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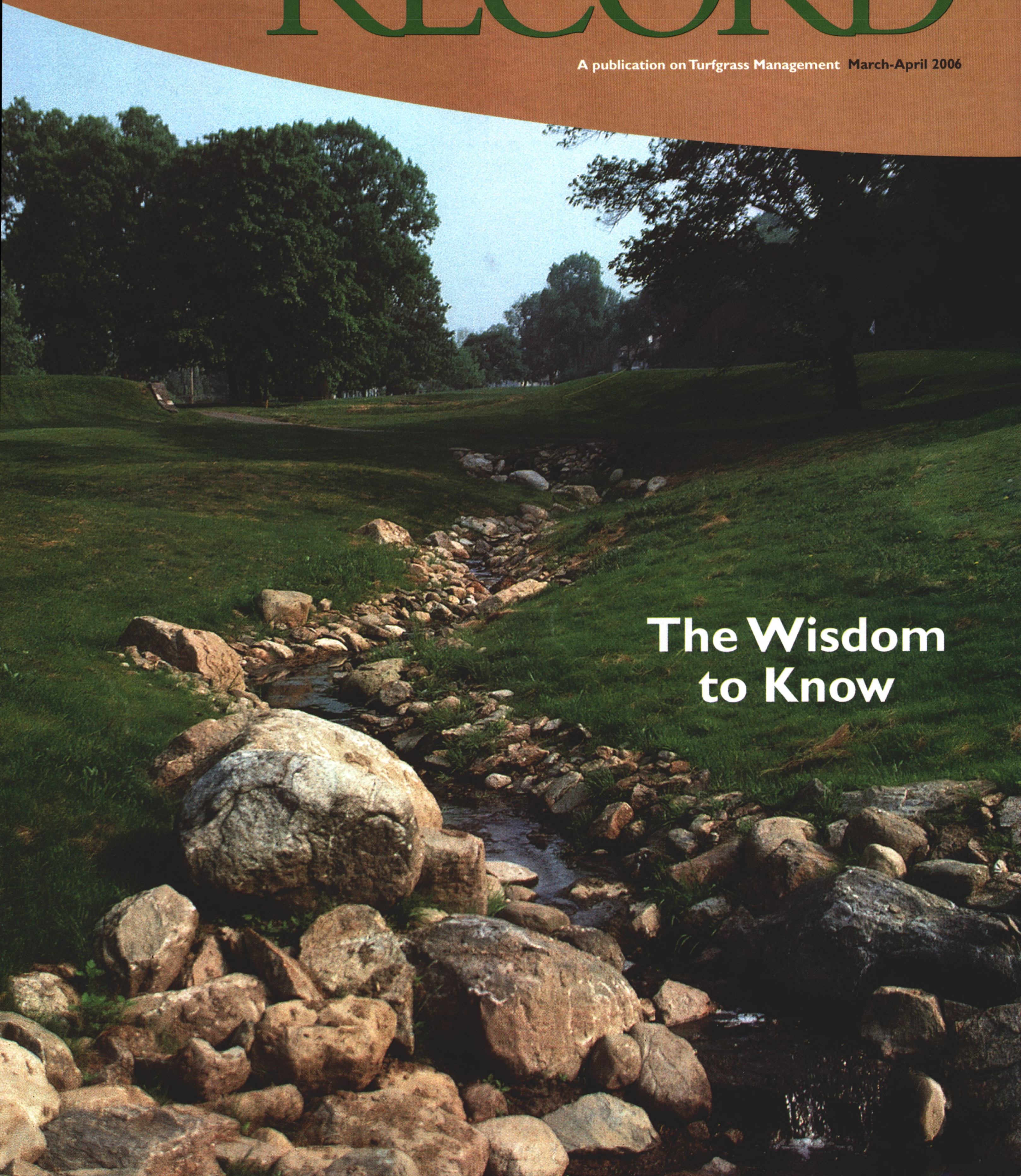

The Wisdom to Know

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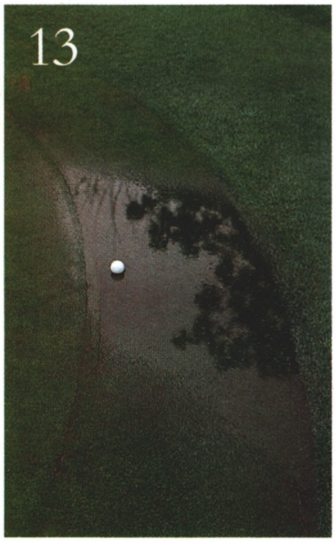
PHOTO BY KURT STEPNITZ



Cover Photo:
For environmentally sensitive areas such as bodies of water, it can be difficult to maintain the necessary balance between aesthetics, playability, and environmental issues.

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Accurate and uniform irrigation applications are important for turfgrass, but this is emphasized on poorly drained soils that are, by nature, less forgiving.

Factors Affecting Success

Having the wisdom to know what you can and cannot control!

BY DAVID A. OATIS

Being a golf course superintendent is much like being a referee: Fifty percent of the golfers are always mad at you and no one ever cheers for you. Few golfers understand the problems a superintendent faces, so before you compliment or criticize, take a closer look at some of the factors that affect their success!

Perhaps you have wondered why certain superintendents are more successful than others, or why some courses perform better than others in any given year. Sometimes it is the money; some courses spend a lot more on maintenance than others. However, some courses simply occupy better sites. The truth is, even courses right next to one another can be so innately different that they will perform very differently in any given year. Soils may be different. Growing environments may be different. Perhaps more is being asked of the turf at one course than at the other. There may also be infrastructure problems at one course and not another. Courses with topnotch irrigation systems typically fare better during droughts than courses with antiquated systems. Courses with good drainage usually perform better during wet years than courses that drain poorly.

Before judging your course or superintendent, understand some of the factors that affect turf performance and ultimately the success of the turf management program. There are indeed many factors involved in the complex world of turf and golf course management, and numerous texts have been written on the subject. This article can address only a few of the major problems that superintendents commonly face.

WHERE TO START?

Doing an inventory of golfer desires and an assessment of course characteristics is a good starting point. There will be obvious problems if the golfers want a links course and the property is not near the ocean!

The next important step is to make sure golfer desires and course characteristics are compatible with one another. Determine what the golfers' priorities are in terms of playability and what they are willing to spend and endure to achieve their goals. This means developing maintenance guidelines, which are a great tool for keeping maintenance programs on track and diffusing arguments about playability. Keep in mind that the committee that hires a superintendent may not be the group he or she answers to just a few years later. See "When In Doubt — Spec It Out" by Pat Gross (March-April 1997 *Green Section Record*) for help in this area.

Make sure the budget is adequate for producing the desired results. If it is not, golfer desires and/or the budget will have to be adjusted. If golfer desires and the budget are not in line, success cannot be achieved. Of equal importance, make sure the property and the design of the course are capable of satisfying golfer goals. Designs can be altered, but not all site characteristics can be changed, and certain designs and playability features are site specific.

Analyze the strengths and weaknesses of the course. This means evaluating every aspect you can think of. Be thorough and be specific. For example, evaluate the water management systems (irrigation and drainage). How well does the course handle moisture extremes? Are the bunkers maintainable and playable? How do they handle too much rainfall? Consider every aspect of the putting greens, such as growing environments, surface drainage, internal drainage, soil modification, cupping area, traffic flow, grass type, etc. Identify whether there are architectural problems with the putting greens that might require reconstruction or significant modification. Use the report-card articles on greens and bunkers written by Jim Moore and Chris Hartwiger ("Helping Your Greens Make the Grade," Moore, March-April 1998; "Help Your Bunkers Make the Grade," Hartwiger, November-December 1998) to help you in your evaluation.

Determine which aspects of each system can realistically be fixed or improved, and which aspects you will have to live with. Prioritize based on golfer impact, importance to turfgrass health, performance, playability, disruption, and cost. Your course may need a new irrigation system, but financially it may be out of reach. Alternatively, upgrading the existing system to make it more effective is rarely a good option, but improving drainage or implementing different mowing strategies may reduce the negative effects of a poor irrigation system.

These are all areas for which assistance can be needed, and your regional USGA agronomist is a great place to start. Getting an outside opinion of your course and the various priorities can be a big help in identifying the most critical aspects to address first.

SITE CHARACTERISTICS

Very few sites are ideally suited for golf. Many are adequate, and others support golf despite the inadequacies of the site. Low, wet sites with heavy soils are least desirable. Severe topography can be picturesque, but it can also increase shade problems and it usually causes traffic to be funneled. Realize that traffic causes more damage to turf grown on severe topography because of the added torque caused by the slope. Sloped turf areas are harder to irrigate than level turf, and south-facing slopes, particularly if they are severe, heat up more quickly. This all impacts turf health. Poor soils, such as heavy clays, shale, or rocky soils, can make digging a hole or installing drainage or irrigation an ordeal. Poor soils also make it tougher to grow consistently healthy turf. In fact, few courses are ideally suited to golf, and most have been further degraded by the overzealous planting of trees. Trees are a major contributor to turf and playability problems.

Geographic location is not something that can be changed, but it has a huge influence on every aspect of turfgrass and golf course maintenance. What is possible agronomically or what may be an agronomic problem in one climate may not be possible or may not exist in another. Understanding local conditions, pest problems, and what works best in your area is essential to developing realistic goals.

The microclimate a course is located in can have a significant impact on turfgrass management. A course's elevation and position relative to geographic features (mountains, rivers, lakes, etc.) influence the weather experienced. For example, elevation will influence temperature. A course with greater elevation will have a slightly shorter season. It often will be slower to warm up in the spring and it may stay cooler in summer, and this creates different turfgrass disease possibilities than warmer courses may experience. The elevated course will cool off more quickly in the fall, so it is important to plan cultivation schedules with the climate in mind.

It can be surprising just how regionalized weather can be. Weather can differ significantly between courses that are just a mile or two apart. A storm may hit one course, dropping several inches of rain, yet almost entirely miss an adjacent one. The microclimate also will influence what turf varieties will perform best and which would not be practical. The microclimate a course is located in cannot be changed, but the microclimate each feature is located in often can be adjusted.

The microclimate each green, tee, and fairway is located in has an enormous impact on their performance. Many courses have rebuilt greens, mistakenly thinking that the problem was in the construction, only to experience equally poor performance with properly built new greens. A few courses have rebuilt the same green several times, only to find the real problem was that the environment the green was located in was poor. Spending time and money on assessing and improving grass growing environments is always money well spent. The growing environment in which turf is located has a bigger influence on its performance than just about any other factor. While the geographic location of the course is not something than can be changed, the microclimate each feature is located in is something that can and should be adjusted. In fact, improving grass growing environments should be one of the highest priorities.

Soil type is something courses have to live with for many areas, and it is a big factor in turf performance. Fine-textured soils such as clays will stay wet and will be slow to drain, quick to compact, and may be difficult to rewet if they become extremely dry. They are very unforgiving. Sandy soils are much more desirable. Surprisingly, courses can have totally different soils in different areas of the course, and courses in close proximity may have very different soils. Also, realize that certain grasses will perform better in some soils. For example, fine fescues, which are commonly preferred in naturalized roughs in the Northeast, need drier, sandy soils to thrive. Plant them on wet, fertile soils and they simply won't perform well. Other grasses are better suited for these sites. Thus, it is important to understand whether the soils will support the desired turf.

Putting greens are an exception, as they are almost always built from or modified with non-

Poor water quality can have a major impact on aesthetics and pond ecology, and it can be a difficult problem to solve.

Few golf courses have soils ideally suited to golf, and many courses suffer with heavy, poorly drained soils that make growing good turf a challenge. Putting green soils can be modified, but most courses have to live with their native fairway and rough soils.

native materials. Because of the area involved (a fraction of the whole property) and their relative importance, great effort is usually expended in adjusting putting green soils. How effectively this has been accomplished, however, will play a big role in determining their performance. Tee soils also are frequently modified, and even fairway soils increasingly are receiving extensive cultivation programs, and some are being modified with sand. Sand topdressing is almost always performed on greens and can be very helpful for fairways, if you can afford it. No doubt about it, soils have a profound impact on turfgrass performance.

Many courses have utilized less than ideal ***construction methods***, and this can have a huge influence on turf performance and maintenance costs. Saving a few dollars or choosing inappropriate construction methods or materials may result in years of elevated maintenance costs, increased golfer disruption, and poor turf performance. Even the best maintenance programs cannot compensate for mistakes made during construction.

It is important to research thoroughly the construction methods to be utilized. Doing so will help direct the maintenance program. This may mean having soil cores analyzed and digging holes in greens to get a firsthand look at what is there. You may be surprised that even older greens built from seemingly native soils have drains underneath them, and when treated with deep aeration, drainage may improve dramatically. Don't probe one green and assume that all are consistent. Identifying precisely where the problems lie is the first step towards developing a plan to deal with them.

Warning: Don't fall into the trap of instituting programs that are successful at other courses if conditions at your course are different. Putting green cultivation programs are a good example. The old, soil-based greens at one course may benefit dramatically from deep aeration and drill-and-fill treatments. However, if you have properly built USGA greens, a drill-and-fill program is not likely to be very beneficial, and the expense and disruption are significant. It is more likely that an aggressive surface cultivation program to control thatch effectively would provide the desired results without the additional expense and disruption of a deep aerification program.

TURF CONDITIONS

Assessing the general health of the turf is another important step. Perhaps it has simply been placed under too much stress (from frequent and low mowing, under-fertilization, etc.) and is unhealthy, thin, and weak. Perhaps thatch levels have been allowed to get out of hand. Thatch must be controlled to produce healthy, reliable turf, better drainage, improved pest control, and good playability. Excessive thatch is a common problem on courses with less than optimal cultivation programs, and it is an especially common problem with high-sand greens. Implementing sound fertility and cultivation programs can improve turf health quickly, but if soil problems or thatch levels are severe, it may take several years to get things back into line.

The turf on one course may not be performing as well as the turf on a neighboring course because of genetics. There are major differences in turf performance, disease resistance, wear tolerance, etc., between turf species and among cultivars of the same species. Turf problems frequently are related to species composition. In the Northeast, old greens commonly are comprised of old bentgrass varieties and annual bluegrass that simply cannot handle the low cutting heights, stress, and disease pressure that modern varieties can withstand. Older courses, where turf has experienced years of natural selection, may have developed an excellent foundation of turf. Newer courses, or ones that have frequently experienced turf loss, may have weaker, less desirable turf.

The difference in putting green performance among courses can be easily attributed to the soil conditions and turf varieties present. Soil conditions can be altered through cultivation, and turf composition can be altered through maintenance practices and overseeding. This is an area to concentrate efforts on, because changes in turf composition frequently will improve playability and turf performance. This usually is a long-term program, taking several years to see results, so it is one that should be put in place as soon as possible. It also is a program that rarely will produce good results if it is not implemented aggressively and consistently. This practice is one that often is cut short in different ways.

Unfortunately, it can be a slow, tedious process. Rapid changes can be obtained by regrassing (via fumigation or use of a non-selective herbicide and replanting). Many golfers do not want to go through this much disruption, but it is the most effective means of effecting rapid change. New cultivars developed in the last decade are light years better than most of the older varieties. Just be sure the growing environments will support the change.

WATER MANAGEMENT

No aspect of turfgrass management has a bigger impact on turf performance and playability than water management. Managing water effectively can get weak turf through tough weather. Manage it poorly, and healthy turf may not survive.

Someone once said, "The only thing more important than ***drainage*** is more drainage," and that is a fact! If there is any doubt as to whether drainage is adequate, it is not! Good drainage produces healthier turf and better playability. It can reduce the potential for summer problems and winter damage. Good drainage gets golfers back out on the course more quickly after precipitation.

Having a reliable and accurate ***irrigation system*** also is important, and having one that applies water uniformly is even more so. Irrigation systems are second in importance only to effective drainage systems, and having an effective irrigation system can actually improve drainage by reducing the problems associated with over/under irrigating.

EQUIPMENT

The equipment inventory may be old, out of date, inappropriate, or in such poor repair that it is not capable of doing the job effectively. Sorting the equipment situation out is an important part of the prioritization process. For example, mowers clearly need to be reliable, and they can have a big impact on turf performance and even species composition. If you find that golfers are complaining because aerification takes twice as long at your course as at a neighboring course, find out why. Perhaps the neighbor is not aerifying effectively or often enough. The reason also may be that your course does not have the right equipment or enough equipment or manpower to get the job done in an expedient manner.

WEATHER

Some years are difficult; some are nearly impossible. The 2005 season leaned toward the impossible in the Northeast, characterized by just about every weather extreme imaginable. Whether a season is difficult for a particular course often depends on the individual course's strengths and weaknesses that were previously mentioned. Timing of the major weather events relative to pesticide applications, the tournament schedule, cultivation events, etc., also can be important factors. High temperatures and a heavy rain event that occur during a major tournament, when turf stress already is high, can push it over the edge. Bad weather that occurs just as a pesticide application is wearing off also can be damaging. Healthy, less-stressed turf will handle challenging weather much better than weak, over-stressed turf.

Warning: Local weather recordings can be helpful, but rainfall is so regional that there is no substitute for having one rain gauge or weather station (or more) on-site.

If there is a silver lining, it is that tough years clearly identify problems that might otherwise be ignored. Even the best maintenance programs may not produce ideal turf conditions in very difficult years, but tough weather can at least be a good teacher.

GOLFER DEMANDS

Everyone seems to want what they perceive as being "the best," but few can afford it. Thus, being realistic regarding goals and resources is essential. Being realistic about what is possible with a given course (and all of its idiosyncrasies) is equally essential. Green committee members must understand the strengths, weaknesses, and limitations of the course and should participate in the budgeting process. If certain programs are desired but not currently budgeted for, a decision must be made: increase the maintenance budget or give up a program or practice that currently is being performed. Spend more or reallocate resources. Many committees require superintendents to make that decision and later are unhappy with the results. It is important that committees fully understand the consequences of their decisions.

As a golfer, it is important to keep motives in mind when considering the performance of a given superintendent and the relative condition of the golf course. The golf course management industry basically is a service industry, and it is in the best interest of a golf course superintendent to maintain a blemish-free golf course with green turf and firm, fast greens. Few, if any, golf course superintendents enjoy aerating putting greens. The process entails a tremendous amount of work, it disrupts playability, and, most important of all, it irritates the people superintendents most want to please: the golfers! Why would a turf manager aerify putting greens, not to mention cut down a tree or apply a pesticide? Because it is in the best long-term interest of turf performance to do so. It is difficult to bake a cake without breaking an egg or two, and aeration, tree removal, and periodic pesticide applications are important and necessary maintenance practices.

MAINTENANCE STAFF

Taking care of those who take care of you is something to keep in mind when it comes to golf course maintenance staff. The most successful superintendents always have excellent staff behind them. Regardless of a superintendent's skill level, the maintenance staff at any course can make or break the maintenance program in a heartbeat. A motivated, well-trained staff is an enormous asset. Developing a conscientious, hard-working crew starts at the top, and it takes time and effort. The wages you offer can certainly affect the quality of staff and your ability to attract applicants, but the working environment you create through your dealings with the crew has an even greater effect. It can drive good employees away or it can make marginal employees better.

Periodic barbeques at the maintenance shop are not very expensive compared to the typical maintenance budget and are a great way to build morale. Playing a team sport at lunch or after normal work hours can be enjoyable and bring crews closer.

CONCLUSION

Many factors influence turf management and a turf manager's performance. Regrettably, many factors are not controllable and others are only marginally so. These uncontrollable and difficult-to-control factors are the cause of most turf problems. Because there are so many of them, it is imperative to effectively manage those factors that can be controlled. It is equally important to know the difference. Considering the ideas presented in the Serenity Prayer offers wisdom that applies especially well to golf course superintendents.

The Serenity Prayer

God grant me the serenity
to accept the things I cannot change,
courage to change the things I can,
and wisdom to know the difference.
— Reinhold Niebuhr

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Understanding Wet Wilt

Shedding some light on an unfamiliar subject.

BY PETER H. DERNOEDEN

The purpose of this article is to discuss wet wilt, a problem in turfgrasses that is not well understood or studied. Indeed, there are only a few, vague references to wet wilt in turfgrass textbooks, including Dr. James B. Beard's *Turf Management for Golf Courses*. The summer of 2005 was not the hottest or wettest in the last 25 years in the Mid-Atlantic Region, but it was among the most stressful, with significant losses of turfgrass on greens. During July and August in the Baltimore-Washington, D.C., corridor, there were more than 22 days when the daytime temperature exceeded 90°F. Average nighttime temperatures were in the low to mid-70s, daily humidity averaged over 78%, and there were numerous thunderstorms. Trouble on many golf courses in the region began following an especially severe tropical storm on July 16. There was, however, heavy thunderstorm activity before and after July 16, 2005. Too much water generally is more destructive than drought to most golf course turfs in summer. Water on the surface or in thatch absorbs heat from the sun. The heat is transferred into the rootzone by soil water and stored. This is why soil temperatures in wet putting greens on hot and sunny days often are several degrees warmer than the air temperature. In the weeks that followed, nearly every golf course in the region experienced some amount of turf loss. Turf losses on greens, tees, fairways, and roughs were especially acute in water drainage patterns or wherever water puddled or slowly drained. Rapid losses of turf were especially severe where aggressive mowing and grooming practices (for green speed) were maintained. Basically, turf was damaged or killed by a combination of excessively wet soils and high day and nighttime temperatures. Mechanical injury from mowers (particularly those equipped with grooved rollers) and fertilizer and chemical burns were common contributing factors to turf loss. Strangely, at least in the Baltimore-Washington, D.C., corridor, only Pythium blight and brown patch were chronic disease problems. Bacterial wilt, take-all patch, and fairy ring on greens and dollar spot in roughs were troublesome for some golf courses; however, anthracnose and Pythium-incited root diseases were uncommon.

Scald on a bentgrass tee is evident due to water perching between a shallow sand rootzone mix and the native soil.

HEAT STRESS

Heat stress is a common summertime problem in many regions of the U.S. For cool-season grasses, heat stress begins when air and soil temperatures exceed 86°F. Root stress in creeping bentgrass, however, can begin at soil temperatures as low as 73°F. There are two basic types of heat stress: direct and indirect.

In general, indirect heat stress can be expected to occur when air and soil temperatures exceed 86°F for prolonged periods. When cool-season grasses are subjected to indirect heat stress, root and shoot growth decreases. Reduced growth is followed by root dieback, loss of turf vigor, density and green color, and possibly death of plants. High-temperature stress also results in an increase in respiration and a decrease in carbohydrate production (i.e., photosynthesis). Carbohydrates are an important source of energy for sustaining shoot and root growth. The imbalance between respiration (use of carbohydrates) and photosynthesis (production of carbohydrates) during periods of heat stress results in a weakened ability of plants to repair themselves, particularly on putting greens. Symptoms of indirect heat stress often appear as a general yellowing or chlorosis, which oftentimes is confused as a disease or nutritional problem.

Direct heat stress occurs in response to a rapid increase in temperatures exceeding 104°F for a relatively short period of time. The most common type of direct heat stress is scald, which occurs when plants are inundated by water. Wet wilt is a stress phenomenon that occurs under several very specific environmental conditions and bridges the definitions of indirect and direct heat stress. While scald was commonplace on tees, fairways, and roughs, it was wet wilt that was a major killer of putting green turf in the Mid-Atlantic Region in July and August of 2005.

The optimum temperature for root growth of cool-season grasses ranges from 50°F to 65°F. New root initiation ceases at a soil temperature of 80°F. Soil temperatures above 86°F will cause root growth to stop and roots to begin to lose their ability to function, and the natural aging process of the existing root system begins. Plants that lose a major portion of their root system in summer, however, sometimes begin to generate new roots, despite high soil temperatures. Roots that do regenerate in the summer are most often found growing in aeration holes. Research is underway at the University of Maryland to study and better understand this phenomenon.

SOIL TEMPERATURES AND SCALD

Soil temperatures have a huge effect on the root systems of grasses. Bentgrass plants on greens normally have pearly white roots that extend 4 to 6 inches or deeper in soil in spring. Often, however, they turn brown and are primarily restricted to the upper 0.5 to 2.0 inches (1 to 5 cm) of soil by late July, when soil temperatures routinely exceed 86°F. Heat stress injury in the rootzone accelerates in wet soils during the summer. On sunny days when air temperatures exceed 90°F, the temperature in the upper 2.0 inches of wet soil can range from 95°F to 100°F. These conditions led to root dysfunction and/or a rapid loss of roots in putting green turf in 2005. Wet soils accumulate heat slowly, but they retain more heat for longer periods, particularly on putting greens where canopy height is normally ≤0.135 inch. Heat retention, however, is more pronounced in native soil versus sand. Plants can condition themselves to tolerate high temperatures, but in most cases large portions of root systems die in response to soil heating, low soil oxygen levels, and/or elevated CO_2 levels as a result of too much water. If water puddles due to heavy rain, over-irrigation or poor surface drainage and inundates plants during sunny and hot weather, turf can be killed or severely damaged in just a few hours. This phenomenon is called scald, and it occurs in response to a rapid heat buildup (>104°F) in standing water in a few hours, which causes proteins to denature followed by plant death. Oxygen depletion (anaerobiosis) also plays a key role in plant death during a scald event. The injury pattern may be random, but scald damage is most severe in low areas where water puddles. A scald-like condition also can occur where there is a significant thatch and/or mat layer (i.e., >0.5 inch). Sunny, hot days that immediately follow a heavy rain can cause excessive heating in a water-saturated thatch and mat layer, which may result in either indirect or direct heat stress.

WET WILT

Wet wilt occurs when there is adequate soil moisture, yet roots cannot absorb water fast enough to meet the transpirational (i.e., a natural cooling process in which water moves from the roots to the shoots and evaporates through openings on leaves called stomates) needs of a plant. This can occur in plants with a limited root system on sunny, warm-to-hot days when there is low humidity and windy conditions. The aforementioned conditions cause stomates to close, and this results in an internal water deficit, which is lethal to plants. Wet wilt also can occur during hot and humid periods when soils are waterlogged. It was this type of wet wilt that was a major factor in turf loss on greens in July and early August 2005. Night temperatures and humidity were very high and turf on greens had little or no relief from high daytime temperature stress. Hence, turf on greens had no ability to recover during this period unless the greens had the benefit of good air circulation and internal soil water drainage. Due to a combination of high soil moisture, low soil oxygen levels, heat stress and stomatal closure, roots were unable to absorb water. Indeed, turf almost literally "cooks" in hot and wet soils. Affected greens initially appeared brownish and water-soaked. Turf soon thinned out in irregular shapes, but damage often followed the natural drainage pattern of the green. It also was common to see damage on the front of sloped greens, where surface water exits and golfers enter the green. Eventually, leaves and sheaths collapsed, turned white, and matted. A week or two later, dead areas developed a blackish appearance. Generally, it was the combination of heat stress, hot waterlogged soils, and mechanical injury from mowing that caused leaves to collapse. It is very difficult to separate damage occurring due to wet wilt versus indirect or direct heat kill (i.e., scald), as these conditions can be interrelated. Oftentimes, any number of turfgrass diseases are blamed or confused as a cause of this type of turf loss. Even when pathogens are present, disease may not be the main cause of the problem.

This mostly annual bluegrass putting green was severely damaged by spiking in the heat of the day during a wet wilt event.

MANAGEMENT OPTIONS

Whenever greens are showing signs of injury from wet wilt or other summer stresses, the height of cut should be increased and mowing frequency decreased. On weak and thinning greens, mowing should be reduced to no more than four or five times per week, and mowing height should be increased to at least 0.150 inch. Increasing mowing height increases leaf area, which improves the ability of plants to produce carbohydrates and to naturally cool via transpiration. An increase in canopy height may help to slightly moderate soil temperature and alleviate stress in the rootzone. It is very important to replace grooved rollers with solid rollers and disengage or remove grooming devices (i.e., brushes and verticutters) once summer stress conditions begin to slow turf growth and recuperative potential. During especially hot and humid periods it is prudent to use lightweight, walk-behind greensmowers equipped with non-abrasive, solid rollers. Although using walk-behind mowers may be impractical for all greens, it certainly would be beneficial to greens that are obviously weakened and showing a loss of turf. Avoid mowing greens in the morning following a major rain event during periods of heat stress. It is when mowers "push water" (i.e., when casual water exists on a green) that loss of turf can be especially severe. Some turf managers substitute rolling for mowing when conditions permit. Greens suffering from heat stress, wet wilt or anaerobic conditions must be carefully managed, and reducing mower stress is essential to turf survival.

Greens suffering from wet wilt stress should not be brushed, vertical cut, topdressed, or otherwise abused mechanically. When soils are excessively wet during summer, irrigation should be avoided until soils become dry enough to require overhead irrigation. During conditions of dry-wilt stress, syringing is recommended to cool the canopy. Syringing can be very helpful during periods of wet wilt, but if water does not evaporate between syringes, the canopy is not cooled. Syringing during wet wilt only can be effectively achieved when an extremely light film of water is delivered to the canopy several times a day. This is best performed by an individual using a hose and nozzle that delivers a mist, rather than using the overhead irrigation system, which can apply too much water to the stressed grass. Fans can be highly effective in cooling the canopy. The moving air provided by fans helps to remove moisture from the canopy, which enables stomates to open. Once stomates open, water can move along a gradient from soil to roots to shoots and out stomatal openings on leaves, which cools the plant. Hence, during conditions of wet wilt, only fans and very light syringes are likely to provide for sufficient cooling of severely heat-stressed turf.

It is very important to promote soil aeration. Roots need soil oxygen to survive. Greens affected by wet wilt should be solid-tine aerated or spiked, but only when it is possible to safely use this equipment on putting surfaces. During periods of wet wilt, it is best to aerate and/or spike in the evening as temperatures are falling. Early morning is the next best time, but all aeration operations should be completed by 8 a.m. on days when air temperatures above 86°F are expected. Aerating and/or spiking in the heat of the day during a wet-wilt event will likely result in extreme damage to putting greens. Once heat stress abates, foliar applications of nitrogen (0.1 to 0.125 lb. N per 1,000 sq. ft.) applied weekly will help turf to recover. Plant protection chemicals should be applied to control any turf disease that may be active. Suspension of plant growth regulator use until putting surfaces have fully recovered would be prudent.

ACKNOWLEDGEMENT

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Low-Carb Diet

Rutgers University scientists demonstrate how the combination of high temperatures and low mowing leads to carbohydrate depletion of putting green turf.

BY BINGRU HUANG, X. LIU, AND Q. XU

Turf quality of creeping bentgrass often declines on golf courses in warm climatic regions during summer months, which is typically accompanied or preceded by root shortening or death. This problem has been broadly defined as *summer bentgrass decline*.[1,2]

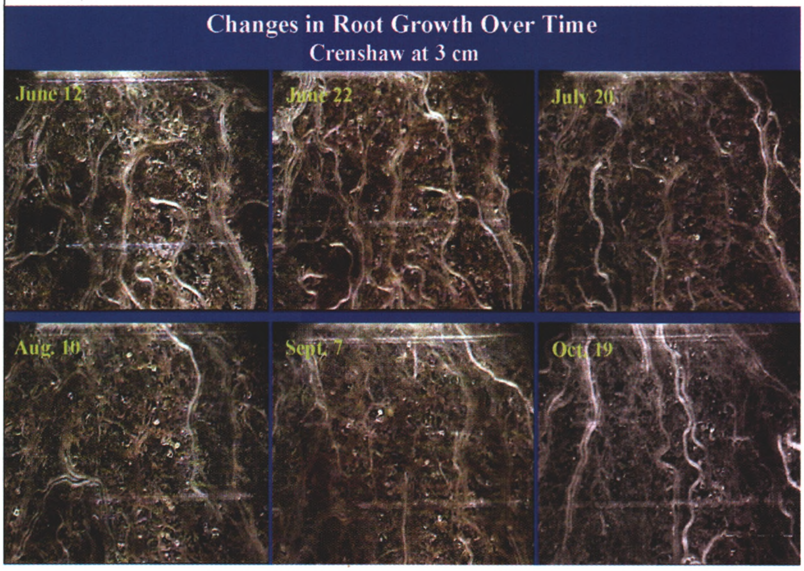
Many cultural and environmental factors may be associated with summer decline in turf quality and root growth. Dernoeden[2] suggested that summer bentgrass decline may be more a physiological rather than a pathological problem. Indirect high temperature is one of the major factors causing loss of turf for creeping bentgrass. Mowing turf too short, such as the ultra-low mowing of today's putting greens, imposes additional stress on the turf by removing large amounts of leaf area that would otherwise be available for photosynthesis and carbohydrate production. Nonstructural carbohydrates in plants serve as energy reserves to be used under stressful conditions.[5] Closely mowed turf may suffer from heat stress injury by depleting carbohydrate reserves due to the increased demand for carbohydrates (i.e., increased respiration) and decreased production of carbohydrates (i.e., decreased net photosynthesis).

This report summarizes results of our controlled-environment and field studies with the aim to better understand how carbohydrate metabolism is related to summer decline in turf quality and root activities of creeping bentgrass. Such information is important for developing effective management strategies to prevent or control summer bentgrass decline.

DECLINE IN TURF QUALITY AND ROOT GROWTH UNDER HEAT STRESS

Decline in turf quality and root growth for creeping bentgrass has been observed under high temperatures (above 80°F) in controlled-environment studies and during summer months in field plots.[3,6,7,9,10] Creeping bentgrass cultivars vary in heat tolerance as demonstrated by differences in severity of turf quality decline with increasing temperatures. Our studies have identified L-93 to be more heat tolerant than Penncross, with less severe decline in turf quality and physiological activities under high-temperature conditions in controlled-environment studies and during summer months in the field.

Root production and mortality of three creeping bentgrass cultivars, Crenshaw, Penncross, and L-93, were monitored using the minirhizotron imaging technique in a USGA-specification putting green mowed at 0.125 and 0.156 inches in Manhattan, Kansas, during 1997 and 1998.[4] For all cultivars, the length and number of newly produced roots decreased, while those of dead roots increased from July to September in both years. Root mortality rate exceeded root production rate, resulting in decline in total root length and number. L-93 maintained higher production of new roots and lower root mortality than Penncross during summer months, suggesting that cultivar difference in root production and mortality was associated with the differences in summer turf performance between heat-tolerant and heat-sensitive cultivars.



Root growth of field-grown Crenshaw creeping bentgrass as shown using the minirhizotron technique in Manhattan, Kan. Photos show root growth observed on June 12, June 22, July 20, Aug. 10, Sept. 7, and Oct. 19, 1998. Root length and number of newly produced roots decreased while dead roots increased from July to September.

Scientists at Rutgers University continue their research to identify factors affecting summer bentgrass decline. The goal is to use the results of these physiological studies to develop cultural management strategies to limit the quality decline of this important putting green species.

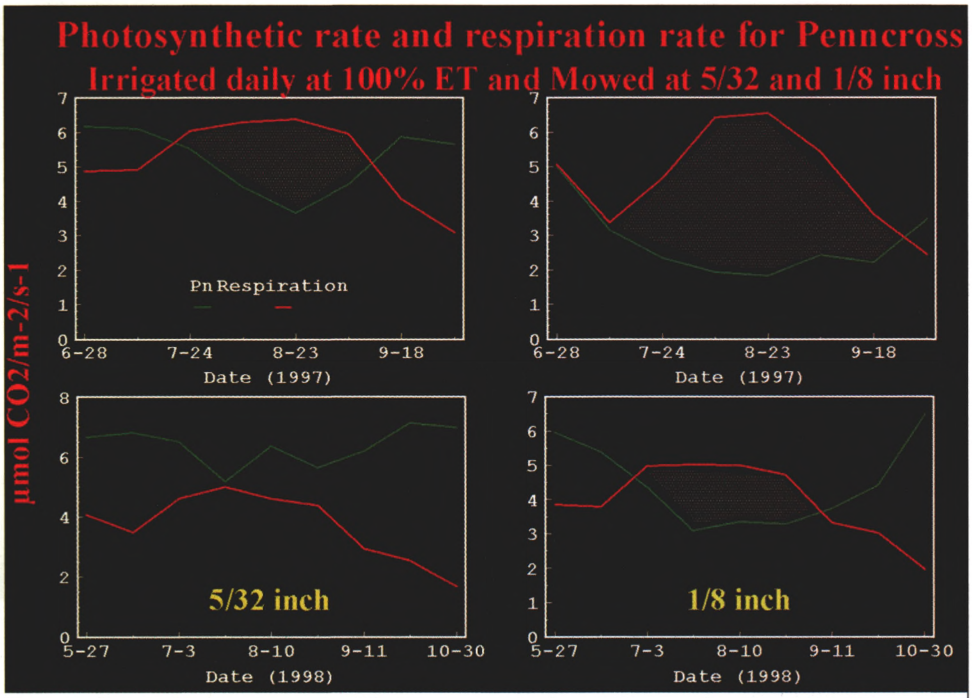
One of our recent studies found that root death and decreases in root metabolic activity, such as hormone synthesis (i.e., cytokinin production) and nutrient and water uptake, precede turf quality decline under heat stress in controlled-environment conditions.[8] Root death occurred at 5 days of exposure to 95°F, followed by decline in cytokinin synthesis, nutrient and water content, and at last with turf quality declining at 20 days of heat stress. These results suggested that decreases in root activity and increased root mortality contribute to loss of turf quality in creeping bentgrass exposed to high temperatures. Improving heat tolerance of the root system is important for maintaining high-quality turf during summer months in warm climatic regions.

CARBOHYDRATE METABOLISM AND SUMMER BENTGRASS DECLINE

A field study was conducted in 1999 and 2000 in Manhattan, Kansas, to investigate whether summer decline in turf quality and root dieback are related to carbohydrate availability during summer months. Penncross and L-93 were examined in the study. Grasses were managed under USGA-specification putting green conditions with daily irrigation and were mowed at 4mm (0.175 inch).

Turf quality and the content of total nonstructural carbohydrate (TNC) and soluble sugars in shoots and roots, as well as carbon allocation to roots, exhibited seasonal variations as temperature changed across the seasons.[12] Turf quality of both cultivars was highest in May, declined to the lowest level in August and September, and returned to a high level in October. Corresponding to seasonal variations in turf quality, the content of total nonstructural carbohydrates, sucrose, and fructans in both shoots and roots for both cultivars was highest in spring and fall and lowest during summer months in both years. Summer decline in carbohydrate content was more pronounced in roots than in shoots.

In addition, the amount of carbon allocated to roots also decreased during summer months, particularly for heat-sensitive Penncross. Our studies conducted in controlled-environment growth chambers found that carbohydrate availability in shoots and roots



Photosynthetic and respiration rates of Penncross creeping bentgrass mowed at 5/32 and 1/8 inches during 1997 and 1998. Green lines indicate carbohydrate-producing photosynthetic rates, while red lines indicate carbohydrate-consuming respiration rates. Data show that as photosynthesis decreases during summer months, especially at the lower mowing height, respiration increases. The result is a net loss of available carbohydrates (shaded area) closely associated with the decline of turfgrass quality.

decreased with increasing temperatures along with the decline in turf quality.[3,6,7,9,10] Our results demonstrated that the decline in carbohydrate availability in shoots and roots, particularly in roots, and limited carbon allocation to roots during summer months contributed to the decline in turf quality and root dieback of creeping bentgrass under high-temperature conditions.

The decline in carbohydrate content in both shoots and roots during the summer may have resulted from an imbalance between carbon production (photosynthesis) and consumption (respiration).[3,7,10] Our study also measured seasonal changes in turf quality, carbohydrate production through photosynthesis, and carbohydrate consumption through respiration using an infrared gas analyzer for creeping bentgrass mowed at 0.156 and 0.125 inch heights.

Turf quality declined more rapidly at the lower mowing height, which was attributed mainly to reduced leaf area, limiting photosynthesis. We found that canopy net carbon fixation rate decreased, whereas respiration or carbon consumption rate increased for both L-93 and Penncross during summer months. Carbon consumption rate exceeded carbon fixation rate in August and September when temperature was highest, particularly for grasses mowed at 0.125-inch height, where photosynthetic capability was most limited. The imbalanced carbon fixation and consumption, particularly for low-mowed turf, may lead to carbohydrate depletion and a decline in turf and root growth during summer months.

In summary, prolonged heat stress may cause carbohydrate depletion, leading to summer bentgrass decline. Close mowing that removes large amounts of leaves from plants can reduce total carbohydrate production, contributing to summer bentgrass decline. Cultural practices that could promote carbohydrate production, including raising mowing height, would be helpful in maintaining quality bentgrass greens during summer.

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Table 1

Sequence of changes in different physiological parameters for creeping bentgrass in response to heat stress.

Parameters	Days of Heat Stress
Root death	5
Cytokinin decline	5-10
K, N, P content decline	15-20
Water deficit	15
Turf quality decline	20

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Lessons Learned on Putting Greens During the Summer of 2005

A severe stretch of midsummer weather taught some painful lessons in part of the Mid-Atlantic Region.

BY DARIN S. BEVARD

The summer of 2005 produced some of the most stressful weather conditions experienced in the Mid-Atlantic Region in the last 10 years. From mid-July to early August, heavy rainfall and high temperatures in many areas led to widespread turfgrass loss. In the transition zone, weather and aggressive maintenance practices often combine to cause some problems on fairways and tees during the summer months, but problems are less numerous on putting greens. In 2005, however, turfgrass decline was not only widespread; decline was severe on putting greens. Reasons for this decline varied, but more conservative putting green maintenance strategies were the difference between isolated problems and widespread decline of putting greens.

When water appears with normal foot traffic, greens should not be mowed, especially under conditions of high heat. Chances for scalping and turfgrass decline greatly increase when these conditions are present.

WHAT HAPPENED?

A combination of torrential rain and temperatures approaching 100 degrees at various times from mid-July to early August placed turf under severe stress. In some instances, this weather pattern reoccurred for two or three days in a row. The common response was to look for a disease pathogen to explain the damage. In most cases, pathogens were not to blame for damage that occurred. Two physiological conditions, scald and wet wilt, were the primary causes of turf loss.

Scald occurs when turfgrass is submerged in standing water after heavy rainfall. When the sun emerges in conjunction with high temperatures, the turfgrass is "cooked," for lack of a better term. Turfgrass can survive standing water for longer periods of time when temperatures are cool. High temperatures and standing water lead to rapid turfgrass decline.

Wet wilt that occurred in 2005 was caused by a combination of saturated soils and high temperatures. Under these conditions, natural mechanisms for cooling the turfgrass plant no longer function properly, and the turf and its roots are damaged. The result was areas of dead grass in low-lying and/or poorly drained areas of putting greens. For more detailed explanations of scald, wet wilt, and other mechanisms of heat stress on turfgrass, see Dr. Peter Dernoeden's article "Understanding Wet Wilt," which also appears in this issue of the *Green Section Record*.

Mechanical damage was a major contributing factor in turfgrass decline on putting greens as well. In fact, in many instances, mowing of greens that were already stressed by wet wilt was the proverbial straw that broke the camel's back, causing a collapse of turfgrass populations.

WHAT WE LEARNED

Drainage is still the most critical aspect of keeping putting green turf alive, especially during periods of *severe heat stress and wet conditions.* When heavy rains occurred, the less time that turf was submerged or saturated, the less the resulting damage. Sand-based putting greens with good thatch management programs and internal drainage suffered minimal damage. Sand-based greens with excess thatch and organic matter content in the upper portion of the soil profile suffered problems similar to their more poorly drained soil-based counterparts. Organic matter and thatch hold water at the surface, and this promotes softer greens that are more prone to scalping and other mechanical damage in any weather. Under high temperatures, water retained in the thatch accumulates heat, further stressing the turf. Excess thatch is an impediment to good putting green drainage and a major contributor to other management problems on greens.

On older, soil-based greens, the lesson was similar. However, surface drainage played a very large role in their success or failure. Flatter greens or poorly drained areas of greens declined in many instances. More contoured greens with good surface drainage suffered less damage. Soil-based greens with supplemental internal drainage also performed markedly better. Supplemental drainage was enough to remove water from green cavities to limit damage.

Under harsh weather conditions, the newer creeping bentgrasses can succumb to summer stress just like their predecessors. In the last five years, establishment of creeping bentgrasses such as the "A" series and L-93, among others, has increased on putting greens. These grasses tolerate heat and low mowing heights under stressful weather conditions and still exhibit a more dense growth habit than older putting green grasses. However, this can provide a false sense of security. The belief that fast green speeds can be maintained on a daily basis with these new grasses without consequence regardless of weather was dispelled in 2005. Some of the most severely damaged greens were established with the newer grasses. Grooming and maintenance practices need to be curtailed on greens with these new grasses just as they do on *Poa annua* or older creeping bentgrasses when severe heat stress occurs. In many instances, golf courses have been closed to establish these newer grasses, and course officials feel entitled to fast greens on a daily basis once they are installed. These grasses perform very well in our region, but they are not bulletproof when weather conditions that are

Areas of greens that hold water are prone to damage whenever heavy rainfall occurs. When air temperatures reach the mid to upper 90s, turfgrass loss likely will occur in these poorly drained areas. Improving drainage in these areas will improve the reliability of the turfgrass.

truly unfavorable for cool-season turfgrasses prevail for long periods.

WHAT ABOUT NEXT TIME?

There will be a next time. The weather pattern that led to putting green decline during the summer of 2005 may not occur on a widespread basis for some years. It could happen again next year. For certain, there is no better time than the present to devise strategies that will be implemented to minimize the potential reoccurrence of the problems experienced on putting greens.

Communicate consequences of maintenance practices during times of severe stress. Communication is the best tool that superintendents have, and it is often under-utilized. Even after heavy rain, when high temperatures were predicted, greens were prepared normally for daily play. Superintendents are under great pressure to provide the best conditions for weekend and tournament play. They should take the opportunity to explain potential consequences of normal preparation to the green committee chair or other course officials prior to implementation under these conditions. This allows course officials to be informed and understand potential consequences of maintenance under severe stress. The benefits of closing greens or skipping mowing when greens are saturated are great. While this may provide inconvenience or slower greens for a day or two, it can be the difference between keeping the grass alive or suffering a long-term decline in playability. Not every course official will be supportive in these situations, but often they are more understanding than they are given credit for. At least offer them the opportunity to be an ally. Unfortunately, this weather occurred when many clubs were hosting member-guest or other major events, providing additional pressure to not only keep greens open, but to groom them to optimum conditions, which caused additional stress.

Do not mow greens that are saturated. Mowing saturated greens (the dreaded pushing water with the greens mower) is always bad, but you're especially asking for trouble when the grass is already stressed. If portions of greens are saturated, mowers will sink in to produce a lower effective height of cut, and this may cause scalping. Even if scalping does not occur, the grass is placed under further stress. At the very least, mowing heights should be raised before cutting saturated greens, and grooved rollers should be replaced with solid rollers to limit stress and mechanical damage.

Soil-based greens with poor surface drainage can be especially hard hit by the combination of heavy rain and high temperature. In some instances, repeated rainfall keeps greens saturated for two to three days, providing little chance for turf survival.

Installation of internal drainage in older, soil-based greens greatly improves their chances for survival in general, but especially under poor weather conditions with wet patterns and high temperatures.

Standing water and high temperatures can lead to rapid turfgrass decline caused by scald and wet wilt.

Other cultural programs such as grooming, verticutting, brushing, and topdressing should be suspended, even though reduced green speed will provide short-term grumbling. If this year is any indication, golfers will become more understanding of slower greens if the greens on their course are alive and playable while other greens falter under increased stress.

Syringe greens when conditions are favorable for wet wilt. Syringing wet greens seems counterintuitive. However, applying a very light application of water to only wet the leaf blades will help to cool the turf plant and increase chances for survival. There needs to be some education here! When golfers see water being applied to already wet and sometimes closed greens, there can be a negative reaction because they do not understand the purpose of the water application. Let them know that you are not watering the greens; you are cooling the turfgrass plants. Remove standing water from greens to prevent scald.

Resist doing anything that just does not feel right. This is a catch-all. However, when the heat is on during the summer, if you have any question whether a maintenance practice is going to cause serious detriment to the turfgrass, don't do it. Your gut feeling is probably right.

These strategies are painfully simplistic. Unfortunately, they were not implemented often enough when unfavorable weather patterns placed severe stress on the turf. Ask yourself if you will have a plan to deal with this type of weather situation in the future to limit turfgrass decline, or will you try to devise a plan under fire? There will be a next time.

Conservative maintenance strategies on greens result in slower green speeds, but they may only be needed for a short period of time, depending upon the duration of stressful weather. If putting green turf is killed, it may take weeks or even months to return the turf to acceptable playability. Many greens in the Mid-Atlantic Region still bear the scars of the past summer. The summer of 2005 is proof that dying is the only thing that grass does quickly, and providing recovery of damaged greens is a long, hard road. Learn from the problems that we experienced.

DARIN S. BEVARD *is an agronomist in the Mid-Atlantic Region, where weather patterns routinely provide significant challenges for management of cool- and warm-season grasses.*

Charles Vancouver Piper: The Agrostologist

A profile of the first chairman of the USGA Green Section.

BY MICAH WOODS

Charles Vancouver Piper is remembered today as the first chairman of the USGA Green Section and as the senior author of the seminal *Turf for Golf Courses* (1917). His contemporaries, however, knew him as a world-renowned botanist and agronomist, and in the scope of Piper's work, his turfgrass investigations were simply a small part of a remarkable and productive career.

Piper was born in Victoria, B.C., in 1867, and his family soon moved to Seattle, where his father had a bakery near the intersection of First Avenue and Cherry Street. As a young man, Piper was an avid botanizer. He joined the Young Naturalists Club and was collecting plants near Seattle as early as 1883. Piper studied at the Territorial University (now University of Washington) there, and in 1885 he graduated with nine other students.

In 1888, Piper climbed Mt. Rainier in a party that included John Muir, the Sierra Club founder. During the descent, Piper nearly lost his life; all save Piper and Muir had crossed an ice bridge over a crevasse, and then the expedition photographer heard a "cry [that] made the very blood in our veins turn cold. This time it was Piper. He stepped into the middle of the bridge and it had given way with him; he had thrown himself forward and caught."

"My alpenstock and the whole ice bridge fell into the crevasse," remembered Piper in 1915. "I have often wondered what would have happened if I had attempted to go across the bridge in the ordinary way."

Charles Vancouver Piper (Courtesy of Manuscripts, Archives, and Special Collections, Washington State University Libraries)

It was at this time that Piper began extensive botanical investigations that he would carry on until his death in 1926. Botany was his passion, and he collected and described many new species. He exchanged plant specimens with herbaria and other collectors; with Edward Lee Greene of Berkeley and Charles Sprague Sargent at Harvard, Piper disputed the former's classification of the Oregon white oak, *Quercus garryana*. When President Cleveland established forest reserves in the 1890s, Sargent wrote to Piper, noting, "There is a very bitter feeling in the west against these reservations and we are going to have difficulty in holding them unless local public sentiment can be aroused in their favor. I count on you to do everything possible to help this good cause."

PULLMAN

All the while continuing to botanize and making collecting expeditions throughout the Pacific Northwest when time allowed, Piper moved to Pullman in 1892 and took on broad responsibilities at the state agricultural college there (now Washington State University). Piper was hired as professor of botany and zoology at the college, and he served as botanist and entomologist at the experiment station, where he was also responsible for plant pathology. He taught on subjects ranging from plant physiology to comparative embryology, answered on average two letters a day from interested farmers, and performed spraying experiments for insect and fungal pests of fruit, grain, and vegetable crops.

We have no record of Piper playing golf or being involved with turfgrasses during the 1890s. Golf was still in its infancy in the United States. The USGA was formed in late 1894, the same year that Tacoma Country and Golf Club was founded near Seattle. Piper was working at that time in all areas of horticulture and agronomy, gathering a store of knowledge about plant pathology, entomology, and agricultural practices. His time at Pullman would serve him well in his later years of turfgrass work.

John Muir (sitting) climbed the summit of Mt. Rainier in 1888. Although not shown in the photo, Piper also climbed the mountain with this group. On the descent, Piper almost lost his life after nearly falling into a crevasse. After losing his alpenstock, he descended the mountain with the assistance of a rope. (Courtesy of University of Washington Libraries, Special Collections PH Coll. 273)

For example, brown patch was a common problem on golf course putting greens in the 1920s, and Piper showed his broad understanding of plant pathology at the 1924 Annual Meeting of the Green Section in New York City. He was asked about the belief that wheat rust was due to a lack of potash in the soil, and if brown patch could be caused by a similar phenomenon. Piper, with his typical directness, responded, "Well, that statement is not true, to begin with." He then began an extemporaneous discussion of the misconception about potash and rust before bringing the story back to turfgrass and brown patch, explaining that healthy plants were usually more resistant to disease.

Piper spent the 1899-1900 school year in the East, studying at Harvard and conducting research at the Gray Herbarium there. For five weeks in the summer of 1902, Piper followed the path of the Lewis and Clark expedition, taking pack horses along the Lolo Trail into the Bitterroot Mountains of Idaho. Whether it was further explorations of Mt. Rainier, pack horse trips through the Blue and Wallowa Mountains, or botanical collections on Vancouver Island or in Alaska, Piper spent his holidays in the wild. His work in later years would take him around the world, from Batavia to Bombay to Berlin, yet Piper was at heart a citizen of the Pacific Northwest. R. Kent Beattie, a noted botanist in his own right, wrote of Piper, "Those who knew him in his later years only remember him chiefly for his brilliant leadership in the agronomic field. But Professor Piper's older friends think of him as a naturalist, especially as a botanical explorer and pioneer. Aptly was he named Vancouver. What George Vancouver did for the geography of Puget Sound and the Pacific Northwest and more, Piper did for the botany."

DEPARTMENT OF AGRICULTURE

In 1903, Piper was hired by the United States Department of Agriculture (USDA) in Washington, D.C., to take charge of the grass herbarium. Over the succeeding years, Piper would serve first as Agrostologist, and from 1907 as Agrostologist-in-Charge, of the office of Forage Crop Investigations. His peers described him as "working with unusual rapidity," having "an astonishing capacity for productive effort," and as "a prodigious worker who knew no relaxation."

During Piper's 23 years at the USDA, he made notable investigations into and was instrumental in the development of the soybean, personally directed the experimental work on grasses and other forage plants, and was renowned in agronomic circles for his discovery and subsequent introduction of Sudan grass into the United States. He was the sole author of *Forage Plants and Their Culture* (1914), a classic that remained in print until at least 1942. Piper was a founding member of the American Society of Agronomy in 1907 and was its president in 1914.

As a scientist, he wrote papers on a wide range of subjects, expressing his broad interests in botany and agriculture. In the *Proceedings of the American Society of Agronomy,* Piper wrote about experimental methods, botanical and agricultural history, and agronomic terminology. An especially interesting article by Piper and Carleton Ball begins, "The purpose of language is to convey ideas." The paper goes on to call for more precision in agricultural terminology, asks for comments and criticism from readers, and then offers a glossary of terms with proposed definitions. There was a hearty response to this paper, and a bulging folder at the National Archives in Washington holds the letters of criticism that Piper requested.

Piper also contributed papers to *Science* on subjects as varied as grass spikelet terminology, the role of botanists at agricultural colleges, and the basalt mounds of the Palouse. In 1922, with William Jennings Bryan in the midst of his campaign to legislate a ban on the teaching of evolution in public schools (which would lead, incidentally, to the Scopes Trial of 1925), Piper responded with a humorous but pointed letter to *Science* about Darwin, the Bible, Bryan, and evolution. All the while, Piper continued to describe new species in the botanical journals, and over the course of his lifetime Piper described more than 100 species. In fact, a genus of orchids, *Piperia*, is named in his honor.

In 1911, Piper made a round-the-world voyage, spending the first part of the year in the Philippine Islands, where he made a comprehensive investigation of forage crops for the U.S. Army. There were over 200,000 horses in the Philippines in 1910, and they were primarily used by the Army. All of their feed, which amounted to 46,000 tons in 1910, was imported from America or Australia. In his report, Piper identified grasses and grains that could be grown in the Philippines to eliminate the unnecessary importation of feed.

He would make another trip on Army business in 1923, this time to investigate forage conditions in the Panama Canal Zone. But in 1912, after his return from Asia via Egypt and Europe, Piper began his turfgrass investigations. Those led to the publication of *Turf for Golf Courses* (with Russell A. Oakley) in 1917, to a series of articles about golf turf in *Golf Illustrated* and *Golf,* and to recognition of Piper and his colleagues at the USDA as a resource for golf courses with questions about their grass.

GREEN SECTION

It is not surprising that the developers of new golf courses soon turned to Piper and the USDA for assistance, for he was the country's leading authority on grasses. This expertise was not lost on the USGA and would lead to the formation of the Green Section in November of 1920. When Piper took up the game himself is not clear, but he was an avid player and a regular participant in tournaments held near the nation's capital. Piper did not always withstanding his contributions to the botanical and agronomic fields. As editor of the Green Section's monthly *Bulletin*, Piper produced a publication of great practical use to readers across the country.

His work included a tremendous amount of correspondence and travel. Piper managed to combine his directorship of the Forage Crops Division with a Green Section chairmanship and ongoing botanical endeavors. These multifarious interests are evident in

A group portrait of Piper's (back row, first person on the left) zoology class in 1883 at the Territorial University of Washington. (Courtesy of University of Washington Libraries, Special Collections PH Coll. 282)

break 100, although he played, according to Oakley, "a very creditable game." And, like so many who love the game and work in the golf industry, Piper said of himself that "when a man becomes interested in golf turf, golf architecture, or golf course construction and maintenance, his game at once declines and soon is abandoned altogether."

Piper's work as chairman of the Green Section would last only five years, from the establishment of the Green Section on November 30, 1920, until Piper's death in 1926, yet his contributions to golf were so valuable that he is remembered in many circles first and foremost as a turfgrass expert, not-

Piper's activities of August 30, 1923, when he was at Portland, Oregon, in the midst of an extensive trip to visit experiment stations in the Western states. Taking a break from his USDA obligations, Piper visited Waverley Country Club and Portland Golf Club, examining the turf and also collecting two species of willow, *Salix fluviatilis* Nutt. and *Salix piperi* Bebb.

The Green Section of the 1920s was organized to conduct research and distribute information. In Piper's report of the Green Section's activities in 1925, he wrote that "quite a few calls were received from golf clubs requesting a visit from one of the officials of

Piper collected *Poa multnomae* (now *P. secunda Presl.*) in 1904 at Multnomah Falls in the Columbia River Gorge. It is housed at the National Herbarium, along with numerous other plant specimens collected by Piper. (Courtesy Smithsonian Institution, Plant Image Collection)

the Green Section to survey local conditions at golf courses. Unfortunately, it was impossible to comply with all of these requests, but where opportunity permitted, the courses were visited and consultation freely granted."

A much larger Green Section was required, and Piper laid out his plan at the 1925 Annual Meeting of the Green Section: "We need more assistants, Mr. Oakley and I are growing old, and we will have to have some youngsters trained to carry out the work. We need these men to travel over the country . . . to get information to give to the clubs. Incidentally, these men traveling around the country will be able to help the clubs on a lot of the problems which they will point out to them."

Ill health forced Piper to rest for much of that summer, and he returned to work only to suffer a stroke at his office on February 8, 1926, dying at home three days later. "At the last," Oakley remembered, Piper "had but one desire, which was that the Green Section be put on a permanent basis so that its functions of investigation and education might enlarge and endure." That desire has come to fruition, and with Piper's initial endeavors, the turfgrass industry and Green Section were set on a most solid foundation.

REFERENCES

Research for this article was conducted at Cornell University's Mann Library, at the National Archives in College Park, Maryland, and at the Manuscripts, Archives, and Special Collections division of Washington State University Libraries at Pullman. Additional information about Piper's work with the Green Section was obtained from USGA Green Section archival papers. The author thanks Jim Snow and Frank Rossi for their assistance in the pursuit of information about Piper.

MICAH WOODS *recently completed a Ph.D. in Turfgrass Science at Cornell University. He has been a golf course superintendent, a writer, and an agronomic consultant.*

The Common Problems of Irrigation Installation Projects

Proper communication and planning help avoid mistakes during new irrigation projects.

BY BRIAN E. VINCHESI

Is your golf course thinking about or in the process of installing a new irrigation system or upgrading your old system? If so, you'll want to avoid the common problems of golf course irrigation system installations. Following are a number of things that can happen and suggestions on how to avoid them during an irrigation project. There are installation concerns as well as administrative concerns that need to be considered and watched out for.

ADMINISTRATIVE CONCERNS

Before the project begins, the boundaries of the golf course, easements, underground public utilities (rights of way), and regulated natural resource areas need to be identified and added to the site plan. This is necessary so that they are available on a site plan for permitting and so that equipment is not installed on property that is not part of the golf course. Easements pertaining to gas, sewer, and potable water supplies require particular consideration, as there are strict construction requirements for working around them.

Identify early in the design process any planned or future modifications to the golf course, including changed fairway outlines, bunker and tee improvements, expanded putting surfaces, etc., so that they can be accounted for in the new irrigation system. You do not want to replace or change any new design work that already has been installed.

Proper pipe burial depth should be maintained throughout the entire irrigation system installation.

Trench settling will be obvious for years, and therefore trenches need to be properly compacted during installation.

Make sure the board understands that an irrigation system is a long-term investment and that they would be wise to account for as many future changes as possible before the new irrigation system is installed.

Local code and permit issues are important to any project and are the responsibility of whoever designed the system. However, as an owner, you want to make sure that all codes and permitting issues have been adhered to and obtained, as non-conformance will become the golf course's liability. Typically, in today's world, some sort of environmental disturbance permit is going to be required for a golf course irrigation system installation.

Communicate daily with the golfers/members about what is going on with the construction via signage, e-mails, or posts to the golf course's web site. Let them know at the first tee or pro shop what holes are going to be closed and where on the golf course they will run into construction. A set procedure should also be in place to deal with complaints. You do not want a situation where anyone can speak to the contractor directly to complain or give advice. Complaints should be funneled through the general manager, the club's (owner's) project manager, or a designated officer of the club. Clearly and regularly communicate to all members, players, etc., the construction process so that everyone knows what is going on and what to expect so there are no surprises.

Make sure that there is a competent contractor's foreman on site for the entire duration of the project and an assistant foreman with defined and clear lines of communication to the golf course management. The foreman should be responsible for all aspects of the project, including change orders, schedule, etc., so this person can deal with any issues that arise. The foreman should have previous golf course experience and should have installed the selected manufacturer's equipment.

Have the contractor keep a daily written log of progress, which should be copied to the golf course superintendent and other responsible parties on a weekly basis. Keep the contractor on schedule. If they fall behind, find out why and, together with the contractor, determine how to get them back on schedule. Track the number of workers each day. The number should stay very consistent, indicating whether or not the contractor will be on schedule. If the number of workers starts to drop consistently, speak to the owner of the contracting company about staffing requirements and bring the project back on schedule.

Just mounding the trenches and waiting for settling is not the proper installation technique. New and existing grades should be evenly matched.

Proper compaction, in lifts, with mechanical equipment is an important consideration in the installation process.

It is imperative that accurate drawings of the installed system be provided at the end of the project, and, if at all possible, as the project proceeds. The record drawing should be required by the contract and funds should be withheld from final retainage until the drawing is provided and assessed for accuracy and completeness.

It is to the project's advantage to make prompt payments to the contractor for the work completed. Percent of work completed should be paid to the contractor minimally within the contract terms if not sooner. Remember, a paid contractor is a happy contractor.

OPERATIONAL/ INSTALLATION CONCERNS

Make sure that all utilities have been marked by a responsible marking entity. This may include the golf course's private utilities being marked at a cost to the course. You should receive a copy of the contractor's registration number for the marking of any public utilities. Include in the specifications that the contractor cannot start excavating until you have a copy of that registration number. To prevent down time for the contractor and disasters on the golf course, provide as much information as available for locations of existing irrigation pipe, wires, drains, utilities, etc. Even with good information, existing utilities will be hit and broken. Be ready to deal with these issues in a quick and professional manner. Drainage lines will be an issue. Be prepared to repair them when damaged, as typically the contractor is only responsible for fixing damaged lines that were marked. Damage to unmarked drainage lines is the responsibility of the golf course.

One of the biggest issues with irrigation system installations is achieving the right burial depth for the pipe. The irrigation system designer will have specified a depth of cover for the pipe, for instance, of 16 inches over laterals. The depth may vary with pipe size, depending on the system specifications. Depth is important, as it protects the pipe and wire and makes the swing joint support the sprinklers properly, as well as making sure the system is not damaged by ongoing maintenance operations, such as deep-tine aeration.

Settling can be an issue. This includes settling over trenches and around valve boxes and sprinklers. Settling can be minimized by properly compacting the trenches at the time of backfill. Backfilling should be accomplished in lifts of approximately 6 inches at a time. Mounding up of trenches for future settling or water settling of trenches is not acceptable. Mechanical equipment such as jumping jacks and sheep foot rollers should be used. After trenching on existing turf, getting the grade of the trenches to match existing grade and to have a seamless transition is difficult, but it can be accomplished with good installation techniques and due diligence. A 3,000- to 5,000-pound vibratory ride-on roller can help in this situation.

Electrical wiring in trenches should be installed loosely, with plenty of slack. The wire should not be installed directly off the wire rolls. The wires should be pulled off the rolls first and then installed, because stretched wire raises the resistance and puts strain on the wire connectors. Additionally, plenty of slack should be left at splices

Wire should be laid, not pulled directly off the roll.

and changes-of-direction, allowing for expansion and maintenance. Are fans needed at any of the greens? Electrical provisions can be easily and affordably accommodated when the irrigation system is being installed. Consider incorporating conduit and electrical upgrades for future fan needs into the overall electrical scheme.

Clearly outline staging areas for the contractor to work from, and specify expectations for an overall professional appearance. For example, require shirts to be worn. You also will want to require dumpsters, construction trailers, and chemical toilets to keep from having the golf course's own facilities used, dirtied, and damaged.

The new irrigation system needs to be flushed thoroughly to prevent debris from entering the sprinklers upon startup. The more debris that is allowed to enter the system, the more problems you will have on startup, and the more maintenance problems will be encountered in the first year.

Do not let the contractor spread out through the golf course. Keep the work contained in as small an area as possible, preferably one hole or less. The more times members or players interact with the construction, the more complaints there will be and the less likely they will be to continue playing during the project. This is no time to lose revenues when this much money is being spent. The installation requirements need to be clearly defined in the contract; otherwise, you will find the contractor working on many different areas of the golf course, doing various things, and never finishing anything.

Trash is always a big problem with a construction project of this size. The contractor's workers should pick up all their trash from the golf course as they work. This includes boxes, tape, excess wire, bottles, cans, etc. Do not let the contractor use an open trench or hole as a trash receptacle. All trash should be carted off to a dumpster and disposed of in a safe and legal manner.

Restoration is the biggest problem with irrigation system construction. Ideally, a golfer will not notice that new irrigation has been installed. For this to be accomplished, there needs to be a clear set of requirements of what the restored work is to look like. Who is responsible for what should be well defined in the specifications and as part of the contract. Many times a club takes responsibility for some of this work; however, it is not advised, as it just clouds the areas of responsibility and often leads to disagreement.

There are options. Is sod going to be cut, removed, and replaced on the trenches, or are they just going to be seeded or sprigged? In southern areas, is the bermudagrass going to be grown back over the trenches, or will it be sodded? If seeded or sodded, what is the loam requirement in inches and type? Avoid reseeding or sodding into subsoil. What is the seeding rate and variety? Is a starter fertilizer needed, and what about mulch? Who is providing what, and who is responsible for installing/applying it? If using either sod or seed, who is responsible for watering it, and for how long?

Rocky conditions, poorly budgeted for or not budgeted at all, can make the difference between a successful and a failed project. Rocky conditions take more time to deal with and can have a significant effect on the schedule. Rocks make more of a mess, causing more damage and requiring more cleanup. Worse, rocks make irrigation system installation project costs increase rapidly, so rock quantities need to be carefully projected, documented, and controlled.

Limit the number or completely eliminate the use of vehicles by the contractor on the golf course. The contractor should be using tractors and utility vehicles, just like the maintenance staff. Pickups, vans, and personal vehicles on the course damage the golf course unnecessarily, even if they are staying on the cart path.

CONCLUSION

As with any large construction project, things will go wrong, and in the end not everyone will be happy. However, if you watch out for the common problems mentioned above, issues should be kept to a minimum and most parties will be satisfied with the result. Communication is the key to a project coming in on time and on budget without problems.

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Rock can add significantly to the irrigation system installation cost. These conditions need to be carefully budgeted.

Research *You Can Use*

Nitrogen Fate in Mature Turf

Michigan State University research demonstrates how high rates of nitrogen fertilization to mature turf can result in unacceptable levels of nitrate leaching.

BY KEVIN W. FRANK, K. O'REILLY, J. CRUM, AND R. CALHOUN

Extensive research has been conducted on nitrate-nitrogen (NO_3-N) leaching in turfgrass systems. Most research has indicated that turfgrass poses little risk to the environment from nitrate leaching.[3] Research conducted at MSU by Miltner et al.[2] reported that the majority of labeled fertilizer nitrogen applied to Kentucky bluegrass never reached the soil. Most of the applied nitrogen was taken up by the plant, immobilized in the thatch layer, or lost to volatilization, while only 0.2% of the applied nitrogen was collected in the drainage water of lysimeters 1.2 meters below the soil surface over a three-year period.

The majority of N fate research has been conducted on relatively young turf stands, ranging in age from one to seven years. However, the age of a turf stand has been proposed as an important factor in determining the fate of N. Bouldin and Lathwell[1] suggested that the ability of a soil to store organic N under relatively constant management and climatic conditions, which are typical of turf systems, would decrease with time and eventually an equilibrium level of soil organic N would be obtained.

Porter et al.[4] examined total N content in soil to a depth of 40cm in 105 turf systems ranging in age from 1 to 125 years old. The data suggest that soil organic matter accumulation is rapid in the first ten years after establishment and slowly builds to an equilibrium at 25 years, when no further net N immobilization occurs. Porter et al.[4] concluded that there is a rather limited capacity of the soil to store organic N and that after 10 years the potential for overfertilization is greatly increased.

Petrovic[3] hypothesized, based on the data of Porter et al.,[4] that older turf sites, or sites with high organic matter contents, should be fertilized at a reduced N rate to minimize the potential for NO_3-N leaching. Petrovic theorized that the rate of N applied to younger turf stands (less than 10 years) should equal the rate at which N is used by the plants, lost to the atmosphere, and stored in the soil. Older turf sites (greater than 25 years of age) lose the ability to store additional N in the soil and therefore should be fertilized at a rate equal to the rate that nitrogen is used by the turf and lost to the atmosphere.[3]

Due to the lack of long-term data on nitrogen fate in mature turfgrass stands, this research was undertaken. The research objectives were to quantify NO_3-N and ammonium-nitrogen (NH_4-N) concentrations in leachate, and determine the fate of fertilizer nitrogen among clippings, verdure, thatch, soil, roots, and leachate for a Kentucky bluegrass turf 10 years after establishment.

MATERIALS AND METHODS

Between 1989 and 1991 at the Hancock Turfgrass Research Center, Michigan State University, four monolith lysimeters were constructed. In September 1990 the area was sodded with a polystand of Kentucky bluegrass (cv. Adelphi, Nassau, Nugget) for a United States Golf Association sponsored leaching and mass balance nitrogen-fate study conducted by Miltner et al. between 1991 and 1993. Prior to the construction of the lysimeters, the area had been in turfgrass for six years. The lysimeters are constructed of grade 304 stainless steel, 0.05cm thick. The lysimeters are 1.14 meters in diameter and 1.2 meters deep. The bottom of the lysimeter has a 3% slope to facilitate leachate drainage to a tube on one side, where leachate is collected in 19-liter glass containers. The leachate is collected on a regular basis. For complete specifications of lysimeter construction, see Miltner et al.[2]

Subsequent to the Miltner studies, the lysimeters and surrounding plot have received continual fertilizer applications and cultural practices to maintain high-quality turfgrass. Leachate collection resumed again in 1998. The experimental design is relatively simple. Two of the large lysimeters and surrounding turf area were treated annually with 245kg N ha^{-1} (5 lb. N per 1,000 sq. ft.) split over five applications. The application dates were May 1, June 1, July 1, September 15, and October 15.

The remaining two lysimeters and surrounding turf area were treated annually with 98kg N ha^{-1} (2 lb. N per 1,000 sq. ft.) split over two applications. The application dates were May 1 and October 15. Lysimeter percolate was

The average total labeled fertilizer nitrogen (LFN) recovered among all sampling components (clippings, verdure, thatch, soil, roots, and leachate) for the low and high N rates were 78% and 73%, respectively. Most of the applied fertilizer nitrogen was recovered in the soil component.

In the fall of 2000, 56 polyvinyl chloride microplots were installed in the plot area adjacent to the lysimeters. Microplots were extracted and partitioned into verdure, thatch, roots, and soil on seven sampling dates to evaluate the fate of labeled nitrogen among turfgrass and soil components.

collected periodically, volume measured, and a subsample collected for nitrogen analysis. The turf was mowed twice per week at 7.6cm (3 inches) and clippings returned. Irrigation was used to return 80% potential evapotranspiration weekly.

In the fall of 2000, 56 microplots were installed in the plot area adjacent to the lysimeters. The microplots are constructed of 20cm-diameter polyvinyl chloride (PVC) piping to a depth of 45cm. The PVC piping was driven into the ground using a tractor and hydraulic cylinder. This process preserved the soil structure within the microplots and the surrounding plot area. On October 17, 2000, ^{15}N labeled urea was applied to the lysimeters and microplots to determine mass nitrogen balance. The microplots were extracted and partitioned into verdure, thatch, roots, and soil on seven sampling dates. Soil and root samples were partitioned into depths of 0-5, 5-10, 10-20, and 20-40cm. Harvest dates followed by DAT (Days After ^{15}N Treatment) for the microplots were:

November 1, 2000 (15 DAT)
December 1, 2000 (45 DAT)
April 19, 2001 (184 DAT)
July 18, 2001 (274 DAT)
October 9, 2001 (357 DAT)
April 20, 2002 (549 DAT)
July 17, 2002 (637 DAT)

In addition, weekly clipping samples were taken to determine the amount of nitrogen in the top-growth of the plant. The leachate from the lysimeters was monitored for nitrate-nitrogen and % ^{15}N enrichment. In addition, soil, thatch, verdure, roots, and weekly clipping samples were sampled for % ^{15}N enrichment to determine mass nitrogen balance for the system.

RESULTS: FERTILIZER ALLOCATION

The average total labeled fertilizer nitrogen (LFN) recovered among all sampling components (clippings, verdure, thatch, soil, roots, and leachate) for the low and high N rates was 78% and 73%, respectively (Table 1). The majority of applied LFN was recovered in the soil, averaging 51% and 38% for the low and high N rates, respectively. Lower amounts of nitrogen were recovered in the roots, thatch, clippings, and verdure.

Over approximately two years, 1% and 11% of LFN was recovered in leachate for the low and high N rates, respectively (Table 1). The largest amount of labeled nitrogen recovered in leachate was during the winter months. The total amount of labeled nitrogen recovered in leachate was much greater than that measured by Miltner et al.[2] On the same site as our research, from 1991 through 1993, Miltner et al.[2] applied N as urea at 39.2kg N ha^{-1} (0.8 lb. N per 1,000 sq. ft.) by either a spring or fall application schedule. Miltner et al.[2] reported 0.2% of applied LFN recovered in leachate from a fall application. For our research, leachate from the low N rate had a similarly low amount of LFN recovered. However, leachate from the high N rate had drastically different results than the Miltner et al.[2] research. Over the two years of our research, 11% of applied LFN was recovered in leachate for the high N rate (49kg N ha^{-1} rate).

Table 1

Mean labeled fertilizer nitrogen recovered from both the low and high rates of nitrogen application treatments (expressed as % of amount applied) from different sampling components of mature Kentucky bluegrass.

Sampling Component	Low N Rate	High N Rate
Clippings	1	2
Verdure	8	9
Thatch	7	7
Roots	10	13
Soil	51	38
Leachate	1	11
Total	78	73

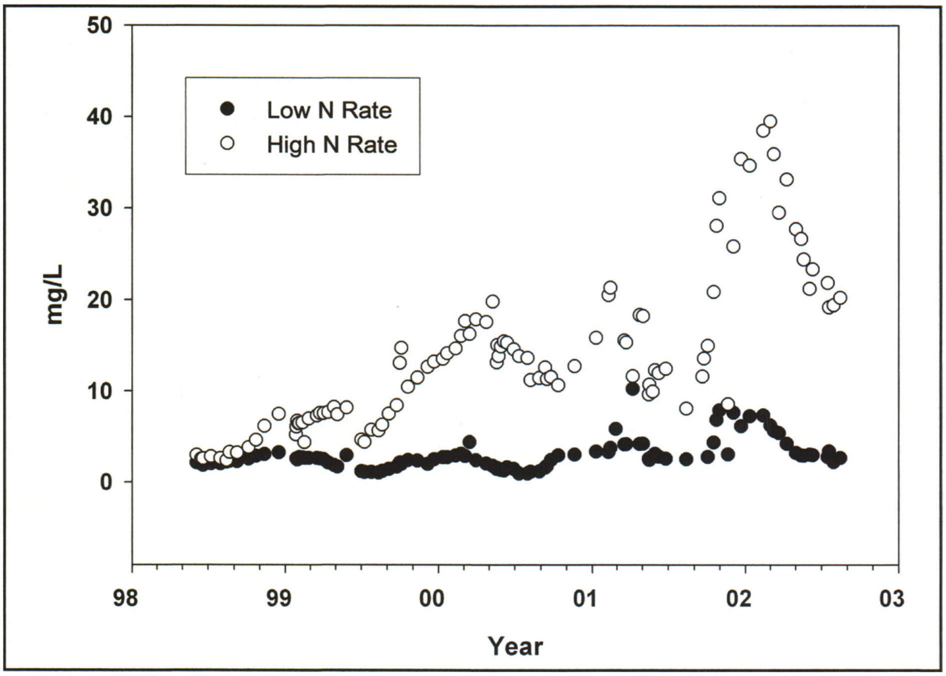

Figure 1. Nitrate-nitrogen concentration in leachate for both the low and high rates of nitrogen fertilization shown for each sampling date from 1998 through 2002.

NITRATE-NITROGEN COLLECTED IN LEACHATE

For the 98kg N ha^{-1} rate (low N rate), NO_3-N concentrations ranged between 1.0mg and 10.0mg L^{-1}. Only on one date in April of 2001 was the NO_3-N concentration equal to the EPA standard for drinking water of 10mg L^{-1} (Figure 1). NO_3-N concentrations in leachate for the low N rate were typically below 5mg L^{-1}. Flow-weighted means of NO_3-N from 1998 through 2002 ranged from 2.6mg to 4.8mg L^{-1} (Table 2).

For the 245kg N ha^{-1} rate (high N rate), NO_3-N concentrations ranged between 3mg and 40mg L^{-1} (Figure 1). On several sampling dates from 2001 through 2002, NO_3-N concentrations exceeded 30mg L^{-1}, triple the EPA drinking water standard. For the high N rate, NO_3-N concentrations in leachate were typically greater than 20mg L^{-1}. From 1998 to 2000, flow-weighted means of NO_3-N for the high N rate ranged from 5mg to 25mg L^{-1} (Table 2).

Table 2

Mean concentration (mg L^{-1}) of nitrate-nitrogen (NO_3-N) when weighted by flow rate for 1998 through 2002 for both low and high N rates of fertilization.

Year	Low N Rate	High N Rate
1998	2.6	5.0
1999	2.0	8.5
2000	2.1	14.7
2001	3.7	18.9
2002	4.8	25.3

The results for the low N rate were similar to the results reported by Miltner et al.[2] at the same site from 1991 to 1993, and they indicate that at the low N rate the potential for groundwater contamination is minimal. At the high N rate, however, the amount of LFN recovered and the concentration of NO_3-N in leachate were substantially greater than the values reported by Miltner et al.[2] At the high N rate, the NO_3-N concentration in leachate from 2000 to 2002 was often between 20mg and 40mg NO_3-N L^{-1}.

CONCLUSIONS

This research indicates that single-dose, high-rate, water-soluble N applications (49kg N ha^{-1} per application) to mature turfgrass stands should be avoided to minimize the potential for NO_3-N leaching. However, just as the original research on this site was conducted over a relatively short time frame of two years, the results presented in this article were from four years of data collection, albeit from a turf stand that has been fertilized for more than 10 years.

The long-term N fate research at Michigan State University is ongoing and future results will be reported. Upon conclusion of the 2002 research season, the USGA opted to fund this research project for an additional five years. A future article will report on data collected from 2003 through 2007. Starting in 2003 the amount of nitrogen applied for the high N rate was reduced from 245kg to 196kg N ha^{-1} (4 lb. N per 1,000 sq. ft.) split over four applications. The low N rate remained at 98kg N ha^{-1} (2 lb. N per 1,000 sq. ft.).

In the first year of reducing the high N rate, the amount of NO_3-N recovered in leachate did not decline from previous levels, but in 2004 and 2005 there was a dramatic reduction in the concentration of NO_3-N recovered in leachate. Future years of data collection will indicate whether the lowered high N rate results in consistently lower levels of NO_3-N leaching.

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Ivan Visits Valley Brook Country Club

How we learned our lesson and how we will be ready next time.

BY JOHN SHAW

A creek that is normally 75 feet wide turned into a 1500-foot-wide torrent of water as 5.96 inches of rain fell on the golf course.

Valley Brook Country Club, in McMurray, Pennsylvania, is a 27-hole course originally designed by Jim Harrison and Fred Garbin and built in 1966. The Red Nine underwent a renovation in 1974, with the greens being redesigned by Robert Trent Jones.

During the summer and fall of 2004 we found out what it is like to experience the wrath of Mother Nature on our course. In June of that year a severe storm formed over our property, resulting in the destruction of 25 large trees. It took us two weeks to clean up the debris. Little did I know, however, that this storm event was just the tip of the iceberg with respect to what was to come. As we entered the summer of 2004, we were just 11 bunkers short of completing a major renovation project. Ironically, we started on the Red Nine bunkers because they were the largest and we wanted to get these features finished for the members first.

On Friday, September 17, 2004, Valley Brook Country Club received 5.96 inches of rain from the remnants of Hurricane Ivan, an amount that we found our course could not handle over such a short period of time. The golf course is divided by Chartiers Creek, with the Red Nine being protected by a dyke system that was part of the original design when the course was constructed in 1966. No one could have foreseen that the creek would rise

After the flood waters receded, our fairways looked more like the surface of the moon than manicured surfaces our members enjoyed.

Skid loaders hauled debris from the property. The leading edge of the loader bucket was fitted with a section of PVC pipe to reduce the potential for damage to the turf.

7 feet above the dyke, flooding 13 holes and causing major damage that would take months to repair.

Chartiers Creek is normally 75 feet wide, but during this storm event it turned into a 1,500-foot-wide rushing river encompassing most of the Red Nine and tearing one of our main bridges from its cement frame. The force of the water carried the bridge one mile downstream, depositing it on a neighboring golf course. As I stood watching the water run across our course, I couldn't help but think about the damage that was being done. What would I find when the water receded?

On Saturday morning, September 18, we started developing a recovery plan. We were very fortunate in that local superintendents were able to supply us with two 6-inch pumps, enabling us to begin removing water that was covering large parts of the course. The loss of the bridge made the recovery process even more difficult because the equipment we needed to initiate the recovery process was on the other side of the creek. We had to haul the equipment 4 miles around the outskirts of the course property on a back road that was used only for construction. After a few trips with the trucks, it was clear that we would need to hire a contractor to build a better road to access the golf course maintenance facility. It also became very clear that we would need to have two equipment staging areas, since work needed to be done on both sides of the creek.

On Sunday, September 19, the water level in the creek dropped enough to allow the backflow valves installed in the dyke to operate as designed. When open and operational, three 12-inch valves ran at full output. We also had the two 6-inch pumps running, discharging 2,000 gallons of storm water per minute from the course to the creek. Even with these backflow valves open and borrowed pumps running at full tilt, it took almost 48 hours to move the water off the course and expose the underlying damage.

The first thing we noticed was a heavy accumulation of silt, tires, trees, and every form of debris imaginable. The smell from the decaying debris and dead fish was indescribable and was an obstacle for some of my crew members with weak stomachs. As a precaution, a doctor who is a member of Valley Brook Country Club administered tetanus shots to employees and volunteers.

We began cleaning off the greens using four 6-inch trash pumps to spread

One-inch hoses were used to move silt and debris off the course. Creating a slurry allowed us to move the material with little damage to the turf below.

Large trash pumps moved high volumes of water over silted areas of the golf course. Once a slurry was created, it was moved with plastic snow shovels.

water across the greens. This allowed us to create a slurry that made it easier to shovel and squeegee the debris. One of our first trials and tribulations was to figure out how to manhandle the 6-inch hose discharging the water. With the combined efforts of my staff, the club's staff, and numerous club members, we were able to clear the greens of the heaviest silt immediately. In this situation, everybody learned quickly that this was a joint effort and that no single person could be able to manage this monumental task. We needed to work together.

On Tuesday morning (September 21), my full crew returned to work, along with 25 volunteers from other clubs and businesses. Some of my fellow superintendents had been making phone calls to line up volunteers to help with the silt removal process. With this kind of help we were able to start removing silt on the tees and fairways using Steiners fitted with snow blades, Toro Sand Pros with box blades, and track loaders fitted with PVC pipe attached to the front edge of the bucket. We also set up 20 1-inch hose attachments that we could insert into our irrigation heads. The hoses were used to produce a slurry, which allowed us to move the silt and debris away from in-play areas much more rapidly.

After working on silt cleanup for more than two weeks, the decision was made to hire a contractor to help get the remaining silt and debris off the course. We needed to accomplish this to have any chance of completing the necessary seeding programs before winter weather arrived. The contractor brought in two tractors with trailers, a skid loader with flotation tires, and a small excavator fitted with a rotational grade-all bucket. The greatest benefit to using outside contractors was the skill and speed with which they performed their cleanup efforts.

We could not completely avoid damage to the course while cleanup was being performed, but once we completed removal tasks, it was surprising to see how little self-inflicted damage resulted. One of the decisions we made was to haul all of the contaminated bunker sand to a 10-acre site that the club owns, where a 10,000-square-foot turf nursery was made with the sand. At the time, it seemed like a waste to haul the material the extra distance, but I'm glad we did, since this nursery is going to be a great asset to the club for many years to come. Because of silt contamination, the nursery will be used only for fairways, approaches, and tees.

Superintendents from neighboring courses, their courses unaffected by the storm, volunteered to help move debris off the golf course.

Our crew and many volunteers worked long hours removing debris from the course.

We employed the services of an outside contractor to remove severely contaminated bunker sand. Unfortunately, the damage occurred only a few months after we had completed a major renovation of all of the bunkers.

While the outside contractor was busy removing silt, my crew began double-aerating and slice-seeding the damaged fairways. We also took the time to core-aerate the greens that were affected by the flood. We were able to do this because we could not seed the rough until the construction company completed the final stages of the clean-up process. As soon as they completed a section of the course, we were seeding behind them.

We were fortunate to have perfect weather in October, and we were able to have all of the seeding finished by October 15. Bentgrass introduced to the fairways germinated in about five days. Since we were already into October, we decided it was too late to seed the roughs with bluegrass. We opted to use turf-type tall fescue varieties and sowed them into the damaged areas with a Seed-o-Vator.

The cleanup process was tiring and emotional. It brought tears to my eyes seeing all of the combined efforts focused on saving turf at Valley Brook Country Club. In the end, turf on all of the greens and tees was saved, along with the majority of turf on 10 of the 13 fairways affected by the storm event. Three fairways had 60% turf loss, with the rough being completely devastated on these holes. Thirty-one of the newly built bunkers were a complete loss. The volunteers helped save a tremendous amount of turf, and for this I will be forever grateful.

We took special precautions during the summer of 2005 to help the new turf make it through extreme environmental conditions. Our first task was to get the club's board of directors to agree to restrict golf carts to paths on the affected holes. This restriction was in effect for the entire season. We roped off the most severely damaged areas from green to tee, and I can assure you that our rough mowing operators will be happy to see the ropes removed next year! We also aerated the areas most severely impacted by silt accumulation with an Aer-Way repeatedly throughout the season. We needed to promote air exchange and did not want our seeding efforts to succumb to suffocation from silt that was sealing off the surface. We mowed by hand where necessary to reduce mechanical wear on juvenile grass. We even roped isolated areas so my crew would not drive through sensitive portions of fairways or rough. We planned on hand watering the recovering areas during the summer months of 2005, but it turned out to be one of those years when we hand watered most of the course for the entire season. I'm glad to say that we made it through the season without any turf loss on any of our main play areas, including the flooded holes that exhibited some of the best turf I have ever seen. Controlling traffic really paid off.

If you ever find yourself in this situation, don't be afraid to tear the grass up a little with plows, skid loaders, etc., since time is everything when you are trying to save as much grass as possible. The experience has allowed us to develop a recovery plan just in case we are flooded again. The following is a list of things that we put into action when Hurricane Katrina came through during the summer of 2005. Luckily for us we did not receive much rain, but we were ready.

VALLEY BROOK COUNTRY CLUB FLOOD CHECKLIST

- Remove from the course:
  - Tee markers
  - Ballwashers
  - Garbage cans
  - Pond fountains
  - Rope and stakes
  - Bunker rakes
- Screw down irrigation valve box lids
- Dismantle pump station (last resort)
- Take in satellite boxes (last resort)
- Secure above-ground diesel fuel tank
- Strap down the urea sulfuric acid tank
- Move equipment out of the trailers in the back parking lot
- Move the fertilizer to the pallet racks
- Move all trailers, plywood, and equipment from the back parking lot
- Move essential recovery equipment to the other side of the creek before flood level is reached
- Check the following:
  - 4-inch trash pumps — intake hoses, hoses, gaskets
  - 1-inch hoses, quick coupler attachments, and distribution nozzles
  - Electric generator
- Shut off power to the maintenance building
- Adapt skid loader bucket and Steiner blade — fit both with PVC pipe
- Back up computers
- Print out blank work schedules
- Close and lock doors at the creek pump pit
- Consider applying additional growth regulator to suppress growth prior to the flood

JOHN SHAW, CGCS, *became superintendent at Valley Brook Country Club in 2003.*

Ten of the 13 fairways covered by water and debris exhibited only minimal damage. Overall, the recovery program was a success.

On Course *With Nature*

The Benefits of Audubon Cooperative Sanctuary Certification

The certification process provides environmental, educational, financial, and personal benefits.

BY FRED YARRINGTON

When a golf club considers joining the Audubon Cooperative Sanctuary Program for Golf Courses (ACSP), it needs to fully understand the benefits it will derive from its participation, as well as the time and effort required to become a Certified Audubon Cooperative Sanctuary. Becoming certified is no different from any other activity: The benefits to you are in direct proportion to the time and effort you give to the task. My perspective comes from going through the process of achieving certification at two different golf courses — one in Florida and one in Vermont.

Everything done properly to promote the growth of strong, healthy turf at minimal costs is normally of benefit to the environment. In joining the ACSP, you become part of a network of golf courses dedicated to the goal of developing environmentally sound maintenance practices that enhance and continue to improve the wildlife habitat on their properties.

The certification process is fundamentally educational. And just like any education program, the beneficiaries of the effort will be those who are involved. You will personally audit the special features of your golf course, the physical characteristics of your maintenance facilities, and the procedures and materials used in the maintenance of turfgrass.

Audubon International provides comprehensive information and documents necessary to complete the certification process. In addition, the staff is available to provide help, suggestions, and assistance when needed. Audubon International also provides a strong support system, which includes Audubon Stewards in every state who have volunteered to assist courses interested in the program.

By completing a Site Assessment and Environmental Plan, you will gain a better understanding about environmentally appropriate procedures. The process provides a means to compare your Best Management Practices and Integrated Pest Management procedures with those considered to be effective environmental practices for the industry, and to make adjustments where needed.

The information generated will provide a form of insurance by documenting that you are protecting the environment and enhancing your property. It helps establish credible assurance that you are handling chemicals, fertilizers, and fuel in a proper manner. Likewise, you'll have reasonable assurance that you are using water efficiently and properly managing water features and irrigation sources to maintain good water quality.

It's very rewarding to demonstrate with confidence that you are providing healthy habitat for a variety of wildlife species. There is nothing more exciting than observing an increase in wildlife activity around a formerly degraded pond that has been enhanced with aquatic vegetation, or the results of creating a bluebird trail, erecting an osprey platform, or putting up a purple martin house.

You also will be offered information pertaining to Outreach and Education projects for your membership and the community outside the club. This component of the program was something we approached slowly and carefully for the two private clubs I helped become certified. But at both courses, we have steadily increased our outreach activities. This not only has improved our members' appreciation for the nature on the course, but it also strengthened our relationships in the local community and improved perceptions of the club as a good neighbor and environmental steward.

I believe that those of us who have the responsibility to care for special acreage like golf courses have an obligation to do as much as we can to improve the environmental characteristics of the land. I personally have benefited from the satisfaction of knowing that the property of my two clubs has been improved and that the ACSP projects we have introduced will have continuing positive financial benefits to the courses. More importantly, we have improved the habitat and environment for wildlife that share the property with us, and we have created a sound foundation so that future generations will be able to enjoy the property we cared for in our time as stewards.

FRED YARRINGTON *has played golf in 48 states and 20 countries, and he has spent more than 40 years as a "golf" volunteer. He currently serves as an Audubon Steward and has assisted the Hole-in-the-Wall Club in Naples, Florida, and Ekwanok Country Club in Manchester, Vermont, in achieving ACSP certification.*

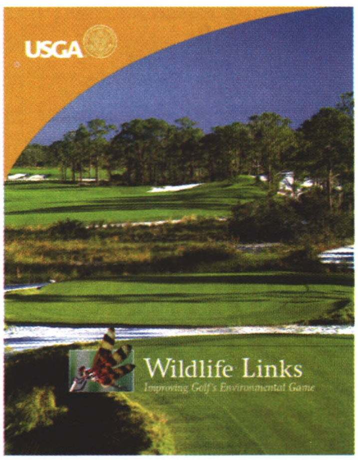
DR. GLENN BURTON

World-renowned agronomist Dr. Glenn Burton passed away at the age of 95 on November 5, 2005. Dr. Burton moved to Tifton, Georgia, in 1936 to work at the Coastal Plains Experiment Station for the U.S. Department of Agriculture, and he continued in that location as head of the Grass Breeding Department for more than 60 years. After retirement, however, he continued to go in to work each day to continue his research in grass breeding.

Dr. Burton is credited with developing several outstanding turfgrasses used on golf courses, home lawns, and sports fields. His development of several Tif- varieties of bermudagrass, including Tifgreen, Tifway, and Tifdwarf, were a boon to southern golf courses. The USGA provided funding support for his work from 1946 to 1996. For his remarkable achievements in breeding grasses for golf, Dr. Burton was honored with the USGA Green Section Award in 1965.

NEW PUBLICATION AVAILABLE

Wildlife Links: Improving Golf's Environmental Game is now available through the USGA Order Department. First established in 1995, Wildlife Links is a joint venture of the USGA and the National Fish and Wildlife Foundation. This research program is golf's first comprehensive investigation of the game's relationship to and impact on wildlife and wildlife habitat on the golf course. The publication is filled with practical information and advice for golf course superintendents and provides examples of habitat projects that can be implemented on golf courses. The publication is available for $5.00 by calling the USGA Order Department at 800-336-4446 and requesting publication #PG5009.



"WHY DO YOU AERATE WHEN I'M TRYING TO PLAY GOLF?"

Communicating to golfers the necessity of some of the basic agronomic management programs and procedures that take place on the golf course often can be a frustrating task for golf course superintendents. Irrigation, aerating, frost delays, Stimpmeter readings, ball mark repair, and bunker etiquette are just a few of the topics about which superintendents often field questions from golfers.

The USGA has just made available 17 animations and video clips on the USGA Web site to help address some of the questions most commonly asked of golf course superintendents. These two- to three-minute clips are appropriate to share with golfers and committee members, and to use in staff training programs.

The animations and video clips are available for viewing on the USGA Web site at www.usga.org/turf. A DVD, titled *The USGA Golfer's Guide: An Animated Journey from Tee to Green*, also is available through the USGA Order Department for $14.95 ($10.95 for USGA Members) at 800-336-4446 (plus applicable shipping and taxes). In addition to the agronomic-based animations, the DVD contains 29 animations pertaining to the Rules of Golf and includes an interactive golf hole.

Take the Challenge

The Green Section's Turf Advisory Service helps pave the way to proper preparation and the ability to handle tough weather.

BY BOB BRAME

Most superintendents would agree that 2005 was a tough year to maintain quality golf turf. Dry, hot, then hot and wet, with hurricanes mixed in, all took a toll on golf course maintenance. However, some courses came through much better than others. Why do some courses handle tough conditions better than their counterparts down the road or even across the street?

The reasons for differences in course conditioning are many. One obvious factor is the natural random variations in the weather. In 2005 some courses experienced hot and wet for longer periods of time. Yet this is not the primary variance, as some who experienced the most extreme weather were still able to present unscathed courses.

Along with the harsh weather patterns in 2005, the economy has become a more pressing issue. Although proper funding has always been a factor with golf course maintenance, its impact has intensified over the last few years. Economic concerns have forced golf course maintenance operations across the country to reevaluate and redefine, which has resulted in budget cuts for some. Is this the primary difference for those that came through relatively unharmed — their budgets weren't reduced? No — courses both with and without imposed budget cuts came through the tough 2005 season in good condition.

Multiple other factors tie into the variations seen in course conditioning. For instance, the turf species being maintained made a difference in 2005, with warm-season grasses coming through generally better than cool-season grasses. The physical attributes of the rootzone structure also play into the equation. Nonetheless, what rises to the top as the primary difference is proper preparation.

It's impossible to accurately predict the weather; therefore, doesn't that elevate the importance of being prepared for tough weather conditions with sound agronomics? Regardless of the budget level, which is ultimately fixed by course officials, isn't the objective to properly apply available funds and prepare for the worst-case scenario? From sound mowing practices and fertilization, to water management and providing the best possible grass-growing microenvironment, proper preparation aligns with preventative. Preventative measures are almost always less expensive and more effective than curative measures.

Regular review of the maintenance operation is very important to proper preparation. Just as a skilled author solicits experienced input to facilitate the rewriting process, a superintendent needs unbiased outside input to ensure proper preparation, as it's very easy to overlook something important. The Green Section's Turf Advisory Service (TAS) comprehensively addresses this need by offering professional, unbiased, and candid counsel.

Based on extended TAS experience as both a superintendent and staff agronomist, there is no question that those who subscribe every year gain the most. History — knowledge of the maintenance operation over time and a relationship with the staff and course officials — will improve the value of recommendations offered. While we're available on any frequency a course desires, a minimum of one visit a year dramatically elevates our value to the maintenance operation and proper preparation. Will yearly TAS visits guarantee no problems? No, but they'll dramatically improve the odds.

A number of courses called with urgent needs in 2005, hoping that a visit could be scheduled the next day. While we're all about helping a course achieve its full potential and we'll juggle the calendar to get there as quickly as possible, it normally takes a few weeks to arrange a visit during peak season. Scheduling and travel logistics are a reality; thus, the importance of planning ahead ensures good continuity. Planning ahead also reduces the cost via our early-signup discount. Every effort continues to be made to hold down the cost of a TAS visit, with more than 60% of the actual expense being paid by the USGA.

If your course is a regular TAS subscriber, we look forward to an ongoing working relationship. If not, **take the challenge** — value satisfaction is guaranteed. Yearly TAS visits will improve your maintenance operation, and the difference will be most evident during tough years.

BOB BRAME *is the director of the Green Section's North-Central Region.*

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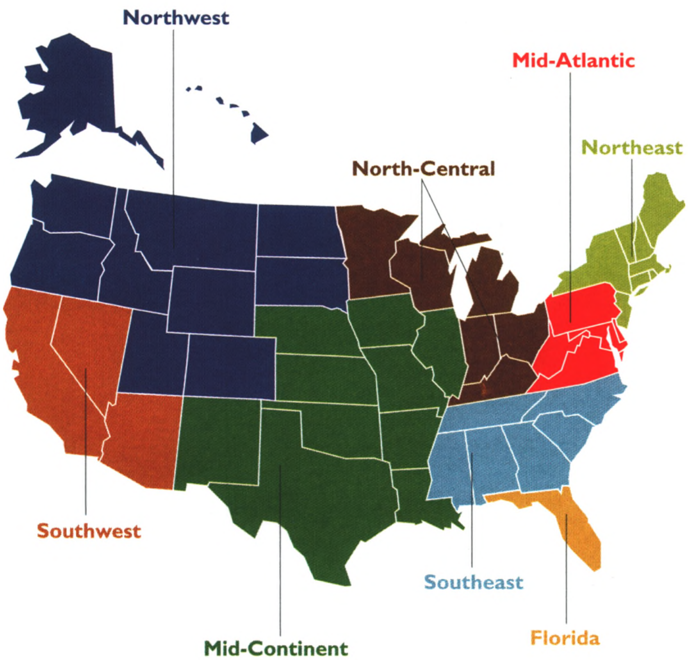

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Turf *Twisters*

Q: As the green committee chairman at our course, I am responsible for communicating with the membership with regard to problems that occur on our golf course. This spring, our bermudagrass fairways are severely infected by spring dead spot disease, which takes a large portion of our growing season to heal. Our superintendent states that spring dead spot is difficult to predict and control. Is this true? (Virginia)

A: Spring dead spot is an increasing problem in much of the transition zone. The severity of the disease is based on many factors, including traffic on dormant or semi-dormant fairways, fall weather, and bermudagrass variety. The disease actually infects the grass during the fall; however, the damage from the disease is not evident until bermudagrass breaks dormancy in the spring. The effectiveness of fungicides is variable and costly, and it can be difficult to time fungicide applications properly. Cultural controls include limiting fall traffic on bermudagrass, and maintaining acidic soil pH. Nonetheless, spring dead spot can occur in spite of chemical and cultural programs targeted for its control.

Q: I have new greens (five months since seeding) but still have some small bare areas and thin spots that have not yet filled in. Is there a trick to fill in these areas besides sodding or plugging? (Oklahoma)

A: If the spot is about 6" or less, simply use a cup cutter and insert it into the ground, as you would changing a cup, one half over the bare spot. Then rotate the plug 180° and pull out the cup cutter. The smaller spots remaining will be filled in very quickly. On a slightly larger spot, this can be done on both sides. This method leaves the area smooth and is very labor friendly compared to plugging.

Q: Should every green on a golf course receive the same light topdressing program? (Washington)

A: Although light topdressing can be very beneficial, greens in heavy shade do not produce the same amount of organic material as those in full sun. If all of your greens are lightly topdressed equally, this can result in "explosions" of ball marks that are virtually unfixable and very firm surfaces during the summer months on shaded greens. Superintendents who have slightly reduced their topdressing amounts on shaded greens have had very good results by allowing more organic material to accumulate near the surface, resulting in ball marks that are more easily repaired and greens that react like those in full sun.

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