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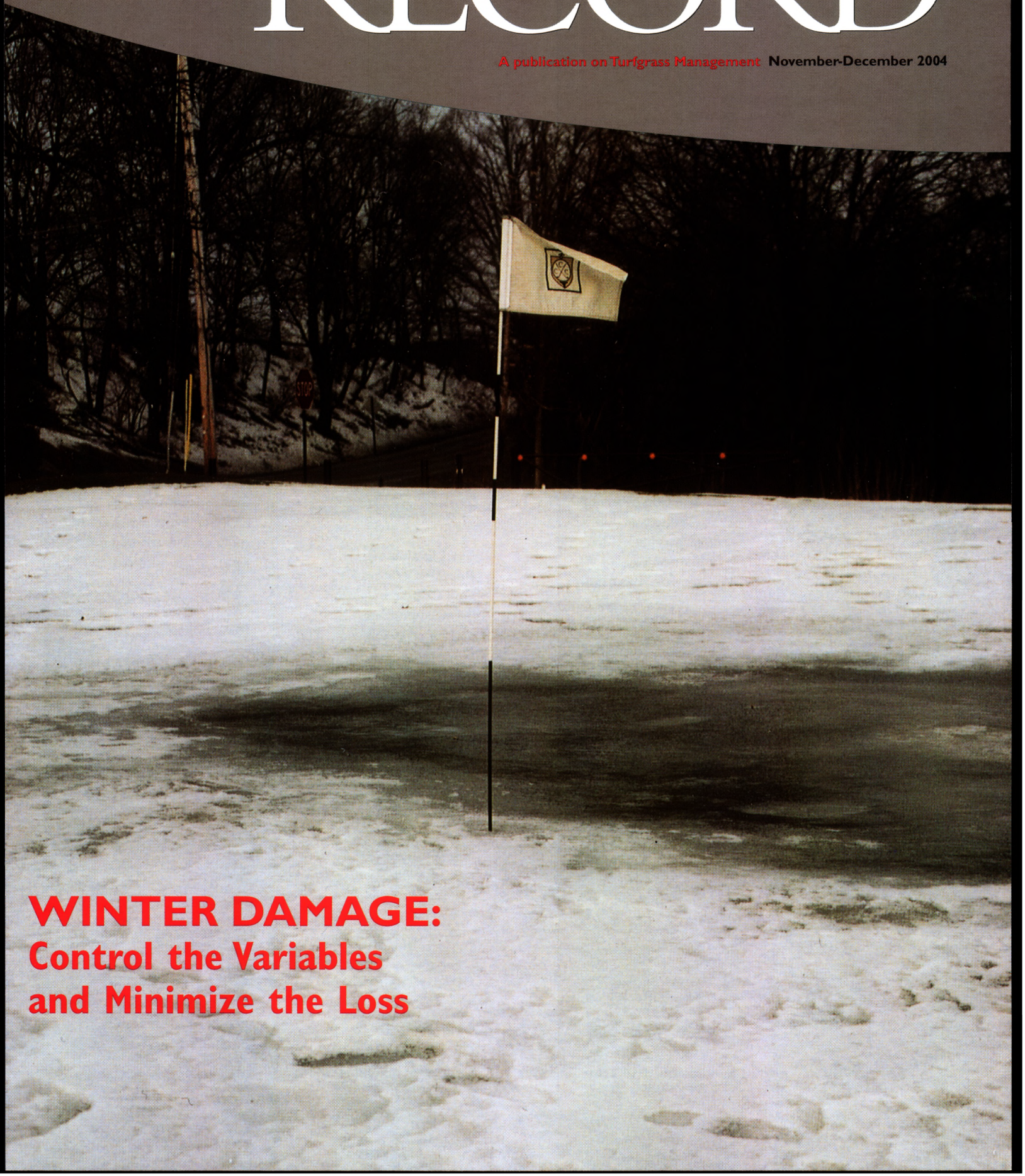

WINTER DAMAGE:
Control the Variables and Minimize the Loss

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Cover Photo
Turf managers should control variables where possible to minimize winter damage.

It is no coincidence that winter damage is more severe in the more shady areas of greens. To minimize the potential for future damage, remove limiting factors. Removing the tree would be a good starting point.

WINTER DAMAGE

Control the variables that can minimize the potential for winter turf loss.

BY KEITH HAPP

Thanks to research and advancements in turfgrass management, golf course maintenance has been impacted by the introduction of various technologies that have enabled turf managers to maintain higher quality conditions than in the past. While technology offers a degree of control, complete control over all of the variables associated with golf course preparation is not possible. This is particularly true when it comes to various aspects of winter injury on northern golf turf. On occasion, Mother Nature lets us know exactly how much, or should I say how little control we have. Over the last decade, numerous areas within the northern tier of states have suffered great turf loss due to direct low-temperature kill, crown hydration damage, wind desiccation, and, in some rare instances, suffocation.

Although there are several agronomic strategies that can be utilized to prepare for the onset of winter weather, control is not completely in the hands of the superintendent. Turf managers can control only certain aspects of turf health. Fertility strategies can be adjusted, cultural programs can be implemented in a timely fashion, plant protectants can be applied, drainage infrastructure can be enhanced, surface drainage patterns can be altered, and, most important, the growing environment can be improved by addressing limiting factors such as shade and airflow restrictions. This article will discuss some of the strategies that are being utilized to mini-

mize the potential for turf loss during severe winter weather.

THE HARDENING PROCESS

Plants withstand freezing in the cells of crown tissue by increasing concentrations of carbohydrates and other nutrient solutes within these cells as the plant hardens in the fall and early winter (Tompkins, 1995). To completely harden, turfgrass plants must freeze for a period of at least one month. This hardening process is reversed in the spring when stored energy (carbohydrates) is rapidly used. The plant dehardens (i.e., defrosts) and becomes very susceptible to low-temperature injury if the contents of cells are again exposed to low-temperature stress. If crown cells freeze after dehardening, severe damage can result. Research studies have revealed how susceptible unhardened biotypes of *Poa annua* can be to temperature fluctuations. Unhardened biotypes only tolerated temperatures of 23° to 28° F, while completely hardened biotypes exhibited tolerance of -13° to -25° F (Tompkins et al., 1995). As a comparison, researchers have reported that creeping bentgrass exhibits maximum hardiness levels of -40° F.

Biotypes of *Poa annua* can rapidly deharden when subjected to temperatures of 45° F for 48 hours (Tompkins, Budar, and Ross, 1996). In many portions of the Mid-Atlantic Region, these temperature fluctuations can and often do occur frequently within a short period of time. For example, during the prime hardening period of the early winter of 2003/2004, the Pittsburgh area experienced a temperature of 61° F on January 3, only to be followed by subzero temperatures seven days later. Under these conditions even the most proactive measures employed prior to the temperature swings can go for naught. The question is, what can turf managers do to improve the potential for the turf surviving severe weather conditions, particularly fluctuations in temperature resulting in rapid freeze and thaw cycles?

MOWING HEIGHT

Turf managers, with the help of the Green Committee, have developed course setup guidelines for maintenance and course preparation. Major components of course setup are the mowing procedures used throughout the property in general, and for the greens in particular. There are many factors that affect putting green performance, and all too often golfers focus on mowing heights to achieve the desired playing effect. Mowing height is critical to the plant's ability to prepare for winter weather. Excessive close mowing late in the year severely compromises the turf's natural defense mechanisms going into winter. Maximizing energy production via photosynthesis is essential to the hardening process. Surface area of the leaf is an important part of the equation. Energy is stored first in the leaves and then transported to the roots for use as winter reserves.

As a first step, set limits as to how the greens will be prepared during the period of plant hardening. For example, pick a date and stop mowing the turf. Use other techniques to prepare for bonus golf late in the year. Rolling could be used rather than regular mowing practices. If mowing has to be implemented, then raise the height of cut slightly until mowing can be completely halted before winter weather prevents any play. Even though it may be late in the season, make sure the mowers are sharp so that additional cutting does not bruise or tear the turf during the critical hardening process. It is no coincidence that turf on the collars often avoids crown hydration damage when grass on the green surface is severely damaged.

FERTILIZATION

Adequate fertilization plays a key role in preparing the turf for winter. Researchers have examined the fertility needs of turf prior to winter weather and have found that elevated levels of potassium and phosphorus are key components to surviving cold-temperature stress (Roberts, 1993; Johansson, 1994). There are a number of different materials that can be utilized to enhance winter hardiness, and it begins with nitrogen fertilization, which is the catalyst for nutrient uptake.

Studies have shown that carbohydrate reserves increase from fall fertilization. For example, researchers at Cornell University revealed the importance of nitrogen to the uptake of potassium (Woods, 2004). Additionally, Roberts (1993) reported that 30% less damage occurred on research plots treated with a 1:2 nitrogen-to-potassium regime. The least tolerant plots were those treated with nitrogen only.

Treating in a controlled fashion with readily available nitrogen sources provides the opportunity to stimulate the desired level of growth without compromising root growth. All too often, large quantities of fertilizer applied late in the

season create a lush turf that is very susceptible to winter damage as well as disease. All fertilization programs utilized late in the season should be focused on supporting the turf's ability to prepare itself for cold-temperature stress. That is, fertilization should be performed to stimulate and support carbohydrate storage. These reserves are critical to the hardening process. They can be maximized by using readily available nutrient sources that offer a predictable response.

TREE MANAGEMENT

In the fall, autumn days get shorter and temperatures decrease. These changes in environmental conditions provide a signal to turfgrass that winter is approaching. To allow the turf to use available nutrients, other essential factors must be considered. First and foremost, adequate sunlight must be provided. Availability of light is essential to photosynthesis during the hardening process (Johansson, 1994). Without sunlight, photosynthesis is restricted, resulting in lower carbohydrate production, and this reduces storage within the root structures. Additionally, shade plays a significant role in winter freeze-and-thaw cycles, particularly severe cold-temperature stress. It is no coincidence that greens that suffer the most during winter weather are located in shadier sites. During the winter months when the sun is lower in the southern sky, radiant energy is spread over a much wider area. The impact of shade is then magnified during freeze-and-thaw cycles.

Evaluate all areas of the course, particularly green complexes, for sunlight exposure, maximizing sunlight on the east and southern borders of these sites. Trees should accent and highlight the course, not interfere with proper course maintenance.

DRAINAGE

The importance of having adequate surface drainage characteristics during the winter cannot be overstated! Surface drainage becomes all the more important when rapid fluctuations in temperature occur. Water can collect in low-lying areas and freeze rapidly, resulting in crown hydration damage and/or direct low-temperature kill. It is not uncommon to see poor surface drainage characteristics near the interface of the collar and the putting green surface. Many turf managers are modifying these areas of their greens to help minimize the potential for any further winter damage.

A sod cutter is utilized to strip the area adjacent to the putting green that is in effect creating a dam or dyke, not allowing the water to escape. The sod is removed and the subsoils are shaved with a sod cutter. When positive water flow is

Follow the trail of draining water. Improving drainage to minimize standing water improves the chances of survival.

On this *Poa annua* green, triplex ring was a positive in this one instance. The traffic pattern resulted in less thatch in the wheel tracks and the turf was not lost to desiccation injury.

established, the sod is replaced. These types of projects are normally conducted late in the fall or during early winter. The sod will heal quite rapidly and playability can be restored before the next season. This type of minor change is not noticeable for daily play. However, during periods of rain or during periods of freeze and thaw, the changes can be significant.

Turf managers have also utilized intercept drains on the high side of a green that is prone to damage from runoff during precipitation or melting snow. Intercept drains, including drop inlets (DIs), can be strategically placed to capture rainfall or melting snow and ice. The position of these DIs is critical. During the winter months when soils are frozen, open stone intercept drains may not adequately accept runoff water. The excess then flows over the green, increasing the potential for crown hydration damage. The best method of positioning these DIs involves spending time on the course during a rain event. Watch the flow of the water and chart areas where additional drainage infrastructure is needed.

AERATION AND TOPDRESSING

Accumulations of excessive thatch will reduce the turf's ability to survive severe winter weather. Plant crowns and other structures elevated from the soil/thatch interface are not buffered as well from temperature extremes. Excessive thatch (more than an inch) is prone to desiccation when located in a windy area and also is prone to direct low-temperature damage when located in low-lying portions of the surface. Thatch that becomes saturated during thawing events is very prone to crown hydration damage. To a large degree this variable can be controlled with core cultivation and topdressing treatments.

There has been a resurgence of using late-season topdressing treatments. For years turf managers have practiced heavy late-season topdressing that provides an added degree of insulation against cold-temperature stress. The theory has been that crowns will be protected from desiccation and will also enjoy improved free drainage near the active growing point of the plant. Problems occur when sand is aggressively dragged or brushed into the canopy of the turf. The best possible scenario exists when treatments are performed in a light and frequent manner. Natural precipitation events then work the sand into the profile. Eliminating dragging manages a stress variable associated with the hardening process. As topdressing accumulates, a more resilient surface can result. Footprinting is often much less noticeable due to the fact that the topdressing is providing a firmer surface upon which to play. Still, the critical issue is topdressing at a rate that matches the growth of the turf and protects the active growing points of the plant.

To a large degree, preparing for winter weather hinges on the support of the Green Committee. We know that routine topdressing treatments provide an element of protection, insulation, and improved free drainage in the upper portion of the soil structure. However, this strategy must be balanced between trying to protect the turf and still providing an acceptable playing condition if weather allows the course to be used late in the season. Frankly, the first question to pose is whether or not bonus golf should take precedence over trying to prepare the course, in fact to protect it from potential severe weather. All too often, focus is placed on putting green performance at a time of year when excessive conditioning could easily predispose the turf to severe damage.

Recently, turfgrass managers have been experimenting with black topdressing sand to aid in controlling the temperature near the surface of the turf. The theory is to maintain growth by stimulating higher temperatures near the soil surface. This controlled plant growth can result in greater storage of carbohydrates, and thus more reserves for greater tolerance of cold-temperature stress (Hamilton, 2003).

TURF COVERS

When it comes to controlling winter damage, questions are always posed regarding the use of geotextile covers. Research has indicated that the use of these tools can be beneficial if desiccation

is the primary concern. These covers will help to minimize water loss from turf that is frozen and may even provide much faster growth response in the spring when the covers are removed.

For information regarding the use of covers, refer to the September/October 2000 issue of the *Green Section Record* ("Winter Protection of Annual Bluegrass Golf Greens"). In most instances, these geotextile covers and other green blankets will protect the turf from certain cold-temperature stresses, but the turf cannot be protected from all of the conditions that can be presented. Crown hydration damage has occurred underneath geotextile covers even when the most laborious precautions have been taken.

TO REMOVE OR NOT TO REMOVE?

A question often posed is whether or not to remove snow cover on an ongoing basis during the winter. Research is clear on this one point. One way to protect greens from injury in the late winter is to maintain snow cover as long as possible. The snow insulates the turf from air temperatures that may warm the soil and induce a reduction in cold tolerance. Basically, the snow cover helps to maintain a dormant state, which prolongs the tolerance to cold-temperature stress. If snow melts rapidly, then the extent of the protection may only last a few days during the nighttime hours. However, this may still be enough to prevent major damage. Naturally, the surfaces need to be inspected to determine if ice accumulation is occurring.

Ice accumulation is another story. The turf can survive under ice, but it is the initial phases of freezing that impact survival. If the plant has hardened, soils have frozen, and a gradual reduction in temperature has occurred, then the potential for damage is reduced. The worst-case scenario occurs when the soil is not frozen, there is rainfall, and the temperature plunges. Damage may then be unavoidable.

Removal of ice has become much more feasible with the introduction of black topdressing sand. This material has offered a high degree of control during certain types of winter weather. Research has indicated that treatments of between 70 and 100 lbs. of actual product per 1,000 sq. ft. can rapidly melt significant accumulations of ice (Hamilton, 2003). Often, treatments performed in the middle of winter can melt through 2 to 4 inches of ice in a 24-hour period. As the snow and ice melt, the runoff must have a place to go. This reemphasizes the need for adequate drainage capacity to move the water away from the turf.

CONCLUSION

There are several factors that help induce natural cold hardening. Low temperature, shorter day length, and reduced soil and plant moisture are prime examples, but these factors are uncontrollable.

Low-temperature hardiness can fluctuate from season to season, and soil temperature plays an important role in determining the degree of hardiness the plant can reach. If factors are favorable, plants will achieve the maximum levels of cold hardiness at the start of winter. However, a plant that can tolerate temperatures of below 0° F in December may only be able to tolerate temperatures slightly below 20° F in early April. It is possible for the turf to experience improved cold hardiness, but the level never reaches the initial cold hardiness established prior to winter. Simply put, as the winter season progresses, there are fewer energy reserves within the plant to draw on to tolerate the colder weather.

Golf tees can be impacted by winterkill as well. Attention to traffic stress, compaction, and proper agronomic procedures are equally critical issues.

Black topdressing sand was used to rapidly melt snow and ice on this putting green surface. Using 75 to 100 lbs. of product per 1,000 sq. ft. removes significant ice accumulation in 24 hours.

Research indicates that fall applications of black sand can increase soil temperatures. This may help turf better tolerate winter freeze-and-thaw cycles.

This further emphasizes the need to fertilize in an appropriate manner and at the proper time in the fall and early winter to maximize the natural stress mechanisms of the turf. The hardening process is of great importance for grasses to survive the winter. Planning to control as many factors as possible will help improve the chances for turf survival, no matter what weather conditions may be presented. While weather is a difficult factor to calculate into management regimes, the need for communication is not. Don't stop communicating to golfers the importance of what needs to take place during a time of year when preparation is everything.

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Research *You Can Use*

Turfgrass Establishment on Various Rootzones

A comprehensive study at Rutgers University sheds light on the efficacy of various rootzone amendments.

BY JAMES A. MURPHY, HIRANTHI SAMARANAYAKE, JOSH A. HONIG, T. J. LAWSON, AND STEPHANIE L. MURPHY

Sand is commonly used to construct putting green rootzones and is often amended with organic amendments, such as peat or soil containing silt and clay to improve physical and nutrient properties for turf. Goals of amending sand include improving plant-soil relationships, altering the growing conditions on or beneath the playing surface, and minimizing soil and turf management problems.[20]

Materials other than peat that have been studied for amending sand include slag, calcined clay, expanded perlite and composted soil,[19] clinoptilolite zeolite,[12,14] rice hulls, sawdust, calcined clay and vermiculite,[15] bark,[2] perlite,[2,10] green waste, wood chips, pulp, sewage and plant residue and fibers,[9] and finer-textured soils.[3,4,7,17,18] Many of these previous reports emphasized physical properties of rootzone mixtures with some information provided on turfgrass response. Amending sand may alter nutritional properties of rootzones, depending on the properties of the amendment and amount added, the properties of the material being amended, and mixing uniformity.[20]

It is important to have a rapid and thorough establishment of turfgrass on newly constructed rootzones, as it can affect the initial revenues and use of a golf course. The objective of this field study was to examine the effects of rootzones varying in amendment type and/or rate, and consequently physical and nutritional properties, on the establishment of creeping bentgrass turf.

SETTING UP THE EXPERIMENT

Three general classes of amendment materials were used (loam, organic, and inorganic) to construct the rootzones at various volume ratios. Rootzone treatments are described in Table 1. A commercially available medium-sized sand meeting USGA guidelines for sand size was used as the major component for rootzones except the 100% loam and 20% compost treatments. The 20% compost treatment used a sand considered too fine based on USGA guidelines. The 100% loam and 20% compost treatments were included for the purpose of comparison (i.e., relatively extreme rootzone properties).

Plots were fertilized with 10-10-10 and 12-24-14 (N-P_2O_5-K_2O) fertilizers, each at N rate of 1 lb. per 1,000 sq. ft. (total 2 pounds per 1,000 sq. ft. of N) before seeding with L-93 creeping bentgrass at 1 lb. per 1,000 sq. ft. Fourteen post-planting fertilizations were made to all plots except 100% loam and 20% compost during 1998, applying a total of 5.1, 2.5, and 2.8 lbs. per 1,000 sq. ft. of N, P_2O_5, and K_2O, respectively. The 100% loam and 20% compost plots received 13 post-planting fertilizations that amounted to 4.7, 2.5, and 2.8 lbs. per 1,000 sq. ft. of N, P_2O_5, and K_2O, respectively.

A fertilization of 46-0-0 at 0.3 lb. per 1,000 sq. ft. of N was required on the non-amended sand plots to produce sufficient turf growth to survive mowing. Five fertilizations were made to all plots between May 7 and June 1, 1999, applying a total of 2.1, 0.5, and 1.1 lbs. per 1,000 sq. ft. of N, P_2O_5, and K_2O, respectively. Irrigation was applied to supplement rainfall, and mowing was maintained at 0.5 inch until the height was gradually lowered to 0.125 inch by the end of May 1999. Plots also were topdressed with their respective rootzone mixes and core cultivated.

Visual ratings of turfgrass establishment and quality were taken, and turf cover for each plot was quantified via line-intersect counting. Samples from the 0- to 4-inch depth were collected in April 1999 to assess rootzone fertility. Three cores were taken from selected plots in 1999 and sectioned into 3-inch intervals to assess rooting.

TURF ESTABLISHMENT RATINGS

Bentgrass establishment through 60 days after seeding (DAS) was better on most of the amended rootzone mixes compared to unamended sand. An acceptable establishment rating (5 or higher) was observed at:

- 13 DAS for 20% compost mixed with finer sand
- 17 DAS on 10% ZeoPro and 100% loam mixes

- 20 DAS for 20% sphagnum, 20% loam, and 20% Profile mixes
- 24 DAS for 10% sphagnum and 10% reed sedge, 20% Irish, and 10% Profile mixes
- 28 DAS for 5% reed sedge, 10% Irish, 5% Fertl-Soil, and 10% compost mixes
- 31 DAS for 5% loam
- 37 DAS for 2.5% loam, 5% sphagnum, 10% Isolite mixes
- 41 DAS for unamended sand, 10% Greenschoice, and 10% Kaofin mixes

Note that unamended sand and Kaofin plots received an additional 0.3 lbs. per 1,000 sq. ft. of N at 37 DAS to promote sufficient growth and enable turf to survive mowing, yet these plots remained the slowest to establish.

The 100% loam plots initially established turf very well until mowing was started, and then the turf establishment suffered. The decline in establishment resulted from mower scalping that was caused by lack of firmness (stability) in the soil under frequent irrigation and uneven settling of the loam.

Table 1

Description of materials and mixing rates used to amend a medium-sized sand and construct rootzones 12 inches deep over a 4-inch gravel layer, except where noted

Amendment	Material Description	Volume Mixes Percent Amendment
None	Medium-sized sand	0
Loam	Loam mixed with medium sand Sand / Silt / Clay (% by volume) 98.2 / 1.0 / 0.7	2.5
	96.8 / 2.2 / 1.0	5
	88.9 / 8.3 / 2.8	20
Loam Over Subgrade	Rootzones constructed 12 inches deep over subgrade with drainage pipe (i.e., no gravel layer) Sand / Silt / Clay (% by volume) 96.8 / 2.2 / 1.0 5.8 / 48.7 / 15.5	
Organic Amendments		
Sphagnum Peat	Sphagnum peat from Sun Gro, Canada	5, 10, 20
Reed Sedge Peat	Reed sedge peat from Dakota Peat, North Dakota	5, 10
Irish Peat	Sphagnum peat from Ireland	10, 20
Kaofin	Granulated recycled paper manufacturing by-product containing cellulose and kaolin from New Jersey (also containing surfactant)	10
Fertl-Soil	Spent mushroom soil compost from Pennsylvania	5
AllGro Compost	In-vessel composted biosolids from AllGro in New Hampshire	10
AllGro Compost with finer sand (AT Sales)*	Finer sand amended with in-vessel composted biosolids from AllGro, Pennsylvania	20
Inorganic Amendments		
Isolite	Porous ceramic - diatomaceous earth	10
Axis	Porous ceramic - diatomite	10
Greenschoice	Porous ceramic - clay based	10
Profile	Porous ceramic - clay based	10, 20
ZeoPro	Nutrient charged clinoptilolite zeolite	10
ZeoPro surface 4-inch	Surface 4 inches of rootzone amended with ZeoPro overlying 8 inches of medium sand	10
ZeoPro Plus surface 4-inch	Surface 4 inches of rootzone amended with ZeoPro containing micronutrients overlying 8 inches of medium sand	10

*Sand used to mix with 20% compost contained a high amount of fine sand based on the USGA guidelines for rootzone composition. All other mixes contain medium sand conforming to USGA size guidelines (see Table 1).

TURF COVER

Turf cover measurements at June 22 and July 8 (22 and 38 DAS, respectively) reflected turf establishment ratings and indicated that the lower amendment rates of loam (2.5% and 5%), sphagnum (5%), reed sedge (5%), and Irish peat (10%) were not as effective in promoting establishment as were greater rates of those amendments. The 20% compost mixed with finer sand and 100% loam plots had the greatest turf cover compared to other mixes. While the 20% compost mix rapidly developed and maintained excellent turf cover, turf cover on 100% loam plots decreased from 92% to 82% by July 8. Again, this decline in turf performance on 100% loam plots was due to mower scalp caused by inadequate surface stability and uneven settling of the rootzone. Amending with 10% Kaofin, 10% Greenschoice, and 2.5% loam did not improve plant cover compared to unamended sand by July 8. Kaofin plots had the least turf cover compared to other plots on June 22 and July 8, which reflected the challenges of establishing turf on these plots.

Improved turfgrass establishment was attributed to improved soil physical and nutritional conditions. Bentgrass established most rapidly on the 100% loam, 20% compost, and 10% ZeoPro plots as would be expected on mixes with a high nutrient content. The positive turf response to the nutrient-charged ZeoPro amendment was expected.[1] Ferguson et al.[11] and Nus and Brauen[15] reported improved creeping bentgrass establishment in field trials using non-charged zeolite.

Increasing amendment rates of loam, sphagnum peat, Irish peat, and reed sedge peat improved the rate of establishment. Most amendments increased

Researchers at Rutgers University compared several organic and inorganic amendments for their physical and nutritional properties as well as their efficacy to improve establishment of creeping bentgrass over unamended sand.

CEC, although the level of CEC was less than 4 cmol kg^{-1}, which is considered low.[8] The majority of fertilizer N in this trial was in the form of ammonium. Thus, it is probable that the improved turf establishment on mixes with increased CEC was attributable to better nutrient retention, particularly ammonium nitrogen. Huang and Petrovic[13] and Ferguson and Pepper[11] reported increased ammonium retention in sand amended with non-charged zeolite, and Bigelow et al.[6] observed lower ammonium loss in leaching studies with Profile and non-charged zeolite.

Greater water retention (capillary porosity at or above the USGA recommended maximum of 25%) was often associated with rapid turf establishment. Murphy et al.[14] reported better turf establishment on mixes with capillary porosity of 25% (0.25 m^3 m^{-3}) or higher (the mixes in that study were not confounded by differences in nutrient retention). Greenschoice and Kaofin mixes were exceptions compared to other amended sand mixes and exhibited either similar or poorer establishment than unamended sand. These two mixes were very dry despite the light, frequent irrigation used during establishment, as evidenced by the low capillary porosity of these mixes, particularly Kaofin.

TURF QUALITY

Turf quality ratings indicated that many mixes performed at a level that was consistent with observations made at early establishment. However, there were some mixes with dramatic changes in performance. Profile plots, which initially had established turf better than the unamended sand, became similar in turf quality to the unamended sand by October 1998. Eventually, turf quality on the Profile plots was lower than the unamended sand. The ZeoPro plots produced very high turf quality up to October 1998. However, quality declined to moderate and low acceptable levels by April and May 1999.

The Kaofin plots, which initially established very slowly (slower than unamended sand), achieved very high turf quality by October 1998 and maintained that level of quality into May 1999. This change in performance on Kaofin plots was attributed to the surfactant (droughtiness and phytotoxicity) dissipating from the Kaofin amendment, and subsequently turf growth improved. The 10% Greenschoice plots, which initially established at a rate similar or slightly less than the unamended, declined to unacceptable levels of quality by October 1998. Turf quality on Greenschoice plots was so poor in May 1999 that the plots nearly failed.

The 5% loam plots (over gravel and over subgrade) produced a moderate level (6.5 to 7.5) of turf quality. However, low acceptable quality levels were observed on 2.5% and 20% loam plots. Thus, turf responses suggested that the 20% loam mix was approaching excessive amounts of the amendment (i.e., silt and clay). As noted previously, surface instability on 100% loam plots continued to negatively impact turf performance from October 1998 to May 1999 to the point that quality was unacceptable by April 1999 and plots could be judged as failing.

The 10% and 20% Profile and 4-inch ZeoPro plots produced relatively low

turf quality ratings that were less than the unamended sand in May 1999. Irrigation was not re-initiated until May 13, 1999. Thus, the improved nutritional characteristics of these mixes that were an asset under the frequent irrigation during seedling establishment were probably negated by the relatively low water availability (capillary porosity) in those plots when irrigation was more limited in 1999. Moreover, the greater ability to retain nutrients, particularly ammonium, probably became less important as fertilization was decreased towards a maintenance level over time and ammonium was depleted from the charged zeolite.

Similarly, low water retention was attributed to the poor turf performance on the 10% Greenschoice plots. Bigelow et al.[5] reported the inability of inorganic amendments to improve available water retention in sand mixes using standard laboratory techniques. In fact, some of their data indicated available water was decreased in sand mixes containing inorganic amendments. Our field data for turf performance on mixes containing inorganic amendments was in agreement with those findings.[5]

ROOTING RESPONSE ONE YEAR AFTER SEEDING

Roots were observed at all depth zones for all mixes, and the relative differences in total root mass among rootzone mixes were generally evident in root mass assessed at all four 3-inch depth intervals. Greatest total root mass was found in the unamended sand, 2.5% and 5% loam, 5% loam on subgrade, 5% sphagnum, 10% and 20% Profile, and 10% ZeoPro mixes. Higher amendment rates of loam and peat in the rootzone mix decreased the total root mass to the point that the high amendment rates of sphagnum, reed sedge peat, and loam had considerably lower total root mass than unamended sand. The lowest total root mass was found in the 20% compost mixed with finer sand and 10% ZeoPro Plus (i.e., containing micronutrients) plots.

Thus, there was a relationship of lower root mass with mixes having greater water storage, yet these mixes also consistently produced high turf quality. Murphy et al.[14] observed that finer-textured and, consequently, wetter sand rootzones resulted in lower root mass at depths below 3 inches and better turf quality during the first year of establishment. These findings indicate that variation in water availability of sand-based rootzones can be sufficient to impact distribution of dry matter between roots and shoots.

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A more comprehensive paper on this project, including data on physical and nutritional properties of these rootzone mixes, can be found on the USGA's *Turfgrass and Environmental Research Online* at http://usgatero.msu.edu.

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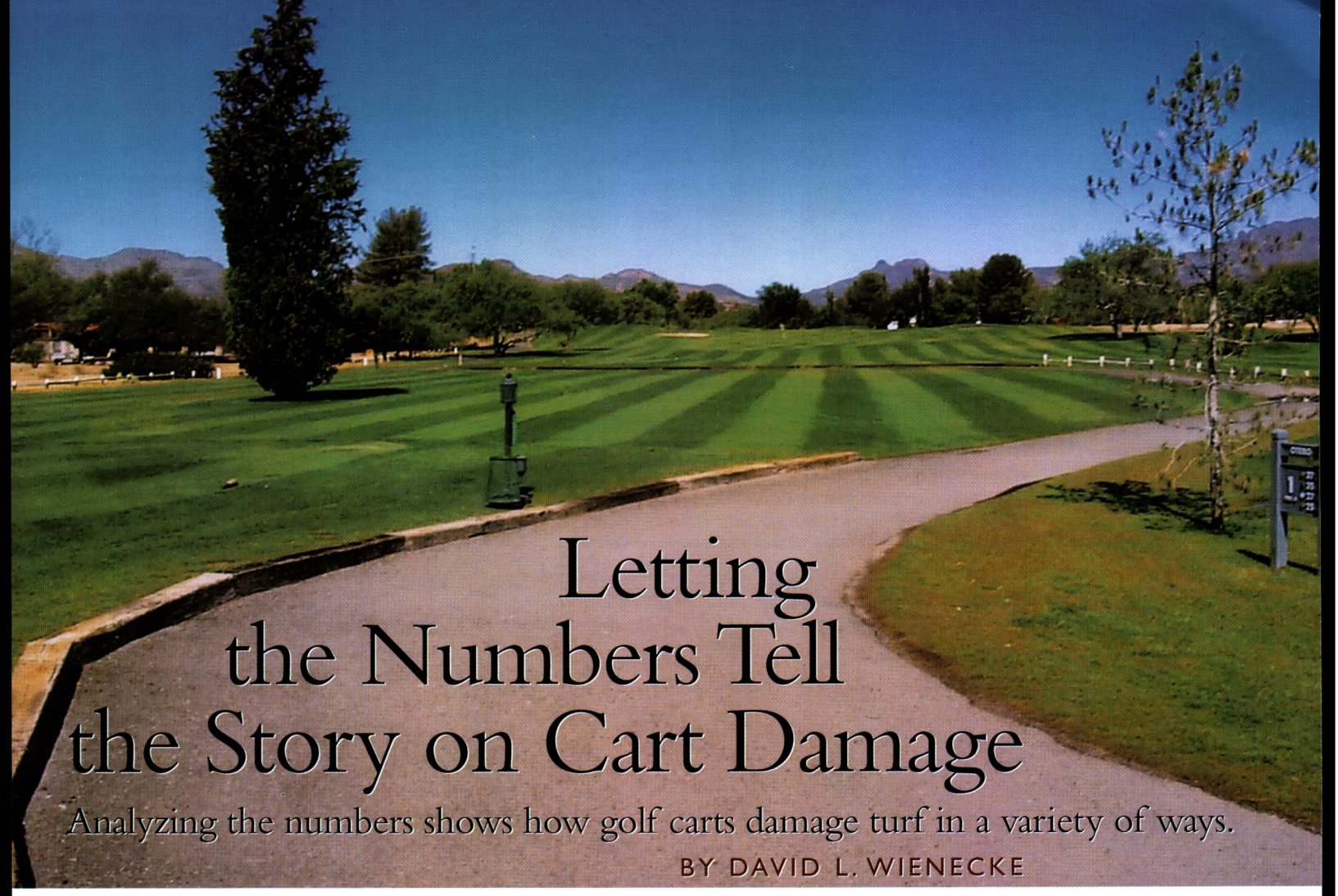


Letting the Numbers Tell the Story on Cart Damage

Analyzing the numbers shows how golf carts damage turf in a variety of ways.

BY DAVID L. WIENECKE

Play golf and ride in a golf cart. It is almost a given these days. But the traffic jam caused by golf carts is getting out of control and is taking an increasing toll on turf. Now golfers are asking, "Why can't I drive my own golf cart on the golf course? It seems to me that one golf cart per person will cause less damage compared to two golfers per cart."

While it is easy to count the money generated by golf cart rentals, it is not so easy to account for the damage and additional maintenance required to compensate for unrestricted cart use. There have been several good research studies in recent years documenting the impact of golf carts on turf wear, and this article will examine these effects by letting the numbers tell the story.

CART DAMAGE DEFINED

Several studies have analyzed the turf damage caused by golf carts and other turf vehicles. The impacts can be broken down into two broad categories:

- Turf injury — The wear damage caused by vehicles is influenced by the speed of travel and the amount of stopping, starting, and turning. The tread design of tires also affects wear damage. Wear symptoms include leaf tissue matting and a subsequent exposure of underlying thatch. With additional traffic, leaf blades are bruised. Ruptured cells eventually give turf a dark, water-soaked appearance. Wilt sets in as water is lost from the leaves, eventually causing a loss of chlorophyll and cell death.
- Soil compaction — The soil compaction caused by carts reduces the shoot growth rate and the recuperative potential of turfgrass. Compaction reduces air and water porosity within the soil as well as water movement through the soil profile. Soil compaction can impact turf growth for several weeks or months, resulting in the total loss of turf cover and chronic problems with poor drainage and the invasion of weeds that prefer compacted soil conditions.

There are other variables, such as soil type and moisture levels, that further impact wear stress. Research by Carrow and Johnson noted that turfgrass growing on sandy soils and some clay soils is more prone to wear injury. Soil compaction is

A well-designed cart path that is easy for golfers to follow with routing and curbs for traffic deflection will reduce turf damage significantly.

greatest when traffic is imposed over excessively wet soils. Any factor reducing turf growth rate, such as soil compaction, high external salt levels, and frozen soils causes a further increase in wear damage compared to a vigorously growing turf.

COMPACTION

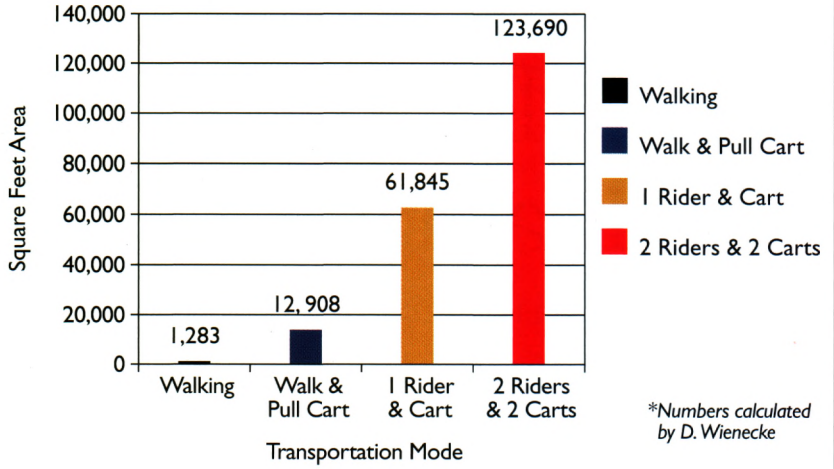
All forms of traffic cause some degree of compaction. This is typically an indirect problem commonly resulting in a reduction in turf vigor. The forces that contribute to compaction include the weight of the golfer or golf cart spread over the turf surface. The following example illustrates the amount of pressure exerted on the turf from various sources:

- 200-pound golfer heel of foot (walking) = 25 pounds per square inch (psi)
- 200-pound golfer ball of foot (walking) = 16.6 psi
- 200-pound golfer full foot (standing) = 10 psi
- 200-pound golfer both feet (standing) = 5 psi
- Pull cart (17 pounds) 2"-wide tires = 2.1 psi (two tires)
- Pull cart (17 pounds) 3"-wide tires = 1.4 psi (two tires)
- Pull cart (17 pounds) 4"-wide tires = 1.1 psi (two tires)
- Electric golf cart (empty, 950 pounds) with four 8"-wide tires = 3.7 psi
- Electric golf cart with one person and gear (1,200 pounds) = 4.7 psi
- Electric golf cart with two people and gear (1,450 pounds) = 5.7 psi
- Maintenance pickup truck (3,000 pounds) = 25 psi (four tires)

Based on compression pressure, we would expect to see walking golfers causing the most damage. In fact, the majority of wear damage observed in the field is caused by four-wheeled motorized golf carts. Why is this true? Read on!

Figure 1
18-Hole Traffic Impact Area*

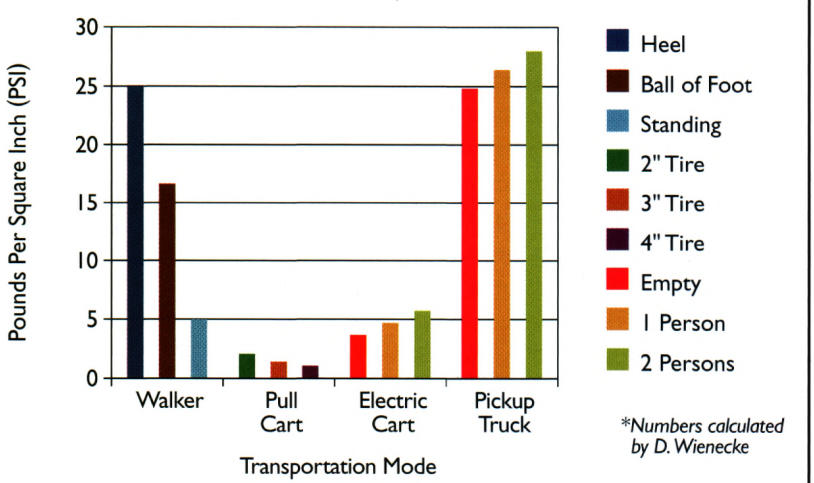
Calculations of areas impacted by walking, pull carts, and riding carts show the significant area of turf potentially damaged by carts when compared to walking golfers. One golfer per cart impacts approximately the same area as two golfers per cart. Two carts with one golfer in each cart potentially will impact twice the area compared to two golfers in one cart.



*Numbers calculated by D. Wienecke

Figure 2
Compression Pressure (PSI)*

Calculations of actual compression pressure show pressure on the heel of the foot while walking is equal to pressure from a four-wheel pickup with one rider. Turf area impacted must also be considered with compression pressure to get a true picture of the cause of vehicle turf damage.



*Numbers calculated by D. Wienecke

AREA IMPACTED — WHERE THE RUBBER MEETS THE ROAD

The damage caused by various modes of transportation can be estimated by measuring the contact area of shoes or tires and multiplying this over the total area covered during a round of golf. The following example illustrates the average area impacted while playing a 6,200-yard golf course:

- Walking golfer with golf bag = 1,283 sq. ft.
- Walking golfer using a pull cart with 3"-wide wheels = 12,908 sq. ft.
- Golfer riding a golf cart = 61,845 sq. ft.
- Two golfers each using a golf cart = 123,690 sq. ft.

Looking at the numbers, it is easy to understand why four-wheel golf carts impact (and compact) the golf course so dramatically.

LESSONS LEARNED

The preceding examples paint a clearer picture of why golf carts cause significant damage to golf

courses. By analyzing the numbers, we can learn the following lessons:

- All vehicles cause turf damage. This includes motorized golf carts, pull carts, and maintenance vehicles. Some of the damage may not be visible for days or even weeks as a result of the effects of soil compaction.
- Walking the golf course and carrying your clubs impacts the golf course far less than pull or motorized carts based on the total amount of area impacted.
- Pull carts impact the golf course less than motorized carts, but all carts impact the golf course more than walking. This is due to the smaller area contacted by foot traffic and the wheels of the pull cart.
- Vehicle traffic has the greatest impact on wear and soil compaction due to the amount of area covered and the increased damage caused by repeated traffic over a concentrated area. Damage is further increased with a greater number of turns, a higher speed of travel, and the number of traffic passes over a given area. Based on the research results, the main focus for minimizing the damage caused by golf carts should be on spreading traffic over a wider area or restricting golf carts to paths.
- There is some evidence to suggest that the newer designs of golf carts can reduce the overall impact on turf injury due to wider tires and smoother tread design.

IDEAS FOR SPREADING CART WEAR AND REDUCING TURF DAMAGE FROM VEHICLES

To reduce the inevitable damage caused by golf carts, it is important for courses to establish policies for cart use. While each course is different, the following suggestions can help with the development of practical policies to reduce the damaging effects of golf carts:

- Encourage golfers to spread cart traffic over a wider area and avoid turning and driving over the same areas repeatedly.
- Vary the entry and exit points along the cart paths each day to spread traffic and wear more evenly.
- All vehicles should be kept at least 30 feet from the edges of tees and greens to avoid damaging sensitive turf areas.
- Carts should never be taken across excessively wet areas.
- The use of carts should be suspended or restricted following periods of heavy rainfall or under persistently wet conditions.
- Golfers should always share a cart.
- Encourage golfers to use the 90-Degree Rule by exiting the path and driving to the first ball,

Wet turf is more susceptible to cart damage. Excluding vehicles from excessively wet areas using signs and barriers will protect the turf until the moisture is reduced via drainage or drying.

Signs coupled with marshal enforcement and golfer education work well for keeping carts on paths. Install signs frequently throughout the course to remind golfers when they need to stay on paths.

then to the next ball, and then returning to the path.

- Restrict carts to the path on all par-3 holes.
- Propose a "walkers-only day" one time per week when no golf carts are allowed on the course.
- Consider closing one additional hole to cart traffic on each nine on a weekly rotation. This allows the turf to recover from damage and gives the maintenance staff time for extra aeration and other procedures to stimulate turf recovery.

Most of the damage caused by golf carts can be minimized when drivers use common sense and observe proper course etiquette. Each person driving a cart must be aware of the damage that vehicles cause and take steps to reduce that damage in order to preserve the condition of the course for all golfers.

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Research *You Can Use*

New Tool for Biological Warfare on Cutworms?

Recent discoveries by University of Kentucky scientists may make biological control of black cutworms a reality.

BY CALLIE ANNE PRATER AND DANIEL A. POTTER

The black cutworm (BCW), *Agrotis ipsilon*, is a major pest of golf courses and sports fields in the U.S. and throughout the world. The BCW larvae make burrows in the thatch or soil, or occupy aerification holes or other cavities, emerging at night to chew down grass blades and stems around the burrow. The damage appears as small dead patches or sunken pockmarks that resemble ballmarks on greens. Birds probing the turf for a meal of juicy caterpillars may pull up tufts of grass with their beaks, further reducing smoothness and uniformity of the putting surface.[3]

CONTROL AND CONCERNS

Because of the low golfer tolerance for such damage, BCW warrants frequent insecticide applications. Some superintendents treat every two to four weeks during the growing season as a preventive measure. Although most modern turf insecticides are intrinsically less toxic than products used a generation ago, some still have the potential to adversely affect pollinators, decomposers, and beneficial natural enemies (predators and parasitoids) that help buffer the turf against outbreaks.[3]

Some insecticides have the potential to run off or leach into surface or groundwater, and to impact aquatic organisms and wildlife. These issues, along with societal concerns, have led to increased restrictions and loss of some insecticide registrations. Some communities have already mandated that only so-called "organic" fertilizers and pesticides be used on turf, and the turfgrass industry itself has set forth a new initiative to seek alternative biological controls.

A NEW DISCOVERY

In the summer of 2003 we made a serendipitous discovery that may provide a new tactic for safe and long-lasting control of BCW on golf courses. Large numbers of BCW were being collected from six Kentucky golf courses to survey for parasitic insects, but the study was thwarted when about 75% of the field-collected larvae died from a pathogen infection. Diseased larvae showed necrotic spots covering the integument (skin), followed by a swollen, milky white appearance. Death by liquefaction occurred within a few days.

With help from colleagues in our Insect Virology Unit, the mystery pathogen from BCW cadavers was isolated, purified, and sequenced using PCR analysis, providing a genetic fingerprint useful for identification. The sample matched profiles of *Agrotis ipsilon* multicapsid nucleopolyhedrovirus (AgipMNPV), a baculovirus originally discovered infecting BCW in Illinois cornfields.[1] The Kentucky strain was amplified by feeding it to healthy caterpillars, allowing them to die, and then harvesting more virus from their carcasses. Liquid and bait formulations of the virus were tested in the lab and field in autumn 2003. High mortality (80-90%) from virus was obtained in both trials. More extensive tests were carried out in summer 2004.

AGIPMNPV MODE OF ACTION

For infection to take place, the caterpillar must ingest virus particles that stick to grass blades and stems. Once ingested, the virus particles dissolve in the alkaline environment of the insect's gut. This releases infective baculovirus virions that penetrate the insect's gut wall. One round of replication occurs in the cells that line the gut. These virus particles are then released into the insect's blood and travel throughout the caterpillar to invade and replicate in other susceptible tissues.

This second generation of virions then becomes coated by a protective protein layer called polyhedrin. The virions plus protein coat are now referred to as occlusion bodies. The insect's cells are unable to contain the numerous occlusion bodies and eventually rupture. The insect liquefies internally and dies. The integument soon ruptures, releasing the liquefied contents that contain millions of virus particles into the environment.[4]

POTENTIAL OF BACULOVIRUSES FOR INSECT CONTROL

Baculoviruses have the potential to be ideal biological control agents. Their protective protein coat dissolves only at a specific pH and other conditions

found in the gut of host caterpillars. This specificity enables the virus to control pest populations without harming non-target organisms.[3] Baculoviruses also are known to infect only the particular insects to which they are adapted, and therefore are safe for humans and other vertebrates as well as plants. Additionally, as a result of their protein crystallized coating, they are able to persist in the population as well as in the environment for extended periods of time.[1]

Once established, baculoviruses may remain active in upper soil layers for many years. This persistence might allow for fewer applications compared to chemical controls, and may possibly provide season-long or even multi-year control. Baculoviruses also are highly pathogenic, allowing them to spread quickly throughout pest populations. On the downside, the specificity of action that is an advantage in one context limits the potential market for a commercial product compared to conventional insecticides that control a broader range of insect pests.

These viruses also have the ability to be mixed with fungicides, herbicides,

The black cutworm (BCW), *Agrotis ipsilon*, is a major pest of golf courses and sports fields in the U.S. and throughout the world. The BCW larvae make burrows in the thatch or soil, or occupy aerification holes or other cavities, emerging at night to chew down grass blades and other stems around the burrow. Damage from black cutworms appears as small dead patches or sunken pockmarks that resemble ballmarks on greens.

and other insecticides, and they can be used in conventional spray equipment. Unlike some chemical controls, baculoviruses do not have broadly toxic residues that may adversely impact the environment. There have been 15 cases of successful, permanent biological control with insect viruses.[2] For example, viruses were used to suppress the European spruce sawfly in Canada and the United Kingdom. In one study, researchers applied an NPV for control of soybean loopers, and when the plots were reevaluated 15 years later, the virus was still providing about 63% control.[2]

PROGRESS TO DATE

In our USGA-funded project we are evaluating the potential for developing this insect-specific virus as a bio-insecticide against BCW in turf. So far we have made some interesting discoveries. For example, most larvae die within a week after becoming infected with the virus. When young larvae become infected, their growth and development are stunted, and they die while still small. In contrast, older infected larvae may continue to feed up until the day of death. Thus, the virus may be better suited as a preventive for season-long suppression than as a rescue treatment in response to damage.

We continue to evaluate field efficacy of AgipMNPV under golf course conditions. For example, one of the main factors limiting the use of baculoviruses as bioinsecticides is their tendency to be degraded by exposure to ultraviolet (UV) light. We currently are evaluating if AgipMNPV formulated with optical brighteners may enhance stability of the virus in sunlight and provide better suppression of BCW under field conditions. Irrigation is another factor that may affect the virus. We are comparing the effectiveness of the virus with and without irrigation, and in combination with spray adjuvants (e.g., spreader/stickers) to increase the virus's foliar persistence.

Persistence of the virus in the host population is vital for sustained control. This is dependent upon horizontal transmission from insect to insect. When larvae die from a viral infection, they release millions of occlusion bodies into the surrounding environment that may infect other host larvae. We will determine the probability of healthy larvae contracting the virus after feeding on turf cores where infected larvae have died. This will give us an idea of how easily this virus is spread throughout the population. We also hope to determine if there might be a synergistic interaction between the virus and endophytic grasses. In other words, will feeding on endophytic grasses make BCWs even more susceptible to the virus?

Once infected with the baculovirus, the black cutworm liquefies internally and dies. The integument soon ruptures, releasing the liquefied contents containing millions of virus particles into the environment.

BREAKING NEW GROUND

This is the first research to investigate use of a virus to control an insect pest in the turfgrass environment. Given the increasing restrictions on broad-spectrum pesticides, this type of research is necessary to ensure that professional turfgrass managers will always have adequate alternatives to chemical control. We have seen naturally occurring baculoviruses nearly wipe out localized BCW populations on golf courses in some years. Thus we are optimistic that commercial development of AgipMNPV baculovirus could offer a viable alternative to traditional insecticides for this perennial pest.

We envision that golf course superintendents might apply AgipMNPV early in the growing season as a preventive measure, causing high mortality in the first-generation BCW populations. Death of those larvae will in turn create a reservoir of virus in the soil and thatch that perpetuates control of BCW through the growing season. The tactic would be both cost effective and environmentally sound, resulting in need for fewer chemical applications. We hope the groundwork provided by this project will encourage interest in developing new biological insecticides for use on turf.

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WALKING GREEN MOWERS: Solution or Problem?

Carefully analyze several factors before determining the best plan.

BY BOB RANDQUIST

When triplex green mowers were introduced into the golf course equipment market in 1968, they were welcomed with open arms by golf course superintendents who recognized the potential cost savings and convenience these mechanical marvels would provide for golf course maintenance operations. I remember very well my first experience mowing greens with a triplex green mower in 1971 at Trosper Park G.C. in Oklahoma City. It was very exciting to be able to mow all 18 greens and the practice greens by myself in only 3 to 3½ hours time. I was usually one of the three employees who spent 2½ to 3 hours each morning mowing greens with a walking green mower and racing to finish ahead of the early morning golfers. Mowing with the new triplex green mower made this task so much easier for us and allowed the superintendent I worked for to assign two other employees to other important jobs. By 1975 the use of triplex green mowers became the preferred method for mowing greens at many golf courses.

Unfortunately, wear pattern and stress-related problems on greens and surrounding areas began to appear as triplex green mowers were used to mow greens over an extended period of time. The simple solution for many of these problems was a return to the use of walking mowers for greens. By the early to mid-1980s, many golf courses began to eliminate the use of triplex green mowers and return to the use of walking green mowers for mowing greens. In response to this trend, I wrote an article published in the November/December 1983 issue of the *USGA Green Section Record* entitled "Should You Change from Triplex Green Mowers to Walking Green Mowers?" that explained why we changed back to using walking green mowers to mow the greens at Southern Hills C.C. in Tulsa, Oklahoma. Since that time, the debate has continued.

THE QUESTION

Is walk mowing greens the best solution for problems caused by triplex mowing greens, or does walk mowing create too many problems for golf course superintendents due to budgetary and/or staffing limitations?

As we attempt to correctly answer this question, let's examine the factors that must be considered: the problems that triplex green mowers cause and some possible solutions for these problems, and the challenges associated with walk mowing greens.

TRIPLEX GREEN MOWERS: PROBLEMS AND POSSIBLE SOLUTIONS

- **Triplex Ring.** One of the first problems that appears with the use of triplex green mowers is a thinning of the turf where the cleanup cut is made around the perimeter of the putting surface. This thinning is caused by two factors: large areas of turf are double cut each day due to the space required to properly lift and lower the mower attachments, and the centrifugal force exerted on the triplex tires as the triplex mower travels in a circular motion around the green. The additional abrasion caused by these factors often adds stress to or physically damages the turf in these cleanup pass areas. This stress can be reduced by slowing the triplex mowing speed, only mowing a cleanup pass every other day, or by mowing the cleanup pass with a walking green mower. In most situations,

Above: With labor costs having increased dramatically over the past few years, options for increasing efficiency without compromising quality are being reviewed at all courses. Left: Turning the triplex green mower too quickly and too sharply resulted in wilted turf. Depending on weather conditions the next day, the result could be brown turf and a slow recovery process.

walk mowing the cleanup pass is the only solution that solves the triplex ring problem.

A triplex ring around the green perimeter is unacceptable to golfers for both aesthetic and playability reasons. Labor savings associated with triplex mowing are often significantly reduced by efforts to eliminate this problem.

- **Wear on turf areas surrounding greens.** Damage to turf areas surrounding greens often occurs as triplex green mowers repeatedly turn on these turf areas. This is especially true when maneuvering room for the triplex green mowers around greens is limited due to bunkering, vegetation, water features, or cart path curbs. This damage to surrounding turf areas greatly increases as cool-season grasses are subjected to heat-related stresses in the summer, or warm-season grasses are dormant or trying to break dormancy in the spring. Matted turf, thin turf, bare ground, or increased weed populations often are the result of this daily triplex mower traffic. Additional costs associated with correcting these problems must be considered when comparing costs for triplex mowing versus walk mowing greens. When adequate maneuvering room is available around greens, this problem can be overcome by properly training equipment operators to make wide, slow turns with the triplex mower. If this is not the case, walk mowing greens is usually the best solution to this problem.
- **Increased soil compaction of a green soil profile.** The argument is often made that the total weight of triplex mowers (1,100 to 1,200 lbs. with operator) causes added soil compaction of a green's soil profile. This point is debatable due to the even distribution of the weight across the three reels and the triplex mower tires. With current aerification tools and methods, this potential compaction can easily be eliminated. The only time this triplex mower weight may be a factor is when mowing is done on very wet greens and triplex tire tracks may be somewhat visible. This is not usually a valid reason for switching to walk mowing greens.
- **Hydraulic leaks.** Unsightly hydraulic leaks on greens will always be a risk when mowing greens with triplex green mowers. Good preventative maintenance, leak detection devices, or the use of readily visible dyes in the hydraulic fluid certainly lessen the potential for excessive damage on putting greens caused by these leaks. However, walk mowing greens is the only way to insure that hydraulic leaks will not be a problem.
- **Uniformity of mowing height.** It can be difficult to keep three separate mowing units on one triplex green mower cutting at the same height and with the same quality over the course of mowing 9 or 18 greens. This is especially true when greens have been recently topdressed with sand. If quality or cutting height changes on one unit and not the other two, the difference may be visible to golfers and the green may appear to be mowed unevenly. With walk mowing, the changes that may occur are not as noticeable since the change tends to be uniform throughout the green being mowed. Proper attention to mowing quality by operators, supervisors, and mechanics

can solve this problem with triplex mowing.

• **Change in the original shape of the green.** When greens with irregularly shaped perimeters are mowed with triplex mowers, triplex mower operators tend to soften the turning radius and round the turns in areas where severe turns are required. Over a period of time much of the original design character of this type of green becomes lost as the green becomes more rounded. In severe cases, interesting hole locations and putting challenges may be sacrificed as a result of triplex mowing greens. This problem usually does not occur with walk mowing greens.

CHALLENGES OF WALK MOWING GREENS

• **Increased cost compared to triplex mowing.** Golf course superintendents and their employers need to carefully examine the difference in costs for triplex mowing vs. walk mowing greens. Several factors affect this cost difference: size of greens and labor hours required for mowing; hourly labor costs for equipment operators; ease of maneuverability around greens and possible resulting costs for additional aerification, traffic damage repair, and additional weed control caused by triplex mowing; initial cost, ongoing maintenance costs, and projected life span of mowing equipment.

While these factors and costs vary from one golf course to another, the net savings realized by triplex mowing greens is usually in the range of $10,000 to $25,000 per year. For almost all golf course operations, this cost difference represents only a small percentage of the total golf course budget. This is a small price for any golf facility to pay for having the best possible putting and aesthetic greens conditions. The importance of providing consistent, quality playing conditions in areas immediately surrounding the greens should not be underestimated. Golfers expect good playing conditions for the numerous shots they will play from these areas during every round of golf.

• **Staffing limitation problems.** When considering walk mowing greens as a solution to the problems associated with triplex greens mowing, the challenge for many golf course superintendents is having daily availability of the 3 or 4 employees needed to walk mow 18 greens. When golf facilities restrict or refuse to allow employee overtime, this can present a real obstacle to walk mowing greens. One excellent solution for this problem is to mow greens with walking mowers on weekdays and mow greens with triplex mowers on weekends. This compromise tends to prevent many of the problems caused by triplex mowing from ever occurring without added undesired overtime labor costs. This issue is primarily a matter of convenience for supervisors and their employees. With creative and flexible scheduling, this problem can usually be solved.

Are walking green mowers the solution or the problem? For any golf facility, only the golf course superintendent and those he works for can answer this question correctly. It is our joint responsibility to carefully analyze all the relevant factors before making the recommendation to use triplex mowers or walking mowers for mowing greens at our golf facility. For most golfers, the improved quality of putting greens and the surrounding playing areas is worth the minimal investment and creative, flexible staff scheduling that walk mowing greens requires. Be open minded and objective when considering the possibility that walking green mowers may be the solution and not the problem for mowing your golf course's greens.

BOB RANDQUIST, *CGCS, has been the director of grounds and maintenance at Boca Rio G.C. in Boca Raton, Florida, for six years. Prior to moving to Florida, Bob was the golf course superintendent at Southern Hills C.C. in Tulsa, Oklahoma, for 19 years.*

Walk mowing of putting greens is the only way to totally avoid hydraulic oil leaks and damage.

Research *You Can Use*

Environment and Culture Affect Bermudagrass Growth and Decline

The roles temperature and shade play in ultradwarf bermudagrass health are not totally understood.

BY RICHARD H. WHITE

Bermudagrass decline is a devastating root disease of highly managed bermudagrass turf, especially on golf greens in the southern United States (Elliott, 1991). It is caused by an interaction of host-predisposing abiotic stresses and the soil-borne, ectotrophic, root-infecting fungus *Gaeumannomyces graminis* var. *graminis* (*Ggg*). Bermudagrass decline results in large areas of turf with weakened, short, brown-to-black root systems and an absence of feeder roots and root hairs. Symptoms include foliar chlorosis, a thinning stand, poor response to fertilizer and irrigation, and premature plant death. The pathogen causes root, rhizome, and stolon rotting. Nutrient and irrigation management is difficult because of diminished root systems. Above-ground symptoms of infection often become evident anywhere from spring green-up through the spring and summer months, when heat and moisture stress challenge the weakened root systems of affected plants. Symptoms also are common during cloudy, wet periods of late summer and early fall.

Tifeagle bermudagrass green at the time of treatment initiation in July.

Drs. Joseph Krausz, Philip Colbaugh, Roy Stanford, and Richard White were part of the turfgrass research team at Texas A&M University that explored the effects of cultural, environmental, and plant growth factors on the recovery of bermudagrass from damage caused by *Ggg*. A strong component of the research was to gain a better understanding of how temperature and light levels influence dwarf bermudagrass growth and development. The influence of light and temperature on dwarf bermudagrass growth was of interest because bermudagrass decline often becomes more severe during persistent cloudy and overcast conditions (Waltz, 2003). Texas A&M University research also focused on cultural practices to enhance recovery of turf exhibiting bermudagrass decline symptoms. Although bermudagrass decline is not inevitable, when the disease does occur, strategies are needed to hasten turf recovery.

CULTURAL STRATEGIES TO ENHANCE RECOVERY FROM BERMUDAGRASS DECLINE

Recommendations for hastening turf recovery from bermudagrass decline often include raising the mowing height and applying acidifying fertilizers and/or foliar feeding (Fermanian et al., 2003). A four-year-old Tifeagle bermudagrass putting green with severe symptoms of bermudagrass decline was used to explore cultural approaches for alleviating the disease symptoms. The green was maintained at 0.125 inch, had a soil pH of 9.1, and was previously fertilized with a coated urea nitrogen fertilizer.

Table 1

Turf quality in August and October for Tifeagle bermudagrass as influenced by monthly aerification with hollow or solid tines and biweekly fertilizer applications to provide 6, 12, and 24 pounds of N per 1,000 sq. ft. annually[1]

	Hollow Tine		Solid Tine	
Nitrogen	August	October	August	October
6	1.5a[2]	2.5a	2.8a	4.0c
12	2.0a	2.9a	3.2a	5.3b
24	2.2a	3.2a	3.0a	6.4a

[1]Plots were rated on a 1-to-9 scale, with 9 as the highest quality. A 5 was considered the minimal accepted quality level for putting greens.

[2]Means within months followed by the same lower-case letter are statistically similar.

Previous applications of several fungicides in a replicated trial conducted on the green the previous year were not effective in controlling the disease.

A series of treatments was established in early July, including nitrogen (N) regimes, aerification, and topdressing arranged in a split-plot design. Nitrogen regimes included bimonthly applications of ammonium sulfate at 0.25, 0.5, and 1.0 lb. N per 1,000 sq. ft. to supply total annual N of 6, 12, and 24 lb. per 1,000 sq. ft. Ammonium sulfate was used in this study because of its acidifying effect on soils. Nitrogen regimes were supplemented with potassium, phosphorus, and micronutrients based on soil tests. Aerification treatments included monthly application of 0.5-inch solid tines and 0.5-inch hollow tines with cores removed. Topdressing treatments included none, 0.125-inch monthly, and 0.02-inch bimonthly. Treatments were initiated in early July and ended in early September. Visual evaluations of turfgrass quality were taken every two weeks. Microscopy was used to assess presence of *Ggg*.

Aerification is an important management tool that is used to remove and control thatch, reduce compaction, and improve root development. In this study, hollow-tine aerification disrupted the surface more than solid-tine aerification (Table 1). Aerification of any type had not been applied to the green for several years, resulting in heavy thatch, increased disease severity, and poor rooting. The poor rooting prevented the initial hollow-tine aerification from producing quality cores and uniform coring holes, resulting in greater surface disruption and a longer healing time than when solid tines were used.

Turfgrass quality improved and evidence of bermudagrass decline symptoms decreased with increasing N, especially for the solid-tine aerification treatments. Although 24 lb. N per 1,000 sq. ft. is considered excessive, this treatment, in conjunction with solid-tine aerification, resulted in rapid turf quality recovery and diminished bermudagrass decline symptoms. Also, turf quality increased and bermudagrass decline symptoms decreased to a greater extent for increasing N in conjunction with heavy topdressing than when compared to no and light, frequent topdressing (Table 2).

The most advantageous treatment combination for recovery from bermudagrass decline symptoms and improvement of turfgrass quality was solid-tine aerification, heavy topdressing, and 24 lb. N per 1,000 sq. ft. This improvement in quality was accomplished without raising the mowing height above 0.125 inch. Excessive N can cause rapid thatch accumulation, and the combination of the greatest amount of N and no topdressing became excessively soft by early October. However, plots that received the greatest amount of N in conjunction with heavy or light topdressing remained firm. Surprisingly, the large amounts of N used did not contribute to an excessive vertical growth rate.

The marked recovery of Tifeagle from bermudagrass decline symptoms for specific treatment combinations occurred even though *Ggg* was still present. Large amounts of N, as used in this study, should not be applied to bermudagrass for long periods of time due to the potential to negatively impact the environment and because of the potential to cause excessive thatch accumulation and contribute to reduced stress tolerance. Increasing N for short periods to enhance recovery followed by lower amounts of N to sustain turf density is, however, a more reasonable approach. Careful rootzone pH management combined with a sound nutrient management plan may reduce severity of bermudagrass decline (Waltz, 2003).

Table 2

Turf quality of Tifeagle bermudagrass in October as influenced by none, biweekly dusting, and monthly heavy topdressing[1]

	Topdressing Treatments		
Nitrogen	None	Dusting	Heavy
6	3.1b[2]	3.0b	3.2c
12	3.5b	3.6b	5.0b
24	4.1a	4.4a	6.1a

[1]Plots were rated on a 1-to-9 scale, with 9 as the highest quality. A 5 was considered the minimal accepted quality level for putting greens.

[2]Means within months followed by the same lower-case letter are statistically similar.

DWARF BERMUDAGRASS GROWTH AND DEVELOPMENT IN RESPONSE TO ENVIRONMENT

The optimum temperature for growth of bermudagrass is 80 to 95°F (Beard, 1973) and for *Ggg* the optimum growth temperature in culture is 86°F (Fermanian et al., 2003). Thus, both the bermudagrass and pathogen should grow and develop well at a range of 80 to 90°F. Controlled environment chambers were used to explore the effect of temperature on bermudagrass and *Ggg* and on subsequent disease development.

Tifdwarf bermudagrass growth response to temperature regimes of 95/80°F (left) and 80/66°F day/night (right). Plants were grown in growth chambers with 14 hours artificial light at about one-third of full sunlight.

A single sprig of Tifdwarf bermudagrass was surface sterilized and then grown in a greenhouse for several months to create planting stock for use in the experiment. Sprigs were obtained from the single stock plant and established in individual containers to receive the following treatment combinations. Treatment combinations included inoculated and uninoculated plants, nitrogen treatments of 4, 8, and 12 pounds of N per 1,000 sq. ft., and temperature regimes of 95/80, 80/66, and 66/51°F day/night temperatures. Artificial lighting provided about one-third of full sunlight.

Nitrogen nutrition influenced growth but was not as influential as the temperature regime. The effects of temperature regimes were robust. Internode length was 0.23, 0.51, and 0.83 inch, and leaf length was 0.29, 0.45, and 0.49 inch for the 95/80, 80/66, 66/51°F (day/night) temperature regimes, respectively. While the growth responses exhibited by Tifdwarf in these growth chamber studies were consistent with growth under low light (shade), temperature was a controlling factor in the degree of response. Additional studies were conducted with light levels of about 10, 25, and 50% of full sun within temperature regimes of 95/80 and 80/66°F (day/night). Decreasing light caused increases in leaf and internode length, but the degree of increase was regulated by temperature. The results of this study indicate that temperature as well as light levels regulate expression of dwarfness in Tifdwarf bermudagrass. Although Tifeagle was not a main focus of the growth chamber study, Tifeagle bermudagrass was exposed to the same temperature regimes to determine if growth responses were similar in Tifdwarf and Tifeagle. Similar responses to temperature regimes were observed for Tifdwarf and Tifeagle.

SUMMARY

The results of this study explain why raising the mowing height is often recommended as a cultural practice to reduce bermudagrass decline symptoms. In coastal and other areas affected by long periods of overcast, rainy weather, growth habit of dwarf bermudagrasses may change dramatically in response to low light and lower temperatures. The altered growth form of Tifdwarf that may occur during overcast and rainy weather would not likely tolerate close mowing heights. Thus, mowing stress would result in increased sensitivity to pathogenic organisms such as *Ggg* and may result in more substantial expression of disease symptoms. Weather data from Texas A&M University indicate that the high and intermediate temperature regimes and light levels used in this study can occur in southern climates in late summer and early fall during periods of heavy rain and week-long

periods of overcast skies. Evidence of the altered growth form was observed within three to four days of exposure to the moderate temperature regime and light levels used in this study.

In addition to the potential implications that the changes in growth habit in response to environment may have for disease tolerance in dwarf bermudagrass, the effect of temperature on dwarf bermudagrass growth habit has tremendous implications for dwarf bermudagrass golf green management. The effects of temperature on growth habit of dwarf bermudagrass may explain why excessively large amounts of N applied during summer did not cause more robust vertical growth of Tifeagle in the field study described earlier in this text. Temperature should also be a major consideration in the timing and severity of cultivation practices such as core aerification. Healing of surface disruption caused by core aerification and vertical mowing may occur extremely slowly during July and August, periods previously perceived to support maximum bermudagrass growth. During exposure to the high temperatures of July and August, for example, the growth habit of many dwarf bermudagrasses may be extremely compact and not conducive to recovery from injury caused by aerification and vertical mowing. Tolerance to pests and wear also may be less during high-temperature periods. Establishment rates of dwarf bermudagrasses may be dramatically affected by seasonal changes in temperature, with slow establishment occurring at temperatures greater than 90°F. This notable discovery about the effects of temperature on dwarf bermudagass growth and development provides strong rationale for additional research on numerous aspects of bermudagrass culture, establishment, and pest and abiotic stress tolerance.

Effect of monthly solid (front three rows) and hollow-tine (back three rows) aerification, nitrogen at 6, 12, 24 and 6, 12, 24 lb. N per 1,000 sq. ft. (front to back), and heavy, light, and no topdressing (left to right) on the appearance of Tifeagle bermudagrass.

RESEARCH SUMMARY POINTS

- Tifeagle bermudagrass recovery from bermudagrass decline symptoms was enhanced by aerification, heavy topdressing, and aggressive fertilization with ammonium sulfate.
- Low light caused increased leaf and internode length in dwarf bermudagrasses, but temperature regulated expression of the dwarf growth habit.
- The alterations in growth form in Tifdwarf bermudagrass caused by low light and cooler temperatures that often occur during overcast rainy periods justifies raising the mowing height to reduce mowing stress that may contribute to bermudagrass decline severity.
- High temperatures cause a compact growth habit in dwarf bermudagrasses and may slow healing of surface damage caused by cultivation or pests.

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Evaluating Recycled Waters for Golf Course Irrigation

To avoid problems, analyze recycled water thoroughly before starting to use it to irrigate a golf course, and monitor it regularly thereafter.

BY M. ALI HARIVANDI

Throughout the United States and in many other parts of the world, an increasing number of golf courses use recycled municipal water for irrigation. Much of the recycled water used for irrigation contains high concentrations of dissolved salts that are potentially toxic to turfgrasses and other golf course plants. Consequently, chemical water analysis and periodic monitoring are key components of sound irrigation management at such sites.

Water analysis done by commercial laboratories provides data on many parameters, most of which are not of great significance for turfgrass irrigation. The most important parameters for this purpose are: total concentration of soluble salts (i.e., salinity); sodium (Na) content; relative proportion of sodium to calcium (Ca) and magnesium (Mg) (Sodium Adsorption Ratio, or SAR); chloride (Cl), boron (B), bicarbonate (HCO_3), and carbonate (CO_3) content; and pH. The following parameters are also often reported on a water test report and should be reviewed, although none by itself plays a major role in determining the suitability of a given recycled water for irrigation: nutrient content (nitrogen, phosphorus, and potassium), chlorine content, and suspended solids.

SALINITY

All recycled waters contain some dissolved mineral salts and chemicals. Some soluble salts are nutrients and thus are beneficial to turfgrass growth; others, however, may be phytotoxic or may become so when present in high concentrations. The rate at which salts accumulate to undesirable levels in a soil depends on their concentration in the irrigation water, the amount of water applied annually, annual precipitation (rain plus snow), and the soil's physical/chemical characteristics.

Water salinity is reported differently by different laboratories. It is reported quantitatively as Total Dissolved Solids (TDS) in units of parts per million (ppm), or milligrams per liter (mgL^{-1}), or reported as electrical conductivity (ECw) in terms of milimhos per centimeter ($mmhos\ cm^{-1}$), micromhos per centimeter ($\mu mhos\ cm^{-1}$), decisiemens per meter (dSm^{-1}), or siemens per meter (Sm^{-1}). Some labs may also report the individual components of salinity (e.g., sodium) in milliequivalent per liter ($meqL^{-1}$). The following equations may be used to convert results from one set of units to another, thus enabling comparisons of data from differently formatted reports:

(1) 1 ppm = 1 mgL^{-1}

(2) 1 mgL^{-1} = $meqL^{-1}$ × Equivalent Weight (see Table 1)

(3) 1 $mmhos\ cm^{-1}$ = 1 dSm^{-1} = 1000$\mu mhos\ cm^{-1}$ = 0.1 Sm^{-1}

The relationship between ECw and TDS is approximately:

(4) ECw (in $mmhos\ cm^{-1}$ or dSm^{-1}) × 640 = TDS (in ppm or mgL^{-1})

Most waters of acceptable quality for turfgrass irrigation contain from 200 to 800 parts per million (ppm) soluble salts. Soluble salt levels above 2,000 ppm may injure turfgrass; recycled irrigation water with salt levels up to 2,000 ppm may be tolerated by some turfgrass species (Table 2), but only on soils with exceptional permeability and subsoil drainage. Good permeability and drainage allow a turfgrass manager to leach excessive salt from the rootzone by periodic heavy irrigations. Sand-based golf greens create the proper soil structure for this form of salinity management.

Table 3 lists the parameters that should be considered in evaluating irrigation water quality. As indicated, re-

Table 1
Conversion factors: mgL^{-1} and $meqL^{-1}$

Constituent	To Convert mgL^{-1} to $meqL^{-1}$	To Convert $meqL^{-1}$ to mgL^{-1}
	Multiply by	
Sodium (Na)	0.043	23
Calcium (Ca)	0.050	20
Magnesium (Mg)	0.083	12
Bicarbonate (HCO_3)	0.016	61
Carbonate (CO_3)	0.033	30
Chloride (Cl)	0.029	35

cycled water with ECw values above 0.7 dSm^{-1} (or 450 mgL^{-1}), present increased salinity problems. Only careful management will prevent deleterious salt accumulation in the soil if water with a high ECw is used for irrigation. Recycled water with an EC above 3 dSm^{-1} should be avoided or diluted with less saline water before use for irrigation. The salt tolerance of turfgrass and other plants is expressed in terms of the salt content of the soil rootzone [e.g., as indicated in Table 2, Kentucky bluegrass will tolerate soil salinity (ECe, indicating electrical conductivity of soil water extract) at levels up to 3 dSm^{-1}]. Therefore, soil physical characteristics and drainage, both important factors in determining rootzone salinity, must also be considered when deciding about the suitability of a given recycled irrigation water. For example, water with an ECw of 1.5 dSm^{-1} may be successfully used on grass grown on sandy soil with good drainage (and thus high natural leaching), but prove injurious within a very short period of time if used to irrigate the same grass grown on a clay soil or soil with limited drainage due to salt buildup in the rootzone.

Table 2 is a general guide to the salt tolerance of individual turfgrasses. As indicated, soils with an ECe below 3 dSm^{-1} are considered satisfactory for growing most turfgrasses. Soils with an ECe between 3 and 10 dSm^{-1} can successfully support only a few salt-tolerant turfgrass species.

Table 2
The relative tolerances of turfgrass species to soil salinity (ECe).

Sensitive (<3 dSm^{-1})	Moderately Sensitive (3 to 6 dSm^{-1})	Moderately Tolerant (6 to 10 dSm^{-1})	Tolerant (>10 dSm^{-1})
Annual Bluegrass	Annual Ryegrass	Perennial Ryegrass	Alkaligrass
Colonial Bentgrass	Creeping Bentgrass	Tall Fescue	Bermudagrasses
Kentucky Bluegrass	Fine-Leaf Fescues	Zoysiagrasses	Seashore Paspalum
Rough Bluegrass	Buffalograss		St. Augustinegrass

From: M.A. Harivandi, J. D. Butler, and L.Wu. 1992. Salinity and turfgrass culture. In: *Turfgrass*. D. V. Waddington, R. N. Carrow, and R. C. Shearman (eds.) pp. 207-229. Series No. 32, American Society of Agronomy, Madison, Wisconsin, USA.

Table 3
Guidelines for the interpretations of recycled water quality for irrigation.

Potential Irrigation Problems	Units	Degree of Restriction on Use		
		None	Slight to Moderate	Severe
Salinity				
EC_w	dSm^{-1}	<0.7	0.7 to 3.0	>3.0
TDS	mgL^{-1}	<450	450 to 2,000	>2,000
Soil Water Infiltration				
Evaluate using EC_w (dSm^{-1}) and SAR together:				
if SAR = 0 to 3 and EC_w =		>0.7	0.7 to 0.2	<0.2
if SAR = 3 to 6 and EC_w =		>1.2	1.2 to 0.3	<0.3
if SAR = 6 to 12 and EC_w =		>1.9	1.9 to 0.5	<0.5
if SAR = 12 to 20 and EC_w =		>2.9	2.9 to 1.3	<1.3
if SAR = 20 to 40 and EC_w =		>5.0	5.0 to 2.9	<2.9
Specific Ion Toxicity				
Sodium (Na):				
Root Absorption	SAR	<3	3 to 9	>9
Foliar Absorption	$meqL^{-1}$	<3	>3	—
	mgL^{-1}	<70	>70	—
Chloride (Cl)				
Root Absorption	$meqL^{-1}$	<2	2 to 10	>10
	MgL^{-1}	<70	70 to 355	>355
Foliar Absorption	$meqL^{-1}$	<3	>3	
	mgL^{-1}	<100	>100	
Boron (B)	mgL^{-1}	<1.0	1.0 to 2.0	>2.0
Miscellaneous Effects				
Bicarbonate (HCO_3)	$meqL^{-1}$	<1.5	1.5 to 8.5	>8.5
	mgL^{-1}	<90	90 to 500	>500
pH	—	normal range:	6.5 to 8.4	
Residual Chlorine	mgL^{-1}	<1.0	1 to 5	>5

Adapted by: M.A. Harivandi from: Westcot, D.W., and R. S. Ayers. 1984. Irrigation water quality criteria. In: Pettygrove, G. S., and T. Asano (eds.). *Irrigation with reclaimed municipal wastewater* — A guidance manual. Report No. 841-1wr. California State Water Resources Control Board, Sacramento, California; and from: Farnham, D. S., et al. 1985. *Water Quality: Its effects on ornamental plants*. University of California Cooperative Extension Leaflet 2995. Div. of Agric. Nat. Resources, Oakland, California.

SODIUM

Sodium content is another important factor in recycled irrigation water quality evaluation. Plant roots absorb sodium and transport it to leaves, where it can accumulate and cause injury. Thus, symptoms of sodium toxicity resemble those of salt burn on leaves. Recycled irrigation water with high levels of sodium salts can be particularly toxic if applied to plant leaves by overhead sprinkler, since salts can be absorbed directly by leaves. Sodium toxicity is often of more concern on plants other than turfgrasses, primarily because accumulated sodium is removed every time grass is mown. Among grasses grown on golf courses, annual bluegrass and bentgrass are the most susceptible to sodium phytotoxicity. In their case, mowing may not provide protection, since grasses are generally cut very shot (a stress in itself), and any sodium accumulation will comprise a large proportion of the small quantity of remaining leaf tissue.

Table 3 provides general guidelines for assessing the effect of sodium in

Weak, thin turf is the result of salt accumulation in heavy soils due to use of recycled irrigation water.

irrigation water. As indicated in the table, the level of sodium tolerated by non-turf plants varies with irrigation application method. Most landscape plants will tolerate up to 70 ppm (mgL^{-1}) sodium when irrigated by overhead sprinkler.

SAR (SODIUM ADSORPTION RATIO)

Although sodium can be directly toxic to plants, its most frequent deleterious effects on plant growth are indirect due to its effect on soil structure. It is this latter effect that is most often of concern to golf course superintendents and other professional managers of intensively used turfgrasses.

When irrigation is applied to soil, the best indicator of sodium effect is a recycled water's Sodium Adsorption Ratio (SAR), a value that should be provided in all laboratory water analyses. Although, in general, water with an SAR below 3 is considered safe for turf and other ornamental plants (Table 3), SAR is an important enough factor in water evaluation to merit thorough understanding.

The high sodium content common to recycled water can cause defloccu-lation or breakdown of soil clay particles, reducing soil aeration and water infiltration and percolation. In other words, soil permeability is reduced by a recycled irrigation water high in sodium. The likely effect of particular irrigation water on soil permeability can be best gauged by the water's SAR in combination with the ECw (Table 3).

Generally, recycled water with an SAR above 9 can cause severe permeability problems when applied to fine-textured (i.e., clay) soils over a period of time. In coarse-textured (i.e., sandy) soils, permeability problems are less severe and an SAR of this magnitude can be tolerated. Golf greens constructed with high-sand-content rootzone mixes, for example, can be successfully irrigated with high-SAR water because their drainage is good.

For recycled waters high in bicarbonate, some laboratories "adjust" the calculation of SAR (yielding a number called "adjusted SAR" or "Adj. SAR") because soil calcium and magnesium concentrations are affected by the water's bicarbonate. In simplest terms, Adj. SAR reflects the water content of calcium, magnesium, sodium, and bicarbonate, as well as the water's total salinity. Other labs are adjusting the SAR value using a newly introduced method and report the adjusted value as R_{NA}.

INTERACTION OF SALINITY AND SAR

Salts and sodium do not act independently in the plant environment. The effect of sodium on soil particle dis-

Application of salty recycled water has caused burn and necrosis of leaf margins.

persion (and therefore permeability) is counteracted by high electrolyte (soluble salts) concentration; therefore, a water's sodium hazard cannot be assessed independently of its salinity. The combined effect of water ECw and SAR on soil permeability is given in Table 3. Note that the table provides general guidelines only. Soil properties, irrigation management, climate, a given plant's salt tolerance, and cultural practices all interact significantly with recycled water quality in the actual behavior of soils and plant growth.

BICARBONATE AND CARBONATE

The bicarbonate, and to a lesser degree carbonate, content of recycled irrigation water also deserves careful evaluation. Recycled waters, as well as well waters, are especially prone to containing excessive bicarbonate levels. Substantial bicarbonate levels in irrigation water can increase soil pH and may affect soil permeability. In addition, bicarbonate content may make itself obvious during hot, dry periods, when evaporation may cause white lime ($CaCO_3$) deposits to appear on leaves of plants irrigated by overhead sprinklers.

Although high levels of bicarbonate in water can raise soil pH to undesirable levels, it is bicarbonate's negative impact on soil permeability that is more often a concern. As mentioned above, the bicarbonate ion may combine with calcium and/or magnesium and precipitate as calcium and/or magnesium carbonate. This precipitation increases the SAR in the soil solution because it will lower the dissolved calcium concentration.

Table 3 indicates tolerable levels of bicarbonate in irrigation waters. The bicarbonate hazard of recycled water may be expressed as Residual Sodium Carbonate (RSC), calculated as follows:

(5) $RSC = (HCO_3+CO_3)-(Ca+Mg)$

In this equation, concentrations of ions are expressed in $meqL^{-1}$ [see Equation (2) and Table 1 for conversions]. Generally, recycled water with an RSC value of 1.25 $meqL^{-1}$ or lower is safe for irrigation, water with an RSC between 1.25 and 2.5 $meqL^{-1}$ is marginal, and water with an RSC of 2.5 $meqL^{-1}$ and above is probably not suitable for irrigation.

pH (HYDROGEN ION ACTIVITY)

The pH is a measure of water's acidity and alkalinity and is measured in pH units. The scale ranges from 0 to 14, with pH 7 representing neutral (i.e., water with a pH of 7 is neither acidic nor alkaline). Moving from pH 7 to pH 0, water is increasingly acidic; moving from pH 7 to pH 14, water is increasingly basic (or "alkaline"). pH units are on a logarithmic scale, which means that there is a tenfold change between each whole pH number. Thus, a water with pH 8 is 10 times more basic than a water with pH 7, and 100 times more basic than a water with pH 6. Water pH is easily determined and provides useful information about the water's chemical properties. Although seldom a problem in itself, a very high or low pH warns the user that the water needs evaluation for other constituents. The desirable *soil* pH for most turfgrasses is 5.5 to 7.0; the pH of most *irrigation waters*, however, ranges from 6.5 to 8.4. Depending on the soil on which the grass is grown, an irrigation water pH range of 6.5-7 would be desirable. Recycled water with a pH outside the desirable range must be carefully evaluated for other chemical constituents.

CHLORIDE

In addition to contributing to the total soluble salt concentration of irrigation water, chloride (Cl) may be directly toxic to plants grown on a golf course. Although chloride is not particularly toxic to turfgrasses, many trees, shrubs, and ground covers are sensitive to it.

Chloride is absorbed by plant roots and translocated to leaves, where it accumulates. In sensitive plants, this accumulation leads to necrosis — leaf margin scorch in minor cases, total leaf kill and abscission in severe situations. Similar symptoms may occur on sensitive plants if water high in chloride is applied by overhead sprinklers, since chloride can be absorbed by leaves as well as roots. Turfgrasses tolerate all but extremely high levels of chloride as long as they are regularly mowed.

Chloride salts are quite soluble and thus may be leached from well-drained soils with good subsurface drainage.

As indicated in Table 3, recycled irrigation water with a chloride content above 355 mgL^{-1} is toxic when absorbed

by roots, while a chloride content higher than 100 mgL^{-1} can damage sensitive ornamental plants if applied to foliage.

CHLORINE

Municipal recycled water may contain excessive residual chlorine (Cl_2), a potential plant toxin. Chlorine toxicity is almost always associated only with recycled waters that have been disinfected with chlorine-containing compounds. Chlorine toxicity will occur only if high levels of chlorine are sprayed directly onto foliage, a situation likely to occur only where recycled water goes straight from a treatment plant to an overhead irrigation system. Free chlorine is very unstable in water; thus, it will dissipate rapidly if stored for even a short period of time between treatment and application to plants. As indicated in Table 3, residual chlorine is of concern at levels above 5 mgL^{-1}.

BORON

Boron (B) is a micronutrient essential for plant growth, though it is required in very small amounts. At even very low concentrations (as low as 1 to 2 mgL^{-1} in irrigation water), it is phytotoxic to most ornamental plants, capable of causing leaf burn (Table 3). Injury is most obvious as a dark necrosis on the margins of older leaves. Turfgrasses are generally more tolerant of boron than any other plants grown on a golf course; however, they are more sensitive to boron toxicity than to either sodium or chloride. Most will grow in soils with boron levels as high as 10 ppm.

NUTRIENTS

Recycled waters always contain a range of micro (trace) elements sufficient to satisfy the need of most turfgrasses. They may also contain enough macro (major) nutrients (i.e., nitrogen, phosphorus, and potassium) to figure significantly in the fertilization program of large turfed areas.

Most laboratories test recycled water for nutrient content and often report nutrients in "lb./acre ft. of water applied." The economic value of these nutrients can be substantial. Even where the quantities of nutrients are low, because they are applied on a regular basis, the nutrients can be used very efficiently by plants. If the laboratory report does not include the lb./acre ft. of nutrients, the following conversion formula can be used to determine this value for any nutrient contained in irrigation water:

(6) lb./acre ft. of nutrient = nutrient content (mgL^{-1} or ppm) × 2.72.

SUSPENDED SOLIDS

Suspended solids (SS) in irrigation water refers to inorganic particles such as clay, silt, and other soil constituents, as well as organic matter such as plant material, algae, bacteria, etc. These materials do not dissolve in water and thus can be removed only by filtration, an essential step for most irrigation systems in which plugged sprinkler head openings and/or valves reduce system efficiency and life.

The suspended solids in domestic municipal water sources are negligible and not a cause for concern. However, suspended solids should be monitored in wells, canals, and especially lakes or ponds storing recycled water used for irrigation. Nitrogen and phosphorus in recycled water can lead to algae growth in storage lakes during the winter. Such growth can pose a major concern when the water is introduced into an irrigation system. In addition to the mechanical problems they present for irrigation systems, suspended solids and algae can seal a soil surface, especially on sand-based golf greens and sand bunkers. Solids can fill in air spaces between sand particles, reducing infiltration and drainage, and increasing compaction. Since these effects vary considerably with type of solid, irrigation system, and turfgrass soils, it is difficult to formulate acceptable suspended solid values for irrigation water. The complexity and variability of irrigation waters and systems make effective filtration the most sensible approach to controlling hazards posed by suspended solids and algae in recycled water.

INTERPRETING WATER QUALITY HAZARD

As the preceding indicates, recycled water quality must be analyzed on an individual basis. There are very few recycled water sources that are absolutely unsuitable for turfgrass irrigation. While the discussion presented here can be used as a general guide to help turfgrass managers determine whether a water quality problem exists, the precise natureand magnitude of a potential problem may require more than water analysis. Climate, soil chemistry and physics, use patterns, and turf quality expectations will all contribute both to any problem and to any potential remedies.

M. ALI HARIVANDI, PH.D., *is an environmental horticulturist for the University of California Cooperative Extension in the San Francisco Bay Area. He also is a member of the USGA Turfgrass and Environmental Research Committee.*

An extreme example of a salty crust on an area where the turf has disappeared.

Considerations in Retrofitting a Golf Course for Recycled Water Irrigation

Start thinking about preparing for the use of recycled water at your course.

BY M. ALI HARIVANDI

Within the United States as well as the rest of the world, the future of the golf industry is tied to water availability and price. Even in areas where water was once an unlimited resource, it is now viewed as limited and highly valuable, particularly in arid, semi-arid, and highly populated regions. The price of potable water rises with scarcity; both rising cost and the increased politicization of using a scarce resource for leisure and entertainment purposes put pressure on golf courses to use something other than potable water for irrigation.

In many locations, using recycled water (i.e., treated municipal sewage water, which may also be known as reclaimed or effluent water) for golf course irrigation is a viable strategy for coping with water shortages and the rising cost of fresh water. Some states, in fact, have already mandated recycled water irrigation on new golf courses and landscapes. Elsewhere, interest in recycled water irrigation continues to increase as more and better-quality recycled water becomes available for re-use.

Irrigating a golf course with recycled water poses unique challenges for a course superintendent. Whether a course is new and in the development phase or well established and switching to recycled water irrigation, issues arise in the areas of environmental stewardship, health, and agronomics. These issues are more easily addressed when a

course can be designed and built with recycled water irrigation in mind than when an established course decides to retrofit (or convert) to recycled water use. In both instances, however, a number of concerns are best handled during the planning phase; in fact, preparing for recycled water irrigation is almost always more efficient and effective than managing the potential negative effects of its misuse.

Resolution of the following infrastructure and management issues will ensure minimal negative impact of recycled water irrigation on the playability and agronomic health of a golf course. It will also ensure that legal and financial responsibilities are carefully considered and all parties are clear on their roles and responsibilities should problems arise. Most of these issues apply equally to courses under development and those being retrofitted for recycled water irrigation. Every site, however, will also be subject to specific health and environmental regulations which, due to the great variation between sites and communities, are not discussed here. Readers are therefore advised that the following discussion is not exhaustive with respect to such issues, complete evaluation of which should occur before contracts are signed.

RECYCLED WATER TREATMENT PROCESS

Recycled water used for golf course irrigation must be at least secondary, and preferably tertiary, treated wastewater. Secondary treatment is a biological process in which complex organic matter is broken down to less complex organic material, then metabolized by simple organisms that are later removed from the wastewater. Secondary treatment can remove more than 90 percent of the organic matter in sewage. The secondary liquid effluent is always chlorinated or otherwise disinfected before release. Often, sewage treatment facilities associated with residential developments consist of aerated lagoons, a less sophisticated secondary treatment process.

Advanced wastewater treatment consists of processes similar to potable water treatment, such as chemical coagulation and flocculation, sedimentation, filtration, or adsorption of compounds by a bed of activated charcoal. Because advanced treatment usually follows high-rate secondary treatments, it is sometimes referred to as tertiary treatment. These processes can provide highly purified waters. Reverse osmosis, an advanced method of water treatment, can actually produce pure water; however, very high initial and operational costs and environmental problems related to disposal of reject saline brine limits the use of this process for golf course irrigation.

The issue of water availability continues to grow and impacts all industries. With rising costs of potable water, the use of recycled water is a viable strategy. Once the water arrives at the treatment facility, it must receive at least secondary, and preferably tertiary, treatment before it can be used on the golf course.

Generally, secondary and tertiary treated waters do not differ significantly chemically — i.e., in their dissolved salt content. However, due to the greatly reduced level of suspended (i.e., not dissolved) solids, tertiary waters are much more desirable for golf course irrigation. Suspended solids can plug irrigation heads and seal sand-based (USGA or California type) golf greens, thereby reducing drainage. Consequently, installing an efficient filtration system is essential when using recycled water for golf course irrigation, especially if the recycled water is only secondary treated effluent.

AGRONOMIC AND MANAGEMENT CONSIDERATIONS FOR RETROFIT

There are unique challenges associated with using recycled water to irrigate golf courses originally designed for freshwater irrigation. Depending on the quality of the recycled water available, the costs of converting an irrigation system and adapting course maintenance to the new irrigation can be substantial. The following items all bear careful consideration in planning for conversion of a course to recycled water irrigation. Most have both cost and management consequences, although some are cost free. Some of the items may have already been addressed by local authorities — e.g., regulatory issues. Every effort is made to include all items of potential concern in this report; however, other, site-specific issues that are not apparent initially may come to light as the conversion project progresses.

IRRIGATION SYSTEM ISSUES

- **Cross connection.** Protection of cross-connection systems may be necessary if the golf course irrigation system is connected to a potable water system or any dedicated fire line using potable water. In general, all physical connections between the recycled water irrigation system and the potable water system must be disconnected.
- **Lakes, wells, and creek protection.** On-site lakes, wells, and creeks whose water is used for potable purposes should be protected from overspray or runoff from recycled water irrigation. Drinking-water fountains on the property should also be protected from overspray. Local regulations may require modification or redesign of the

irrigation system to ensure these protections.

• **Quick couplers.** It may be necessary to tag or replace all quick couplers on the course with specialized couplers that prevent inadvertent drinking of recycled water by maintenance personnel or others.

• **Labeling, tagging, and painting.** On new golf courses, purple irrigation system components generally signify (and warn unsuspecting users of) the presence of recycled water. On existing golf courses, all buried components of the existing irrigation system are often "grandfathered in." However, a golf course may be required to label all visible irrigation system components with purple tape, tags, paints, etc. It may also be necessary to install signs warning of recycled water use in more than just English (in most cases, warnings in Spanish are also mandatory) throughout the course, at the clubhouse and pro shop, and on scorecards. The cost of this "publicity" will depend on the type and magnitude of labeling a course chooses.

• **Pumping costs.** Depending on the pumping capacity and pressure requirements of the existing system, a booster pump and electricity for additional pumping may be required. The pressure provided by the treatment plant releasing the recycled water is often inadequate for irrigating a golf course.

• **Water storage facilities — construction and maintenance.** If recycled water cannot be stored in existing lakes on the course, additional storage facilities may be required. Covered storage tanks or "lined" ponds are options. The size and location of such storage facilities must be thoroughly evaluated in relation to environmental issues as well as for both fixed and operational costs. Note: Recycled water storage facilities require a high level of maintenance. Generally, covered (or buried) storage tanks require less maintenance than lakes, since the absence of light eliminates algae growth; on the other hand, settling of suspended matter is a problem in tanks. With frequency depending on water quality, storage tanks must be periodically emptied and cleaned. The initial cost of constructing lined storage lakes may be less than that of installing covered tanks; however, the maintenance cost is generally higher. Due to elevated levels of nutrients such as nitrogen and phosphorus, algae and weed growth is a constant problem in storage lakes. Substantial labor and chemicals are often needed to keep pond water clean and suitable for irrigation. Depending on the quality of the water, the cost of maintaining a storage pond for recycled water could be several times higher than maintenance costs for a pond of potable water (due primarily to algae and weed growth, and odor problems). If any existing lake at a course is converted for storage of recycled water, it may require lining to prevent potential groundwater contamination.

It is commonplace that purple irrigation system components generally signify and warn unsuspecting users of the presence of recycled water.

• **Irrigation water filtration.** Given the suspended matter content of recycled water, a dependable irrigation filtration system may be essential. Particularly if recycled water is stored in ponds, where algal bloom is a constant problem, filtration must be of high quality. If the existing filter system at a course is sub par, it must be replaced before beginning recycled water irrigation. Without effective filtration, algae and other suspended matter will plug irrigation nozzles, reducing irrigation efficiency and uniformity, and requiring additional labor for repeatedly unplugging heads. In addition, without adequate filtration, the fine, suspended particles delivered in recycled water may plug pore spaces in the rootzone of sand-based golf greens, impeding both drainage and leaching — costly problems!

• **Irrigation water blending.** Recycled water may need to be blended with fresh water to reduce its salt content. If blending, often done in a storage tank or lake, is not possible, a course may be alternately irrigated with recycled and fresh water to leach salts (a process called "flushing"). Cost and logistics would determine which approach is used at a given golf course.

• **Adjacent properties.** Depending on local regulations, golf courses irrigated with recycled water may be required to protect adjacent properties from runoff or overspray from their irrigation. Compliance with such regulations may mean redesigning the irrigation system to allow irrigation of the perimeter with fresh water.

AGRONOMIC ISSUES

• **Recycled water dissolved salts.** In most cases, recycled water will have a higher dissolved salt content than the water already being used for irrigation. In addition to salinity, other important chemical components of the recycled water are pH, sodium, calcium, magnesium, chloride, boron, bicarbonate, and residual chlorine. Depending on the levels of these chemical constituents, management practices on the course may need to change to counteract potential negative effects on soil, turfgrasses, and other plants. Such effects may range from slight to substantial. Without an analysis of the recycled water, it is impossible to predict the extent of its effect on management; however, any or all of the following may be needed:

1. Irrigation water blending (i.e., recycled with fresh).

2. Injection into the irrigation water of acids, gypsum, or other amendments.

3. Application of gypsum, sulfur, and other amendments to the soil.

4. Additional core aerating to reduce soil impermeability caused by elevated sodium levels.

5. Installation of additional drainage lines in low-lying areas to remove leached salts.

6. Application of additional herbicides and fungicides to combat weed and disease problems if existing grasses are stressed by the presence of salt.

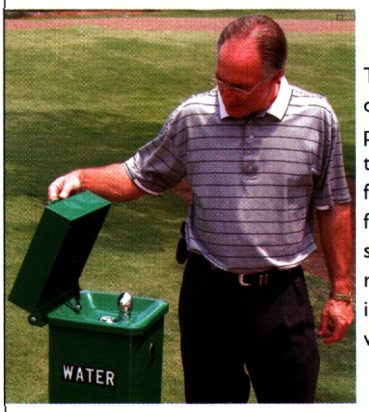
7. Application of more water than is currently applied to leach salt below the grass rootzone (leaching requirement).

8. Regular and more frequent soil and water testing. Twice a year, soils must be lab tested to identify potential salinity problems. Soil samples should be taken from representative greens, tees, fairways, roughs, and general landscaped areas. Recycled water must be lab tested at least quarterly to determine the level and fluctuation of dissolved salts.

- **Trees, shrubs, and other non-turf plants.** Depending on the recycled water's salt content as well as the sensitivity of the course's trees, shrubs, and other plants, remedial actions may be required to prevent plant injury. The most common remedial practice is modification of the irrigation system so that water from sprinklers does not wet plant leaves. Although trees and shrubs may tolerate certain levels of salt accumulation in the soil, they can exhibit injury from saline water sprayed on their foliage.
- **Consultant fees.** Agronomic issues relating to recycled water can be complex, requiring the input of consulting specialists. Most golf course superintendents work closely with a turfgrass water quality consultant. The cost of such service, as well as lab test fees, is a consistent recurring cost associated with recycled water irrigation, and it should be added to the management budget.

ENVIRONMENTAL AND MANAGEMENT ISSUES

- **Groundwater monitoring.** If a golf course is located above a drinking water aquifer, a comprehensive groundwater quality monitoring program may be required if the course is irrigated with recycled water. At issue is whether the golf course or the sewage treatment plant is responsible for mounting and paying for such a program.
- **Odor problems.** Depending on the level of treatment, recycled water irrigation may cause an odor problem. It should be decided in advance who will be responsible for correcting the situation.



This special design protects the water fountain from being struck by recycled irrigation water.

- **Liability issues.** Although extremely rare, human health problems, adjacent property contamination, and other negative impacts may result from recycled water irrigation. It is highly advisable to determine ahead of time whether the golf course or the sewage treatment plant, or both, will take responsibility for such outcomes.
- **Equipment deterioration.** Turfgrass maintenance equipment rusts and deteriorates in other ways more quickly when exposed to saline irrigation water. How big a problem this may be at a given golf course will depend on the salinity of the recycled water.
- **Golf course superintendent compensation.** Switching from fresh to recycled irrigation water will add to the responsibilities (and therefore on-the-job time) of the golf course superintendent. In addition to extra agronomic tasks that the use of recycled water imposes, the superintendent will spend more time inspecting, keeping records, preparing reports, and filing documents with environmental and regulatory agencies. He will also have to spend more time with regulators, community representatives, consultants, laboratories, and vendors providing goods or services related to recycled water. Total labor needs on the course, including that of the superintendent, often rise 10-20% when recycled water irrigation replaces freshwater irrigation, the actual figure depending on the quality of water used.

ADVANTAGES OF RECYCLED WATER

- **Conservation and availability.** Using recycled water is an excellent means of conserving fresh water. Water availability, especially during a drought or other water shortages, is almost guaranteed when using recycled water.
- **Cost.** Recycled water is almost always less expensive for golf course irrigation than fresh water.
- **Nutrient Content.** All recycled waters contain nutrients required by turf plants (e.g., nitrogen, phosphorus, and potassium). The quantities of nutrients available at a given site and their impact can only be evaluated after recycled water becomes available and can be tested for nutrient content. This limitation notwithstanding, most recycled waters contain enough nutrients to completely eliminate fertilization of roughs and even fairways, and to substantially reduce the fertilizer required by greens and tees.

AUTHOR'S NOTE

Use of recycled water for irrigation is rapidly spreading worldwide. The author is interested in staying abreast of issues arising from recycled water irrigation on golf courses in regions with varying social, environmental, political, and climatic conditions. Readers are encouraged to communicate issues related to recycled water irrigation that are not covered in this article. The author will compile and periodically cover these issues in new publications. The author may be reached at: maharivandi@ucdavis.edu.

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On Course *With Nature*

Good News for the Bottom Line and Environmentally Sensitive Golf Course Development

Yes, you can have it both ways.

BY NANCY RICHARDSON

Whether there is an economic advantage to environmentally sensitive golf course development is of central importance not only to investors and developers, but to environmentalists as well. If the answer is *No*, the added costs of building in an environmentally sustainable way will be a burden that many in the golf industry will not choose to pay. If the answer is *Yes*, there is a much greater likelihood that environmentally sensitive golf course development will continue to gain support.

Over the past year, members of Audubon International's Signature Programs (for properties in the design and development stages) have been reviewing their economic bottom lines and reporting their findings as part of a survey to gauge the business value of environmental stewardship. The programs' 118 Signature golf courses — comprising 50,000 acres in 33 U.S. states, as well as in Canada, China, Portugal, Puerto Rico, and South Africa — are being designed, built, and managed according to stringent environmental standards. Members considered operational costs, up-front investments, and the importance of the program in marketing and promotion.

Their responses bode well for the future of sustainable golf course development.

- 96% viewed their participation in the Signature Program as "a good business decision," with the remaining 4% indicating that they "don't know" at this time.
- 90% of respondents reported that they believed annual operation and maintenance costs for their facilities were either "lower than" or the "same as" the costs of an equivalent, non-Signature member golf course. 43% of respondents attributed lower operation and maintenance costs to their participation in the Signature Program.
- 63% of respondents stated that participation in the Signature Program, including up-front monetary and staff investment in the program, has saved or will save money, as compared to a course designed, constructed, and managed without Audubon International assistance. Another 20% of the remaining respondents stated that they "don't know" yet.
- 90% stated that they believed the *Certified Audubon Signature Sanctuary* status earned through following program guidelines has or will have value in marketing and promotional efforts, with the remaining 10% indicating only that they "don't know."

"In Austin, or anywhere in the country for that matter, environmental stewardship is a great business decision," says Anne Hickman-Hudgins, Environmental Landscape Coordinator for Barton Creek Resort and Spa in Texas. "Community outreach and education is a benefit to establishing our club as a role model for other properties."

"Combining wildlife preservation and development is not only the right thing to do, but it makes good business sense," agrees Jim L. Awtrey, CEO of PGA of America (PGA Golf Club in St. Lucie, Florida, is a Certified Signature Sanctuary). "Long-term operating costs can be significantly reduced while providing valuable environmental benefits to the community. It is a business-environmental partnership that serves everyone."

"The concepts incorporated in the Signature Program will absolutely pay for the cost of what we're doing over five to ten years .... We'll have better-managed water and irrigation systems and use less chemicals," reports Bill Fiveash of East West Partners, developers of Old Greenwood Golf Course in California.

Just as wildlife inventories and water quality data help to determine environmental outcomes, data about operational costs and return-on-investment are critical in evaluating the financial value of environmentally sensitive development and management. Taken together, these benchmarks are beginning to demonstrate clearly that embracing sustainable development benefits the quality of life, the environment, *and* the bottom line.

NANCY RICHARDSON *is the director of the Audubon Signature Programs, based in Henderson, Kentucky. She can be reached at (270) 869-9419 or e-mail nrichardson@audubonintl.org.*

2005 TURF ADVISORY SERVICE

To keep up with the increasing costs of providing a high-quality advisory service to member clubs and the game of golf, it is necessary for the USGA to increase the fees charged for the Green Section's Turf Advisory Service. The 2005 fee schedule continues to offer a $300 discount for fees received by May 15, 2005.

	Payment received by May 15, 2005	Payment received after May 15, 2005
Half-Day Visit	$1,400	$1,700
Full-Day Visit	$1,900	$2,200

Despite the increase, the USGA will subsidize the Turf Advisory Service (TAS) by about 50% in 2005, reflecting a commitment to provide golf courses with the best of services from a top-quality staff of 18 full-time agronomists. A Green Section visit is a bargain for the many benefits that are realized. The TAS strengthens the golf course superintendent's and Green Committee's position, and it provides a positive environment to discuss common problems and realistic solutions and expectations at whatever level of golf course budget is available.

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

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

ISTRC New Mix Lab LLC
1530 Kansas City Road, Suite 110
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I certify that the statements made by me above are correct and complete.

JAMES T. SNOW, Editor

All Things *Considered*

No, It Really Is Not Just Your Golf Course!

The issues at your golf course are often being experienced by other courses in your area.

BY DARIN S. BEVARD

How many times have you said it at your club? "Ours is the only course that is having this problem. I played at the course down the street, and they did not have any problems. Their golf course was perfect." Please, be honest. Have you said it? I'll bet you have. The "only course with a problem" syndrome raises a red flag, in my opinion. More importantly, we should evaluate reasons why this statement is made so frequently.

There are many other things that happen only at "your" golf course. Yours is the only golf course that ever closes. No one else closes. Yours is the only golf course that ever has a frost delay. No other courses ever have a frost delay. Your course is the only one that had any winter damage, disease, etc. Basically, every other golf course is perfect. Why don't golfers recognize problems when they visit other golf courses in the same way that they do at their own?

HEAD UP VS. HEAD DOWN

The "head up vs. head down" syndrome is one explanation for the "only our course" problem. When playing a new course, or at least one that they do not play on a regular basis, golfers tend to have their head up. They look around at the scenery and analyze each golf hole. They simply enjoy their new surroundings and soak in the golf experience. A thin spot here or a weed or two (or more) there go unnoticed. The goal is just to enjoy a different golf course. Additionally, most golfers will play a round of golf in 72 to 100 strokes. This does not lend itself to seeing every area of a golf course and providing a critical evaluation. Playing their regular course daily provides ample opportunity to notice problems.

At their own golf course, their head is down. Every blemish is noticed and criticized, regardless of the cause. They have seen everything that there is to see on their own golf course. There is no reason to look around because their golf course is not a new experience.

BIG EVENT SYNDROME

"Big Event Syndrome" is another common cause of "only at our golf course." Be it member/guest or some other premier event at the "other" club, golfers often visit other golf courses for these special events. The condition of the golf course is peaked. Every detail is tended to; the greens are fast; every bunker is raked. The maintenance staff at that golf course has been preparing in one way or another for several weeks leading up to the event. If you look at your own club and think back to your big events, I believe you will find that your golf course was in top condition as well. The golf course superintendent makes a special effort to showcase the golf course for any major event, but these conditions cannot be sustained on a daily basis at most golf courses.

Many different factors impact daily conditions on the golf course. Weather is the biggest factor that regularly affects turfgrass maintenance. Most maintenance decisions are based on what practices can be implemented under a given set of weather conditions. When it is hot and dry at your golf course, it is hot and dry at other local courses as well. Maybe XYZ Country Club has a new irrigation system that allows them to manage water more efficiently when environmental stresses arise.

Other factors influence daily conditions, including construction methods, turfgrass variety, irrigation efficiency, and last but certainly not least, available resources to implement maintenance practices (budget). In our region, similar problems are widespread at different golf courses at any point during the growing season.

Your golf course may have problems. Realize that you are not alone. Every golf course has problems that need to be addressed. At times, problems will occur on your golf course and not at others. The point of this rant is not to say that no problems exist on your golf course. We all know that they do. But your golf course is not perfect and neither is any other course that is maintaining turfgrass with the same basic resources as your own. Do not make the mistake of comparing your golf course conditions to a facility that has far more resources.

Every facility should strive to correct problems that exist and improve the golf course overall. But do not talk yourself into believing that yours is the only course having problems. The grass is not always greener, faster, or better at the course down the road! It is probably about the same color as yours.

DARIN BEVARD *is an agronomist in the Mid-Atlantic Region.*

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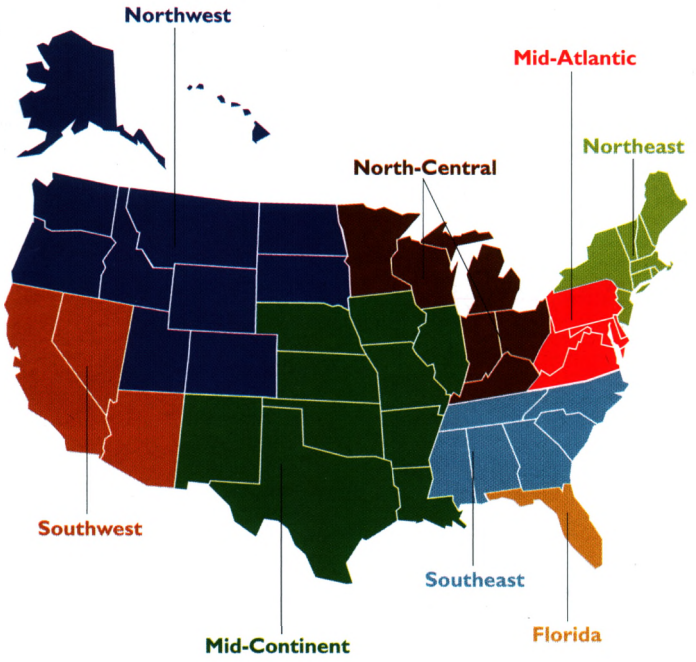

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Turf *Twisters*

Q: I live about 30 feet from a golf course. At approximately 6:10 a.m. each morning the mower cuts the grass just outside my bedroom window and I hear a number of other pieces of loud equipment being operated. What can golf courses do to be more neighbor-friendly? (North Carolina)

A: Unfortunately, the answer to your question concerning early morning disruptions is not an easy one. The maintenance crew must complete their morning tasks before golfers arrive, so that means they must start as soon as it is light enough to see. There are a few options that can help: If only a few homes are affected, sometimes the grounds crew can wait until the end of their 2-hour morning rush to work in that area; some of the noise-producing work may be done the evening before; identify the machinery causing the majoring of the noise (e.g. blowers) and use these tools after 9:00 a.m.; or a growing number of courses are using battery-powered, low-noise-producing machinery for early morning work. Discuss your concerns with the golf course superintendent and ask if one or more of these options could be implemented.

Q: How did the USGA come up with 80% sand / 20% peat for a putting green rootzone? (North Dakota)

A: There is nothing in the USGA guidelines for building greens that calls for such a mixture. In fact, the guidelines do not mandate any amendments if the sand provides the necessary porosity and saturated hydraulic conductivity values. It must also meet the particle size distribution specifications. Most sands, however, cannot meet these requirements without some modification. The ideal percentage of sand and amendment can only be determined by a physical soil testing laboratory. As a general rule, the mixing ratio usually falls somewhere between 80/20 and 95/5, depending entirely on the materials used.

Q: We are trying to replace a number of declining sugar maple and ash trees on the golf course. The Norway maple tree was highly recommended as a fast-growing replacement for those trees. What are your thoughts? (Connecticut)

A: The Norway maple (*Acer platanoides*) is a vigorous, non-native, and invasive tree species. It is densely canopied and has aggressive roots that compete significantly with the turf for sun and water. The dense shade created by the canopy makes it nearly impossible to provide an acceptable playing surface under the tree. The wood is softer and more brittle than

the traditional sugar maple, making it more prone to storm injury. The tree's root system also has a tendency to wrap around the base of the trunk, girdling and eventually killing the tree. The tree is undesirable in the view of many state foresters and biologists due to its invasive qualities. The best policy for long-term success is to select tree species that are endemic to your region and that have a proven track record. Contact your local Cooperative Extension agent to identify those species.

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