that provides the name and amount of each active ingredient and the total amount of inert ingredients in the formulation.

Integrated Pest Management (IPM). The Maryland Department of Agriculture's law and regulations have defined IPM as "a managed pest control program in which methods are integrated and used to keep pests from causing economic, health related, or aesthetic injury through the utilization of site or pest inspections, pest population monitoring, evaluating the need for control, and use of one or more pest control methods including sanitation, structural repair, nonchemical methods, and, when nontoxic options are unreasonable or have been exhausted, pesticides, in order to minimize the use of pesticides and minimize the risk to human health and the environment associated with pesticide applications. "

Insect Growth Regulator (IGR). A pesticide that mimics insect hormones responsible for controlling molting and development of some insects systems. This disrupts the insect's ability to develop from the immature form to an adult.

K

Key Location. A site in a landscape or structure where pests occur more frequently or cause greater amounts of damage that requires intervention.

Key Pest. An insect, mite, disease, nematode or weed that frequently results in unacceptable damage and typically requires a control action. Key pests vary among geographic regions. Key pest status is dependent on action thresholds set for the pest and the status may differ among specific sites on school grounds and buildings. For example, cutworm may be a key pest on high-visibility athletic fields, but not on adjacent lawn areas. Routine or regularly scheduled pesticide applications may mask key pests.

Key Plant. A plant that frequently experiences unacceptable plant damage and typically requires treatment. Key plants vary among geographic regions. Improper site selection, plant selection, installation, and maintenance can result in a plant becoming a key plant by increasing its susceptibility to pests.

L

Label. The written material attached to or on all pesticide containers that provides the instructions users must legally follow.

Least Hazardous Materials. A control strategy that uses materials, practices and methods, including the use of chemicals, in a manner that causes the least exposure or harm to humans and the environment. The "least hazardous materials" strategy considers the pest control method, toxicity of the product, and exposure to occupants. For example, the use of a nonvolatile material formulation and/or application method is considered a "least hazardous materials" strategy, as opposed to a broadcast application and/or use of a volatile material.

M

Maintenance Pruning. Periodic pruning involving the removal of dead, diseased or weak branches from the crown; thinning of the crown; removing lower branches to provide clearance; reducing the crown height or spread; or removing branches to improve the structure or appearance of the tree.

Least-Impact Pest Control Options. Pest control actions that have very low mammalian toxicity, or ready-to-use, nonvolatile formulations of baits in tamper-resistant bait stations placed in areas inaccessible to children and staff. Nonchemical pest control options, such as cultural, mechanical, or physical controls, are considered least-impact options.

Maryland Department of Agriculture (MDA). The state agency responsible for administering the statutes contained in the Maryland Pesticide Applicators Law and Regulations. MDA is responsible for regulating the sale, use, and storage of pesticides.

Mechanical Control. The removal of pests by vacuuming, hand picking, pruning, crushing, dislodging by water or air, or disruption of pest activity and movement by impediments.

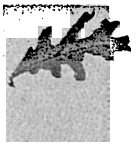
Monitoring. A systematic pest inspection conducted at regular intervals to determine the types of pests, their numbers, the amount of damage caused by pests, entry points, access to food, water, and harborage sites, and the effectiveness of treatment methods. Beneficial organisms are also observed during monitoring.

Native Plants. Trees, shrubs, vines, ground covers or herbaceous plants that would have been present before modern humans altered the landscape.

N

Natural Enemies. Predators, parasites, and pathogens that kill insect or mite pests.

Nonchemical Controls. Pest control measures that do not use pesticides or other chemicals. Nonchemical controls include biological, physical, mechanical, and cultural tactics and strategies.



Nontarget. Any site or organism other than the site or pest toward which to control measures are directed.

O

Ornamental Plants. Cultivars developed for their aesthetic qualities, functionality, and/or disease and insect resistance.

Organic Matter. The organic part of the soil, including plant and animal residues, cells and tissues of soil organisms, and substances produced by soil organisms. Usually makes up less than 10% of soil matter.

P

Pathogen. A living microorganism, usually a bacterium, fungus, mycoplasm or virus, that can cause disease when a host is present under the right environmental conditions.

Permeability. The ability of water, gases and roots to move through the soil. Soil texture, structure, and pore space affect permeability.

Pest. Any living organism (animal, plant or microorganism) that interferes or threatens human, animal or plant health, property or the environment. A pest in one environment may be beneficial in another. For example, many plants that are considered weeds when found in lawns can be essential to the restoration of natural landscapes after a disturbance such as flood, fire, or human intervention.

Pesticide. A substance used to control, prevent, destroy, repel, or mitigate any pest.

Pest-proofing. A nonchemical, physical control measure to prevent the entry or movement of pests into or out of a structure or area. Pest-proofing might include sealing and caulking of crevices and holes, or installing screens and door sweeps.

Pesticide Applicator Law and Regulations. The Maryland statutes that outline the requirements concerning how pesticides are sold, used, stored, and disposed.

Pesticide Business License. The license issued by the Maryland Department of Agriculture that is required of any business offering pest control services or applying general or restricted-use pesticides for hire, or as part of a service or contract agreement.

Physical Control. Habitat alteration or changes in physical structure to reduce pest populations or their activity. Physical controls address problems such as caulking, holes, and cracks, sealing doors and windows, reducing moisture , or improving ventilation.

Pore Space. The openings between soil particles.

Primary nutrients. Nutrients most needed by plants, including nitrogen, phosphorus and potassium.

Q

Quality Control. An inspection and review of the pest control program to evaluate success and identify shortcomings of the program.

Glossary

R

Reduced-Impact Pest Control Options. Pest control options with low mammalian toxicity, formulations that do not present an obvious physical hazard, and with active ingredients that are not known to cause cancer or disrupt human hormones.

Re-Entry Period. The time that must elapse from the completion of a pesticide application until the students and staff may re-enter the building.

Registered Pesticides. Pesticide products that have been registered by the Environmental Protection Agency (EPA) for the uses listed on the label.

Repellent Planting. Plants or plant combinations that give off chemicals that keep insects and other pests away from surrounding plants.

Residual Pesticide. A pesticide that continues to remain effective on a treated surface or area for an extended time period following application.

Routine Pesticide Application. A prescheduled pesticide application performed as a preventive measure without confirmation of pest presence or levels of infestation.

S

Salt Index. Used to compare solubility of chemical compounds. Indexes are assigned relative to sodium nitrate, $NaNO_3$, which has a salt index of 100. The salt index of fertilizer, which should be listed on the label, should be less than 50.

Sanitation. Measures that promote cleanliness and pest-free surroundings. Indoors pest control sanitation involves removing pest food sources and physically altering potential access and harborage sites. Outdoors removal of plants or plant parts that serve as harborage or a source of inoculums for pests.

Scouting (see also Monitoring). Planned, routine monitoring of a crop, ornamental planting, landscape, or structure for the purpose of detecting pests, pest damage, or conditions conducive to pests or pest damage. Beneficial insects and their activities are also observed.

Secondary Nutrients. Nutrients needed in small amounts for plant growth, including calcium, magnesium, sulfur, boron, copper, chlorine, iron, magnesium, molybdenum, and zinc.

Soil Amendments. Fertilizers or other materials added to soils to improve plant growth. Soil amendments can be organic or inorganic.

Soil Nutrients. The organic matter and minerals needed for plant growth that are present in soil. Nutrients needed in the greatest amounts include nitrogen, phosphorus and potassium. (See also primary nutrients and secondary nutrients.)

Soil pH. The measure of the hydrogen ion concentration in soil. A pH value of 7.0 is neutral; values below are acidic and those above are alkaline.

Soil Structure. The arrangement of the particles in soil.

Space Spray. A pesticide that is applied as a fine spray or mist to a confined area, usually used to kill flying or crawling insects.

Spot Treatment. A pesticide application restricted to specific areas or plants. For indoor pests areas do not exceed 2 ft^2. Spot treatments are applied where pests are likely to occur, such as portions of

floors or walls, or the base or underside of equipment. In landscapes and on grounds spot treatments include individual plants, parts of plants, sections of turfgrass but never entire landscapes.

Sustainable plants. Noninvasive plants that require minimum maintenance because they are well-adapted to local growing conditions.

T

Tamper-Resistant Bait Station. A container for toxic bait that is used for rodent and insect control. Tamper-resistant bait stations provide the least risk to children, pets, and other animals. As defined by the US Environmental Protection Agency (EPA), the bait stations must be durable, lockable, have warning labels, and be anchored to keep them in place.

Thatch. The layer of dead grass stems and roots that builds up in a lawn.

Thinning. Removal of tree branches by cutting back to a crotch.

Threshold (see also Action Threshold). The level of pest density (based on number of pests observed, trapped, counted, etc.) that requires some action. Pest thresholds in urban pest management may be site-specific. For example, different numbers of cockroaches may be tolerated in different sites (such as the kitchen vs. garbage rooms). In some situations pests cannot be tolerated and the threshold may be set at zero.

Topping. An extreme version of pruning, when stems, branches and sometimes the trunk of the tree are cut off the tree top without considering placement of cuts or the health of the plant. Topping is not recommended.

Toxicity. The ability of a pesticide to cause harmful, acute, delayed, or allergic effects.

Tree Spades. Large blades attached to a vehicle used to remove and transplant larger trees.

U

Utility Pruning. Maintenance pruning to provide space for utilities and structures.

V

Void Treatment. A pesticide application method in which a spray or dust is injected or blown into the empty spaces inside walls, false ceilings, or other enclosed areas.

W

Water-holding Capacity. The ability of soil to hold water. The water-holding capacity of the soil is related to soil texture and the size and number of soil pores.

WIN (Water Insoluble Nitrogen). Slow-release nitrogen that does not dissolve in water.

Watersprouts. Suckers that grow out from the bottom of grafted trees where roots are grafted to the trunk.

X

Xeriscaping. Water-efficient landscaping.

References

Bosmans, R.V. 1994. *Poison Ivy.* HG Mimeo 34. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 2 pp.

Brown, A.E., H. Rasmussen, and E. Crow. 2000. *Synopsis of the Maryland Pesticide Applicators Law and Regulations.* Pesticide Information Leaflet No. 35. Maryland Cooperative Extension, University of Maryland, College Park, MD. 8 pp.

Chesapeake Bay Program. 1999. *Better Backyard: A Citizen's Resource Guide to Beneficial Landscaping and Habitat Restoration in the Chesapeake Bay Watershed.* Chesapeake Bay Program, US Environmental Protection Agency, Annapolis, Maryland. 56 pp.

Daar, S., T. Drlik, H. Olkowski and W. Olkowski. 1997. *IPM for Schools: A How-to Manual.* US Environmental Protection Agency, Washington, DC and Bio-Integral Resource Center, Berkeley, CA. EPA 909-B-97-001. 213 pp. www.epa.gov/region09/toxic/pest/school/index.html

Davidson, J.A., E. Lewis and M.J. Raupp. 1998. *Integrated Pest Management in Schools: IPM Training Manual for Grounds Maintenance.* Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 160 pp.

Dernoeden, P.H. 2000. *Maryland Turfgrass Disease Control Recommendations.* AG numeral 80. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 4 pp. Webpage by the Institute of Applied Agriculture, University of Maryland, College Park. http://128.8.190.44/umturf/Diseases/MTC%20PRIMARY%20PAGE

Dernoeden, P.H. 1999. *Broadleaf for Weed Control in Established Lawns.* AG 79. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 4 pp.

Dernoeden, P.H. 1999. *Irrigation and Water Conservation on Home Lawns.* AG 88. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 4 pp.

Dernoeden, P.H. 1999. *Perennial Grass Weeds and Their Control in Turf.* AG 73. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 3 pp.

Dernoeden, P.H. 1997. *Diagnosing Common Lawn Diseases.* AG 84. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 7 pp.

Magdoff, F. and H. van Es. 2000. *Building Soils for Better Crops.* Second edition. Sustainable Agriculture Network, University of Vermont, Burlington, Vermont. 230 pp.

Malinoski, M.K., and D.L. Clement. No date. *IPM Series: Annuals and Perennials.* HG Mimeo 94. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 6 pp.

Malinoski, M.K., J.H. Traunfeld, and D.L. Clement. 1996. *IPM: A Common-Sense Approach to Managing Problems in Your Landscape.* HG Mimeo 62. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 8 pp.

Maryland Cooperative Extension. 1997. *Why Test Your Soil?* Leaflet 142. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 2 pp.

Maryland Department of Agriculture. Fact sheets. Maryland Department of Agriculture, Annapolis, MD.

References

Integrated Pest Management-What Is It? 1995

Notification Requirements for Pesticide Applications to Public School Grounds. 2000.

Pest Control and Sanitation-What Can I Do? 1995

Public School IPM and Notification Requirements. 1999.

Structural Pest Control Using the IPM Approach. 1999.

Maryland Department of Agriculture. 1995. *Guidelines for Integrated Pest Management (IPM) in Schools.* Maryland Department of Agriculture, Annapolis, MD. 9 pp.

Maryland Department of Agriculture. 2000. *Implementation of Integrated Pest Management in Maryland Public Schools.* Maryland Department of Agriculture, Annapolis, MD. 16 pp.

Maryland Department of Agriculture. 1997. *Summary of Structural Pest Control Programs and Implementation of Integrated Pest Management (IPM) in Maryland Public School Systems.* Maryland Department of Agriculture, Annapolis, MD. 37 pp.

National Park Service. 1999. *The National Park Service Integrated Pest Management Manual.* National Park Service in, Fort Collins, Colorado. www.nature.nps.gov/wv.ipm/manual.htm

Pennsylvania Integrated Pest Management Program. 2001. *IPM for Pennsylvania Schools: A How-To Manual.* Penn State College of Agricultural Sciences Cooperative Extension, State College, Pennsylvania. 110 pp. http://paipm.cas.psu.edu

Pinto, L.J. and S.K. Kraft. 2000. *Action Thresholds in School IPM Programs.* Maryland Department of Agriculture, Annapolis, Maryland. 8 pp.

Pinto, L.J. and S.K. Kraft. 1999. *Integrated Pest Management in Schools: IPM Training Manual.* Maryland Department of Agriculture, Annapolis, Maryland. 56 pp.

Ricciuti, P.J. 1997. *Landscapes that Help the Chesapeake Bay.* Factsheet 701. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 4 pp.

Ricciuti, P.J. 1997. *Lawn Renovation.* HG 37. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 2 pp.

Ricciuti, P.J. 1997. *Saving Your Soil and the Chesapeake Bay.* Factsheet 704. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 2 pp.

Ricciuti, P.J., D. Clement, and M.K. Malinoski. 1999. *IPM Series: Turf.* HG 63. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 7 pp.

Stauffer, S., R. Ferrentino, C. Koplinka-Loehr, and K. Sharpe. 1998. IPM Workbood for New York State Schools. Cornell Cooperative Extension Community IPM Program, Ithaca, NY.

Tjaden, R.L. and G.M. Weber. 1999. *Riparian Buffer Management: Grasses for Riparian Buffers and Wildlife Habitat Improvement.* Factsheet 728. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 8 pp.

Traunfeld, J. and E. Nibali. 1998. *Soil Amendments and Fertilizers.* HG Mimeo 42. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 8 pp.

Traunfeld, J., D.L. Clement, and R.V. Bosmans. 1998. *Watering Tips for Drought Conditions.* HG Mimeo 85. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 2 pp.

Turner, T.R., D. Funk, and J. Krouse. 2001. *Turfgrass Cultivar Recommendations for Certified Sod and Professional Seed Mixtures in Maryland.* AG Mimeo 77. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 8 pp.

Turner, T.R. 1999. *Caring for the Newly Seeded Lawn.* AG Mimeo 67. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 2 pp.

Turner, T.R. 1999. *Nutrient Management Guidelines for State Property and Commercially Managed Turfgrass.* AG Mimeo 115. Maryland Cooperative Extension, University of Maryland, College Park, Maryland. 10 pp.

US Fish and Wildlife Service and Alliance for the Chesapeake Bay. 1998. *BayScaping for the Long Term.* US Fish and Wildlife Service, Chesapeake Bay Field Office, and Alliance for the Chesapeake Bay, Annapolis, Maryland. 6 pp.

US Fish and Wildlife Service and Alliance for the Chesapeake Bay. 1998. *BayScaping to Conserve Water.* US Fish and Wildlife Service, Chesapeake Bay Field Office, and Alliance for the Chesapeake Bay, Annapolis, Maryland. 6 pp.

US Fish and Wildlife Service and Alliance for the Chesapeake Bay. 1998. *Conservation Landscaping.* US Fish and Wildlife Service, Chesapeake Bay Field Office, and Alliance for the Chesapeake Bay, Annapolis, Maryland. 6 pp.

Additional Resources

Alliance for the Chesapeake Bay
6600 York Road, Suite 100
Baltimore, MD 21212
410-377-6270
Alliance for the Chesapeake Bay, Chesapeake Regional Information Service (CRIS)
800-662-CRIS
www.acb-online.org

Chesapeake Bay Program Office
US Environmental Protection Agency
410 Several Avenue, Suite 109
Annapolis, MD 21403
800-YOUR BAY
www.chespeakebay.net/bayprogram

Home and Garden Information Center
Maryland Cooperative Extension
12005 Homewood Rd.
Ellicott City, MD 21042
800-342-2507
www.agnr.umd.edu/users/hgic

Invasive Species Alerts
www.agnr.umd.edu/users/hgic/invasive.html

Howard County Master Garden program office
3525-L Ellicott Mills drive
Ellicott City, MD 21043
410-313-2707

Maryland Department of Agriculture
50 Harry S. Truman Parkway
Annapolis, MD 21401
410-841-5700
www.mda.state.md.us
For information on the IPM program, pest control and pesticide use contact the Pesticide Regulation Section. For information on fertilizer recommendations contacted the Nutrient Management Section.

Maryland Department of Natural Resources
Tawes State Office Building
580 Taylor Avenue
Annapolis, MD 21401
410-260-8367
www.dnr.state.md.us

US Fish and Wildlife Service
Chesapeake Bay Field Office
177 Admiral Cochran Dr.
Annapolis, MD 21401
410-573-4500
www.fws.gov/r5cbfo

Maryland State Cooperative Extension County Offices
Allegheny County
701 Kelly Road, Suite 101
Cumberland, MD 21502
301-724-3320

Anne Arundel County
101 Crain Highway, NW, Suite 307
Glenn burning, MD 21061
410-222-6758

Arundel Center North
Metro: 301-970-8250 x 6757
Baltimore City
17 S. Gay Street
Baltimore, MD 21202
410-396-1753

Baltimore County
9811 Van Buren Lane
Cockeysville, MD 21030
410-666-1022

Calvert County
PO Box 486
150 Main Street, Suite 300
County Services Plaza
Prince Frederick, MD 20678
410-535-3662
Metro: 301-855-1500

Caroline County
207 S. Third St.
Denton, MD 21629
410-479-4030

Carroll County
700 Agriculture Center
Westminster, MD 21157
410-848-4611
Baltimore Metro: 410-875-2801

Cecil County
Cecil County Courthouse
129 East Main Street, Room 7
Elton, MD 21921
410-996-5280

Charles County
9375 Chesapeake Street, Suite 119
LaPlata, MD 20646
301-934-5403
Metro: 301-753-8195

Dorchester County
County Office Building
PO Box 299
501 Court Lane, Room 208
Cambridge, MD 21613
410-228-8800

Frederick County
330 Montevue Lane
Frederick, MD 21702
301-694-1594

Garrett County
1916 Maryland Highway, Suite A
Mt. Lake Park, MD 21550
301-334-6960

Harford County
PO Box 663
2335 Rock Spring Road
Forest Hill, MD 21050
410-638-3255

Howard County
3525-L Ellicott Mills Drive
Ellicott City, MD 21043
410-313-2707
Metro: 301-621-4300

Kent County
203 Calvert Street
Chestertown, MD 21620
410-778-1661

Montgomery County
18410 Muncaster Road
Derwood, MD 20855
301-590-9638

Prince George's County
6707 Groveton Dr.
Clinton, MD 20735
301-868-9366

Queen Anne's County
505 Railroad Avenue, Suite 4
Centreville, MD 21617
410-758-0166

St. Mary's County
21580 Peabody Street
PO Box 663
Leonardtown, MD 20650
301-475-4482

Somerset County
30730 Park Dr.
Princess Anne, MD 21853
410-651-1350

Talbot County
PO Box 519
125 Bay Street
Easton, Maryland's 21601
401-822-1244

Washington County
1260 Maryland Avenue
Hagerstown, MD 21740
301-791-1304

Wicomico County
PO Box 1836
Salisbury, MD 21802
410-749-6141

Worcester County
PO Box 219
Snow Hill, MD 21863
410-632-1972