INFORMATION BULLETIN 213

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Athletic Field Maintenance

A Guide for Sports Turf Managers

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The Soil

Soil is a complex plant growth medium that provides water, nutrients, and physical support. Athletic field soils should be springy or yielding, yet firm enough to resist compaction under hard use and heavy traffic. There are few turfgrass areas where the soil receives more abuse than on athletic fields. A basic understanding of soils and how to manage them is very helpful for maintaining quality athletic fields.

Soils have four major parts: mineral matter, organic matter, air porosity or space, and capillary or water-filled porosity. The proportion of each varies with soil type and condition. The mineral fraction is the largest component of a soil.

Soil particles range in size from less than 1 micron (µm) to 2 millimeters (2,000 µm) in diameter. Larger particles are often present. Depending upon their size, soil particles are grouped into various soil separates including clay, silt, and sand. Soil texture is determined by the relative proportion of these various sizes of soil particles. Sand particles are the largest. They provide the structural backbone of a soil and contribute to the air-filled pore space. Sand has little nutrient- or moisture-holding capacity.

The silt group particle sizes are between sands and clays. Silt is undesirable in athletic field soil because it compacts, and provides little in the way of plant food storage.

Clays are the smallest of the three size classes. Clays have a large surface area and are chemically very active in the soil. Clays are the major mineral fraction responsible for plant food or nutrient storage in a soil. Like the silt fraction, however, clay compacts easily.

The relative proportion of each particle size class in a soil determines the soil textural class. The USDA system of classification (Table 1) has arranged sands into 5 groups and soils into 12 textural classes (Figure 1) based on the proportion of sand, silt, and clay.

Most sports fields are constructed with native soils already present on the site. This lowers the cost, but many of the soils in the Northeast are fine-textured. These heavy soils have high water holding capacities and surface drainage problems. Table 2 lists the physical characteristics of several soil types, and shows that not all soils are useful for sports fields.

Soil Modification

Heavy soils high in silt and clay are more likely to compact than sandy soils. Sports turf managers often add sand to an existing field to improve the physical properties of the soil. Methods have included mixing sand into the soil, or simply topdressing the soil with a layer of sand. If done properly, both methods can improve the soil conditions. If certain rules are not followed, however, the end results can be disastrous. Soil should be modified so that the final top mix contains at least 75 percent sand.

Table 1. Textural classification of soil particles (USDA) and desired range.

Separate	*Diameter size (mm)*	*Sieve size (openings/inch)*	
Very coarse sand	2.00-1.00	10	
Coarse sand	1.00-0.50	16	Range for soil mixes and topdressings
Medium sand	0.50-0.25	32	
Fine sand	0.25-0.10	150	
Very fine sand	0.10-0.05	270	
Silt	0.05-0.002		
Clay	<0.002		

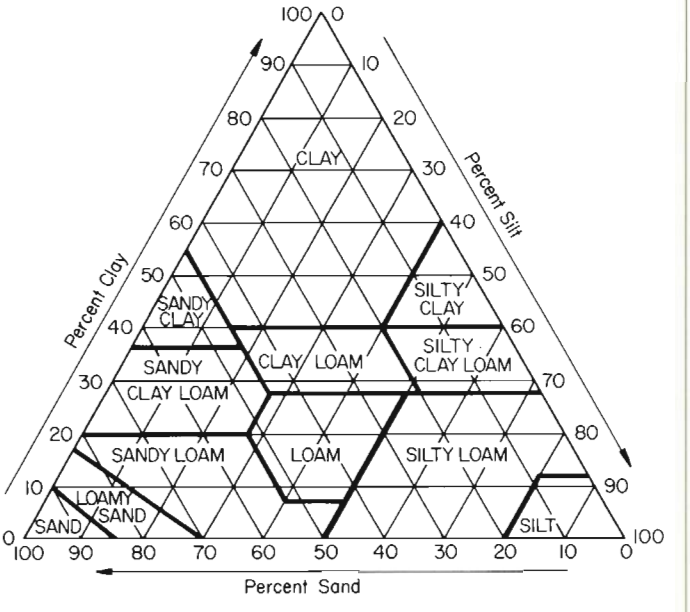


Figure 1. Textural triangle with soil textural classes reflecting the relative percentages of sand, silt and clay (from Turgeon, 1985).

Athletic field built with a modified, high sand growth medium.

Table 2. General physical characteristics of different soil textures.

	Physical characteristics		
Soil texture	*Drainage*	*Ease of compaction*	*Water and nutrient holding capacity*
Sand	excellent	none	limited
Loamy sand	excellent	limited	limited
Sandy loam	good	limited to moderate	moderate
Loam	good to fair	moderate	moderate to substantial
Silt loam	fair to poor	substantial	substantial
Clay loam	fair to poor	substantial	substantial
Clay	poor	substantial	substantial

A soil should be modified at least 8 inches deep. A 12-inch depth is better. It requires about 12 cubic yards of sand per 1,000 square feet to increase the sand content of a soil from 30 percent to 80 percent in the top 8 inches. To ensure uniform mixing, spread 2 inches of sand on the soil and mix it to an 8-inch depth. Repeat this until all the sand has been worked into the soil.

Sands will vary in composition with particle size. Some sands are not suitable for soil modification. A uniform sand in a medium size class is better for soil modification. Table 1 lists the size distribution of sands desirable for modification. Tests can determine if a sand is suitable for modification. Soil tests can also determine what proportions of sand and soil you should use for a suitable athletic field soil. Your Cooperative Extension office can provide more information and tell you where these tests are offered.

Organic matter is the next often used physical amendment. A high quality organic matter source will improve the physical properties and the nutrient- and water-holding capacity of a soil. Use a high-quality peat humus or reed sedge peat. Hypnum or sphagnum moss peats are also well adapted for this purpose. Avoid using mucks or other organic soils that contain a high percentage of soil. A high-quality peat should contain at least 90 percent organic matter. Thoroughly mix 2 cubic yards of organic matter per 1,000 square feet into the top 6 to 8 inches of soil.

Other organic matter sources include sewage sludge, composed leaves, grass clippings, and others. These materials decompose rapidly in the soil and are not as effective as decomposed peats.

Obviously, the proper modification of a soil is expensive and exacting. Contact your county Cooperative Extension or state turfgrass specialist for more information and guidance on soil modification.

Surface Drainage

Good drainage is important for sports fields. Excess water should be removed from the soil surface and the root zone. Plants, including turfgrasses, require ample amounts of oxygen in the root zone for normal root functioning. Saturated soils lack the free oxygen required by roots. Turfgrass growth is inhibited, and nutritional and disease disorders can develop under poor drainage conditions. Also, poorly drained soils are more prone to compaction. The lubricating effect of water between soil particles allows them to slide into compacted plates.

Proper drainage involves the removal of water from both the soil surface and from below the surface (subsurface). Surface drainage prevents precipitation or irrigation from forming puddles on the soil surface. Subsurface drainage is necessary when water percolates through the topsoil faster than the natural subsoil drainage will allow. When this happens, a temporary water table may exist close to the soil surface, keeping the root zone too wet.

Surface drainage should be designed into all sports fields, and this can be provided and/or improved by several means. First, a soil modified with a high percentage of sand is quite porous, and would more rapidly remove water from the soil surface. Athletic fields are now being built with sand for this and other reasons. Soil modification, however, is very ex-

acting. Most soil mixes will require a minimum of 75 percent sand to be effective. Consult your Cooperative Extension agent before modifying any turfgrass soil.

Surface drainage on a football field may be obtained by crowning the field. The design should provide for a 12- to 18-inch crown (1 to 2 percent grade) sloping uniformly from the center of the field to the sidelines. Tile lines should be placed along the sidelines, with open catch basins, to rapidly remove the surface runoff. Figure 2 shows the proper crowning and tiling of a football field. *Crowning is not necessary on sand fields.*

The high crown of a football field makes the field unacceptable for other sports such as soccer and field hockey. Multiple-use fields and baseball diamonds should have no more than 0.5 percent grade.

Vertical trenching

Vertical trenches may be installed to improve the surface drainage in problem turfgrass areas. Vertical trenches are installed by first digging trenches 12- to 18- inches deep on 10- to 15-foot centers. It is preferred that the trenches be no wider than 3 inches. This will reduce the amount of soil to be removed and the amount of sand required to backfill the trenches.

If a crown already exists in the area being trenched, it is best to run the trenches across the slope so that any surface runoff will be removed by the trenches. The trenches should be sloped (0.5 - 1 percent) to a terminal outlet. The outlet can be an existing drain tile.

Once the trenches are dug and clean, place 2-inch ID slitted drain tubing in the bottom of the trench. Backfill the trenches to overflow with a washed sand. The sand must reach the surface. This is extremely important. *Do not place a layer of topsoil over the sand.* Doing so makes the trenches ineffective, and in fact would create a water table close to the soil surface. Figure 3 is a cross section view of a vertical trench. Trenches may be sodded or seeded, or allow the turf to grow over the exposed trenches.

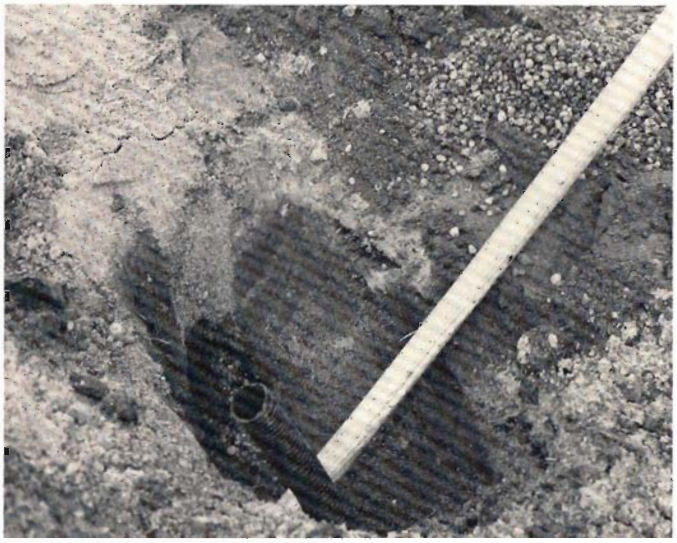
Subsurface Drainage

Naturally well-drained subsoils usually provide adequate internal drainage. Heavier subsoils that are slow to drain often need a subsurface drainage system to remove excess water.

There are several things to consider when designing a drainage system. First, it must be determined if a water table does in fact exist in the area, and if so, at what depth. Drains will remove water only when a water table is present or when the soil is saturated. Therefore, subsurface drainage tile may not be necessary unless a water table persists for several days after a rain. Also, drainage may not be needed in turfgrass areas if the water table is more than 3 feet below the soil surface.

There are many different types of drainage system designs used in sports fields. The more common *herringbone* and *continuous lateral* designs are shown in Figures 4 and 5, respectively.

Drainage tiles are normally placed at a depth of 2 feet or more on turfgrass areas, with 15- to 20-foot spacings. The trenches should be dug 6 to 8 inches wide with a minimum



A cross section of a vertical trench. Notice how sand is backfilled to the soil surface.

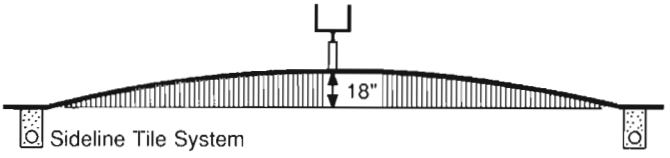


Figure 2. Cross section of a football field showing crown to provide surface drainage.

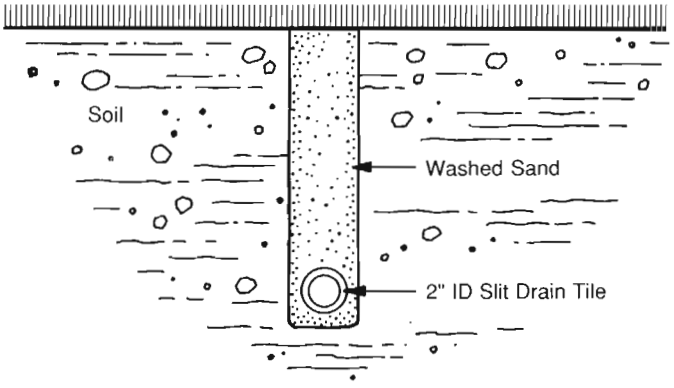


Figure 3. A vertical trench will rapidly remove surface water.

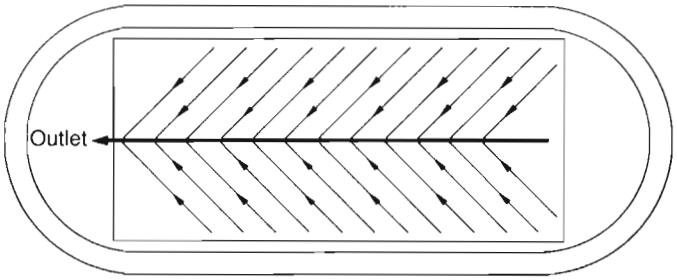


Figure 4. A herringbone drainage design on an athletic field.

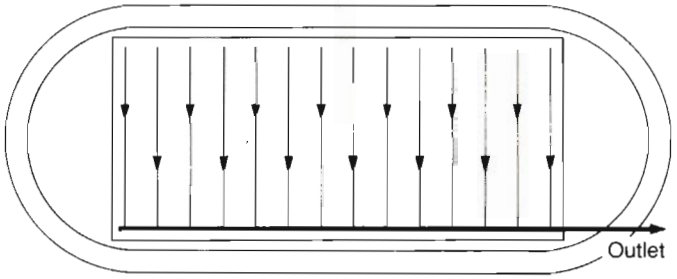


Figure 5. A continuous lateral drainage system on an athletic field.

of a 0.5 percent grade. A 2-inch layer of washed pea gravel is placed in the trench and leveled to grade for the tile placement. Place 3- or 4-inch corrugated drainage tile into the prepared trench. Be sure to cap blind ends and secure all joints to prevent soil from washing into the drain. Backfill the trenches with a 2- to 4-inch layer of pea gravel on top of the tile. Fill the remainder of the trench with the growth medium that will be used.

Do not fill the trench to within 4 inches of the surface with pea gravel. To do so would actually reduce the draw of the tile and leave the soil surface wet.

Drainage fabrics that prevent soil particle movement into the tile are available. If fabrics are used, be sure to consult the manufacturer for installation recommendations.

Water will drain from a field only as fast as the slowest part of the soil profile. Many sports fields have internal drainage systems that are not being used because the topsoil is impermeable. The problem here is lack of surface drainage, not subsurface drainage. Remember, drainage tiles are installed to remove water tables. If a subsurface tile system is present, it can be modified for better surface drainage.

To do this, locate existing drain tile with a probe. Trench above the tile to the depth where pea gravel is exposed. Remove the soil and backfill the trenches to overflow with a washed sand. If the tile is off the problem area, vertical trench with 2-inch tubing to the tile.

Cambridge system

The Cambridge system is another method of improving surface drainage in existing fields. It uses a combination of subsurface drains and vertical, sand-filled slits cut into the surface. A grid pattern of sand-filled trenches that connect to subsurface drainage quickly removes surface water .

The Cambridge system has been used successfully in Europe for many years. Because it may be difficult to do with conventional equipment, this method should be installed by a licensed Cambridge system contractor.

Prescription athletic turf (PAT) system

The prescription athletic turf (PAT) system is an elaborate installation that manages water content throughout the root zone. The primary growth medium in the PAT system is a compacted sand overlying an impermeable barrier (plastic sheeting). Suction pumps attached to the drainage system provide for rapid removal of surface water. Using moisture sensors and automated controls, a PAT system can effectively manage the water in the root zone by subirrigating or surface irrigating as needed.

The PAT system is patented, and should be installed only by a licensed contractor.

Soil Reaction

Soil reaction is an indication of the acidity or alkalinity of a soil and is measured in units of pH. The pH scale extends from 0 to 14; each whole-number unit reflects a 10-time change in the hydrogen (or hydroxide OH^-) ion concentration. Lower numbers indicate a more "acid" soil condition. Turfgrass species are adapted to a wide range of soil pH, but optimum growing conditions usually exist where the pH is neutral (pH 7.0) to slightly acid (pH 6.0).

Soil pH can be raised with periodic applications of lime. Liming acid soils results in better rooting, increased turfgrass vigor, improved availability of some plant nutrients, reduced availability of toxic elements, and more favorable microbial activity. Better microbial activity will reduce thatch. Liming materials include quicklime (Ca0), hydrated lime [$Ca(OH_2)$], calcitic limestone ($CaC0_3$), and dolomitic limestone ($CaC0_3$ - $MgC0_3$).

Limestone moves through the soil profile very slowly. Therefore, it is best to till lime into the soil prior to establishing a new turf. On established turf, lime may be incorporated by core cultivation.

The amount of lime necessary for neutralizing excessive soil acidity varies with soil texture. Clay soils may require nearly twice as much lime as sandy soils for the same pH adjustment. Test reports from the Cornell University Soil Testing Laboratory include recommendations for lime application based on the buffered pH or lime requirement test. Having the buffered pH test is the only way to accurately determine how much lime to add.

Depending upon the type of lime used, the amount applied at any one time should not exceed 25 to 50 pounds per 1,000 square feet. If hydroxide [$Ca(OH_2)$] or oxide (Ca0) forms are used, rates higher than 25 pounds may severely injure the turfgrass, especially when temperatures are high.

Excessive soil alkalinity can also occur and result in shortage of several plant micronutrients (essential nutrients needed in very small amounts). This problem often can be reduced by using acidifying fertilizers such as ammonium sulfate and urea, as well as elemental sulfur. The amount of sulfur required is determined by soil tests (see Table 3). No more than 5 pounds of finely ground elemental sulfur per 1,000 square feet should be applied at any one time. Due to the high possibility for sulfur-induced injury, applications should be done only in periods of moderate to low temperatures.

Table 3. To lower soil pH add the following pounds of elemental sulfur per 1,000 square feet.

	Soil texture		
pH Soil test	*Sandy loam*	*Loamy*	*Clayey*
8.0-7.0	4.0	8.0	11.0
6.5	5.7	11.3	15.7
7.5-7.0	1.7	3.3	4.7
6.5	3.3	6.7	9.0
7.0-6.5	1.7	3.3	4.7

Establishing Field Turf

Before an athletic field is established, a final grading must be done to ensure that the field is smooth and that the desired crown is obtained. Following correct procedures and planting high-quality seed or sod are the keys to successfully establishing an athletic field.

Seeding

The best time to seed a field in the Northeast is between August 15 and September 15. In northernmost areas seed should be planted by mid-September, while more southerly playing fields usually can be seeded in late September with good results. Fall planting is better than spring or summer because seeds germinate and grow rapidly in the warm soil. Warm days and cool nights are ideal for seedling growth, and there is less weed competition in the fall.

Establishment in spring and summer is possible with irrigation. However, fields planted in spring and summer may become infested with annual weeds unless they are controlled. The additional recommendation for spring seeding is to use the preemergence herbicide siduron. Siduron is the only preemergence herbicide safe for new seedings of bluegrass, fescues, and ryegrass. Siduron is marketed under the name Tupersan® and by various starter fertilizers with preemergence weed control. Once a barrier of siduron has been established, the soil should not be further disturbed. Wherever the barrier is broken, annual weeds will emerge. Do not use a crabgrass preventer unless it is labeled for new seedings.

Sodding

An athletic field may be established with sod at any time of the year, but irrigation should be available during hot, dry weather. A properly installed sodded field can be playable within a few weeks. Proper soil preparation is important in the successful establishment of a sodded field. This is especially true if the soil on which the sod is grown varies in texture from the soil on the field.

Sod will vary in quality. Be sure to select sod that is composed only of species recommended in this bulletin, and free of undesirable grasses and broadleaf weeds.

Soil Preparation

A well-prepared seedbed or sodbed is essential for rapid, successful establishment of an athletic field. Fertilization is very important at the time of seeding or sodding. This is the only time a soil amendment, lime, sulfur, or fertilizer can be well-mixed into the root zone.

Before preparing the seedbed or sodbed, broadcast fertilizer according to soil test recommendations, then mix it in to a depth of 4 to 6 inches. Soil testing information may be obtained from your county Cooperative Extension office.

When a soil test has not been made, apply 3 to 6 pounds of 0-46-0 (triple superphosphate) or 6 to 10 pounds of 0-20-0 (ordinary superphosphate) per 1,000 square feet, and work into the soil to a 4- to 6-inch depth using a rotary tiller or other cultivation equipment. To prevent clodding, do not till a wet soil. Overtilling also is

undesirable because it destroys the soil structure.

York rake or harrow the field to finish-grade just prior to seeding or sodding. Light rolling will expose any low spots or irregularities in the seedbed. Rerake these areas if necessary.

After the seedbed or sodbed has been prepared, and just before seeding, apply a commercial turfgrass starter fertilizer according to label directions. A starter fertilizer should have about a 3-4-1 nitrogen-phosphorus-potash ratio (for example, 18-24-6). Apply the fertilizer at a rate to provide 1 pound of actual nitrogen per 1,000 square feet. Additional fertilizer at a rate of 1 pound of nitrogen per 1,000 square feet should be applied to the field 3 to 4 weeks after germination, when the grass is 1 to 1 1/2 inches tall.

Weed control is important in a new turfgrass seeding. Some herbicides are safe to use in new seedings; check the weed control section of this bulletin for specific recommendations.

Species and Variety Selection

Select high-quality seed or sod of grass species and varieties best adapted to the site. The grasses on an athletic field should be able to tolerate heavy traffic and have the ability to recover from damage. A mixture of Kentucky bluegrass and perennial ryegrass provides these qualities. A mixture of 80 percent Kentucky bluegrass and 20 percent perennial ryegrass should be seeded at a rate of 2 to 3 pounds per 1,000 square feet. The mixture should include two or three bluegrasses and one or two improved perennial ryegrasses.

Check the current *Cornell Recommendations for Commercial Turfgrass Management* for the complete and updated list of turfgrass varieties.

In areas south of Interstate route 80 (south of Orange and Putnam counties in New York State), tall fescue may be used on sports fields. Tall fescue is drought tolerant, disease resistant, has a low nitrogen requirement, and is very wear resistant. The main drawbacks of tall fescue are its coarseness, intolerance of close mowing, and susceptibility to low-temperature injury. New turf-type tall fescue cultivars are being released that have been improved in these respects. Check the *Cornell Recommendations* for current information on tall fescue cultivars and adaptation. New fields of tall fescue should be seeded at a rate of 7 to 10 pounds of seed per 1,000 square feet. Do not mix tall fescue with other grass species. Seed may be broadcast or drilled. In either case, divide the total seed quantity in half. Sow one-half in one direction and the other half at right angles.

After the starter fertilizer and seed have been applied, drag the area to cover the seed to a depth of no greater than 1/4 inch. Roll lightly to firm the soil around the seed.

Grass seedlings are very susceptible to drying out, and therefore the surface of a newly seeded field should not be allowed to dry. Water should be applied only in amounts necessary to keep the soil surface moist. Avoid overwatering and runoff.

The new grass should be mowed when it reaches 3 to 3 1/2 inches in height. Mowing at this time will promote the spreading and thickening of the grass. Young grass seedlings should not be allowed to grow excessively long before the first mowing. Likewise, newly sodded areas should be mowed as needed.

Broadleaf weeds are quite unavoidable on newly established turf. Mowing will eliminate many of the weeds, and most of the remaining broadleaf weeds can be easily controlled with a broad-spectrum herbicide applied after at least two mowings. See the weed control section of this bulletin.

Maintaining Field Turf

The nutrient requirements of athletic fields will vary with soil type, grass species, amount of play, and the intensity of culture. The best way to determine fertilizer requirement for a field is to have the soil tested. Soil tests provide valuable information on pH and phosphorus and potassium requirements of the soil. Contact your county Cooperative Extension agent for soil testing information.

Fertilizer Materials

More nitrogen is required than any of the essential nutrients and is the nutrient around which fertilizer programs are developed. Nitrogen nutrition is important to turfgrasses because it can affect shoot growth, root growth, density, recuperative ability, and susceptibility to environmental stress and diseases.

The ideal fertilizer program provides uniform growth and quality throughout the growing season. A sound fertility program based on nitrogen source is important in moving toward this ideal. Nitrogen sources are divided into two broad groups—quickly available (water soluble) and slow-release (water insoluble).

Quickly available nitrogen sources include urea, ammonium nitrate, ammonium sulfate, diammonium phosphate, and others. These materials are water soluble, and the nitrogen is immediately available for plant uptake. Fertilization with soluble nitrogen sources results in a quick flush of growth, but rapid depletion of available nitrogen. Soluble sources are more likely to burn the turf if they are misapplied. Several light applications of these materials are better for obtaining uniform growth over a long period of time. Soluble nitrogen sources are usually less expensive per pound of nitrogen than the slow-release fertilizers.

Slow-release fertilizers include natural organics, synthetic organics, or coated nitrogen materials. The release of nitrogen from these materials may be due to microbial breakdown alone, or in combination with chemical and physical breakdown. Since the activity of microorganisms depends on soil temperature and moisture, nitrogen availability with slow-release fertilizers may vary with the season and weather.

Natural organic fertilizers include activated sewage sludges, manures, animal tankage, and others. The release of nitrogen from natural organics is due to microbial decomposition. Therefore, nitrogen availability is low in cool or dry months. Natural organics have a low foliar burn potential. They tend to have a low nitrogen analysis, therefore the cost per unit of nitrogen is usually high.

Ureaform (UF) is a generic name for the reaction product of urea with formaldehyde. Three types of UF products are available for turfgrass fertilization: the methyol ureas, methylene urea, and the longer-chained UF polymers.

Methyol ureas are water soluble and are applied as liquid applications. The nitrogen is rapidly converted in the soil to plant-available forms. Methyol ureas are similar to other quick-release sources in that they produce a rapid response of short duration. However, they have a much lower burning potential than the quick-release sources. These products must be applied several times each year to maintain uniform quality.

Methylene urea is used in O. M. Scott and Sons® products. The release of nitrogen from methylene urea is intermediate between methyol urea and other ureaform products. It produces a rapid response with short to intermediate residual. These products need to be applied at least three times a year to maintain uniform quality.

The ureaform used in Nitroform® and many other formulations contains a higher percentage of very slowly available nitrogen. Release of nitrogen depends on microorganism activity, therefore, nitrogen availability is greatly limited in cool times of the year. Ureaform nitrogen is very long lasting and is best if used in formulations with water soluble sources.

IBDU (isobutylidene diurea) is a synthetic organic nitrogen source that is not totally dependent on microbial activity. IBDU has an advantage of releasing nitrogen during periods of cool weather, if moisture is adequate. IBDU has a very slow initial release rate but excellent residual. It is well suited for formulation with quick release nitrogen sources Two or three applications of IBDU or formulations containing IBDU are necessary to maintain turf quality through the season.

Sulfur-coated urea is an example of a slow-release fertilizer made by coating a soluble nitrogen material with an impermeable coat of sulfur. Sulfur-coated urea will release nitrogen uniformly during periods of cool or warm weather. Sulfur-coated urea is an excel-

lent nitrogen source by itself, or in formulations with small amounts of quick-release nitrogen. Two or three applications of sulfur-coated urea will maintain quality turf through the season.

Many fertilizers contain both slow-release and soluble nitrogen in the same formulation. Such fertilizers would have the advantage of containing quickly available nitrogen, as well as the long-term benefits of slow-release nitrogen.

A turf-grade fertilizer is normally defined as a complete fertilizer (which contains nitrogen, phosphate, and potash), having at least 35 percent of the total nitrogen as water insoluble nitrogen (WIN). Water insoluble nitrogen is released slowly over several days or weeks. Fertilizers with at least 35 percent WIN can be applied at higher rates than quick release fertilizers with little risk of burning the turf. A fertilizer bag may have the following label:

20-5-10

Guaranteed Analysis

Total Nitrogen (N).....20%

8% Water Insoluble Nitrogen (WIN)

Available Phosphate (P_2O_5).....5%

Water Soluble Potash(K_2O).....10%

On the label, the 20 percent represents the total percentage of nitrogen in the bag. The 8 percent represents the percentage of nitrogen in the bag that is water insoluble or slow-release. The percentage of the total nitrogen that is water insoluble may now be determined. Divide the percent water insoluble nitrogen by the percent total nitrogen, and multiply by 100. In this case 8% ÷ 20% x 100 = 40% of the total nitrogen is water insoluble. Since the fertilizer contains more than 35 percent WIN it is considered a turf grade fertilizer with slow-release properties.

Phosphorus is an essential nutrient that is most important during establishment. Phosphorus promotes rapid growth and improved rooting of seedlings and is included in high amounts in "starter" fertilizers. Phosphorus applications to mature turf should be based on soil test recommendations.

Potassium is a very important nutrient, and is usually lacking in New York soils. Potassium has been shown to improve tolerance to disease and environmental stress. Potassium applications should be based on a soil test. Without a soil test, however, at least half as much potassium as nitrogen should be applied to athletic fields every year.

Fertilization Programs

A nitrogen fertility program should encourage enough turfgrass growth so that the turf is able to recover from divot injury, but not so succulent that wear tolerance is reduced. Below are two suggested fertilizer programs, one for high-maintenance fields, the other for low-maintenance or tall fescue fields.

Table 4 lists the amount of fertilizer material needed to obtain a recommended rate of nitrogen for various fertilizer analyses.

Core Cultivation

Surface compaction of the soil is a major cause of turf deterioration on athletic fields. Compaction prevents the infiltration of water into the soil, and results in increased puddling and runoff. Compaction also prevents the free exchange of gases into and out of the soil, robbing the soil of needed oxygen. Roots in compacted soils tend to be shallow and weak.

High-Maintenance Fields

Application date	*Application rate lbs. N/1000 sq. ft.*	*Comments*
May 1-15 or time of overseeding	1.0-2.0	Use slow-release if higher nitrogen rate is used.
June 15-30	1.0	Optional—not necessary if high rate of slow-release is used in May.
August 15-31	1.0	
November 1-15	1.0-1.5	Use water soluble, IBDU, or SCU.

Low-Maintenance Fields

Application date	*Application rate lbs. N/1000 sq. ft.*	*Comments*
May 15-31 or time of overseeding	1.0	
August 15-31	1.0	Preferred timing for fields fertilized once a year.

Core cultivation is one of the most important methods of relieving surface compaction. Intensively-used fields should be core cultivated as often as four times a year. The critical times to core cultivate a field are in the spring just prior to overseeding, in early summer after the spring sports season, in early fall prior to fall sports, and again in the late fall after the fall sports season. Very heavily used fields should be cultivated whenever possible.

There are several types of cultivators and cultivator tines available. A hollow tine or open spoon tine are most effective for alleviating compaction. These cultivators physically remove soil plugs and drop them on the surface. After the plugs dry, they can be broken up by dragging the field with a steel mat or piece of chain-linked fence, or with a rotary mower.

The tine spacing on most cultivators is such that several passes should be made in different directions for the best results. Spikers, slicers, or similar types of equipment will penetrate surface barriers such as thatch, but do little for repairing surface compaction.

Irrigation

Athletic fields require about 1 to 1 1/2 inches of water per week during the growing season. An irrigation system capable of supplying the required water uniformly on the field is desirable and, in many cases, essential. If water is available, there are irrigation systems that fit a wide range of budgets, from the most sophisticated automatic system to pressure-driven rain trains.

A watering program should consider soil type, grass species, and other factors, but should be based on turfgrass need. The turf should be irrigated only when necessary. Overwatering may promote disease development, shallow rooting, and thatch development. Water the turf thoroughly, but only when necessary.

Thatch Control

Thatch is a tightly-mixed layer of dead and living plant tissue that forms between the soil surface and the leaves. Thatch development is normal in athletic fields but excessive amounts may be harmful. Too much thatch (more than 3/4 inch) will make the turf more subject to environmental stress and diseases, provide shelter for damaging insects, or reduce the effectiveness of pesticides and fertilizers.

Grass species and cultivars have different rates of thatch formation. Some grasses will thatch faster due to vigorous growth. Mowing vigorous bluegrass cultivars shorter than 1 1/2 inches will reduce the vigor and thatching tendencies of these grasses. Other grasses such as fine fescues will develop thatch because they decompose slowly.

Fungi, bacteria, and other microorganisms actively decompose thatch. Earthworms and insects also help to control thatch by mixing soil into the thatch and improving soil aeration. Encouraging these organisms will speed thatch decomposition. Soil pH influences microbial activity and thatch decomposition. Apply lime or sulfur to maintain the soil at pH 6.0 to 7.0.

Core cultivation will encourage thatch decomposition by improving soil aeration. Also, cultivation will improve the physical properties of the thatch by mixing soil with it. Adequate irrigation and fertilization also will aid in thatch decomposition.

Topdressing a field with a thin layer of soil will help maintain a smooth playing surface and aid thatch decomposition. Use a soil or sand close in texture to the existing soil; different-texture soils result in layering that slows water infiltration. Topdressing should be done at least once annually to prevent layering.

Mowing

Mowing is the routine management practice often taken lightly by athletic field managers, but it shouldn't be. Proper mowing practices are essential in maintaining high-quality turf, and that means correct mowing height. Because mowing height is directly related to root growth, higher mowing heights are suggested for the off-season to encourage deeper rooting. The chart on the following page suggests mowing heights for athletic fields.

Mow as often as needed. As a rule of thumb, no more than 1/3

Table 4. Approximate pounds of material (nearest 1/2 pound) required to supply rate of nitrogen recommended per 1,000 square feet.

Pounds nitrogen recommended	*Urea 46-0-0*	*10-5-5*	*16-8-8*	*25-3-3*	*20-3-7 20-5-10*	*SCU 36% N*	*Natural organic 6% N*	*Ureaform 38% N*	*IBDU 31% N*
1/2	1	5	3	2	2 1/2	*	*	*	*
1	2	10	6 1/2	4	5	3	8 1/2	*	3
1 1/2	3	15	9 1/2	6	7 1/2	4	17	4	5
2	*	20	13	8	10	5 1/2	33 1/2	5 1/2	6 1/2
2 1/2	*	25	15 1/2	10	12 1/2	7	42	6 1/2	8
3	*	30	19	12	15	8	50	8	10

* Not recommended at these rates.

Cutting heights for athletic fields:

Use	*Cutting height (inches)* In season	Off season	
Baseball infields, Field hockey fields	3/4 - 1 1/2	2 - 2 1/2	
Baseball outfields, Soccer fields, Cricket outfields	1 - 1 1/2	2 - 2 1/2	
Football fields, Lacrosse fields, Rugby fields	1 1/2 - 1 3/4 1 1/2 - 2	2 - 2 1/2 2 1/2 - 3	bluegrass-ryegrass tall fescue
Bowling greens, Cricket wickets, Tennis courts	1/4 - 3/8	same	creeping bentgrass
Intramural fields	2 - 2 1/2 2 - 2 1/2	2 - 2 1/2 2 1/2 - 3	bluegrass tall fescue

Mowing direction can produce attractive stripes on fields.

of the leaf tissue should be cut off in any one mowing. This usually means once a week for most large athletic fields with mowing heights greater than 1 1/2 inches, two or three times a week for baseball infields, and daily for bowling greens, cricket wickets, and tennis courts. As mowing heights are lowered in preparation for the playing season, they should be dropped gradually, beginning several weeks before the start of the season.

Reel mowers are generally preferred for athletic turf. They are popular because they cut cleaner and have the ability to produce attractive striping patterns. Rotary mowers, however, are easier and less expensive to maintain, and are more versatile for mowing rough areas. Regardless of the type of mower used, the equipment should be kept sharp and properly adjusted.

With the exception of bowling greens, tennis courts, and cricket wickets, grass clippings should be returned. The clippings are a valuable source of nutrients and do not contribute to thatch. Clippings should be removed if the grass is wet or excessively long at the time of mowing.

Listed below are a few common problems associated with mowing, and their solutions:

• Brown, ragged blade tips — dull-mower injury. Sharpen mower blades, or replace if necessary.

• Brown, greasy spots or streaks — leak in hydraulic system. Find leak and repair.

• Rippling or marcelling — moving too fast. Inform operator of proper mowing speed, usually found in operating manual.

• Brown grass, stems showing, no green leaves ("scalping") — mowing height too low, wrong mower used, or excessive thatch. Readjust mowing height. If thatch is excessive, see section on thatch control.

• Narrow strip of unmowed grass — damaged or nicked reel or bedknife. Grind or lap reel and bedknife until nick is removed. Replace if necessary.

• Uneven mowing — one reel unit set differently from others, or mowing height not set evenly across the unit. Make necessary adjustments.

Overseeding

Athletic fields are often subjected to such intense wear that some areas can not be expected to recover through normal cultural practices. Annual overseeding of most athletic fields is necessary to maintain turf quality and playability.

Early fall would be the optimum time to overseed an athletic field, but this is often when the field is getting maximum use and overseeding is impossible. The second, and more realistic time to seed is mid- to late spring. Avoid dormant seeding in late fall because seed germination could be greatly reduced due to seed rot through the winter.

Successful spring overseeding starts with selecting the right grass species and varieties. In areas that are prone to severe wear annually, seed with a blend of two or three perennial ryegrass varieties at a rate of 4 to 5 pounds of seed per 1,000 square feet. On severely worn or bare areas, increase the seeding rate to 6 pounds per 1,000 square feet. On areas subjected to light or moderate wear, use a mixture of 80/20 Kentucky bluegrass/perennial ryegrass at a rate of 2 pounds of seed per 1,000 square feet. The bluegrass component should be a

blend of at least two improved bluegrass varieties and one or two improved perennial ryegrass varieties. Consult the *Cornell Recommendations for Commercial Turfgrass Management* for variety recommendations.

To overseed an athletic field:

1. Mow the field as short as possible without causing turf injury and remove the clippings. This will ensure that adequate sunlight reaches the soil surface to hasten seed germination. Maintain the field at this reduced height until germination is noticed.

2. Core aerify the field in at least four directions. Core aerification prepares a partial seedbed by bringing soil to the surface. If possible, drag the field with a flexible-tine harrow several times to prepare a seedbed.

3. Apply a high-phosphorus fertilizer (for example, a 4-6-1 or 2-4-1 ratio) at a rate to provide 1 pound of actual nitrogen per 1,000 square feet. Nitrogen and phosphorus are essential for rapid reestablishment of overseeded turf.

4. Overseed immediately following aerification. A disk-type seeder that deposits the seed into the soil is preferred. However, if a disk seeder is not available, the seed may be broadcast. In either case, sow half the seed in one direction and the other half at right angles to the first to ensure uniform coverage.

5. Drag the area with a drag mat, a flexible tine harrow, or a piece of chain link fence.

6. If spring seeded, immediately apply siduron (e.g. Tupersan® or Scotts Starter Fertilizer and Preemergence Weed Control®) at the recommended label rate to prevent annual grass competition. Siduron is the only preemergence herbicide safe to use in the seedbed.

7. Water the field as necessary to keep the soil surface moist. Do not use an herbicide to control broadleaf weeds until the newly seeded areas have been mowed twice.

Weed Control

Frequent physical damage to athletic turf by players and the required management to speed recovery makes weed control difficult. Frequent injury opens the turf, providing areas for weed infestation. Overseeding damaged turf restricts the use of herbicides for weed control. Unfortunately, the repair work must often be done at the "wrong" times for turf reestablishment but peak germination times for problem weeds. Still, with careful cultural management and herbicide use, a relatively weed-free athletic field is possible.

Cultural Management

On all turfgrass areas, the first line of defense against weed invasion is to maintain vigorous turf. Any stresses, such as improper species or variety selection, compacted soils, low fertility, improper irrigation, or damage from insects or diseases, will open the turf to weed infestations and be more favorable to weed growth than to turfgrass growth. For example: in compacted soil, weeds such as knotweed, goosegrass, and prostrate spurge are better able to survive than the turfgrasses. Also, the resulting poor turfgrass root growth will limit the grass's ability to compete with the weeds for available resources, especially during dry periods. To avoid such problems the field must be properly constructed. An adapted turfgrass species and cultivar must be selected and maintained by proper mowing, fertilization, irrigation, and pest control.

Newly seeded and overseeded turfgrass

In newly seeded or overseeded turf it is very important to have the desirable grass species established prior to the germination and establishment of summer annual weeds such as crabgrass, goosegrass, oxalis, and spurge. Very few herbicides can be used immediately prior to or after seeding. Tables 5 and 6 list suggested intervals from herbicide application to seeding, and from seeding to application of some commonly used turf herbicides.

Table 5. Suggested intervals from herbicide application to seeding.

Preemergence Herbicides

siduron (Tupersan®): No restrictions

DCPA (Dacthal®): 60 days

bensulide (Betasan®): 4 months

pendimethalin (Halts ®, Pre-M ®): 4 months

oxadiazon (Ronstar ®): 4 months

benefin (Balan ®): 12-16 weeks

benefin + trifluralin (Team ®): 12-16 weeks

Postemergence Herbicides

bromoxynil (Buctril®): No restrictions

chlorflurenol (Break-Thru®): No label restrictions
but 3 - 4 weeks are recommended.

dicamba (Banvel®): No label restrictions
but 3 - 4 weeks are recommended.

2,4-D + MCPP + dicamba (Trimec®, others): 3 - 4 weeks

2,4-D + triclopyr (Turflon D®, Turflon II Amine®): 2 weeks

2,4-D + 2,4-DP + dicamba (Super Trimec®): 3 - 4 weeks

2,4-D + 2,4-DP (Weedone DPC®): 4 weeks

fenoxaprop (Acclaim®):
fescues and perennial ryegrass - no restrictions
other turfgrasses - 21 days

MSMA (Daconate 6®, others): 2 weeks

Table 6. Suggested intervals from seeding to herbicide application.

Herbicides	*Suggested interval or timing*
Preemergence herbicides	
siduron (Tupersan®)	No restrictions
DCPA (Dacthal®)	1 - 2 inches new growth
bensulide (Betasan®)	Established turfgrass
pendimethalin (Halts®, Pre-M®)	Established turfgrass
oxadiazon (Ronstar®)	Established turfgrass
benefin (Balan®)	Established turfgrass
benefin + trifluralin (Team®)	Established, 1 year
Postemergence herbicides	
bromoxynil (Buctril®)	No restrictions
2,4-D (Weedar 64®, others)	After 3rd mowing
chlorflurenol (Break-Thru®)	Established turfgrass; some growth retardation may occur with higher rates which would be undesirable during establishment
dicamba (Banvel®)	After 2nd mowing
2,4-D + MCPP + dicamba (Trimec®, others)	No restrictions; after 2 - 3 mowings is suggested
triclopyr + 2,4-D (Turflon D®, Turflon II Amine®)	After 2nd mowing
2,4-D + 2,4-DP + dicamba (Super Trimec®)	No restrictions; after 2 - 3 mowings is suggested
2,4-D + 2,4-DP (Weedone DPC®)	After 2nd mowing
fenoxaprop (Acclaim®)	At least 4 weeks from emergence
- fescues and perennial ryegrasses	Treat only established stands (1 year old)
- Kentucky bluegrasses	Summer applications to turf seeded the previous fall is possible if turfgrass has established itself well
MSMA (Daconate 6®, others)	Apply to well established turf only; may injure bentgrass and fescues

Siduron (Tupersan®) is the only herbicide labeled for control of summer annual grassy weeds at or immediately following seeding. DCPA can be applied when the new turfgrass seedlings are about 2 inches tall. Other preemergence herbicides should be applied only to established turf. There are usually some grassy weeds that escape control by siduron followed by DCPA in 2 to 3 weeks. These may be controlled in midsummer by postemergence applications of methane arsonates (MSMA or DSMA).

The control of broadleaf weeds in turf is generally by postemergence applications of herbicides. These herbicides often vaporize easily and are potentially harmful to nearby ornamental plants. These materials should be applied in cool, calm weather when there is little chance of off-target drift. Tables 5 and 6 list restrictions on common broadleafed weed control herbicides used in newly seeded or overseeded turf areas. Control perennial weeds prior to over-seeding with an appropriate herbicide (Trimec®, Turflon-D®, Weedone DPC®, others). Observe the suggested intervals from application to seeding (Table 5).

If weed control prior to overseeding is not possible, observe the restrictions in Table 6 for applications to seedling turfgrasses. Note that bromoxynil is the only herbicide recommended for seedling turfgrass (for control of seedling annual broadleafed weeds). One of the other herbicides should be used for the control of perennial broadleafed weeds.

Established turfgrass

Numerous herbicides are labeled for annual grassy weed control in established turf. These preemergence herbicides also control certain small-seeded annual broadleafed weeds. Perennial broadleafed weeds are controlled using postemergence herbicides. See *Cornell Recommendations for Commercial Turfgrass Management* for herbicide recommendations.

Remember, the best weed control is to maintain a healthy turf. If turf is healthy and vigorous, weed problems will be easier to manage.

Insects and diseases

There are several diseases and insects that will damage athletic turf. Good management is the best prevention for these pests. Should an outbreak occur, proper diagnosis of the disease or insect is the first step in curing the problem. Your Cooperative Extension agent may assist you in correctly diagnosing the problem. Consult the *Cornell Recommendations for Commercial Turfgrass Management* for the most up-to-date pest control recommendations.

Care of skinned areas

The skinned areas of a baseball diamond are a very important part of the field and should be properly managed. The skin should be firm, but resilient, and should have good surface drainage. Drainage tile should be installed around the perimeter of the infield, as shown in Figure 6. If the soil in the infield is impermeable, backfill the trenches to the surface with washed sand. The

infield should have a 0.5 percent grade from the pitcher's mound towards the basepaths and outfield.

Various calcined clay products are popular for use in the skinned areas. The calcined clay is an excellent absorbant, and produces a very desirable infield surface. Several of these products come in different colors ranging from gray to red. Examples of products available for skinned areas include Diamond Dry®, Terra Green®, Turface®, and Beam Clay®.

To improve existing infields, apply calcined clay at 200 to 250 pounds per 1,000 square feet and rototill to a 2- to 4-inch depth. Drag the area with a screen drag until the field is level. Roll with a 1-ton roller, then drag again until the field is smooth. For new construction, contact the product manufacturer for specific recommendations.

The infield should be dragged prior to each use. Drag the field starting at first base and work toward third base in a spiraling pattern (Figure 7). Vary your pattern by alternating clockwise and counterclockwise directions to prevent uneven spots. The drags should be kept away from the grass so that a lip does not form in the grass. If a lip develops on the edge of the grass, the soil may be washed back into the infield using a high pressure hose.

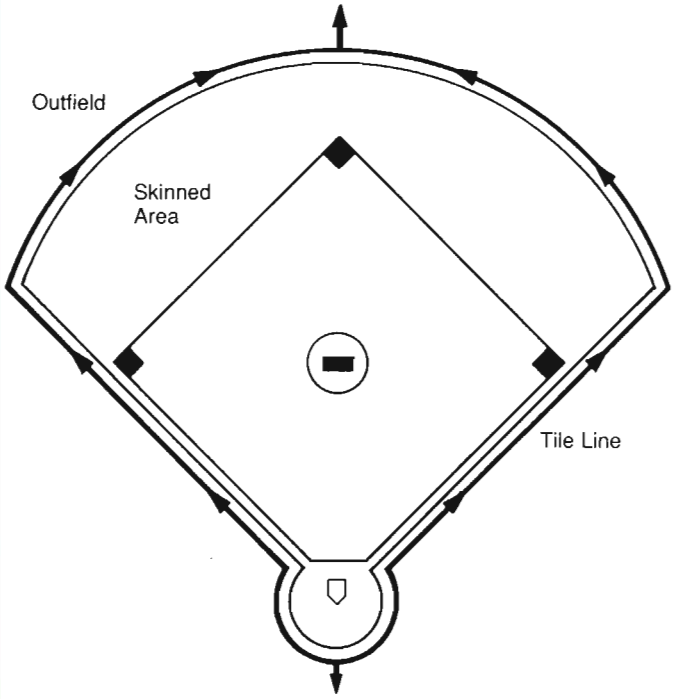


Figure 6. Baseball diamond showing drainage of the infield.

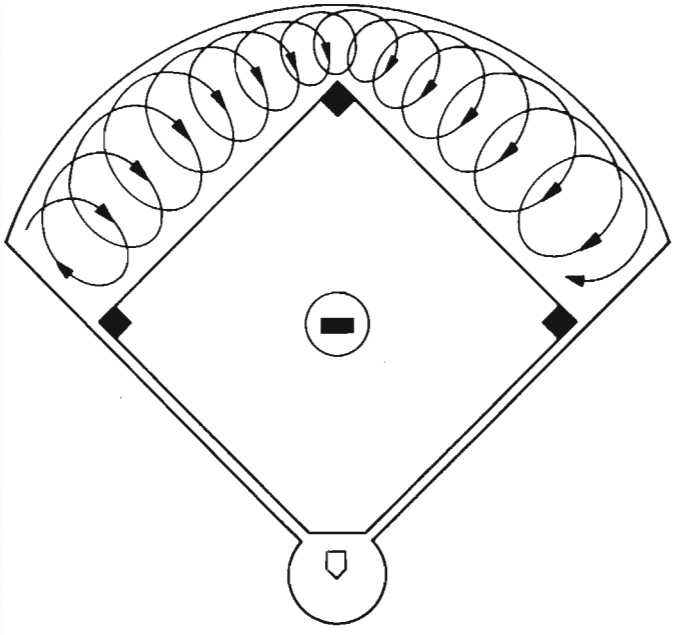


Figure 7. Directions for dragging skinned areas of baseball diamonds. The direction should be reversed each time.

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Cornell Cooperative Extension

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