

***Abstract:** This publication is written for lawn care professionals, golf course superintendents, or anyone with a lawn. Its emphasis is on soil management and cultural practices that enhance turf growth and reduce pests and diseases by reducing turf stress. It also looks at mixed species and wildflower lawns as low maintenance alternatives to pure grass lawns.*

By **Barbara Bellows**
NCAT Agriculture Specialist
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Illustration 1. A healthy lawn complements a healthy garden. (Photo by Ron Francis, Natural Resources Conservation Service)

Related ATTRA Publications

[Farm-Scale Composting Resource List](#)
[Alternative Soil Testing Laboratory Resource List](#)
[Alternative Soil Amendments](#)
[Sources of Organic Fertilizers and Amendments](#)
[Flame Weeding for Vegetable Crops](#)
[Notes on Compost Teas](#)
[Biointensive Integrated Pest Control](#)

Introduction

One 1996 survey found that more pesticides are used on turfgrass than on any other ornamental (1). High-maintenance turfgrass sites such as golf courses use large amounts of fuel, fertilizer, pesticides, and water (2). However, homeowners, landscapers, and golf course managers are becoming increasingly interested in organic and least-toxic turf care. Reasons for this increased interest include (3):

- Elimination of pesticides from recreational areas such as lawns, parks, golf courses, and athletic fields to eliminate exposure of people and pets
- Decreased susceptibility of turf to pests, diseases, and drought
- Reduced runoff and leaching of excess nutrients and pesticides into surface and ground waters
- Enhanced biodiversity in urban regions, which contributes to the conservation of species (birds, insects, herbs, others)

Organic and Least-toxic Turfcare Practices

Organic or least-toxic turf management reduces stress on the turf. Turf experiences stress from heat, drought, wetness, compaction, nutrient deficiencies or imbalances, and disease and pest infestations. To minimizing stress on turf, you need to pay attention to the following principles:

- Establish and maintain a healthy soil environment
- Include a diversity of species in the lawn environment
- Use cultural practices that reduce stress on turf growth
- Understand and work with your local soil and climate conditions
- Use biological pest control methods

A Healthy Soil Environment for Turf

Good quality soil with an active population of earthworms, fungi, bacteria, and beneficial nematodes is critical for creating and maintaining healthy lawns. According to Dr. Eric Nelson (2), turfgrass specialist at Cornell University, “The challenge of the turfgrass manager is to become an expert not only in the management of what everyone can see above the ground, but in the management of beneficial soil microorganisms to maximize turfgrass health.”

“The heart of organic lawn care is the natural build up of your soil. Healthy soils nurture a healthy turf, which grows much better and has an increased resistance to stress caused by heat, cold, drought, insect pests, diseases, and weeds. A successful organic fertilizer program provides for the long-term needs of your lawn by adjusting deficient nutrients with organic fertilizers and soil conditioners.”

Shannon Pope, proprietor of Healthy Soils, an organic lawn care service

“The challenge of the turfgrass manager is to become an expert not only in the management of what everyone can see above the ground, but in the management of beneficial soil microorganisms to maximize turfgrass health.”

Dr. Eric Nelson, Cornell University

Fungi, bacteria, beneficial nematodes, and earthworms in the soil are important for the decomposition of thatch, enhancing soil aeration through the formation of soil aggregates, and reducing populations of soil-borne plant pathogens. To support a healthy and diverse population of soil organisms, soils need to have on-going additions of organic matter, a near neutral pH, and a balanced supply of nutrients. In addition, soil organisms thrive best in soils that are well aerated and moist but not wet.

Soil management practices that promote the growth of beneficial soil organisms include:

- Adding compost
- Monitoring soil pH and managing for consistent soil fertility

- Preventing soil compaction
- Reducing or eliminating the use of synthetic chemicals

Compost additions. Continued applications of synthetic fertilizers and pesticides create a toxic environment for earthworms, fungi, bacteria, and beneficial nematodes through radical changes in pH and the build up of toxic salts and other compounds (heavy metals) sometimes found in fertilizers. In contrast, mature compost enhances populations of soil organisms by providing them with an excellent source of nutrients.

Soil quality. When soil organisms use and decompose compost, they form slimes, gels, and filaments that bind soil particles together into soft clumps called aggregates. Soil aggregates improve conditions for turf growth by increasing soil pore space, which then allows for less restricted root growth and easier flow of water, nutrients, and air through the soil and to plant roots. The low density of compost helps increase soil softness or friability, while its high surface area and chemical activity increase the water and nutrient holding capacity of soil. Several turf specialists recommend applying high rates of compost to improve degraded soil (4, 5). The NOFA Standards for Organic Lawn Care (6) recommends applying one inch or three cubic yards of compost per 1,000 square feet for marginally-good soils. For very sandy or low-organic matter soils, they recommend a two-inch layer or six cubic yards of compost per 1,000 square feet.

Compost as a fertilizer. Mature compost provides turf plants with a balanced source of nutrients that are released slowly into the soil. In their excellent book, *Ecological Golf Course Management*, Paul D. Sachs and Richard T. Luff (4) state:

...plants have a hard time understanding and adapting to the feast to famine scenario associated with many chemical-feeding programs. During periods when nitrogen is inadequate plants respond by elongating roots. When a tidal wave of nitrogen becomes available from an application of soluble nitrogen, an extra-diffusive root system absorbs more than the plant needs, some serious side-effects that include disease susceptibility, insect attraction, burning, and other problems can occur. In a healthy ecosystem, however, there are mecha-

nisms that buffer and regulate the amount of nitrogen available to plants.

Unlike soluble, synthetic fertilizers that immediately release available nutrients into the soil, the organic residues used to form compost must decompose before their nutrients are available to plants. Good quality compost contains both readily available and stored nutrients. Once compost is added to the soil, weak acids secreted by plant roots release the available nutrients from compost, and over time soil organisms break down and mineralize additional nutrients. See Appendix, Table 1, for characteristics of good quality composts.

Compost maturity. As will be discussed in more detail below, compost can effectively suppress some turf pathogens. However, the compost must be mature—fully composted and cured—for it to provide these disease suppressive benefits. In cured compost, heat-loving microorganisms have decomposed the organic stock materials, and then more moderate temperature microorganisms have stabilized various organic acids into humus. Compost piles that are well aerated, contain a balanced mix of stock materials, and are managed at optimum temperature and moisture content will decompose and cure more rapidly than less intensively managed compost piles. Mature compost will have generated enough heat to kill most pathogens and weed seeds and will have undergone sufficient mineralization of organic materials to supply readily available nutrients (7, 8, 9).

You can make a preliminary assessment of compost maturity simply by filling a plastic bag with moist compost, sealing it, and letting it sit in the sun for a few days. If the compost has an earthy smell when you open the bag, it is mature; if it smells of sulfur or ammonia, it is still immature (5). In addition, special soil analysis laboratories can assess the types of microorganism dominating the compost pile and the level of biological activity. The ATTRA publication [Alternative Soil Testing Laboratory Resource List](#) provides contact information and descriptions of the analysis capabilities for many alternative soil testing laboratories.

If you are purchasing compost, make sure that it is from a reputable source and that it is mature,

nutritionally well balanced, and does not contain heavy metals, pathogens, or other toxic substances (7, 9, 10). If you want to make your own compost, the ATTRA publication *Farm-Scale Composting Resource List* provides a compendium of books and Web sites that can guide you.

Compost application. Compost can be tilled into the soil during turf renovation, used as a topdressing, or sprayed on as compost tea. Solid compost can be applied as an unmixed material or mixed with sand for easier handling. The method of application depends on whether you want to improve soil quality, enhance soil fertility, or control pests and diseases.



Tilling compost into soil during lawn renovation.

When fertilizing turf, base the compost applications on the nutrient needs of the turf, which are described in greater detail below. To accurately calculate the amount of compost needed to meet the nutrient needs of a lawn or turf, sample the soil and test the nutrient content of the compost. Since compost is a biological material, its nutrients are released slowly – depending on the quality and maturity of the compost and the climate where the compost is applied, only about one-third to one-half of its nutrients are available during the first year after application.

For maintenance of existing turf, apply compost as a topdressing. Compost may be applied as an unmixed material. However, in the turf industry, compost is typically mixed with sand 50/ 50, while for golf courses, topdressing mixes typically contain 70% to 90% sand and 10% to 30% compost (4, 11). The advantages of mixing compost with sand are easier application and better

distribution. But adding sand to compost can cause compaction problems if the topdressed soil is high in clay. To best mix compost with the soil in existing turf, core aerate the turf, broadcast the compost, then run a drag chain over the ground to sweep the compost into the aeration holes.

The best time to apply compost is in the spring or fall. Compost applied in the spring provides nutrients during the main growing season while compost applied in the fall helps prolong the growing season, strengthens root growth for the dormant season, and promotes early spring growth (12). As will be discussed in more detail later, compost mixed with cool-season grass seed in the fall facilitates effective overseeding.

Managing for soil fertility. Turfgrass requires nitrogen (N), phosphorous (P), potassium (K), and other nutrients. As for fields or gardens, turf should receive fertilizer applications based on its nutrient needs. To accurately calculate the amount of compost needed to meet the nutrient needs of a lawn or turf, sample the soil at least every other year. Your local Cooperative Extension Service can tell you how to collect and submit soil samples for analysis. You may also want to refer to the ATTRA publication *Alternative Soil Testing Laboratory Resource List* for laboratories that provide biological as well as chemical analyses. While soil sampling takes time and sample analyses may be costly, good fertility management can save fertilizer costs and help protect water quality. The NOFA Standards for Organic Land Care lists “adding nitrogen, phosphorus, or potassium without a soil test” as a prohibited practice (6).

Nitrogen needs. Proper nitrogen fertilization is especially important for healthy turf. Too little nitrogen will yield turf that lacks vigor and good color. Too much nitrogen reduces turf’s tolerance to drought and increases thatch (the layer of dead stems and roots that builds up beneath grass) and susceptibility to disease. Timing of nitrogen applications is also critical. Cool-season grasses should be fertilized in the spring or fall when grass roots and shoots are actively growing. They should not receive fertilizer in the late spring or summer when they are dormant. Conversely, warm-season grasses should be fertilized in the late spring or summer when

Guide for Determining Compost Application Rates (developed from information provided in references 4 and 12)

Step 1. Test the compost nutrient content. A nutrient test should be conducted on each compost pile you will be using. Especially if you are using commercial compost, test it for nutrient content as well as for the presence of heavy metals or pesticides. If the compost is to be used for disease control, an analysis of microbial populations should also be conducted (see Table 1).

Step 2. Determine the amount of nutrients needed. Most soil testing laboratories provide recommendations on the amount of nutrients to be applied, based on the type of soil and plant variety you will be using. When calculating the amount of nutrients coming from compost, remember that only about one-third to one-half will be available during the current growing season.

For uniform turf growth throughout the growing season, apply the majority of your compost in the spring and fall, with some topdressing during the summer. For example, you may want to apply 50% of the nutrients needed in the spring and 30% in the fall, with four topdress applications, each providing 5% of the required nutrients.

Step 3. Determine the weight of compost needed (nitrogen based)

To calculate the amount of compost needed, divide the amount of nitrogen to be applied by the percentage of nitrogen in the compost, for example:

Nitrogen to be applied = 6 pounds /1,000 ft²

Nitrogen content of compost = 2.0% on a dry weight basis

Moisture content of the compost = 40%

Thus:

Compost to be applied = 6 pounds N / (0.02 x 0.4) = 750 pounds of compost / 1,000 ft²

To translate pounds/1,000 ft² into pounds/acre, multiply by 43.5.

Thus:

750 x 43.5 = 32,625 pounds or 16.3 tons of compost would be needed to cover an acre.

Step 4. Calculate the volume of compost needed

Bulk compost is usually sold by the cubic yard rather than by weight. To calculate the volume of compost needed, you need first to determine the weight of the compost for a given volume, such as a cubic foot.

For example, if your compost weighs 25 pounds per cubic foot:

then, its weight per cubic yard is 25 pounds/ ft³ x 27 ft³/ yd³ = 675 pounds/ yd³

Continuing with the example given above:

750 pounds of compost / 675 pounds per yd³ = 1.1 yd³ / 1,000 ft³ of compost needed.

Or

32,625 pounds of compost / 675 pounds per yd³ = 48.4 yd³ / acre needed.

Step 5. Depth of compost layer to apply

It is easier to apply compost by thickness rather than by weight per area. To convert cubic yards of compost needed into thickness of the compost layer to be applied:

Divide yd³/1,000 ft² by the conversion factor 3.086

Or

Divide yd³ / acre by the conversion factor 134.44.

Continuing with our examples:

1.1 yd³ / 1,000 ft³ needed / 3.086 = 0.35 inch or 3/8 inch of compost to be applied.

or 48.4 yd³ / acre / 134.44 = 0.35 inch or 3/8 inch of compost to be applied.

Note that normal agronomic compost application rates range from 5 to 10 tons/acre. The recommended compost application rates for turf are higher than the agronomic rates, because of the higher economic value of turf and, depending on its use, the greater potential for compaction by people walking or playing sports on yards or athletic fields. For restoring degraded land, the recommend rates for compost additions can be as high as 250 cubic yards or 84 tons per acre, especially when the natural topsoil is missing (5).

they are actively growing. These grass species should not be fertilized in the fall or winter when they are dormant (13, 14).

Turf species, soil conditions, length of the growing season, and cultural practices all affect the amount of nitrogen fertilizer required. In general, cool season grasses such as Kentucky bluegrass, fine fescue, tall fescue, and perennial ryegrass require 2 ½ to 3 pounds of N per 1,000 square feet (109–130 lbs./acre) per year, while warm season grasses such as bahiagrass and bermudagrass require 5 to 10 pounds of N per 1,000 square feet (217–435 lbs./acre) (13, 15). Turf needs more nitrogen in southern states, where the growing season is longer, compared to northern latitudes where the growing season is shorter.

Compost as a source of nutrients. Compost provides a complete source of turf nutrients, including micronutrients. Since these nutrients must either be dissolved into solution by organic acids or mineralized by microbial activity prior to becoming available before they are available to plants, several weeks may pass before turf grass responds to initial applications of compost. Annual or semi-annual applications of compost will eventually provide a continual release of nutrients to turf. This nutrient release will slow or cease during the winter, when cold temperatures slow the growth of soil organisms. As a result, turf that is dependent on compost for nutrients may green up slowly in the spring. If you want green turf early in the spring, you will probably need to supplement compost with other natural or synthetic nitrogen sources.

Natural nutrients sources. While compost is an excellent natural nutrient source, its balance of nutrients may not be the same as those required for healthy turf growth. Consequently, you may occasionally need to apply more targeted nutrient supplements. Table 2 contains a list of nutrient supplements and their designation as organically approved, permitted, or prohibited. For additional information on soil amendments and organic fertilizers and where to obtain these products, see the ATTRA publications *Alternative Soil Amendments* and *Sources of Organic Fertilizers and Amendments*, respectively.



Illustration 2. Soil testing helps you provide your lawn with the correct amount of nutrients without risking contamination of the environment (Photo by Lynn Betts, Natural Resources Conservation Service)

Soil pH refers to the acidity (soil pH lower than 7) or alkalinity (pH greater than 7) of a soil. Most turf grasses thrive best at a near neutral pH of 6.5 to 7.5. Soil that is either too acid or too alkaline hinders the availability of nutrients. It also limits the ability of soil organisms to release nutrients from compost, to form soil aggregates, and to break down thatch. At a low pH, phosphorus, calcium, and magnesium become deficient, and nitrogen fixation by clover and soil algae is impaired. At a high pH, the micronutrients iron, manganese, and boron become unavailable for plant uptake.

To raise the soil pH (make the soil less acid), apply lime. Lime is available in two mineral forms: as a pure calcium limestone or as a combination of calcium and magnesium, referred to as dolomite. It is also available in different grinds. Finely ground limestone is more chemically reactive and will change soil pH relatively rapidly, while more coarsely ground limestone may require a year or more to affect soil pH. To lower soil pH, add sulfur, typically available in the form of the mineral gypsum.

The nitrogen in topdressed fertilizers is subject to loss through volatilization. Between 13% and 60% of the nitrogen in urea topdressed on turf is lost to volatilization. Similarly, much of the available nitrogen in topdressed compost can be lost to the atmosphere before it becomes available for plant growth (16). Incorporating compost or fertilizer into the soil can decrease the chances for volatilization. As will be discussed in more detail below, core aerating the soil prior to applying compost allows it to fall into the aeration holes and become partially incorporated into the soil.

Caution when applying nitrogen to turf. Use care not to overapply nitrogen to turf. Large doses of soluble nitrogen can injure or kill both plants and soil organisms. If you are using synthetic sources of nitrogen, nitrate forms of nitrogen tend to be less injurious to turf than ammoniac forms. Immature compost or other materials with a high nitrogen content should not be used in the preparation of new or renovated turf, since these materials can cause seedling death (16). High nitrogen availability also increases the succulence of turf grasses and their susceptibility to attack by pests and diseases, including chinch bugs, sod webworms, parasitic nematodes, and brown patch.

The average homeowner uses ten times more chemical fertilizers per acre than farmers use on farmland (17).

Turf fertilization and water quality. Applying too much fertilizer or providing turf with nutrient applications that are out of balance with the nutrient needs of the turf can cause water pollution problems. The average homeowner uses ten times more chemical fertilizers per acre than farmers use on farmland (17). Too much nitrogen fertilization, especially when applied to bare ground or when plants are not actively growing, can result in nitrogen leaching into the groundwater. Overfertilization with phosphorus fertilizers can result in phosphorus runoff, which contributes to algae growth in lakes and streams. Depending on the source materials used in compost production, continual applications of compost can cause phosphorus to build up in the soil.

This is particularly true for compost made from animal manure and less of a problem when compost is made from lawn clippings and other landscape materials. However, organic matter additions stimulate microbial activity, which increases the capacity of soil to hold nutrients against leaching and runoff (18).

Soluble nitrogen applied through an irrigation system has less potential for leaching than if it is broadcast or topdressed on the sod, since only small amounts are added to the soil with each application. Organic soluble nitrogen sources include fish emulsion, fish powder, bat guano, seabird guano, worm castings, manure teas, and compost teas. Synthetic slow-release nitrogen fertilizers, such as sulfur coated urea or resin- and polymer-coated materials such as Osmocote™ and Nutricote™, are less likely to contaminate groundwater than are soluble fertilizers.

For large turf areas such as golf courses, parks, or athletic fields, ponds or constructed wetlands can collect and treat nutrients and sediments from storm water runoff. These areas also can provide flood control, wildlife habitat, and a source of irrigation water (14).

Preventing and correcting soil compaction. Turf grows poorly in compacted soil because its root growth is hindered, water infiltration is slowed, and water and nutrient movement through the soil is restricted. Compacted soils also put stress on turf by creating greater temperature extremes. You can decrease soil compaction by aerating the soil and providing the soil with regular additions of compost.

People walking, exercising, or playing on the grass can compact turf soils. Even mowing the lawn can compact the soil, especially if the soil is moist or wet when it is mowed. Applying high rates of nitrogen fertilizer (especially ammoniac nitrogen) and continually removing grass clippings without adding organic matter back to the soil also contribute to soil compaction.

Turf soil may be thin and compacted because of the natural characteristics of the soil in the area or because of poor landscaping following housing construction. Often when homes are built, the topsoil is removed or heavy equipment compacts the soil. If nothing is done to lessen the

soil compaction or if only a fraction of the topsoil removed is put back, turf will grow poorly. It will also be subject to water and nutrient stress, because the soil is too thin or consists largely of nutrient-poor and easily compacted clay subsoil.

Thatch. Thatch is turf root growth that forms on the surface of compacted soils. Lawn clippings do not form thatch. In fact, if managed properly, they can help break down thatch. Thick thatch contributes to soil compaction and hinders water infiltration, soil aeration, and the growth of soil organisms. Over fertilization and over watering causes a thick thatch to build up. On smaller yards or in yards where thatch is built up in isolated areas, raking can loosen it. You can leave this loosened thatch on the lawn to decompose or add it to your compost pile. Larger yards may require a mechanical dethatcher. However, large dethatchers can be very destructive to turf and the soil structure. Many turf professionals prefer using management practices that encourage natural thatch decomposition by earthworms. Regular applications of compost, combined with soil aeration, provide earthworms and other soil organisms with the air, moisture, and nutrients they need to grow and break down thatch (4, 19).

Aeration. Turf soils can be aerated by regularly applying compost to stimulate microbial activity or by combining mechanical aeration with compost additions. The appropriate type of mechanical aeration for you depends on the size of the lawn or field you are treating. You can aerate a very small lawn with a garden fork, by inserting the fork 6 inches deep every 4 to 6 inches and working it back and forth gently. On larger yards, you can use a mechanical, walk-behind aerator. These machines pull cores 2 to 3 inches deep. For best results, make three or more passes across the yard, then break down the cores left on the soil surface with a rake or drag chain. For fields and larger turf areas, tractor-mounted “shatter-core” aerators can treat deep compaction or drainage problems by penetrating 6 inches or more into the soil (19).

Following mechanical aeration, topdress compost onto the field or lawn. The topdressed compost will fall into the core holes, resulting in a partial incorporation of the compost into the soil. Mixing 40% compost with 60% sand produces a



A professional aerator.

heavier mixture that will fall into the holes more readily. The compost stimulates the activities of earthworms and soil microbes that break down excess thatch, form soil aggregates, and create tunnels through the soil. As biological activity in the soil increases, mechanical aeration may no longer be required. Instead, biological aeration, stimulated by regular surface applications of compost, may be sufficient (7, 19, 20).

While adding topsoil may appear to be the solution to thin soils, this treatment must be undertaken with care. Many commercial topsoils contain a plethora of weed seeds and may contain heavy metals or toxic chemicals. The type of soil added may not be compatible with the soil being treated, with the resulting soil mixture being compacted. If a lawn or field has very thin soil and soil additions are necessary, make sure to get the soil from a reputable source. If you are unsure of the soil quality, or you are going to work with a soil supplier on a regular basis, you may want to analyze the soil for contaminants such as heavy metals. When adding topsoil, mix it with compost before applying it to the turf. Then till this compost-soil mixture into the existing soil so that there is no clear dividing line between the existing and the new soil (19).

Reducing or eliminating the use of synthetic chemicals. Earthworms, other soil invertebrates, and soil microorganisms are essential for maintaining soil structure, recycling organic debris such as thatch, and mineralizing nutrients in turf soils (7, 19). Most pesticides are toxic to earthworms. Similarly, the soluble fertilizers ammo-

nium nitrate and methyl urea significantly reduce earthworm populations (21). Both pesticides and fertilizers kill soil organisms through direct toxicity. They also retard their ability to regrow by increasing soil acidity and compaction. In addition, high soil nutrient concentrations associated with fertilizer additions suppress the growth of mycorrhizal fungi, a type of soil organism that assists grass in taking up nutrients and water from the soil.

In contrast to soluble fertilizers, compost contains carbon and nutrients that promote the growth of soil organisms. Making the transition from a chemically maintained turf to an organic or least-toxic turf can reduce thatch build up and produce a turf that is resistant to pests and diseases.

Species Diversity in the Lawn Environment

Turf species. Turf composed of a single species is highly susceptible to becoming weedy and demands more nutrients and water than turf composed of a diversity of species (12). To minimize maintenance problems, use species that are appropriate for your location and for the specific conditions within the yard. Also, choose varieties that are resistant to common pests in the area and that do not demand a lot of nitrogen.

To minimize maintenance problems, use only species that are appropriate for your location and for the specific conditions within the yard.

Table 3 (see Appendix) lists growth characteristics of common turf grasses. Within these species, different varieties have been developed to provide specific advantages, such as shade tolerance, resistance to a particular pest or disease, or the ability to stand up to wear. Often, a mixture of grasses performs better than a single species. For example, Kentucky bluegrass is often mixed with tall fescue or fine fescue to provide better wear and disease resistance. In more northern areas, a mixture of fescue and ryegrass allows for rapid soil coverage, less weed invasion, and better adaptation to both sun and shade conditions (19). In mid-latitude locations, a mixture of cool season and warm season grasses allows for cold tolerance at the beginning and end of the season along with heat and drought toler-

ance in mid-summer. A mixture of appropriate turf species also protects the whole yard against pests and diseases. Your local Cooperative Extension Service can provide you with information on turf varieties and cultivars that are appropriate to your area.

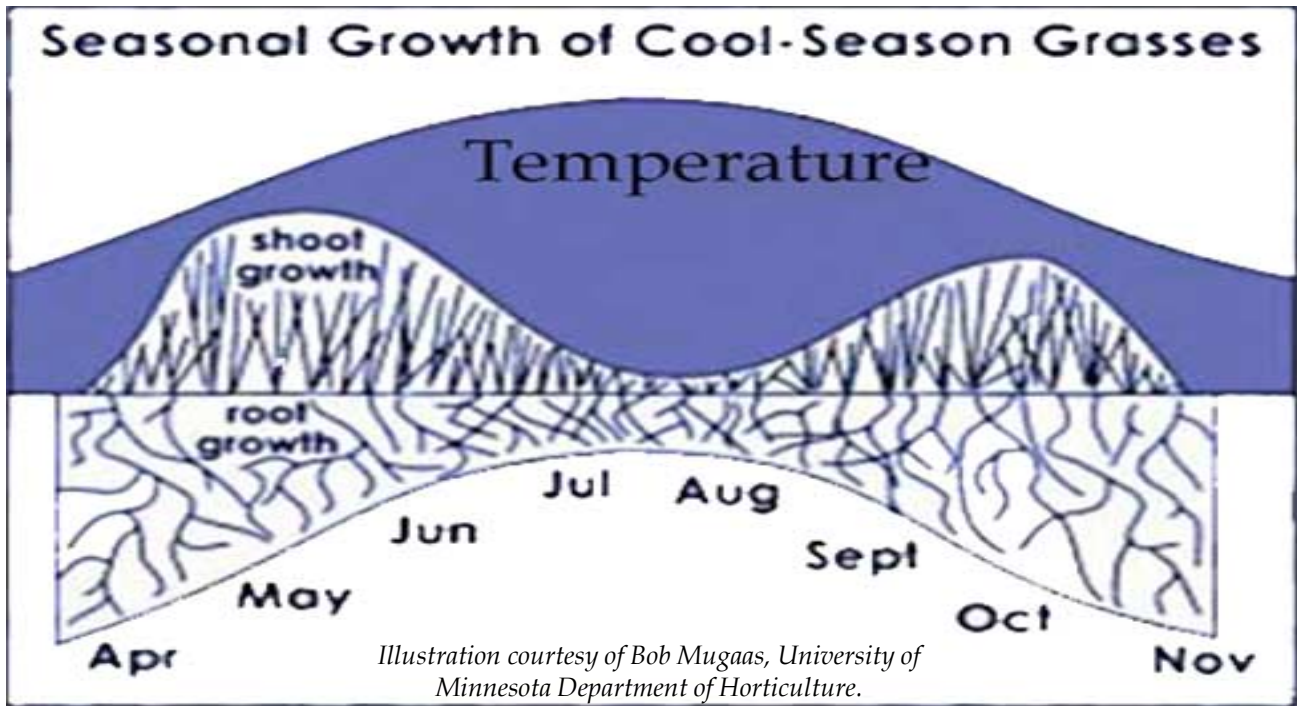
Good quality seed is fundamental to establishing good turf. Read and compare seed labels carefully before purchasing turf grass. Inexpensive mixtures often contain seeds of grasses that either have weedy characteristics or are annuals and need to be reseeded yearly. Common filler grass varieties include annual ryegrass, orchard grass, timothy, annual bluegrass, bentgrass, and rough bluegrass (22, 23). To avoid weed control problems, use seed from a reputable dealer and check the label for the following information (23):

- Grass variety listed by trade name — not by generic name, e.g. Aries Kentucky bluegrass rather than just Kentucky blue grass
- Germination rate of seed — should be at least 75% for Kentucky bluegrass and 85% for others
- Weed content less than 0.5%
- Inert matter less than 5%
- No noxious weeds stated on the label

A good source for comparative information on the performance of different turf varieties under a range of environmental conditions is the National Turfgrass Evaluation Program (NTEP) Web page, <<http://www.ntep.org/>>. Trials conducted nationwide by the NTEP are designed to help breeders and growers select cultivars that are well-adapted to their particular areas or specific turf uses.

Mixed species lawns. For greater diversity, you may want to consider mixing Dutch White Clover (*Trifolium repens*) or subterranean clovers (*Trifolium subterraneum*) into the turf mixture (3, 6).

Cool-season grasses do most of their growing during the spring and fall, while warm-season grasses have their strongest growth during the summer. Root growth for cool-season grasses peaks during the two months prior to maximum shoot growth in the spring and during the two months following the peak of shoot growth in the fall.



By evenly blending clover with grass seed, you can obtain a uniform distribution of clover in the lawn. Adding clover to the turf cover can:

- Increase the drought-tolerance of the lawn
- Provide two pounds of nitrogen per 1000 square feet annually
- Decrease disease infestations by increasing the population of pest predators
- Decrease weed infestations



Illustration 3. Dutch white clover is an excellent addition to a mixed species lawn. (<http://www.ampacseed.com/clover1.htm>)

In more arid or degraded landscapes, black medic is a good complement to turfgrass or wildflowers in a natural lawn. It can also serve as a temporary restoration crop to aid in turf establishment. Like clover, medic fixes nitrogen, helps aerate the soil with its deep root system, grows close to the ground, and is non-invasive (24).

In addition to legumes, a combination of grasses native to your locality can provide a highly resistant, low-maintenance yard or turf. For example, a combination of little bluestem (*Schizachyrium scoparium*), common or Pennsylvania sedge (*Carex pensylvanica*), and tufted hairgrass (*Deschampsia flexuosa*) is well adapted to the Northeastern coastal areas (25), while blue grama (*Bouteloua gracilis*), buffalograss (*Buchloe dactyloides*), purple three-awn (*Aristida purpurea*), and sideoats grama (*Bouteloua curtipendula*) are native grasses of the arid Southwest (26). You can get information on grass native to your area from your Cooperative Extension office.

Some nurseries have created “no mow” lawn mixes composed of slow growing turf grasses, such as hard fescue and creeping red fescues. These grasses require little maintenance since they have deep roots and are resistant to drought. The fescue mix is suitable for the cooler, medium-rainfall areas of the upper Midwest and north-eastern United States, and southern Canada (27,

28). Sedges and rushes serve as a low-maintenance ground cover suitable for moist climates. Genetically-modified “no-mow” grass varieties are also being developed. Researchers creating these varieties have identified a gene in grasses that controls plant height by restricting the activity of a growth hormone (29).

Wildflowers. Including wildflowers as part of a yard provides options for adding color and variety to your landscape. The diversity of species in wildflower lawns or meadows increases pest and disease resistance while attracting beneficial insects and birds. Substitution of different plant varieties permits easy adaptation to local sun, shade, and moisture conditions. And since wildflower meadows are not usually mowed, they are perfect for slopes, ditches, and other hard-to-manage areas (30, 31).

Choosing seed. To ensure that a wildflower planting will thrive, select wildflower mixtures that are either native to or well adapted to the local climate and soil conditions. Note that many non-native, naturalized species, including Queen Anne’s Lace, chickory, Dame’s Rocket, Ox Eye Daisy (Shasta Daisy), Bachelor’s Button (Corn flower), and Butter and Eggs, are used heavily in most commercial wildflower seed mixes because they grow rapidly on freshly worked soil. Since these plants exhibit aggressive, weedy behavior, they can readily out-compete other species or contribute to weed infestations in surrounding areas (31).

Establishing a wildflower lawn. A wildflower area is often difficult to produce from seed because many home owners or lawn managers are unable to distinguish weeds from desirable plants when the plants are still small. While fall planting allows for earlier blooming of flowers in the spring, spring planting allows for better weed control (32).

As with any turf management practice, successful establishment of a wildflower lawn requires appropriate land preparation. Surprisingly, wildflower gardeners usually discourage tilling since it can destroy seeds of prairie species laying dormant in the soil, hurt tree roots, and cause erosion. A common method of land preparation is to first smother the existing turf over winter under layers of newspaper held down by a layer

of sand and compost mix (33). Then, in the spring, remove any remaining plant growth by burning it or scalping the soil with a lawnmower before planting seeds. If you wait until spring to start preparing ground for wildflower planting, you can till the soil, allow one to two weeks for weeds to grow, kill the weeds with a herbicide or by flame weeding, then plant the wildflower seeds. For more information on flame weeding, see the ATTRA publication *Flame Weeding for Vegetable Crops*.

Mixing wildflower seed with an annual cover crop helps control weeds while enriching the soil. You can use either agronomic cover crops such as buckwheat, annual flax, wild rye or oats, or you can use native cover crops. Evening primrose, black-eyed Susan, and nodding wildrye are appropriate for the upper Midwest, while purple three-awn and Mexican hat are suitable for the South or Southwest (28).

Since many wildflower seeds are small, you have better control over their distribution if you mix them with compost, potting soil, or sand before broadcasting. Attempt to plant approximately fifteen to thirty seeds per square foot. This will ensure that there are enough plants to crowd out weeds without the wildflowers being so close together that they are not able to bloom (31, 33).



Illustration 4. Wildflowers add diversity to lawns. (Photo by Lynn Betts, Natural Resources Conservation Service)

Wildflower seed mixtures. Most wildflower mixtures contain a combination of perennial, biennial, and annual plants. While the early blooming annual plants produce a large quantity of seed, much of this seed will probably not fall on bare ground. Reseeding annuals into the wildflower planting each spring will help maintain a balance between annuals and perennials, as well as decrease the potential for weed competition.

Grasses, especially native warm-season prairie grasses, are a natural complement to wildflowers. The grass species little bluestem (*Andropogon scoparius*), sideoats grama (*Bouteloua curtipendula*), and indiagrass (*Sorghastrum nutans*) are excellent companions for wildflowers since they grow readily on almost any normal, well-drained soil, and can tolerate very dry conditions. In contrast, common lawn grasses – such as Kentucky bluegrass, tall fescue, and smooth brome grass – grow too aggressively to serve as good companions to wildflowers (31).



Illustration 5. Prairie grasses can add diversity and beauty to a natural lawn (Photo courtesy of Prairie Nursery, Westfield, WI.)

To rapidly establish a wildflower area, you can purchase wildflower mats or wildflower sod. Wildflower mats are usually made of a wood fiber, are biodegradable, and serve as a mulch to help keep down weeds while the seeds impregnated into the mat are germinating (34). Wildflower sod costs considerably more than seeds or mats, but this method is probably the most labor saving and dependable method for establishing a wildflower area. As with the selection of seeds, carefully review the list of plant species included before purchasing sod or mats. Wildflower sods or mats that have the greatest potential for retaining blooms will contain plants that are either native to or compatible with local environmental conditions and have a high percentage of perennial species.

Choosing and installing sod. Most sod contains high-maintenance grasses and is grown using synthetic inputs. If you use sod, try to choose one grown that uses compost and contains a mix-



Recently laid wildflower turf.

ture of grasses appropriate to your locality. Good soil preparation, including soil tillage or aeration and compost incorporation, will enhance establishment and help maintain the healthy and productive growth of either grass or wildflower sod.

Mulches. Mulches serve as attractive and low-maintenance complements to turf. They are particularly useful in shady or wet areas that do not support healthy grass growth. They can also be used on walkways or other areas that receive heavy traffic. Organic mulches are preferable, since they decompose and add organic matter to the soil. However, inorganic mulches, such as stones, can be reused and do not need to be replenished as often as organic mulches. When using mulches, do not pile them too high. Thick mulches hinder air and water movement through the soil, stimulate trees to sprout surface roots, and favor burrowing and plant damage by herbivores (6).

Cultural Practices that Reduce Stress on Turf

By creating healthy soil and selecting appropriate species for your climate, you have taken the first steps towards establishing a healthy turf. The next steps involve mowing and watering practices that stimulate rather than stress plant growth. Overseeding allows you to quickly rejuvenate turf that has come under stress or to extend the length of time that turf grass is actively growing and remaining green.

Mowing correctly can kill weeds, save water, reduce diseases, stimulate root growth, and provide grasscuttings for fertilizer (35). Mowing incorrectly can cause stress on turf, introduce dis-

eases, promote weed growth, and encourage thatch build-up.

Reducing stress. Increasing the height of cut during mowing is key to reducing stress on grasses and increasing the vigor of both leaf and root growth. Research trials and the experience of turf professionals have demonstrated that increasing the mowing height to 2 to 2 ½ inches can reduce weed invasions, encourage deeper root growth, and improve drought resistance (19). For native grass lawns, heights up to 3 inches are recommended (20, 36). Time the intervals between mowings so only one-third of the grass is removed each time you mow. This moderate trimming helps stimulate root growth without significantly reducing the leaf area available for photosynthesis.

Increasing the mowing height is particularly important when turf is under stress by heat, drought, or shade. Do not leave your mower set at the same height all year—or even while you are mowing different sections of your lawn on the same day. Instead, increase the mower height to reduce stress on turf growing in the shade and when you mow during the summer heat. Since turf species grow more slowly when they are under stress, the time between mowings should allow turf in hot or shady conditions to regrow sufficiently before it is mowed again. This may mean mowing shady sections of your lawn at intervals different from those used in sunny areas. By increasing your mower height, you can both reduce stress on turf species as well as the incidence of some common turf weeds. In contrast, probably the most stressful mowing practice for turf grass is allowing grass to reach a height of 7 inches or more, then mowing it to a height of 2 inches or less just before the summer drought. This abrupt change in height shocks and seriously weakens a lawn (19).

By increasing mower height, you can both reduce stress on turf species as well as the incidence of some common turf weeds.

Mower type. Mulching mowers and grasscycling mowers chop grass clipping finely and blow them down into the turf. This provides a lawn with a clean appearance while encouraging rapid decomposition of the clippings. Grass clippings

that are returned to the soil, rather than being collected and bagged, replenish organic matter and can annually add between 2 to 5 pounds of nitrogen per 1000 ft² (12, 19). If you use a non-mulching mower and leave clippings on the soil, mow lawns early in the day to allow the clippings left on the ground to dry out so that they do not serve as a source for disease transfer (4).

Manual reel mowers provide less soil compaction while eliminating polluting emissions associated with gas mowers. For smaller yards, manual mowers do not require great effort, especially when the mower is sharp and the grass is cut at an appropriate time and height. When choosing a mower, be careful to get a model that is able to cut to a 2 ½ to 3 inch height, since many reel mowers are not adjustable.

Mower maintenance. Maintaining sharp mower blades enhances mowing efficiency, reduces stress on grass, and facilitates decomposition of grass clippings. Sharp mower blades also reduce mower vibration, lengthen mower life, and reduce fuel consumption by gasoline mowers by as much as 22 percent (14). Conversely, a dull blade favors the spread of diseases since it cuts grass with a rough tear that provides more surface area for disease to enter than does a clean cut. Many turf professionals recommend sharpening mower blades at least once a month, or after eight hours of mowing (12).

Water management. Healthy lawns that are well aerated and have a moderate to high level of organic matter need less water than do more compacted lawns. Soils that are not compacted allow for good water infiltration and movement to plant roots, while organic matter acts as a sponge, absorbing water and holding it for use during dry periods.

Proper watering. Watering less frequently and more deeply encourages root growth deep into the soil rather than on the surface, where it forms thatch. Deeper root growth allows plants to withstand dry conditions better, and the formation of less thatch enhances soil aeration. Deep roots have better access to soil nutrients and water, especially in the dry season. They also promote turf growth over weed growth, since many turf grasses develop a deep root system, while many weeds have shallow roots (36).

Mowing guidelines to reduce turf stress (36):

- Mow grass higher when temperatures are high to encourage more root growth and reduce soil temperatures.
- Manage grass located in shady or moist areas differently from grass located in sunny areas: grass in shady areas should be mowed to a higher height and less frequently than grass in sunny areas.
- Regularly sharpen mower blades, since tearing grass with dull blades creates stress and provides an ideal entry point for pathogens.
- Clean mowers regularly to remove potential sources of inoculum that could be spread to other parts of the lawn or field.

Most grasses are adapted to seasonally dry conditions and compete best if the soil in the root zone is allowed to become partially dry between waterings. For best turf growth, wait until the soil has dried to a depth of 2 to 4 inches then irrigate to replenish the water to the depth of the root zone (19). When rewetting a dry soil, slowly wet the surface, wait an hour or so for the water to penetrate, then thoroughly irrigate the lawn. If you do not pre-wet the soil, you will lose water and soil nutrients to runoff, since dry soil is water repellent and does not allow good water infiltration (19, 36).

For best turf growth, wait until the soil has dried to a depth of 2 to 4 inches then irrigate to replenish water to the depth of the root zone.

Watering also needs to be timed according to the soil texture, the rate of water infiltration into the soil, and the flow rate of your irrigation or sprinkling system. If you apply water faster than the soil can absorb it, the excess will run off rather than soak into the soil (22). Besides being wasteful, this runoff can transport diseases across the lawn and may cause water pollution if it runs into storm sewers or creeks.

Overwatering. Watering grass too frequently or too lightly causes lawns to develop shallow root

systems, encourages water logging, increases the potential for a variety of soil-borne diseases, and stimulates the growth of weeds such as buttercup, speedwell, and annual bluegrass (19). Watering during the morning places less stress on grass and decreases the potential spread of fungal diseases (37).

Heat management. Reducing the water supply to the lawn just before to the onset of the summer heat prepares a lawn to become dormant (37). However, deeply watering the lawn once during each rainless month allows turf grasses to retain enough growth to remain competitive with deep-rooted weeds such as dandelions (19). If your area receives a light rain during an otherwise dry month, the best time to water is immediately following the rain to ensure that the full root-zone has become wetted (31).

If you want to maintain green lawns throughout the hottest days of summer, water the grass briefly (for about 10 minutes) every hot afternoon, to minimize heat stress, then provide heavy waterings as needed. You can test soil moisture by feeling the top 2 to 4 inches of the soil to see whether it has become dry, or you can use a moisture meter. You can also rely on evapotranspiration information for the area that is provided by local weather stations or agricultural colleges. Applications of seaweed extract can further reduce heat stress in turf. By stimulating antioxidant production, the natural hormones in seaweed may help grasses sustain a balance between photosynthesis and respiration (4, 36). Leaving grass clippings on the soil and topdressing with compost also mulches and cools the soil while stimulating microbial activity.

Overseeding. Overseeding is a practice that allows you to rejuvenate a lawn and fill in bare spots where weeds might otherwise grow (19). Overseeding also allows you to slowly replace inappropriate or disease-prone varieties with more appropriate or more disease-resistant varieties. In some areas, overseeding extends the length of time a lawn remains green into the fall. For lawn rejuvenation, overseeding may be done either in the spring (April or May) or in the fall (September or October). Prior to broadcasting seed into the existing turf, make a pass over the area to be overseeded with an aerator or heavy rake. Or you can plant seed with a slice-seeder.

These techniques provide the conditions for good seed-to-soil contact. Seed can be broadcast or planted alone, followed by a topdressing layer of compost. If turf seed is broadcast planted, it can be mixed with compost, and the two can be broadcast together onto the prepared turf (19, 23). Following seed planting, press the seed into the soil with a roller or, for small renovation patches, by walking on the overseeded area.

In the mid-latitude, humid areas of the country, warm season grasses thrive in the summer and cool season grasses thrive in the fall and into part of the winter. Under these conditions, you can maintain a green lawn throughout much of the year by establishing a turf dominated by perennial warm season grasses, then overseeding in the fall with an annual cool season grass. The overseeded grass will keep the turf green into the fall and continue growing in the early spring. Then it will die out when the warm season grasses reemerge in late spring.

Biointensive Pest Control Methods for Turf

Biointensive pest control seeks primarily to prevent pest and disease infestations by reducing turf stress and encouraging the growth of pest predators. Building soil quality, avoiding

overfertilization, choosing locally appropriate and disease resistant turf species, and mowing and irrigating correctly are practices that reduce turf stress while also reducing the potential for pest and disease infestations. Cultural control measures, such as using a diversity of species and removing disease-infested leaf litter from the lawn, also help prevent pests and diseases from becoming established or spreading. If preventative measures are not entirely effective, topdressing with compost and employing biological pest and disease control agents are good ways to protect your turf.

Once you are aware of a pest or disease problem, your first step is to identify the cause of the damage. The **Resources** section of this publication lists several books that you can use to identify weeds, insects, and turf diseases. Personnel at your local Cooperative Extension office should also be able to help you identify and treat turf pest problems.

Turf diseases. Prevention is the key to disease management in turf. Planting resistant varieties, keeping mower blades sharp, avoiding overfertilization and over-irrigation, and biologically enriching the soil with mature compost are practices that will produce a vigorous, disease-resistant turf.

“My program begins with a detailed lawn evaluation. I look first at the turf type. Then, I look for problem areas. Most of the time the weeds that are in the lawn will tell me what are the problems and what needs to be done. For example, are they summer, winter, or spring weeds? Are they annuals or perennials? Can they be controlled using pre-emergence measures or are they better controlled after emergence? Can they be spot controlled, or do control measures need to be used across the turf area?”

“What time of year are you evaluating the lawn? If it is early spring and there are bare spots, a summer annual weed will probably invade. Look for problems with shade from trees, any disease or pest problems, too much or too little water, and thatch build-up. Key in on the condition of the turf. Is it thick and well-established? Or, is it thin and patchy? Take a shovel and look at your soil and the root systems of the grass. This is where most problems begin. If there are several inches of healthy soil and a strong root system, then a maintenance program is all that is needed. However, if the soil is thin and the roots are short or bunched, the lawn needs an application of compost or other organic material to build-up the soil.”

“Be realistic and don’t make promises to your clients that you cannot keep. It will take time to adjust deficiencies. Take advantage of the highest growing period of your turf types. This is when most noticeable gains can be achieved and when the turf needs the greatest amount of nutrients and care.”

Shannon Pope, proprietor of Healthy Soils, and organic lawn care service

Cultural control practices for turf grass disease control include (20):

- Altering the environment within the turf crown by raking, coring, or spiking
- Applying natural supplements such as lime, ash, compost, liquid seaweed, or fish emulsion to alter disease-favoring conditions in the turf crown
- Overseeding with turf varieties that are resistant to diseases
- Waiting for weather conditions to change and seeing whether this reduces or eliminates disease symptoms

A list of specific cultural control practices that are effective against certain turfgrass diseases is provided in Table 4 (see Appendix).

Pest and disease control with compost. In addition to providing a steadily available source of nutrients, compost suppresses some turf pathogens. Research at Cornell University (2, 11) demonstrated that topdressing with compost suppressed some soil-borne fungal diseases just as well as conventional fungicides. This effect lasted about thirty days, but was lost by sixty days after the application (12, 38). Diseases shown to be suppressed by compost include:

- dollar spot (*Sclerotinia homeocarpa*) in creeping bentgrass and annual bluegrass
- brown patch (*Rhizoctonia solani*) in creeping bentgrass, annual bluegrass, tall fescue
- pythium root rot (*Pythium ramanicola*) in creeping bentgrass and annual bluegrass
- typhula blight (*Typhula* spp.) in creeping bentgrass and annual bluegrass
- red thread (*Laetisaria fuciformis*) in perennial ryegrass
- pythium blight (*Pythium aphanidermatum*) in perennial ryegrass
- necrotic ringspot (*Leptosphaeria korrae*) in Kentucky bluegrass

Characteristics of disease suppressive composts. The composition, age, and preparation methods of composts are keys to their providing disease suppressive benefits. Compost must be mature and fully cured to suppress diseases. Immature compost has a high concentration of ammoniac nitrogen (NH_4) and increases, rather than decreases, the incidence of *Fusarium* diseases (39). Disease



Brown patch disease can be controlled by the application of certain types of compost.

suppressive composts contain thoroughly decomposed organic materials that have been allowed to “cure.” During curing, bacteria and other microorganisms that help form humus and suppress diseases replace the heat-loving organisms involved in the early stages of organic matter decomposition. Compost that has been sterilized or allowed to decompose until most of the available nutrients have been used is biologically inert and unable to suppress diseases (4, 16, 39).

Compost applications control diseases by supplying the soil with millions of microorganisms that are antagonistic to turf pathogens. Compost also provides nutrients that stimulate the growth and reproduction of antagonistic organisms already in the soil. However, the type of compost determines the type and numbers of soil organisms and the degree of disease suppression they provide.

Compost can suppress diseases in two ways. It may contain a high population of disease-suppressive organisms, or it may contain substances that stimulate the growth of disease suppressive organisms already present in the soil. Preliminary results from studies conducted by Eric Nelson and his colleagues at Cornell University (8) indicate that compost derived from either brewery sludge or municipal biosolids was effective in controlling the soil-borne fungal disease *Pythium*, because it contained high populations of disease suppressive organisms. However, compost derived from poultry litter, while as effective in controlling *Pythium* did so by providing appropriate nourishment to disease suppressive organisms in the soil.

Different composts provide selective control of some diseases. For example, composted sewage sludge increased the incidence of *Fusarium* on carnations and peas, but decreased the incidence of *Fusarium* on cucumbers (40). Composted poultry litter provided 75% control of brown patch but only 15% control of typhula blight, while composted brewery sludge provided only 25% control of brown patch but 70% control of typhula blight (40). Studies by Elaine Ingham and her coworkers (42) indicate that compost made from succulent materials such as grass clippings, green leaves, food waste, and manure is probably best for turf production, since these materials favor high bacterial populations. In contrast, compost made from woody materials, straw, and dry leaves favors the growth of fungi and is best used for the production of tree crops.

To obtain optimum disease control, broadcast mature compost monthly. Applications of pesticides or highly concentrated soluble fertilizers will disrupt or kill beneficial soil organisms and minimize the effectiveness of the compost. A topdressing of solid compost can be applied alone or as a mixture of 70% compost and 30% sand, then incorporated into the soil with an aerator or drag chains. Alternatively, compost tea, a liquid solution prepared from high quality compost, can be applied as a spray.

Compost tea. You can make anaerobic compost tea by soaking a burlap bag full of compost in a barrel of water for up to two weeks. Soaking for four to seven days at temperatures below 65° to 70° F provides the highest level of disease suppression (8). Aerobic compost is prepared in the same manner, except that the ratio of water to compost should be no more than 10 to 1, and the compost should be soaked in the water for no more than 48 hours. Another method for producing aerated compost is to add compost to a brewer or vat that has air bubbling through it. Both anaerobic and aerobic compost extracts protect against plant diseases (43). Research examining the effect of compost tea on golf greens found that treated grass had longer roots, fewer diseases, and higher density than untreated turf. For this study, compost tea was applied weekly to bi-weekly at the rate of one gallon per 1000 square feet (44). For more detailed information on the production and use of compost teas, see the ATTRA publication [Notes on Compost Teas](#).



A compost tea brewing tank in California.
Steve Diver

Microbial fungicides. If preventative measures are ineffective in controlling diseases, you can use microbial fungicides that are labeled for turf. The fungus *Trichoderma harzianum* helps control several diseases, including brown patch (caused by the pathogen *Rhizoctonia solani*), dollar spot (caused by *Sclerotinia homoeocarpa*), and pythium root rot and blight (caused by *Pythium graminicola*) (45). Commercial products containing *Trichoderma* include BINAB T™ from BINAB Bio-Innovation AB, a Swedish company, and Turfshield™ from BioWorks, Inc. Companion™, produced by Growth Products, is a concentration of four species of *Bacillus* bacteria. It is recommended for both general maintenance and remedial treatments of turf diseases. Studies conducted at the Rutgers Center for Turfgrass Science showed that applications of Companion™ caused a 30 to 50% reduction in summer patch (45). A new anti-fungal strain of bacteria labeled as APM-1 is being developed for turf use by researchers at the New England Turfgrass Foundation. It is not currently available commercially, but may be in the near future (4, 46).

For additional information on biological or botanical treatments of turf grass or horticultural plant diseases, see the Agrobiologicals Web page (<<http://www.agrobiologicals.com/>>). This page has an excellent database of pests and diseases. It also lists biological and botanical control products and contact information for the companies selling them.

Turf insect pests. While pesticides kill insect pests listed on their labels, many pesticides are non-specific. That is, they kill beneficial insects

as well as pests. Pesticides also kill many soil organisms that decompose organic matter, form aggregates, and suppress diseases. As a result, pesticides may decrease insect infestations in the short term, but create other conditions that increase turf stress. Thus, turf managed with pesticides often has more pest problems and requires more intensive management than turf managed with biological products.



Grubs feeding on turf.

Cultural control measures. As with the control of turf diseases, preventative cultural control measures can greatly reduce insect damage. Cultural control practices for turf insects include:

- Reducing stress on turf by building up soil quality with regular additions of mature compost, protecting the soil from compaction, avoiding over fertilization and over watering, and increasing the mowing height.
- Decreasing thatch through a combination of aeration and compost applications to stimulate the activity of thatch-eating earthworms.
- Increasing the diversity of plants within the turf as well as in gardens, flower beds, and other areas adjacent to the lawn. Natural areas, in particular, serve as useful refuges for many beneficial insects. Plants in the parsley (Umbelliferae) and daisy (Compositae) family are especially useful for encouraging the growth of parasitic wasps (20).
- *Syringing* or applying about 1/10 of an inch of water mid-day during hot, dry weather helps control chinch bugs and lawn grubs (20).

- Using pest- and disease-resistant varieties and seeds that contain endophytes (see below).

To effectively control turf pests, it is necessary to correctly identify the pest and understand its life cycle. The **Resources** section of this publication lists books that provide detailed descriptions of turf insect pests, their major host species, and their growth cycles. Secondly, scout for pests above ground, in soil samples, or emerging from the ground when you apply soapy water to the soil. Monitoring provides information on the presence and changes in populations of insect pests. By combining monitoring and life cycle information, you can determine whether infestations have reached a point where some treatment is required (19, 47).

Endophytes. Perennial ryegrass and many different types of fescue are bred with endophytes — fungi that live symbiotically within the cells of the grass. Grasses that contain endophytes produce a bitter toxin that repels most insects and kills many of those that continue to feed. Besides protecting grasses from insect pests, endophytes also produce hormone-like substances that stimulate the growth and vitality of the grass. Care must be used when planting endophyte-infected seed, since the endophyte will die if the seed is stored too long or at too high a temperature. However, once the endophyte-infected grass is planted, the endophyte grows and reproduces with the grass as long as the grass remains viable (4).

Biological and botanical insecticides useful in turf management include (4):

- *Beauveria bassiana*, an entomopathogenic (insect-eating) fungus
- *Bacillus thuringiensis* (Bt) a bacteria used in the control of turf eating caterpillars
- Milky spore, formed by the bacteria *Bacillus popilliae*, controls Japanese beetle grubs
- Entomopathogenic (insect-eating) nematodes control grubs
- Neem, a botanical insecticide derived from the leaves of a tree native to India
- Repellents containing garlic juice and extracts from hot peppers that persuade insects to go elsewhere to lay their eggs
- Insecticidal soaps

Biological insecticides need to be handled and applied with care in order to be effective. Since control is a result of the activities of living organisms, the source of the product and how it is shipped affect the viability of the organisms (48). In addition, soil conditions at the time of application must be favorable to the growth of the organisms. For example, entomopathogenic or insect-eating nematodes survive best in moist, loamy soils that have soil temperatures between 65° and 85° F. Since they are able to withstand high pressure, you can apply these biological control organisms using a sprayer or irrigation equipment (49). The ATTRA publication *Biointensive Integrated Pest Management* provides detailed information on biological control practices. It also contains extensive lists of suppliers for biopesticides and microbial pest control agents.

Table 6 (see Appendix) summarizes cultural and biological control measures for common turf insect pests.

Turf weeds. Weeds are plants growing in the wrong place. The type of lawn you are interested in having will define which plants are weeds. For example, for someone developing a natural lawn, white clover is an integral component of the turf. For people wanting a pure grass lawn, white clover is a weed. Using good turf management practices that favor the growth of desired species allows these plants to out-compete undesired species. Essential management practices for weed control include (22):

- Growing grass species appropriate for your region and your soil conditions
- Eliminating soil compaction
- Reducing wear on the lawn or turf
- Providing turf soil with appropriate and balanced levels of fertilization
- Overseeding with cool-season grasses to maintain grass growth in the fall and spring
- Watering turf deeply and infrequently during dry periods
- Ensuring proper drainage
- Increasing mowing height

Table 5 (see Appendix), which summarizes soil, weather, and management conditions that favor the growth of weeds. To reduce stress on turf

and decrease infestations from weeds, make management changes to alter these weed enhancing conditions.

Mowing to control weeds. Raising the mower height reduces the incidence of some common turf weeds. Research conducted at the University of Maryland showed that mowing turf at 3 inches, especially during the spring, provided as much control of crabgrass as did the use of herbicides (50). The higher cut reduced the stress on the turfgrass and they were able to choke out the crabgrass.

Mowing at a lower cut during seed set can help control annual bluegrass, crabgrass, goosegrass, foxtail, barnyardgrass, fall panicum, and dallisgrass. This technique must be carefully timed to coincide with early seed set. Attach a clippings bag to the mower to collect and remove seed heads. Also be careful not to mow so low that you stress the desired turf species (4).

When not mowing to collect and remove seed heads, leave the grass clippings on the soil to control weed growth. Clippings from a variety of different turf species contain allelopathic compounds that suppress the germination and growth of certain weeds (4, 47). Many turf grass roots also produce allelochemicals that suppress the growth of weed seeds. Raising the mowing height favors root growth and the production of these allelochemicals.

Corn gluten meal is effective in the pre-emergence control of various weed species, including crab grass, foxtail, pigweed and dandelion. This animal feed product controls weed growth by inhibiting root formation (51). Studies demonstrate that repeated applications increase the effectiveness of this natural herbicide. These studies show that corn gluten meal initially reduced weeds by 60 percent, by 80 percent the second year, and by 90 percent in the third year. The main drawback to using corn gluten meal is its high cost, which makes its use economically feasible only in small areas. The average cost is \$1.50/lb., with recommended applications rates of 40 to 65 pounds per 1,000 square feet (52). Since it contains 10% nitrogen, it should be managed as both a fertilizer and a herbicide. University of Iowa turfgrass researcher, Nick Christians has compiled a list of suppliers of corn gluten meal,

which is available at:

<http://www.public.iastate.edu/~isurf/tech/cgmwebsite.html>.

Vinegar has recently gained attention as an effective natural post-emergence herbicide. It works by degrading the waxy cuticle layer on weed leaves, resulting in desiccation. More frequent applications or applications with a stronger solution are needed to control weeds with very thick cuticle layers. While vinegar typically contains approximately 5% acetic acid, distillation can increase this concentration to 15%, and freeze evaporation can increase it to 30%. Research conducted by the USDA Agricultural Research Service demonstrated that vinegar at 10, 15, or 20% acetic acid concentrations killed 80 to 100% of giant foxtail, common lambsquarters, smooth pigweed, and velvetleaf (53). Some gardeners have seen increased effectiveness by adding lemon juice to the vinegar and applying it during the heat of the day (53).

Like corn gluten meal, vinegar is an expensive treatment for large areas. Approximate costs for broadcast application of vinegar are \$66.00 per acre for 20% acetic acid and \$99.00 per acre for 30% acetic acid (54).

While vinegar readily degrades in the soil and has no long-term impact on soil organisms (soil pH decreases at the time of application but returns to its original level in less than two days), it is caustic. When applying this material, you should wear a mask to avoid inhalation and gloves to prevent skin contact (55).

Summary

A lawn that is healthy requires less irrigation and resists pests and diseases. Establishing and maintaining a healthy lawn means reducing or eliminating conditions that put stress on the turf. A soft, microbially-rich soil allows for rapid water infiltration, good water and nutrient holding capacity, unimpeded root growth, efficient nutrient mineralization, and effective antagonistic control of pests and diseases. Regular additions of mature compost enhance soil quality while providing biological control of diseases and certain weeds. Raising mowing height to 2 ½ to 3 inches, keeping mower blades sharp, and returning mower clipping to the soil stimulates healthy

turf growth and reduces the potential for diseases. Similarly, watering infrequently – but to the depth of root penetration – minimizes both turf stress and the environmental conditions that favor root diseases. A diversity of species within a lawn reduces insect and weed infestations. Natural lawns including clover, wildflowers, or groundcovers that are drought or shade tolerant add variety to a landscape while reducing maintenance time and expenses.

Acknowledgements

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Organizations

Golf Course Superintendents Assoc. of America

1421 Research Park Dr.

Lawrence, KS 66049-3859

Telephone: 800-472-7878, 785-841-2240

<http://www.gcsaa.org>

The Golf Course Superintendents Association of America (GCSAA) supports research on environmentally sensitive turfgrass care. Their magazine, Golf Course Management, includes articles on least toxic pesticide use and practices, integrated pest management (IPM), biological control, wildlife and golf courses, water saving practices, and compost use in golf course management, among other topics.

Turfgrass Resource Center / Turfgrass Producers International

1855-A Hicks Rd.

Rolling Meadows, IL 60008

Telephone: 800-405-8873, 847-705-9898.

FAX: 847-705-8347

E-mail: info@TurfGrassSod.org

Web page: <http://www.TurfgrassSod.org>

A member's Web page with information about turfgrass varieties, turf soil management, and lawn watering practices. Also includes a database of turfgrass specialists.

National Turfgrass Evaluation Program

Kevin Morris, Executive Director
National Turfgrass Evaluation Program
10300 Baltimore Ave. Bldg. 003, Rm. 218
Beltsville Agricultural Research Center-West
Beltsville, MD 20705
Telephone: 301-504-5125
E-mail: kmorris@ntep.org
Web page: <http://www.ntep.org/contact.htm>

The National Turfgrass Evaluation Program (NTEP) is one of the most widely-known turfgrass research programs in the world. NTEP currently evaluates seventeen turfgrass species in as many as forty U.S. states and six provinces in Canada. Their Web page provides annual evaluation results on turfgrass quality, color, density, resistance to diseases and insects, tolerance to heat, cold, drought, and traffic.

United States Golf Association Green Section

P.O. Box 708
Far Hills, NJ 07931
Telephone: 908-234-2300
USGA Publications: 1-800-336-4446
Web page: <http://www.usga.org/green/index.html>

Golfcourse maintenance publications cover turf management, IPM for golf courses, landscape restoration, environmental issues for golf course management and construction, irrigation systems, waste water reuse, and bird conservation on golf courses.

NOFA Accredited Organic Land Care Professionals

c/o NOFA Connecticut
PO Box 386
Northford, CT 06472-0386
Web page: <http://www.organiclandcare.net/professionals.php>

They wrote the Standards for Organic Land Care. Their Web page also lists names of lawncare professionals in the Northeast who are NOFA Accredited Organic Land Care Professionals.

Resources

Books

Least-toxic and Organic Lawn Care

Standards for Organic Land Care: Practices for Design and Maintenance of Ecological Landscapes. Organic Land Care Committee. 2001. 66 p.
Northeast Organic Farming Association of Connecticut
PO Box 3
Northford, CT 06472-0386.
Web page: <<http://www.nofaic.org/store/ct/index.php>>

This manual describes how to grow an organic lawn following an ecological stewardship philosophy for designing and maintaining landscapes. Written by landscape professionals, scientists, and citizen activists. It includes lists of preferred, allowed, and prohibited materials and practices for organic land care. Purchase of this manual includes the booklet A Citizen's Guide to Organic Land Care, which answers, in customer-friendly terms, the questions: what is an organic lawn? and what are the advantages of an organic lawn?

Organic Lawn Care

Bruneau, A.H., Fred Yelverton, L.T. Lucas, and Rick L. Brandenburg. 1997. Publication AG-562.
North Carolina Cooperative Extension Service.
32 p.
Department of Agricultural Communications
North Carolina State University
Box 7603
Raleigh, NC 27695-7603

Practical information for homeowners. Maintenance schedules, sources of organic fertilizers, organic control strategies for insects and diseases, and recommended cultivars and planting dates for North Carolina.

Handbook of Successful Ecological Lawn Care

Sachs, Paul D. 1996. 290 p.
Edaphic Press
PO Box 107
Newbury, VT 05051
Telephone: 802-222-4277

Well-researched handbook, written for professionals who install and maintain lawns. The

book is divided into two sections. The first, called *In the Field*, includes chapters on turfgrass dynamics, installing a new lawn, cultural practices, turfgrass pests, and soil testing and fertility. Part Two focuses on the business aspects of running a lawn care business. This book is comprehensive in its approach to the soil-turf complex.

Ecological Golf Course Management

Sachs, Paul D., and Richard T. Luff. 2002. 197 p.
Wiley Publishers
Web page: <<http://www.wiley.com/cda/sec/0,,10734,00.html>>

A comprehensive publication on ecological turf management. It focuses on managing the health and welfare of all soil organisms from a single-celled bacterium to fully developed turf plants. It also points out ways to exploit natural plant defense systems that have been largely ignored and to engage many of the powerful allies that live above and below ground.

Down-to-Earth Natural Lawn Care

Raymond, Dick. 1993. 176 p.
Storey Communications
25 Main St.
Williamstown, MA 01267
Telephone: 800-793-9396

Natural lawn care for residents or landscape professionals.

Pest and Disease Control

Turfgrass Problems: Picture Clues and Management Options

Eva Gussack and Frank S. Rossi. 2001. 214 p.
Natural Resource, Agriculture, and Engineering Service (NRAES)
Cooperative Extension
152 Riley-Robb Hall
Ithaca, New York 14853-5701
Telephone: 607-255-7654
Fax: 607-254-8770
E-mail: nraes@cornell.edu.
Web page: <<http://www.nraes.org/publications/nraes125.html>>

A compact, spiral-bound guide with over 130 color photos designed to help readers identify turfgrass problems and implement appropriate management strategies. The guide covers problems of cool-season turfgrasses caused by non-living (abiotic) or living (biotic) factors. Each problem discussion includes photos, a detailed

description, conditions under which the problem tends to occur, and non-chemical management strategies. Also includes chapters on scouting and sampling procedures and symptom timelines for when in the season problems are likely to occur.

IPM Handbook for Golf Courses

Schumann, G., P. Vittum, M. Elliott, and P. Cobb. 1998. 264 p.
Wiley Publishers
Web page: <<http://www.wiley.com/cda/sec/0,,10734,00.html>>

An excellent introductory handbook for golf course superintendents. Describes IPM and how it can be performed on golf courses. Chapters include site assessment, scouting and monitoring, cultural control strategies, biological and chemical control strategies.

Biological Control of Turfgrass Diseases

Cornell Media Services Resource Center. 12 p.
Ithaca, NY 14853
Telephone: 607-255-2080
Web page: <http://www.cce.cornell.edu/publications/gardening.cfm>

Lists biological controls for turfgrass diseases and describe the use of organic fertilizers, suppressive composts, and microbial fungicides.

IPM for Lawns.

Bio-Integral Resource Center. 1987. 70 p.
PO Box 7414
Berkeley, CA 94707
Telephone: 510-524-2567
Web page: <<http://www.birc.org/>>

Bio-Integral Resource Center (BIRC) specializes in finding non-toxic and least-toxic, integrated pest management (IPM) solutions to urban and agricultural pest problems.

The Chemical-Free Lawn

Schultz, Warren. 1989. 208 p.
Rodale Press
33 E. Minor St.
Emmaus, PA 18098
Telephone: 800-527-8200

Designed for homeowners. Includes information on assessing lawn problems, species and cultivars, seeding, sodding, sprigging, fertilizing, mowing, watering, and fighting weeds, insects, and diseases without chemicals.

Compendium of Turfgrass Diseases. 2nd ed.
Smiley, Richard W. et al. 1992. 102 p.
American Phytopathological Society
3340 Pilot Knob Rd.
St. Paul, MN 55121-2097
Telephone: 612-454-7250

Management of Turfgrass Diseases. 2nd ed.
Vargas, M.J., Jr. 1993. 320 p.
Lewis Publishers
2000 Corporate Blvd. NW
Boca Raton, FL 33431
Telephone: 800-272-7737

Managing Turfgrass Pests
Watschke, Thomas L., Peter H. Dernoeden, and
David Shetlar. 1994. 384 p.
Lewis Publishers
2000 Corporate Blvd. NW
Boca Raton, FL 33431
Telephone: 800-272-7737

Alternative Lawns

*Easy Lawns: Low-Maintenance Native Grasses for
Gardeners Everywhere*
Stevie Daniels (ed.). 1999. 111 p.
Brooklyn Botanic Garden
1000 Washington Ave.
Brooklyn, NY 11225
Telephone: 718-622-4433
Web page: <[http://www.bbg.org/gar2/topics/
sustainable/handbooks/lawns/](http://www.bbg.org/gar2/topics/sustainable/handbooks/lawns/)>

*This book is a compilation of information on the
establishment of no-mow and native grass prairie
lawns. Each chapter focuses on low-main-
tenance lawn species and management practices
for different regions of the country.*

*The Wild Lawn Handbook: Alternatives to the Tradi-
tional Front Lawn.*
Daniels, Stevie. 1995. 256 p.
Macmillan
New York, NY

*A practical guide for transforming grass lawns
into beautiful alternative lawns using native
grasses, ferns, mosses, wildflowers, low-grow-
ing shrubs, and perennials. Includes detailed
instructions on choosing, installing and main-
taining a wild lawn, including a chapter on land-
scaping ordinances.*

*Gardening with Prairie Plants: How to Create Beau-
tiful Native Landscapes*
Wasowski, Sally. 2002. 285 p.
University of Minnesota Press
Minneapolis, MN

*A beautifully illustrated guide to establishing
prairie landscapes. Describes methods for de-
signing, installing, and maintaining yards with
prairie plants. Provides extensive and detailed
profiles of prairie flowers and grasses and how
to use them in prairie lawns.*

Electronic database

Turfgrass Information Center
Michigan State University
100 Library
East Lansing, MI 48824-1048
Telephone: 517-353-7209

E-mail: tgif@pilot.msu.edu

Web page: <<http://www.lib.msu.edu/tgif/>>.

*The Turfgrass Information Center (TIC) at
Michigan State contains the most comprehen-
sive collection of turfgrass educational materi-
als publicly available in the world. The TIC
maintains the Turfgrass Information File
(TGIF), an on-line computer based bibliographic
database of turfgrass research data. Subscrip-
tions or flat rates available. See their Web site
for more information.*

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By **Barbara Bellows**
NCAT Agriculture Specialist

Edited by Paul Williams and David Zodrow
Formatted by Cynthia Arnold

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The electronic version of **Sustainable Turf Care**
is located at:
HTML
<http://www.attra.ncat.org/attra-pub/turfcare.html>
PDF
[http://www.attra.ncat.org/attra-pub/PDF/
turfcare.pdf](http://www.attra.ncat.org/attra-pub/PDF/turfcare.pdf)

IP123

APPENDIX: Table 1. Characteristics of good quality compost for turf

Compost Characteristic	Analysis
Appearance	few recognizable components of original material remain. Structure is light and crumbly.
Color	dark brown to black (but not dark black, which indicates overheating during the composting process)
Texture or particle size	fine texture, particles smaller than 1/2 inch for incorporation, smaller than 1/8 for topdressing
Odor	earthy aroma, no smell of ammonia or sulfur
Temperature	not warm to the touch
Moisture content	30 to 50%
Carbon to nitrogen ratio (C:N ratio)	15:1 to 20:1
Organic matter	more than 25%
Humus	color chromatography test between 50 and 80 for finished compost
Ammonium	0.2 to 3.0 ppm
Nitrate	< 300 ppm
Sulfides	zero to trace
pH	6.5 to 8.5; pH 7 optimal
Heavy metals	lower than allowable limits
Soluble salts	conductivity less than 3 millimhos
Microbial profile	<ul style="list-style-type: none"> • 10,000 to 20,000 species of bacteria per gram • aerobic bacteria populations should be between 100 million to 10 billion CFU/gdw • aerobic bacteria should outnumber anaerobic bacteria by ratio of 10:1 or more • Pseudomonas bacteria populations should be between 1 thousand to 1 million CFU*/gdw • nitrogen-fixing bacteria populations should be between 1 thousand to 1 million CFU/gdw • yeasts and fungi populations should be between 1 to 10 thousand CFU/gdw • actinomycete populations should be between 1 to 100 million CFU/gdw

* CFU/gdw is colony forming units per gram dry weight

Sources: 4, 5, 6, 40

APPENDIX: Table 2. Organic Nutrient Sources

	Nitrogen Sources	Phosphorus Sources	Potassium Sources
Preferred	<ul style="list-style-type: none"> alfalfa meal compost compost tea 	<ul style="list-style-type: none"> compost compost tea green manures 	<ul style="list-style-type: none"> alfalfa meal compost compost tea
Allowed	<ul style="list-style-type: none"> vegetable meal such as soybean meal, corn gluten meal, cotton seed meal, and peanut meal blood meal from U.S. sources fish emulsion or meal 	<ul style="list-style-type: none"> greensand rock phosphate steamed bone meal from U.S. sources 	<ul style="list-style-type: none"> greensand seaweed Sul-Po-Mag potassium sulfate
Prohibited	<ul style="list-style-type: none"> leather meal Chilean nitrate synthetic nitrogen fertilizers 	<ul style="list-style-type: none"> synthetic phosphorus fertilizers 	<ul style="list-style-type: none"> muriate of potash synthetic potassium fertilizers
	Do not use: <ul style="list-style-type: none"> uncomposted manure, since it contains weed seeds and pathogens sewage sludge, since it may contain heavy metals and pathogens 		
Source: 6			

APPEINDIX: Table 3. Characteristics of Common Turf Grasses

Lawn Grass	Heat or Cold Tolerance	Shade	Drought	Durability or Wear	Pest Resistance	Soil Preference	Maintenance Level	Establishment Method
Warm-Season Grasses								
Bahiagrass	Heat tolerant	Moderate - Poor	Good - Excellent	Poor - Good	Nematodes- V. Good Diseases - Good	Acid, sandy	Low - Moderate	Seed, sod
Bermudagrass	Heat tolerant	Poor- Very Poor	Good- Excellent	Good - Excellent	Nematodes-Poor Diseases - Good	Wide range	Medium - High	Sod, sprigs, plugs, seed
Carpetgrass	Heat tolerant	Fair -Moderate	Poor	Poor	Nematodes-Poor Diseases - Moderate	Acid, wet	Low	Seed, sprigs
Centipedegrass	Heat tolerant	Fair-Good	Good	Poor	Nematodes-Poor Diseases - Good	Acid, infertile	Low	Seed, sod, sprigs, plugs
St. Augustinegrass	Heat tolerant	Good- Very Good	Good - Poor	Poor- Good	Nematodes-Good Diseases-Moderate	Wide range	Medium	Sod, plugs, sprigs
Zoysiagrass	Heat tolerant	Good	Good- Excellent	Good - Excellent	Nematodes-Poor Diseases - Good	Wide range	High	Sod, plugs
Cool-Season Grasses								
Kentucky Bluegrass	Heat - moderate Cold - moderate	Good	Good	Good	Diseases- moderate	Wide range	Moderate -High	Seed, sod
Rough-stalk Bluegrass	Heat - moderate Cold - moderate	Moderate	Poor	Poor	Diseases- moderate		Moderate	Seed, sod
Tall Fesue	Heat - moderate Cold - moderate	Good - Very Good	Very Good Good	Good - Very Good	Diseases- moderate	Wide range	Low - Moderate	Seed, sod, plugs
Red Fescue	Northern		Good- Very Good		Resistant to red thread	Acid soils	Low	Sod, plugs, sprigs
Annual Ryegrass	Heat- poor Cold - moderate	Poor	Poor	Good	Diseases- moderate		High	Seed
Perennial Ryegrass	Heat - moderate Cold - moderate	Good- Very Good	Good - Poor	Good	Allstar - high insect resistance		Low- Moderate	Seed, sod
Native Grasses								
Buffalograss	Heat-good Cold - moderate	Good	Very Good	Moderate	Disease-good		Low	Seed, sod, plugs
Blue Gamma	Heat-moderate Cold -good	Good	Good	Moderate	Disease-good		Low	Seed, sod
Crested Wheat grass	Heat-moderate							Seed, sod

Sources: 56, 57, 58

APPENDIX: Table 4. Cultural Practices for Turf Disease Control

Disease	Grass species affected	Resistant varieties	Aeration	Mowing	Fertility	Watering / Leaf wetness	Other
Anthraxnose			increase aeration	<ul style="list-style-type: none"> increase mowing height 	increase	<ul style="list-style-type: none"> reduce leaf wetness 	
Brown patch	<ul style="list-style-type: none"> Fescue Ryegrass Bluegrass Bermudagrass St. Augustinegrass 		increase aeration		<ul style="list-style-type: none"> reduce N in late spring, summer adjust pH to 6 - 6.5 	<ul style="list-style-type: none"> water deeply, infrequently water early in day reduce leaf wetness provide good drainage 	<ul style="list-style-type: none"> topdress compost
Dollar spot	<ul style="list-style-type: none"> Bluegrass Ryegrass Centipedegrass Bermudagrass Zoysiagrass 	available	increase aeration	<ul style="list-style-type: none"> collect and compost clippings 	<ul style="list-style-type: none"> adequate fertilization necessary raise pH 	<ul style="list-style-type: none"> water deeply, infrequently avoid drought stress water early in day reduce leaf wetness 	<ul style="list-style-type: none"> prevelent in dry weather topdress compost
Fairy ring	All cool and warm season grasses		increase aeration		increase N, iron		<ul style="list-style-type: none"> remove excess organic matter decrease thatch rototill or remove soil
Fusarium				<ul style="list-style-type: none"> increase mowing height 	reduce N	<ul style="list-style-type: none"> avoid drought reduce leaf wetness 	<ul style="list-style-type: none"> reduce thatch prevelent in cool weather
Leaf spot	<ul style="list-style-type: none"> All cool-season grasses Bermudagrass 	available		<ul style="list-style-type: none"> increase mowing height especially in late spring and summer keep mower blades sharp 	reduce N	<ul style="list-style-type: none"> water deeply, infrequently water early in day reduce leaf wetness 	<ul style="list-style-type: none"> reduce thatch
Necrotic ring spot		available	increase aeration		minimize stress	<ul style="list-style-type: none"> minimize stress 	<ul style="list-style-type: none"> reduce thatch topdress compost
Powdery mildew	<ul style="list-style-type: none"> Bluegrass 	shade-tolerant cultivars	increase aeration	increase mowing height	reduce N	<ul style="list-style-type: none"> water deeply, infrequently water early in day reduce leaf wetness 	<ul style="list-style-type: none"> reduce shade prevelent in cool weather
Pythium blight				do not mow when wet	reduce N	<ul style="list-style-type: none"> do not water at night improve drainage 	<ul style="list-style-type: none"> reduce shade topdress compost
Pythium root rot			increase aeration	increase mowing height		<ul style="list-style-type: none"> improve drainage 	<ul style="list-style-type: none"> reduce shade heavy fall compost application

APPENDIX: Table 4. Cultural Practices for Turf Disease Control - Continued

Disease	Grass species affected	Resistant varieties	Aeration	Mowing	Fertility	Watering/ Leaf wetness	Other
Red thread/pink patch	All cool-season grasses	available		collect and compost leaf clippings	increase fertility, pH	<ul style="list-style-type: none"> water deeply, infrequently reduce leaf wetness 	<ul style="list-style-type: none"> improve air movement prevelent in cool weather prevelent in dry weather topdress compost
Rust	<ul style="list-style-type: none"> Fescue Ryegrass Bluegrass Zoysiagrass 	available		collect and compost leaf clippings	increase	<ul style="list-style-type: none"> minimize stress maintain good soil moisture reduce leaf wetness 	<ul style="list-style-type: none"> reduce shade prevelent in dry weather
Slime molds	All cool and warm season grasses			collect and compost leaf clippings			<ul style="list-style-type: none"> remove mold by brushing or washing turf reduce thatch prevelent in cool weather
Southern Blight	<ul style="list-style-type: none"> Bluegrass Ryegrass 				fertilize properly	<ul style="list-style-type: none"> water deeply, infrequently reduce leaf wetness 	<ul style="list-style-type: none"> reduce thatch
Summer patch				increase mowing height	lower pH		
Stipe smut		smut-free seed			reduce N	minimize stress	
Take-all patch	<ul style="list-style-type: none"> St. Augustinegrass 			increase mowing height	lower pH increase P, K decrease Ca	improve drainage	
Yellow patch					reduce N	<ul style="list-style-type: none"> reduce leaf wetness 	reduce shade
Yellow tuft					reduce N increase iron	<ul style="list-style-type: none"> reduce leaf wetness improve drainage 	

Sources: 12, 13, 22

APPENDIX: Table 5. Cultural and Biological Control Methods for Turf Insect Pests and Other Athropods

Insect Pest	Geographical Locations Affected	Endophytes	Cultural control methods	Botanical Pesticides	Biological Insecticides
<i>Root feeders</i>					
White grubs	<ul style="list-style-type: none"> • Northeast • Southeast • Midwest • Plains states • Northwest • Southwest 	available for cool-season grasses	<ul style="list-style-type: none"> • withhold water in July and early August when eggs need water to hatch • increasing mowing height to 3 inches enhances milky spore effectiveness 	<ul style="list-style-type: none"> • Neem 	<ul style="list-style-type: none"> • <i>Bacillus popilliae</i> (Milky spore) to control Japanese Beetles • <i>Beauveria bassiana</i> • <i>Bacillus japonensis</i> • Entomopathogenic nematodes
Mole crickets	<ul style="list-style-type: none"> • Southeast • Gulf states 				<ul style="list-style-type: none"> • <i>Bacillus popilliae</i> • Entomopathogenic nematodes • <i>Beauveria bassiana</i>
<i>Stem feeders</i>					
Billbugs	<ul style="list-style-type: none"> • Southeast • Plains states 	available for cool-season grasses	<ul style="list-style-type: none"> • remove thatch to reduce habitat • reduce compaction • water deeply in spring 	<ul style="list-style-type: none"> • Neem • Diatomaceous earth for adults 	<ul style="list-style-type: none"> • Entomopathogenic nematodes • <i>Beauveria bassiana</i>
<i>Juice suckers</i>					
Chinch bugs	<ul style="list-style-type: none"> • Northeast • Southeast • Gulf states • Southwest 	available for cool-season grasses	<ul style="list-style-type: none"> • resistant varieties of grass • water regularly, especially early in season 	<ul style="list-style-type: none"> • Neem • Insecticidal soap 	<ul style="list-style-type: none"> • <i>Beauveria bassiana</i>
Mites			<ul style="list-style-type: none"> • frequent light watering 	<ul style="list-style-type: none"> • Insecticidal soap 	
Spittlebugs	<ul style="list-style-type: none"> • Zone 8 		<ul style="list-style-type: none"> • water thoroughly to remove bugs • water lightly during heat of the day 		
<i>Leaf eaters</i>					
Sod webworms	<ul style="list-style-type: none"> • Northeast • Southeast • Gulf states • Midwest • Plains states • Northwest 	available for cool-season grasses	<ul style="list-style-type: none"> • mow to 3 inches • remove thatch to reduce habitat • ensure good drainage • avoid drought conditions 	<ul style="list-style-type: none"> • Neem • Insecticidal soap 	<ul style="list-style-type: none"> • Entomopathogenic nematodes • <i>Bacillus thuringiensis</i>
Crane flies	<ul style="list-style-type: none"> • Northwest 		<ul style="list-style-type: none"> • enhance fertility • aerate lawn 		

APPENDIX: Table 5. Cultural and Biological Control Methods for Turf Insect Pests and Other Arthropods - Continued

Insect Pest	Geographical Locations Affected	Endophytes	Cultural control methods	Botanical Pesticides	Biological Insecticides
Cutworms	<ul style="list-style-type: none"> • Northwest 	available for cool-season grasses	<ul style="list-style-type: none"> • remove thatch to reduce habitat • use pheromone traps to monitor time of egg laying • mow and bag clippings to remove eggs from leaf tips 	<ul style="list-style-type: none"> • Neem • Insecticidal soaps 	<ul style="list-style-type: none"> • Entomopathogenic nematodes • Bacillus thuringiensis
Armyworms	<ul style="list-style-type: none"> • Southeast • Gulf states 	available for cool-season grasses	<ul style="list-style-type: none"> • remove thatch to reduce habitat 	<ul style="list-style-type: none"> • Neem • Insecticidal soaps 	<ul style="list-style-type: none"> • Entomopathogenic nematodes • Bacillus thuringiensis
Other Arthropods					
Slugs and snails	<ul style="list-style-type: none"> • Moist, humid climates 		<ul style="list-style-type: none"> • eliminating wet areas in lawn • setting out traps • planting non-preferred plant species 	<ul style="list-style-type: none"> • Copper barriers • Horsetail (Equisetum) extract • Sawdust • Wooddash 	<ul style="list-style-type: none"> • Slug-attacking nematodes (available currently only in Britain)

Sources: 6, 13, 58, 59

APPENDIX: Table 6. Conditions that Favor Weed Infestations

Weed	Soil moisture	Soil pH	Soil Compaction	Soil fertility	Mowing	Shade
Annual bluegrass	Poor drainage		High	High N	Too low	
Barnyardgrass	Poor drainage					
Birdsfoot Trefoil	Droughty conditions			Low N		
Black Medic	Droughty conditions			Low N		
Broadleaf Plantain		High	High			
Burdock					Infrequent	
Buttercup	Poor drainage					
Chickweed				High N	Too low	
Cinquefoil	Droughty conditions High surface moisture	Low		Low fertility		
Coltsfoot	Poor drainage	Low				
Common Mullein		Low		Low fertility		
Corn Chamomile	Poor drainage	High				
Corn Speedwell			High			
Crabgrass	Droughty conditions			Low N	Too low	
Creeping Bentgrass	Droughty conditions High surface moisture				Too low	
Creeping Speedwell						Too much shade
Creeping Thyme		High				
Curly Dock	Droughty conditions					

APPENDIX: Table 6. Conditions that Favor Weed Infestations - Continued

Weed	Soil moisture	Soil pH	Soil Compaction	Soil fertility	Mowing	Shade
Dandelion		High			Too low	
English Daisy		Low				
Foxtail				Low fertility		
Goosegrass	Droughty conditions		High			
Hawkweed		Low		Low fertility		
Henbit				Low fertility		
Hop Clover		High				
Lady's Thumb	Poor drainage	Low				
Leafy Spurge	Droughty conditions					
Mallow				Low fertility		
Nutsedge	Poor drainage					
Pigweed	Droughty conditions					
Prostrate Knotweed	Droughty conditions		High			
Prostrate Spurge	Droughty conditions		High			
Red Sorrel		Low				
Speedwell	Droughty conditions			Low N	Too low	
Wild Parsnip				Low fertility		
Yarrow	Droughty conditions					
Yellow Woodsorrel	Droughty conditions					

Sources: 4, 13

Sustainable Turf Care Executive Summary

Barbara C. Bellows

The key to organic or least-toxic turf management is reducing turf stress. Turf experiences stress from heat, drought, wetness, compaction, nutrient deficiencies or imbalances, and disease and pest infestations. To minimizing stress on turf, you need to pay attention to the following principles:

- Establish and maintain a healthy soil environment
- Include a diversity of species in the lawn environment
- Use cultural practices that reduce stress on turf
- Understand and work with your local soil and climate conditions
- Use biological pest controls

Establish And Maintain A Healthy Soil Environment

A lawn that is healthy requires less irrigation and better resists pests and diseases. Mature compost provides turf plants with a balanced, slow-release source of nutrients. Compost can be tilled into the soil to renovate land for healthy turf growth or applied to existing turf as a topdressing. When topdressing, the best time to apply compost is in the spring or fall. Compost applied in the spring provides nutrients to the soil and turf during the main growing season, while compost applied in the fall helps prolong the growing season, strengthens roots for the dormant season, and promotes early spring growth. Other organic sources of plant nutrients include vegetable and alfalfa meals for nitrogen, rock phosphate and greensand for phosphorus, and alfalfa meal, greensand, and seaweed for potassium.

Besides serving as a complete source of nutrients for turf growth, compost provides food for soil organisms. These organisms help create a soft, porous, well-aerated soil. They also break down thatch and allow for more effective water and nutrient use.

Include A Diversity Of Species In The Lawn Environment

Turf composed of a single species is highly susceptible to becoming weedy and demands more nutrients and water than turf composed of a diversity of species (12). To minimize maintenance problems, use a combination of species appropriate for your location and for the specific conditions within the yard. Also, choose varieties that have resistance to common pests in the area and that do not have a high demand for nitrogen.

Adding legumes such as Dutch white clover, subterranean clover, or black medic can add nitrogen to the soil, increase drought-tolerance, and decrease diseases and weed infestations. When mixed evenly with turf grass species, the resulting lawn has a soft, natural look.

Slow growing or “no mow” lawn mixes provide another option for low-maintenance lawn care. A combination of hard fescue and creeping red fescue is suitable for the cooler, medium-rainfall areas of the upper Midwest and the northeastern United States, and southern Canada. Various sedges and rushes can be used in moister regions.

Wildflowers provide additional color and variety to a yard while also attracting beneficial insects and birds. When purchasing wildflower seeds, select mixtures that are either native to or well adapted to your local climate and soil conditions. Avoid inexpensive seed mixes that contain a high percentage of weedy, aggressive, annual species. Native, warm-season prairie grasses provide an excellent companion to prairie flowers.

Use Cultural Practices That Reduce Stress On Turf

Mowing and watering are normal lawn maintenance practices that can either be used to create a healthy lawn or misused to produce a highly stressed lawn. Raising the mowing height to 2 ½ to 3 inches, keeping mower blades sharp, and returning mower clipping to the soil stimulates

healthy turf growth, controls weeds, and reduces the potential for diseases. Watering infrequently, but to the depth of root penetration, stimulates healthy root growth, minimizes turf stress, and reduces environmental conditions that favor root diseases.

Overseeding allows you to rejuvenate a lawn and fill in bare spots where weeds might otherwise grow (18). Overseeding also allows you to slowly replace inappropriate or disease-prone varieties with more appropriate or more disease-resistant varieties. In mid-latitude areas, it will extend the length of time a lawn remains green into the fall. For lawn rejuvenation, overseeding may be done either in the spring (April or May) or in the fall (September or October).

Other cultural practices that help control turf grass diseases include aerating the soil and turf by raking, coring, or spiking. You can also stimulate the growth of microbial antagonists by applying natural supplements such as lime, ash, compost, liquid seaweed, or fish emulsion.

Biological Pest Control Methods

A light topdressing of high-quality mature compost applied every 30 days can provide effective control of some root pathogens and reduce weed infestation. Compost applications can suppress some soil borne fungal diseases as well as conventional fungicides. You can topdress solid compost or mix with 20 to 30% sand, then incorporated into the soil with an aerator or drag chains. Alternatively, you can apply compost tea – a liquid solution prepared from high quality compost – as a spray.

Various biological pesticides are labeled for turf. The fungus *Trichoderma harzianum* controls several diseases, such as brown patch, dollar spot, pythium root rot, and blight. A commercial mixture of four species of *Bacillus* bacteria provides remedial treatment of turf diseases. *Bacillus popilliae*, also known as milky spore, controls grubs of Japanese beetles and mole crickets. Two species of insect-eating nematodes can be used to control white grubs, billbugs, sod webworms, cutworms, and army worms. These pest predators survive best in moist, loamy soils that have soil temperatures between 65° and 85° F. Since they are able to withstand high pressure, they

can be applied using a sprayer or irrigation equipment.

Perennial ryegrass and many types of fescue have a symbiotic relationship with special fungi or endophytes. Grass varieties that contain endophytes produce a bitter toxin that repels most insects and kills many of those that continue to feed. Besides protecting infected grasses from insect pests, endophytes also produce hormone-like substances that increase the growth and vitality of the grass. While endophyte-infected seed must be stored carefully and planted promptly to ensure the survival of the endophyte, once the endophyte-infected grass is planted, the endophyte grows and reproduces with the grass as long as the grass remains viable.

The easiest and most effective method of weed control is to increase species diversity in the lawn. By raising the mower height to 3 inches, especially during the spring, you can obtain the same level of crabgrass control as with herbicides. Leaving grass clipping on the lawn after mowing can control the germination and growth of certain weeds, because the clippings contain allelopathic compounds. Two organically-approved herbicides have demonstrated a high level of control. Corn gluten meal provides pre-emergence control of various weed species, including crab grass, foxtail, pigweed and dandelion. Concentrated vinegar, containing 10 to 20% acetic acid, is an effective post-emergence herbicide that kills giant foxtail, common lambsquarters, smooth pigweed, and velvetleaf. Unfortunately, both of these products are only economical to use in small areas or as a spot-treatment.

