USGA GREEN SECTION

RECORD

A publication on Turfgrass Management July-August 2003

Looking Kindly at Kikuyugrass

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July-August 2003 Volume 41, Number 4

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Kikuyugrass is often misidentified as St. Augustinegrass. Kikuyugrass is distinguished by the pointed leaf tip, flat leaf blade, and the long fringe of hairs that parallels the stem near the leaf collar. In contrast, St. Augustinegrass has a sharply folded leaf and blunt leaf tips.


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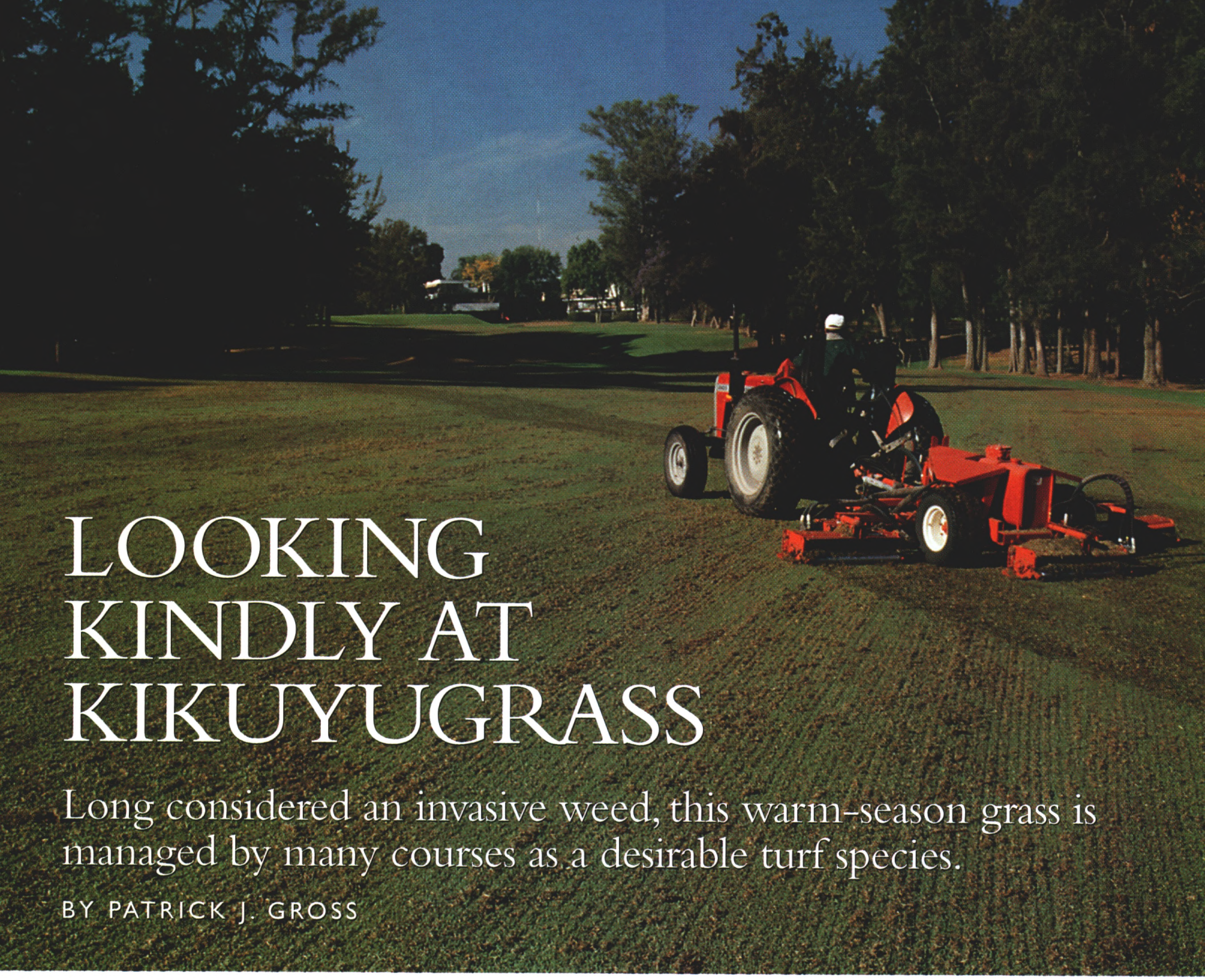


LOOKING KINDLY AT KIKUYUGRASS

Long considered an invasive weed, this warm-season grass is managed by many courses as a desirable turf species.

BY PATRICK J. GROSS

Routine vertical mowing is a key management practice to control thatch and maintain good playing quality on kikuyugrass fairways.

Kikuyugrass is the Rodney Dangerfield of turf — it gets no respect. While many courses fought the invasion and spread of kikuyugrass for decades, others have learned to manage this grass to provide good playing quality on tees, fairways, and rough. Why the change of heart? Some courses had no choice but to learn to manage their former enemy as it gradually spread over most of the course. Other courses did not have the budget or resources to control infestations with multiple herbicide sprays, physical removal, and sodding. As superintendents learned more about the grass, they were able to adapt management practices to provide a dense, uniform turf with good playing quality. Although much of the literature to this point has focused on the control of kikuyugrass, this article will look at the culture and management of kikuyugrass as a fine turf for golf courses.

HISTORY AND BACKGROUND

Kikuyugrass (*Pennisetum clandestinum*) is a warm-season grass that is native to the Kenyan highlands of Africa. It is a course-textured grass with a rapid growth rate, and it is commonly used as a forage grass and turfgrass in mild coastal climates and sub-tropical regions. The spread of kikuyugrass was aided by the Dutch, who brought the grass from Kenya to South Africa and Australia during the Boer War. Kikuyugrass was eventually transported to other areas and is now cultivated in many mild climates throughout the world, including South Africa, Australia, New Zealand, Mexico, Spain, Central America, South America, and portions of the United States.

Improvement of kikuyugrass began in the 1950s when the Australian government awarded a grant to a plant breeder to develop a seeded forage type for livestock. The rapid growth rate, palatability, and high protein content made kikuyugrass an ideal forage for cattle and livestock. The breeder, Dr. Whittet, developed the cultivar that bears his name and sold the first 22 lb. batch of seed to the Eykamp family for commercial seed production in New South Wales, Australia, where the *Whittet* variety is still grown today.

The establishment of kikuyugrass in the United States occurred in 1918 when it was imported to Pacific Palisades, California, as an erosion control for ditch banks, and it gradually spread to the coast and inland valley areas. Many golf course superintendents and homeowners misidentified the grass as St. Augustinegrass due to the similarities in leaf blade width, color, thick stolon, and dense canopy. From California, the grass was transported and spread to several states, including Hawaii, Arizona, and Texas.

Don Eykamp, son of the original grower, brought kikuyugrass seed to the United States in 1995 with the intention of producing seed and improving the species for the American forage and turf market. The main stumbling block was that kikuyugrass was listed as a noxious weed in most states due to concerns that it might be a host for an insect or a fungus that could devastate the United States millet crop. The host plant relationship was disproved, but the federal government continues to list kikuyugrass as a noxious weed, citing that it has an invasive growth habit. The status of kikuyugrass currently is under review, and a ruling by the governing agency, APHIS, is expected in the coming year.

In the meantime, seed production of *Whittet* went forward in Arizona under special permit. During this time, further improvement in kikuyugrass occurred in the seed fields of Arizona as a result of natural selection. A patch of kikuyugrass with a finer texture and improved density was observed in a field of *Whittet*. The seed from the unusual patch was replanted, and the progeny displayed the same desirable characteristics, resulting in the new variety *Arizona-1* (also called *AZ-1*).

Today, kikuyugrass is managed as the primary turf in fairways and rough at several golf courses, including prominent PGA Tour stops Riviera Country Club, Torrey Pines Golf Course, and La Costa Resort and Spa.

KIKUYUGRASS CHARACTERISTICS

Kikuyugrass has been described as "bermudagrass on steroids." It is a coarse- to medium-texture warm-season grass with a rapid growth rate. The leaf width ranges from ⅛" to ¼", comparable to Japanese lawngrass (*Zoysia japonica*) and St. Augustinegrass (*Stenotaphrum secdundatum*). The wider leaf blade is typical of the native types, while the narrow leaf blade is typical of improved varieties under intensive management. The leaf blades are flat and pointed at the tip and typically grow in length from 1" to 10". Leaf color is a medium to lime-green that some golfers and superintendents find objectionable.

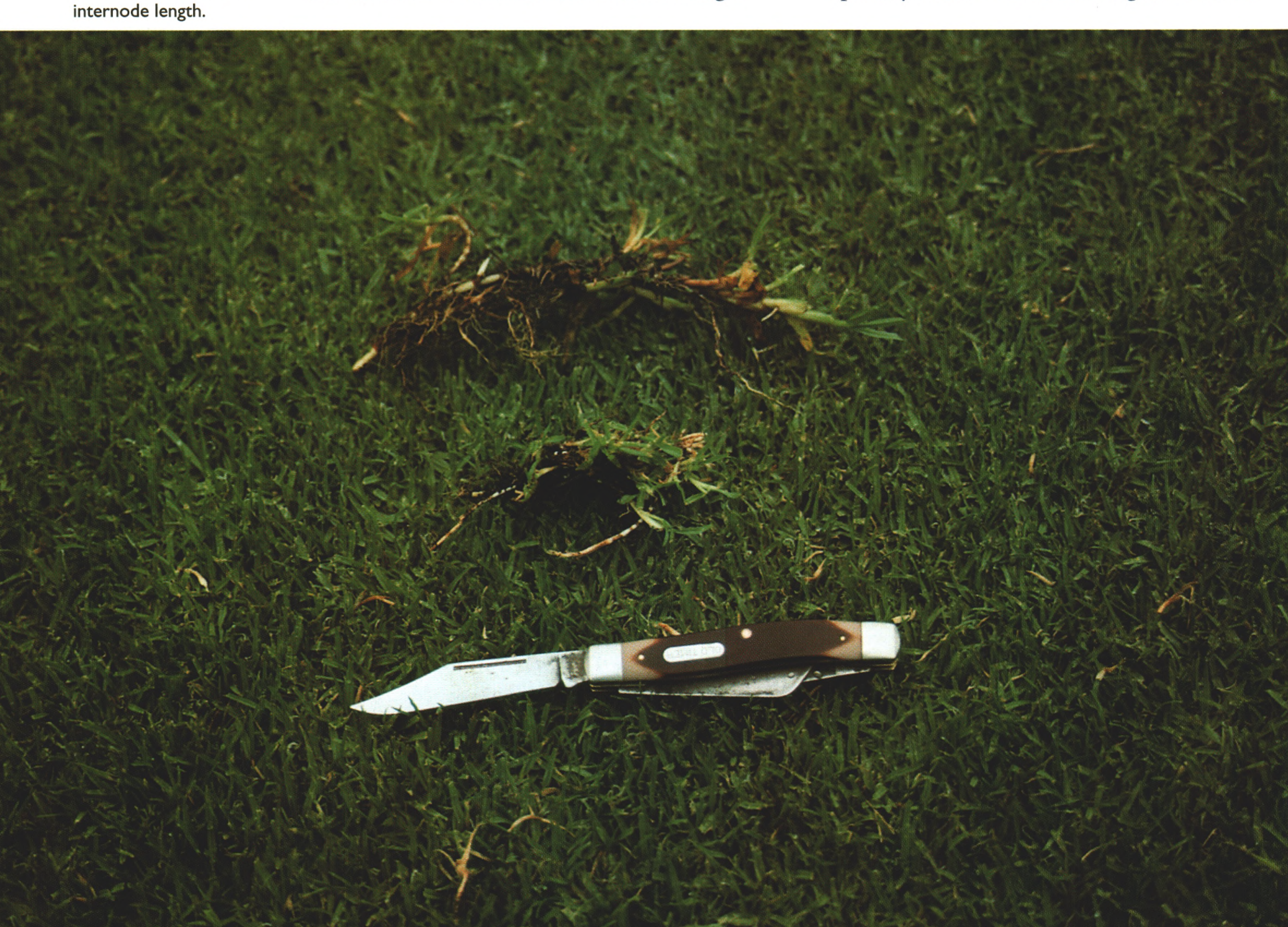
Long considered a noxious weed, kikuyugrass is now considered a desirable turf by an increasing number of golf courses in temperate climates.

Kikuyugrass is often confused with St. Augustinegrass due to similarities in texture, color, growth habit, and the thick, fleshy stolons. Kikuyugrass is distinguished by the pointed leaf tip, flat leaf blade, and the long fringe of hairs that parallels the stem near the leaf collar. In contrast, St. Augustinegrass has sharply folded leaves and blunt leaf tips. Another distinguishing characteristic of kikuyugrass is the prominent anther and white filament that extends above the canopy on closely cut turf. The white filaments typically are visible in the spring and fall, but they can be seen throughout the year in some locations. The white filaments return within a day of mowing, giving the turf a silvery cast. The female part of the flower is near the base of the plant, and the seed is formed within the leaf sheath. The seeds are rounded and dark brown, approximately ⅛" in length.

The growth rate of kikuyugrass is very rapid under warm, moist conditions. Shoot extension can exceed 1" per day at the height of the growing season. Active growth occurs at temperatures between 60° to 90°F, and it can survive well at temperatures near 100°F. Kikuyugrass sustains active growth and retains color at temperatures below 60°F, when most other warm-season grasses exhibit a loss of color and a slower growth pattern. In California, kikuyugrass may not go dormant during the winter along the coast, although it tends to enter dormancy from late November until February in colder inland valley locations. Kikuyugrass appears to have the best winter color retention of all the warm-season grasses and can tolerate light frost without a loss of color.

Kikuyugrass spreads by stolons, rhizomes, and seed. The thick, fleshy stolon and relatively wide leaf blade contribute to a somewhat open growth habit at mowing heights above 1½". Canopy density is significantly improved at mowing heights below ⅝". Rooting occurs at the nodes of stolons under moist soil conditions. Rooting is significantly restricted in dry soil, causing the turf to become puffy and more prone to mower scalping.

The rapid growth rate and thick mat layer associated with kikuyugrass contribute to excellent traffic tolerance and recovery from divot injury. The rapid growth rate is both a benefit and a challenge for maintenance. Excessive thatch contributes to spongy surface conditions, mower scalping, and diminished quality. If left unmowed, kikuyugrass has been observed growing over fences, up utility poles, and into trees and shrubs. Under routine mowing and maintenance, it can invade greens and tees unless a routine edging and hand-picking program are in place to control encroachment. Kikuyugrass provides good playing conditions and ball support when closely mowed, but the heavy thatch layer tends to limit ball roll on fairways and provides unpredictable bounces on the putting green approach. It can be especially treacherous in the rough, where the



Kikuyugrass responds well to applications of the growth regulator trinexapac-ethyl. A stolon from an untreated area (top) exhibits a wider leaf blade and greater internode length compared to a stolon from a treated area (bottom) that displays a finer leaf blade, darker green color, and shorter internode length.

thick stolons and wide leaf blades tend to grab the club and make it difficult to extract the ball.

Kikuyugrass tolerates a wide range of soil conditions. Optimum growth seems to occur in medium- to heavy-texture soils with a neutral to alkaline pH. Like many warm-season grasses, kikuyugrass has good tolerance to heat, drought, and salinity. It prefers adequate soil moisture but survives drought with a slight loss of color and a reduction in growth rate.

PROPAGATION AND ESTABLISHMENT

The irony of kikuyugrass is that it spreads rapidly where it is unwanted, but it can be slow to establish in existing turf or when efforts are made to actively cultivate and spread it. Control efforts are usually abandoned once kikuyugrass populations reach 30% to 40%. At this point, most superintendents begin active programs to cultivate and spread kikuyugrass to encourage a uniform stand.

The primary methods of propagation are sod, plugs, sprigs, and seed. The most successful method of establishment is transferring sod to provide a solid turf cover. Until recently, golf courses in the United States had to propagate their own sod in a nursery area, but commercially grown sod is now available in Southern California at a cost of approximately 85¢ to $1.00 per square foot.

Some courses have attempted to establish plugs of kikuyugrass in existing stands of bermudagrass using a specially modified aerifier that removes 2" to 3" diameter cores for transplanting. The plugs can be slow to establish even if planted in the fall when bermudagrass is less competitive. Plugs planted on 12" centers in the fall will provide reasonable coverage by the end of the next growing season.

Sprigs collected following vertical mowing can be used to establish kikuyugrass in bare or renovated areas. Stolons should be spread evenly over the soil, pressed or spiked into the surface, and topdressed with a light covering of compost to retain adequate moisture. Good establishment is usually evident within 4 to 6 weeks when temperatures are above 60°F.

Seed can be established on bare soil with relative ease. The recommended seeding rate is

A distinguishing characteristic of kikuyugrass is the prominent anther and white filament that extends above the canopy on closely cut turf, which can give the turf an objectionable silvery cast but does not affect playing quality.

½ lb. per 1,000 sq. ft. or 25 lbs. per acre. The germination percentage of the seed is approximately 85% to 90%, and germination is usually evident within 6 to 10 days when soil temperatures are 65°F or above. Seeding into existing turf has been a challenge for many superintendents. The recommended planting method is to lightly dimple the surface with a core aerifier, broadcast the seed at the rate of 1 lb. per 1,000 sq. ft., followed by a very light covering of compost. Ample moisture is critical during the germination and establishment period. Efforts to slit seed kikuyugrass into existing turf generally have been unsuccessful.

KIKUYUGRASS MANAGEMENT

While kikuyugrass can survive with only a moderate level of maintenance, a more intensive program is necessary to provide optimum playing conditions. Components of a successful management regime should include frequent mowing, thatch control, carefully controlling nitrogen applications, irrigation management, pest control, and other routine management practices.

• **Mowing.** Kikuyugrass tolerates a wide range of mowing heights from ¼" on tees and collars to greater than 2" in the rough. Because of the rapid growth rate, frequent mowing with a motor-driven reel mower is necessary to provide good surface quality and minimize scalping. Heavier cutting units are preferred over lightweight mowers because the added weight pushes the reels further into the turf canopy to help control thatch and provide a better quality cut. Daily mowing is required when the cutting height is less than ½", such as on tees and collars. Optimum cutting heights for fairways range from ½" to ⅝", with a mowing frequency of four to five times per week during the active growing season. It is recommended to maintain kikuyugrass rough at a mowing height of 1½" and not more than 2" to avoid excessively difficult conditions for the average golfer. Mowing of the rough normally is required two times per week during the active growing season. Ignoring recommended mowing frequencies can contribute to mower scalping and an unsightly appearance throughout the course. Once kikuyugrass is scalped, it can be slow to recover. To reduce scalping injury, some superintendents begin fairway mowing in the early spring at ½" and gradually raise the cutting height to ¾" by mid November, which also provides additional mat and wear tolerance during the

Advantages and Disadvantages of Kikuyugrass

Advantages	Disadvantages
Excellent traffic tolerance	Medium to coarse texture
Rapid recovery from wear and divot injury	Rapid thatch accumulation
Good heat, drought, and salinity tolerance	Medium to lime-green color
Best winter color retention of the warm-season grasses	Persistence of white filaments/anthers above the turf canopy
Active growth and color retention at temperatures < 60°F	Tendency for mower scalping
Competes against weed invasion	Frequent mowing required to control rapid growth
Tolerates a wide range of soil and water conditions	Sensitivity to herbicides
Low nitrogen requirement (2-3 lbs. per 1,000 sq. ft. per year)	

Opposite page: Kikuyugrass has a rapid growth rate and can develop a dense thatch layer as observed on this bunker lip.

winter. It is important to point out the accelerated wear on mowing equipment when maintaining kikuyugrass. The added wear typically reduces the expected life span of mowers by 10% or more.

• **Vertical mowing.** Vertical mowing is an important program for controlling rapid thatch accumulation during the active growing season. Studies at the University of California at Riverside showed that optimum quality was achieved with three vertical mowing treatments (April, July, September) at approximately the depth of the turf canopy (½"). Because of the heavy yield of clippings that must be removed and swept following such a treatment, many superintendents prefer to vertical mow lightly, approximately ¼" below the turf canopy, on a monthly schedule from April through September.

• **Aeration.** Core aeration should be performed a minimum of one time per year and preferably two to three times per year to aid in thatch control, encourage healthy root growth, and promote rhizome development. Additional treatments will be necessary where excessive thatch is a problem. Kikuyugrass also benefits from deep aeration (6" to 10") with a solid-tine aerifier in the spring. The deep aeration treatment does a better job of relieving soil compaction and also contributes to better air and water movement for healthy root growth and rhizome development going into summer.

• **Fertility.** Kikuyugrass is very sensitive to nitrogen applications, requiring only 2 to 3 lbs. of nitrogen per 1,000 sq. ft. annually. In some cases, the nitrogen supplied by effluent water is adequate to sustain active growth without the need for supplemental applications. Excessive levels of nitrogen further accelerate the already rapid growth rate and contribute to mower scalping. Research at the University of California at Riverside showed that applications of 16-16-16 at the rate of 1 lb. actual nitrogen per 1,000 sq. ft. in April, June, and August produced the best visual quality while minimizing scalping injury. Many superintendents prefer to apply 2 lbs. actual nitrogen per 1,000 sq. ft. in the late spring using a slow-release carrier and supplement with monthly applications of ⅛ lb. to ¼ lb. of nitrogen per 1,000 sq. ft. through the active growing season. Kikuyugrass responds well to applications of chelated iron and manganese to enhance green color without promoting excessive growth. Iron is often applied monthly with light rates of nitrogen as part of a spoon-feeding program. Applications of phosphorus, potassium, and other nutrients should be made based on the results of annual soil tests.

• **Water requirements.** Kikuyugrass will take as much water as you can give it, but it prefers evenly moist soil conditions for active root growth and development. Good irrigation coverage is important to prevent localized dry spots and loss of root growth that contributes to puffy surface conditions and mower scalping. Growth can be controlled to some degree by restricting irrigation as long as the soil does not become too dry. Kikuyugrass is drought tolerant but appears to require more water than other drought-tolerant species such as bermudagrass.

• **Pest control.** Kikuyugrass is sensitive to most commonly used broadleaf herbicides, which can result in discoloration and suppressed turf growth following application at recommended label rates. Many superintendents use a combination of 2,4-D, mecoprop, and dicamba at ¼ to ½ the recommended label rates to control broadleaf weeds when the turf is actively growing. Kikuyugrass is very sensitive to triclopyr and MSMA, which

Key Points for the Successful Management of Kikuyugrass

Mow frequently with a heavy, motor-driven reel mower

Light vertical mowing three or more times during the active growing season

Core aerate to control thatch and encourage root and rhizome growth

Maintain even moisture

Limit nitrogen to 2-3 lbs. per 1,000 sq. ft. per year

Edge greens and remove stolons by hand to control encroachment

Use trinexapac-ethyl to enhance color and density

are commonly recommended for control in unwanted areas. Applications of clopyralid do not appear to cause any damage and can be used to control certain broadleaf weeds without damaging the turf. Although kikuyugrass is reported to have no disease problems, many courses in California are experiencing significant damage from brown patch and take-all patch. Research by Stowell and Gelertner of PACE Research Institute indicates that applications of manganese sulfate at the rate of 1 lb. of material per 1,000 sq. ft. can suppress take-all patch and aid in turf recovery while reducing the need for fungicide sprays.

• **Use of plant growth regulators.** Kikuyugrass responds well to routine applications of trinexapac-ethyl during the active growing season. Research by Stowell and Gelertner of PACE Research Institute found that monthly applications of trinexapac-ethyl liquid from April through September at the rate of 0.2 oz. to 0.5 oz. per 1,000 sq. ft. dramatically enhanced color and density while reducing scalping injury and thatch formation. Rates of the WSB formulation of trinexapac-ethyl should be reduced by half to achieve the same results. Temporary yellowing can occur following the first application of trinexapac-ethyl, but turf color recovers within two weeks after the first application. Discoloration can be masked by the addition of nitrogen and chelated iron at light rates to the spray mixture.

• **Controlling encroachment.** Stolons of kikuyugrass can rapidly encroach into tees, collars, and putting greens if not actively controlled. Most superintendents find it necessary to edge the perimeter of greens every one to two weeks during the active growing season and remove any encroaching stolons by hand. Another method to control encroachment near greens is to establish the collar with perennial ryegrass and treat encroaching stolons with recommended label rates of quinchlorac or a combination of MSMA and triclopyr.

CONCLUSION

Superintendents have learned to successfully manage kikuyugrass as a fine golfing turf for fairways, roughs, and even tees by embracing the strengths of the grass and overcoming the problems with creative maintenance practices. The same was done in the past with bermudagrass and seashore paspalum, which were considered by many to be invasive grassy weeds until plant breeders took the initiative to improve the turf characteristics of these grasses. With recent advances in biotechnology and plant breeding, there is ample opportunity to develop new varieties of kikuyugrass that capitalize on the positive attributes of winter color retention, wear tolerance, and low fertility requirement while working to improve the texture and winter hardiness and reduce rapid thatch accumulation. It is interesting to see the beginning of such advances with the recent release of *AZ-1* kikuyugrass, and with luck and hard work, there will be more cultivars to follow. In the meantime, more and more courses are taking a kindly look at kikuyugrass and realizing that their former enemy can become their friend in an effort to provide good golfing conditions throughout the year.

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Research *You Can Use*

Ball Marks on Bentgrass: Blame the Golfer, Not the Cultivar

Contrary to popular belief, ball marks are not necessarily the cultivar's fault.

BY JAMES A. MURPHY, T. J. LAWSON, AND JOSEPH CLARK

Growth of the game of golf and advancements in turfgrass breeding have led to the construction of new putting greens or resurfacing of existing greens with new and improved bentgrass cultivars. In general, the newer bentgrass cultivars possess finer leaf texture, greater shoot and root density, and improved tolerance to pests and environmental stress relative to earlier-released cultivars, many of which are still commercially available. Nonetheless, it is common to hear superintendents who now manage the newer cultivars say that they would prefer growing older, longstanding cultivars like Penncross. Why is this so? One of the most common reasons given is that the newer cultivars are perceived to be less aggressive with regard to growth habit and recovery from divots or ball marks. Poorly repaired or not repaired at all, ball marks are a major factor that limits turf quality and playing conditions on putting greens.

Field experience and research are scarce when it comes to the durability and recuperative ability among the newer cultivars of bentgrass, especially as it relates to ball marks. Although observations about growth rate and recuperative ability on the golf course may be accurate, interpretations and conclusions based upon these observations can be confounded by a number of other factors beyond the scope of the cultivar itself. Important factors that can contribute to the severity of ball mark

Dr. Jim Murphy demonstrates the ball mark simulator during the Rutgers University Turfgrass Field Day.

Table 1

Ball mark damage ratings on a sand putting green marked on August 14 and October 20, 2001.
Entries are ranked according to recovery rating 74 days after initial marking.

Cultivar	Initial Damage 8/14/01	Damage Rating (Days After Marking)			Initial Damage 10/20/01	Damage Rating (Days After Marking)
		7	32	74		7
	Rating (9 = least damage, 1 = greatest damage)					
G-2	6.4	4.2	6.6	8.1	5.1	3.1
A-4	5.9	3.7	6.9	8.1	4.2	2.2
Century	5.6	3.7	6.8	7.9	4.7	2.9
SR 7200	6.1	4.8	6.8	7.8	5.3	2.5
L-93	4.7	3.5	5.8	7.7	5.0	2.5
Cato	5.5	3.7	6.6	7.7	5.3	2.8
Southshore	5.6	4.0	6.6	7.7	5.4	2.5
MVB	6.2	4.0	6.2	7.4	4.7	2.8
SR 1020	4.6	3.6	6.0	7.4	5.9	2.6
Putter	4.5	3.6	6.1	7.3	4.6	1.8
SR 1119	5.1	3.7	5.8	7.2	6.1	2.7
Pennlinks	5.1	3.8	5.9	7.1	6.4	2.3
Penneagle	4.7	4.0	5.9	6.8	6.3	2.8
Providence	4.6	3.4	6.0	6.7	5.5	2.3
Penncross	3.9	3.4	5.6	6.4	6.3	2.3
$LSD_{0.05}$	0.9	0.8	0.8	0.9	1.3	NS
TRAFFIC						
None	5.9	3.8	6.4	7.7	—	—
Compaction	6.0	4.1	6.8	7.9	5.5	2.6
Wear & Compaction	3.8	3.4	5.6	6.7	5.3	2.5
$LSD_{0.05}$	1.3	NS	NS	0.7	NS	NS
CV%	18.4	21.0	13.4	13.0	20.3	34.8

Cultivars in **boldface** print are velvet bentgrass species. All other cultivars are creeping bentgrass species.

$LSD_{0.05}$ = Least Significant Difference. There is a ≥ 95% probability that the difference between two means is due to cultivar effects if it is ≥ the LSD value.

NS = Not Significant. There is a ≤ 5% probability that the difference between two means is due to cultivar effects.

CV% = Coefficient of Variation (expressed as a percentage). Provides an indication of the degree of variability in measurements among cultivars at each rating date.

damage and rate of recovery include the age of the turf (maturity of the thatch and mat layers), rootzone mix and its physical properties, topdressing material, cultural management, growing environment, and turfgrass cultivar. A sound assessment of each factor, independent of the other factors, is needed to properly conclude which contributes to damage and recuperation from ball marks on putting greens.

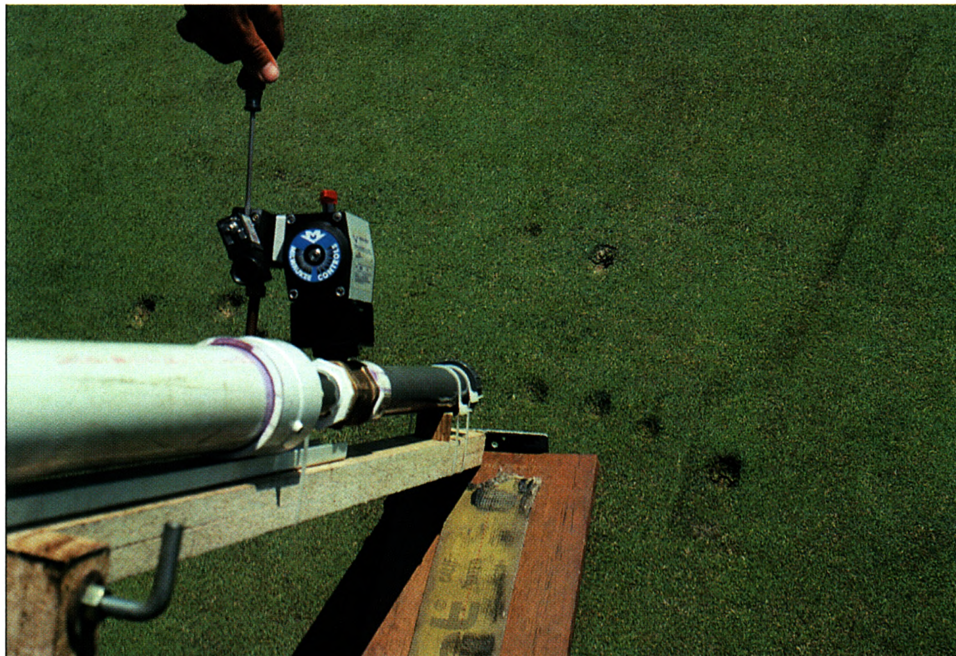
The objective of this project was to evaluate the rate of ball mark recovery among 13 creeping bentgrass and two velvet bentgrass cultivars without the confounding effects of age, construction, topdressing medium, cultural management, and growing environment.

STUDY CONDITIONS

This study was conducted during 2001 and 2002 on a sand-based putting green located at the Rutgers Horticultural Research Farm II in North Brunswick, N.J. The putting green was constructed in 1998 according to USGA recommendations using a mix consisting of 85% sand and 15% peat (by volume). Creeping bentgrass cultivars were seeded in May 1999 at a rate of .75 lb. per 1,000 sq. ft. The velvet bentgrass entries, SR 7200 and MVB, were seeded at .44 and .88 lb. per 1,000 sq. ft., respectively. During the study, turf was mowed six to nine times per week at .115" and fertilized with 3.9, 2.8, and 2.9 lbs. of N, P_2O_5, and K_2O per 1,000 sq. ft., respectively, in 2001 and 1.8, .6, and .6 lbs. of N, P_2O_5, and K_2O per 1,000 sq. ft. in 2002. The plots were cultivated with solid tines once or twice and topdressed three to five times per season with a medium sand. Some layering of topdressing and thatch was evident, but this did not produce management or performance problems related to excessive puffiness, scalping of the turf, poor water infiltration, or rooting of the green. The combined thickness of the thatch and mat layers was less than one inch during the evaluations reported here. Irrigation and fungicides were applied as needed to avoid drought and disease stresses.

Traffic treatments were initiated in October 1999. Wear and compaction treatments were applied four times per week using a modified walk-behind Sweepster and a Brouwer water-filled turf roller, respectively, from May through September. Compaction treatments also were applied using a one-ton Wacker pavement roller that occasionally was operated with vibration applied to the rollers.

The experimental design consisted of a split-plot factorial arrangement of treatment combinations: four levels of traffic (no traffic, wear, compaction, and wear plus compaction) represented the main plots, and 15 bentgrass cultivars represented the sub-plots, with three replications of each combination.



Two or three ball marks were made in each research plot. Visual ratings were taken to evaluate initial severity and subsequent recovery over time.

Ball marks were simulated by pneumatically ejecting golf balls from a PVC cylinder at a static pressure of 6, 8, or 10 p.s.i. Two or three marks were made in each plot. Visual assessments were made for initial severity as well as recovery of ball marks.

RESULTS

Significant differences in ball mark damage and recovery were found among the bentgrass cultivars grown on sand on most rating dates in 2001 (Table 1). In general, less damage and more rapid turf recovery occurred on the newer bentgrass cultivars, notably A-4 and G-2, which are being increasingly used on golf courses in the Northeast and throughout North America. Contrary to common perceptions, the velvet bentgrass cultivars SR 7200 and MVB also ranked among the best in regard to injury and recovery. On the other hand, older cultivars like Penncross incurred the most damage from ball marks and also took the longest time to heal.

Not surprisingly, ball mark injury was more severe and recovery time was slower on turf that received a combination of wear and compaction. Interestingly, cultivars that received only compaction treatment did not respond differently to ball marking compared to non-trafficked cultivars, indicating that

Results showed that ball mark injury and recovery were exacerbated by simulated wear using a modified walk-behind Sweepster.

Table 2
Ball mark damage ratings on a sand putting green marked on July 13 and 26, 2002.
Entries are ranked according to recovery rating 27 days after final marking.

Cultivar	Initial Damage 7/13/02	Damage Rating (Days After Marking)			Initial Damage 7/26/02	Damage Rating (Days After Marking)		
		7	25	41		11	19	27
	Rating (9 = least damage, 1 = greatest damage)							
Century	3.9	5.8	8.3	8.7	4.7	6.1	6.8	7.5
MVB	5.6	6.4	8.2	8.1	5.8	6.8	7.1	7.3
A-4	5.0	6.1	8.3	8.3	4.7	5.9	6.5	7.0
SR 7200	5.2	6.7	8.0	8.2	5.0	5.7	6.3	6.8
L-93	3.9	5.0	8.5	7.8	4.6	5.4	5.9	6.8
Cato	2.7	3.8	7.9	7.3	4.7	5.3	5.3	6.3
G-2	4.9	6.1	8.7	8.6	5.0	5.3	5.5	6.1
Penncross	3.2	5.0	7.6	7.3	3.8	4.5	4.9	5.9
SR 1119	3.5	4.8	8.1	8.3	4.6	5.3	5.7	5.8
Putter	2.9	4.6	8.0	7.9	3.4	4.8	5.0	5.8
SR 1020	3.8	5.5	8.5	7.8	3.6	4.8	4.9	5.7
Southshore	4.8	5.6	8.2	7.8	4.3	4.6	4.9	5.7
Pennlinks	3.0	3.8	7.5	7.3	4.0	4.1	5.2	5.5
Penneagle	3.8	4.7	7.6	6.3	4.0	4.7	4.6	5.5
Providence	3.3	4.7	8.1	7.4	4.3	4.9	5.1	5.4
$LSD_{0.05}$	1.6	1.5	NS	NS	0.7	0.8	0.7	0.7
TRAFFIC								
None	—	—	—	—	4.5	6.5	7.1	7.7
Wear	—	—	—	—	4.8	5.4	5.6	6.4
Compaction	—	—	—	—	3.7	5.2	5.8	6.8
Wear & Compaction	—	—	—	—	4.7	3.9	3.9	4.1
$LSD_{0.05}$	—	—	—	—	NS	NS	NS	NS
CV%	28.1	19.1	7.1	12.9	15.2	15.0	11.4	11.2

Cultivars in **boldface** print are velvet bentgrass species. All other cultivars are creeping bentgrass species.

$LSD_{0.05}$ = Least Significant Difference. There is a ≥ 95% probability that the difference between two means is due to cultivar effects if it is ≥ the LSD value.

NS = Not Significant. There is a ≤ 5% probability that the difference between two means is due to cultivar effects.

CV% = Coefficient of Variation (expressed as a percentage). Provides an indication of the degree of variability in measurements among cultivars at each rating date.

wear damage, more than compaction, exacerbates the problem of ball mark damage. This suggests that the management practice of rolling for increased ball roll would only exacerbate ball mark damage when the turf was experiencing aggressive damage from wear. Cultivars receiving wear treatment only were not assessed in 2001.

The ball mark experiment on sand was repeated two additional times in 2002 (Table 2). Relative injury and recovery among cultivars was similar to 2001; however, results from 2002 suggest that an additional year of turf maturation narrowed differences among cultivars and helped to expedite recovery from ball marks. Although fewer significant differences were found with respect to the effects of traffic on ball mark injury and recovery, general trends once again indicated that ball injury and recovery time are exacerbated by the presence of both wear and compaction stress. Thus, management efforts to substantially reduce either wear or compaction should improve turf tolerance to ball marking as well as recuperation.

CONCLUSIONS

Currently, some golf course superintendents and architects are reluctant to use improved and better-adapted cultivars of bentgrass because of unsubstantiated field observations and conclusions that these newer cultivars are less aggressive and slower to recuperate when compared to earlier-released cultivars like Penncross. Thus, they continue to choose older cultivars largely because of the comfort of knowing their growth habit and performance characteristics. While turf vigor and recuperative ability are no doubt related to the cultivar genetics, it appears that other factors including turf maturity are more responsible for field observations of severe ball marking problems.

Today, newer cultivars are established on rooting media that contain a high percentage of sand. In most cases, these greens have not had time to mature (develop a mat layer) to the point where performance and play are similar to older sand- or soil-based greens that superintendents are accustomed to managing. Furthermore, superintendents should consider the possible role that annual bluegrass plays in their perception that older cultivars (e.g., Penncross) were more aggressive than the newer monostands of cultivars they now manage, especially during the spring when annual bluegrass growth is considerably more aggressive than bentgrass. Furthermore, observations of rapid healing of ball marks on older Penncross putting greens may be due to the rapid invasion of annual bluegrass seedlings into the damaged ball marks rather than healing from the bentgrass cultivar itself.

Age of a putting green turf is probably the most important confounding factor affecting people's perception of newer bentgrass cultivars. The highly attractive cover of a newer bentgrass cultivar on a recently established green may provide a false sense of maturity occurring under that turf cover. In reality, it likely will require two or more complete growing seasons before the subsurface mat layer and rootzone stabilize and become resistant to the forceful impact and spin of a golf ball. This stability and impact resistance is largely a function of the soil structure that develops from the growth of crowns, stolons, and roots in the upper surface layers of the putting green. Over time, these parts of the grass plants become integrated with the rootzone and topdressing material applied to the surface. Subsequently, as this interwoven mixture of grass and soil develops, a structure analogous to a fiber mat is formed, adding strength and stability to the putting surface. Much lecturing and discussion is focused on how to manage excessive layering of this mat relative to the health of the turf, when in fact the contribution of the mat layer to the durability of a putting green is often overlooked.

In summary, whether you're contemplating or currently managing newer bentgrass cultivars, recognize that time and patience are needed for maturation of new putting greens, and realize the cultural management that worked for older cultivars like Penncross may not be what's best for cultivars that are finer textured and considerably more dense. One only has to look at the National Turfgrass Evaluation Program on-site putting green trials (http://ntep.org/-onsite/ost.htm) to see how advancements in breeding have produced bentgrass cultivars with improved turf quality characteristics and tolerance to stress. Last, but certainly not least, did we fail to mention that it would be extremely helpful if golfers repaired their own ball marks?

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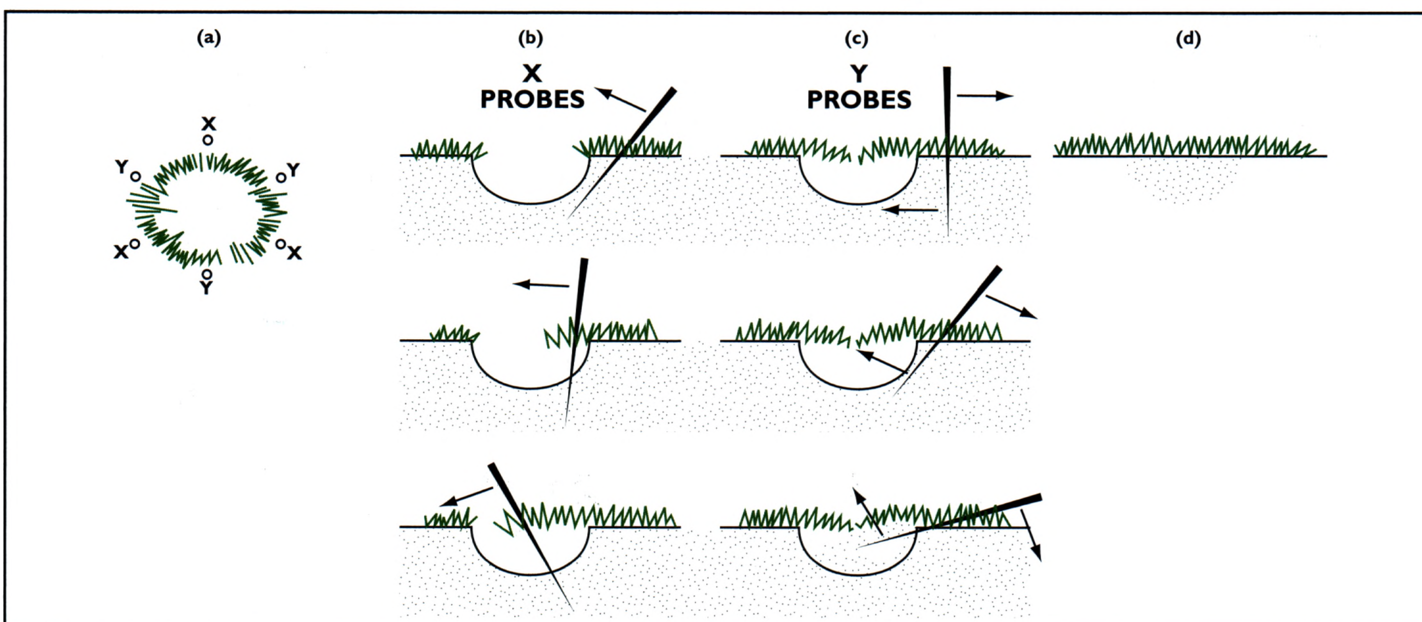


Proper repair of ball marks is more than just quickly stabbing a ball mark with a golf tee. By taking a few moments to follow the proper procedure, the number of ball marks found on putting greens would be reduced considerably. Procedure for repair of ball marks on putting green: a) X-marks indicate probe penetration to stretch the turf over ball mark; Y-marks indicate probe penetration to loosen and raise the soil. b) Stretch turf by inserting the sharp probe into the soil at a 45° angle and 0.5" outside the perimeter of the ball mark and moving the probe toward the ball mark and down. c) Loosen soil beneath the ball mark by inserting the probe vertically into the soil at 0.5" outside the perimeter and pressing away from the ball mark and down. d) Firm turf with a putter, the palm of the hand, or a shoe. (*Turf Management for Golf Courses*, James B. Beard, 2002, page 148).

DONATE YOUR GREENS

Use your golf course as a research test plot prior to renovation.

BY CHUCK GAST

Members of the research team from the University of Arkansas discuss herbicide test results on the 15th green at the Country Club of Little Rock.

Everyone remembers the old sage advice ... "When opportunity knocks, you should at least open the door and see what's on the other side." Well, I believe that we, as superintendents, have been letting a valuable opportunity pass by without even considering it.

As you've probably figured out already, this article is about conducting a few unobtrusive research tests by utilizing test plots on an out-of-the-way turf area. Well, not exactly. Most good superintendents already perform subtle trial-and-error experiments on the nursery green or the maintenance shop lawn, so that wouldn't be much of an eye-opener. What I'm suggesting is to take it a step or two further: an entire golf hole, tee to green, and don't hold back. Let me explain.

As mentioned, we've all conducted our own test plots over the years to help determine the best course of action at our facility. But let's be honest — we probably don't treat it as routinely as we should to get the most accurate information, as we've got another 120+ acres that need to be healthy.

We took this turfgrass idea a step further when Dr. Jim Robbins from the University of Arkansas phoned one day and asked to conduct some fertility tests on our El Toro zoysiagrass fairways. What better way to get accurate data specific to our golf course while helping others to benefit from our research? We staked out a small plot at the beginning of the fourth fairway, where Dr. Robbins performed all the work on a very routine basis. Our only request was to be gentle, as this area was in play.

Then, early in 2001, the Country Club of Little Rock embarked on a major renovation program fueled primarily by the need for an expanded practice facility at this nearly 100-year-old country club. To expand the range, located internally on the course, two golf holes were to be added on the perimeter of the property to compensate for the two holes that were to be ungulfed and eliminated by this range-expansion project.

That's when the idea hit me — how about conducting some full-blown, no-holds-barred experiments on this defenseless, soon-to-be-executed turfgrass? The first step was to run it by the Golf Committee before performing hari-kari on their golf course. After that, it didn't take long to figure out that I didn't have the expertise or the time to devote to this project, especially in the middle of a major renovation program. A couple of phone calls later to Dr. Jim Robbins, horticulture specialist, and Dr. John Boyd, weed scientist, both the with University of Arkansas Turfgrass Program, set the stage.

It was like Christmas all over again. The excitement in their voices with the initial phone call, not to mention the look on their faces when they arrived at the course with their "house call" doctor's bag in hand, was just the beginning of the fun. As approved by the Golf Committee, these designated turfgrass areas on the 15th hole, tee to green, were theirs to do with as they wished for the advancement of turfgrass science, with environmental awareness in mind. My job was to continue our routine turfgrass programs to provide a real-time experimental scenario and otherwise stay out of the way. Keep in mind that these golf holes were still in play at the onset of these trials around the middle of March, and play continued through the end of June, when the bulldozers arrived.

Throughout the spring of 2001 it was intriguing to watch the turfgrass reaction to the variety of experiments to which it was subjected. Dr. Robbins focused a number of fertilizer sources and rates on the SR 1020 bentgrass greens as well as the Meyer zoysiagrass collars. The full gamut of too little, too much, and just right was clearly evident on plots throughout his test areas.

Similarly, Dr. Boyd's herbicide trials provided very clear and dramatic results. Dr. Boyd focused primarily on the response of the SR 1020 bentgrass to various herbicides and rates. The damage to the bentgrass illustrated what can happen when herbicides are misused on greens mowed at 0.13" and subjected to an annual rate of 28,000+ rounds a year.

Throughout this testing period, the trials were evaluated and photographed by Robbins, Boyd, and their associates. Our facility is closed on Mondays until 12:00 noon, and this window provided a routine, unobstructed time frame to conduct a majority of their experiments. Additional observations throughout the week were conducted at their discretion during early morning hours.

To assist in our efforts of spreading the word to our members as to our "diabolical" plans on the 15th hole, we installed a small, inexpensive sign at the back of the green, explaining the Golf Committee's approval and the intended experimental procedures. This provided an on-site explanation as the turfgrass took on a patchwork look during the research efforts.

While the scientists were performing various tests on the green, we were conducting our own little drought tolerance test on our El Toro zoysiagrass fairway. Since the irrigation system was undergoing a complete overhaul during this same time period, we took the opportunity to experiment with the El Toro. This fairway was to be eliminated to make way for the driving range landing area, and the existing irrigation system was cut off, to be replaced later as the range was expanded. Consequently, this old fairway area did not receive any supplemental irrigation for well over a four-month period, from the middle of March through the beginning of August. To nobody's surprise, the El Toro zoysiagrass was dormant by mid-June as it entered into some stage of drought avoidance.

A sign doesn't have to be deluxe to communicate a message. An inexpensive yet effective sign was placed behind the 15th green site to provide an on-site explanation of the programs underway.

Around mid-July, it was determined that the newly renovated 14th fairway would be ready for sod within a few weeks. Rather than bulldoze the existing turf on the old fairway, we brought out the hoses and roller base sprinklers and surprisingly resurrected the straw-colored turf. With the help of the local Quail Valley Farm turfgrass producer, we harvested the zoysiagrass and recycled it on the new 14th fairway. We gained some valuable knowledge about the true toughness of El Toro and saved the club some construction costs in the process. The entire procedure was a win-win all the way around.

Throughout this process, we gained factual and pertinent information directly relative to our specific turfgrass and growing conditions. We were able to define treatment options and accurately determine limits of exposure to various materials at different application rates, and we gained valuable on-site information about the response that could be expected when turfgrass is pushed to the limit with regard to irrigation application. Plus, all this was accomplished through the assistance and guidance of professional turfgrass researchers.

In retrospect, the only regret relative to this entire operation is the fact that we didn't start sooner, thereby allowing more time to conduct more exercises. Once we initiated this program, it became evident that we were limited in our treatment options, as the deadline for renovation/construction was set.

Therefore, the take-home message is this: As turfgrass managers, we all have future plans and goals that we would like to accomplish in specific areas throughout our facilities. Rather than focus just on the obvious renovation procedures, give some consideration to the potential information that can be learned through turfgrass trials prior to firing up the bulldozers. Begin to formulate ideas and topics of interest well in advance of the project, so that once the renovation schedule is in place and you receive proper approval, you can immediately initiate controlled studies specific to your facility. By all means, don't forget to include local university turfgrass research personnel in the program for the most accurate test data.

As turfgrass managers in today's marketplace, we must constantly strive for improved turfgrass quality through efficient management practices. What better way to fully understand the specific parameters of your turfgrass than through real-time test trials with the help of turfgrass researchers?

So, the next time opportunity knocks, don't waste a valuable learning experience. Donate your greens!

CHUCK GAST, *CGCS, has been the golf course superintendent of the Country Club of Little Rock since 1999. From 1990 to 1995, he was an agronomist with the USGA Green Section's Florida Region.*

Each morning many putting green maintenance tasks are completed before play begins. Don't consider the maintenance needed for daily play to be on the same level as preparations for special events.

PUTTING SURFACE PACE

Some factors can be controlled; others cannot. Are you prioritizing properly?

BY KEITH HAPP

Week in and week out, televised golf events portray tournament and championship venues as landscapes of perfection. The behind-the-scenes stories and efforts to prepare these venues often are not discussed by announcers, leading golfers to believe that these sites are maintained in this manner every day of the year. What is often lost during the hectic golf season is that the playing surfaces are alive and, as such, their performance is subject to many factors. Weather, maintenance equipment, and agronomic factors all impact putting green speed and ball roll. Although many agronomic factors affecting putting green performance are controllable, not all facilities have the maintenance infrastructure to implement proactive procedures. Many factors that affect putting green speed and performance are just not controllable. Weather is the leading factor that affects plant health, turf growth, performance, durability, and green speed.

Green speed is measured with a Stimpmeter. This tool is a management device that allows surface pace to be evaluated and monitored on a specific course, but it should not be used to compare putting surface performance between courses. There are too many variables, such as budget, labor resources, equipment, and golfer demands, to allow fair and valid comparisons

A polystand consisting of *Poa annua* and bentgrass presents many challenges when trying to condition putting surfaces for play in the spring. Differing growth rates between species affect ball roll.

to be made. Use of the Stimpmeter provides assistance in preparing the greens for special events.

Stimpmeter readings on American golf courses generally range from 7 feet to 12 feet, depending on many factors (e.g., slope, contours, green size, grasses, weather, budget, etc.). Experience shows that trying to keep the speed above 10 feet on a consistent basis usually causes difficult-to-manage turf problems and is not recommended. Standards or an acceptable range for green speed should be established to help manage turf health and the variables associated with putting green performance. Well-defined expectations, which should include a reasonable margin of variability, allow maintenance programs to be developed that can achieve realistic putting green performance goals within a predetermined budget.

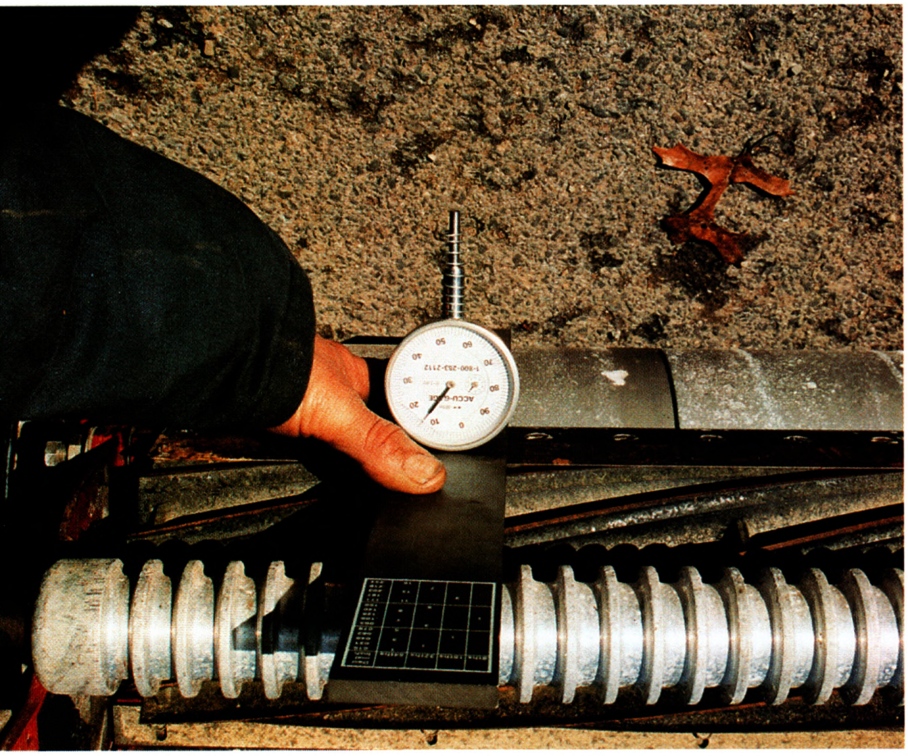
There are a number of management techniques that can be implemented to achieve the desired ball roll and green speed. The key is to produce the desired pace without crossing the line and exerting undue stress that predisposes the turf to many potential problems.

AGRONOMIC FACTORS

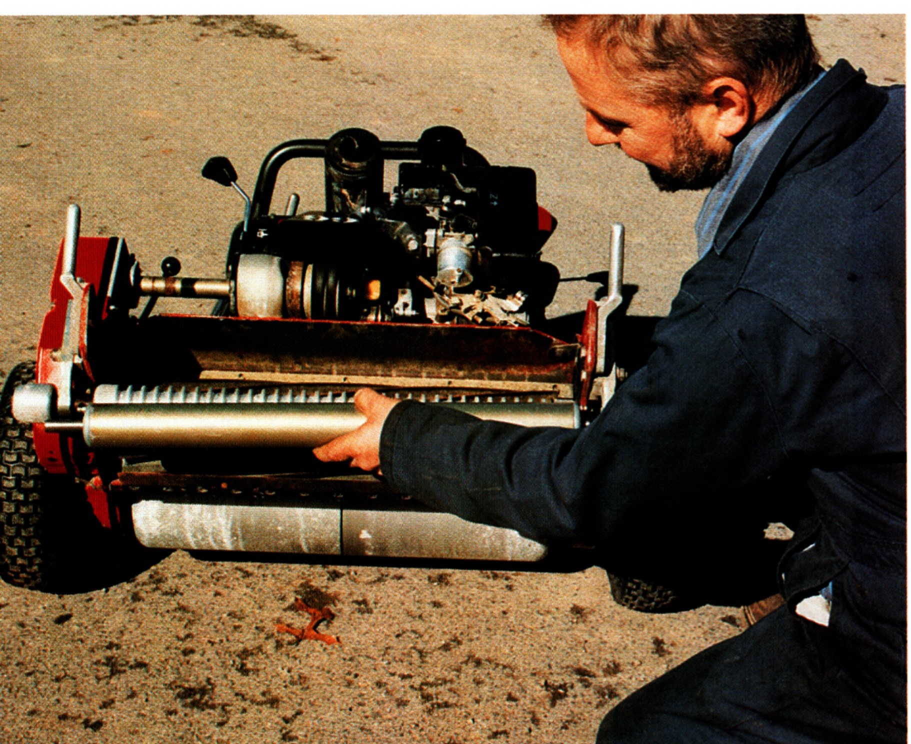
To condition turf for putting, a number of issues have to be examined. These include: soil texture (well drained vs. not well drained), thatch accumulation, grass type (*Poa annua*, bentgrass, bermudagrass), consistency of turf stand (mono vs. poly stand), green size, traffic stress, and environmental conditions such as shade.

Soil texture affects drainage capacity and moisture retention. Heavier soils tend to retain water, are prone to footprinting, and are subject to compaction problems. Surface drainage characteristics play a critical role with regard to management of soil moisture. Not all surfaces have adequate surface drainage characteristics to overcome less-than-adequate soil texture. Green speed and performance are affected by wet soils. In fact, attempts to maintain a high green speed under saturated soil conditions can result in catastrophic turf failure. Scalping damage can easily occur, weakening the plant and having an immediate impact on natural defenses against disease infection. If the turf is subject to excessive shade, further complications will result. The duration of leaf wetness and soil saturation is extended when direct sunlight exposure is limited. Under these conditions, rapid turf decline could be experienced if excessive green speed is demanded.

While some thatch is essential, too much is detrimental. Pest issues are more difficult to control and mower scalping is always an issue on playing surfaces that have accumulated excessive



It takes more than a close shave to prepare putting greens for play. Prolonged use of close mowing predisposes the turf to a multitude of pest issues and potential problems.



Mowing with grooved rollers and using grooming attachments can enhance putting surface performance. However, weather factors must be taken into consideration before these attachments are used for an extended period of time.

organic matter. Maintaining a reasonable amount of thatch (¼ to ⅜ inch) is beneficial. For example, some thatch is necessary to maintain a "mat" that provides a level of protection and resiliency against traffic stress and ball impacts. With regard to green speed, excessive thatch decreases ball roll. When thatch accumulations are managed, maintenance programs focused on increasing ball roll are much more effective. Basically, there is an inverse relationship between thatch accumulation and putting green performance. Putting quality and turf health decrease as thatch accumulation increases.

Additionally, there will be some inconsistency on small greens that have limited hole locations and/or offer limited entrance and exit points to the green. Focused wear compacts thatch, and in these areas ball roll is faster. In areas that do not receive the same level of traffic, varying green speeds often result.

Grass species affects ball roll. Basal tillering grasses such as *Poa annua* and the newer bentgrasses can offer excellent playing quality. Their upright growth habit allows the ball to roll on the tips of the grass leaves, versus rolling across the leaf blades of an aggressive creeping grass variety. Older bentgrasses, for example, are characterized by their lateral, stoloniferous growth habit. This results in a grainy appearance that, if left unmanaged, negatively impacts ball roll. A polystand of turf can pose problems during certain weather conditions. Trying to get Penncross creeping bentgrass to grow upright in the spring is a difficult and sometimes losing proposition. Aggressive efforts to alter the natural growth can easily predispose the turf to damage later in the season. A polystand of grass will take longer to condition, but as the weather becomes more favorable, excellent surfaces can be presented.

Surface contours directly impact putting green speed. Severely sloping greens present problems due to the gravitational forces exerted on ball roll. Requests from golfers to obtain unrealistic green speed up a slope can result in unplayable conditions when faced with a downhill putt. Additionally, when green speeds soar on severely undulating greens, usable hole locations will be lost, resulting in concentrated traffic and turf wear.

MAINTENANCE FACTORS

All too often the mowing height is used as the sole strategy to achieve the desired putting green speed. Golfer expectations are a driving influence on putting green maintenance programs in general and putting green mowing heights in particular. Indeed, golfer expectations have pushed the mowing height issue to the limit of what a turfgrass plant can withstand. Currently, equipment is capable of cutting putting green turf to a height of 1/16". This equates to .0625 inch or, in metric terms, just above 1.5 mm. That is approximately the thickness of a nickel. Excessively low height of cut does not leave any margin for error. It also doesn't leave adequate leaf tissue for the plant to produce the essential ingredients for sustained growth. We are rapidly approaching mowing heights that are, in effect and in reality, cutting the life out of the turf. Ultra-low mowing heights *cannot* be sustained throughout the season without experiencing some level of surface deterioration.

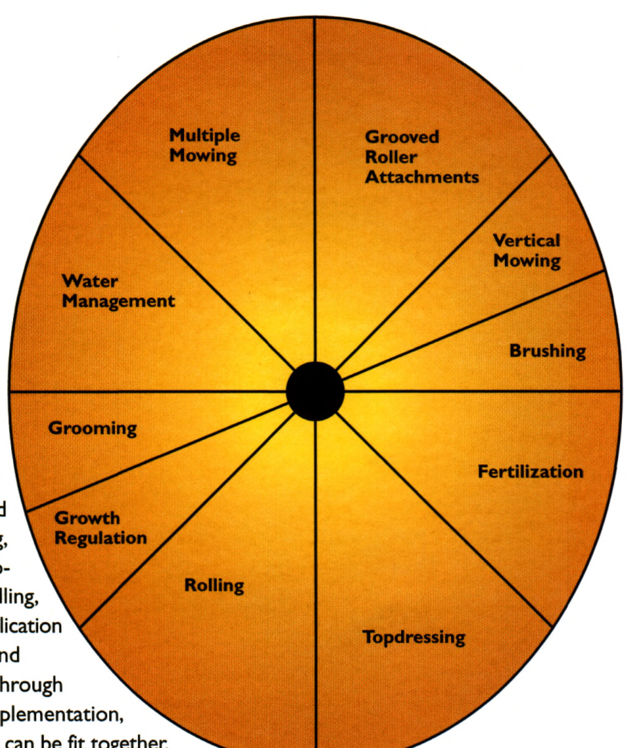
A number of strategies can be integrated into a holistic program to produce the desired ball roll and pace. Courses that host tournaments perform these tasks regularly to prepare for the special event. Preparation often begins months and sometimes years prior to the event, depending upon the scope of the competition. Five to six years of specific preparation can go into conditioning a golf course for a U.S. Open Championship. The turf is conditioned and plant health is maximized so that it can better tolerate aggressive maintenance regimes and the high volume of play that will be experienced over a short period of time. Maintenance programs are fine-tuned to deliver precise playing conditions. Green speed is a result of efforts to produce optimum ball roll. Once the competition is completed, maintenance regimes are readjusted to support everyday play and turf health.

There has been a great deal of research conducted on the maintenance factors affecting putting green speed. However, there is an art to utilizing these strategies successfully. A balance should be maintained and a certain amount of discretion should be exercised to avoid compromising turf health for prolonged periods of time. Knowing "when to hold 'em and when to fold 'em" applies to turfgrass management. No program should be set in stone, and some level of compromise will always be necessary.

Basic agronomic programs must be in place in order to grow grass that can tolerate aggressive surface preparation strategies. While some thatch is essential, too much is detrimental.

CHRISTOPHER HAPP

There are controllable and uncontrollable factors that affect putting green speed. The weather greatly influences the pace that the ball travels over the surface.



Maintenance strategies that can be used to influence putting green speed include but are not limited to: multiple mowing, use of grooved rollers, vertical mowing, brushing, grooming, topdressing application, rolling, water management, application of growth regulators, and balanced fertilization. Through planning and careful implementation, the pieces of the puzzle can be fit together.

WEATHER FACTORS

Climatic conditions affect the growth of the grass plant, which directly impacts surface performance. Environmental conditions make a difference and must be factored into the strategies that may be used to produce the desired green speed. For example, green speed will drop during periods of high humidity and/or high soil moisture. The effect is even more pronounced if excessive thatch accumulations are present. When moistened, thatch swells. This is when footprinting and scalping damage can occur. Efforts to counteract this natural phenomenon should be in place well in advance of the condition.

Conversely, when humidity is low and the soil is dry, desired green speeds are easier to maintain. In the Mid-Atlantic Region, these conditions are more often experienced in the spring and fall. Favorable soil temperatures result in consistent and reliable turf growth that allows conditioning programs to be more effective. Soil temperature can be used as a means of detecting changes in turfgrass growth. Favorable temperature regimes allow the turf to tolerate aggressive maintenance practices without experiencing rapid turf decline. Basically, cultural strategies implemented in the fall and continued in the spring prepare the turf for the dog days of summer, and this has a great impact on the level of playing consistency that can be expected.

CONCLUSION

Providing putting surfaces that offer true and consistent ball roll is not as simple as lowering the mowing height. Many variables need to be considered when designing putting green management strategies. The first and most important step is to have well-defined criteria for putting green conditioning. Break down the criteria even further to distinguish between regular daily play and special events. Establish an acceptable range of putting green speed for each category of play. Then weather, maintenance infrastructure, and agronomic factors can be evaluated to produce putting green performance criteria that are realistic and, most importantly, tailored to your operation.

KEITH HAPP *is an agronomist in the Mid-Atlantic Region, visiting courses in the states of Delaware, Maryland, Pennsylvania, Virginia, and West Virginia.*

Research *You Can Use*

Field Testing Plant Growth Regulators and Wetting Agents for Annual Bluegrass Seedhead Suppression

Researchers use Chicago-area golf courses to explore suppressing annual bluegrass flowering.

BY RANDY KANE AND LEE MILLER

Left: Research supported by the Chicago District Golf Association tested the ability of plant growth regulators and wetting agents to suppress annual bluegrass seedhead formation. Above: Heavy *Poa annua* seedhead formation on Midwest putting greens is typical in mid to late May in most years.

Many of the annual bluegrass biotypes inhabiting the golf courses of Illinois have a *winter annual* life cycle. That is, these biotypes germinate from seed in autumn, overwinter in a vegetative state, flower and set seed in the spring, and then decline or completely die out during the heat of summer.

Where annual bluegrass is a significant component in a turf, profuse seeding may occur in late April through May and can become objectionable for several reasons. First, profuse seeding can turn an annual bluegrass-contaminated green or fairway almost white in color, prompting questions about grass health. Second, putting greens with significant annual bluegrass populations provide very poor putting surfaces during spring flowering. Seedheads adversely affect ball roll, causing greens to become slower and more bumpy. Third, heavy seeding of annual bluegrass contributes to the seedbank in surface soil and thatch layers, thus promoting the long-term survival and spread of the species.

There is a growing body of evidence that suggests heavy seeding may not be beneficial for the near-term survival of flowering annual bluegrass. Seed production may divert photosynthate away from vegetative tissues (leaves and roots) to the flowers, resulting in reduced root depth and shoot growth after seeding. Annual bluegrass that hasn't set seed (e.g., in treated plots) is usually better able to survive summer stresses than plants that have flowered and set seed (2). It is interesting to note that most of the plants identified as *perennial biotypes* of annual bluegrass produce less seed than *annual biotypes*, which may contribute to their longer-term, perennial habit.

Chemical seedhead suppression can help maintain the color and playability of fairways, as well as the speed and trueness of putting greens. Also, many superintendents feel that by reducing seed set and the annual contributions to the seedbank, other chemical and management programs used to reduce or eliminate annual bluegrass from cool-season turf may become more effective. There also is a great deal of interest in trying to preserve the purity of newly renovated turf by keeping nearby annual bluegrass from contaminating the renovated site (e.g., a resurfaced putting green).

TECHNIQUES TO INHIBIT ANNUAL BLUEGRASS FLOWERING

How do you reduce or suppress annual bluegrass seed set in the spring? Several herbicides and plant growth regulators are known to inhibit seeding of *Poa* species and other grasses, including older products like maleic hydrazide, mefluidide, and endothal (Table 1). However, most products used in annual bluegrass programs have problems with consistency of seedhead suppression, length of time seedheads are suppressed, or phytotoxicity. Also, application timing and proper stage of plant growth are critical for best seed inhibition, and calendar dates for application may vary widely from year to year. Note that there is a "base-50" growing-degree-day prediction model for timing of the first spray for seedhead suppression (3), but this model seems to be as unpredictable as the annual bluegrass itself (Table 2).

Historically, the best results for seedhead suppression on annual bluegrass fairways have been found using mefluidide ("Embark") (1, 5). However, timing and phytotoxicity problems have limited its use, especially on greens-height turf. Many superintendents have tried early spring applications of gibberellin inhibitor plant growth regulators (PGRs) such as paclobutrazole ("Trimmit") or flurprimidol ("Cutless") to try to slow the encroachment of annual bluegrass into bentgrass turf. They reported some seedhead suppression following early season treatments, but seedhead suppression usually is not the primary goal of these applications.

A few adventurous superintendents have also used the wetting agent Aqua-Gro L (5) to limit spring flowering of annual bluegrass, and they have found that Aqua-Gro is less phytotoxic than Embark, but it provides more variable results. (Aqua-Gro L is no longer manufactured.)

Embark Turf & Ornamental can cause discoloration and thinning of creeping bentgrass mowed at greens height-of-cut (below pen).

Preliminary field tests have suggested the ethephon ("Proxy") has good activity for annual bluegrass seedhead suppression (4). Proxy is a new PGR for the turf market, but it has been available in agricultural applications for years. Proxy may be safer and have more timing flexibility than Embark, and it could be a potential substitute for Aqua-Gro L. Proxy reportedly has the tendency to make treated turf lighter green to yellow-green, but this can be counteracted to some extent with iron applications. Also, tank-mixes of Proxy plus trinexepac-ethyl (Primo) have shown good results with less turf discoloration.

PRODUCTS TESTED AND APPLICATION TECHNIQUES

Three golf course sites were treated with PGRs and wetting agents in April and May of 2000-02, including both greens- and fairway-height turf. Initial treatments were timed to coincide with flowering of the earliest annual bluegrass biotypes. Individual plots were 40-50 sq. ft. in size and were replicated two or three times, depending on space available. Treatments were applied with a CO_2-powered backpack sprayer (35 psi, flat fan nozzles).

Proxy was tested alone and in tank mixes with Primo and Trimmit. Single and multiple applications of Proxy were made at 5-7.5 fl. oz. per 1,000 sq. ft. rates. Primo was applied alone and in tank mixes at 5-10 fl. oz. per acre. Trimmit was applied at rates ranging from 6-8 fl. oz. per acre. Aqua-Gro L

has been tested for a number of years on putting greens at 8 fl. oz. per 1,000 sq. ft., usually with follow-up applications at 4-8 fl. oz. per 1,000 sq. ft. one week later.

The wetting agent Cascade was also included in the study to see if a different type of wetting agent chemistry could inhibit seedheads (note that the manufacturer makes no claims of seedhead control). Embark (Turf & Ornamental Growth Regulator formulation) at 1.3 fl. oz. per 1,000 sq. ft. was included as a standard, and to test for phytosafety on greens-height turf.

SUMMARY OF RESULTS FROM EARLY STUDIES

A general overview of field test data from Chicago area trials in 2000-01 on greens-height turf can be found in Table 3. Note that the percent seedhead

Table 1
Chemicals that have been used for annual bluegrass (*Poa annua* L.) seedhead suppression

Trade Name	Common Name	PGR Mode of Action
"MH" or SlowGro	Maleic hydrazide	Type I cell division
Endothal	Endothal	Type I cell division
Embark	Mefluidide	Type I cell division
Prograss	Ethofumesate	Type I (?)
Enhancer, Trimmit	Paclobutrazole	Type II GA inhibitor
Cutless	Flurprimidol	Type II GA inhibitor
Primo	Trinexepac-ethyl	Type II GA inhibitor
Proxy	Ethephon	Ethylene effects
Aqua-Gro L	NA (wetting agent)	Unknown

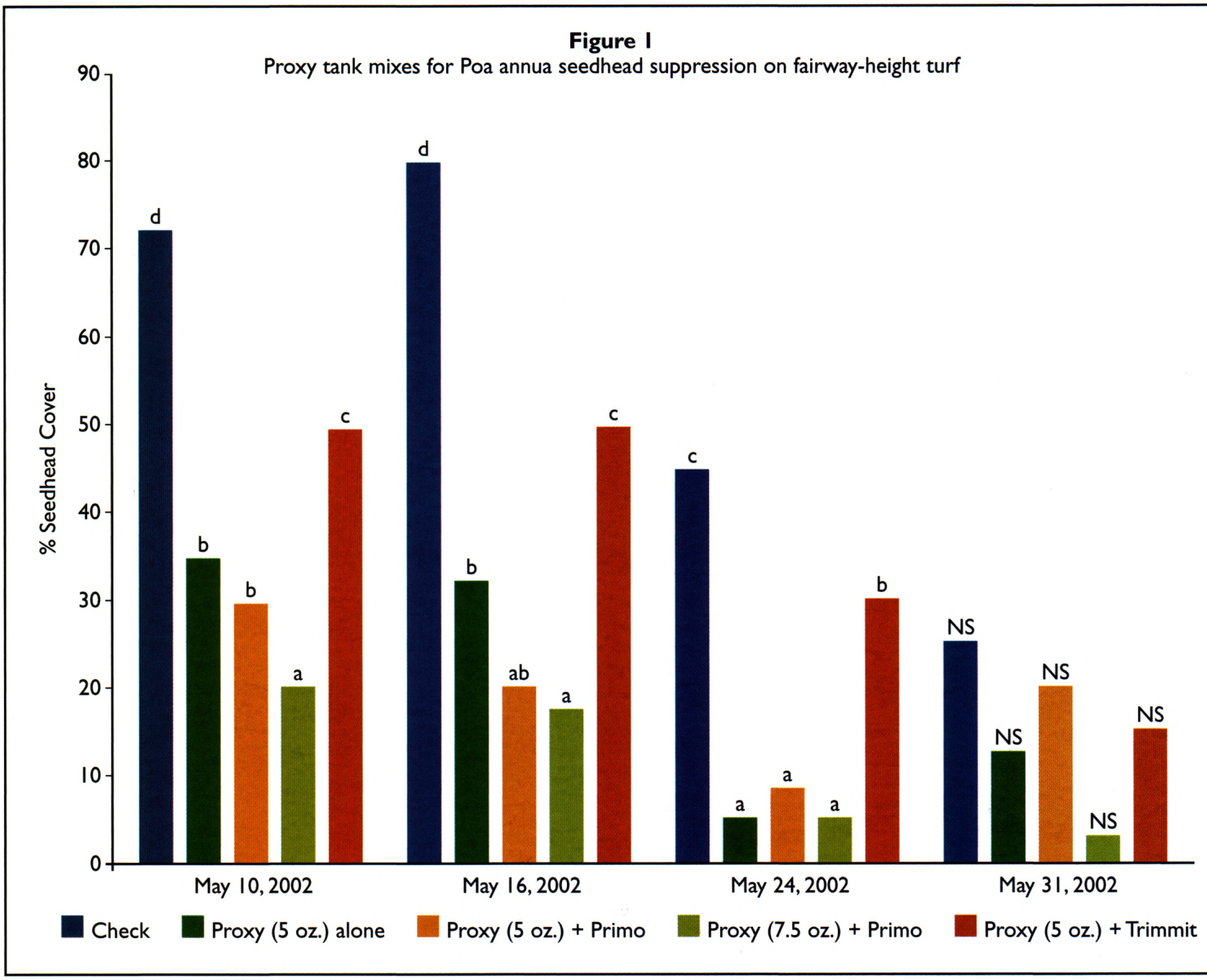
Table 2
Comparison of base-50 growing-degree-day annual bluegrass model to first visible flowering over the last four years

Year	Date that $GDD_{50} \geq 50$	First Visible Flowering
2002	April 15	April 24-28
2001	April 12	April 27-29
2000	April 7 or April 24	May 3-7
1999	April 4	April 15

Table 3
General overview of percent annual bluegrass seedhead suppression by PGRs and wetting agents for tests conducted in the Chicago suburbs (2000-01)

Product	No. of Applications	Rate per 1,000 sq. ft.	% Seedhead Suppression* May 10	May 24	June 1
Aqua-Gro L	3	8,4,4 fl. oz.	55	50	25
Cascade	2	4 fl. oz.	25	0	20
Trimmit	2	0.18 fl. oz.	0	0	0
Primo	2	.125 - .25 fl. oz.	0	15	0
Proxy	1-2	5 - 7.5 fl. oz.	80	85	80
Proxy+Primo	1-2	5 + .125 fl. oz.	80	85	80
Embark T&O	1	1.3 fl. oz.	90	95	80

*Data show percent reduction in seedheads compared to untreated plots.



inhibition is an average of several tests, and results can vary greatly with weather conditions, application timing, and annual bluegrass biotypes present in treated areas. Embark is consistently the best flower suppressor, but phytotoxicity (primarily on creeping bentgrass) remains a major concern in northern Illinois. Phytotoxicity of Embark treatments was expressed as a dark blue-green to brown color, with some thinning of the stand. Once warmer weather arrived, turf color and density recovered.

Proxy and Proxy + Primo treatments provided seedhead suppression approaching that of Embark in our trials in 2000 and 2001. In some cases, suppression with split applications of Proxy lasted longer than single Embark applications. However, higher rates or repeat applications of Proxy caused yellowing and thinning of treated turf, especially at greens height. Note that repeat Proxy applications were made only 7 to 10 days apart; less discoloration has been observed in other tests if the interval between applications is 28-35 days (4). Tank mixing Proxy with Primo appeared to reduce the discoloration and thinning of turf, although further testing will be required to confirm the effect.

Of the other products/rates tested, only Aqua-Gro L exhibited significant seedhead suppression, and the effect was short-lived and inconsistent from site to site and season to season. The anti-gibberellin growth regulators Primo and Trimmit did not appear to inhibit seedhead formation, and in some situations, these treatments appeared to have more seedheads than check plots. This effect could be due to stunting of the seed stalk to the point where the seedheads remained below the cutting height and were not removed by mowing.

OBSERVATIONS FROM 2002 STUDIES

For 2002 greens-height trials, we concentrated on Proxy alone or in tank mixes with Primo or Trimmit (Table 4). We also began a second set of treatments a week later to see if a later application was as effective as a well-targeted first application. The Proxy and

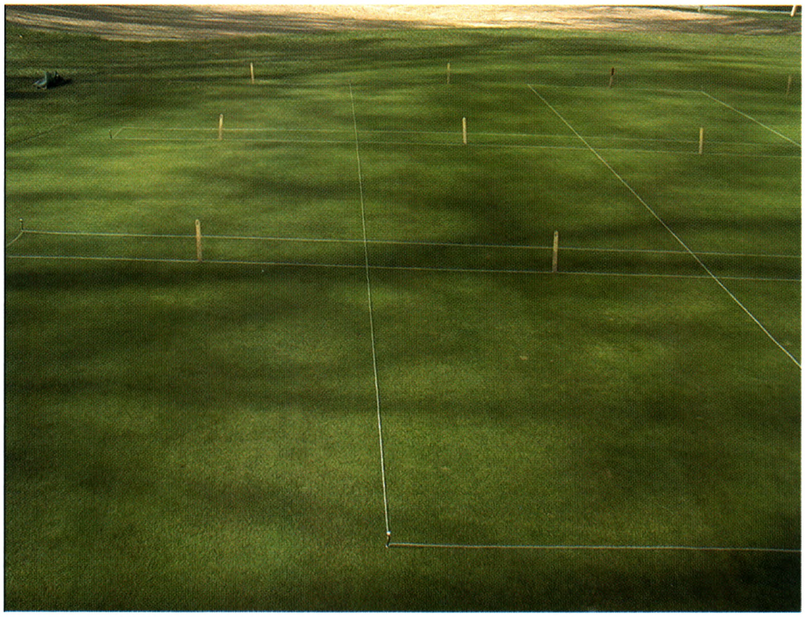
Table 4
Percent of annual bluegrass seedhead suppression on putting green turf by Proxy alone and in tank mixes with anti-gibberellin PGRs (2002 studies)

Product	Rate per 1,000 sq. ft.	Application Date	% Seedhead Suppression* May 10	May 24	June 1
Proxy	5 fl. oz.	April 18	75	56	40
Proxy	5 fl. oz.	April 24	8	44	48
Proxy + Primo	5 + .125 fl. oz.	April 18	83	74	52
Proxy + Primo	5 + .125 fl. oz.	April 24	33	78	68
Proxy + Trimmit	5 + .14 fl. oz.	April 18	42	70	68
Proxy + Trimmit	5 + .14 fl. oz.	April 24	16	74	70

*Data show percent reduction in seedheads compared to untreated plots.

Proxy+ tank mixes did not perform as well as in the previous two years. On certain rating dates, the level of seedhead suppression was hovering around 50 percent, with the best levels around 70% suppression. Previous tests provided about 90% suppression. Variability in seedhead suppression with PGRs is common (3, 5) and may be due to differing weather and application timing parameters, as well as to the inherent variability of annual bluegrass biotypes. Proxy treatments applied a week later than the supposed target date still performed well once the time lag was taken into account.

Finally, we took a look at some Proxy tank mixes sprayed on a mixed annual bluegrass/creeping bentgrass fairway (Table 5 and Figure 1). Taking the Proxy rate up to 7.5 fl. oz. per 1,000 sq. ft. improved the seedhead suppression, and no noticeable phytotoxicity was observed at this rate when tank mixed with Primo at 10 fl. oz. per acre. Proxy does not have a separate label rate for fairway treatments or a recommended rate for putting greens on the 2002 pesticide label. It is likely that some broader uses and application rates will appear on future labels.



Shade patterns influence *Poa annua* growth and its competition with bentgrass.

Table 5
Percent annual bluegrass seedhead suppression on fairway turf — 2002*

Product	Rate per 1,000 sq. ft.	% Seedhead Suppression** May 10	May 16	May 24	May 31	June 7
Proxy	5 fl. oz.	52	59	89	48	54
Proxy + Primo	5 + .25 fl. oz.	59	75	80	20	31
Proxy + Primo	7.5 + .25 fl. oz.	73	78	89	88	92
Proxy + Trimmit	5 + .28 fl. oz.	32	38	33	40	0

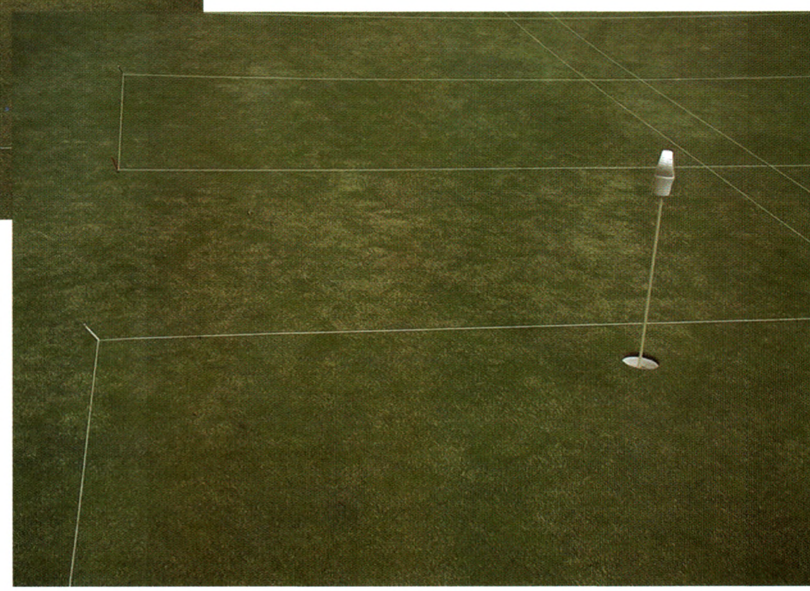
*Application date for all treatments was April 23, 2002.
**Data show percent reduction in seedheads compared to untreated plots.

CONCLUSIONS AFTER THREE YEARS OF TESTING

After three years of testing products for annual bluegrass seedhead suppression, some conclusions can be reached.

- Seedhead production in annual bluegrass is detrimental for various reasons, including poor playability, aesthetics, and reduced plant vigor.
- The most consistent seedhead suppression follows treatments with mefluidide or ethephon, although both chemicals have limitations regarding application timing or possible phytotoxicity.
- Embark can cause discoloration and thinning of bentgrass following cold weather, but it remains the best product for seedhead suppression, especially on

Higher rates of Proxy (without Primo or chelated iron) caused some discoloration of treated turf mowed at putting green height. Patchy seedhead development is evident in the check plot at left.



Visible seedheads were evident in untreated plots when compared to surrounding treatments that demonstrated varying abilities to suppress seedheads.

fairways, where some phytotoxicity is tolerable.

- Proxy can be nearly as effective as Embark for seedhead suppression, but results are variable from year to year and from site to site.
- Proxy can cause some objectionable color and growth effects, but tank mixes with Primo or other PGRs may alleviate some of these problems.
- If Proxy (+Primo) applications are made early in spring, a follow-up application 4-5 weeks after the first may be beneficial to maintain the seedhead suppression into June.
- Wetting agents gave inconsistent results and were approximately 50% as effective as mefluidide or ethephon, at best.
- Anti-gibberellin PGRs such as paclobutrazole and trinexepac-ethyl did not significantly reduce seedheads in our studies.
- Seedhead suppression can be highly variable from year to year or site to site because of weather fluctuations, application timing, and annual bluegrass variability.

ACKNOWLEDGEMENTS

Thanks to our on-site cooperators and supporters for these studies: John Gurke, Superintendent, Aurora C.C.; Dan Anderson, former Superintendent, Fox Valley C.C.; Jim McNair, Superintendent, Orchard Valley G.C.; Jon Jennings, Superintendent, Chicago G.C.; Bruce Branham, Ph.D., Associate Professor, University of Illinois, Department of Natural Resources and Environmental Sciences; Paul Vermeulen, Director, Mid-Continent Region, USGA Green Section.

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Research *You Can Use*

Strategies to Maintain Amphibian Populations on Golf Courses

Exploring the roles of golf courses in the environment.

BY PETER W. C. PATON AND ROBERT S. EGAN

Biologists are increasingly concerned with amphibian populations because of documented declines on local, regional, and even global scales. A variety of factors have been implicated in these declines (e.g., introduced predators, fertilizers, pollutants, and UV-B radiation in sunlight), and one of the leading factors is the impact of habitat fragmentation on pond-breeding amphibians (4).

This article focuses on pond-breeding amphibians because the majority of amphibian species in the Northeast breed in ponds (six species of salamanders and 10 species of frogs), while fewer species breed in streams or uplands (5). In this article, strategies are discussed to maintain populations of pond-breeding amphibians on golf courses in New England based on a variety of studies conducted since 1997 at the University of Rhode Island.

Amphibians can be exceptionally sensitive to changes in microclimate and microhabitat because they have permeable skin that makes them susceptible to desiccation. Thus, habitat ecotones (mixed vegetation communities formed by overlapping habitats), such as the transition between forests and turf fairways, may represent potential dispersal barriers to amphibians moving across the landscape. Fragmented landscapes, such as golf courses, can impact amphibian populations. Amphibians that breed in ponds have complex life cycles that make them particularly vulnerable to fragmentation and loss of habitat.

An adult gray treefrog is a common species found in New England ponds. This species overwinters in trees and breeds during the month of May. Because they prefer trees, golf course fairways can be a dispersal barrier to this species.

Ponds are often used by adults only for mating and depositing eggs, and by larvae during development until metamorphosis (i.e., the transformation into terrestrial organisms). Adults are usually highly site faithful to their breeding pond, returning to the same pond year after year, whereas metamorphs (young of the year) tend to disperse across the landscape and often breed in new ponds. For most of the year, adults and juveniles of most pond-breeding species reside in forested uplands and forested wetlands near breeding ponds, with many individuals traveling considerable distances to reach their non-breeding territories (e.g., salamanders of the genus *Ambystoma* travel 180 yards and farther).

Pond-breeding amphibians migrate twice a year, once from their non-breeding habitat to the breeding pond, and then back to their non-breeding territory at the completion of the breeding season. Therefore, managing the landscape to maintain populations of pond-breeding amphibians is a challenge for golf course designers and superintendents because it requires a detailed understanding of the physical and habitat characteristics of breeding ponds, an understanding of habitat requirements during the non-breeding season, and knowledge of the intervening habitats used during migration to and from ponds and non-breeding habitat. What makes it even more difficult is that biologists are just beginning to untangle the complex habitat requirements of pond-breeding amphibians, particularly during migration and the non-breeding season.

As part of a Wildlife Links project funded by the USGA, we conducted a number of short- and long-term experiments and observational studies to assess the impact of turf and golf courses on pond-breeding amphibians

Figure 1
Percent of 59 ponds sampled on golf courses in southern New England (Rhode Island, Connecticut, and Massachusetts) with various species of pond-breeding amphibians

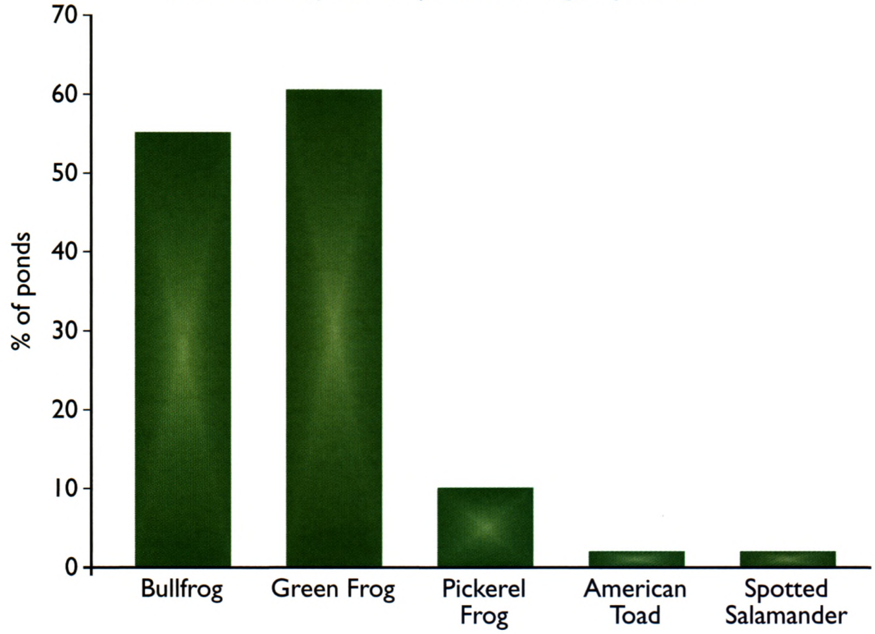
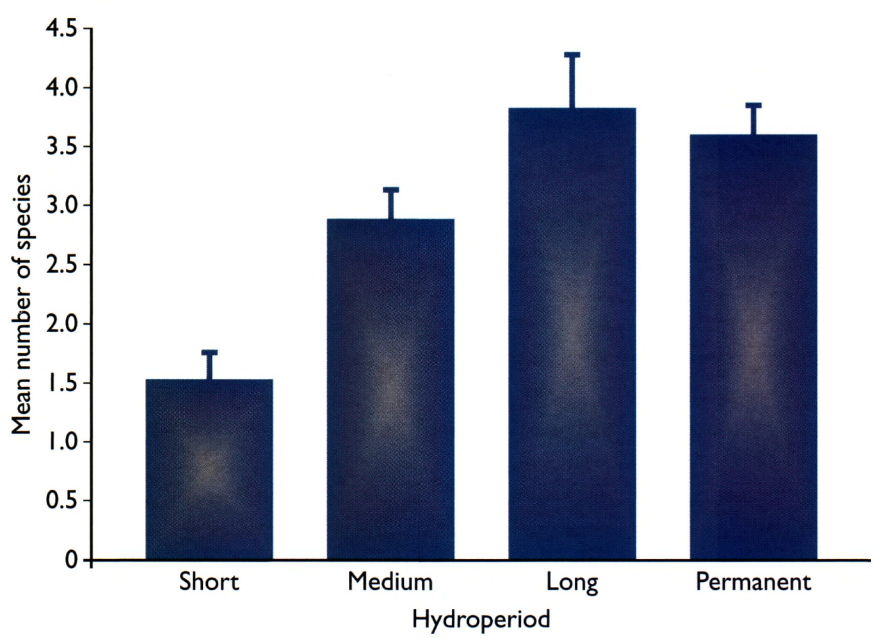


Figure 2
Relationship between pond-breeding amphibian species richness (mean number of species per pond, + standard error) and hydroperiod in 137 ponds in Rhode Island. Ponds with a short hydroperiod are defined as those drying in June or July, medium-hydroperiod ponds dry in August or September, long-hydroperiod ponds dry in October or November, and permanent ponds never dry during the year.



in southern Rhode Island. Our goal in this article is to give readers a sense of what we believe are the key management issues that people working in the golf turf profession need to understand.

HYDROPERIOD OF BREEDING PONDS

To assess pond-breeding amphibian use of ponds on golf courses, we used dip-nets to sample 59 ponds at 32 golf courses in Rhode Island, Connecticut, and Massachusetts during the spring and early summer of 1999. Most ponds on golf courses had either green frogs (*Rana clamitans*) or American bullfrogs (*R. catesbeiana*), with few other species detected (Figure 1). This was primarily because most of the ponds we sampled on golf courses were permanent. In addition, many ponds on golf courses we sampled had fish.

During 2000 and 2001, we used dip-nets to sample amphibian community structure at 137 randomly selected ponds across the urbanization gradient in Rhode Island. We found that hydroperiod (i.e., the number of days with standing water in the pond basin) was one of the most important variables determining amphibian community structure. Ponds with a long hydroperiod (drying in October or November) tended to have the most species (Figure 2), while ponds with a short or medium hydroperiod (drying annually from June through September) tended to have unique species not found in permanent ponds.

For example, wood frogs (*Rana sylvatica*) and marbled salamanders (*Ambystoma opacum*) were usually detected only in ponds that dried before September. Tadpoles of both species are among the first to complete metamorphosis, typically emigrating from ponds by early July (5). In contrast, tadpoles of American bullfrogs were found only in permanent ponds, and green frogs were more likely to be found in long or permanent hydroperiod ponds. Both these species have tadpoles that take much longer to complete meta-

This natural pool is an example of the areas used by pond-breeding amphibians in the Northeast. The pond usually dries every September and has five frog species and three salamander species that use it as a breeding site.

morphosis (two years for bullfrogs and one year for green frogs), thus requiring ponds with longer hydroperiods for successful reproduction.

The take-home message from this research is that if you want to maintain the entire amphibian community on your golf course, you have to maintain ponds with a variety of hydroperiods on or adjacent to the course. It is critical to have ponds that dry annually because some species only use seasonally flooded ponds (10).

In addition, ponds should not be stocked with fish. Fish are major predators of amphibian eggs and larvae, which is why many species of amphibians tend to avoid ponds with fish. Finally, we have found that the vegetation in ponds can be important to certain species. For example, wood frogs tend to have larger populations in ponds with extensive coverage of buttonbush (*Cephalanthus occidentalis*), whereas spring peepers tend to thrive in ponds with no canopy closure.

EFFECT OF GRASS HEIGHT AND HABITAT ON MOVEMENTS

To assess whether grass height affects movement behavior of amphibians, during the 1998 field season we constructed two square pens (50 ft. on each side) on a four-hectare section of bentgrass, which is used by the Turfgrass Group at the University of Rhode Island for a variety of experiments. The perimeter of our experimental pens was encircled with 0.5m-tall silt fence. The pens were subdivided into four quarters (25 ft. per side). Each quarter (randomly selected) was mowed to various grass heights (.25", .5", 1", and > 1"-2"-5").

All experiments were conducted on rainy nights, when amphibians were likely to move. During the experiment, an individual amphibian (wood frog, American toad, green frog, bullfrog, or pickerel frog) was placed in the center of the array, and its movements were monitored for a three-minute period. We also constructed another set of experimental pens at ecotones between a forest and mowed lawn < .5" and a forest and lawn.

During grass height experiments, we found no evidence that frogs preferred any grass height during the three-minute trials, during which their movements were random with respect to grass height. This suggests that grass height, at least in the height range we quantified, that is typical of current golf courses in North America does not hinder or enhance amphibian movements. This is true for the species we sampled, but we did not have the opportunity to investigate any salamanders or some frogs (spring peepers, gray tree frogs, and wood frogs), whose movements could be affected by grass height. However, we did find that amphibians (frogs, in this case) preferred to move into forested habitats rather than either turf or barren areas. In both cases, the evidence shows that wooded habitats were preferred over turf or barren ground. This suggests that amphibians preferred forested habitat as movement corridors over open habitats such as fairways.

EFFECT OF TURF ON DISPERSAL OF AMPHIBIANS FROM A SERIES OF PONDS

We also conducted an observational study to assess the influence of habitat on movement behavior of amphibians. From 1998-2000, we monitored the immigration and emigration of adults and emigration of metamorphs across a wooded landscape fragmented by turf fields. We documented considerable variation within and among species in their initial departure direction from breeding ponds, which suggests that habitat near breeding ponds has little influence on movement patterns.

Farther from breeding ponds, adults of species that reside in forested habitats during the non-breeding season occurred less often at an ecotone between a turf field and woodland (e.g., wood frog, spotted salamander, spring peeper, gray treefrog, and red-spotted newt). In contrast, species that winter in aquatic habitats readily cross the turf-woodland edge (e.g., green frog, American bullfrog, pickerel frog). Metamorphs of most species tended to be habitat generalists during migration, whereas adults tended to exhibit more habitat selection.

To further test the influence of habitat on migration, we removed the overstory and understory in five small patches (10m by 40m) in a woodland where we had been monitoring movements for the previous two years. Based on this experiment, we found that movement patterns of at least four species were affected by small-scale vegetation removal.

Overall, these results suggest that habitat associations of pond-breeding amphibian species during migration are similar to those during the non-breeding season. Species that reside during the non-breeding season and winter in forest habitats (e.g., wood frog, marbled and spotted salamander, red-spotted newt, spring peeper, gray treefrog) tend to migrate through forested habitats and avoid open expanses, such as fairways. This is particularly true for adult amphibians that avoid open habitats more than young of the year.

In contrast, species that winter in aquatic habitats such as streams or ponds (e.g., American bullfrog, green frog, and pickerel frog) are less likely to be impacted by forest fragmentation because they are willing to cross open habitats. This explains why ponds on golf courses tended to be dominated by this latter group of species. As mentioned earlier, both bullfrogs and green frogs prefer permanent ponds for successful reproduction. In addition, both species readily cross open habitats, such as fairways, to reach breeding ponds/wintering sites.

Other researchers have documented patterns similar to those we found in Rhode Island. For example, deMaynadier and Hunter (1,2), working in the forests of Maine, classified wood frogs as "management sensitive" because they avoided traveling across clear cuts. Adult spotted salamanders also generally avoid openings in woodlands, although other researchers (3) suggested that migratory movements by spotted salamanders were unaffected by vegetation or topographic structure.

So what does this mean for golf course designers and superintendents of existing courses? Available evidence suggests the habitat characteristics of a golf course can impact movement behavior of some species of pond-breeding amphibians. In New England, species that winter in forested habitats

Wood frog egg masses attach to buttonbush shrubs in the center of a small pond in western Rhode Island. An estimated 1,500 egg masses were in this pond, covering a five-foot diameter area. Both wood frogs and spotted salamanders usually attach egg masses to woody vegetation.

An adult male wood frog lounges near the water's surface. Males arrive at breeding ponds in early March and actively call to attract females to the pond. This species spends most of the year in forested habitat within 200 yards of breeding ponds. In experiments conducted in Rhode Island, this species was reluctant too cross open expanses of turf, such as fairways.

A young red-spotted newt, often referred to as an eft, is very small when it emerges from the breeding pond area. Efts remain on land for three to seven years, often wandering great distances before returning to the ponds to breed.

University of Rhode Island scientists are studying amphibian movements on golf courses in the Northeast to gain a better understanding of how water feature design can help improve habitat for these wood frogs and other amphibians.

appear to be the most affected by habitat fragmentation. Thus, designers should maximize the amount of forest cover on a course while simultaneously creating forest travel corridors between breeding ponds and non-breeding habitat.

The species most sensitive to habitat fragmentation all primarily breed in ponds that dry annually. These ponds are best identified during surveys conducted in March and April when they are most likely to be flooded. If a seasonally flooded pond is found, steps should be taken to maintain a forested buffer around it. No definitive guidelines are available on how wide this forest buffer should be, but Semlitsch (8) estimated that approximately 95% of the population of mole salamanders usually occurs within 196 yards of the pond.

Maintaining such a wide forest buffer around all seasonally flooded ponds on a course may be impractical. Yet, alternative management steps could include maximizing the forest/shrub buffer around ponds. This includes creating forested travel corridors that allow movement from seasonally flooded ponds and their associated buffer to large patches of potential non-breeding habitat.

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Moss Infestations in Putting Greens

Eradication by electromotive destruction of chlorophyll.

BY ARTHUR P. WEBER AND THOMAS O. McAVOY

The proliferation of moss infestations in putting greens can be correlated to the asymptotic lowering of mower heights in the pursuit of "fast green speeds." The side effect, stressing and thinning the turf cover, promotes the invasion of undesirable species, e.g., moss, to impair the consistency of the green surface as a putting medium (1).

Of the about 9,500 purported moss variations, *Bryum argentium*, commonly known as silvery thread moss, has been identified as the dominant invasive species. The botanical phylum *Briophata* includes mosses and liverworts, the simplest of land-dwelling plants which, from fossil records dating back some 400 million years, prevail as enduring primitive species whose morphology, growth, and survival characteristics differ radically from higher plants, e.g., the putting green turfgrasses within which they coexist.

BIOLOGY

Mosses do not have roots and, in their absence, the plants anchor to a surface with rhyzoids attached to a substrate. Consequently, mosses can thrive on surfaces as dissimilar as rocks, concrete walks, and masonry walls. Neither do mosses have a defined vascular system for water and nutrient delivery or, conversely, as a pathway to facilitate control or eradication.

Mosses survive long periods of drought, dehydrate, and sustain prolonged dormancy, to then resume photosynthesis upon rehydration. Receptors and patterns of water uptake have been advanced, the modus operandi of which remain obscure. Uniquely, water uptake by *Bryum argentium* is comparatively rapid, categorizing the plant as being ectohydric (2,3,4,5).

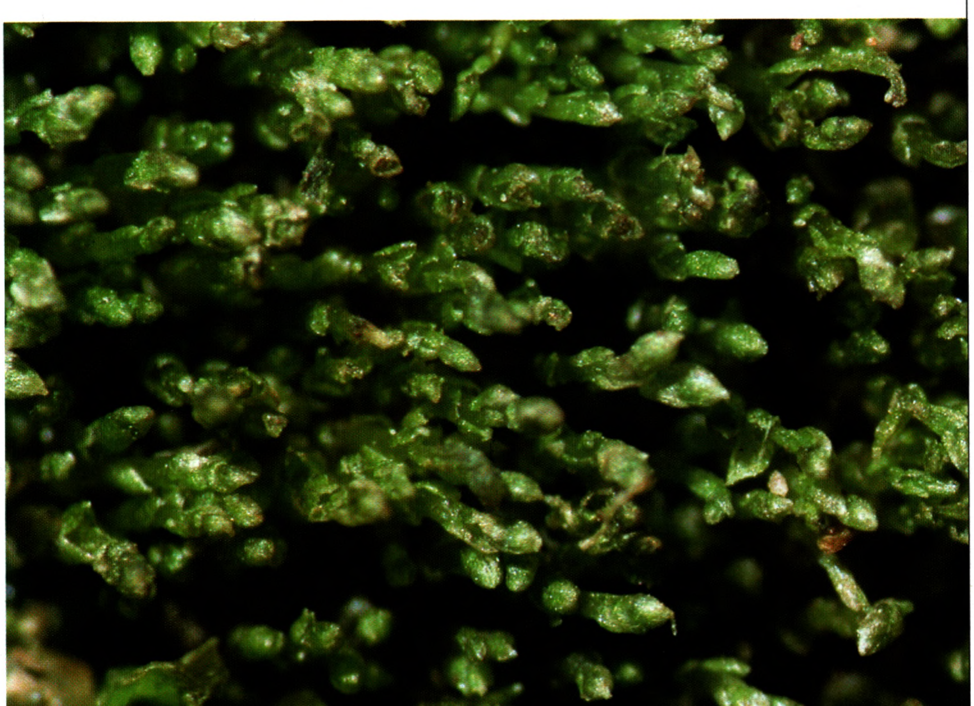


Figure 1. When moss is viewed in cross-section, it has a sponge-like appearance and is densely packed with very small voids.

MORPHOLOGY

Bryum argentium moss infestations prevail as sponge-like biomasses which, when microscopically viewed in cross-section, provide a densely packed labyrinth of minuscule voids and interstices. Photomicrographs, depicted in Figure 1, were taken at 10x, 30x, and 63x magnification to correspondingly decreasing 22mm, 13mm, and 3.5mm fields of view, using a Nikon SMZ Zoom Stereo Microscope with a 1x objective lens and Nikon Coolpix 4500 4 megapixel digital camera.

Given that the surface-to-volume ratios of voids vary inversely with size and shape, *Bryum argentium* infestations comparatively interface to their ambient environment with an extraordinarily high biomass surface relative to volume. This key attribute, in the absence of root hairs to absorb water and leaf stomata to respire carbon dioxide and oxygen, serves to sustain photosynthesis by extended surface adsorption and absorption.

ECOLOGY

Although *Bryum argentium* persists within a broad divergence of ambient parameters, remarkable exceptions have been metal-contaminated soils. The toxicity sequence has been found to be Hg > Cu > Pb > Ni > Cd > Zn >

Mg, the heavy metals being the most toxic. Mercury (Hg) based management controls, particularly, had been found to be highly effective but were discarded for not being environmentally viable. Recently, application programs using copper hydroxide-based fungicides have been advanced for post-emergence moss control (6,7,8,9,10,11,12,13,14,15,16).

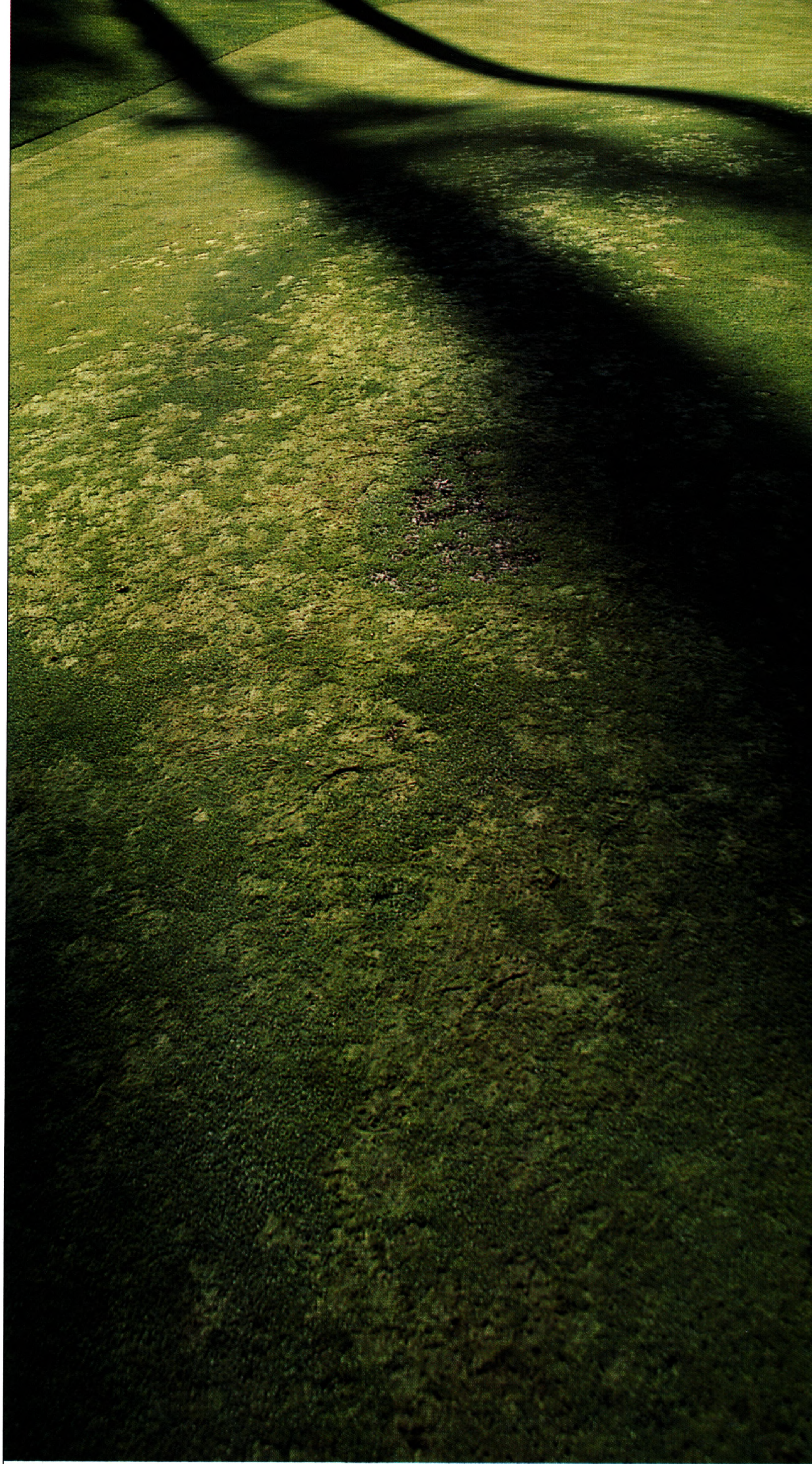
ELECTROCHEMISTRY

The toxicity response to metals by *Bryum argentium* parallels the Activity Series, i.e., an arrangement of metals in the order of their tendency to react with water and acids so that each metal in the series displaces from solution those below it and is displaced by those above it. Because the displacements involve the transfer of electrons from the reducing agent to the oxidizing agent and may be used as a source of electric current, the Activity Series is also known as the Electromotive Series.

To obtain this result, the oxidation/reduction reaction must take place in an appropriate apparatus, e.g., a battery cell, so constructed that the transfer of electrons from one atom to the other, as a current between electrodes, takes place along an intervening conductor. However, sufficient energy, in the form of a relative potential difference between the electrodes, must be made available as an electromotive force to overcome any interposed resistance to the electron current flow from the reducing agent to the oxidizing agent.

METAL ELECTRODE POTENTIALS

In order to compare the electrode potentials between metals and their solutions, it is customary to use solutions in which the concentration of the metal ions is "Normal," i.e., molar. As a basis for comparison, inasmuch as absolute electrode potentials cannot be determined with reasonable accuracy, the potential of a platinum electrode saturated with hydrogen gas under one atmosphere pressure against a solution that is "Normal" with respect to the



Shade and contours on this green contribute to a poor growing environment. As the area is scalped, moss becomes more competitive, dominating the area.

Figure 2
Activity Series a/k/a Electromotive Series
Potentials of elements in contact with normal concentration of the ion at 25°C

Element	Ion	Potential in Volts	Element	Ion	Potential in Volts
K	K^+	–2.92	H_2	H^+	0.00
Na	Na^+	–2.71	Sb	SB^{+++}	+0.10
Ca	Ca^{++}	–2.5(?)	As	As^{+++}	+0.3(?)
Mg	Mg^{++}	–1.55	Cu	Cu^{++}	+0.34
Al	Al^{+++}	–1.34	Cu	Cu^+	+0.47
Zn	Zn^{++}	–0.75	Hg	Hg^+	+0.79
Fe	Fe^{++}	–0.44	Ag	Ag^+	+0.80
Cd	Cd^{++}	–0.40	Hg	Hg^{++}	+0.86
Co	Co^{++}	–0.24	Au	Au^+	+1.5(?)
Ni	Ni^{++}	–0.22	O_2	OH^-	+0.11
Sn	Sn^{++}	–0.14	I_2	I^-	+0.62
Pb	Pb^{++}	–0.12	Br_2	Br^-	+1.08
Fe	Fe^{+++}	–0.04	Cl_2	Cl^-	+1.35
			F_2	F^-	+1.9(?)

hydrogen ions is called zero. Figure 2 comparatively tabulates the relative electrode potentials, expressed in volts, of various elements at 25°C in contact with solutions that are "Normal" with respect to their ions, thereby electromotivally quantifying the Activity Series.

From Figure 2, the limiting potential difference across a battery cell, measured in volts, can be calculated. For example, metallic magnesium, in contact with a "Normal" Mg^{++} ion solution, acquires a negative potential of -1.55 volts, while mercury in contact with a "Normal" Hg^+ ion solution acquires a positive potential of +0.79 volts. The limiting voltage, therefore, across the electrodes of such a magnesium/mercury battery cell would be the algebraic difference between the relative electrode potentials: $+0.79 - (-1.55) = 2.34$ volts.

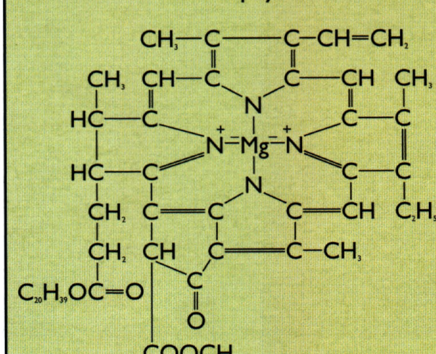
CHLOROPHYLL

The green pigment essential to photosynthesis, chlorophyll, is a porphorin structured molecule containing a hydrophilic carbocyclic ring with a lipophilic phytyl tail, nitrogen bridged from a negatively charged magnesium ion at the core of the molecule (see Figure 3). It is a photoreceptor up to 700mm and transfers such radiant energy to its chemical environment, thus acting as a transducer in photosynthesis (17).

HYPOTHESIS

Heavy metals elicit a toxic response from *Bryum argentium* because of the electromotive destruction of the chlorophyll. The electrical resistance between the negatively charged magnesium ion at the core of a chlorophyll molecule and, say, a surface interfaced positively charged mercury ion is such that the relative potential difference

Figure 3
Chlorophyll



between the ions is large enough to permit the Mg^- ion to be oxidized by losing and transporting its electron to reduce the Hg^+ ion to metallic mercury.

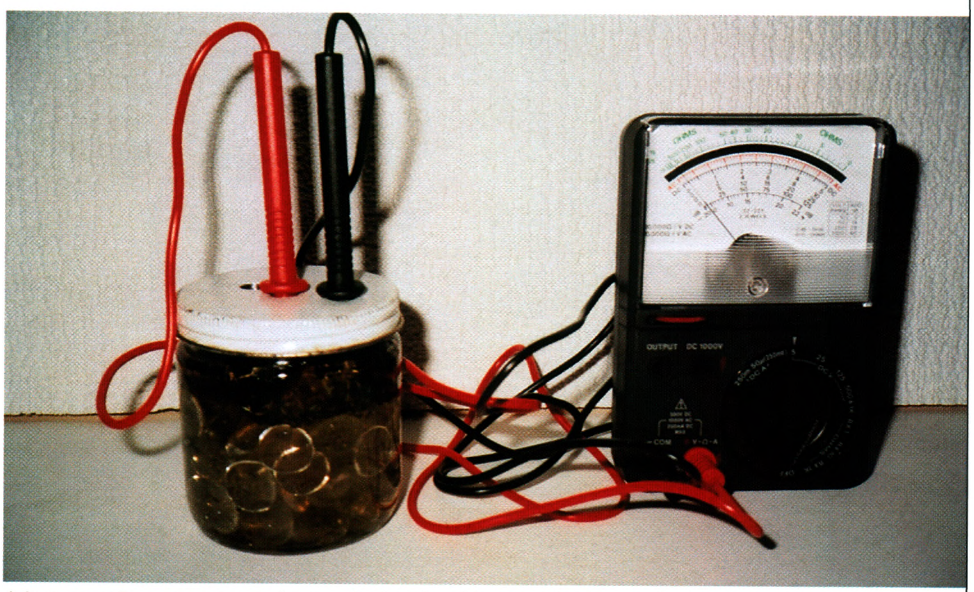
The decreasing relative electrode potential difference between the metals of higher ranking than mercury in the Activity Series is apparently insufficient as a driving force to overcome the molecular binding energy of the Mg^- electron in chlorophyll and resistance to the conduction of the electron in *Bryum argentium*, wherein chlorophyll functions as the negative electrode of a galvanic cell. Significantly, copper was empirically found to be the nearest toxicity competitor to mercury and, as it turns out, ranks just above mercury in the Activity Series, with a relative Cu^{++} cupric ion electrode potential of +0.34 volt, or relatively $0.79 - 0.34 = 0.45$ volt less than a mercuric ion.

Theoretically, the Activity Series forecasts that silver, developing at least the same relative electrode potential as mercury, would galvanically destroy the chlorophyll in *Bryum argentium* as effectively as mercury.

VERIFICATION

In support of the hypothesis, moss infestations at the Old Westbury Golf and Country Club, Old Westbury, New York, were totally and permanently eradicated by spot drenching with low application rates of highly diluted aqueous solutions of silver nitrate. Surrounding grass plants remained vigorous inasmuch as the topical application and penetration of the required silver dosage attenuated short of the grass plant rootzones. By-product nitrate in solution remained as a turf repair nutrient.

To experimentally verify that the chlorophyll had been electromotivally destroyed, a battery cell was assembled. Harvested *Bryum argentium* moss outcroppings (the cathode) were steeped in water containing a trace of salinity as a conductive electrolyte and were separated by a diaphragm from aqueous



A battery cell was constructed to verify that the chlorophyll had been electromotively destroyed.

silver nitrate solution (the anode). The induced electron current flow was indicated by a voltage difference across the immersed cathode and anode terminals of a calibrated multi-meter. Chlorophyll destruction caused the moss to blacken around the cathode terminal and metallic silver to deposit on the anode terminal.

The battery was assembled within a 6 fl. oz. transparent glass screw-top jar, 2⅜ in. diameter by 2¾ in. high. The diaphragm, a hollow cardboard cylinder, centrally positioned and epoxy affixed within the jar, was ¾ in. outside diameter by 1/16 in. thick, and stood 2¾ in. high. To displace excess volume, the annulus around the cylindrical diaphragm was half-filled with glass beads, on top of which 10 grams of harvested *Bryum argentium* was steeped in 100 ml of a 0.01% saline aqueous solution. The core of the cylindrical diaphragm was filled with 23 ml of 0.22% silver nitrate solution (0.14% silver). The multi-meter indicated a direct current voltage that peaked and dwelled at 0.6 volt for some 90 minutes before gradually diminishing as the chlorophyll was destroyed and the battery cell exhausted.

FIELD TRIALS

The putting greens in the study, constructed in 1962, were the "push-up" type, sand amended, approximately 70% creeping bentgrass (Pencross) and 30% annual bluegrass (*Poa annua*), double cut daily at ⅛ in. mower bedknife height to not less than 9½ ft. Stimpmeter speed, fed 1½ lbs. of nitrogen per 1,000 sq. ft. per year, preventively fungicide treated, verticut, and topdressed bimonthly in season. The trials remained ongoing throughout the 2002 calendar year.

Only one application, with a minimum aqueous solution concentration of 0.22 weight percent silver nitrate (0.14 weight percent silver), prepared by dissolving 1 gram of silver nitrate in 16 fl. oz. of water, and spot treated by drenching at the rate of 1 fl. oz. per 6 sq. in. of moss outcroppings, in every instance and under all environmental and ecological conditions successfully eradicated moss infestations, without semblance of reemergence. Treated and eradicated moss outcroppings appear as darkened areas.

SUMMARY

Establishment of silvery thread moss (*Bryum argentium*) populations in putting greens has been exacerbated by the lowering of mower bedknife heights to comply with golfers' preference for fast greens.

In the absence of roots or a defined vascular system, but configured with an uncommonly high biomass surface-to-volume interface, moss populations sustain photosynthesis by ectohydric hydration and respiration within broad environmental conditions. Remarkable exceptions have been metal-contaminated soils.

The toxicity response of *Bryum argentium* to metals correlates to the relative electrode potentials of metals and their solutions in the Activity Series, a/k/a the Electromotive Series. The heavier the metal, the greater, too, is the relative potential difference with the porphorin structured magnesium core of chlorophyll molecules essential to photosynthesis. Consistent with the toxicity correlation of the Activity Series, mercury-based controls have been effective, but not being environmentally acceptable, they have been discarded. Copper, the metal ranked immediately above mercury in the Activity Series, falls short of the mark.

We hypothesize that the toxic response to heavy metals results from the electromotive destruction of the chlorophyll. The Activity Series forecasts that silver would as effectively destroy the chlorophyll in *Bryum argentium* as does mercury, the relative potential difference being sufficient to electromotively cause the negatively charged magnesium ion core of chlorophyll to oxidize and release its electron to reduce a positively charged silver ion to metallic silver. The assembly of a working *Bryum argentium*/silver nitrate battery cell experimentally confirmed both the hypothesis and the forecast.

Silvery thread moss in 70% bentgrass/30% annual bluegrass putting greens was successfully eradicated during ongoing year-round field trials, at low application rates of highly diluted silver nitrate solutions, without adversely affecting the vigor of surrounding grass plants (patent pending).

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Top: Over the years, golf course superintendents have tried iron sulfate as a control for moss encroachment, but oftentimes the result was incomplete control of the problem. Above: Silver nitrate was used to spot-treat moss in the research plots. Treated and eradicated moss outcroppings appeared as darkened areas.

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DR. ARTHUR P. WEBER, *a chemical engineer, has been a member of the USGA Green Section Committee since 1984.* THOMAS O. MCAVOY, CGCS, *is superintendent at Old Westbury Golf Club (New York).*

THE TURF ADVISORY SERVICE

Part Two: 50 Years of Service to Golf

BY JAMES T. SNOW

The conclusion of Part One of this three-part series (*Green Section Record*, May/June 2003, pp. 4-9) saw the establishment of the Western Region office by Charlie Wilson and the subsequent opening of offices in five additional regions between the years 1953 and 1957. In the February 1953 issue of *USGA Journal and Turf Management*, the organization of the Regional Turf Service was described: "Each Region will consist of about 200 USGA clubs which subscribe for the Regional Service. They will be divided into about eight groups of 25 clubs each."

The article goes on to describe the following benefits of subscribing to the Regional Turf Service:

1. At least three direct consultations with the Regional Director each year, on the following schedule:
   a. One half-day visit to the club by the Regional Director, followed by a written report from him.
   b. Two group conferences in which the Regional Director will meet with the golf course superintendents and green committee chairmen of the 25 clubs in each group.
2. Assistance by correspondence and telephone.
3. A periodic Turf Letter from the Regional Director to the subscribing clubs in his region, at least six times a year.
4. A subscription to the *USGA Journal and Turf Management*, published seven times a year.
5. A voice in the direction of broad-gauge turf research whose results would benefit golf courses.

The fees associated with the service were broken down as follows:

1953 Regional Turf Service Fees

	Less Than 18 Holes	18-27 Holes	More Than 27 Holes
Service fee, including travel	$ 58	$ 78	$ 98
Appropriation to turf research	15	20	25
Subscription to *USGA Journal and Turf Management*	2	2	2
Total Fee	**$ 75**	**$100**	**$125**

Not surprisingly, the benefit that involved two group meetings per year with 25 superintendents and 25 green committee chairmen did not last long due to the difficulty of scheduling dates when all or most could attend. Instead, the agronomists in most regions made a great effort to visit a majority of their

The basic principles of good turf management haven't changed during the 50 years since the Turf Advisory Service began, but the tools available today to help us maintain high-quality turf have changed considerably.

The Green Section staff in May 1971, left to right: William G. Buchanan, Duane Orullian, William H. Bengeyfield, F. Lee Record, James B. Moncrief, Alexander M. Radko, and Holman Griffin.

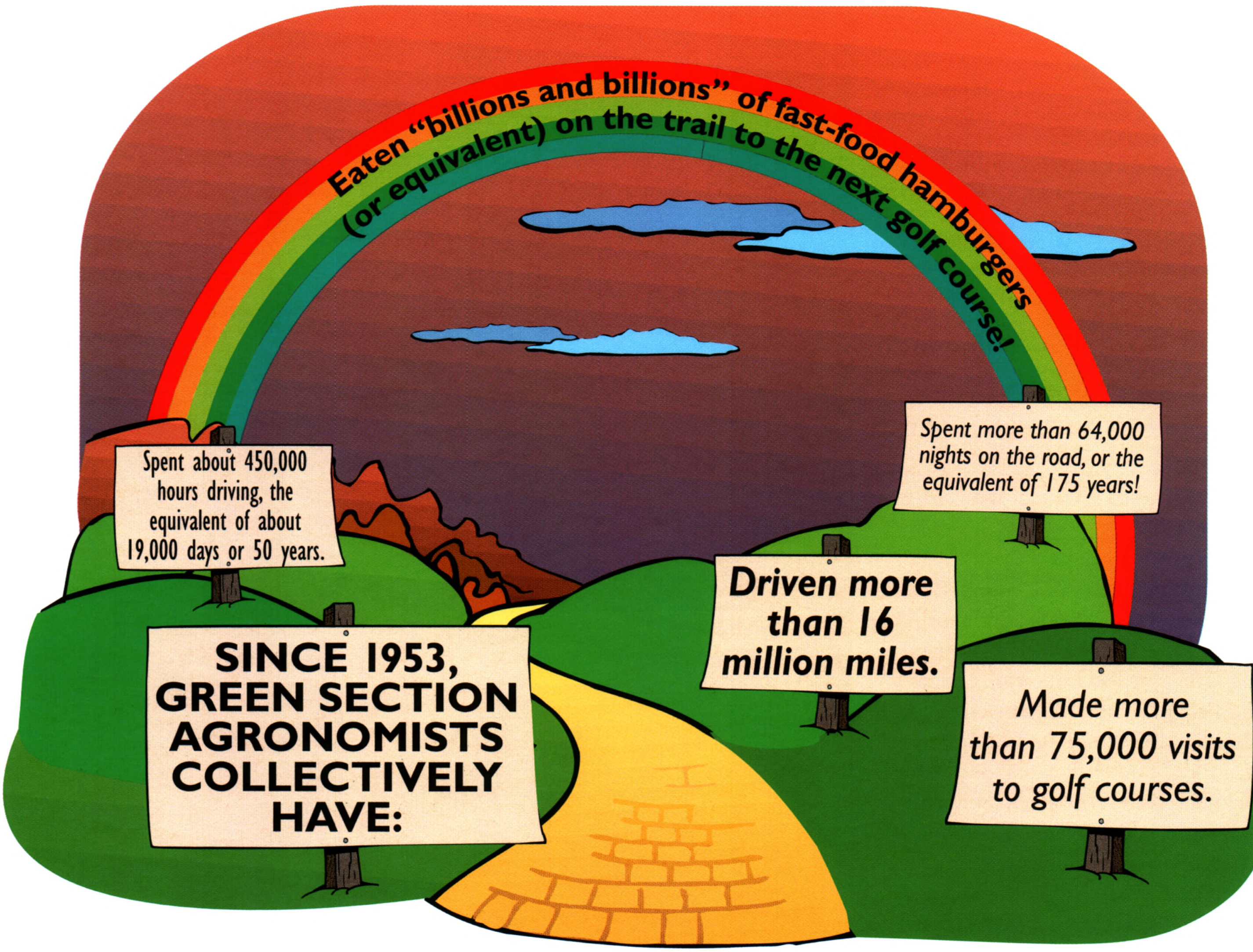
Green Section fall staff meeting, 1990, left to right, first row: Jim Snow, Jim Moore, James Connolly, Chuck Gast, Mike Kenna. Second row: John Foy, Tim Moraghan, Dave Oatis, Larry Gilhuly, Jim Latham. Third row: Jim Skorulski, Stan Zontek, Paul Vermeulen, Bob Vavrek, George Manuel, Bob Brame, Pat O'Brien.

clubs twice per year. The second visit was brief, such that they could visit two to four clubs per day, depending on the area. In some regions this policy lasted until the early 1980s, at which time courses could choose to obtain an additional visit for an extra fee.

Although fees for the service have climbed steadily over the years, the program has never broken even. From the very first year, the USGA has subsidized the service to keep fees within a reasonable range for a majority of golf courses. Today, the fees charged cover less than 50% of the cost of maintaining a staff to conduct the service.

THE FUN PART AND THE TOUGH PART

Life as a USGA agronomist has its ups and downs, as does any job, and it



definitely is not for everybody! The highs are indeed *high*: the fun of visiting golf course superintendents and course officials at 100+ courses annually, learning what works and what doesn't, and the joy of offering advice to golf courses and seeing it work, much to the delight of everyone at the course; the excitement of traveling near and afar, learning about cultures, seeing fantastic sights, making friends, and picking up yet more perspectives on golf turf management; the feeling of confidence and pride that what you've worked so hard to learn is practically unique and is of great use to others for their jobs, their game, and the benefit of the game of golf; and knowing that you're part of a team of hard-working, talented, dedicated professionals who support and inspire each other and who love what they're doing.

Then there's the *tough* part: writing lengthy reports at the end of an exhausting day, knowing that tomorrow often brings the same routine — two visits, two reports; getting behind in report writing and spending your family time at the office on Saturday and Sunday; being on the road and missing your daughter's lacrosse game, your son's birthday, or your anniversary; spending many nights on the road (range: 45-160 nights; average ~80 per year) and having dinner by yourself (if you have time for dinner at all!); spending more of your life getting to where you need to be (driving or flying) than you do doing what you're there for; visiting the same club year after year and seeing that they haven't done a single thing you've recommended, the course looks as awful as ever, and the golfers are complaining as loudly as ever. Those who overcome these hurdles tend to love the job and stay for a long tenure. In the long run, the highs far surpass the lows!

One of the ways that some families cope with Green Section travel is to have the spouse serve as a part-time or full-time secretary/administrative assistant — a part of The Team. They and all of our support staff are hard-working, dedicated professionals who contribute a lot to the success of the TAS program. Currently, spouses serve (or have served) as key office staff in several regions: John and Shelly Foy (Florida), Stan and Marti Zontek (Mid-Atlantic), Bob and

Top right: This picture records the very first Green Section automobile for Charlie Wilson, who had just started the Green Section Western Regional office (about 1951). Charlie is taking possession of a new Mercury from Ed Lowery, a USGA Executive Committee Member who owned a Lincoln-Mercury dealership in San Francisco.

Bottom right: Ed Lowery was the little fellow who caddied for Frances Ouimet when he won the 1913 Open at The Country Club as an amateur and made golf history. The silhouette of this picture has become the Golf House logo. Ed Lowery was also responsible for bringing USGA Champions Ken Venturi (1964 Open) and Harvey Ward (1955 and 1956 Amateurs) to the game of golf. He was always a staunch supporter of the Green Section and did much to establish the Regional Turf Service in the west in the early days.

Rhoda Brame (North Central), Bud and Karen White (Mid-Continent), Jim and Kay Moore (Mid-Continent and Construction Education), Larry and Peggy Gilhuly (Northwest), and Mike and Susan Kenna (Research). Historically, other dynamic duos have included Al and Ann Radko, Jim and Lois Latham, Brian and Maureen Maloy, Monty and Joy Moncrief, Robby and Mary Robinson, Karl and Sali Olson, and Charlie and Marion Wilson.

As with any organization, success stems from the knowledge, character, and work ethic of the people who work there, and the Green Section is very fortunate to have employed so many agronomists and staff with these distinctive qualities.

Next Issue: Part Three will conclude this series with perspectives on the Turf Advisory Service as it relates to Green Section publications, agronomists' outreach efforts, the role of our Green Section Committee volunteers, and the importance of turfgrass research as a basis for TAS recommendations.

From 1976 to 1990, JIM SNOW *logged many miles as a Green Section agronomist. In January 1990 he succeeded Bill Bengeyfield as National Director of the USGA Green Section.*

When small patches of habitat are what exist in an area, connecting them together with corridors of similar habitat is one way to help wildlife populations survive and move through an area.

On Course *With Nature*

The Corridor Connection

Suitable corridors connecting habitat patches can make the difference between survival and extinction.

BY LARRY WOOLBRIGHT

Many human activities convert wildlife habitat to other uses, like farming, housing, or recreation. In the process, habitat gets broken up into small patches, and wildlife can have a harder time surviving. When patches become too small, existing wildlife populations can go extinct.

This issue often is faced during new golf course development, but its ramifications last long after the course is open for play. Isolated "islands" of habitat that remain post development often contain wildlife populations made up solely or predominantly of aged individuals with no or few young to keep the population going. These *living dead* populations give the impression that the species has survived post development, when, in fact, they have not sustained the capacity to reproduce in viable numbers.

The obvious solution to this pressing problem is to preserve large areas of habitat. Yet, when small patches of habitat are all that exist, connecting them together with corridors of similar habitat is one way to help wildlife populations survive, despite growth and development.

A SAFER WAY TO GO

Scientific research shows that animals, even birds, prefer to travel along habitat corridors rather than cross clearings or other obstacles. In one study, songbirds chose wooded routes to travel between

Carts and wildlife are often a deadly combination. An attractive steel bridge carries a cart path high above a wildlife corridor at Coyote Moon Golf Course in Truckee, California.

forested patches, even when they were three times as long as cutting across a clearing.

It's not only forest animals — even species that live in open habitats use habitat corridors for travel. Butterflies, for example, use grassy corridors to move between open clearings surrounded by dense woodland, and their numbers are higher in patches connected by corridors than in isolated patches.

For that reason, in Audubon International's collaboration with the Tuscany project by WCI Communities, Inc., in south Florida, we recommended that golf course roughs and community gardens be planted with butterfly food plants and that all should be connected to a local power line easement to link together habitat patches. Power companies are often willing to work with local communities to provide butterfly plantings along their power lines.

Sometimes habitat corridors can be combined with other conservation projects. Many of our members maintain vegetated buffer zones to protect the edges of streams, rivers, or other water bodies from runoff. These buffers often can be connected to nearby patches of habitat to serve as corridors. At The Old Collier Club in Naples, Florida, a Gold Audubon Signature Sanctuary, naturalized buffer zones along stream drainages connect habitat patches on the golf course to hundreds of acres of protected mangrove swamp.

HOW WIDE SHOULD THE CORRIDOR BE?

There are no simple rules about how wide or tall a naturalized area must be in order to serve as a corridor. One study found that only corridors more than 33 feet wide were used by the birds on that site, while another found that a vole used corridors only 1.5 feet wide. Each species of animal has its own requirements. We recommend that corridors be made as wide and tall as possible. Forested corridors must also include understory and ground cover vegetation.

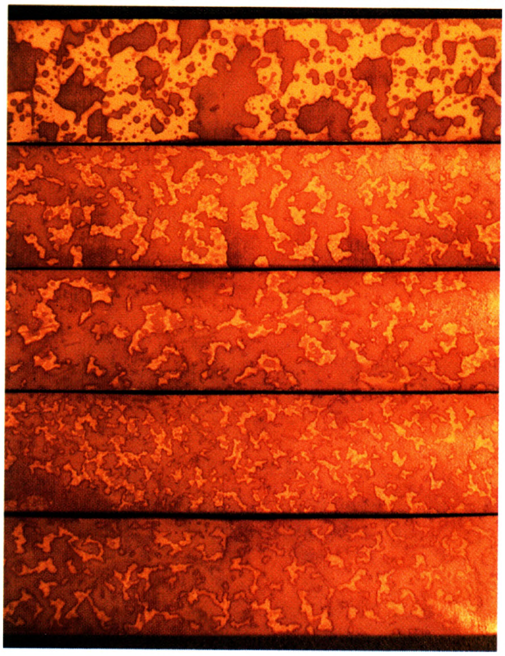
Among the most common obstacles to good corridors are roads and cart paths. Not only do they cause gaps in the corridor, but cars cause a great deal of direct mortality to animals trying to cross roads. The best solution is not to have roads in wildlife habitat. The designers of WCI's Evergrene community in Florida moved two roads in response to these concerns. Placing a roadway on a bridge over the corridor can help, if the roadway cannot be moved. Coyote Moon Golf Course in California has an attractive steel bridge that carries the cart path high above the wildlife corridor, and Raptor Bay in south Florida has a cart path on a boardwalk that crosses an entire slough.

Most properties offer opportunities to provide corridors to connect patches of wildlife habitat. Every place serves as home to some sort of wildlife, if only insects or other very small animals. The goal is to connect the vegetated and naturalized areas of each property with corridors that are as wide, as much like the habitat being connected, and as continuous as possible. And keep in mind that prime habitat to connect with them might lie on neighboring property.

As director of research for Audubon International, LARRY WOOLBRIGHT, PH.D., *conducts scientific research, carries out field surveys, and develops environmental design plans for Audubon Signature Program members.*

News *Notes*

PHOTO BY JEFFREY GREGOS, UNIVERSITY OF WISCONSIN



CORRECTION

The image appearing on page 26 in the May/June 2003 *Green Section Record* was captioned incorrectly. This image compares nozzle spray patterns using water-sensitive paper. More yellow color represents less coverage. Good coverage helps ensure better disease control. From the top: RA Raindrop, Flood Jet, Turbo Tee Jet, Twin Jet, and XR Tee Jet.

WHAT'S HAPPENING IN YOUR BACKYARD?

The Turf Advisory Service is the heart of the Green Section's activities. Each staff member travels and speaks with superintendents, Green Committee members, and course officials at 100-plus courses each year. Their activities provide a unique perspective that is available through no one else in the industry.

Although you may not communicate regularly with your Green Section agronomist throughout the summer, you can take advantage of what he is observing in the field. The USGA Web site offers regional updates written by the Green Section agronomists. Each regional office writes a short synopsis of activities and problems taking place in that area of the country. Your course may be experiencing a problem that others are dealing with as well. The Web site update may provide some useful information to help you communicate with your golfers. These updates help keep people informed of the latest happenings in the region and provide helpful hints for recovering from unexpected troubles. The site can be found at: www.usga.org/green.

GREEN SECTION INTERNSHIPS AWARDED FOR 2003

For the seventh year, the USGA Green Section has awarded internships to outstanding turfgrass management students. During 2003, the Green Section will provide the opportunity for 15 students to travel with the Green Section staff on Turf Advisory Service visits. Each intern will travel for one week with an agronomist in his region between the months of May and August. The goal of the internship program is to provide students with a broader view of the golf course industry and the opportunity to learn about golf course maintenance through the perspective of the Green Section agronomists. More information about each intern can be found on the USGA Green Section Web site at www.usga.org/green.

Intern	Year in School	University	Advisor
Jonathan Baker	Senior	Purdue University	Dr. Zac Reicher
Michael Bednar	Junior	Washington State University	Dr. William Johnston
Jacob Close	Senior	Oregon State University	Dr. Tom Cook
Brandon Haley	Junior	Clemson University	Dr. L. B. McCarty
Roger Havlak	M.S. Candidate	Texas A&M University	Dr. Richard White
Adam Hixson	Ph.D. Candidate	University of Florida	Dr. Billy Crow
John Kaminski	Ph.D. Candidate	University of Maryland	Dr. Mark Carroll
Jeffrey Madison	Senior	State University of N.Y. - Cobleskill	Mr. Robert Emmons
Armen Malazian	Junior	California Polytechnic University	Dr. Kent Kurtz
Joshua Mangum	Senior	Utah State University	Dr. Paul Johnson
Ty McClellan	Senior	Kansas State University	Dr. Jack Fry
Mark Mitchell	M.S. Candidate	University of Florida	Dr. Grady Miller
Sean Reehoorn	Junior	Michigan State University	Dr. James Crum
Scott Tolar	Junior	Mississippi State University	Dr. Michael Goatley
David Townsend	Senior	Virginia Tech	Dr. Erik Ervin

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

Hummel & Co.
35 King Street, P.O. Box 606
Trumansburg, NY 14886
Attn: Norm Hummel
Voice phone: (607) 387-5694
FAX: (607) 387-9499
E-Mail: soildr1@zoom-dsl.com

Thomas Turf Services, Inc.
2151 Harvey Mitchell Parkway South, Suite 302
College Station, TX 77840-5247
Attn: Bob Yzaguirre, Lab Manager
Voice phone: (979) 764-2050
FAX: (979) 764-2152
E-Mail: soiltest@thomasturf.com

Tifton Physical Soil Testing Laboratory, Inc.
1412 Murray Avenue, Tifton, GA 31794
Attn: Powell Gaines
Voice phone: (229) 382-7292
FAX: (229) 382-7992
E-Mail: pgaines@friendlycity.net

Turf Diagnostics & Design, Inc.
310A N. Winchester St., Olathe, KS 66062
Attn: Sam Ferro
Voice phone: (913) 780-6725
FAX: (913) 780-6759
E-Mail: sferro@turfdiag.com

All Things *Considered*

Stay Focused

For proper focus to be maintained, it must first be defined.

BY BOB BRAME

All too often a maintenance program has no agreed-upon prioritization of available funds. When this occurs, the superintendent is forced to make solitary decisions that actually should be made by the committee and/or owner(s) with the superintendent's input. This can produce irregularities such as immaculate bunkers and marginal putting surfaces or beautiful ornamental plantings and poor tees. The end result is poor value as it relates to the play of the game, lack of direction, and less-than-satisfied golfers. The solution is found in the following exercise.

Start by calling a meeting of the committee, bosses, or the general combination of individuals who are responsible for golf course conditioning policy. The superintendent's role is to carry out the bosses' desires, by way of his/her professional input. As such, it's very important to identify exactly what is desired with course conditioning. Once assembled, ask each individual to prioritize the different components of the course. Itemize all components on a poster or marking board so that all participants can work with an agreed-upon list. The possibilities include, but should not be limited to: putting surfaces, fairways, tees, collars, green surrounds, intermediate (step cut) rough, primary rough, secondary or tall rough, bunkers, water hazards, trees, clubhouse grounds, and ornamental plantings. The listing will vary depending upon the makeup of each course, but the intent is to list all agreed-upon components. What's not on the listing is not part of the superintendent's responsibility. Each individual (working alone) should then develop a prioritized column of the various components.

There really is no right or wrong regarding the individual prioritization of course components, with the exception of greens. Anyone who does not place greens first on his or her list should be encouraged to serve on a different committee. Discuss the prioritization laid out by each person. The diversity in how components are ordered will likely serve to underscore why this exercise is so important, as it exposes the challenge faced by the maintenance staff in trying to please/accommodate committee desires. In fact, if there are any differences at all, it places the superintendent and staff in a very difficult situation. Thus, the next phase of the exercise is agreeing upon a committee-endorsed ordering of components. Though it may require significant discussion, this phase of the exercise is not complete until all agree upon a prioritization that the superintendent will then use as a template. As a side note, neither the superintendent nor any of the staff should compile an individual listing of components. They should be part of the discussion that will be required to compile the individual lists, but the staff should not have voting delegate status. Their job is to carry out what the committee lays out.

To the agreed-upon prioritized listing, objectives should now be outlined under each component so that realistic budgeting can follow. Examples under the category of greens would include the desire to use walk-behind as opposed to triplex mowers and spot hand watering, per weather mandates, to facilitate dry conditioning. The superintendent and other key staff should be actively involved with this phase of the exercise. The end result should be an agreed-upon prioritization of components and adequate funding to achieve all sub-component objectives. The exercise will take time, but it's time well spent.

The next and final phase of the exercise is to work the plan — stay focused. When weather conditions or other unforeseen issues force the need for more input towards a high-ranking component, the options are to increase the budget or draw from the lowest-priority component, moving up from the bottom until the need is met. An example would be to rake bunkers less often (or eliminate raking completely) to facilitate needed hand-watering of greens during harsh weather. That, of course, is based on greens being the top priority and bunkers being the lowest component. A weather-induced increase in pesticide applications for fairways would result in a similar give and take — increase funding or reduce/eliminate the input on the lowest-priority component.

To stay focused, it is necessary first to establish a focus. This is not the responsibility of the course superintendent; in fact, if a prioritization listing is not done, the committee bears some of the responsibility for less-than-acceptable conditioning.

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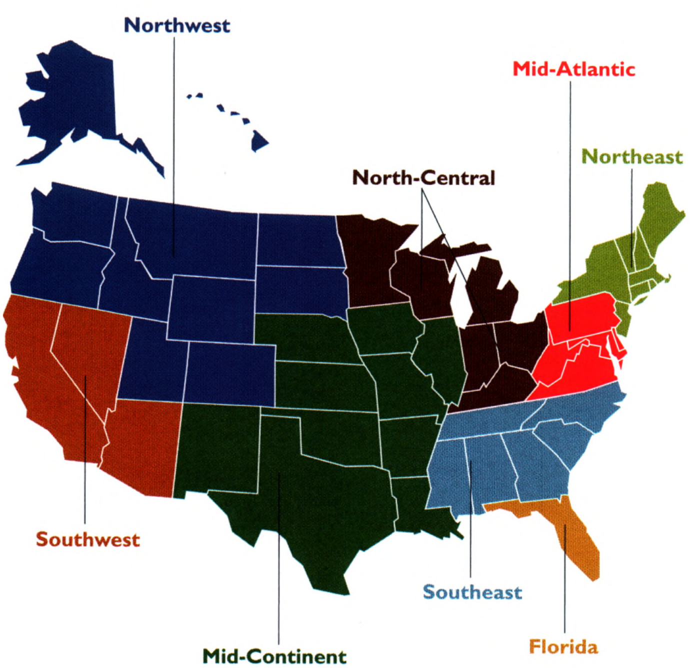

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Subscriptions $18 a year, Canada/Mexico $21 a year, and international $33 a year (air mail).

Subscriptions, articles, photographs, and correspondence relevant to published material should be addressed to: United States Golf Association, Green Section, Golf House, P.O. Box 708, Far Hills, NJ 07931.

Green Section Record (ISSN 0041-5502) is published six times a year in January, March, May, July, September, and November by the United States Golf Association®, Golf House, Far Hills, NJ 07931.

Postmaster: Address service requested — USGA Green Section Record, P.O. Box 708, Golf House, Far Hills, NJ 07931-0708.

Periodicals postage paid at Far Hills, NJ, and other locations. Office of Publication, Golf House, Far Hills, NJ 07931.

Printed on recycled paper

Turf *Twisters*

Q: I am hearing the term *vertical aeration* used more and more. What does this mean? Is this different from standard core aeration? (West Virginia)

A: This term refers to the use of deep vertical slicing tactics to aggressively remove thatch and organic debris. It is a form of vertical mowing that is often used in combination with standard core aeration techniques. Channels can be cut into the soil profile to a depth of 2.5 inches. Research has demonstrated that this is not a stand-alone treatment strategy. Although a great deal of organic material can be harvested, it is extremely difficult to work topdressing back into the channels created by the machines.

Q: We are in the process of adding more paved cart paths to our golf course and the superintendent at our course insists on building the paths to a minimum width of eight feet. We feel the wide paths will be too costly and will adversely impact play and the look of our golf course. What width do you recommend for cart paths? (Maine)

A: A width of eight feet is preferred for cart paths, and wider widths are recommended adjacent to some tees and greens where carts may be parked. The eight-foot width will make the paths more durable and enable the staff to move maintenance equipment over the golf course more easily. Work with your superintendent and a golf course architect to design and locate the cart paths where they will have the least impact on play and appearance. Spending additional money up front for wider paths and effective design is your best bet for success.

Q: Can zoysiagrass tees and fairways be core aerified in the spring as opposed to midsummer to avoid disruption during the peak golfing season? (Arkansas)

A: Although it is possible to aerify low-cut zoysiagrass in the spring (mid-May), the benefits of so doing are diminished, weed encroachment is encouraged, and recovery time is extended. This being the case, it would be best to continue aerifying tees and fairways during the latter half of July when cultivation of the soil improves the movement of water into the soil and the zoysiagrass can quickly grow over the open holes, thus smothering weed invasion and minimizing recovery time.

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