through aerification and topdressing to create a more compatible soil type. Modifying the soil type could help the fields drain better and recover better.

Overseeding with the appropriate grass species can help you get your fields back into playing shape quicker. Turf extension agents are a valuable source for determining what grass species may be appropriate for the needs of the field. For smaller areas, pre-germinated seed incorporated into a divot-like mix can also help high use areas recover quicker (see Sidebar).

Asses fertility needs based on the amount of wear the turf will be under, the time of year, cost and the results of fertility tests (soil and/or tissue). The turf plants will need more nutrients the more they are under stress.

Mowing height should be appropriate to the usage of the field. Maintaining the turf at a higher height will help the turf survive increased traffic.

Sodding extremely worn areas offers a solution with a quick turn around. The sod must have a similar soil structure as the area that you are repairing and time for the sod to establish (4-6 weeks minimum).

A good maintenance program takes years to develop. The plan is a living and breathing document that will change with time. Keep thorough records of what maintenance activities were done throughout the year to help establish the plan for the next year.

Tactic 7: Network

Networking with other turf professionals helps generate additional tactics for addressing high traffic problems. Get involved with the local sports turf chapters and visit other facilities to learn what tactics other turf managers use to meet similar challenges. Sharing ideas with one another will help us all become better at maintaining our overused fields.

Turf managers have many tools available that can make the job easier. Don't hesitate to try a new approach to tackling high traffic problem areas. Test a small area of the field first to see if the tactic will work for the situation. Taking a proactive approach in addressing the damage high traffic can cause is the first step in helping the field survive, as well as remain safe and playable. ■

Abby McNeal is the athletic turfgrass manager for the University of Colorado and a member of STMA.

7IRON REPORT No 2

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1 2

1
Ten-gallon fuel capacity assures a full day of operation without refueling. Inventive top-draw tanks enhance reliability, since fuel system is much less likely to be clogged by debris.

M 6 5 3
23-hp
54-inch 7-Iron deck

M 6 5 5
25-hp
54-inch 7-Iron deck

M 6 6 5
25-hp
60-inch 7-Iron deck

4
Frame-mounted Ross MB Series 14.5 cubic inch wheel motors and large-capacity hydraulic oil reservoir are just some of the features that make Mid-Series machines the most durable zero-turning-radius mowers around.

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Photo courtesy of: John Stier

Aeration:

A Prescription for Sick Fields

BY DR. JOHN STIER

Aeration is a type of cultivation that produces holes in the ground. The benefits may be either short or long term, occasionally both, depending on the type of aeration employed.

The main types of aeration include coring, drilling, spiking and slicing. Coring (often called aerifying) can be accomplished using tines (hollow or solid) or water injection. Hollow tines bring soil cores to the surface while solid tines push the soil deeper into the ground. Tines range from 1/4 to 1 inch diameter. Tines are usually 3 inches long although longer tines are occasionally used. Spiking uses solid tines less than 1 inch in length, while triangular-shaped knives mounted on a drum or disk are used for slicing. Drilling is a type of solid-tine cultivation that uses drill bits approximately 16 inches in length. Knowing the reason for aerating will help you choose the process and equipment which is right for your situation.

How Aeration Is Helpful

Aeration can produce the following results depending on the type of equipment selected and the type of turf and soil:

- Alleviate compaction problems, including some weeds
- Improve water infiltration
- Mix soil layers
- Incorporate lime or soil amendments into an established turf
- Smooth fields
- Manage thatch
- Facilitate overseeding

The main reason for aerating a turf is to reduce compaction-related problems. Compaction is mostly a problem on clay, silt and loam soils. Turfgrasses grow poorly in compacted soils, resulting in thin turf, bare ground or weeds. Aeration provides space in the soil for roots to grow and allows oxygen to enter the soil for root metabolism. It allows fertilizer and water to better penetrate the soil and be absorbed by turf roots. The improved root growth provides more vigorously growing turf which recovers better from traffic and outcompetes weeds. Dense growths of knotweed, annual bluegrass (Poa annua) and other weeds that have short, fibrous root systems may indicate a compaction problem exists.

Aeration holes temporarily increase soil drainage rates. Drainage rates will approach previous rates as the holes close up, but some long term benefits are possible with regular aeration.

Core cultivation, which brings soil to the surface, can help mix soil and organic layers that reduce root growth and water infiltration. Coring can be especially useful to mix two soil types which result when sod grown on an organic (peat) soil is placed over a clay or sand-based root zone. Even in a sand-based root zone which was sodded with soilless sod or established from seed, coring helps reduce layering problems produced as the turf builds an organic layer over the sand.

The holes left by coring can place lime, fertilizer, and other types of soil amendments including sand into the root zone of an established turf. When used for this purpose, it is important to apply the material immediately after coring before the holes close.

Aeration can be useful for smoothing athletic fields. Coring with hollow tines or spoons brings soil to the surface which acts as a form of topdressing. This can help smooth the surface as the cores disintegrate with the soil falling to the lowest-lying areas. The holes provided by coring allow soil to be moved into them by rolling—without macropores in the soil, rolling by itself has little chance of smoothing the field without excessively compacting the soil.

Traffic usually prevents a significant thatch layer from forming. In low-traffic areas, core cultivation helps manage the thatch layer: as cores of soil are brought to the surface and disintegrate, the soil falls into the thatch, creating a "mat" layer. The mat layer is less spongy than the thatch layer which reduces the potential for scalping. It provides a better environment for root growth than thatch alone because it buffers the roots from temperature extremes and is a better source of water and nutrients. It may also assist in thatch breakdown by providing a better environment for microbes.

Overseeding can be more successful if integrated with aeration because it provides seed to soil contact which is crucial for successful germination. Hollow tines are better for this than solid tines because soil is brought to the surface. Spikers press the seed into the soil to obtain seed to soil contact.

Different Types of Aerators for Different Purposes

Aerators can be self-propelled walk-behind units or larger units pulled by a utility vehicle or small tractor. Aerators have either a vertical or a circular motion. Vertical-motion aerators generally make the deepest holes while minimizing the surface disruption around the holes. Vertical-motion aerators work well over a range of soil types and moisture levels. They provide more consistent depth of penetration, often as deep as the tines are long. These units move slowly compared to circular motion aerators. Circular motion aerators employ tines, spoons, or knives mounted on a disk or drum. These are usually pulled by a vehicle operating at much greater speeds than the walk-behind units. Due to the lack of downward force, they usually do not create holes as deep as vertical-motion units and they disrupt the turf around the hole as the tines or spoons enter and exit the soil. In dry, compacted soil the circular motion aerators may not penetrate enough to be effective. Irrigate dry soil a day or two before aerating to provide proper moisture levels for good penetration.

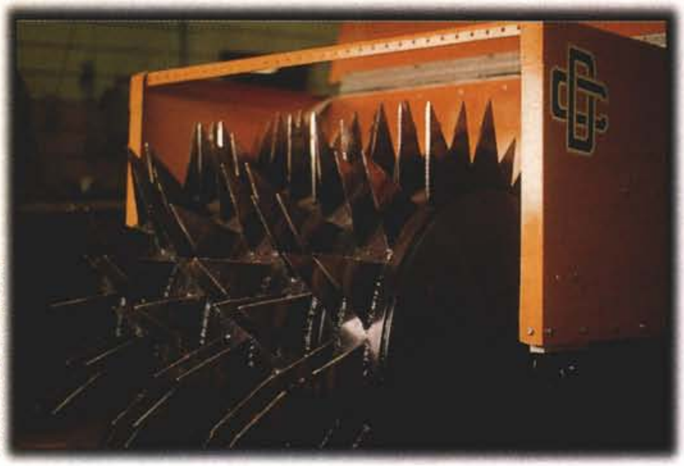

Photo courtesy of: John Stier

A slicer with triangular knives from Detroit Country Day School, Detroit

The Tines Make a Difference

Hollow tines provide more of the advantages listed from aeration than any other type because they pull up soil cores. They do break easier than solid tines and the presence of the cores may be undesirable. Solid tines provide good penetration but can compact the soil at the bottom and sides of the core holes more than hollow tines, particularly in wet soils.

Slicing provides minor, short term improvements in drainage and aeration with little disruption to the turf surface. It is particularly useful during summer stress periods when turf growth is slow or before an event when cores would be objectionable. Slicing severs stolons and rhizomes, causing them to initiate new plants that can thicken a turf. Spiking provides less benefit, though it is useful for breaking up soil crusts during establishment and for overseeding.

Water injection units shoot jets of water deep into the soil with extremely little surface disruption; the holes may be less than 1/4 inch in diameter on the surface but 12 inches or more deep. Water injection does not bring soil to the surface but can stimulate root growth. Due to the high cost of the units, their slow speed, and need for a nearby water source they are rarely suitable for aerating entire fields. They are used mostly for putting greens on golf courses. ■

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Comparison of Different Turfgrass Aeration Methods

BY DR. ROBERT N. CARROW, UNIVERSITY OF GEORGIA

Cultivation Procedure	Comments Tine diameter (inches)	Depth of Penetration (inches)	Deep Cultivation Method (>6 in. deep)	Deep Injection Possible
1. **Coring with hollow tine, spoon, screw devices**				
a. Tractor-drawn units with spoons or tines that enter the soil at an angle. Some units are motorized.	Several types—interchangeable spoons, hollow tines, slicing blades. 1/2-3/4	3-6		
b. Drum-type	Several types Hollow tine	2-3		
c. Verti-Drain, Soil Reliever	Hollow tine	10-12	Yes	
d. Vertically operated tines	Most common form of cultivation. Many types, hollow tine. 3/8-7/8	3-5		
e. Deep-Drill Aerofier	Screw device			
—Floyd McKay	1/2-3/4	5-10	Yes	Yes—Granulars
—Green Care	3/4-2	16	Yes	
2. **Coring by solid tine devices**				
a. Verti-Drain, Soil Reliever	1/2-1 dia.	12-16	Yes	
b. Shatter-core vertically operated tines.	1/2-3/4 dia.	3-5		
c. Units where tines enter the soil with a rotary pattern (Aera-Vator)	1/2 dia.	3 1/4		
d. Small diameter solid tine often as a quad tine	1/4 dia.	2-3		
3. **Slicing** —Solid tines or blades, not power driven. Many types.	Blades pulled through the soil or the weight of the unit pushes tines into the soil			
a. Straight-line tines	Most common	3-7	Some Units	
b. Straight-line blades (Verti-Slicer, Verti-Groover)	Thin width blades	2-6	Yes	Yes—Granulars
c. Offset tines (Aerway Slicer)	Larger width blades, 1/4-1/2	6-8	Yes	
4. **Spiking**—Blades are not power driven (i.e. do not cut through the soil but penetrate by machine weight)	Small spikes or knife-like blades. Units may be pull type or motorized drive (Spikeaire).	1/4-2		
5. **Forking**	The "original" spot treatment cultivation method	6	Yes	

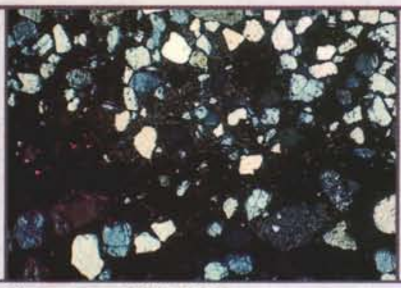

Photo courtesy of: Michael DePew

Sustainable Saltwater Irrigated Sports Field Developments

by Michael DePew and Stewart Bennett, Environmental Turf Solutions, Inc., Pineland, Fla.

Water quality as a component of irrigation management is becoming of greater concern to sports turf managers. Rapid growth in many urban areas has led to a shortage of fresh water resources. This has become a problem not only in the arid and semi-arid western U.S., but many areas in the more humid east also face urban water shortages. Some areas with adequate fresh water resources nevertheless face problems with disposal of effluent water from municipal and industrial waste processing.

Due to either fresh water shortages or effluent disposal needs, the use of effluents and alternative water resources for sports, golf, parks and landscape use has become more commonplace. Brackish water ranging from 2,000 ppm TDS up to seawater concentrations (~35,000 ppm) has been proposed for irrigation. Approximately 97 percent of the earth's water resources are comprised of saltwater. Of the remaining 3 percent comprising fresh water, approximately 2 percent is tied up as ice in the polar regions.

Saltwater Utilization for Irrigation

New advances in agronomic management technology have made the use of saltwater for irrigation a viable alternative. Principals of Environmental Turf Solutions, Inc. (ETS) embarked on a private research and development program initiated in 1990. This program has led to the development of soil ecology and irrigation management protocols and halophytic (salt-tolerant) turfgrasses. This program has led to improved cultivars of Seashore dropseed (Sporobolus virginicus) and Seashore paspalum (Paspalum vaginatum). 'Saltfine' Seashore dropseed and 'Seaway' Seashore paspalum are cultivars suitable for use in lawns, sportsfields and golf courses. 'Seagreen' Seashore paspalum is a fine-textured turf suitable for use on closely mown putting greens.

With proper management, the use of water with salinities in the range of 10,000-20,000 ppm TDS may become commonplace. The key to the use of high salinity water for irrigation of halophytic turf is the management of the soil to maintain a high redox state (well aerated). Because of this requirement, soil modification is called for on many sites. If the redox potential of the soil becomes too low, many mineral transformations can occur which disrupt the desirable soil ecology. In the process, phytotoxic substances are produced in the soil which causes turf damage and may even lead to turf dieback. One such phytotoxic compound is hydrogen sulfide which is characterized by a "rotten egg" smell.

Traditional salinity management techniques call for shorter intervals between irrigations along with excess applied water as a leaching fraction for salinity control. For sodium control, gypsum (as a calcium source) is often employed as an amendment. While these methodologies can work effectively at lower salinities (<5,000 ppm), at higher salinities these techniques do not apply. Excessive leaching can lead to increased rather than reduced salinity, especially at the surface. This is due to a salt partitioning affect.

The properties of a mixed salt solution in the soil is such that a partitioning of salt ions occurs with leaching. Chlorine (Cl-) and calcium (Ca2+) ions for example are more readily leached than sulfate and sodium (Na+) ions. While Cl- and Ca2+ are readily leached lower in the soil profile, the formation of sodium sulfate is favored near the surface due to its movement as a function of evaporation. While sodium sulfate is a soluble salt, upon precipitation it forms a somewhat impervious crust or layer near the surface. This is due to the characteristic of sodium sulfate to form a salt precipitate with overlapping crystalline edges. This phenomenon reduces the exposed surface area of the salt, thereby reducing its effective solubility and may render a layer somewhat impervious.

A sulfur (S) enriched and impervious layer sodium sulfate is subject to the reduction of sulfur by anaerobic bacteria. The bacteria that reduce the sulfur do so in the process of breaking down organic matter. During this process, Na is liberated and combines with carbonate ions which are released from the breakdown of organic matter to form sodium carbonate. Sodium carbonate at equilibrium in an aqueous solution has a pH of 10. At this pH, fine silicate soil particulates are unstable and begin to go into solution. Subsequent reprecipitation of silicates leads to cementation.

These are just a few of the scenarios that may occur and affect the soil ecology in a saline irrigated soil. The transformation and translocation of minerals in a highly saline soil solution are wide and varied. The physical, chemical and biological processes in the saline soil favor a system that operates in nature in the formation of wetlands (hydromorphic soils). The resulting hydromorphic soils in an athletic field are not ideally suited for high quality production of turf. The key to successfully utilizing saltwater for irrigation is the maintenance of a high soil redox state (well aerated soil). For highly brackish and saline water (5,000 to 20,000 ppm) soil modification may be needed. If >20,000 ppm salinity is called for, a rigidly specified sand-based system is required.

The ETS-developed halophytic turf has been developed in saline environments and have known high salinity tolerances. Other halophytic turf developed or produced in fresh water ecosystems may have unknown or unpredictable performance when placed into a saline environment. In a properly considered saline landscape development, salinity is managed such to maintain a proper (well oxidized) saline soil rather than it being considered a detrimental factor. Figure 2 lists some criteria which may prove helpful for managing a saline ecosystem.

It is impossible to consider all of the factors for developing and maintaining a saltwater irrigated installation in a brief article. It must be emphasized, however, when dealing with advanced salinities (>5,000 ppm), traditional standard techniques for salinity and sodium management at lower salinities must be altered to reduce detrimental effects initiated by salt partitioning. However with proper management, it is possible to develop and sustain saltwater irrigated (>5,000 ppm) installations. ■

Michael DePew and Stewart Bennett are two of the principals of Environmental Turf Solutions, Inc. located in Pineland, Fla. DePew is an agronomist/soil scientist that works with soil ecology issues for ETS. He also serves as chair of the technical standards committee for STMA. Bennett is a Certified Golf Course Superintendent and the head of Golf Operations at Alden Pines Country Club. Alden Pines is where much of the field development work for ETS has been conducted. Contact www.etsturf.com or www.saltgolf.com.

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Figure 2

Tips for Developing Salt Water Irrigated Fields

1) Soil modification may be required.
2) A well aerated root zone is required (soil redox >+100 mv).
3) Maintain an oxidated irrigation water source.
4) Halophytic turf with known salinity tolerances is required.
5) Mechanical soil aeration and sand topdressing should be employed.
6) Do not 'overleach' the root zone to avoid salt partitioning.
7) Avoid application of S bearing compounds. If Ca is needed for Na management, use $CaNO_3$ or $CaCl_2$. Do not use S or sulfuric acid (H_2SO_4).
8) Avoid the use of lime, particularly dolomitic (Mg-bearing) lime.
9) Consider muriatic acid (HCl) injection for pH control and neutralization of irrigation water bicarbonates.

Tips for Developing Salt Water Pumping and Irrigation Infrastructure

1) A constantly pressurized system reduces corrosion.
2) Avoid "coated" materials as flaws in the coating (cracks or chips) accelerate corrosion in the area of the flaw.
3) If considering corrosion-resistant components first prioritize:
   a) pump house floor
   b) manifold
   c) pump components
4) Good service life can be given by ductile iron fittings and valve in head plastic sprinklers.
5) Salt water is best obtained from a well such that a "filtering effect" from the aquifer decreases problems associated with barnacle formation within the irrigation system..