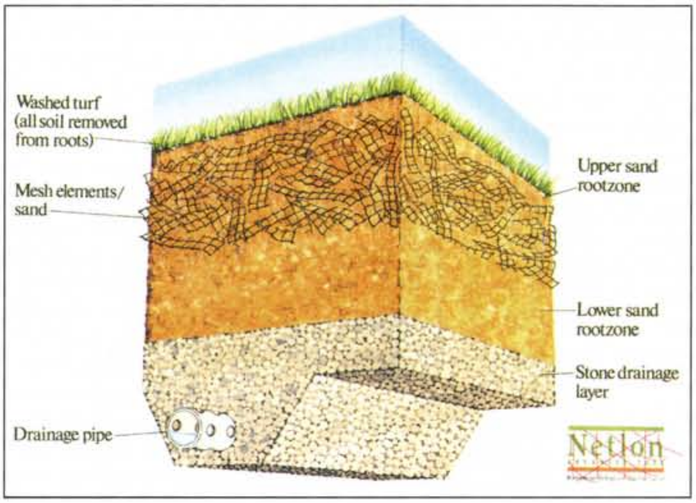
noted. To further examine the nature of the turf development and to assess the reasons for differing turf reactions, additional testing was conducted. Researchers undertook an objective assessment of the health of the turf in test plots with and without the mesh elements, and an assessment of the causes of the health through microscopic examination of the rootzone matrix.

Viewed through the microscope, undisturbed sections of the rootzone demonstrated the existence of minute voids associated with the mesh elements, which appeared to facilitate good aeration at the microscopic level. A hypothesis for the formation of these voids is that whenever the soil is subjected to traffic – from people or vehicles – the mesh element matrix may well be flexing slightly under the loads and causing a micro-cultivation effect in the rootzone.

Research had already fully-documented superior water infiltration rates, healthy deep rooting and an absence of "black layer" in rootzones containing mesh elements. Studies continued to assess whether the mesh elements might also be associated with the presence of these voids and micro-aeration of the soil.

Turfgrass Health

To conduct the testing, mesh elements had been mixed into a carefully-graded, high-sand rootzone mix to achieve a maximum dispersal through the rootzone when it was laid. The plots were planted with vegetative sprigs of Tifway bermudagrass which were broadcast at a rate of 14 bushels per 1,000 square feet. This was followed with a light topdressing and fertilization. The measurements of turf growth and health were made over eight years after the plots were established. Control plots - without the inclusion of the mesh elements - were established and maintained in exactly the same manner as the mesh-containing plots.



Profile of rootzone containing Netlon.

Turfgrass health was measured in terms of the depth of the turf canopy and of the root depth within core samples taken from plots - both those with mesh inclusion in the rootzone and those control plots without mesh inclusion. Test comparisons included three 4-inch diameter by 8 1/2-inch-long cores,

continued on page 14

Self-Cultivation

continued from page 13

from three replications of the two plot treatments.

As can be seen from Table 1, the measurements showed a striking difference between plots in terms of the depth of the turf canopy and thatch; the depth of the roots (which actually exceeded the depth of the core sample in the mesh-containing plots); and the viability of the roots (measured as the percentage of white, full, healthy roots in the core as opposed to black, spindly roots, which were especially apparent in the control plots below a depth of 3 inches).

Rootzone Studies

Micromorphology studies were conducted by Michael DePew, L. Wilding and James B. Beard to evaluate the physical and structural properties of paired rootzones — those with and without mesh inclusion — by several techniques, including thin soil-section micrographs.

Soil samples were collected in pairs from the no-mesh and mesh-inclusion turf plots. These cores were frozen in liquid nitrogen, cut to size and freeze-dried. The thin sections of the test-plot cores were then impregnated with epoxy, mounted, cut, ground and polished for the development of micrographs.

Using a cross-polarized light microscope, voids were revealed around the mesh-element strands in the sections from the mesh plots. No such voids were present in the no-mesh plots.

Aeration Through Micro-Cultivation

It is hypothesized that, when the pressure from traffic (e.g. athletes, other sports-related personnel, equipment, pedestrians, animals or vehicle traffic) is transmitted through the rootzone from the surface, the pressure causes the mesh to flex. When the small pieces of mesh (approximately 4 inches by 2 inches) are incorporated throughout the soil profile at a density great enough so that they become randomly interlocked, the pressure and the subsequent flexing also are transmitted between the pieces of mesh, thus helping to spread the area of load. As the load pressure is removed, the inherent stiffness of the mesh material causes it to spring back to its original shape. This movement can thus create the voids observed throughout the soil profile.

TABLE 1

A comparison of no-mesh versus a 4.2 pounds per cubic yard mesh density on Tifway bermudagrass grass after four years.

Plant Response	Rootzone Treatment no-mesh	Rootzone Treatment mesh inclusion
Depth of turf canopy and thatch (inches)	1.6	2.5
Root depth (inches)	5.9	8.5 plus
Root viability (%)	14	100

The conclusion is that grass plots with mesh elements included produced grass with a much greater production of vegetative matter, a greater canopy height, and a deeper, fully-healthy root system.

This micro-cultivation action could therefore be causing micro-aeration around the roots and contributing significantly to the very-evident root health. Having a permanent micro-aeration action incorporated within the rootzone in this fashion could greatly reduce or eliminate long-term needs for aeration on high-use sports turfs. This hypothesis is consistent with the superior level of turf growth and health of the mesh-containing trial plots over the no-mesh plots as observed over an eight-year testing period.

Clay Bridging and Black Layer

Scanning the root core sections with an electron microscope revealed the further interaction of the mesh with soil particles. In the sections from the no-mesh control plots, finely-textured clay could be seen extending continuously and bridging between the sand particles. In addition, iron oxide had accumulated in these layers, which corresponded to the observed black layer depth of between 3 3/4 inches and 5 inches below the soil surface on the no-mesh plots.

In contrast, at the same soil depth, sections from plots with mesh showed finely-textured clay coating the sand particles without bridging between them.

In the no-mesh control plots, this clay-bridged sand contributed to reduced soil-water infiltration and percolation, followed by the development of a micro-waterlogged zone above the clay-bridged zone. This created an anaerobic condition which inhibited healthy root development. This is certainly one potential cause of black layer in sand rootzones.

The presence of voids, maintained by the micro-cultivation and micro-aeration of the mesh flexion as discussed above, would certainly assist in better water micro-percolation and the promotion of aerobic conditions favorable to vigorous root growth.

Use of mesh elements in athletic turf fields currently is being used with good success in the U.S. and overseas. Examples of such use include the Santa Anita Turf Racing Courses - where the "athletes" exert considerable force - the Melbourne Cricket Grounds in Melbourne, Australia, which is the world's largest sports field, and Murrayfield, the world-renowned home of the Scottish Rugby Union. ❑

Editor's Note: Stephen Guise is National Sales Manager and Consultant for Netlon Limited, Fullerton, CA, Treasurer of the national Sports Turf Managers Association, and a founding member of the Southern California Chapter of STMA. This article was adapted from the British publication "Groundsman," Volume 47 # 5, May 1994.

Hollow tines can be used for both conventional and deep aeration.

Large aerators have made cultivation of sports fields more practical and effective. Photo courtesy: Cushman/Ransomes.

Cores brought up during aeration are an excellent topdressing.

Autumn Aeration Tips:

Keeping Ahead of Compaction

By Mary Owen

Sports turf managers are in arguably the busiest time of year for activities on athletic fields, especially those in municipalities. Intense schedules mean heavy play and ultimately some degree of soil compaction. Plans should be formulated now for correction later, and in extreme instances of compaction, measures should be taken now to remedy the situation.

As soils become more compacted because of wear of the turf and traffic, the overall quality and vigor or the sward deteriorates. There is less tillering and less rhizome development, therefore the grass cannot recover and remain dense. The resiliency, the shock absorbing capacity of the turf, is reduced. Player injuries can increase in frequency and severity.

Roots are physically unable to penetrate as deeply as in aerated, friable soil. Not only is water and nutrient uptake reduced, but so is anchorage. There is less leaf growth. Plants are unable to utilize nitrogen as efficiently as those growing in well-aerated soils. In fact, when high nitrogen applications are made to turf growing in compacted soils, which is often done as a means of compensating for less vigorous growth, rooting is even further restricted.

Core aeration provides a better environment for turfgrass growth by increasing the infiltration of water and air into the soil. Oxygen, which is taken up by plant roots and is critical to respiration, becomes more available to plants. The result is an increased ability of the plant to do work needed for metabolism, to grow new leaves, to put out new tillers and rhizomes, and to increase the volume and depth of roots.

Compacted soils have increased bulk density. Bulk density is a measure of the weight of a specific volume of soil. The more soil material in a given volume, the greater the weight, the higher the bulk density, and the more compacted the soil. As soil becomes compacted, the amount of pore space, the empty space that is capable of holding water or air, is decreased. These spaces also provide the pliancy of the soil, which allows for physical ease of root penetration.

More heat is required to raise the temperature of compacted soils, especially those which tend to be heavy and wet. These types of soils will stay cooler longer in spring and can be the cause of delay in turfgrass seed germination as well as a contributor to poor control of annual grassy weeds.

The relief of compaction increases not only the infiltration of air, but also the percolation of water into the soil. There is a reduction in puddling and potential for runoff. There is less likelihood of ice buildup and damage such as occurred during the winter of '93-'94 on many fields in New England.

On the other hand, core aeration performed too late in the season, especially with core holes left open, might increase the likelihood of root damage caused by desiccation should the ensuing winter prove to be an open and deeply cold one.

Deep-tine cultivation, such as is done with the VertiDrain, can remedy surface as well as subsurface compaction. As the solid-blade tines penetrate the soil, they do not force the soil downward. Instead, half of the soil touching the tine is moved ahead of the tine, and half is moved behind. As the tine is raised and the machine moves forward, soil is literally pulled upward alongside the cultivation hole. The result is a greatly loosened rootzone with the soil and turf surface actually being raised. The tines are followed by a roller which helps to smooth out the surface.

Deep-tine aeration is being used successfully on athletic fields and in other areas where repeated surface-core or solid-tine aeration has created a compacted layer, where rootzone and/or underlying conditions are poor, where water infiltration is severely restricted, or where traffic has been intense with little correction over time.

Aeration provides an excellent opportunity for subsequent slice seeding, topdressing and other practices. Topdress with a material appropriate for the soil present or alternatively by dragging the cores and thus shattering the soil present back down into the aeration holes.

Soil should be moistened before aeration, so that less friction is produced at the soil/tine interface and tine penetration will be most efficient.

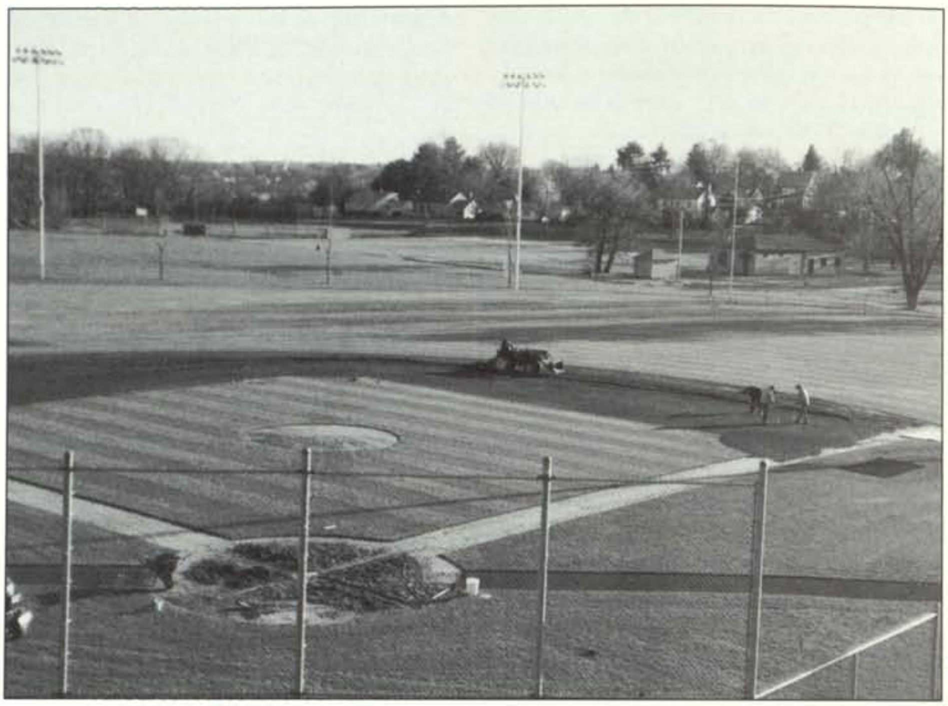
While autumn, at the conclusion of the fall sports season, is an excellent time to aerate, there are several other times when aeration would be beneficial, depending on the scheduled use of the fields involved. They are spring, just prior to overseeding; later spring, just after the spring sports season; and early fall, prior to the fall sports season.

Aeration should otherwise be performed whenever conditions warrant. Avoid the hottest times of the summer months, as the physical disruption might only compound the stress of heat, humidity and high soil temperatures on cool-season turfgrasses. If compaction must be relieved during stressful times, choose smaller diameter tines and irrigate immediately after to reduce stress levels.

Aeration is one of the most important cultural practices you can perform to positively influence overall plant health, soil condition, and turf quality. Make sure it is on your "To Do" list. ❑

Editor's Note: Mary Owen is regional turf specialist with the University of Massachusetts Cooperative Extension System.

Making Athletic Fields Safer



By Eric Nelson Ph.D.
and Barry Larson

We need to pay more attention to maintenance programs on athletic fields. In a survey of 12 high schools by Penn State University, the firm of Harper, Morehouse, Waddington & Buckley (1984) found that more than 20 percent of the injuries to football players was possibly related to game or practice-field conditions. If we expand the survey to other sports, including field hockey, lacrosse and soccer, we would see similar results. If we can relate injuries to field conditions, and if there are ways to make fields safer, then school districts might find themselves liable for damages to an athlete who was injured on a poorly-maintained field.

How can we make fields safer? Too often, most of the attention goes towards maintaining game fields, with complete neglect of practice fields. The Penn State study found that although 90 percent of the athletes' time may be spent on practice fields, 80 to 90 percent of available money and effort was used to maintain game fields. Since *half* of all injuries occurred on the practice field, we also may need to focus on practice facilities before charges of negligence are made.

The first step to achieving safer fields is to make or get an objective evaluation of surface smoothness and turfgrass cover — two characters that are indicators of potential problems. The second step is setting priorities to rectify the situation. Timing and cost will factor into some solutions.

Drainage and Surface Smoothness

Poor surface smoothness can be related to problems caused by construction, maintenance practices and overuse. It is important to determine which of these alone, or in combination, is the source of the problem. Poor surface characteristics can decrease turfgrass survival, due to drainage problems. Rough, undulating athletic fields also can result in serious injuries to athletes. Many times an athlete will run at top speed with little attention to where his next step will be. If slight mounds, depressions, grass clumps or stones are present on the field, then loss of control and injury due to missteps are likely.

The best solution to maintaining a smooth surface begins with careful construction to provide good surface (and subsurface) drainage. Small depressions that hold water are responsible for poor traction, soil compaction due to traffic and resultant loss of turf cover. These holes are much easier to see and should be filled, graded and settled before turf establishment begins. Stones larger than a half-inch should also be removed from the rootzone soil prior to establishment. Proper construction will make future turfgrass establishment and maintenance easier and less costly—and will provide a safer facility.

Surface smoothness can be maintained on heavily-used fields with regular core aeration followed by dragging with mats or weighted chain-link fence. Soil will move from higher mounds into low spots to even the surface. Core aeration will also reduce soil compaction to allow better movement of water, air and fertilizers into the soil—resulting in healthier turfgrass roots. Overseeding to thicken turf should be combined with aerification followed by a mechanical slicer/seeder to help get good seed-to-soil contact for strong establishment. These procedures should be carried out at least twice per year. More times may be necessary with heavily-used fields. Timing is critical to get grass well established before intensive use or environmental stress. Immediate post-game inspections and repair of torn sod and divots will keep fields smoother between aerifications.

Quality of Cover

Once sod characteristics and drainage are addressed, the quality of vegetative cover is another factor that can be dealt with to reduce injury risk. Better turfgrass cover provides better traction and softens the playing field (Rogers, et al., 1988). Powell and Schootman (1993) found increased incidents of ankle injuries on artificial versus natural grass. Turfgrass survival of athletic fields can be affected by species and variety selection, maintenance programs (including overseeding, core cultivation, irrigation and fertilization), soil properties (including drainage and aeration) and intensity of field use.

In northern climates, the most popular mixes for establishment and overseeding of athletic fields are Kentucky bluegrass/perennial ryegrass mixtures, which are by far the most wear-tolerant cool-season turfgrasses for athletic fields. They complement each other well. Typically, there should be a solid base of Kentucky bluegrass established, followed by semiannual overseeding with mixes containing a higher percentage of perennial rye. The choice of mix depends on location, maintenance programs, length of time between seeding and field use, amount of turf cover versus bare soil and intensity of field use.

Further south and into the transition zone, tall fescue blends and tall fescue/Kentucky bluegrass mixtures are gaining popularity for their improved heat and drought tolerance. Tall fescues perform best on limited-use athletic fields, such as softball and baseball diamonds, but they have done well on higher-use sports fields with good management. Tall fescues benefit from at least nine months of growth and development from establishment before allowing play on the field.

On fields with more concentrated use in the summer, cold-tolerant bermudagrass or zoysiagrass will provide very wear- and heat-tolerant turf with less irrigation. These are the best bets for quality athletic turf both within and south of the transition zone.

Several maintenance procedures alone or in combination can help improve grass retention on athletic fields. Weeds such as knotweed, *Poa annua*, crabgrass, goosegrass and clover, are indicators of soil compaction and drainage problems. Simply controlling weeds with herbicides will not fix the problem. Again, aerification is an important first step towards improving the environment for turfgrass roots. Core cultivation in combination with overseeding relieves compaction, improves water infiltration, increases soil aeration and thickens the turf. It is one of the most beneficial steps one can make to improve the quality of an athletic field.

Improving Wear Tolerance

There are several simple tricks to use for improving wear-tolerance, stress-tolerance and softer fields. Try raising the mowing height of grasses an additional half-inch to a full inch to improve all three. Sound irrigation intensity, uniformity and scheduling should strive to reduce plant stress without creating soggy soils. Timely fertilizer applications (especially nitrogen and potassium) will go a long way toward maintaining healthy, vigorous and wear-tolerant turf on athletic fields.

The single greatest problem with athletic facilities today is overuse. We simply do not have enough facilities to spread out the use and associated wear that could permit vegetative recuperation. This would allow time for performance of proper maintenance practices. There is no grass field made that can stand up to multipurpose and multi-season use by athletes (soccer, baseball, football, track and field, field hockey), marching bands, physical education classes, intramural sports and parks and recreation programs. Proper planning, scheduling, maintenance and administration are key to providing enough high-quality facilities to keep campuses and communities active and safe.

Giving the limitation on number and size of facilities, we need to do the best with what we have. Budgets should be set up to provide quality construction, with annual funds targeted for preventive maintenance. Safer athletic fields take commitment with constant monitoring and repair. However, the money and effort placed toward safety are really an investment, not an expense. ❑

Dr. Nelson is the director of turfgrass research and Larson is a turf specialist with Medalist America of Albany, OR.

Fall Overseeding Update:

Gaining Control Over Transition

By Bruce Shank

Overseeding started out as a competitive technique used by southern golf course superintendents during the winter to make snowbirds feel at home. First, they overseeded greens, then tees, now most of them go wall-to-wall. The attraction of year-round green grass caught on, spreading to resorts, industrial parks and condominiums.

The National Football League started to utilize overseeding with ryegrass in the sixties. It first painted dormant fields green for televised playoff and championship games. The Super Bowl brought budgets up and enabled the NFL consultants, Dr. Jim Watson and George Toma, who have now been working together for nearly 30 years, to try a new approach to late season turf.

Watson was aware of research being performed by Dr. Howard Kaerwer, research director for Northrup King in Minneapolis, MN. Kaerwer believed perennial ryegrasses represented a tremendous market for seed companies and worked with southern superintendents to work out any kinks in overseeding. He selected one of the first improved perennial ryegrasses for overseeding, NK 100. Meanwhile, breeders like Dr. Bill Meyer with Turf Seed in Hubbard, OR, and Dr. Gerry Pepin with International Seed in Halsey, OR, worked on production problems such as rust. International released Derby and Ph.D. and Meyer improved Manhattan, Citation and others. Dr. Reed Funk at Rutgers University made some of the most striking jumps in ryegrass quality with his extensive breeding program. Palmer is a product of Funk's work.

Many improvements would be made in ryegrasses within a matter of a decade, perhaps too many. The finer, darker new perennials also had a tendency to hang on in the spring and disrupt orderly spring transition.

Seed drill is a convenient way of overseeding bermudagrass sports fields. Photo courtesy: Jacobsen.

Mississippi State University was one of the first universities to study overseeded ryegrasses in the '70s. Wayne Philly, research assistant at MSU, has rated overseeded perennial ryegrasses for 15 years. "Weather makes transition different every year, so it's hard to draw definite conclusions about particular varieties," states Philly. "In the past few years, ryegrasses have been getting more and more aggressive. They don't transition out as easily, so golf course superintendents are trying *Poa trivialis*. But, *Poa triv.* has an abrupt transition. One day it's there and two days later its gone. That can be a problem if you're not expecting it."

The MSU tests are set up on a seed count basis. "Many people don't realize that depending on the variety and even the crop, the seed count for perennial ryegrass varies anywhere from 180,000 to 300,000 seeds per pound. We've been planting the plots at 55 *pure live seeds* per square inch, not by pounds per 1,000 square feet. This takes germination rates into consideration. We may begin to increase the rates to observe the effect of density on performance and transition."

The strengths of perennial ryegrass are its fast germination, ability to be cut short, attractive color, and relatively modest price. Depending on the use of the turf, seeding rates normally range from 10 pounds per 1,000 square feet (for color) to more than 30 (for putting greens). That works out to be 800 to 2,500 pounds for a regulation football or soccer field. High rates might be needed in the center and other primary wear areas. Seed can be applied more than once during the season and will germinate if daytime temperatures reach the mid-50s F. Translucent covers can be used to increase soil temperatures. Seedling diseases from *Pythium* and *Rhizoctonia* can be solved with coated seed (including potassium) or fungicide applications (metalaxyl, chloroneb, ethazole, propamocarb). These diseases are caused by heavy thatch, poor drainage, excessive nitrogen and high humidity and can be spread by foot traffic or equipment.

Spring transition can be managed by favoring the bermudagrass. Bermudagrass is more drought tolerant, likes daytime temperatures in the 80s or above, and doesn't require much nitrogen in the spring. When temperatures rise in the spring, increase the irrigation interval, cut back on fertilizer, and open the turf canopy with light verticutting and aeration. Don't expose the dormant bermudagrass to very low temperatures and possible winterkill by starting transition measures too early in the spring.

Rough Bluegrass

Continued problems with transition force some groundskeepers to overseed with rough bluegrass (*Poa trivialis*). It is lighter green, very fine bladed, more shade tolerant than ryegrass, spreads laterally, and has a higher seed count per pound. It does not germinate quite as rapidly. One option is to mix it with perennial ryegrass. "A mixture of 80 percent ryegrass and 20 percent *Poa trivialis* by weight has a seed count

continued on page 22