less than 5% passing the 100 sieve screen (see photo 7).

Big-Roll Sod. Look for sod that is mature (1 to 1-1/2 years old) and grown on soil that is similar to the native soil of the field. If it's available (and especially if the drainage system described above is installed), use sod with sandy soil. If it's not available at this time, use native soil sod. Aerating and topdressing with sand will begin next year and provide better rooting and better drainage.

Before the sod is installed, apply starter fertilizer recommended by soil test results and go over the surface with a finishing tractor attachment like a power rake. This attachment removes small debris and provides a flat, smooth surface to prepare the soil for sod.

Then install the big-roll sod using Kentucky bluegrass in the north and bermudagrass in the south (see photo 9).

YEARLY RENOVATION

Create a 3 to 4 inch sand-cap over a 10-year period with this yearly renovation program starting the year after the sod is installed. The sand layer will allow surface water to drain quickly into the underdrains (if installed). The field will get better each year.

Aerate and topdress with 3/8" of the sand that was recommended for the subsurface drainage trenches. You will need about 75 tons to topdress the field (goal post to goal post and sideline to sideline including the bench areas). This process should be done every spring between April and May for cool season grasses and between May and June for warm season grasses. The results are better rooting, thicker turf that will hold up to more events, and improved drainage. Use a solid-tine vibrating aerator unless you can remove the cores that a hollow-tine core aerator leaves behind. Mixing the topsoil cores with the coarse sand will contaminate the sand and prevent drainage (see Photo 10).

Don't worry about creating a perched water table that will prohibit drainage by topdressing with a different material than already exists on the field. In fact, the opposite is true; placing coarse material over fine material allows water to drain freely through the coarse material and into the fine textured soil below and eventually into the underdrains (if installed). A perched water table is created by placing fine material over coarse material preventing water from draining through the fine material until it reaches almost 100% capacity. USGA putting greens and high profile sports fields are built using a perched water table with the intent of keeping the sand moist.

After 10 years of when the sod was installed, replace the sod as you would the carpet on an artificial turf field. Let's face it, nothing lasts forever.

This time you won't be able to use a plow to remove the grass. Use a big-roll sod cutter or other conventional machine to physically remove the sod and the thatch layer to dispose of off-site.

Remove some of the sand at this time leaving about 1-1/2" to 2" of the sand below. This will allow for yearly topdressing with sand for the next 10 years.

Install sod that is grown on a coarse sand soil or washed sand to prevent a perched water table (placing fine over coarse texture).

Beginning in the spring of the following year, start topdressing with about ¼" if sand yearly (50 tons of sand). That will bring the sand layer back to 4" before it's time to replace the sod again. Then start all over by removing the sod and 2" of sand and so on and so forth.

ESTIMATED BUDGET

Initial reconstruction cost to remove the grass, grade, and sod: $60,000

Optional: full field irrigation $32,500

Optional: subsurface drainage installed on 20 ft centers. $32,500

Yearly renovation: $8,000

After ten years replace the sod: $60,000

The total for a 10 year commitment program: $124,000 (excluding irrigation and drainage). ■

Jim Puhalla is the president of SportScape International, Inc. in Boardman, OH specializing in Sports Field Design, Consulting, and Construction Supervision and coauthor of 3 sports field books.


Figure 1


Figure 2


Figure 3

Improving Native Soil Fields

THE QUALITY AND LONGEVITY of an athletic field is directly related to the drainage capability of the soil. How fast water drains into and through the soil (infiltration rate, KSat) is the best indicator of how many games can be played and how the field will react during a rain game. Ideally, fields should have a minimum infiltration rate of 1 inch/hr., but it is not uncommon to see soils with infiltration rates of 0.01 inches/hr. or less.

The infiltration rate of a soil is influenced by the soil texture and the level of compaction the soil is subjected to. Fields with low infiltration rates create very poor playing conditions. When wet, they turn to mud, when dry they turn to concrete (Figure 1). Turf plants will not grow in these soil conditions and so the field gets taken over by weeds like prostrate knotweed, clover, dandelions and *Poa annua*. Turf growth is so poor that nutrients are not taken up, so the turf becomes chlorotic/yellow and does not recover from wear. Slow turf growth is more susceptible to diseases like red thread and rust. It is also impossible to get seed established on hard, compacted soils (Figure 2). Improving the infiltration rate of the soil therefore is the key to improving field conditions.

There are short term fixes to improve infiltration. These include using aeration equipment like a core aerator, spiker, deep-tiner or verti-drain. These machines punch holes in the soil, allowing water to enter and O^2 and CO^2 to enter and exit. After a period of a couple of weeks or less however, those holes seal over and the previous conditions return.

A long-term fix is to amend the soil with a material that improves the infiltration rate, namely sand. As well as improving infiltration rates, topdressing evens out the playing surface and fills holes that could cause athlete injury (Figure 3). Applying 50 tons of sand to a field per year via topdressing appears to be an effective rate. It is possible to apply higher rates of 60-100 tons, especially if the sand is applied in two increments (spring & fall). The sand is either applied alone or in combination with soil or compost. The soil &/or compost typically makes up 10-30% of the mix. Adding compost to the mix is a good way to get some organic material into the soil if it is lacking. Compost improves the soil health (increased oxygen, reduced bulk density, increased water holding capacity) and also adds nutrients. The soil component in a topdressing mix helps to maintain surface stability (sand alone does not have good shear strength) and also retains moisture, which is important for seed establishment.

The soil &/or compost typically makes up 10-30% of the mix. Adding compost to the mix is a good way to get some organic material into the soil if it is lacking.

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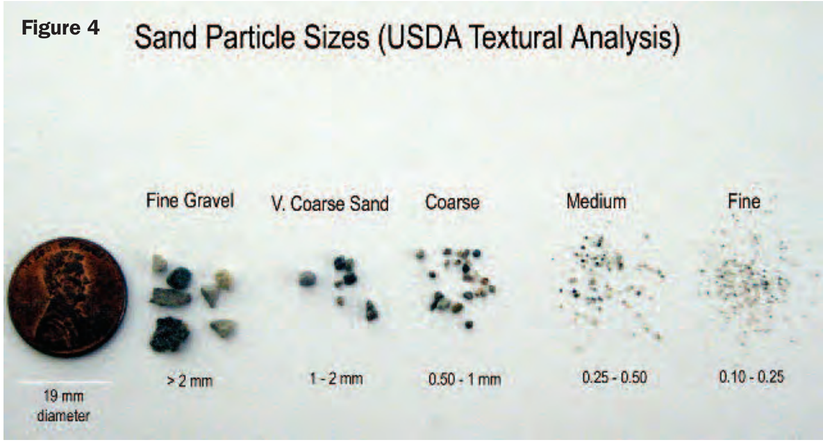
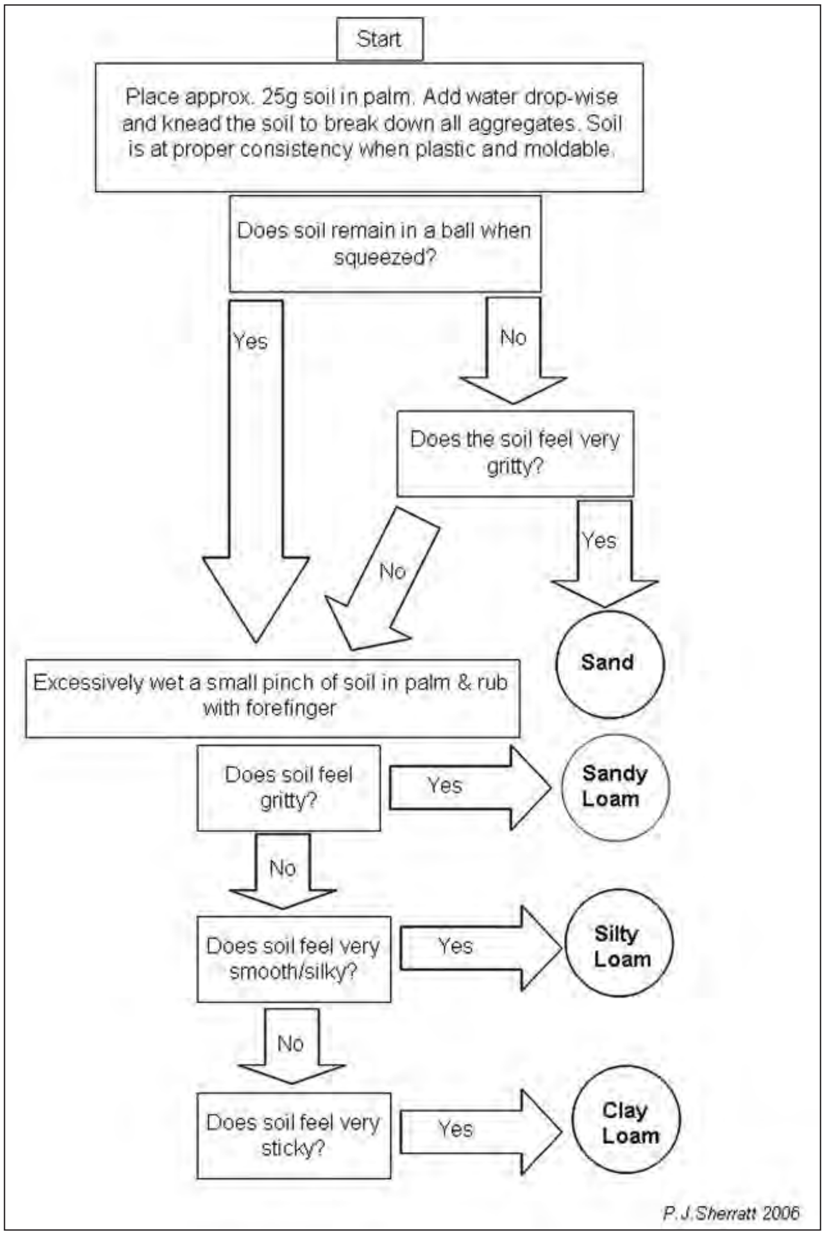




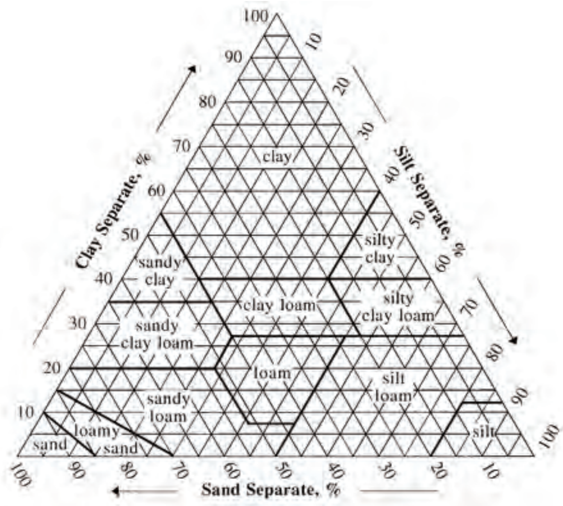
▲ **Figure 5:** Hand-texture test. The flowchart is easy to follow and results in a better understanding of what a silty, clay or sandy soil feels like.

The sand component of the mix should ideally be medium-coarse in size and uniform. In many situations, the sand component of the mix does not meet this specification and it is not unusual to see sand mixes that contain large amounts of silt and clay or gravel. Silt and clay particles are very fine and they clog a soil system. Air spaces are blocked and the soil becomes prone to compaction. When dry, silt and clay soils are rock-hard, but they turn to a quagmire when wet. For these reasons, very fine sand, silt and clay are generally restricted in mixes to less than 15% of the total mix.

There are no set guidelines for the amount of gravel allowed on a sports field but there is a landscape recommendation. ASTM D 5268-92 "Standard Specification for Topsoil Used for Landscaping Purposes" suggests that no more than 5% deleterious material (rock, gravel etc.) be included in a topsoil mix. Gravel is not a suitable material to improve soil physical or chemical properties and on a playing surface it can disrupt play and possibly cause player injury. In addition, gravel on the surface could damage mower blades and be very difficult to grow grass or seed in. For a whole multitude of reasons then, gravel should not exceed 3-10% of the total mix.

Unfortunately, this has not been the case in many situations. Site visits to sports fields over the years have shown that many topdressing mixes contain far too much gravel. In one notable instance, a college soccer field was constructed with a material that contained 44% gravel. That particular field had also been graded and then leveled with a vibratory roller, making it as hard and impenetrable as a parking lot. The ultimate

▼ **Figure 6:** The textural triangle. To plot sand, find the percent sand along the bottom and follow the line diagonally left. To plot clay, find the percent clay along the left edge and follow the line horizontally across from left to right. To plot silt, find the percent silt along the right edge and follow the line diagonally left. Example: Soil containing 30% sand, 30% clay and 40% silt would be a "Clay Loam."



goal of topdressing with sand is to achieve at least 70% sand by weight in the rootzone. At this point, the sand particles bridge, creating macropores and reducing particle density. Without a doubt, initiating a sand topdressing program significantly improves native soil field quality and longevity.

One way to ensure that topdressing material contains the right amount of sand, silt, clay and gravel is to carry out some DIY quality control. There are several easy ways to do this:

Firstly, avoid the temptation to accept any sand, just because it's free or cheap. Dressing fields with high amounts of gravel or silt and clay will probably make the fields perform a lot worse than before

Get familiar with what the sizes look like. Being able to distinguish between gravel and coarse sand can be helpful when taking delivery of an order (Figure 4)

Send a sample away to a soil testing lab to have a textural analysis done on the sand component. The lab will furnish results that state clearly the percent of fine, medium and coarse sand and gravel.

Carry out a hand-texture test (Figure 5). While not precise, it offers an idea of the type of soil in hand and it helps for the turf manager to become accustomed to what different soils feel like.

Perform a soil settlement test, sometimes called a "Jar test" (a good practice for baseball infield mixes too):

Take a small soil sample.

Quarter fill a water bottle or mason jar with the soil.

Add tap water until the bottle is three-quarters full.

Replace the lid and shake until the water and soil are thoroughly mixed.

Leave to settle for 2-3 days

After 2-3 days, the soil will have settled out into discreet layers, with the gravel and sand on the bottom, then the silt, and then the clay (being the smallest particle, clay settles last).

Measure the total thickness of the soil, then each individual layer, to determine what percentage sand, silt, and clay is present. For example, if the total mineral layer is 2 inches thick and the sand layer is 1-inch thick, there is 50% sand.

The sand, silt and clay components can be plotted against the soil textural triangle to determine soil texture (Figure 6)

One of the main issues with starting a topdressing program is that a topdresser is needed to apply the material, unless an outside contractor is paid to make the application. Also, the program is not a "one time" occurrence, but must take place each year, ideally in conjunction with aeration, which will take time and money. However, in every instance where a sand topdressing program has been adopted, the results have been so dramatic and the fields have improved so significantly that school boards and administrators usually look for extra sources of funding to try to start topdressing programs on additional fields.

It may take a couple of years to see the benefits of dressing with sand. Obviously, the more sand applied, the faster the desired 70% by weight goal will be reached. It is not a good idea to apply more than 0.25 inch at any one time as the sand can be abrasive to both turf equipment and the grass, but two or three applications could be made each year, outside of the playing season. If there is money and manpower available, a new "fast-track" sand build-up system could be employed. This system was recently developed by Michigan State University and can be accessed through their website.

In addition to improving the rootzone soil, there are several drainage options for fields:

Surface Drainage refers to the ability of water to shed or run off the surface due to the installation of a slope or crown. The severity of the slope or crown depends upon the amount of sand in the rootzone. Fine textured soils with <45% sand should have crowns/slopes of 1.5 - 2 % while rootzones with >70% sand can have smaller crowns/slopes of 0.75 – 1.0 %. For a more detailed guideline on this, refer to ASTM WK37583 – New Guide for Construction or Renovation of Native-soil Athletic Fields.

Internal Pipe Drain: The origin of this type of installation is in agriculture and it is relatively cheap to install. It consists of a grid of piping below the surface of the subsoil. The benefits are (1) the gradual lowering of the water table and (2) shorter drying time. However, this system is not accustomed to dealing with high volumes of water in short periods of time, such as during a game. Also the area affected by the drainage pipes is usually restricted to within a few feet or so of the pipes. The main objectives of pipe drainage is to lower water tables, control or cut off flow of extraneous water, and drain any surface water directed to them.. The disadvantages to this system are that the water must flow to the drains in order for them to be effective.

Slit Drains: Slit-drained fields are designed so that surface water bypasses the native soil, and the local soil has less of an influence on drainage rate. A common specification is to install sand slits 1-inches wide, 10-inches deep, on 3 ft. spacing (Figure 7). Most importantly, the slits must transmit surface water through the native soil surface to a more permeable material underneath - such as a gravel layer or permeable fill over pipe drains. The slits run perpendicular to the pipe drains. Two problems can occur with slit drained fields: (1) when the permeable material does not come into contact with the sand slit (i.e. there is a soil layer between the sand slit and the underlying permeable material), or (2) when the slit is not kept directly at the field surface and the slit is sealed off by adjacent native soil. This can occur rapidly, even during one game if field conditions are very wet. To prevent the latter, a heavy annual sand topdressing program has to be initiated to make sure that the slits are not "capped off" over time. Research by the STRI has indicated that these types of field can accommodate 6 hours adult play per week (95-125 events per season). In addition, they have suggested that, if managed correctly, a slit-drained field should last about 7 years before needing to be slit again.

Suspended Water Table (USGA, PAT system or similar): By far the most expensive of the options to install and maintain, the suspended water table (SWT) construction consists of internal drain pipe, a gravel blanket and a sand rootzone. The biggest benefit is that it resists compaction and has very high infiltration rates. The challenges are that they require greater input (water, fertilizer) and they can lose grass cover quickly from over-use if the sand is not stable, or if regular over-seeding and topdressing is not performed. Organic matter accumulation is also a challenge. Switching from a native soil field to a SWT field is not economically viable in many cases and can only really be justified from a financial point of view if play has to be guaranteed irrespective of the weather (except snow and frost).

OTHER NATIVE SOIL FIELD IMPROVEMENTS

Moving on from discussing the intricacies of removing water quickly from soil fields, adding water to soil fields is also an important part in native soil field improvement. Irrigation is undoubtedly the most underused management practices on native soil fields, especially during renovations or overseeding/sodding operations. It is highly unlikely that turf will recuperate from wear or that new seedlings will survive if supplemental water is not added to the field during drought (Figure 8). Even in Ohio, with 40-inches of precipitation per year, it is not uncommon to have drought conditions June, July and August.

Figure 7

▲ **Figure 8:** This new field was constructed in the spring and then not irrigated during the summer. The football season then had to be played at another location.

Adding water to a field does more than grow healthy grass, but can significantly reduce surface hardness on fine textured, dry and compacted soils. Dry and compacted native soil fields can have Gmax (hardness) readings in excess of 400, which is four times harder than recommended for athlete safety. And with the CDC reporting that 135,000 children between the ages of 5 and 18 are treated each year for concussion and other head injuries, it is best to make sure that the playing surface is not one of the contributing factors.

Guidelines for best management practices on native soil fields, like mowing, regular and timely applications of fertilizer, over-seeding etc. can be found through the STMA website or University turfgrass program website. For example, Ohio State has a free factsheet entitled "Standard Guide for Maintaining Sports Fields and Recreational Turf in Ohio." ■

Pamela J. Sherratt is the sports turf extension specialist for the turf program at The Ohio State University in Columbus.

JOHN MASCARO'S PHOTO QUIZ

John Mascaro is President of Turf-Tec International

Can you identify this sports turf problem?

Problem: Stadium field has lines of melted snow from end to end

Turfgrass area: Major league soccer stadium

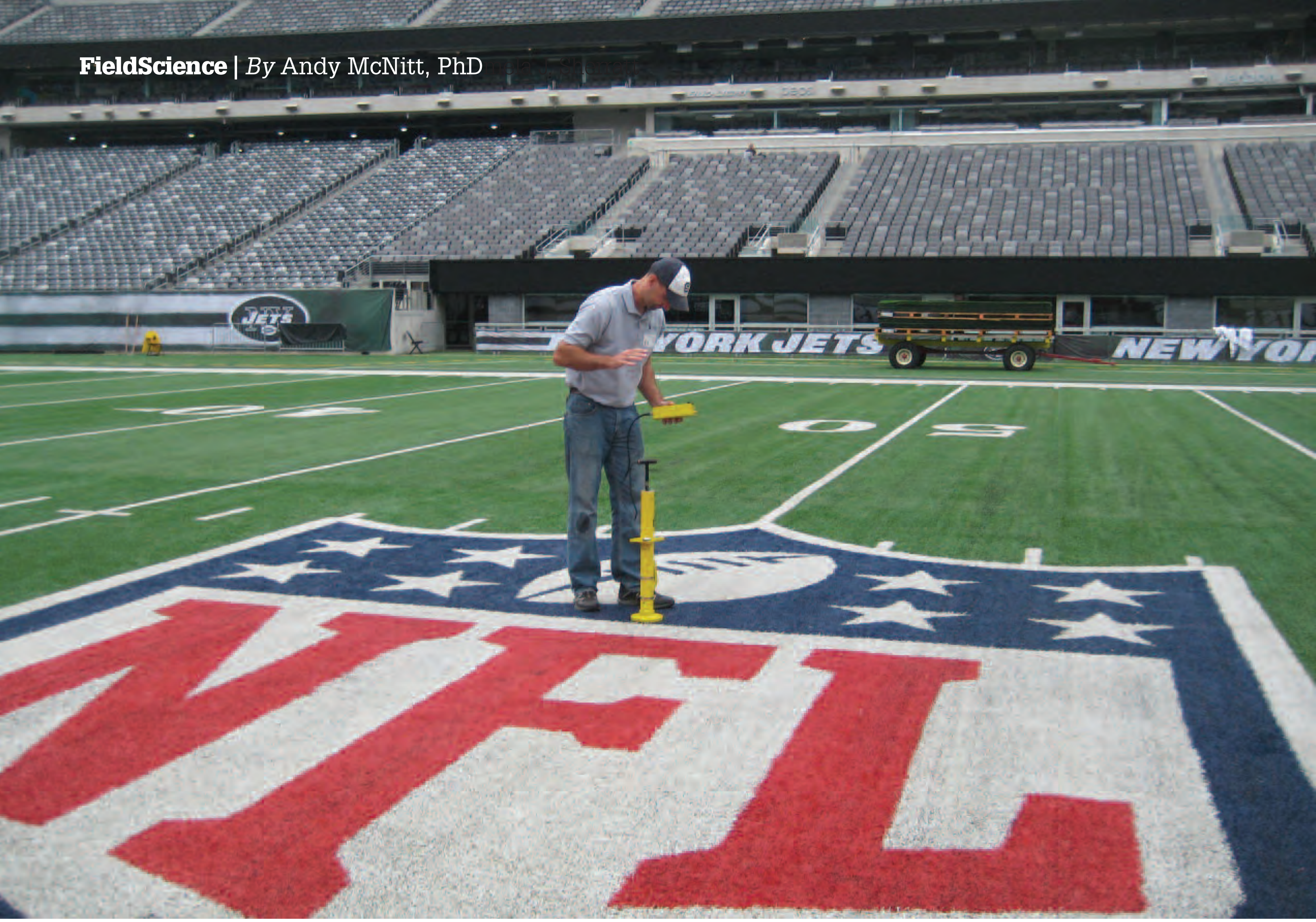
Location: Turkey

Grass Variety: Bluegrass/ryegrass mix

Answer to John Mascaro's Photo Quiz on Page 33

Background illustration courtesy of istockphoto.com

 By Andy McNitt, PhD



Issues and technologies used on NFL playing surfaces

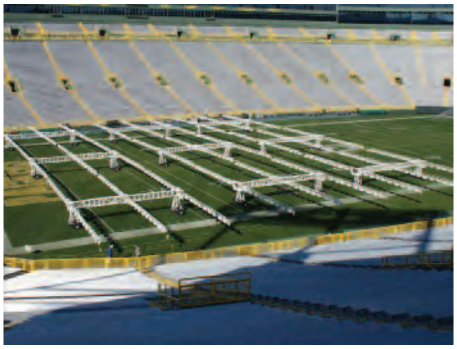
I'VE HEARD IT OVER AND OVER AGAIN from those in the turf business: "If I could mow at one inch, I'd be able to have pristine looking turfgrass like in all these NFL stadiums." I politely reply that if those kinds of skills and knowledge existed anywhere, there would already be lots of smart people using them to improve these surfaces.

Let's review a few facts that aren't always in our frontal lobe while we watch an NFL game from the comfort of our homes on a late November Sunday.

First, it's November. It's getting seriously cold now and the light levels are extremely low. Think about the effects of "winter play" on a golf course.

Yes, most of the NFL's northern fields have an ethylene glycol heating system running under the sand rootzone. The heating systems provide some benefit by extending the growing season further into the fall and limiting frost development on areas that require painting; however, light is still limiting. The sun is low in the sky and the stadium seating is being placed as close to the playing surface as possible. This means very steep seats and significant shade. Yes, south facing endzones are sometimes built lower or more open but there are many fields where the sun never hits the field from the endzone through the 20 yard line in November.

In the fall direct sunlight is very limiting and if the heating system is used to push the turfgrass excessively, the turf becomes severely etiolated. Also, the heating system can push moisture to the soil surface. In theory, the ideal set up for an NFL football game on a sand rootzone is to have ample moisture in the rootzone but have it a little dry in the top half inch or so. When the heating system is running during cold weather, moisture in the rootzone is vapor-



▲ **Left: THE SUN** is low in the sky and the stadium seating is being placed as close to the playing surface as possible. This means very steep seats and significant shade. **Middle:** Artificial lighting systems have been developed and are being used in Lambeau Field in Green Bay. **Right:** Most stadia, save three, in the NFL are used for multiple and varied revenue generating and charity events that can find parts of the turfgrass covered for up to 7 days.

ized. It moves up through the sand and eventually encounters the cold air temperature where it condensates. This flips the moisture strata where now it is wet on the surface and dryer further down in the rootzone.

While a tremendous help, the heating systems are not a silver bullet for growing turf in cold conditions.

Light is a truly limiting factor in the fall and in some stadia throughout the season. Artificial lighting systems have been developed and are being used in Lambeau Field in Green Bay. Here at Penn State, we've been experimenting with a rollable light tarp. This system contains a series of LED lights in the wavelengths needed for optimal growth. The wavelengths can be varied to provide optimal growth conditions for particular species and in some instances for particular cultivars. We continue to work to get this system commercialized.

Besides limitations of light and heat well into the fall and winter, it's important to realize the tremendous amount of traffic/damage that occurs to these surfaces. Football fields look big when watching the game on TV. When you attend an NFL game the stadium is large and bigger than life. This subconsciously makes us multiply the size of the field. The field looks immense. Really, the majority of the game is played on a small area. Research has shown that for most games about 80% of the traffic occurs between the numbers and between the 20-yard lines. The area receiving 80% of the damage is about 15,800 square feet, or the size of about two and a half golf greens. Think about that for a moment.

Most stadia, save three, in the NFL are used for multiple and varied revenue generating and charity events. There are the NFL events, college football games, high school football games, the FOP versus the FOF charity event. Lacrosse championships, soccer tournaments and professional soccer events dot the schedule. Then in summer when the temperatures are sometimes extreme, the stadium hosts between one and three summer concert events and/or monster truck rallies where at least parts of the turfgrass may be covered for up to 7 days and other parts must accommodate large cranes, and countless passes with forklifts, trucks and other utility vehicles.

Considering the amount and kinds of events held on these surfaces, it's a testament to the field managers that they are able to provide a safe and playable surface week in and week out. Remember, there are no frost delays. Unlike baseball nobody stops playing for a little rain or even snow.

For those of you managing high school

▶ **ORGANIC MATTER accumulation in the top couple inches of the surface can begin to act like silt and clog the macropores that conduct air and drainage water.**

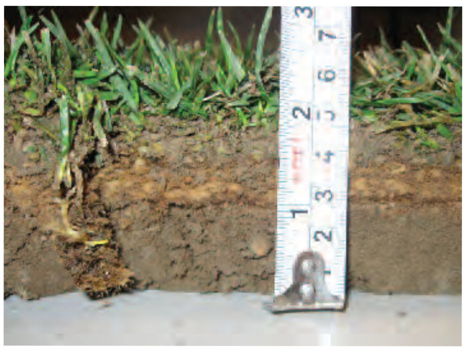
fields that host well over 100 events per year, the pure number of events may look unimpressive. You should realize that the kinds of events do differ. To give you a point of reference, when I evaluate the amount of damage caused by a Division I football game on a Saturday to an NFL game on a Sunday, it like the difference I observe on a high school field between a 7th grade game and a varsity football game. Seriously, the difference is dramatic. It's the size and speed of the players (Energy = Mass x Velocity). It's not how strong the players are, it's how fast they can move very large bodies. And when these large bodies have momentum and want to change direction, the shear forces on the turf system are tremendous.

On these higher-end sand-based systems, grinding out of the turf through abrasion is a secondary damage of the turf behind divoting. So the management philosophy of an NFL field manager and a high school field manager are different.

A high school turf manager caring for a native soil field receiving many, many events per week is trying to limit, and more importantly trying to constantly recover from wear due to abrasion and soil compaction. Thus, the turfgrass needs ample nitrogen to help it recover and should have a higher cutting height to help reduce the effects of abrasion. Aeration is done to reduce soil compaction.

On these higher-end NFL and college fields that have lower numbers of events, perhaps only two per week, but where the events are at a much higher intensity, maintenance practices vary. Research on Kentucky bluegrass grown on sand indicates that within reason a lower mowing height results in less damage due to divots. In the past, Beaver Stadium at Penn State was mowed as low as 7/8" and typically exhibited a low amount of divoting. A common mowing height for Kentucky bluegrass in the NFL is 1.25 inches although some are mowed at a lower height year round.

▼ **ALL BUT A HANDFUL** of natural grass NFL stadia resod at least 1.5 times per year and as many as four times per year, bermudagrass fields included.



During summer months, before the beginning of the football season, some nitrogen and water is withheld in order to "harden off" the bluegrass. Stressing the plants somewhat has proven to reduce divots compared to having succulent plants heading into the season. When the weather cools, additional nitrogen is applied in order to stimulate growth. Also, significant spring nitrogen applications are suggested during any cultivation or renovation procedures. Cultivation followed by core harvesting on sand rootzones is done to reduce organic matter buildup in the rootzone.