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AERATION AND TOPDRESSING

Contents

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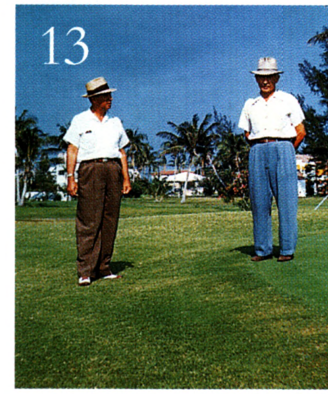

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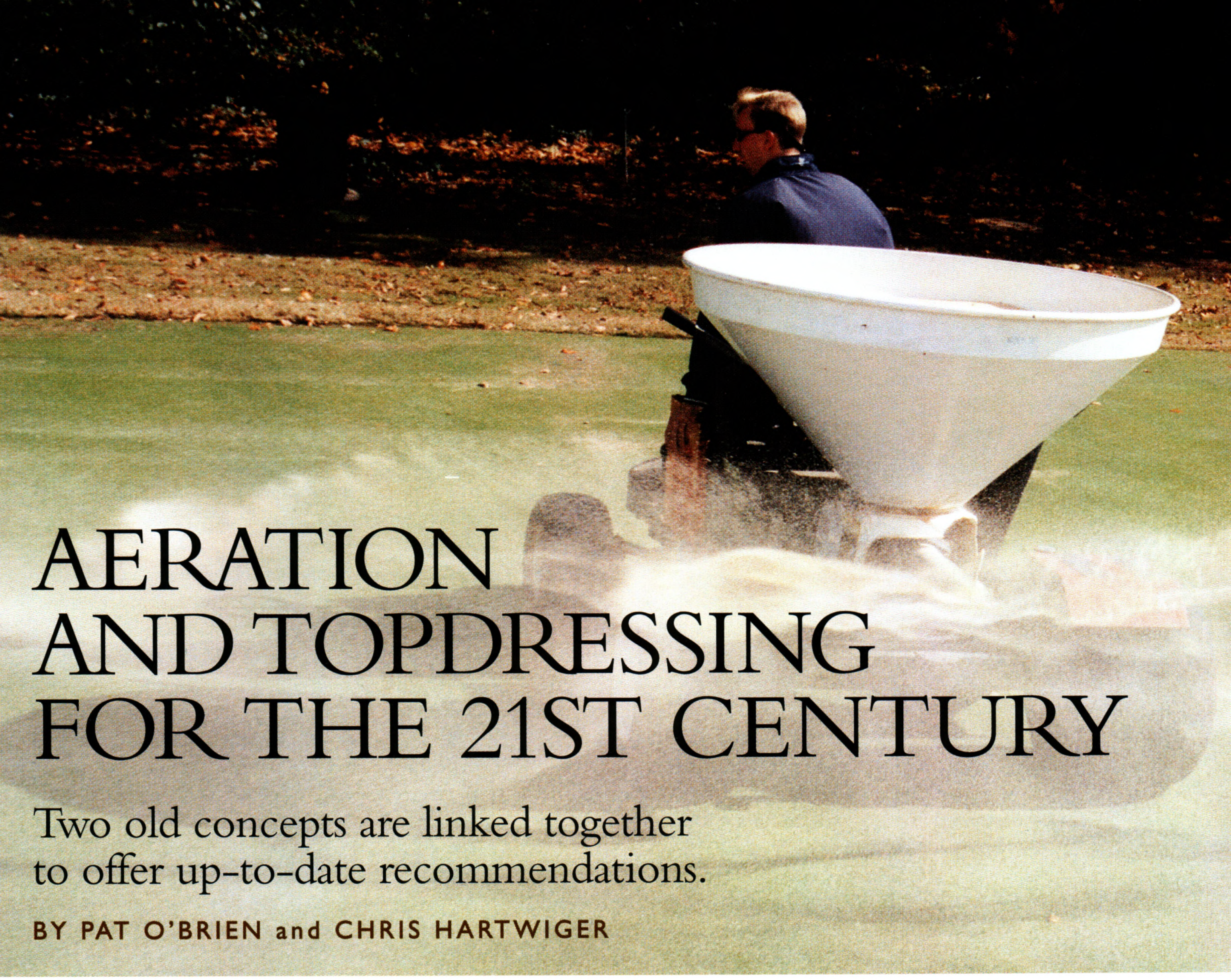
Cover Photo
Micrometer measurements of tine size and spacing patterns taken in the field will help with material calculations for estimating sand costs to fill the aeration holes.



AERATION AND TOPDRESSING FOR THE 21ST CENTURY

Two old concepts are linked together to offer up-to-date recommendations.

BY PAT O'BRIEN and CHRIS HARTWIGER

Using dry sand and the proper topdressing equipment improves worker productivity and helps reduce golfer complaints.

Putting green aeration and topdressing are literally and figuratively dirty words. Golfers begrudgingly accept the fact that to protect the long-term health of the grass on a putting green, it is necessary to aerate and topdress each year. With more sophisticated products and techniques, gone are the days when putting greens were aerated in the spring and fall and buried in a blanket of sand. But lost in the changes to these programs may be an incomplete understanding of how much aeration and topdressing are needed to protect the long-term health of the greens.

The long-term health of putting greens depends on maintaining sand as the primary medium. If organic matter accumulates beyond a reasonable degree, the physical benefits of sand are diminished and putting green physical properties decline along with the health of the turf. For too long golf courses have been making changes in their aeration and topdressing programs without comparing these changes to a standard or target level. A previous *Green Section Record* article titled "Core Aeration by the Numbers" detailed how tine size and spacing affects the amount of surface area impacted by an aeration treatment and made a recommendation to impact 15-20% of the surface each year (O'Brien and Hartwiger, 2001). This recommendation did not go far enough because it did not include surface topdressing applications, which go hand in hand with core aeration in diluting organic matter accumulation. This article expands upon these concepts and links core aeration and sand topdressing.

THE SIGNIFICANCE OF CORE AERATION AND SAND TOPDRESSING

According to University of Georgia turfgrass researcher Dr. Bob Carrow, the number-one problem experienced on sand-based putting greens is the excessive accumulation of organic matter in the upper portion of the soil profile (Carrow et al., 2002). Core aeration and sand topdressing are the two most effective means to control the content and distribution of organic matter in this zone. The scientific literature is full of references to the benefits of core aeration and sand topdressing. Unfortunately, details on how much aeration and topdressing are needed are lacking.

The moment any type of grass is planted on a putting green rootzone mix, the soil physical properties in the upper few inches of the rootzone begin to change (Habeck and Christians, 2000; Curtis, 2001). In a new putting green the cycle of root growth, decline, and new growth is repeated year after year. Roots grow down through the soil in the large soil pores (macropores) and provide the plant with needed water, oxygen, and nutrients. When a root is no longer viable, it begins to plug up soil macropores and can hinder the ability of living plants to function.

Table 1
Conversion rates for sand topdressing

Ft.^{3} of Sand per 1,000 ft.^{2}	Lbs. per 1,000 ft.^{2} Dry Sand	Depth of Application in Inches
0.50	50	0.006
1.00	100	0.012
2.00	200	0.024
4.00	400	0.048
50.00	5000	0.600

Dr. Carrow conducted extensive research (Carrow, 1998) in the mid-1990s on the organic matter dynamics in the rootzone of sand-based putting greens. He concluded as organic matter in a sand-based putting green reaches 3-4% by weight, the percentage of soil macropores begins to decrease. The reduction of pore space has three distinct implications, and a host of primary problems can be expected: 1) The diffusion of oxygen into the rootzone begins to decline. Oxygen is vital for plant growth as well as soil microorganism balance and function. 2) Water infiltration decreases, which can result in puddling and saturation of the surface. 3) Moisture content in the upper rootzone increases, which can make the surface less firm. The decrease in macropores (aeration pores) is accompanied by an increase in capillary or water-holding pores.

If organic matter accumulation begins to exceed 3-4% by weight, putting greens become vulnerable to a host of secondary problems such as disease, wet wilt, soft surfaces, poor root growth, black layer, and more frequent high-temperature injury. These secondary problems are often called summer bentgrass decline (Carrow et al., 2002), and trying to treat them curatively can be expensive. They occur often at courses that have not adequately aerated and topdressed the greens. Many of these courses are doomed to many years of frustration because they are not willing to make the effort to do the additional aeration and topdressing needed to prevent the situation.

Dr. Carrow's research shows that core aeration and applying sand can help dilute organic accumulation and create new macropores. The remainder of this article will be devoted to developing an aeration and topdressing program that keeps organic matter levels below 3-4% by weight. This proactive approach ultimately will cause less disruption and be less expensive than trying to alleviate primary and secondary problems through a curative approach.

The *organic matter dilution program* is a catch-all term that includes core aeration accompanied by sand topdressing to fill the holes and sand topdressing applied directly to the surface. References to *core aeration* refer only to hollow-tine aeration at a standard depth of 3 inches. Aeration depth can vary significantly based upon machine and type of tine used. Deep-tine aeration or similar practices designed to correct deep rootzone issues are not considered. *Surface topdressing* refers to sand applied directly to the turfgrass canopy. Light, medium, and heavy topdressing applications are approximately 0.50 ft.^{3} per 1,000 ft.^{2}, 2.0 ft.^{3} per 1,000 ft.^{2}, and 4.0 ft.^{3} per 1,000 ft.^{2}, respectively.

AERATION AND TOPDRESSING RECOMMENDATIONS

The case has been made for the importance of using core aeration and sand topdressing to dilute the accumulation of organic matter. The question is, How much of each needs to be done? We propose answering this question in a slightly different way. The answer requires linking the topics of aeration and topdressing together. We link the two together because they are the key elements in an organic matter dilution program. Core aeration removes organic matter. Filling the holes with sand makes sure those columns stay open. Dustings of sand applied directly to the surface also help manage organic matter accumulation.

Applying at least 40-50 ft.^{3} of sand per 1,000 ft.^{2} per year is recommended to keep organic matter content below 3-4% by weight in the upper portion of the rootzone. Although this recommendation is brief, understanding all its ramifications is more complex, and it should stimulate many questions that will be addressed in the following sections.

UNDERSTANDING SAND VOLUMES

Rates of sand topdressing can be difficult to conceptualize. Table 1 shows quantities of sand expressed in different units and yields some interesting comparisons. Conveniently, it turns out that 100 pounds of dry sand is equivalent to 1.0 ft.³ of sand. Wet sand is approximately 6-10% heavier for an equivalent volume. Finally, the sand quantities are expressed in inches, which are easier to conceptualize for large quantities of sand.

TO CORE OR NOT TO CORE, THAT IS NOT THE QUESTION

By now, many readers will have looked at the recommendation and said, "Aha. If we apply 40-50 ft.³ of sand per 1,000 ft.² through regular topdressing applications, we will not need to core aerate the greens." It is easy to see how this interpretation could be made, but this strategy is not recommended. There are agronomic and practical reasons for not trying this approach. There are merits to removing organic matter through core aeration and packing these vertical columns that cut through the high organic matter zone with sand. Applying 50 ft.³ of sand per 1,000 ft.² through surface topdressing would only require approximately 25 applications of 2.0 ft.³ per 1,000 ft.², or one application every two weeks. This would be far too stressful during the summer and would be difficult to work into the canopy during periods of slow winter growth. Invariably, interference with play and weather make this program impractical.

Similarly, do not try to meet the topdressing requirement with only core aeration and filling the holes with sand. This method could result in layering. All applied sand is not worked into the holes; some falls between the holes. This excess sand would only be mixed into the canopy twice per year if the greens are aerated twice per year. Additionally, it would be difficult to keep sand as the primary component of the rootzone matrix near the surface without regular surface topdressing applications.

SAMPLE PROGRAMS

The best program is one that includes a certain amount of core aeration along with regular sand topdressings. When considering tine sizes, select a size that allows easy and complete backfilling of the aeration holes. Based upon field observations, the smallest hole that can be reliably filled with sand is created by a tine of just less than ½ in. Holes of ⅜ in. diameter are not easily filled, even with the driest sand. Outlined below are a few sample programs to stimulate thought. There is no single program that is right for everybody, but with an overall goal of total topdressing applied, a plan that meets the needs of any course can be developed.

- **Program 1: Big Holes, Big Spacing.** This approach uses traditional aeration equipment with ⅝ in. tines on a 2 in. × 2 in. spacing. The greens are aerated once in the spring and once in the fall. A total of 36 ft.³ per 1,000 ft.² (3,600 lbs. per 1,000 ft.²) is applied for the two core aerations. See Table 2 to see sand volumes required to fill aeration holes for other tine sizes and spacing patterns.

The remaining 14 ft.³ of sand necessary per 1,000 ft.² to meet the 50 ft.³ goal is applied via light to moderate topdressings throughout the year. A light to moderate topdressing is considered to be anywhere from 0.5 ft.³ to 2.0 ft.³ per 1,000 ft.² This is roughly equivalent to 50 to 200 lbs. of sand per 1,000 ft.²

- **Program 2: Dethatching.** This program is for new construction only or for a putting green that has met the topdressing requirement. A dethatching machine is used to physically remove organic matter from the upper portion of the

Table 2
Volumes of sand needed to fill aeration holes for various tine sizes and configurations

Outside Aeration Tine Diameter (in.)	Spacing (in.)	% Surface Area Impacted	Ft.³ of Sand per 1,000 ft.² Needed to Fill Holes to 3 in. Depth	Lbs. of Dry Sand per 1,000 ft.² Needed to Fill Holes to 3 in. Depth
1/4	1 × 1	4.91%	12.27	1227
1/4	1 × 2	2.45%	6.14	614
1/4	2 × 2	1.23%	3.07	307
3/8	1 × 1	11.04%	27.61	2761
3/8	1 × 2	5.52%	13.81	1381
3/8	2 × 2	2.76%	6.90	690
1/2	1 × 1	19.63%	49.09	4909
1/2	1 × 2	9.82%	24.54	2454
1/2	2 × 2	4.91%	12.27	1227
5/8	1 × 1	30.68%	76.70	7670
5/8	1 × 2	15.34%	38.35	3835
5/8	2 × 2	7.67%	19.17	1917

profile. Spring and fall dethatching treatments are performed. Less disruption to play is the primary advantage. This program is not recommended as a curative approach on greens with excessive organic matter. It is too difficult to incorporate sand into the channels made by the dethatching equipment, especially when the grooves are cut greater than 0.25 in. deep.

The amount of sand incorporated into the canopy following dethatching is much lower than with core aeration. As channel depth increases, sand incorporation decreases because the channels collapse and seal off. This may be considered a disadvantage because much more time must be spent applying light and moderate topdressings throughout the year. For example, assume the greens are dethatched with 3/64 in. blades. Approximately 14% of the surface area is impacted, but only 1-3 ft.^{3} per 1,000 ft.^{2} of sand is applied. This amount is highly variable and depends on how well the dethatching channels stay open. This leaves 40-44 ft.^{3} per 1,000 ft.^{2} left to be applied through light and moderate topdressings.

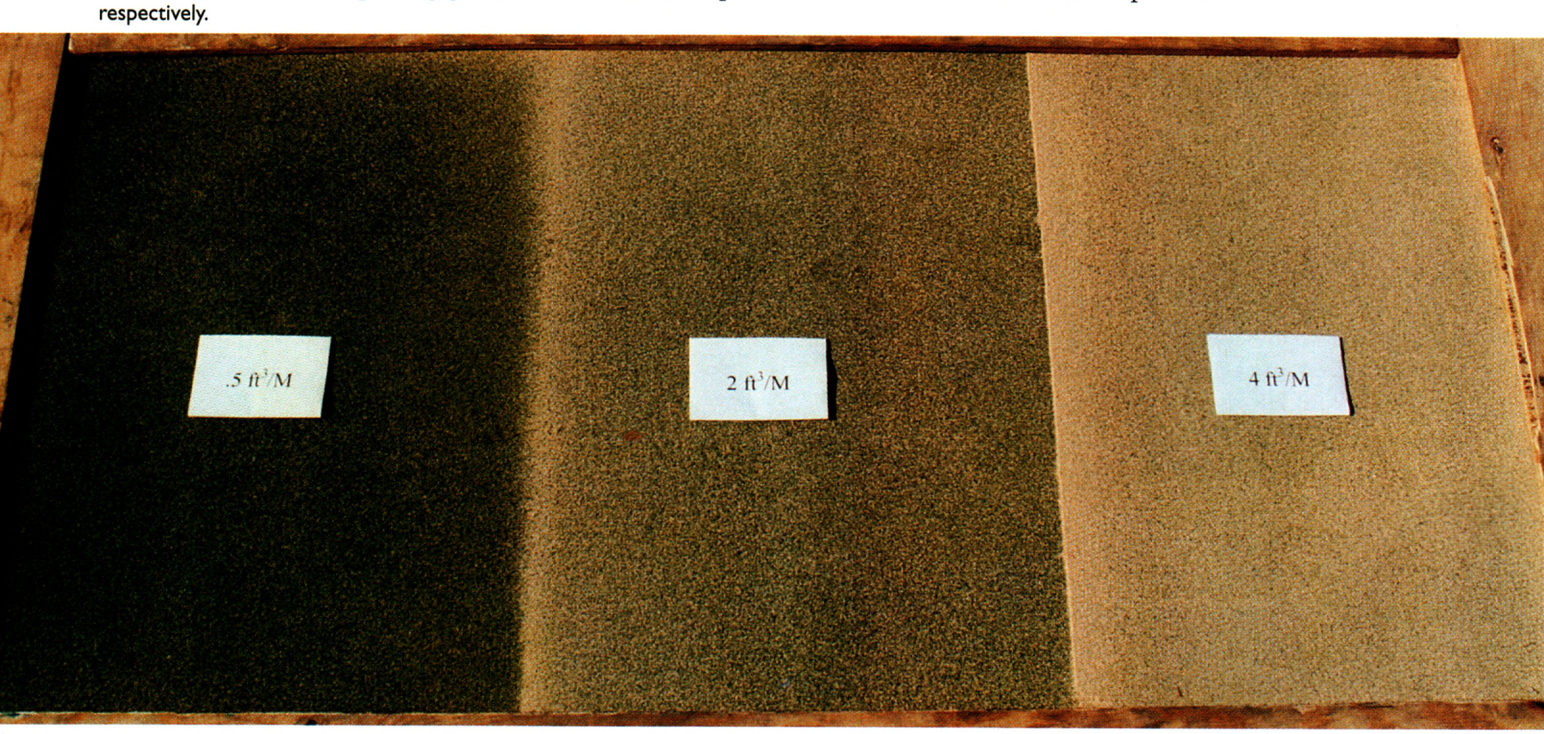
Many courses that use a dethatching machine use it in combination with an aerator. Some dethatch and aerate at the same time, while others dethatch and aerate on separate dates.

The moderate topdressings (2.0 ft.^{3} per 1,000 ft.^{2}) should be applied at a time of year when organic accumulation is most rapid. On bentgrass putting greens in the South, the period of October through April is the most prolific period of organic matter production. Bermudagrass greens generate the most organic matter in the summer months. Light topdressings can be applied at any time of the year.

• **Small Holes, Small Spacing.** A sample program using this approach might include the following: super quad tines with an outside tine diameter of 0.420 on a 1 in. × 1⅛ in. spacing. The greens are aerated twice in the spring and once or twice in the fall. The total amount of sand required to fill the holes after each aeration is approximately 6.15 ft.^{3} per 1,000 ft.^{2} or 18-24 ft.^{3} per 1,000 ft.^{2} per year. The remaining 16-32 ft.^{3} per 1,000 ft.^{2} can be applied through light or moderate topdressings throughout the year.

This approach relies on smaller tine diameters and a tighter spacing pattern. The advantage of this program is reduced healing time because smaller diameter holes require less time to heal than larger holes. The disadvantages are the need for special equipment and more difficulty filling the aeration holes. As hole size decreases, the likelihood of sand particles bridging over the surface of the hole increases. The super quad tine only goes 1.75 in. into the rootzone, which could be a concern with a thick layer of organic accumulation. An aerator with variable spacing and a tractor with a creeper gear are necessary to duplicate this program. For best results, take the time to make sure the holes are open and clean, and try to use the driest sand possible.

Seeing is believing with volumetric measurements. Light, medium, and heavy surface topdressing rates are approximately 0.50 ft.^{3} per 1,000 ft.^{2}, 2.0 ft.^{3} per 1,000 ft.^{2}, and 4.0 ft.^{3} per 1,000 ft.^{2}, respectively.



THEORY VS. REALITY: CALCULATING SAND VOLUME

Every golf course is faced with a unique set of circumstances. Determining the total amount of topdressing applied can be challenging. Table 2 shows the approximate amount of sand necessary to fill aeration holes with sand for common tine sizes and spacing.

When recommended topdressing amounts are in hand, the turfgrass manager must adjust the topdressing applied if it is determined that the sand is not working easily into the holes. Sometimes the greens are damp or the sand is wet. The degree to which sand is filled into the holes can vary, too. The key point is not whether the suggested amount is applied to fill the holes, but how much sand actually is applied. This information is helpful when calculating yearly volume and determining how much sand must be added through light or moderate topdressing applications.

When calculating sand volume applied, another consideration is estimating how much sand is thrown onto areas other than the putting green. This is an issue when spinner topdressers are used to apply light or moderate topdressings.

MEETING THE RECOMMENDATION: IS MORE OR LESS NEEDED?

The beauty of coupling aeration and topdressing together and making an annual topdressing recommendation as a target value is its simplicity and flexibility. It may need to be adjusted upward or downward, depending on individual circumstances. The Atlanta, Georgia, climate was selected for this recommendation. Other areas may require a higher topdressing or lower requirement based upon some of the factors listed below.

- **Nitrogen Levels.** Nitrogen is directly related to organic matter production. Higher nitrogen programs may be required on putting greens with extremely high traffic levels or on greens that must be grown in from some type of seasonal damage. More topdressing may be required. Greens managed under low nitrogen programs may require somewhat less sand.
- **Soil pH.** A soil pH > 5.5 is optimal for bacterial activity and organic matter decomposition. Soil pH much below this level reduces organic matter decomposition, and more topdressing may be required.
- **Turfgrass Species.** The 40-50 ft^3 per 1,000 ft^2 recommendation is the minimum requirement for many bentgrass and/or *Poa annua* putting greens and may need to be adjusted annually. Non-overseeded Tifdwarf or Tifgreen bermudagrass putting greens will have a slightly lower annual topdressing requirement, somewhere in the range of 35-40 ft^3 per 1,000 ft^2. Non-overseeded ultradwarf greens may require 40-50 ft^3 per 1,000 ft^2. Overseeded Tifdwarf or Tifgreen bermudagrass putting greens will require 40-50 ft^3 per 1,000 ft^2, but with newer ultradwarf cultivars that tend to accumulate organic matter in the surface 1-2 in., a somewhat higher amount may be necessary. For newer bermudagrass cultivars, the "small holes, small spacing" program applied at more than two times per year is a good option. High annual topdressing sand rates are important for the newer bentgrass cultivars that tend to accumulate organic matter in the surface or in climates where organic matter accumulation is favored. In these situations, the "small holes, small spacing" program is worth trying.

Organic matter accumulation in the upper rootzone is the primary reason why putting greens sometimes fail over time. Proper aeration and topdressing programs can prevent excess organic matter accumulation.

UNUSUAL FIELD CONDITIONS

Two common field conditions exist that may require a higher sand requirement or an adjustment as to when sand should be applied.

- **Rapid Root Dieback.** This condition is characterized by the rapid death of a bentgrass root system caused by high temperatures in the summer months. When bentgrass roots die back suddenly, the nature of some of the organic matter

Rapid root dieback on bentgrass putting greens in the summer produces a gel-like layer in the upper rootzone and low soil oxygen levels. Turf loss can occur within 24 to 72 hours, and extra aeration and topdressing will be needed to promote recovery.

changes from live root structures to decomposing organic matter with a gel-like consistency. Dr. Carrow states, "It is not the lack of roots from root dieback that is the problem, but the creation of an excessively moist layer from the decomposing root tissues with very low oxygen during hot weather in response to the rapid root dieback" (Carrow et al., 2002). The remaining roots are under low oxygen stress and cannot take up enough water for transpirational cooling. Reduced water uptake, stomatal closure, and high-temperature kill can follow. Field symptoms are a yellowing of the turf and death over a one- to three-day period of hot, humid weather. This scenario can occur at organic matter levels of 3-5% by weight in the top 1 in. of the rootzone, but it is much more likely when organic matter is greater than 5% by weight (Carrow et al., 2002). After the hot weather has ended, it will be necessary to continue diluting this rapid accumulation of organic matter created from the dead roots as well as organic matter arising from new root initiation. The topdressing requirement will increase and should be met through a combination of surface topdressing and filling aeration holes.

- **Cool-Weather Organic Accumulation.** Root growth can be rapid during periods of cool weather. Roots grow down through the macropore channels and adventitious roots grow near the surface. Although live organic matter does not reduce oxygen availability as severely as decomposing organic matter, oxygen infiltration and water infiltration can decrease as the roots fill many of the macropores. This is commonly observed in the winter to early spring months when greens begin to puddle more substantially after a rain. The problem is more severe in cooler climates with prolonged soil temperatures above 32°F, but less than 55°F. Bentgrass/*Poa annua* will grow in temperatures above 32°F, but soil microbes necessary for organic matter decomposition do not function below 55°F. These conditions are more common in northern climates and, particularly, coastal northeastern and coastal northwestern climates. Other than a reduction in water infiltration, surface symptoms are not observed, but suboptimal oxygen levels can reduce the rate of deeper rooting. After spring aeration, adequate oxygen will be available for maximum root growth.

PROGRESS REPORT

Turf managers who have embarked on an organic matter dilution program will be curious about how the program is working. There are three ways to assess the program's effectiveness.

The first is to send a core sample of the top 1-2 in. of the rootzone profile to a physical soil testing laboratory. Request a test to determine organic matter by weight.

A result of less than 3% organic matter by weight is good news and indicates that organic accumulation has been well diluted with sand. A result of 3-5% organic matter by weight is borderline, and problems caused by plugged macropores could occur. Pay careful attention to the organic matter dilution program over the next few seasons. A result of 5% or more is cause for concern. A serious effort must be made to reduce organic matter buildup. Place more emphasis on core aeration and topdressing to fill the holes. Some superintendents may sample and find organic matter contents greater than 5% without any apparent symptoms at the time of sampling, but the chances for future problems are much greater.

In the cooler regions of bentgrass adaptation, organic matter content can be above the 5% limit without immediate concern. The reason is that these climates have fewer hot periods in the summer. When periods of high heat do occur, bentgrass can decline rapidly. Also, in these climates organic matter can continue to increase to a point where decline occurs from oxygen stress, regardless of the temperature.

Cases of seasonal organic matter accumulation fluctuations occur on bentgrass during the winter in the southern transition zone and on overseeded bermudagrass greens in the late spring. Root growth during cool periods may increase organic matter 1-2% from the fall level due to live roots contributing to the overall organic matter content. The seasonal changes suggest that sampling for organic matter for both bentgrass and bermudagrass should be in May and late summer. The highest organic matter content will occur during May, especially on overseeded bermudagrass greens, and late summer should be the time of the year with the lowest organic matter content.

A second method to assess the program's effectiveness is to take field observations of the soil profile. If layering is present, as evidenced by a distinct sand or organic matter layer(s), it is likely that topdressing applications are being made too far apart or that light applications between moderate applications are too light. Also, look for the columns of sand created by aeration and topdressing. Checking this right after aeration allows the turf manager to see if the holes are being completely filled with sand.

A final assessment method involves the use of a double ring infiltrometer to take seasonal infiltration readings. Readings taken in conjunction with organic matter sampling can be especially useful. By taking an infiltration measurement at the same place on a green a few times a season, the superintendent can obtain several important pieces of information. First, the changes in infiltration by season will be apparent. Second, after taking readings for a few years, the superintendent can see if infiltration rates are increasing, decreasing, or staying the same in response to the organic matter dilution program.

CONCLUSION

"More sand, laddie," is a quote attributed to Old Tom Morris. Although Old Tom probably never imagined that the science and art of putting green maintenance would ever reach today's quality levels attained on a daily basis, his emphasis on sand still rings true. The information presented in this article has the scientific backing to confirm what most in the industry know — that aeration and topdressing are the foundation for successful putting greens.

ACKNOWLEDGEMENTS

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REFERENCES

Beard, J. B. 2002. *Turf Management for Golf Courses*, 2nd ed. Ann Arbor Press, Chelsea, Mich.

Carrow, R. 1996. Summer decline of bentgrass greens. *Golf Course Management*. 64(6):51-56.

Carrow, R. 1998. Organic matter dynamics in the surface zone of a USGA green: practices to alleviate problems. The USGA *1998 Turfgrass and Environmental Research Summary.* Golf House, Far Hills, N.J.

Carrow, R., P. O'Brien, and C. Hartwiger. 2002. Why Putting Greens Sometimes Fail. Unpublished manuscript.

Curtis, A. 2001. Evolution of a sand-based rootzone. *Golf Course Management*. 69(3). www.gcsaa.org/gcm/2001/-mar01/03evolution.html.

Habeck, J., and N. Christians. 2000. Time alters greens' key characteristics. *Golf Course Management*. 68(5). www.gcsaa.-org/gcm/2000/may00/oftime.html.

Hartwiger, C. 1997. A shower a day fills the holes ok. *USGA Green Section Record*. 35(3):18.

O'Brien, P., and C. Hartwiger. 2001. Core aeration by the numbers. *USGA Green Section Record*. 39(4):8-9.

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Putting Green Regrassing and So Much More

A putting green regrassing project became a significant golf course regrassing project.

BY WARREN SAVINI

The agronomic issues behind putting green regrassing are fairly simple. Establishing new creeping bentgrass on our old push-up style putting greens eliminated many potential turfgrass problems. However, the overall planning and implementation of such a project was laced with hard work, sleepless nights, and a little uncertainty. A simple regrassing project for the putting greens at Rolling Green Golf Club turned into so much more. The goal of this article is to provide some insight into the reasons for regrassing and some lessons learned during implementation.

When you mention that you are from Philadelphia, people try to impress you with their best Rocky impersonation. *The City of Brotherly Love* is known for many things: Independence Hall, The Liberty Bell, soft pretzels, and cheese steaks are just a few of them. Unfortunately, the Philadelphia area is infamous for summers that seem to go on forever and grasses that are often ill-suited to tolerate them. The heat and humidity take their toll on the grass and golf course superintendents alike.

Many older Philadelphia golf courses date back to the early 1900s. This long tradition includes many push-up greens and a lot of tired *Poa annua*. Ask superintendents about their number-one concern during these long, hot summers and most will answer, "Keeping my *Poa annua* alive." The demand for green speed has chased out most of the old bentgrasses. We cut greens extremely low just to keep pace with the golf course down the street. This sets the stage for summer putting green problems: temperatures in the upper 90s, double cutting, rolling, topdressing, and anything else that can be done to promote green speed. The next thing you know, *Poa annua* is infected with anthracnose, bacterial wilt, and any

Anthracnose and bacterial wilt caused turfgrass losses of up to 60 percent. Playability was greatly reduced and the membership was not pleased.

number of other maladies. Such was the case at Rolling Green Golf Course, and the greens failed miserably. We all know *Poa annua* can be pushed too far, but everyday expectations throw us in the line of fire and away from sane agronomics.

Rolling Green Golf Course was designed by William Flynn and opened in 1926. I accepted the superintendent's job in late winter of 2001. The greens had had a serious bout of anthracnose the previous summer. I came from a course with 100 percent *Poa annua* greens. When the search committee from Rolling Green toured my golf course during the hiring process (in October, not mid-August!), the committee saw smooth, fast *Poa annua* greens. I guess that sealed the deal, and I was hired.

THE PROBLEM STARTS

Anytime you take a new superintendent's position, it is a challenge. When anthracnose is involved on *Poa annua* putting greens, it is a huge challenge. In March of 2001, we noticed small yellow spots infecting our *Poa annua*. A sample sent to a diagnostic lab confirmed that anthracnose was the culprit. All of the appropriate fungicides you can think of were applied to control the disease. By mid-April, the anthracnose was under control, and I was thinking that we had just survived the first glitch of the season. Little did I know what was still to come.

In mid-May, dime-sized spots started to form on the high and dry areas of the *Poa annua* greens. Heavy spring rains saw these spots progress to the low areas of the greens and coalesce into larger areas that mimicked anthracnose. A turf sample was sent to the University of Maryland, and the diagnosis came back as bacterial wilt. Every known anthracnose fungicide was used, and now we had to spray copper hydroxide to control bacterial wilt. USGA agronomists, turfgrass pathologists, and golf course superintendents all came to see the devastation.


Many trees were removed to improve sunlight penetration prior to regrassing the greens. Several greens struggled during the summer because more trees should have been removed.

By the end of June, turf loss on all of the greens ranged from 10 to 60 percent. A plant pathologist was brought in to make recommendations to the Green Committee. These discussions provided background information for the Green Committee to make an educated decision about the problems and potential solutions. One option was to continue spraying fungicides, overseed the greens with creeping bentgrass in August in an effort to increase creeping bentgrass populations and pray that the problems did not repeat themselves. This option was filled with a great deal of uncertainty. The second option was to close the course in August, fumigate the greens with methyl bromide, and establish one of the newer creeping bentgrass varieties that are more resistant to anthracnose and tolerant of low mowing heights.

THE DECISION

After the dust settled, the committee looked at playability, lost revenue, canceled outings, and club championships. Expectations dictated that we choose the best option for the future of the club. In early July, the Board of Directors voted unanimously to close the course in early August to fumigate and regrass the greens. My head was spinning. It was my first summer and the greens were hit with every problem in the book. What did I get myself into this time? Full membership support during this time of crisis helped the situation. Unfortunately, we had only three weeks to pull the project together. This business has a way of humbling you very quickly, and I was humbed once again. Such is life when working with nature.

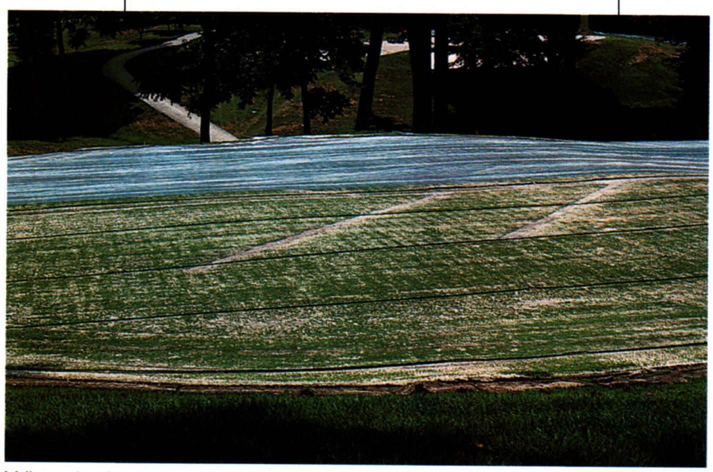
Preparations began the following morning. We scheduled visits to other golf courses in the area that had gone through similar regrassing projects and evaluated their methods and results. These trips turned out to be valuable, as there is no substitute for experience. Creeping bentgrass variety, seedbed preparation, and satisfaction with the final product were all discussed. Every course had one common recommendation: remove enough trees to improve direct sunlight penetration to the greens. Bad growing environments lead to bad greens, regardless of the grass used.

The scope of the project expanded. Not that regrassing the greens was not enough; the list of renovation ideas kept growing since the course would be closed. Regrassing the fairways and tees, practice tee expansion, creek restoration, and, of course, tree removal were all discussed. Time was of the essence. It was already the second week of July. Contractors still needed to be locked in for the project to get started in early August.

The final proposal included the removal of 72 trees and the heavy pruning of 20 more, fumigation and regrassing of the greens to creeping bentgrass, fumigation and leveling of all tees, fumigation and regrassing of 14 acres of fairways and all approaches, creek restoration on the seventh and eighth holes, and reconstruction of the 16th green to USGA specifications. This was no longer a simple "gas and regrass" project. Hiring contractors to start this project was a major task. The logistics required cooperation from all parties involved for this project to be a success. What started as a discussion of putting green regrassing had grown into a major project, although the putting greens were still the focus. Fortunately, things came together rapidly on a tight timetable.

The greens were fumigated with methyl bromide and seeded on schedule during the second week of August. Trees were coming down and trees, fairways, and approaches were fumigated with Basamid and seeded to creeping bentgrass. Visits by USGA agronomists and area superintendents who had gone through similar projects were always welcome. While you think that you can pull together a project of this magnitude in a short amount of time, doubt creeps into your mind and you wonder if everything will come together. The support of your peers greatly helps pull you through the tough times. One lesson I learned is not to be afraid to ask for help. Turfgrass academia, USGA agronomists, and area superintendents are all resources at your fingertips. All you need to do is ask to get input. I used all of these resources before, during, and after this project.

By the middle of September all greens, tees, and fairways were seeded. We had a great fall with an extended Indian summer. There was an initial concern that heavy pesticide use for disease control was inhibiting germination. Waiting for germination on the greens was the most gut-wrenching aspect of the project. What would happen if the grass did not grow? Fortunately, I never had to answer this question. Seed germination was slow in areas with insufficient irrigation coverage, but hand watering helped with this problem. During grow-in, the shortcomings of an irrigation system become obvious. This is just one more problem that had to be addressed. Insufficient tree removal had more to do with slow germination than anything. As winter approached, we felt that the project was successful. With all the projects completed, it was time to recharge my batteries and prepare for the spring.



When the fumigation tarps were applied in early August 2001, the finality of what was about to happen began to really sink in.

The course reopened for play on April 13th. For the most part, the members were pleased with the regrassing and other projects. The summer heat of 2002 started in the third week of June. Record heat coupled with significant water restrictions ensued — just what I didn't need — a long, hard summer. The greens held up to heavy play (180 to 210 rounds per day). The collars thinned significantly on many of the greens, providing more stress for me. Greens located in pocketed areas provided problems throughout the summer. This took me back to our visits to other golf courses. They told us to remove as many trees as needed, and they pointed out that bentgrasses need more sunlight than *Poa annua*. Additional tree removal was scheduled for the winter of 2002-2003. By the fall of 2002, the greens had recovered from the summer. Overall, the entire project was a great success, and we look forward to next summer.

SUMMARY

Regrassing greens to creeping bentgrass can eliminate a lot of problems. Although these new grasses come with challenges of their own, the new problems are more manageable than anthracnose and bacterial wilt! The entire process was stressful and not as easy as some may think.

Is regrassing right for your golf course? The greens will answer that question for you. Repeated bouts of anthracnose, summer patch, and maybe a little bacterial wilt for good measure may indicate that you are fighting a losing battle. If expectations cannot be met, regrassing should be considered. Take the time to educate yourself with facts and figures about regrassing. Use consultants from universities, the USGA, or the private sector to provide input. Course officials seem to be more willing to act on recommendations from a third party.

The most important thing is to communicate with your Green Committee and course officials. Keep all lines of communication open and provide continuous updates on progress. Be prepared for a very trying time during the actual implementation of any major project. In spite of the best planning, headaches and surprises will occur. However, once completed, the end result in our case was very rewarding.

WARREN SAVINI, JR., *is the golf course superintendent at Rolling Green Golf Club.*

Can Ryegrasses Speed Establishment of Kentucky Bluegrass Fairways?

Fairway cover is accomplished faster when ryegrass is in the mix, but with negligible bluegrass establishment.

BY E. H. ERVIN, D. R. CHALMERS, and S. D. ASKEW

Throughout the Appalachian Highlands of the Transition Zone, perennial ryegrass (PR) is a predominant species used on golf course fairways. Its rapid establishment rate, dark green color, medium-fine texture and density, ease of striping, good wear tolerance, and persistence at mowing heights down to 0.5 inch make it a desirable fairway choice. In areas of high *Poa annua* pressure such as the Appalachian Highlands, PR's high tolerance level to ethofumesate (Prograss®) has also favored its use. However, epidemics of gray leaf spot (*Pyricularia grisea*) in the summer of 1998 destroyed many PR fairways across the Mid-Atlantic and Midwest regions.

Bluegrass cultivars produce an excellent playing surface, but they are slow to establish from seed. Research has shown that seed mixtures consisting of ryegrass percentages more than 15% do not allow bluegrass seed to compete for space.

Kentucky bluegrass (KB) is not affected by gray leaf spot and has many of the same turfgrass qualities as PR. So why has it not been used more extensively for fairways in the upper transition zone? Until the mid-1990s, no cultivars were available that performed adequately at present-day fairway heights of 0.5 to 0.75 inch. Additionally, KB is sensitive to ethofumesate injury and is slow to germinate and establish. While spring-seeded PR fairways may be ready to open by June 1, KB may not be ready until August 1. Recent advances in breeding compact-type Kentucky bluegrasses have resulted in the release of five to ten cultivars that university research suggests will persist and function as a high-quality fairway at mowing heights down to 0.5 inch. Although there are now promising fairway cultivars available, the superintendent is always pushed to renovate and reopen as fast as possible, and on this point the slow-germinating bluegrasses are a handicap.

Our objective was to determine whether Transist intermediate ryegrass (IR), when planted as a companion with KB, would allow for the rapid establishment of a fairway playing surface while not unduly inhibiting KB development. Intermediate ryegrasses are a cross between perennial ryegrass and annual ryegrass. They were developed as bermudagrass fairway overseeding alternatives to PR. Intermediate ryegrasses are similar in texture and color to PR, but their relatively poor heat tolerance allows a smoother spring transition back to a bermudagrass playing surface. In short, we were hoping to take advantage of the characteristics of both species: fast germination of the ryegrass followed by summer decline to leave behind the KB as the permanent playing surface.

This trial was conducted on a portion of the eighth fairway at the Virginia Tech golf course. Glyphosate (Roundup Pro™) was applied twice in April 2001, the area was verticut aggressively and the dead vegetation removed, and lime was applied to raise the soil pH to 6.5. On May 1, four compact-type Kentucky bluegrass cultivars (America, Apollo, Unique, and Rambo) were either planted alone at 2 lbs/1000 ft² or in mixes with Transist IR or Phantom PR at 4.5 lbs/1000 ft². Seeding at these rates meant that 70% of the seeds applied to each mixed plot was KB, while 30% was either PR or IR. Also applied at seeding were a starter fertilizer (1 lb N/1000 ft² from 10-10-10) and Tupersan® (siduron) for preemergence crabgrass control.

Mowing began on May 29 at a one-inch height, twice per week. Chlorothalonil was applied in May and June for dollar spot control, and a 20-20-20 fertilizer was applied at 0.5 lb N/M on May 15 and May 29. On June 11, the area was turned over to the superintendent to receive regular course maintenance, including mowing three times weekly at 0.75 inch. No fungicides were applied after early June 2001 in an attempt to disfavor the ryegrasses.

RESULTS

On May 31, at four weeks after seeding (WAS), most of the PR+KB and IR+KB mixes had attained 70% to 80% cover and a quality level of 5 to 6, indicating that these plots were "ready to open" (Table 1). At this point the KB-alone plots had attained only about 25% cover. Sufficient cover for opening was not reached on KB-only plots until about July 24, almost two months later than the mixes containing either ryegrass. None of the KB cultivars developed faster than the others.

Direct counts of the species present in each plot by July 31 indicated that almost no KB had established in PR or IR mixes (Table 1). It is clear that the ryegrasses germinated and developed so quickly that the slow-germinating KB, even though it made up 70% of the seed planted, was not able to compete effectively for resources (space, light, nutrients, water) and become established. Conditions during the 2001 summer were cooler than normal, providing extended dollar spot disease pressure without any substantial periods when more devastating ryegrass diseases such as gray leaf spot, Rhizoctonia blight, or pythium blight could develop. Basically, it was a very good growing season for both bluegrasses and ryegrasses. By the next spring all plots had obtained nearly 100% cover. However, removal of all species but KB in each plot with selective herbicides in the fall of 2002 revealed that much of this cover was due to *Poa annua* invasion (Table 1). Our results indicated that Rambo and Unique were the most competitive with *Poa annua* and the ryegrasses.

SUMMARY

The four compact-type Kentucky bluegrasses in this trial were able to persist at a 0.75-inch fairway height. However, they were not competitive with PR or IR and were invaded easily by *Poa annua*. Future attempts at hastening establishment of KB fairways in the Appalachian Highlands of the Mid-Atlantic should include 5% to 15% PR or IR by seed count rather than 30%.

DR. ERIK ERVIN *is assistant professor of turfgrass ecology at Virginia Tech,* DR. DAVID CHALMERS *is associate professor and extension turfgrass specialist at Texas A&M University, and* DR. SHAWN ASKEW *is assistant professor of turfgrass weed science at Virginia Tech.*

Table 1

Visual quality, estimated percent cover, and tiller density of Kentucky bluegrass monostands or mixes with intermediate ryegrasses or perennial ryegrasses

	5-31-01		7-24-01		Tillers/cup cutter plug on 7-31-02		3-25-02		Percent KB present or removed herbicidally by 10-1-02	
Treatment	**Quality**	**Cover**	**Quality**	**Cover**	**KB**	**IR/PR**	**Quality**	**Cover**	**KB**	**Other**
America KB	2.8	24	4.4	73	60	0	5.9	94	37	63 *Poa*
Apollo KB	2.8	26	4.5	69	58	0	6.3	96	46	54 *Poa*
Rambo KB	3.0	21	4.6	68	69	0	5.8	97	61	39 *Poa*
Unique KB	2.5	26	5.0	65	72	0	5.9	93	66	34 *Poa*
America + PR	5.3	55	5.5	89	1	81	7.0	99	8	92 PR
America + IR	6.0	73	5.5	88	1	51	5.8	97	13	87 IR/*Poa*
Apollo + PR	6.0	70	5.6	91	1	56	6.8	99	7	93 PR
Apollo + IR	6.0	75	5.5	94	1	54	6.0	97	20	80 IR/*Poa*
Rambo + PR	5.5	69	5.9	89	1	75	7.3	99	12	88 PR
Rambo + IR	5.5	88	5.3	85	2	67	5.5	96	13	87 IR/*Poa*
Unique + PR	4.5	64	5.3	79	1	64	6.8	99	12	88 PR
Unique + IR	5.8	70	5.5	93	2	52	5.6	95	29	71 IR/*Poa*
LSD (0.05)	1.3	18	0.9	19	17	26	0.5	4	16	NA

NOW YOU SEE IT, NOW YOU DON'T

Maintenance personnel are told to avoid scalping the perimeter collars and, as a result, slowly move the green edge by minute amounts. Ultimately, greens lose their shape over time, but they should not be restored too quickly.

Golf courses change imperceptibly over time. Many subtle changes directly impact play.

BY LARRY GILHULY

Ever see a magician make objects disappear and reappear? We marvel at these obvious tricks, try to figure them out, and usually just walk away shaking our heads in amazement. Golf course superintendents also are magicians, except they create playing surfaces that golfers try to figure out and walk away shaking their heads in frustration. Although superintendents are responsible for the entire playing surface on a day-to-day basis, Mother Nature, golfers, and the maintenance staff combine their forces every day to change how the golf course looks and plays. The changes are practically invisible, yet just as the magician can make things disappear and reappear in a short period of time, the above threesome can and does produce the same results over many years. Let's take a look at some of the most common changes brought on by maintenance, golfers, and Mother Nature.

INVISIBLE CHANGES ON THE GREENS

The putting surfaces on every golf course are an ever-changing product of turf growth and player traffic, with maintenance practices addressing these two factors. Golfers often seem to forget or not to think about the fact that the playing surface is alive, and they can do massive cumulative damage to plants that are being shaved just a bit higher than the best razors! So how do greens change over time, and what can be done to keep them consistent? Here are two distinct subtle changes to watch for on your golf course that change how your greens grow and play.

- **Mowing practices.** Mowing is the most visual, yet one of the most common agents of change on putting surfaces from the first day of mowing. As maintenance personnel mow the outer perimeter of the greens, they generally are instructed to avoid scalping the perimeter collars. This leads to moving the mower (especially triplex units) away from the edge by minute amounts, adding up to inches and feet of lost putting surface over the years. This is usually accompanied by interesting green perimeter contours becoming rounded over time, resulting in loss of usual interest and good hole locations.
- **Shade vs. sun — watch the topdressing frequency.** One of the most common green maintenance practices is light and frequent topdressing. It generally is done every two or three weeks and is tied to the growth rate of the turf. Why is it, then, that greens in the sun and shade are topdressed at the same frequency when their growth rates are different? Ever notice that greens in the shade are sometimes much firmer than those in the sun? That is due to the lack of organic material created by the turf and too much sand being applied during regular topdressing. Try reducing topdressing frequency on shaded greens to match their slower growth rate, and you also will notice that ball marks will be easier to repair.

WATCH OUT FOR THE GREEN SURROUNDS

Although putting surfaces deserve very close scrutiny to maintain their consistency, the areas that surround the greens change more than any other location, with major supporting roles from Mother Nature, golfers, and the maintenance staff. Here are the three most common changes that occur around the greens, along with several methods to minimize their impact on playing conditions and turf growth.

• **Approach the greens with a sand aid.** It is amazing how much maintenance time is spent on greens and bunkers, yet one of the most important playing locations (aprons) receives little more than twice yearly aeration and topdressing. Shouldn't the area directly in front of the green receive practically the same program as the greens? What about those hole locations five paces from the front of the green? If you are maintaining firm greens, how can a player expect to hit shots into firm greens with soft aprons? The simple answer is to expand your light topdressing program onto your aprons as discussed in the November/December 2000 *USGA Green Section Record* article titled "Temporary Sanity."

• **Bunker mentality.** The most obvious subtle change that occurs daily near bunkers is the blasting of sand onto adjacent turf areas, where sand builds up over time and creates changes to surface contours and difficult growing conditions. If the blasting of sand is not addressed routinely, then sand buildup must be eliminated by removing the sod and underlying sand, recontouring the base, and resodding.

• **Don't dam your surface flow.** This subtle change is the result of the very program that is used to improve the greens — topdressing with sand! Since topdressing generally is dragged in a circular pattern, more sand finds its way to the perimeters of the greens. This extra sand often accumulates immediately next to the green, resulting in very slow growing "sand dams" that interrupt the flow of water off greens. There are several ways to avoid this situation, including the use of a blower to disperse the sand after topdressing, increased aeration of the collar without adding sand, followed by rolling, and very careful dragging following topdressing. If you currently have these dams, sod removal and lowering is the fastest and most effective approach; however, some superintendents have had success by physical removal with aeration or deep vertical mowing, followed by rolling the collar or increasing topdressing on the green perimeters to match the height of the collar.

Over time, tee mowers can have the tendency to slowly change the tee mowing angles.

DON'T CROWN AROUND WITH THE TEES

Putting surfaces and surrounds deserve the most attention on a golf course, but tees receive the greatest amount of physical abuse. Aeration is required to relieve compaction and is an excellent way to reestablish turf, but filling divots is where the real action is in regard to invisible changes with the tees. Have you ever noticed how many tees become "crowned" over years of use? Think about it for a minute and the answer becomes obvious. Assuming your tees originally were relatively flat, golfers generally avoid tee markers and tend to use the center portions of tees. As divots are taken in these center areas, golfers or maintenance workers fill the divots with sand mix. The tendency is to put too much material in the divot scars, causing a crowning effect over the years. In addition, players avoid the downslope or upslope on the sides of the tees, which further adds to the crown in the center. Perhaps the only answer to this problem is to use a sod cutter and lower the center portion back to the original level. Or is it? Try moving the markers regularly to encourage more play on the sides of the tees, and apply extra topdressing on the perimeters of the tees to counteract the sand used for filling divots.

The other change on tees that greatly impacts playing conditions is mowing patterns. Just as the green mower is instructed to avoid scalping on

the edge, the tee mower is given the same instructions and produces the same predictable results. The mowing pattern can change over time and often will direct players to the right or left of the intended target. Course setup personnel or the tee mower then make the common mistake of setting the tee markers perpendicular to the parallel sides of the tee rather than perpendicular to the intended line of play. Periodically check this simple change to make sure the edges of the tees are properly aligned.

GOING OUT ON A LIMB

While the changes discussed previously are very slow and generally are created by golfers or the maintenance staff, Mother Nature really takes over when it comes to the slow and massive impact trees can have on your golf course. There are four basic areas that need to be addressed routinely to minimize this impact, or the option becomes the most controversial — tree removal.

• **Let greens see the light.** Small trees planted in the wrong area eventually become big trees that cast massive shadows on greens. In some cases, regular pruning allows enough light for good turf growth, but in many cases the trees slowly choke off the lifeblood of turf, resulting in poor putting surfaces. If all measures have been taken to improve a green and it still does not respond, deep pruning (about 6" below soil level) is required.

• **Let players enjoy the view.** In addition to growing taller, many trees can become very wide, slowly affecting shot values or ruining views of the course. In many cases, regular pruning is all that is needed, but in some cases trees need to be removed. As trees are planted on the course, always think of what they will look like someday. Ask yourself, "Will it impact the play of the hole? Will it impact turf growth? Will it block a good vista?"

• **Don't get hung out on a limb.** Low-hanging limbs are a major problem for both the maintenance staff and golfers. Players should be able to find and identify their golf balls under trees, and be sure to raise the canopy high enough to allow for recovery back onto the fairway.

• **Get to the root of the problem.** While most tree issues are centered on the negative impact of shade, there are nearly as many problems created by roots. Regular root pruning needs to be practiced near greens, tees, and fairways, with a special emphasis on traffic zones, to improve the playing surface. However, trees that develop prolific root systems at the surface may need to be removed, as they pose a concern with equipment damage and possible physical harm to players.

THE GRAND FINALE!

Golf courses are always undergoing changes, some of which can have a negative effect on the appearance and playability of your course. Paying close attention to daily, weekly, monthly, and yearly programs conducted by the maintenance staff can minimize these subtle changes. Since Mother Nature and golfers are not going to change, the maintenance staff represents the only variable that can address these concerns. Now, if we could only figure out a way to have every golfer come away from the course with amazement!

Extra care should be used around the green perimeters to avoid an accumulation of sand next to the outside green edge. These "sand dams" have the potential to interrupt the flow of water off the green.

LARRY GILHULY *provides subtle and not-so-subtle agronomic advice as the director of the Northwest Region of the USGA Green Section.*

Nutrient and Sediment Runoff from a Prairie Golf Course

Tracking runoff offers important insights for management.

BY STEVE STARRETT and YUNSHENG SU

The Colbert Hills Golf Course community in Manhattan, Kansas, occupies a land area of more than 1,000 acres, with 60% of its area in the Little Kitten Creek watershed. As the golf course was constructed, the Little Kitten Creek watershed undertook a dramatic change in land use, from native prairie to a golf course. In an effort to understand the impact of golf course construction on water quality, the USGA's Turfgrass and Environmental Research Program granted a five-year research project to Kansas State University to compare nutrient runoff losses from the new golf course with nutrient losses when the site was in its previous native prairie condition.

More than 900 surface water samples were collected and tested from three time periods. These periods included: (1) pre-construction (before July 1998), (2) during construction (August 1998 to April 2000), and (3) early stage of golf course operation (May 2000 to July 2001). The project was designed to determine nutrient and sediment losses as a result of golf course construction. Specifically, these determinations included efforts to: (1) evaluate the impacts of construction and operation of Colbert Hills Golf Course on surface water quality of Little Kitten Creek in terms of sediment content and nutrient concentrations (total N, total P), (2) identify the source of nutrients lost during construction and operation of the golf course, (3) determine the influence of fertilizer applications on nutrient concentrations in streams during golf course operation, (4) find out the relationship between stream discharge and pollutant concentrations.

SITE DESCRIPTION

The Little Kitten Creek watershed has a typical Midwest topography, with elevations ranging from approximately 1,100 to 1,400 feet, decreasing from north to south. Alluvial lands are located near channels and are frequently flooded. The soil series most common in the watershed are well drained, with medium-to-rapid surface runoff and low permeability.

As part of the Flint Hills rangeland in northeastern Kansas, the Little Kitten Creek watershed had a pre-construction land use of the typical mixture of tall grasses (89%), forests (11%), and negligible residential lands. Construction of the golf course began in July 1998. By early 1999, alteration of land cover had attained its peak when about 220 acres (20% of the total) of native cover was removed. By April 2000, most of the construction work was completed, and disturbed lands were reestablished with turfgrass. Application of fertilizers, pesticides, and irrigation was initiated during turf establishment.

DATA COLLECTION AND ANALYSIS

In order to monitor the environmental impacts of the construction and operation of the golf course, three stream gauging stations were set up in the watershed. Two stations were positioned on the north side of the area to monitor the quality of water entering the golf course, and one station was located at the south boundary of the golf course to monitor the quality of water leaving the course. Water samples were taken during runoff events; therefore, resulting concentration values were much higher than a quarterly or monthly sampling regime would have produced because our samples are only from high-flow conditions. Commonly, water samples collected quarterly or monthly would be from low-flow conditions.

The water quality of unpolluted water bodies is dependent on the local geological, biological, and climatological conditions. These conditions control the mineral quality, ion balances, and biological activity of the water body. To preserve the quality of the aquatic environment, natural balances need to be maintained. Knowledge of the background quality is necessary to assess the suitability of water for use and to detect human impact. Background water quality monitoring was conducted prior to the start of golf course construction in July 1998 and served as a baseline to evaluate the impacts of construction and operation of Colbert Hills Golf Course.

DURING AND POST CONSTRUCTION

Water quality monitoring spanned the entire construction period from August 1998, when construction work officially started, to April 2000, when the golf course officially opened for play. Preliminary studies indicated a substantial increase in sediment content (TSS) from 100-2,000 mg L^{-1} at pre-construction to

100-24,000 mg L^{-1} during construction. Concentrations of total nitrogen and total phosphorus were significantly greater during the construction period compared to pre-construction. Since there were no human inputs of these compounds, the nitrogen and phosphorus increases in this period were believed to be due to the increase of eroded soils that carry particle-bound nitrogen and phosphorus.

During turf establishment, turfgrass care intensified with fertilizer applications and irrigation. This posed a potential danger of polluting the surface water systems through irrigation return water and rainfall runoff. Information regarding fertilizer applications (names of applied chemicals, date and amount applied, etc.) was obtained from Colbert Hills Golf Course management. Relationships between fertilizer applications and nutrient concentration in streams were analyzed. It must be noted, however, that since this is an ongoing project, more data will be added and continued to be analyzed.

RESULTS REFLECT CONSTRUCTION IMPACT

Water quality data were divided into three sets: pre-construction, during construction, and post-construction. At one of the major inflows into the golf course, 25, 141, and 43 water samples were taken at the three development stages. As expected, statistical analyses show that the development of the golf course has little impact on stream water quality at this location in terms of concentrations of total nitrogen, total phosphorus, and total sediment load.

However, at the major outflow the results are quite different. Twenty-eight, 138, and 87 samples were taken at the three development stages at this location. Statistical analyses indicate that the average concentrations of total nitrogen and total phosphorus during construction were two to three times those under native land cover conditions. The sediment content was even higher.

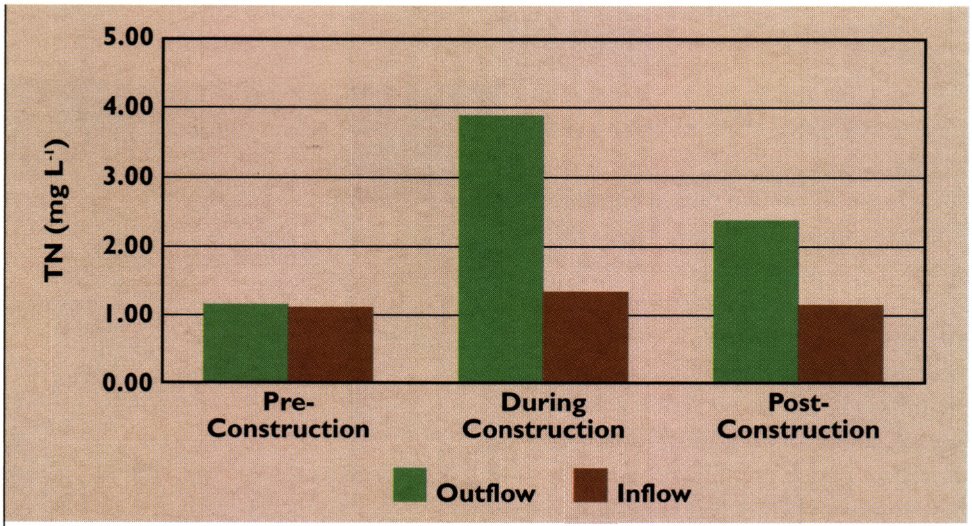


Figure 1. Average concentrations of total nitrogen (TN) in water sampled from upstream (inflow) and downstream (outflow) of Colbert Hills Golf Course before course construction, during construction, and post-construction after turf was established.

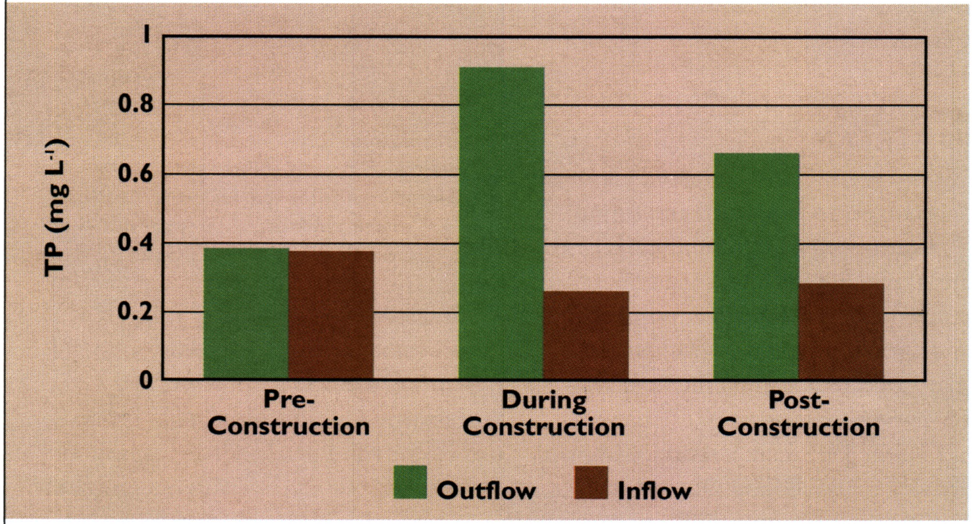


Figure 2. Average concentrations of total phosphorus (TP) in water sampled from upstream (inflow) and downstream (outflow) of Colbert Hills Golf Course before course construction, during construction, and post-construction after turf was established.

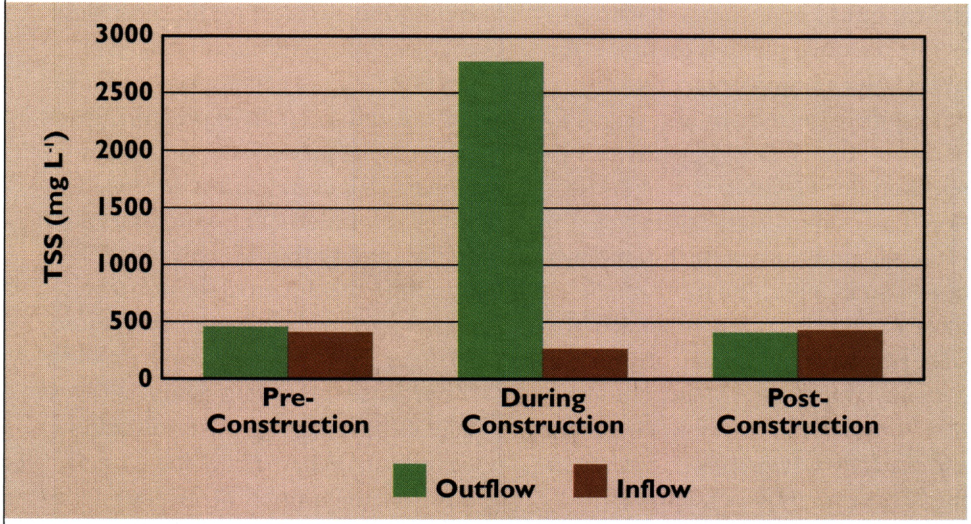


Figure 3. Average concentrations of total suspended solids (TSS) in water sampled from upstream (inflow) and downstream (outflow) of Colbert Hills Golf Course before course construction, during construction, and post-construction after turf was established.

During operation, however, sediment content was brought down significantly, to an average of 397 mg L^{-1} — lower than that at the native prairie condition. This reduction is no doubt due to the turfgrass establishment. The average concentrations of total nitrogen and total phosphorus were 2.38 mg L^{-1} and 0.67 mg L^{-1}, respectively, much lower than those in the construction period, but still about twice as much as those in the native prairie condition. Spatial (inflow and outflow) and temporal (pre-, during, and post-construction) variations of average concentrations of total nitrogen, total phosphorus, and total sediment load are shown in Figures 1-3.

SOURCES OF NUTRIENTS IN STREAMS

Various researchers (1) studied a forested and rangeland watershed and found that streams in forested and rangeland areas have significantly smaller nutrient concentrations than streams in urban and agricultural land-use areas. This may indicate that large nutrient concentrations in streams in urban and agricultural areas are a result of human activity, especially soil tillage, as well as fertilizer and manure applications in watershed areas.

During the pre-construction and construction periods, there were no human inputs of nutrients (fertilizer). It can be reasoned that soil erosion is the major source of nutrients in streams during these periods. In fact, vegetation of about 20% of the watershed area was removed during golf course construction. The original land covers were primarily undisturbed thick and dense grasses and forests. The rootzone of those undisturbed areas contained a large percentage of organic matter that contained nutrients. During construction, topsoil was vulnerable to runoff, and the hilly topography of the watershed accelerated the soil erosion process.

During golf course operation, both fertilizer and pesticide applications are necessary to maintain turfgrass at acceptable levels (2). In addition to plant uptake and adsorption, and absorption by soil and thatch, applied fertilizers and pesticides are capable of being washed into streams by significant rainfall or irrigation, especially when soils are already saturated.

More than 900 surface water samples were collected in an effort to understand the impact of golf course construction on water quality at the Colbert Hills Golf Course (Kansas).

Fertilizer application records registered information about the date of application, name of fertilizer, fertilizer analysis, type of fertilizer (soluble or granular), rate of application, total area treated, and so on. As expected, impacts of fertilizer applications on nutrient concentrations in streams depended largely on the amount (rate) of fertilizer applied and timing of application. To minimize the potential for nutrient runoff into surrounding surface waters, fertilizer applications should be avoided immediately preceding significant rainfall. In reviewing the fertilization records of Colbert Hills Golf Course, however, the impacts of fertilizer applications on nutrient concentrations in streams were minimal during the 1.5-year monitoring period. Few incidents were observed when fertilizer applications coincided with spikes of high nutrient concentrations in streams of Little Kitten Creek watershed.

THE POWER OF MATURE TURF TO INHIBIT EROSION

A significant land-use change was observed in the Little Kitten Creek watershed in the process of turning a native prairie into a championship golf course. The period having the worst water quality was during golf course construction from August 1998 to April 2000. Once the turfgrass was established, however, total sediment load was reduced to levels even lower than that of the native prairie.

Nutrient concentrations in streams were greatly improved during operation from the construction period, but still higher than the native prairie levels. Soil erosion is the major source of stream nutrients in native prairie conditions and during construction. Since total sediment load was significantly reduced after turf establishment, fertilization practices were contributing to nutrients detected in the watershed streams during operation. However, if care is taken to avoid fertilizer applications just prior to significant rainfall events, the potential for nutrient runoff is greatly reduced.

LITERATURE CITED

1. Dennehy, K. F., D. W. Litke, P. B. McMahon, J. S. Heiny, and C. M. Tate. 1995. Water-quality assessment of the South Platte River Basin, Colorado, Nebraska, and Wyoming — Analysis of available nutrient, suspended-sediment, and pesticide data, water years 1980-92: U.S. Geological Survey Water-Resources Investigations Report 94-4095. Washington, D.C.
2. Gross, C. M., J. S. Angle, and M. S. Welterlen. 1990. Nutrient and sediment losses from turfgrass. *Journal of Environmental Quality* 19:663-668.

STEVE STARRETT, PH.D., P.E., *is associate professor, and* YUNSHENG SU, PH.D., *is a former graduate research assistant in the Civil Engineering Department at Kansas State University.*

When the USGA Green Section Turf Advisory Service Program was launched in 1953, the staff consisted of five people (left to right): Charlie Wilson (agronomist), Fred Williams (administration), Dr. Fred Grau (National Director), Anne Drennau (secretary), and Al Radko (agronomist).

50 Years of Turf Advisory Service

USGA Green Section Staff & Turf Advisory Service Agronomists 1921 – 2003

Timothy Ansett

William Bengeyfield

William Brewer

William L. Brown

William Buchanan

Marvin H. Ferguson

Chuck Gast

Agronomist Name	Years with The USGA
Alexander, Paul	1969★
Allen, Wayne	1960 – 1961★ 1962 – 1963★
Ansett, Timothy	1980 – 1983★
Antaya, Kathy	2001 – 2002★
Baird, James	2000 – present★
Batten, Steve	1982 – 1984★
Bengeyfield, William *(National Director)*	1954 – 1978★ 1982 – 1990
Bengtson, John W.	1937 – 1941
Bevard, Darin	1997 – present★
Brame, Robert	1990 – present★
Brewer, William	1976 – 1981★
Brown, William L.	1941 – 1942
Buchanan, William	1970 – 1983★
Carrier, Lyman *(Agronomist)*	1921 – 1924
Cheesman, Jerry	1963 – 1964★

★ *Turf Advisory Service Agronomist*

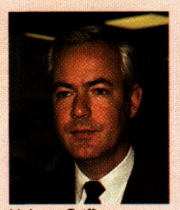
Agronomist Name	Years with The USGA
Clemens, Harold *(Chicago Turf Demonstration Gardens, USGA funded until 1934)*	1931 – 1934?
Connolly, James	1988 – 1994★
Cornman, John F.	1940
Croley, Charles	1961 – 1963★
Cunningham, George	1926 – 1930s?
Dahl, Arnold B.	1920s – 1930s?
Darrow, Robert	? – 1936
Davis, Fanny-Fern *(Director of Green Section)*	1938 – 1941, 1942 – 1945
Elder, Robert *(Research Assistant)*	1951 – ?
Erusha, Kimberly *(Director of Education)*	1990 – present
Ferguson, Marvin H. *(Agronomist, National Research Coordinator)*	1940 – 1951, 1953 – 1968★
Forbes, Ian *(Research Assistant)*	1941 – 1942 1945 – 1952
Foy, John	1985 – present★
Gast, Chuck	1990 – 1995★

We welcome you in celebrating the 50th anniversary of the USGA Green Section's Turf Advisory Service! Having been primarily a research organization since its establishment in 1921, the Green Section changed its direction completely in 1953 with an emphasis on direct service to USGA member clubs and courses.

In concept, golf courses would pay a fee to the USGA to subscribe to a program called the Green Section Regional Turf Service. A regional agronomist would visit subscribing courses each year, providing a half-day on-site visit to each course and following up with a written report of his findings and recommendations. The program was a success, and the basic tenets of the program — an on-site visit and a follow-up written report — continue to be the cornerstone of the service today, in 2003.

USGA Green Section Staff & Turf Advisory Service Agronomists 1921 – 2003


Fred V. Grau


Holman Griffin


Douglas Hawes


James Holmes


Donald Hoos


James Latham


Brian Maloy


George Manuel


Robert Mazur


James Moncrief


John Monteith, Jr.

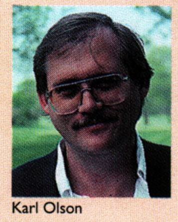
Agronomist Name	Years with The USGA
Gilhuly, Larry	1983 – present★
Grau, Fred V. *(Director of Green Section)*	1945 – 1953
Griffin, Holman	1962 – 1976★
Gross, Patrick	1991 – present★
Hallowell, Charles	1955 – 1961★
Hampton, H.E.	1964★
Happ, Keith	1993 – present★
Harman, Raymond	1960 – 1966★
Harrington, George E. *(Assistant Director to Grau)*	1940 – 1941 1946 – 1949
Hartwiger, Chris	1995 – present★
Hawes, Douglas	1978 – 1984★
Holmes, James	1957 – 1969★
Hoos, Donald	1978 – 1983★
Huck, Michael	1995 – 2001★
Jones, G.H.	1940 – 1941★
Kenna, Mike *(Director of Research)*	1990 – present

Agronomist Name	Years with The USGA
Kollett, James	1961 – 1962★
Latham, James	1956 – 1960;★ 1984 – 1994★
Lowe, Todd	2000 – present★
Maloy, Brian	1996 – 2002★
Manuel, George	1990 – 1995★
Mazur, Robert	1969 – 1970★
Moncrief, James	1957 – 1982★
Monteith, John, Jr. *(Director of Green Section)*	1928 – 1942
Moore, James *(Construction Education Program)*	1984 – 1996★ 1996 – present
Moraghan, Tim *(Director, Championship Agronomy)*	1987 – present
Nelson, Matthew	1996 – present★
North, H.F.A.	1936 – 1937
Nus, Jeff *(Research Manager)*	2000 – present
O'Brien, Patrick	1979 – present★
Oakley, Russell A. *(USDA/USGA)*	1921 – 1931

In this and the remaining issues of the 2003 *Green Section Record*, we shall highlight some aspect of the Turf Advisory Service(TAS). In this issue we take the opportunity to thank and recognize those who have served on the Green Section's agronomy staff since its inception in 1921. The list is in alphabetical order and includes the years of service for each individual. A star by the years of service indicates that the person served as a regional agronomist in the Turf Advisory Service program. Where a star is not present, the person may have served as a research scientist or in a significant administrative role.

Where pictures were available and space permitted, we've included pictures of many of the ancestors of today's Green Section family. Pictures of current staff members will appear in future issues. See if you can recognize some of yesteryear's agronomists before you look at the names!

USGA Green Section Staff & Turf Advisory Service Agronomists 1921 – 2003



Karl Olson

Duane Orullian

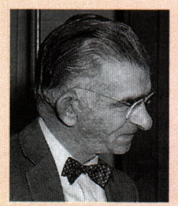
Alexander Radko

Lee Record

B.P. Robinson

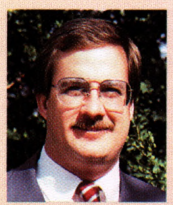
Carl Schwartzkopf

Brian Silva



T.T. (Tate) Taylor

James Timmerman



Gary Watschke

Charles Wilson

Agronomist Name	Years with The USGA
Oatis, David	1988 – present★
Olson, Karl	1983 – 1986★
Orullian, Duane	1968 – 1970★
Pieters, A.J. *(USDA/USGA)*	? – 1940
Piper, Charles V. *(USDA/USGA)*	1921 – 1926
Rabbitt, Alton E. (Ike)	1937 – 1938
Radko, Alexander *(National Director)*	1947 – 1981★ 1976 – 1981
Record, Lee	1962 – 1976★
Robinson, B.P.	1954 – 1956★
Sadlon, Nancy *(Environmental Specialist)*	1990 – 1994
Saffel, Michael	1992 – 1993★
Schwartzkopf, Carl	1971 – 1981★
Senseman, Robert	1994 – 1995★
Silva, Brian	1981 – 1983★

★ ***Turf Advisory Service Agronomist***

Agronomist Name	Years with The USGA
Skorulski, James	1989 – present★
Slater, Richard	1967 – 1968★
Snow, James *(National Director)*	1976 – 1990★ 1990 – present
Taylor, T.T. (Tate)	1956 – 1961★
Timmerman, James	1968 – 1970★
Vavrek, Robert	1990 – present★
Vermeulen, Paul	1988 – present★
Watschke, Gary	1985 – 1988★
Welton, Kenneth	1928 – 1935
Westover, Harvey L. *(USDA/USGA)*	1920s – 1943
Whaley, M. Stewart	1925
White, Charles (Bud)	1978 – 1987,★ 2002 – present★
Wienecke, David	2001 – present★
Williams, Fred H. *(Executive Secretary)*	1922 – 1959
Wilson, Charles	1950 – 1955★
Zontek, Stanley	1971 – present★

USGA Sponsored

Research *You Can Use*

Measuring Nitrogen Loss from a Floating Green

A unique opportunity to assess nutrient losses.

BY WILLIAM J. JOHNSTON and CHARLES T. GOLOB

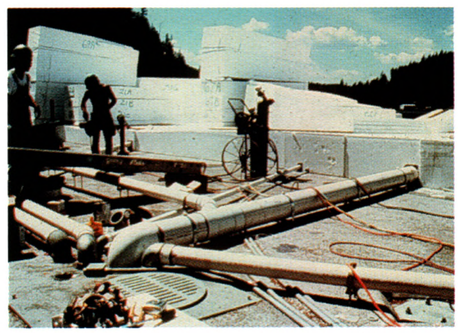
Environmental concern by the turfgrass industry and the public has promoted the development and implementation of best management practices (BMPs) for golf courses. A major area of concern on golf courses is the application of fertilizer to potentially highly leachable sand-based putting greens.

Several nitrogen leaching studies have been conducted. However, except for the work of Johnston et al. (5) and Rummele (10), many leaching studies tend to be conducted at small-scale university research plots under very controlled conditions, and they may not accurately represent golf course conditions of management and play.

WHY THIS STUDY WAS DIFFERENT

Our research was unique because no study had monitored leachate flow and nutrient concentration on an entire golf course green receiving play. In addition, the green received its normal maintenance by the golf course superintendent throughout the three years of the study. By accurately monitoring flow through the rootzone and sampling the leachate to obtain nitrogen concentrations, the total quantity of nitrogen being leached could be determined.

The overall goal of this study was to provide scientific data for the development of best management practices for sand-based turfgrass systems. To accomplish this goal, the objectives were to measure flow through a sand-based putting green under golf course management and play, and determine the nitrogen concentration and quantity in the leachate and grass clippings.



After installing the drainage system, polystyrene-filled concrete cells staggered in two layers provided the buoyancy of the floating green.

THE FLOATING GREEN — A MASSIVE FIELD LABORATORY

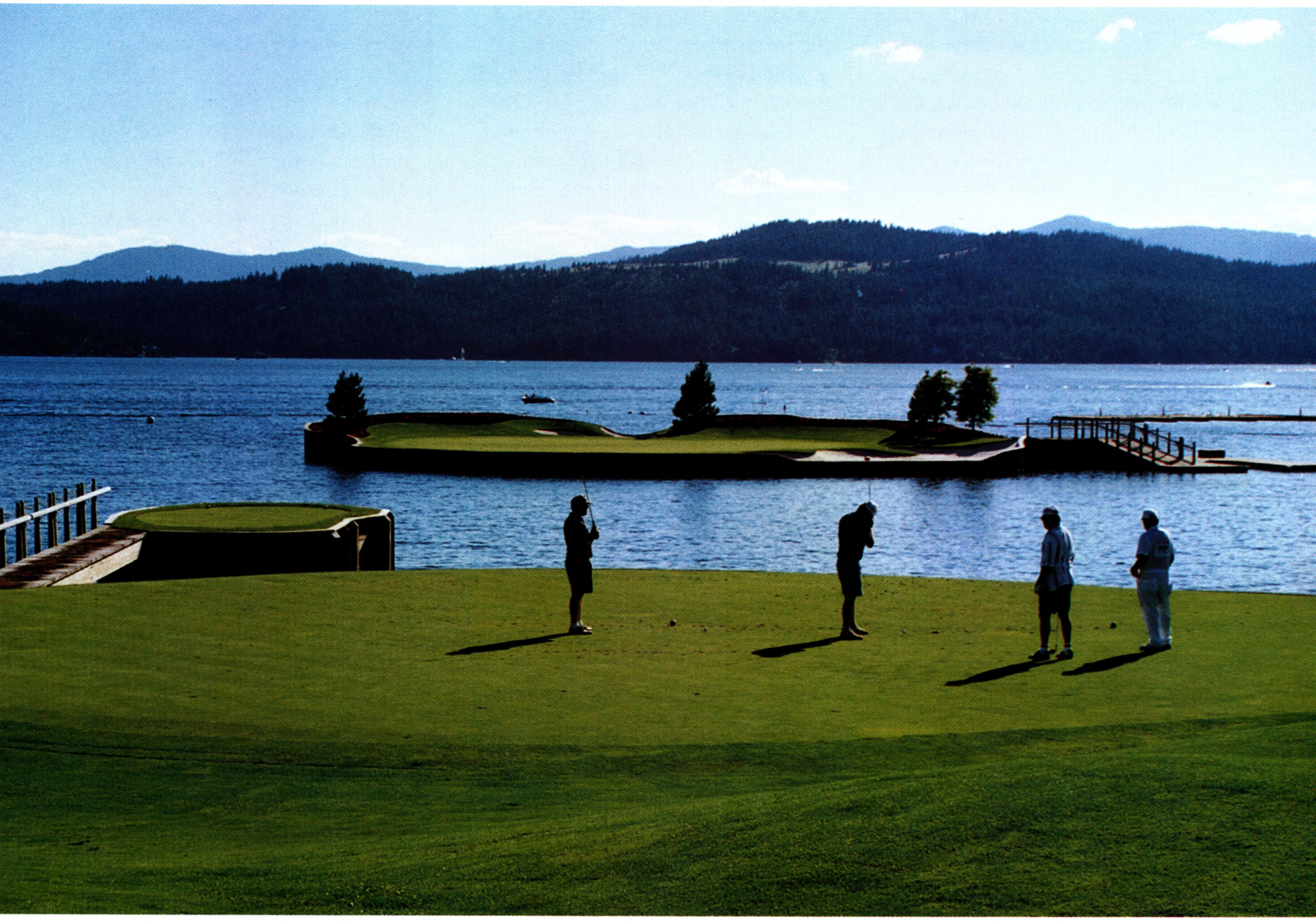
The 15,000 ft^2 floating island green used in this study was constructed in 1990 at the Coeur d'Alene Resort Golf Course, Coeur d'Alene, Idaho. Buoyancy was provided by approximately 100 polystyrene-filled concrete cells (30 ft. × 10 ft. × 3.5 ft.) staggered in two layers. To minimize weight, the green contours (subsurface grade) were constructed of Styrofoam sections.

The 7,000 ft^2 putting green has a USGA-recommended rootzone with 14 in. of sand above a 4 in. layer of pea gravel. The putting surface was sodded to Penncross creeping bentgrass (*Agrostis stolonifera* L.). The green was irrigated with water pumped directly from Lake Coeur d'Alene. Since Lake Coeur d'Alene is a large body of water (approximately 25,000 acres), as expected, there was negligible fluctuation in lake water NO_3-N and NH_4-N concentrations during the study. NO_3-N and NH_4-N were 40 and 80 ppb, respectively (0.04 mg L^{-1} and 0.08 mg L^{-1}, respectively).

MONITORING FLOW AND SAMPLING LEACHATE

Downward flow of leachate into the Styrofoam was prevented by an impermeable liner placed above the Styrofoam sections and beneath a herringbone drainage system connected to two 850-gallon storage tanks located under the front and rear bunkers. The putting green drainage was isolated from the surrounding area by a vertical liner. All leachate passing through the putting green soil profile flowed through a small trapezoidal flume attached to the main drain prior to flowing into the rear storage tank. When the rear tank was nearly full, leachate was pumped via a 4 in. flexible tube to a drainage field on shore.

From the flume a leachate sample was collected daily and flow was recorded every 30 minutes. Leachate samples were stored within an automatic sampler at 34°F (1°C) to insure sample stability, transported to Washington State University, and frozen until nitrogen analysis was performed with a flow solution analyzer. A weather station was installed at the site to record environmental parameters. Soil moisture potential and temperature probes were placed 39 in. onto the green and 5 in. below the surface. Data were collected every 30 minutes to correspond to the collection of the flow sample.



Using a unique floating green at Coeur d'Alene Resort Golf Course (Idaho), Washington State University researchers were able to track nitrogen leachate after nitrogen fertilizer applications.

FERTILIZER APPLICATIONS

A foliar fertilizer, 24-0-24 Nitro-K Plus II at 0.1 lb. N per 1,000 ft.^{2} (1.75% ammoniacal N, 3.0% nitrate N, 19.3% urea N), was applied by the golf course superintendent every 7 to 10 days during the growing season. In addition, Ferromec (15% urea N) was added to the foliar fertilizer at a rate of 1 oz. per 1,000 ft.^{2} The total nitrogen applied annually to the green ranged from 3.4 to 4.2 lb. per 1,000 ft.^{2}

Nitrogen was increased to 0.3, 0.6, 0.7, 0.9, or 1.2 lb. N per 1,000 ft.^{2}, one application at each rate, to observe the effects of higher N rates. Nitro-K Plus II was applied at 0.3 or 0.6 lb. N per 1,000 ft.^{2} on August 5 and September 4, respectively. Scotts 26-4-13 with minor elements (0.6% ammoniacal N, 9.9% urea N, 10.8% water-soluble organic N, and 4.7% water-insoluble N) was applied at 0.9 lb. N per 1,000 ft.^{2} on April 8, 1999, and 0.7 lb. N per 1,000 ft.^{2} was applied September 17, 1999, as Scotts Starter Fertilizer 19-25-5 (4.3% ammoniacal N, 7.4% urea N, 6.3% water-soluble organic N, and 1.0% water-insoluble N). In 2000, 1.2 lb. N per 1,000 ft.^{2} was applied on May 2 as Scotts 17-3-17 (3.3% ammoniacal N, 6.9% urea N, 3.9% water-soluble organic N, and 2.9% water-insoluble N).

Grass clippings were collected from the green daily during the growing season by the golf course superintendent, weighed, sub-sampled, and frozen. The clipping samples were later dried in a 60°C oven for three days and weighed. Clippings were separated from top-dressing sand and analyzed for nitrogen using a combustion auto-analyzer.

Annual precipitation during the study was 25 inches, with more than two-thirds occurring from late October to early March, a period when the golf course generally was closed (the golf course was open April 1 to October 31). Precipitation and flow through the green were related, i.e., as precipitation increased, the flow through the green increased. Low-flow during winter occurred when the soil profile was frozen. When soil temperatures increased and snow melt occurred, there was a notable increase in flow. Mean flow rate through the green over the three-year study was 1,151 gallons per day. Peak flow rates can be attributed to rainfall events, e.g., during the week of August 4, 1999, when a 2 in. rainfall occurred during a 24-hour period.

N CONCENTRATION IN LEACHATE

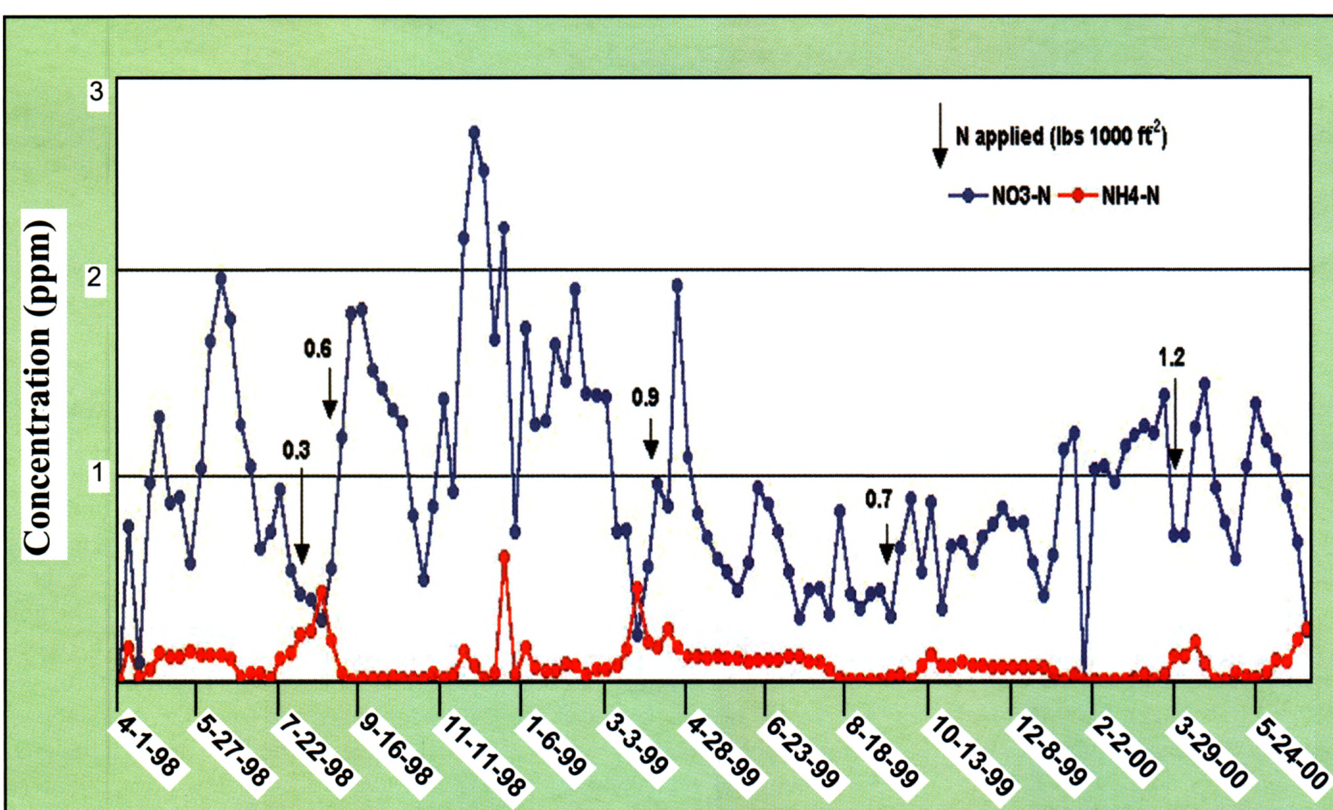
Analysis for NO_3-N and NH_4-N indicated low levels of N in the leachate. NO_3-N ranged from 0 to 3.1 ppm, well below the U.S. Environmental Protection Agency limit of 10 ppm. NH_4-N levels ranged from 0 to 0.6 ppm. There is no EPA standard for NH_4-N in groundwater. Low concentrations of NO_3-N in the leachate may be attributed in part to light, frequent foliar N applications, periods of high leachate flow, and rapid turfgrass growth with high nitrogen uptake.

Increased nitrogen fertilizer rates increased leachate NO_3-N concentration during the 7- to 21-day period following application. Others have reported higher NO_3-N leaching as N fertilization rates increased. However, at no time during an 8-week post-application period were NO_3-N concentrations excessive (i.e., greater than 1.9 ppm).

The highest quantity of nitrogen was leached during late fall and late winter/early spring when water flow and nitrogen leachate concentrations were high and grass growth was minimal. An increase in the amount of nitrogen leached occurred 7 to 14 days following fertilizer applications, but results were confounded by increased flow that also occurred during this period. Since, in general, concentration decreases as flow increases, which as noted above did not occur, there was an increase in the amount of nitrogen leaching following fertilizer applications.

Clipping dry weight variation can be attributed to mowing height variation, periodic mowing of cleanup lap, and environmental factors. The daily bentgrass clipping nitrogen content ranged from 2.4% to 7.3% and reflected increased nitrogen applications. Mean nitrogen content of the clippings was 4.6%. This is within the range of 3% to 6% N on a dry weight basis reported for turfgrass. The amount of bentgrass clippings removed from the green was a less accurate predictor of when nitrogen was applied than percent N in the clippings. Low leachate concentrations combined with high nitrogen content of the clippings suggests efficient nitrogen uptake by the grass.

Over the three years of this study, total recovered N was 59% (11% in leachate, 48% in clippings). Non-recovered nitrogen could be present in non-available forms in both the soil and thatch, with some potential loss due to volatilization (13, 14). However, it is believed not to be an environmental concern (6, 12).



Leachate nitrogen concentrations from a golf green at Coeur d'Alene, Idaho, 1998-2000. Arrows indicate timing of nitrogen applications (lbs of N per 1000 ft.^{2}).

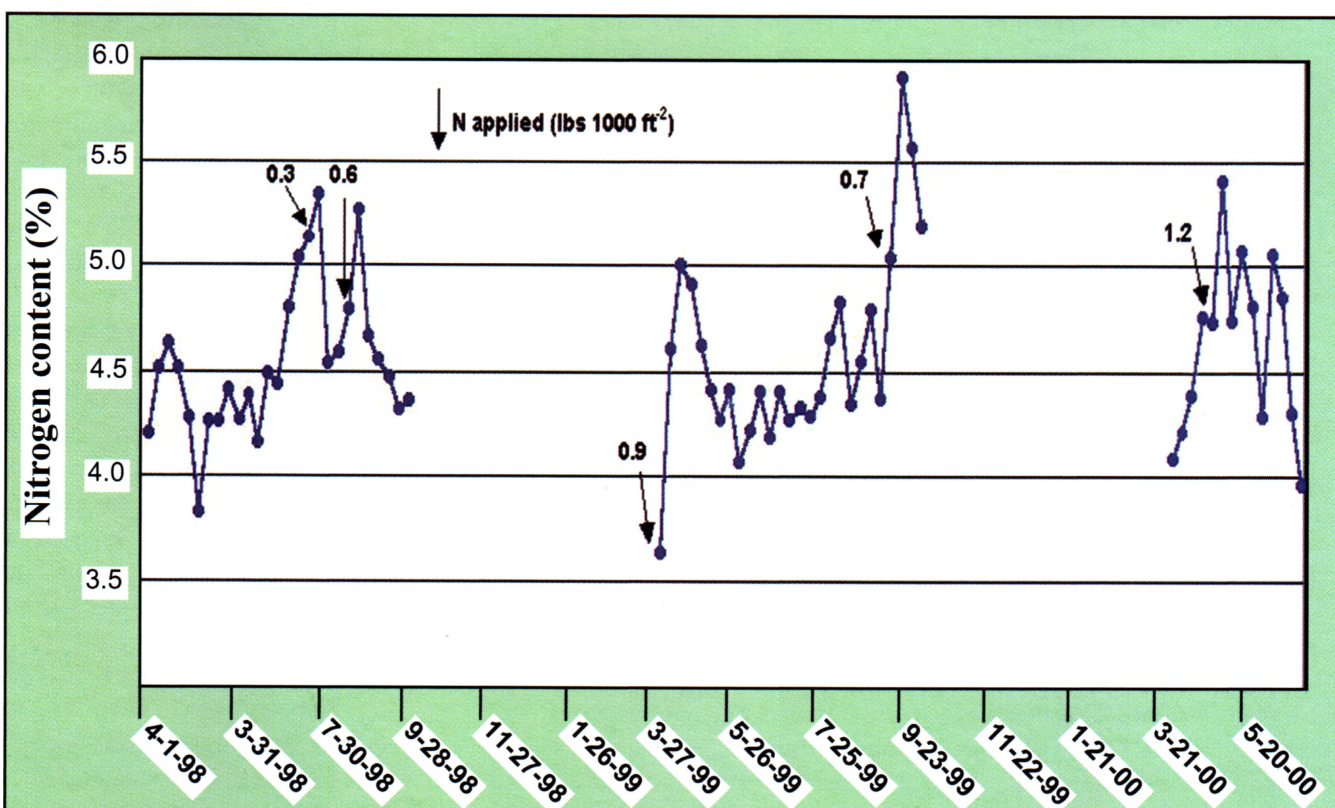
ACKNOWLEDGEMENTS

This research was supported in part by grants from the United States Golf Association, Northwest Turfgrass Association, Western Canada Turfgrass Association, and Inland Empire Golf Course Superintendents Association. The authors would like to recognize the on-site assistance of John Anderson, golf course superintendent at the Coeur d'Alene Resort Golf Course, and the labor and technical assistance of WSU turfgrass students Jeff Schnurr and Chris Kleene and WSU faculty Dr. Bill Pan and Dr. Eric Miltner.

LITERATURE CITED

1. Beard, J. B. 2001. Turf Management for Golf Courses. 2nd Edition. Ann Arbor Press, Chelsea, Mich.
2. Brauen, S. E., and G. Stahnke. 1995. Leaching of nitrate from sand putting greens. *USGA Green Section Record* 33(1):29-31.
3. Brown, K. W., J. C. Thomas, and R. L. Duble. 1977. Influence of management and season on fate of N applied to golf greens. *Agron. J.* 69:667-671.
4. Chapman, E. J. 1994. The effect of nitrogen fertilizer rate, application timing, and root-zone modification on nitrate concentrations and organic matter accumulation in simulated sand-based putting greens. M.S. thesis, Washington State Univ., Pullman, Wash.
5. Johnston, W. J., C. T. Golob, C. M. Kleene, W. L. Pan, and E. D. Miltner. 2001. Nitrogen leaching through a floating sand-based golf green under golf course play and management. *Intl. Turf. Soc. Res.* J. 9:19-24.
6. Miltner, E. D., B. E. Branham, E. A. Paul, and P. E. Rieke. 1996. Leaching and mass balance of 15N-labeled urea applied to a Kentucky bluegrass turf. *Crop Sci.* 36:1427-1433.
7. Petrovic, A. M. 1990. The fate of nitrogenous fertilizers applied to turfgrass. *J. Environ. Qual.* 19:1-14.
8. Petrovic, A. M. 1995. The impact of soil type and precipitation on pesticide and nutrient leaching from fairway turf. *USGA Green Section Record* 33(1):38-41.
9. Rieke, P. E., and B. G. Ellis. 1974. Effects of nitrogen fertilization on nitrate movements under turfgrass. p. 120-130. In: E. C. Roberts (ed.). Proc. 2nd Intl. Turfgrass Res. Conf., Blacksburg, Va. 17-21 June 1973. ASA, Madison, Wis.
10. Ruemmele, B. A., J. J. Bresnahan, J. T. Bushoven, and J. R. Hull. 1999. Nitrogen flow through golf course putting greens. p. 137. In Agronomy abstracts. ASA, Madison, Wis.
11. Schnurr, J. P., W. J. Johnston, and C. T. Golob. 2001. Use of an inclined vibrating deck to separate bentgrass clippings from topdressing sand. In 2001 Agronomy abstracts CD-ROM. ASA, Madison, Wis.
12. Starr, J. L., and H. C. DeRoo. 1981. The fate of nitrogen fertilizer applied to turfgrass. *Crop Sci.* 21:531-536.
13. Titko, III, S., J. R. Street, and T. L. Logan. 1987. Volatilization of ammonia from granular and dissolved urea applied to turfgrass. *Agron. J.* 79:535-540.
14. Wesely, R. W., R. C. Shearman, E. J. Kinbacher, and S. R. Lowry. 1987. Ammonia volatilization from foliar-applied urea on field-grown Kentucky bluegrass. *HortSci.* 22:1278-1280.

W. J. JOHNSTON *is a professor of turfgrass science and* C. T. GOLOB *is a graduate student at Washington State University in Pullman.*



Nitrogen content (%) of clippings from a golf green at Coeur d'Alene, Idaho, 1998-2000. Arrows indicate timing of nitrogen applications (lbs of N per 1000 square feet).

Specially Designed Wetlands Treat Golf Course Runoff

Phytozones can help with water quality management.

BY KRAIG MARQUIS

Many golf course superintendents find water quality management one of the most challenging aspects of their jobs. Success in managing water sources for golf, wildlife, aesthetics, irrigation, and overall water quality depends on having a basic understanding of factors influencing water quality and on adopting Best Management Practices (BMPs).

Members of the Audubon Signature Program have a special advantage of working with Audubon International to build in systems that protect water quality right from the start. One approach to protect water quality in lakes uses a unique wetland treatment system known as a *phytozone*. In general terms, a phytozone is similar to a shallow forebay at the edge of a lake. The design is unique, however, because it integrates the treatment benefits of a detention basin and a created wetland.

CASE STUDY: RAPTOR BAY, ESTERO, FLORIDA

Raptor Bay is a WCI Communities, Inc., resort-class championship golf course development with residential timeshare units and associated amenities located in Estero, on Florida's Gulf Coast. Raptor Bay Golf Club was designed by Raymond Floyd. In March of 2002 it won certification as the third Audubon International Gold Signature Sanctuary golf course in the world, meeting Audubon International's highest standards for development in concert with the environment.

The entire project encompasses approximately 510 acres, of which more than 150 acres will remain undeveloped and preserved in perpetuity under conservation easements. This large preserve area is home to an active nesting pair of bald eagles and several gopher tortoises, and is planned to feature a nature trail and interpretive signs detailing the unique ecosystem.

The Raptor Bay property consists primarily of pine flatwoods with pockets of cypress strand and xeric oak scrub vegetation communities. Halfway Creek, classified as a Florida Outstanding Water, runs through the property and drains into the Estero River and then into Estero Bay.

PHYTOZONES AT RAPTOR BAY

In order to protect water quality in the created lakes on site and water bodies downstream of the project, including Halfway Creek and Estero Bay, approximately 22 acres of phytozones, or small wetland pockets, were constructed to treat runoff from the golf course. The phytozones at Raptor Bay are characterized by a wide earthen berm that separates a shallow pool from the main body of the lake. Each is constructed to receive runoff directly from the stormwater drainage system or from swales around the lakes.

Once the runoff is discharged into the phytozone by pipe or swale, it is detained before flowing into the main body of the lake. The phytozone temporarily stores and slows the movement of the runoff and therefore promotes settling of solids and attached pollutants. Vegetation planted in the phytozone absorbs and filters dissolved nutrients.

The phytozones at Raptor Bay are sized to treat runoff from smaller, more frequent storm events that have the greatest potential to degrade water quality. Preliminary water monitoring results have indicated that water quality is good and that the phytozones are functioning effectively.

Phytozones can have the added benefit of providing habitat and feeding areas for wading birds and other wildlife. Results from the wildlife monitoring program at Raptor Bay indicate a substantial increase in the variety of bird species on the property. Surveys conducted in December 2001 and December 2002 added 22 new bird species, including nine new water-dependent birds, to Raptor Bay's bird list. Rare birds, including listed species, have been observed feeding along the lake banks and vegetated berms. These berms are especially popular because they provide additional forage area and protect the birds from predators and the occasional unknowing golfer searching for a stray golf ball.

KRAIG MARQUIS *is Audubon International's Senior Scientist/Sustainable Communities Coordinator for Florida. To find out more about the Audubon Signature Program, visit www.auduboninti.org or call (270) 869-9419.*

Tom Coffey (left), president, Naples Orchid Society, and George McBath, ornithologist, provided in-depth information at the Audubon Cooperative Sanctuary Program workshops on working with orchids and bird species often found on Florida golf courses.

AUDUBON COOPERATIVE SANCTUARY PROGRAM WORKSHOPS

In November 2002, the USGA Green Section worked with Audubon International to host four one-day workshops in Florida to promote active participation in the Audubon Cooperative Sanctuary Program for Golf Courses (ACSP). Many courses take the first step to join the program but fail to complete the documentation necessary to achieve certification. The workshops were designed to help superintendents begin completing the first certification category: site assessment and environmental planning.

Over the course of the four days, 150 people took time to spend the day learning about environmental education on the golf course. Approximately 90% of the participants had registered for the ACSP but had failed to take the next step of submitting their environmental plan. Invited speakers, Audubon International staff, and Green Section staff presented examples of various projects taking place on golf courses actively participating in the ACSP. Audubon staff spent the afternoon working with the superintendents to take them through completing their site assessment and environmental plan. After the workshop, participants needed only to return to their golf course to fill in the specifics about their property and submit their paperwork. Effectiveness of the workshop and follow-through of the participants will be measured in following the workshops.

The Audubon Cooperative Sanctuary Program for Golf Courses, administered by Audubon International, is designed to help golf courses play a significant role in enhancing and protecting wildlife habitats and natural resources, while reducing environmental risks. There is much to be proud of since the first golf courses joined the program in 1991. Today, 2,094 courses throughout the United States are enrolled, 954 have become certified in one or more categories, and 408 have achieved designation as Certified Audubon Cooperative Sanctuaries by implementing and documenting a full complement of conservation activities in six categories.

WHITE PRESENTED SERVICE AWARD

Karen White received the Georgia Golf Course Superintendents Association Distinguished Service Award at their Annual Meeting on November 3, 2002. Karen served as Executive Director of the GGCSA from 1989 to 2002 before joining the USGA Green Section staff in 2002 as an administrative assistant in the Mid-Continent Region. Her husband, Bud White, works as a regional agronomist in the Mid-Continent Region, covering the southern half of the region.

PHYSICAL SOIL TESTING LABORATORIES

The following laboratories are accredited by the American Association for Laboratory Accreditation (A2LA), having demonstrated ongoing competency in testing materials specified in the USGA's Recommendations for Putting Green Construction. The USGA recommends that only A2LA-accredited laboratories be used for testing and analyzing materials for building greens according to our guidelines.

Brookside Laboratories, Inc.
308 Main Street, New Knoxville, OH 45871
Attn: Mark Flock
Voice phone: (419) 753-2448
FAX: (419) 753-2949
E-Mail: mflock@BLINC.COM

Dakota Analytical, Inc.
1503 11th Ave. NE, E. Grand Forks, MN 56721
Attn: Diane Rindt, Laboratory Manager
Voice phone: (701) 746-4300 or (800) 424-3443
FAX: (218) 773-3151
E-Mail: lab@dakotapeat.com

European Turfgrass Laboratories Ltd.
Unit 58, Stirling Enterprise Park
Stirling FK7 7RP Scotland
Attn: John Souter
Voice phone: (44) 1786-449195
FAX: (44) 1786-449688

ISTRC New Mix Lab LLC
1530 Kansas City Road, Suite 110
Olathe, KS 66061
Voice phone: (800) 362-8873
FAX: (913) 829-8873
E-Mail: istrcnewmixlab@worldnet.att.net

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35 King Street, P.O. Box 606
Trumansburg, NY 14886
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Just When You Think You've Heard It All . . .

Superintendents share stories regarding the most outlandish maintenance requests from golfers.

BY PATRICK J. GROSS

If you are in the golf business long enough, you get the feeling you've seen and heard just about everything. Most golfers are very passionate about the game and have specific ideas about what constitutes the perfect golf course. But when does the demand for perfect conditions cross the line from realistic to ridiculous? Here are a few examples of outlandish stories and unusual golfer requests from several superintendents.

Keeping bunker sand dry. Golfers seem to be very temperamental when it comes to the characteristics and playing quality of bunkers. Many loathe wet sand, preferring to always play from a dry bunker. In their mind, it should be possible to keep every drop of rain and sprinkler spray from hitting these precious hazards. One green committee member especially concerned about keeping the bunkers dry asked what it would cost to remove the sand from the bunkers each evening, store it in a dry location, and then put the sand back in the morning.

Smoother bunkers. Not only do the bunkers need to be dry all the time, but the sand surface must be perfectly smooth — not just regular smooth, but perfectly smooth. Maintenance crews now use a variety of rakes to groom the sand, from riding mechanical bunker rakes to flexible metal leaf rakes, each leaving a shallow furrow or rake mark after the bunker is groomed. One green chairman was particularly annoyed by the shallow rake marks, saying they were unfair because they produced an "impeded lie." Try to find that in the *Rules of Golf*!

Orderly yardage markers. Many courses today have installed small yardage disks on the sprinklers to indicate the distance to the green. Of course, the yardage disks rotate as the sprinklers rotate, so you may have to occasionally twist your head or take an extra step to decipher the number on the disk. Apparently, this was too much effort for one golfer who asked, "Why can't the superintendent straighten out the yardage markers each morning so they point toward the green? Otherwise, the course looks messy!"

It's like putting on a tee. Play was backed up one weekend morning, and a golfer waiting to tee off on the first hole pulled out his putter to stroke a few balls. Soon, the superintendent passed by and the golfer called him over. He told the superintendent, "I don't know what you're doing around here, but the course is in terrible condition. These tees aren't even puttable!"

A former junkie weighs in on weed control. A new superintendent inherited a course with crabgrass problems. A regular golfer at the course was eager to share his advice on weed control with this tip: "Instead of spraying all the grass, why don't you just inject herbicide into the individual crabgrass plants with a hypodermic needle and syringe?" He was serious.

The unattainable green speed. One controversy that will be with us forever is green speed. Rest assured that no matter how fast the greens are, they will never be fast enough. But how would you respond to a golfer who said the greens should be "fast/slow"? When asked to explain what he meant, the confused golfer said, "When you putt uphill on our greens, the ball rolls way too slow. Isn't there a way to make the greens faster when you're putting uphill and a little slower when you're putting downhill?"

These are just a few examples, and you can probably add several of your own crazy stories to the list.

Life would be so easy for superintendents if they could place a sign on the first tee instructing golfers to "keep off the grass." Then golfers would not have to put up with all those annoying imperfections. But as golf psychologist Bob Rotella pointed out, "Golf is not a game of perfect." That applies to the mechanics of the golf swing as well as the natural imperfections in surface quality typically encountered throughout the golf course. While superintendents constantly strive to improve golf course conditions, golfers will continue to provide friendly and not-so-friendly advice about what they think is the proper way to maintain a golf course. Listening to these bits of advice can be quite humorous. Don't be surprised by such ridiculous requests, because just when you think you've heard it all, another one is sure to come your way.

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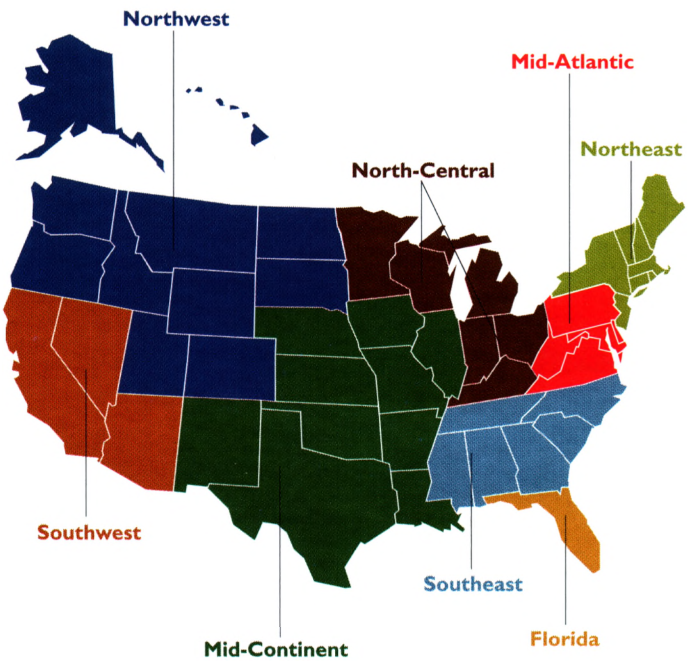

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Turf *Twisters*

Q: Next to playing golf, another of our loves is watching it on TV. Each week we see what appears to be a perfect, emerald green golf course with no blemishes. We spoke with the golf course superintendent where we play as to why our course does not or cannot resemble those that we see. It seems that money is the primary excuse given. Are there any tips you can provide that we can pass along to the superintendent so we too may enjoy the emerald green conditions that are enjoyed by the professionals? (Connecticut)

A: We hate to disappoint, but the superintendent at your golf course is absolutely correct in telling you that the conditions you see week to week on television do not come cheaply. Those golf courses have been prepared for months and sometimes years for that single event, working with budgets that are very much higher than at your golf course. Do not be fooled by the common misconception that the greener the grass, the healthier and better it is to play on. This cannot be further from the truth, as lush, green grass is usually more susceptible to disease, traffic damage, and heat and drought stress. Excessive water, fertilizer, and pesticides also are required to maintain the unnatural conditions day in and day out, and playing conditions generally deteriorate. Memorize these few words spoken by Alexander Radko, former National Director of the USGA Green Section: "Green is not great — golf is played on grass, not color."

Q: Our maintenance budget has been reduced for this season, but I'm sure players will continue to expect the same level of quality as in the past. Any suggestions to help protect the maintenance operation from severe criticism? (Wyoming)

A: Developing maintenance specifications will clearly outline what is expected of the maintenance staff and what players can expect on the golf course. Obviously, the maintenance specifications will have to correlate well with the budget. Going through this exercise will allow course officials and players to put a direct cost on the maintenance procedures necessary to achieve the desired level of playing quality. Developing specifications is a good way to establish priorities on the golf course.

Q: The past winter brought some very low temperatures, and we are concerned about the health of portions of our bermudagrass greens. Is there a quick way to assess how much, if any, damage has occurred? (Georgia)

A: There is no good way to accurately measure a percentage of damage. However, experienced turf managers can use a pocket knife to quickly estimate the health of the bermudagrass in a particular area. Insert the knife vertically into the green and make a 6" to 12" cut. As you are cutting, you should be able to feel the knife slice through the stolons and rhizomes. Healthy stolons and rhizomes will cut with a distinctive click or snap. If the knife passes through without resistance, it is likely the bermudagrass has been severely damaged. Remove a small section of the green and separate the stolons from the soil. Bend a stolon in half. A healthy stolon will break with a snap. One that is damaged or dead will be so soft that it will easily bend in half without breaking.