MORE PROBLEMS

Figure 5 illustrates a problem common to all sand bunker types ... that of sand accumulation on the collar resulting from years of bunker shots. As is usually the case, the collars suffer due to the sand build-up and low water-holding capacity. As is usually the case, the solution to this bunker maintenance problem is not quick, easy or economical. It requires hand-digging and removal of accumulated matter back to the original soil and resodding with new turfgrass. Because this type of problem requires years to develop, corrective measures are only infrequently needed. However, when they are needed, they are in fact and indeed needed.

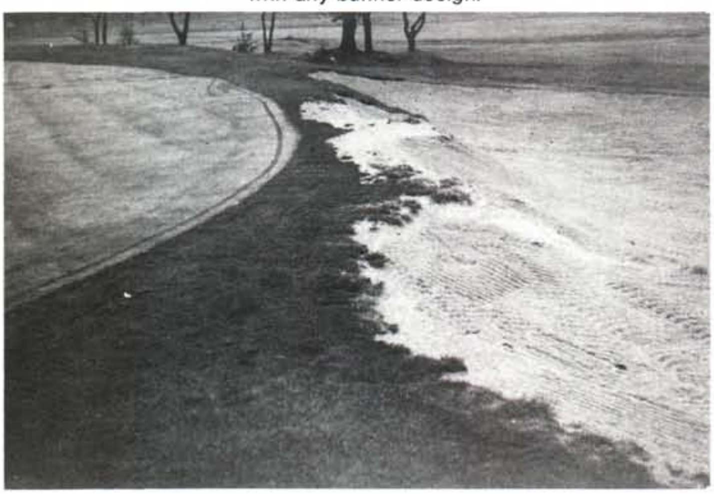
DEFINING A HAZARD

So far, this article has shown several differing types of sand bunker design and how they may be renovated when deterioration sets in. We are not attempting to judge design but rather to stress the need for continued maintenance of these important play areas. Good looking and playing sand bunkers of whatever design are an asset to any modern golf course.

This final point should be stressed. Sand bunkers are hazards. By definition, a "hazard" is any bunker or water hazard. A sand bunker is an area of bare ground, often a depression, which is usually covered with sand. Grass covered ground bordering or within a bunker is not part of the hazard. (Definition 14a.) A problem can arise if there is no clear boundary to a sand bunker (see Figure 2). If a ball is clearly in a hazard, certain Rules of Golf pertain ... non-grounding of a club, etc. There is a question then, "Is the ball in a hazard or is it not in a hazard?" Keeping lips and margins well defined will reduce or eliminate such questions in the mind of the golfer.

Unfortunately, in today's overall golf course maintenance operations, hand labor of the type needed for good sand bunker upkeep is usually at a minimum. Every type of bunker on a golf course requires maintenance and/or major renovations at some time or another. It is essential that this work be done so that sand hazards will play well, be well defined, and be good looking.

Figure 5. Sand build-up from exploded bunker shots. A problem with any bunker design.



Turfgrass Wear[1]

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Turf located on public areas such as parks, golf courses, and sport fields will be subjected to increasing traffic in the coming years. These open green areas near urban centers will be used more frequently and intensively than ever before by individuals whose mobility has been restricted by the increased cost of energy for travel to more distant outdoor recreational areas. Discretionary time available for leisure activities is expected to amount to at least as much or possibly more than in the past, thus providing substantial amounts of time for outdoor recreational activities. These increasing traffic pressures on recreational and sport facilities will re-

[1]Data on which much of this article is based is the result of wear investigations supported by a grant from the United States Golf Association Green Section Research and Education Fund. The paper was presented at the 1975 Texas Turfgrass Conference.

quire that the turfgrass manager become more knowledgeable about turfgrass wear tolerance and the cultural practices that can be used to minimize damage from traffic.

Traffic has two distinct effects that should be taken into consideration when interpreting the resulting turfgrass damage. One, called turfgrass wear, is associated with damage to the above ground plant parts. Scuffing and tearing actions of foot and vehicular traffic tends to crush the leaves, stems, and crowns of the turfgrass plant. In addition to these direct effects, the injured tissues are more prone to disease infection and environmental stresses such as drought. The second aspect of traffic involves the "hidden effect" of soil compaction. In this case the soil particles are physically pushed together into a more dense soil that is characterized by reduced aeration and water infiltration rates. Both the wear and compaction components of traffic can be very detrimental to turfgrass quality.

Most research, articles, and lectures have emphasized primarily the soil compaction component of traffic. However with the anticipated increased usage of turfgrass areas, the importance of wear tolerance and its manipulation will have to become better recognized in the future. The following three sections will discuss in detail the major approaches utilized to minimize the effect of wear on turfgrasses.

I. TURFGRASS SELECTION

There are wide variations in the inherent wear tolerance of turfgrass species as shown in Table 1. These differences are significant enough to justify selecting the more wear tolerant species for a particular soil and environmental condition on sites where intense traffic is anticipated. The specific mechanism contributing to this interspecies turfgrass wear tolerance is being investigated through a grant from the U.S.G.A. Green Section Research and Education Fund. Allied research supported by the same agency conducted by Beard, Shearman, and Anda has been directed towards characterizing the wear tolerance among cultivars within a specific turfgrass species.

To establish controlled wear stresses across a series of turfgrass species and cultivars, a wear simulator was developed for small plot use. The apparatus simulated both foot and tire wear on turfs with minimal soil compaction. Foot traffic was simulated by a sled pulled in a circular twisting pattern with a pressure of 4 pounds per square inch being applied. The tire traffic simulator was comparable to that of a riding greensmower.

The comparative wear tolerance of 18 Kentucky bluegrass cultivars was evaluated in July of 1974 by Beard and Anda using the wear simulator. The turfs were five years old at the time the wear stress was superimposed. Cultural practices included mowing twice weekly at 1.5 inches with clippings returned; irrigation as needed to prevent wilt; and nitrogen fertilization at a rate of 5 pounds per 1,000 square feet per growing season. Phosphorus and potassium were applied as needed based on soil tests. Thatch accumulation was minimal and consistent throughout all plots. No pesticides had been applied during the previous four years. At the time the wear simulation treatments were applied, the treatment area was visually free of weed infestation and injury from insets or diseases.

Specific wear tolerance comparisons of the 18 Kentucky bluegrasses are shown in Table 2. There was a five fold increase in wear tolerance from the lowest to the highest listed cultivar in terms of wear tolerance. This study indicates that there are substantial differences in wear tolerance among the commercially available Kentucky bluegrass cultivars which could be effectively utilized in establishing more wear tolerant turfs for intensively trafficked areas.

A similar cultivar evaluation study was conducted on nine bentgrasses maintained under putting green conditions. The turf was six years old and possessed no visual disease or insect injury at the time the wear treatments were applied. Cultural practices included mowing six times weekly at 0.25 inch with clippings being removed; irrigated as needed to prevent wilt; fertilization at 5 pounds nitrogen per 1,000 square feet per growing season; and topdressing twice yearly for thatch control. Phosphorus and potassium was applied as needed based on soil tests.

The comparative wear tolerances of seven commercially available and two experimental bentgrasses are shown in Table 3. Among the commercially available cultivars the striking superiority of Penncross creeping bentgrass is of particular interest. The much lower wear tolerance of Emerald and Toronto creeping bentgrasses should also be noted. Plans are underway through support of the United States Golf Association Green Section to conduct comparable studies on the commonly used warm season turfgrass cultivars. Hopefully these investigations will be underway during this coming growing season at Texas A&M University.

These comparisons among species and cultivars within species are based on wear simulation of mature turfs. It should be recognized that fully established turfs are definitely superior in wear tolerance to young seedlings. Thus it is important for traffic to be withheld from turfgrass stands during the seedling establishment period. Similarly, dormant or extremely slow growing turfs do not have the wear tolerance and recuperative potential of dense, actively growing turfs.

II. CULTURAL PRACTICES

The wear tolerance of a turf increases as the green vegetation or turfgrass shoot biomass increases. Therefore, lower cutting heights increase the proneness to wear injury. Similarly moderate amounts of thatch accumulation also contribute to a cushioning effect which increases turfgrass wear tolerance.

Wear tolerance is also reduced if the turfgrass leaves are quite succulent and delicate in nature. This condition is most likely to occur under excessive nitrogen fertility levels; intense irrigation; low potassium fertility levels; or under the shaded canopy of trees. The significance of these cultural practices in turfgrass wear tolerance should not be taken lightly. For example, a turf mowed at 1.0 to 1.5 inches, with 0.3 inch of thatch, and fertilized at a moderate level of nitrogen nutrition and a high potassium level can be as much as 10 to 15 times more wear tolerant than a turf mowed at 0.5 inch, with no thatch accumulation, and maintained under high nitrogen and irrigation levels.

III. TRAFFIC CONTROL

Turfs cannot be expected to persist under continuous, intense traffic. Even artificial turfs will wear out within four to five years use. Fortunately turfs have good recuperative potential if the traffic stress can be diverted, withheld, or reduced for a period of time. A preventive approach in which the traffic level is adjusted to a level that the specific turf will tolerate without excessive damage is even more desirable. This traffic control can be achieved through subtle design techniques which disperse traffic over the area or redirect it across hard surface walks or roadways. These techniques involve the proper selection and placement of trees, shrubs, walks, roadways, contour barriers, and bunkers. Designs which offer a large number of alternate routes from one location to another are particularly effective where the site permits such an approach.

Finally, traffic should be withheld from turfgrass areas during periods of severe wilt stress or when the leaves have been frosted during the early morning. This will minimize mechanical damage to the brittle protoplasm which occurs under these stress conditions. Similarly, winter traffic on turfs covered with a wet slush should be avoided just prior to periods of severe freezing.

SUMMARY

The major points discussed in this article only touch the surface of the traffic problem. As further research is conducted, additional guidelines regarding specific turfgrasses and cultural practices that can be utilized to minimize the effects of traffic can be expected. The Texas A&M turfgrass researchers anticipate that this area will receive major emphasis during the next few years.

TABLE 1. The Relative Wear Tolerance of Twelve Turfgrasses When Grown In Their Respective Regions of Adaptation

Relative Ranking	Turfgrass Species: Warm Season	Turfgrass Species: Cool Season
Excellent	Zoysiagrass Bermudagrass Bahiagrass	
Good		Perenial ryegrass Tall fescue
Medium	St. Augustinegrass	Red Fescue
Poor	Carpetgrass Centipedegrass	Creeping bentgrass Colonial bentgrass
Very Poor		Rough bluegrass

Adapted from "Turfgrass: Science and Culture."

TABLE 2. A Comparison of Verdure Remaining and Percent Reduction In Verdure for 18 Kentucky Bluebrass Cultivars After 800 Revolutions of a Turfgrass Wear Simulator.**

Kentucky Bluegrass Cultivar	Verdure Remaining (Grams Wet Wgt.)	Percent Reduction In Verdure
A-34	7.88 f*	22.7 ab*
Merion	5.68 e	24.0 ab
Baron	5.45 e	18.4 a
Nugget	4.60 de	45.8 abcd
A-20	4.51 de	31.7 abc
Georgetown	4.47 cde	47.3 bcd
Primo	3.92 cde	33.5 abc
Fylking	3.56 bcd	55.6 cd
Adelphi	3.45 bcd	58.8 cd
Newport	3.45 bcd	57.6 cd
Sodco	3.22 abcd	58.7 cd
Galaxy	3.09 abcd	62.7 d
Bonnieblue	3.04 abcd	65.6 d
Belturf	2.71 abc	53.5 cd
Campus	2.05 ab	58.0 cd
Sydsport	1.96 ab	62.7 d
Kenblue	1.90 ab	44.5 abcd
Park	1.59 a	59.0 cd

*Any two treatments with the same letter in each respective column were not significantly different from each other, at the 5% level, by Tukey's test.

**From a study by R.B. Anda and J.B. Beard.

TABLE 3. The Comparative Wear Tolerance of Seven Commercially Available and Two Experimental Bentgrasses After 410 Revolutions of the Wear Simulator

Turfgrass Cultivar	Percent Reduction In Verdure	Verduring Remaining (Grams)
MSU-28-Ap	39.8	6.07
MSU-18-Ap	32.8	3.90
Penncross	53.0	3.64
Pennpar	58.7	3.07
Cohansey	65.9	2.56
Seaside	59.8	2.55
Toronto	53.6	2.46
Emerald	67.7	2.12
Astoria	64.4	1.83