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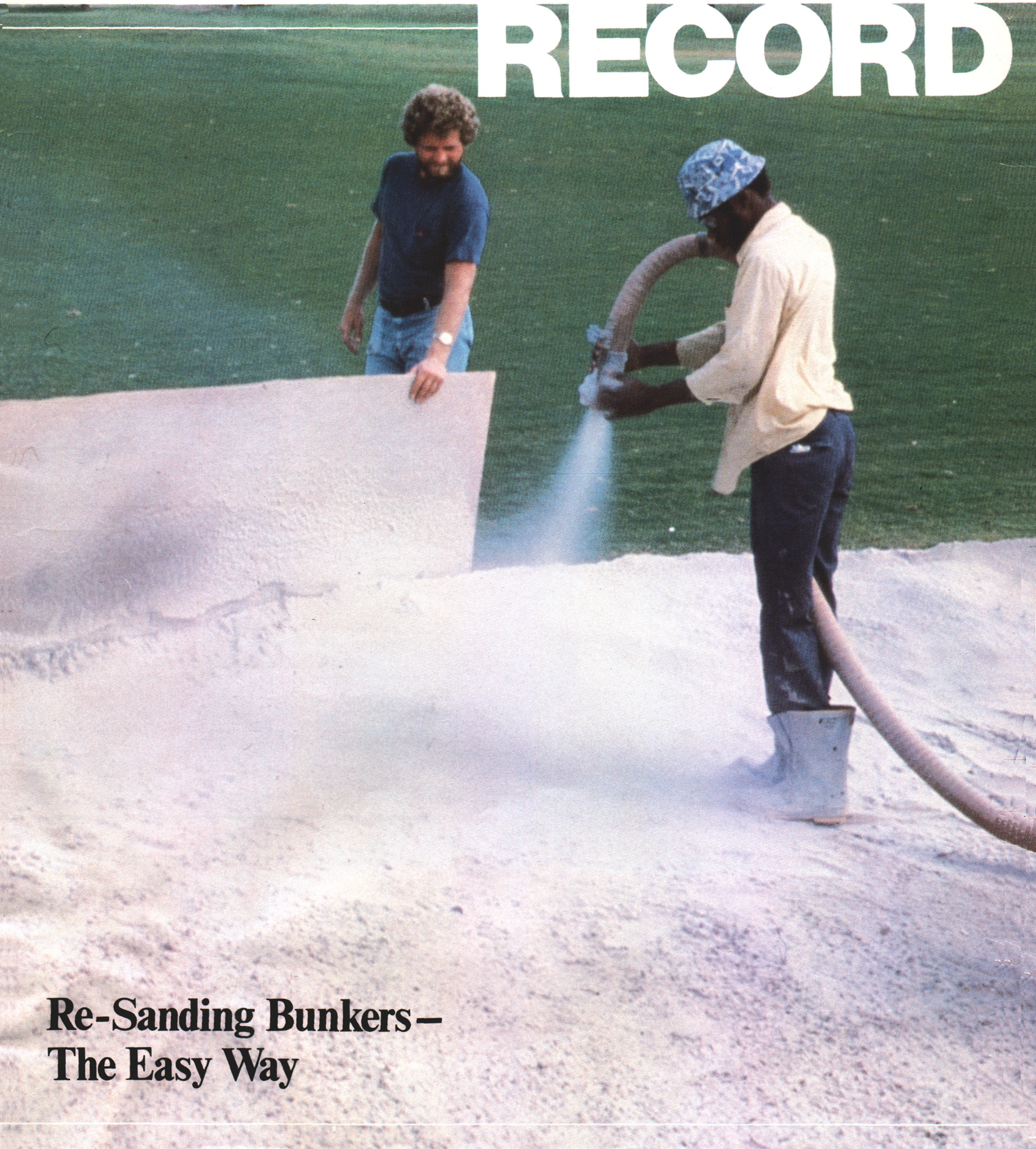

Re-Sanding Bunkers – The Easy Way

USGA

Green Section RECORD

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Cover Photo:

The gunite method for replacing sand in bunkers. See page 5.

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USGA President Frank D. Tatum, Jr. (left) and Green Committee Chairman William C. Campbell congratulating Dr. C. Reed Funk (center) upon receipt of the Green Section Award.

1980 GREEN SECTION EDUCATION CONFERENCE

Dr. C. Reed Funk 20th Recipient of USGA Green Section Award

DR. C. REED FUNK, research professor of turfgrass agronomy at Rutgers University, in New Brunswick, New Jersey, became the 20th recipient of the annual USGA Green Section Award for distinguished service to golf through work with turfgrass. The Award was presented to Dr. Funk by Frank D. Tatum, Jr., of San Francisco, California, President of the USGA, and William C. Campbell, of Huntington, West Virginia, Chairman of the USGA Green Section Committee. The ceremony took place during the 24th Annual Green Section Conference on Golf Course Management, which was held in Chicago on January 25.

In introducing Dr. Funk, Mr. Campbell stated:

"In 1961, the USGA established the Green Section Award to honor those persons who deserve special recognition for distinguished service to golf through work with turfgrass. The USGA believes there are many men and women who have made measurable contributions respecting the arena upon which the game of golf is played. Their contributions and service may be evidenced by their achievements over a number of years or by a single act. In continuing to present the Green Section Award, the USGA wishes to identify, celebrate, and hold up for emulation

President Charles H. Tadge (second from left) presenting GCSAA Citation for excellence in championship course preparation to: Wilbert C. Water, of Inverness Club, Toledo, Ohio, site of the 1979 Open Championship; William L. Burdick, of Canterbury Golf Club, Cleveland, Ohio, site of the 1979 U.S. Amateur Championship; Frank Nichols, of Brooklawn Country Club, Fairfield, Connecticut, site of the 1979 U.S. Women's Open Championship.

individuals who exemplify outstanding dedication to the game of golf through their work with turfgrass."

Dr. Funk is best known as the project leader of one of the world's most extensive turfgrass breeding programs. It began in 1962 and it is still going on. Through his research at Rutgers, he developed the first successful method of producing Kentucky bluegrass cultivars by intraspecific hybridization of apomictic parents. He released the Adelphi, Bonnieblue, and Majestic bluegrass cultivars developed through this new technique.

He also developed and released the first turf-type cultivar of perennial ryegrass, known as Manhattan, which is widely recognized and used throughout the world. Manhattan and other germplasm sources developed at Rutgers contributed to the cultivars Citation, Yorktown, Yorktown II, Diplomat, Derby, Regal, Omega, Fiesta, Dasher, Blazer, Pennant and Premier, all currently used in many breeding programs in North America and Europe.

He has accumulated one of the most valuable collections of *Poa* and *Festuca* germplasm now available in North America. He developed techniques for screening this collection for turf performance, for response to important management practices, and for resistance to many important disease problems. The cultivars Touchdown, Brunswick, Plush and Glade originated from this *Poa* collection. An attractive turf-type tall fescue is being developed from the collection of *Festuca arundinacea.* Also, the first turf-type cultivar of *Poa trivialis L.* developed in North America was developed by Dr. Funk. It is called Sabre.

Dr. Funk is a member of the American Society of Agronomy, the Crop Science Society of America, the American Genetic Association, the American Sod Producers Association, the New Jersey Turfgrass Association, the Pennsylvania Turfgrass Council, the Golf Course Superintendents Association of America, and the Golf Course Superintendents Association of New Jersey.

Dr. Funk also served on the subcommittee for Glossary of Crop Science Terms of the Crop Science Society of America; the Foundation Seed Committee, Patent and Copyright Policy Task Force, and Turfgrass Committee of the New Jersey Agricultural Experiment Station. He was the chairman of the regional committee for Breeding and Evaluation of Kentucky Bluegrass for Turf. He is a member of the Genetics and Breeding Subcommittee and National Research Program Steering Committee. Dr. Funk is the author or co-author of 168 scientific, technical and popular publications.

IN ACCEPTING THE AWARD, Dr. Funk stated:

"It is indeed a great honor to be chosen to receive the USGA Green Section Award. I gratefully accept this award on behalf of all who are contributing to the field of turfgrass breeding. The accomplishments that I am associated with have been the result of team efforts involving students, technicians, fellow turf specialists, golf course superintendents, seedsmen and growers. It has been a challenging, sometimes frustrating, but an exciting and rewarding experience for all.

"It takes many years and the cooperation of many people to develop a successful turfgrass variety. Merion Kentucky bluegrass was discovered by Joseph Valentine on the Merion Golf Club in Ardmore, Pennsylvania, in 1936. It was increased and evaluated initially by research workers at the United States Department of Agriculture, the USGA Green Section, and the Pennsylvania Agricultural Experiment Station, and also by progressive seed growers in the Pacific Northwest. Finally, beginning in the early 1950s, seed became available to the American consumer. Since then, over 70 million pounds of Merion seed has been used in North America. This variety revolutionized the sod industry and has had a tremendous impact on all other aspects of the turfgrass industry.

"The parental germplasm of Manhattan perennial ryegrass was discovered growing in Central Park, in New York City, in 1961. Since 1968, over 25 million pounds of Manhattan seed has been used in this country and abroad. The initial success of Manhattan stimulated turfgrass breeders throughout the world to initiate or expand their efforts to improve perennial ryegrass for turf. Currently, 20 million pounds of turf-type ryegrass seed are produced annually for the American market. Millions of additional pounds are used in Europe. Manhattan germplasm has contributed to the development of many newer varieties including Derby, Omega, Diplomat, Yorktown II, Fiesta, Dasher, Blazer and Belle.

Adelphi Kentucky bluegrass was the first bluegrass variety produced by controlled hybridization. Its mother was discovered by Tom Topp and Al Radko on a fairway of the Bellevue Country Club in Syracuse, New York. Dr. Felix Juska found its father growing in his turf trials in Beltsville, Maryland. The cross that produced Adelphi was made during the late winter of 1964. The first turf plot was seeded in 1965. Adelphi was subsequently evaluated at many universities and research institutions throughout the world. Next it was necessary to evaluate seed production potential in the Northwest. The efforts and support of Bob Russell and Arden Jacklin made this possible and Adelphi became a commercial variety.

"Most new varieties will take at least 10 years of development and testing before seed becomes available for commercial use.

"Selection, hybridization and mutation breeding create the genetic variation for plant breeding programs. The plant breeder must then identify and isolate the superior plants from variable populations of tens of thousands of individuals. Spaced-plant nurseries, clonal plots and disease screening procedures are used. Next, it is important to evaluate the best selections in small turf plots subject to varying types of stress. The best entries are subsequently chosen for replicated performance trials at different locations and under different management variables. Tolerance to chemicals and other environmental stress factors should be assessed. Finally, there is no real substitute for ultimate user evaluation. The user must be pleased if this new variety is to succeed.

"The USGA Green Section has made a tremendous contribution to turfgrass varietal improvement. Prior to World War II, the USGA Green Section initiated or assisted in the programs that led to Merion Kentucky bluegrass, Meyer zoysiagrass, and a number of outstanding bentgrass varieties. In recent years, the USGA Green Section Research and Education Fund has provided generous financial support for turfgrass breeding and other research programs at Rutgers and other State Universities. Green Section agronomists have provided advice, encouragement and invaluable germplasm collections. For this support we are all most grateful. It should also be noted that turfgrass varieties developed with Green Section assistance have contributed not only to better golf, but also to millions of home lawns, recreation areas and soil conservation.

"There is a great future for turfgrass breeding. The future can bring us new varieties vastly superior to those presently available. It will take time, money, dedication and skill. A team of capable young plant breeders working with management specialists, pathologists, nematologists, entomologists, etc. and willing to devote a lifetime to such efforts will develop such varieties. Both the turfgrass professional and the average home owner will have the satisfaction of being able to do a better job as these superior varieties become available to them."

Remarks by USGA President Frank D. Tatum, Jr.

ON BEHALF OF the USGA I want to express our appreciation for a couple of rather basic things. We in the USGA deal with the fundamental, basic policy questions that are involved in the extraordinarily complex problems of administering golf in an increasingly complex world. Everything that we are doing, or at least trying to do, would, however, be absolutely meaningless, in the final analysis, because nothing matters unless the golf course is properly and effectively maintained — not the skill of the player, not the skill of the architect, not the architecture of the clubhouse, not the quality of the membership — not anything.

We are very sensitive to the fact that what you who are involved in turfgrass do involves an extraordinarily complex art and science. I've been close enough to it to be satisfied that in a real sense more art than science is involved. It is with a sense of real appreciation, therefore, that I look at a perfectly maintained golf course and realize how much caring has gone into the production of this magnificent result.

I can't pass up the opportunity to enlist you in what I'd like to think of as a development crusade, to somehow mobilize ourselves to control the amount of water that's going onto the golf courses in this country. It seems to me that it's a pervasive problem which very, very seriously affects the playing of the game.

I want you to know that we understand the difficulty because of the problems of communications with Green Committee Chairmen and members, but I also want you to know that we feel very, very strongly that this is a problem that afflicts the game more seriously than any other. We would just like to enlist your support in trying to beat it.

Now the other crusade.

WE REALLY CAN'T sit back and see the game consumed by golf carts. These abominations are among the more serious problems you have to cope with. It isn't right that all of us simply give up. Somehow we must be able to persuade people in America that playing a game in one of those abominal things simply cannot be called playing golf.

Finally, I would just like to congratulate Dr. C. Reed Funk, the recipient of the Green Section Award, both personally and on behalf of the Executive Committee. His accomplishments say a very great deal about him, and it says a very great deal about this organization that it means so much to have an Award like this presented to somebody who obviously so richly deserves it.

Jay Sigel

A Playing Comparison of British and American Courses

by **JAY SIGEL**, British Amateur Champion; Walker Cup Team; World Amateur Team; Aronimink Golf Club, Newtown Square, Pennsylvania

WHEN MEMBERS OF an American club discuss the condition of their golf course, the conversation typically dwells on color, not on playability. I suspect that television has helped to develop these attitudes; I have been in a number of TV production facilities and noted their great concern for the TV viewer and on how they might color the picture to make it more appealing for the viewer. This is also the prime reason for overseeding dormant bermudagrass fairways with ryegrasses, to make the event more attractive for the viewer, not to improve the dormant bermudagrass playing surface.

Twenty-five years ago my home course didn't have watered fairways. Each year our grass turned brown. During the six to eight weeks of summer, I also remember the high level of playability of that golf course, the feeling of being able to control a shot from the turf because that turf was firm. I know that the older players also enjoyed this because they got more roll. Also, the speed of the greens certainly was faster; the overall pace of the course was much quicker, and it seemed to translate into faster play.

Let's compare the British and the American golf courses as I see them. The British courses have no motorized carts at all that I could see on the four courses we played — St. Andrews and Muirfield, in Scotland, and Hillside and Royal Birkdale in England. The color of these golf courses is drab, like the weather there. Height of the grass, I think, is of interest. Approach fringes were very, very short, enabling us, during the Walker Cup Match, to putt the ball from up to 40 yards off the green. Of course, the fairways were also very close-cropped. The rough was very high and variable in growth and plant population. You'd have to call it rugged compared to ours.

A lie in the rough in Britain or Scotland requires a very delicate shot just to move a ball back to the fairway. On our courses, a lie in the rough can sometimes be better than one we might have in the fairway. Sand in their bunkers is extremely firm, and the bunkers themselves are very deep. I've had conversations about water with a number of people, and of the four courses I played, the only watering system I saw was at Hillside, where the British Amateur was played, although I understand that St. Andrews has an irrigation system.

In general, only a few British courses have watering systems, and I know of none as sophisticated as ours. Their greens are very firm, but certainly not as good to putt as our greens. They are grainier than ours and very close-cut. American players liked their firmness. They were very consistent.

I believe Tony Jacklin recently said that one of the reasons American players produce generally better results is that they are better putters, and that better putters are developed on better greens. Our putting surfaces are far more smooth than those on the four courses that I saw.

THE BRITISH DO NOT play winter rules; they do not even know what winter rules are! I found that interesting. They don't know what mulligans are either. That alone must spare their first tees from much abuse.

I must admit that until I became a member of the Green Committee at Aronimink last year, I really hadn't given much thought to differences in golf course management practices. Now I wonder why have we moved so far away from the conditioning like the courses where the game originated and away from an emphasis on good playability? I guess part of the answer is that the average American golfer's fetish for soft, lush turf often pressures the superintendent into applying more water and fertilizer. This in turn increases *Poa annua* encroachment and related problems of summer turf weaknesses. By forcing growth and color, we increase maintenance requirements which in turn increases budget expenditures. Does forcing growth then make good golf sense?

As for the better player, I don't think he minds *Poa annua* one bit, as long as it is cut closely. He doesn't become concerned if the turf turns brown and the *Poa annua* thins out or dies as long as he can strike the ball cleanly with the club face. We all recognize that this is the way golf is played in Great Britain. Golf there is played on grass, not color. If the American golfer could play from a firm surface, he would be able to control the ball better. In my opinion he would improve his game and he would enjoy golf more.

Shouldn't we try to give this playability back to the game? Wouldn't that conserve energy and precious water? Wouldn't that save dollars for clubs that now are experiencing troubled times? I pose these questions though I certainly don't have the answers. I thank you all for helping me to better understand some of your problems in the regrettably brief association I've enjoyed with you. Thank you for inviting me.

The gunite method compacts the sand in place. The plywood board keeps sand within the bunker.

Installing Sand in Bunkers—A Better Way

by **ROBERT A. STRAIT**, Certified Golf Course Superintendent, Deer Creek Country Club, Deerfield Beach, Florida

BUNKERS ON GOLF courses as hazards are necessary. How many and how large the bunkers should be depends upon a number of factors, especially on how the golf course architect envisions the specific requirements of the site. Some golfers love bunkers, many others fear them, but one thing is certain — bunkers are expensive to maintain.

Because they are costly to maintain, superintendents continually search for more effective time-saving methods for maintaining the sand and the surrounding areas. The mechanical sand rake was a welcome advancement; it reduced the need for hand raking, and freed workers for other maintenance work. Now one worker operating a mechanical sand rake can do much of the work and touch-up himself, if bunker sand facings are not severe. If facings are severe, then extra help is required to smooth the sand where the mechanical rake cannot operate. Even though the mechanical sand rake has been a major advancement in bunker care, other improvements are needed. There is a need for a better trimming mower to maintain the turf along the edge of the bunker that is not easily accessible with conventional mowers, a better method of edging to define the bunker limits, and a better method of installing sand in bunkers; the conventional method of trucking and shoveling sand into bunkers is too costly and is very time-consuming.

The specific problems involved are:

1. Hauling large quantities of sand is very difficult on the regular maintenance trucks. Broken axles and broken hydraulic lines are common in hauling heavy loads of sand. It also means that these vehicles are tied up for a long time, and, therefore, not available for other work.

2. A large part of the work force is unavailable for routine maintenance when they are hauling sand. Morale is affected when the course isn't well-groomed.

3. Interference with golfers is drawn out over a long period. Golfers' patience and nerves are strained.

4. Dump trucks cannot move in and out of bunkers to place the sand where it is needed. This forces excess shoveling by workers.

5. Moving sand in large quantity with shovels produces a soft sand that causes the ball to bury. Much time and water (irrigation or rainfall) is required to firm the sand. This takes several months.

6. Moving sand in quantity requires many trips to the sand pile, new roadways and ruts are made and the edges of bunkers are damaged.

There had to be a better way, and after a lot of thought, I believe I have a solution:

FOR THE LAST THREE seasons, we have successfully used a gunite machine to place new sand in our bunkers. This machine is the same one used in the construction of swimming pools. It will accept bulk sand and force it through the hose under high pressure. The force is such that it compacts the sand while spreading it in place. One man easily guides a 2-inch (inside diameter) hose to place the sand where it is needed. It is capable of delivering up to 10 yards of sand per hour, using the following procedure. Two truck drivers are required. Each loads his own truck with sand. A helper shovels the sand into the mixing hopper and another helps move the hose. The gunite contractor provided the machine operator and a man to handle the hose in bunkers. The machinery is placed in the rough approximately 200 feet from the green. Only the hose is taken to the bunker site. The sand is delivered to the site through the hose.

The time study (Figure 1) provides a comparison of costs between the old conventional method of placing sand in bunkers and the gunite method. Costs for the gunite method were approximately 50 percent of the old conventional method. The first test run was accomplished in 1978. We liked the technique and used it again on our second course and improved upon our efficiency by placing approximately 450 yards of sand into bunkers in 52 hours in 1979.

It was, in our opinion, a totally successful operation. I feel that with modification, this machine, or one that works like it, has endless possibilities. For example, I can imagine dressing bunkers with a thin layer of sand for an important golf tournament, or top-dressing a green in a matter of seconds, applying limestone, hydrated lime or fertilizer without stepping on the putting surface. It is our responsibility as turfgrass managers to continue to search for new ideas. You too may at least find it to be a solution to an old and difficult problem.

Time Study — Sand Installation in Bunkers

	Old Method				New Method			
Front loader cost per hour Two dump trucks cost per hour	$10.00/hr $16.00/hr	+	=	$26.00/hr	$10.00/hr $16.00/hr	+	=	$26.00/hr
Manpower cost per hour Manpower needed per hour	$ 3.00/hr 5	×	=	$15.00/hr	$ 3.00/hr 4	×	=	$12.00/hr
Sand used per bunker Number of bunkers	4½ yards 65	×	=	296 yards	4½ yards 65	×	=	296 yards
Average size of bunkers Time to install 4½ yards of sand Time to level sand & repair edges	3200 sq. ft. 2.25 hrs 1 hr	+	=	3.25 hrs	3200 sq. ft. ½ hr N.A.	+	=	½ hr
Total installation time Contractor equipment & manpower cost	65 traps × 3.25 hrs N.A.		=	211.25 hrs	× ½ hr		=	32.5 hrs $50.00/hr

Equipment plus manhour cost times total time		
$26.00 + $15.00 = $41.00/hr X 211.25 hrs	=	$ 8,661.25
Total sand used times hypothetical price:		
296 yards times $7.00 yard		$ 2,072.00
TOTAL:		$10,733.25

Equipment plus manpower cost times total time:		
$26.00 + $12.00 = $38.00/hr X 32.5 hrs	=	$1,235.00
Total sand used times hypothetical price:		
296 yards times $7.00 yard		2,072.00
Contract hourly price times total time:		
$50.00 hour times 42 hours		2,100.00
TOTAL:		$5,407.00

Perforated plastic 4-inch tubing serves as drain line. Worker covers drain with gravel.

Construction of The USGA Green by The Superintendent

by LOUIS E. MILLER, Golf Course Superintendent
Louisville Country Club, Louisville, Kentucky

OF THE MANY DIFFERENT methods of constructing a putting green, the USGA method is accepted as probably the most successful. The USGA method of building has been refined and tested for a number of years and, if all the proper steps are followed in sequence, the result should be a correctly built green that should last for many years.

If you are considering rebuilding one green or your entire course, the first step is to engage a competent golf course architect. I have seen too many greens designed by the superintendent or a member of the green committee that have been disasters. At our club, we hired an architect whose work was quite reputable. His design kept the existing character of the course, yet added an innovative flare to the new greens.

A committee was established consisting of the superintendent, golf professional, and two members of the green committee. Once the board of directors had approved the construction of three greens, the committee was to work with the architect and approve the design. The project was to be done over six years, rebuilding three greens each year.

As soon as the board approved the project, we began making our topmix. In wanting to stay away from any soil at all, we sent samples of the sand and peat to the USGA supported laboratory at Texas A&M University. The laboratory recommended we use 80 percent sand,

Making the final grade with the grader box prior to overseeding the green.

which was classified as a medium washed sand, and 20 percent Millburn peat. This material had a percolation rate of 7.4 inches per hour.

We mixed off-site beginning in June, using two front-end loaders and a Lindig soil shredder. We found that by using two loaders and mixing the material before putting it through the shredder, two men could mix about 100 tons in a six-hour period. The high sand content made it necessary to clean and change the oil on the breathers and crankcases of all equipment each day. We were able to mix 2,000 tons in about one month.

Our target date for construction was set for the day after Labor Day. Arrangements for the heavy equipment, which in our case consisted of a track-type high lift and a backhoe, were made three months in advance. A rule of thumb here is that you can budget about three days for the high lift and one day for the backhoe per green. Try to have operators who have done this type of work before, because it makes the job a lot easier.

The sod was removed from the green the morning construction was started and used to establish a temporary putting green. This lessens the shock to the membership and gives them a satisfactory surface to putt on during construction. The architect's job is finished once he gives us the final draft of the blueprints. Staking and gradework should be handled by the superintendent (using a transit properly is part of his professional requirements). The two main stakes to be considered throughout the construction are the center stake and the backsight stake, which is established in the center of the fairway. The backsight stake is absolutely essential; it assures that the green will be properly oriented with the fairway. If a cut or fill is required, then the center stake and four others will suffice until a rough grade is reached. This just speeds things up for the operator. The green can then be staked on 16 points with the proper grade marked on each stake.

THE BASE GRADE of the new green should conform roughly to the finish grade, except that it will be 18 inches deeper. Once the base grade is established, the next step is to install the tile lines. In our case, the design of the tile system varied with each green with a minimum spacing of 12 feet and a maximum of 20 feet. The main thing to be sure of is that they all have the proper fall. We used 4-inch plastic perforated tile with ½ inch gravel to bed and cover the pipe. During the tiling phase, I moved to the next green site with the heavy equipment and my assistant took over the tile installation. This requires two transits, or, at minimum, one transit and a level. A transit with a plumb line and full vertical adjustment on the instrument will be required for the stake work. A level will be good enough for checking the grade work in tile installation. The soil taken from the tile trenches can be slightly mounded between the lines and rolled with a power roller. This speeds the flow of water to the tile lines while drains are functioning.

Once the lines are installed, a series of grade stakes can be driven into the base grade. Ten to 12 stakes will be enough. Come up four inches from the base grade, and using a felt-tip marker, draw a line around the stake. This will be the 4-inch grade for the gravel bed. Come up two more inches and draw another line of another color; this will act as the grade line for the 2-inch buffer layer of coarse sand between the gravel bed and the final topmix. Come up 12 more inches and draw another line, which will be a "rough" final grade line for the green mix itself. These lines speed the filling process.

The gravel bed can be spread by one operator using a tractor with a blade or grader box and a laborer to hand-rake the tight spots next to the edge and around the stakes. The gravel can be trucked right to the green, and 10- to 12-ton loads on tandem trucks helps to reduce tracking on the course.

The coarse sand blanket can be spread in the same manner as the gravel blanket. A spot check from time to time by the superintendent helps insure the quality of this installation. A sand bunker rake is an ideal tool to level the sand blanket, especially when working around the grade stakes.

BY THIS TIME, the work force and the entire project will be well spread out. The superintendent and heavy equipment will be working on the last green or the third green, depending upon how many you plan to do. The tiling crew, supervised by the assistant, should be working on the second green, and the operator and laborer spreading the gravel and coarse sand will be working on the first green. Once you are spread out like this, there is a tendency to pick a few men from your regular crew to help with construction. Don't make the mistake of letting the routine maintenance on the course lapse simply for the sake of the construction. You still have the obligation to provide good playing conditions for the members. If turf declines, then you and everyone involved are open to criticism. If you need extra men and you are pushing against the weather and the calendar, then hire them. You should have added at least a 10 percent contingency fund to the construction budget anyway. While on the subject of contingencies — there will definitely be some. Things such as old water lines and tile lines, along with existing irrigation lines and wires, will have to be contended with. One good bite with a backhoe into a couple of dozen irrigation wires can play havoc with your day. Learn to take these things in stride. Broken pipes and delays, due to the flooding they cause,

(Top right) The mechanical sand rake is used to install the 2-inch sand layer which lies beneath the topmix.

(Right) The green is shelled-out to a depth of 18 inches and is now ready for drain lines, gravel, sand and topmix. Note original center mound grade and grade stakes.

are a way of life in reconstruction, no matter how well planned. A good supervisor will handle these contingencies efficiently without disrupting the overall project.

The irrigation to the green can be installed by a crew of three men in one day. The size and amount of pipe, heads, valves and swingjoints can be ordered in advance. The most important part of this portion of the program is the proper spacing of the irrigation heads. You might consider using some part-circle sprinklers, especially around bunkers, because the USGA green requires more water than a green of a heavy clay, and there is no need to water the sand in bunkers. A small, wheel-type trencher with a 36-inch boom and a 4- to 6-inch cutting width will be sufficient. Backfilling can be done easily with a tractor and a blade.

Once the heads are in, it is a good idea to stake them. It is easy to cover them in final grading, and hitting one with a disc or pulverizer can ruin it. We found that we can work the irrigation in with the tiling. Here again it strings the work out even more, so you find yourself constantly checking on the progress, or lack of it. We are fortunate that we have a two-way radio system on several pieces of equipment, and a lot of small problems can be handled over the radio, thus eliminating unnecessary running around.

THE BACKHOE CAN begin forming the bunkers when the highlift has just about finished the earthwork on the second green. If the bunker is extremely large, then the highlift can help with the excavation. The finish work can be left to the backhoe. After we staked the bunkers, we have found that if sections of irrigation hose are laid around the stakes, it gives the exact design of the bunker and all its curves and makes it easier on the backhoe operator. The type of backhoe we used has an added attachment called an "adjust-a-bucket." This is a smooth bucket with an extra hydraulic cylinder that permits the bucket to swing 180 degrees horizontally. The operator can follow the design of the bunker, curves and all.

A good operator can also form the base of the bunker to drain into one low area. A tile line should be installed from the low area into the main tile line exiting from the green. If the bunker is above the green, then the tile from the bunker can be tied into the tile system of the green. Lay the tile exit as far away from the green as possible. If you run it out just a short distance from the green, you will have a lagoon by the end of the next summer. A French drain will not be good enough to handle the amount of water coming out of the green or the bunkers. Run the drain line into a drainage ditch or into the woods. Believe me, you will be glad that you did. You will do it sooner or later.

Placing the topmix on the green is probably the largest single phase of the operation. Here is where you get on the phone and use the "beg, borrow and steal" method to round up four or five dump trucks from nearby courses. All of the clubs in our area have been most generous; they often send an operator for a day or two. Two front end loaders can keep the trucks filled, especially after they are spread out, traveling from the mix area to the green site. A small track-type of highlift is ideal for handling the mix and spreading it onto the new greens.

We usually rent a Case 350 for this job. It handles the material well and compacts it nicely. Once it is in place on the green, the dump trucks drive right to the fill area and dump their topmix load. This eliminates having to push it so far with the highlift. We have never had any problem with compaction with the trucks moving out onto the green. With any kind of luck, you can fill three greens in a 12-hour day.

Remember the grade stakes that you put in earlier? Once you have reached grade lines marked on them they can be pulled. It will be necessary to have a transit set up to check the final contours on the green. You can expect to take about four hours per green putting in the final contours using the track-type highlift and a tractor with a grade box. Once the contours have been established, then get the committee together to be sure that everyone involved agrees with the final shape of the greens. I have experienced a situation where changes had to be made after seed had germinated because someone didn't approve of the architect's design. This shouldn't be a major problem if the committee knows anything at all about reading blueprints.

THE NEXT STEP IS to incorporate the starter fertilizer and seed the putting surface. We used Penncross bent at two pounds per 1,000 square feet. Knowing the size of each green, the seed was weighed and applied in three directions to insure uniform coverage. We have had our best results with lightly raking the surface after seeding and then rolling it. The green and bunkers are then rimmed with two strips of sod. This helps to define them both and helps keep the proper design of the green.

If you have time and you have made any deep cuts in the construction, then you might want to have a pH test to check for lime requirements. Chances are that you won't have time since you are undoubtedly racing against the weather. This can be checked later and the lime could be applied over the winter. All that remains now is to grade the banks and surrounding area and prepare the final seedbed. The seed types may vary here, especially for the fairway, if needed, and the banks. Just be sure the right seed is planted in the right place. Here again, after the seedbed is prepared, add the starter fertilizer and the seed. We then mulch everything except the putting surface.

All that is left now is to turn on the water.

If you have any kind of favorable fall weather at all, then you can expect to see germination in five to seven days. We hold off placing the white sand in the bunkers until winter or the following spring, because until the grass is established around the green, you will have soil washing in the bottom of the bunkers, and this just makes the sand dirty. There are two schools of thought on this, however. Some people prefer to get the sand into the bunker and leave it in a pile until they are ready to spread it.

The next step is to repair ruts and any other damage caused by trucks during construction. Some time spent with a disc, a rake, some seed and mulch, and the problem is solved.

Some of the sprinkler heads may not turn properly around the greens. This is caused by sand working its way around the heads. All that is required here is to take them apart and clean them out. It is just part of the game.

We have been involved with constructing the USGA type of green for three years, and we are satisfied with the results. If you plan this type of construction as far in advance as possible, it will eliminate a lot of problems. It can be done smoothly and rapidly. The last four greens that we built took 22 work days from start to finish, which averages out to five and a half days per green at a cost of $1.29 per square foot, including the white sand in the bunkers. We saved a considerable amount of money by doing it ourselves. If you plan to build a green, do it right the first time.

Around urban areas, chemical pollutants are absorbed and detoxified by green plants. Turf and trees also serve as effective "dust traps." No. 4 hole at Montammy Golf Club, New Jersey.

Golf Courses and The Environment

by **PHILIP A. WOGAN**
Golf Course Architect, Beverly, Massachusetts

MEMBERS OF THE general public, watching golf, whether on television or at tournament sites, must think that golf courses receive substantial support from the environmentalists. Golf course architects, however, know this simply is not true and that we are becoming more and more ensnared in environmental problems.

In the late 1960s and early 1970s, environmentalism became the new watchword. Many conditions affecting the environment and our health needed correction; hence, the laws to clean up our air, streams, etc. were enacted to protect health. Along with this movement, many naturalists and wildlife advocates became active to protect their special interests.

In his new book, *Environment, Technology, and Health*, Dr. Meril Eisenbud states that many divergent views of opposing environmental objections have been due, in part, to misinformation and misrepresentation of facts. He also states that, because of inaccurate, emotional and misleading coverage of environmental issues by the news media, and as a result of the political clout of single-issue advocacy groups, opinions concerning environmental issues are very far apart. According to Dr. Eisenbud, polarization has developed hand-in-hand with politicization, and together they have often prevented programs of environmental protection from evolving rationally.

As a result of regulations advocated by various environmental agencies, conflicts exist between different legitimate and quasi-environmental groups over what constitutes desirable environmental objectives.

As dedicated and professional environmentalists, we consider golf course development an improvement of man's habitat; because of the many regulations however, the creation of a golf course meets potential pitfalls. For example, the regulations designed to improve or to reduce air pollution can result in actions which are self-defeating. Consider, for example, the clearing and grubbing operation in the early stages of golf course construction. In Massachusetts a few years ago, the State Office of Environmental Affairs issued regulations that prevented any outdoor burning of trees, brush and leaves; however, the regulations permitted the use of huge diesel-powered chippers which spewed out their noxious pollutants, contaminating the air to a much greater degree. At the same time, this chipping operation greatly increased construction costs. Because of problems encountered in the new wave of environmentalism, we should present our views, along with supporting evidence to back up our contention that golf courses, on balance, benefit man's habitat.

LET US EXAMINE golf course construction to determine how it affects the environment. In clearing and grubbing, often fifty percent or more of the area has to be cleared of trees to provide for the golf course area. Certain beneficial effects may result from this clearing. Of the wooded areas remaining between the fairways and other areas, there will be a certain amount of selective thinning and pruning. The remaining trees — the healthy ones — would grow faster. The removal of dead and fallen trees, along with slash and dense undergrowth, would reduce the tree disease. Much of the wooded area in the country has been previously cut over, and has never been properly managed. These areas would now come under the supervision of the golf course superintendent. The fairways, themselves, could act as firebreaks, helping to prevent fire damage to the entire area. The cleared areas rarely used by the general public, would then be available for golfers, cross-country skiers, joggers and others, and would result in greater appreciation and enthusiasm for the natural environment. The open spaces would encourage an increase in the population of the type of wildlife that prefers this type of habitat. In opposition to this, those species of plant and animal life that prefer the dense undergrowth characteristic of unmanaged wooded areas would be adversely affected. The overall environmental effect, however, would be no less desirable than in the original site.

Another essential operation in the development of a golf course is the cutting and filling operation. It is necessary to change existing contours to develop landforms inherent in the nature of the game such as greens, tees, fairway bunkers, etc. In altering the upland contours, it is necessary to reduce steep grades and abrupt slopes to meet conditions suitable for the game. Upland contours are altered so that water-holding pockets are eliminated and also to produce adequate surface drainage. Producing more gradual sloping will reduce the effects of erosion, increase the visibility of the target areas, thereby increasing the safety of the golfers, allowing for greater ease of maintenance. In any construction there are always some short-term detrimental effects. There may be a temporary change in the water table, and ground water aquifers may be

Grass provides oxygen, acts as an enormous air conditioner and beautifies the environment. No. 13 hole at Knickerbocker Country Club, New Jersey.

changed or relocated. During the period of construction of six months to a year, a certain amount of soil erosion may temporarily pollute streams that pass through the property. Any change in the landforms must alter the eco-system; however, it is not long before another desirable eco-system is established.

Now, we come to the use of wetlands. Wetlands have almost become sacrosanct and statutes have been passed in many states to protect them from indiscriminate use. Briefly, wetlands are defined in many statutes by the amount of standing or slowly-running water that occurs near the surface during normal growing seasons and by the species of vegetation they support. Interpretation of these statutes has been so strict sometimes, particularly on local levels, that small, isolated low areas which may hold surface drainage water and may exhibit vegetative growth characteristic of wetlands, are called wetlands. Calling some of these isolated, depressed areas wetlands is no more justified than calling a sandbox a desert. Without question, wetlands, along with uplands, perform a number of valuable functions. They help in flood control; they help to stabilize the water table; they provide a unique habitat for many plants and animals. However, in order to perform these functions, a wetland must be of considerable size.

IN CONSTRUCTING golf courses, it has been necessary and desirable sometimes to use portions of swamps, meadows or bogs. This is true for two reasons:

1. It has been relatively cheap land because it has few other commercial uses.
2. Its water can be used for irrigation, water hazards, and aesthetic values.

Constructing a golf course in a wetland of viable size does not involve using a large portion of the area; it does, however, infringe upon a part of it. Obviously, the habitat of that immediate area is altered, but it is true that it has been replaced by another desirable, though different, habitat.

There are possible detrimental effects. A change in the wetlands may destroy the breeding ground of some forms of swamplife and may temporarily disrupt the drainage of adjacent landforms. Many of the adverse effects, however, can be minimized through proper design and construction techniques. For example, much of the area that is not required for the golf course itself can be left untouched and incorporated into the overall design concept. Innisbrook, in Tarpon Springs, Florida, is a good example of this approach. Larry Packard, the golf course architect, created biological harmony between the golf course habitat and the surrounding cypress swamp.

Another area of environmental concern in golf course construction involves straightening, realigning, or relocating a stream bed. This is often necessary on a small scale because it makes more land usable and makes the relationship between the land and stream bed more suitable for a golf course. It also provides for easier and more efficient maintenance of stream bed areas.

Several beneficial effects of stream channeling:

1. An increase in the flow velocity, resulting in higher oxygen content.
2. A reduction in eutrophication.
3. A more desirable habitat for certain types of aquatic life.

Some adverse environmental effects:

1. The disruption of stream bed or banks, resulting in a temporary increase in the amount of erosion. This would be due to an increased velocity flow and the removal of erosion-controlling vegetation.
2. The removal of streamside trees, brush and other vegetation would produce higher water temperatures as a result of more sunlight, thus changing the existing ecosystem.
3. Here again, we would have the disruption of certain breeding grounds.

To the naturalist, stream channeling means miles of barren concrete-lined sluiceways. In golf course construction, we obviously have something different in mind. The purpose would be to recreate a stream in another location which would blend with the natural landforms.

We have touched on a few of the facets of golf course construction which might, to a greater or lesser degree, affect the environment. Let's now look at golf course maintenance.

TWO OF THE PRACTICES necessary for the maintenance of a golf course that provoke the ire of the avocational and quasi-environmentalists are the use of fertilizers and pesticides.

Since golf courses require large acreages of turf, it is not surprising that they use fertilizer. The problems resulting from the use of fertilizer for the production of crops is greatly minimized on golf courses for the following reasons:

1. Since golf courses are covered with a permanent crop, there is much less need for plant food on a per-acre basis than would be required for most farming operations.
2. Since turf roots absorb a high percentage of available plant food, there is significantly less migration of fertilizer contaminants, if any, into the surrounding streams and lakes.
3. Phosphorous is an ingredient in many fertilizer applications; however, it has been demonstrated that phosphorous attaches itself to the soil particles and is not redissolved in sizable amounts. It is through soil erosion that more of the phosphorous gets into water sources. Control of soil erosion with a dense, healthy turf minimizes the danger of phosphorous pollution to an insignificant level.
4. Most golf course grasses require low concentrations of phosphorous. In many instances on established golf courses, the superintendent, in his maintenance program, often uses fertilizers containing no phosphorous in order to control the proliferation of *Poa annua* —annual bluegrass.
5. Nitrogen, as an ingredient in fertilizer, is used to such an extent by the active growing grass plant that very little is leached through the soil. This is due partly to a low concentration of available nitrogen and to the slow-releasing nature of fertilizer often used by golf courses.

In a recent study conducted at Texas A&M by the USGA Green Section, it was shown that where soluble forms of fertilizer, including ammonium nitrate and ammonium sulfate, were applied, high concentrations of nitrate were found in the leachate from experimental greens. These concentrations exceeded standards established by the EPA. The study also showed, however, that with proper irrigation, the use of slow-release fertilizers and proper spacing of fertilizer application, nitrate contamination of water sources could be well within EPA limits. Where greens are located close to water sources, drainage systems can be designed which will conduct the leachate away from ponds and streams so that contamination becomes almost non-existent.

Now what about the use of pesticides? A lot has been written, mostly negative, regarding pesticides. The use of pesticides is an important aid in helping to improve the quality of life. They help control many diseases of plants, animals, and humans, and they are partly responsible for making our agricultural system the most productive in the world. The problem is with the injudicious use of these substances. Pesticides used by golf courses have both positive and negative effects. On the positive side, fungicides and insecticides are used in the turf industry to keep turf healthy and vigorous. Most fungicides used on golf courses are quickly biodegradable and don't move great distances in the soil. Since turf has great powers of absorption, pesticides applied directly to the plant area will be retained in the general area and will not be carried off by surface water drainage before it becomes non-toxic once again. Since the turf on a golf course is not consumed by range animals, there is no chance of pesticides entering the food chain, nor is there a chance for accumulative buildup of pesticides in animal tissue. Shortly after application, most herbicides begin to break down as outside forces act upon them. Through adsorption, the herbicides are attached to particles of soil until the various decomposition processes begin their work. In turf, where there is very little erosion, there is little, if any, relocation of the herbicides.

Some negative effects do result from the improper use of pesticides. Improper use of fungicides may damage turf, diminishing the beneficial effects. Misuse of herbicides may temporarily sterilize the soil, thereby preventing the germination of plants. In cases where drifting may occur, the use of certain pesticides may contaminate areas outside the target zone, resulting in possible harm to man and wildlife. In other cases, pesticides may contaminate adjacent ponds and streams and may possibly be toxic to aquatic life as well as to those animals using the water for drinking. The superintendent and his assistants can encounter health hazards through the improper handling of pesticides.

Golf courses serve as fish and wildlife sanctuaries and golf affords healthful recreation for millions of people. No. 14 hole at National Golf Links of America, Southampton, New York.

NOW, LET'S CONSIDER the positive contributions that golf course development makes to the environment. For many years golf courses have provided a pleasurable, outdoor sport and recreational activity for millions of people of all ages, and it has been a means of improving the quality of their lives.

The golf course enables millions to enjoy the wonders of their natural surroundings. Since golf courses are built on a variety of landforms, such as the links courses at the seashore, the inland courses often abutting wetlands, and the mountain and desert courses, it has enabled millions of golfers to communicate with many different ecological situations and to gain a knowledge and appreciation of these varied environments. Golf courses built in the past century have been responsible for keeping hundreds of thousands of acres in open land. Where these open lands exist near densely populated urban areas, they have produced untold benefits toward improving the quality of life.

In many communities, both private and municipal courses serve a vital social need by holding civic functions and charitable events. In smaller communities, the golf club often serves as the only social and recreational outlet for many residents and provides a social gathering point for the community. High school and college teams are invited to use the course for their interscholastic and intercollegiate matches.

During the growing season, the average 18-hole golf course of one hundred fifty acres provides enough oxygen for 10,350 people. This same acreage is responsible, too, for reducing large quantities of carbon-dioxide, produced mostly by burning fossil fuels. Around the urban areas, sulfur dioxide, ammonia, nitrogen oxide and other products can be absorbed and detoxified by green plants. Many plants are, of course, affected by pollution, as is animal life, but research indicates that turf is more tolerant of polluted air than other plants and is able to turn these

noxious pollutants into useful plant ingredients.

Turf acts as an enormous air conditioner. It purifies the air of chemical pollutants, and with grass, along with trees, is an effective dust trap. Grass and trees act to control the velocity of the airstream so that dust particles can settle out. At the same time they help to moderate the air temperature. Studies have shown that because of evapotranspiration, turf is usually 20 percent or more cooler than any pavement or artificial turf, and even five feet above the surface, the temperature is 10 degrees cooler above the turf areas. Water purification and conservation is another contribution that golf courses make to the environment. The creation of ponds and lakes for the dual purpose of enhancing the beauty and playability of the course itself, as well as supplying a source of water for irrigation, is a valuable conservation measure. Water resource is a growing concern in many parts of the country, and, therefore, any conservation from capturing excess runoff into reservoirs aids in water conservation. The use of this water, through sprinkler systems, helps in the purification, through aeration, thereby helping to restore some of the oxygen content of water.

Another water conservation method is the use of sewerage effluent by an increasing number of golf courses. Architect Bill Amick's new course, Mangrove Bay, in St. Petersburg, Florida, has the blessing and the financing of the Environmental Protection Agency for the wastewater distribution system. This subject was discussed in detail last year in Chicago at the Wastewater Conference.

IN MANY AREAS, particularly in the North, golf courses, during the winter periods, can be used for other recreational activities. A golf course is an ideal site for the increasingly popular sport of cross-country skiing. Also, other winter sports, such as ice skating, tobogganing, snow shoeing and, in a number of cases, downhill skiing, can be undertaken. During the season when the golf course is in active use, many clubs allow fishing in their ponds and streams. In many instances jogging and hiking are popular pastimes.

GOLF COURSE DEVELOPMENT can often improve our surroundings by creating a greater use of substandard land. Many unsightly areas such as sanitary landfills, gravel pits, and strip-mined areas, can be greatly improved by the creation of a golf course. A good example of a golf course that is built on sanitary landfill is, again, Mangrove Bay. The turning of worked-out gravel pits into golf courses and recreational areas has helped to eliminate the visual pollution in a number of areas. With funds earned from gravel sales, these scars on the landscape can be eliminated. Two examples are the Wampatuck Country Club, in Canton, Massachusetts, designed by Geoff Cornish, and the Colonial Golf Club in Lynnfield, Massachusetts, designed by the late Bill Mitchell. X. G. Hassenplug has designed the Laurel Green Country Club, an executive course, on a strip-mined area in Westmoreland County, in Pennsylvania.

IN MANY PARTS OF the country, small farm holdings may not be economically feasible to continue as a farming operation, yet the landowner may wish to keep his property as open land. Converting wooded or farm land into a golf course is one desirable property use which can provide a continued income and a reasonable tax resource. However, overkill with a high tax assessment, particularly near urban centers, can discourage this type of conversion. The landowner, in order to stay solvent, sells his property to a developer of industrial, commercial or residential sites. The principle of assessing land as to its highest and best (economic) use, rather than its actual use, has been a regressive policy for farm and recreational land.

The arbitrary or frivolous opposition by zealous members of narrow-based special interest groups who want their esoteric interests protected can prevent many projects of economic benefit to mankind from going forward. Any group wishing to maintain the status quo of the open land of others because they are concerned about increased traffic flow, the possibility of a club liquor license, or the loss of their personal hunting ground has used environmental laws as their stalking horse. The resulting possibility of extended delays, numerous hearings and unnecessary planning and engineering can cause a proposed project to be abandoned to avoid this needless harrassment and unproductive costs.

In the past 10 years laws have been passed that were designed to protect and improve the environment. In urban areas, the automobiles were contaminating our air beyond reason, paper and chemical mills were polluting our lakes and rivers, and strip miners were despoiling the landscape. Our environment needed protection, thus the laws and regulations. After the legislators enacted the laws, the regulatory agencies — federal, state and local — interpreted these laws and formulated all inclusive rules and regulations. Oftentimes the regulation set standards that were based on studies and facts of doubtful validity. We know that the EPA has in the last few months revised some of these standards so that they more closely relate to reality. Golf course development has been caught in the web of these environmental requirements. The intent of the legislators was not to hamper desirable environmental projects, but the effect of bureaucratic interpretation has done just that. Usually the higher echelons of government agencies are quite sympathetic toward the use of open land for a golf course; however, the tyranny of the bureaucratic system, particularly in the lesser offices, has made golf course development difficult and, in some cases, marginal.

IT IS FUTILE FOR us to bemoan the fact that golf has been restricted in its development and operations by the current wave of environmentalism. We cannot lose this battle by default. A number of positive actions can be taken in protecting and advancing the game.

First, on the national and state levels, the various associations in the golf field should marshal their forces in a cooperative effort to influence existing and proposed legislation. This may be through a public relations effort along with some lobbying designed to benefit our field of endeavor. The purpose of these efforts should be directed toward the following:

1. To have an input in new and proposed legislation where the game's interests are involved.

2. To seek relief, exceptions, and permissible uses under existing legislation, as in the case of the farming industry, with respect to wetlands.

Second, on the local level, many superintendents, architects, and club members have appeared before conservation commissions, zoning boards, planning boards, and other local agencies on behalf of new golf course projects or existing courses. At these hearings, we should not only be able to support our projects as desirable, environmental developments, but also we should be able to document, in detail, the various implications that are involved. We should have facts and concepts that would support our contention that the project or alteration would be a desirable ecological change.

Third, we must continue to promote research into various methods and materials that will diminish any harmful effects of our construction and maintenance practices.

In short, we should pursue in an aggressive and positive manner our contention that golf benefits man's habitat and improves the quality of life.

For 1980, It's National Golf Week

Golf's annual charity program, National Golf Day, is nearing us once again, but take a second look. National Golf Day has become National Golf Week.

The 1980 campaign will have a local look and the national Round of Champions is gone. Now each club professional will conduct his own National Golf Week competition and will follow the format of his choice.

The PGA of America, which spearheads the annual drive for a host of golf charities and agencies, suggests a target contribution of $3. It will be the week of June 23rd to 30th.

One of the recipients of National Golf Day . . . err . . . National Golf Week, . . . is the USGA Green Section. Since 1952, the PGA has contributed more than $282,000 to the Green Section. This money has been used to support a number of golf turfgrass research projects and in this way the funds go back into improving conditions for the players.

Drainage Is Important to Turfgrass Management

Surface risers with grates are installed in low areas for additional drainage and serve as visual checkpoints of water flow through drain lines.

by CHARLES H. TADGE, Certified Golf Course Superintendent, Mayfield Country Club, South Euclid, Ohio;
President, Golf Course Superintendents Association of America

GOOD TURFGRASS management is synonymous with good water management, and drainage is one of the keys to good water management. I remember O. J. Noer saying that "the two most important ingredients for building and maintaining a good golf course are common sense and drainage. If you are short on common sense, then put in more drainage." Drainage is the removal of excess water from the soil, and that results in a better environment for the grass plant, the golfer and the maintenance staff.

The word drainage is an all-encompassing word. It can be divided into two general categories: surface and subsurface drainage. Surface drainage systems are designed primarily to remove water that has not entered the soil profile. That is done by developing the slope of the land so that the excess water will flow by gravity into streams, ponds or storm sewer pipes.

Subsurface drainage, the other category, removes water that has already entered the soil profile. Unfortunately, this type of drainage is often overlooked during golf course construction. Subsurface drainage is basically the type of drainage to be discussed here, but actually any drainage problem must be considered a combination of surface and subsurface water removal. They are related, and you will see that our approach combines the two.

Three basic steps must be followed:

1. Identify the problem.
2. Develop a plan of attack.
3. Implement the plan.

IT IS USUALLY EASY to locate the place where a drainage problem exists. Next we need to determine why it is a problem. Perhaps it is a heavy impervious soil with tile that is not functioning or with no drain tile at all. Sometimes we must study a course for several years before we really know the extent of the drainage problems. At Mayfield, we found a problem on 17 of the 18 fairways that extended to many areas in the adjacent rough. Of our 92 bunkers, no more than six drained properly. Three or four greens and several tees also had poor drainage. The problems were generally due to a very heavy clay soil with an underlying shale base and non-functioning tile lines.

Developing a proper plan of attack is most important. There are countless aspects to consider and many questions to answer. If the problem lies with existing tile, a study must be made to determine if it is feasible to make the old tile functional or to install new tile. Will French drains — holes filled with gravel or gravel-filled slit trenches — suffice without drain tile? Does the problem exist in only a few isolated spots, or is it extensive? Should the work be done by the maintenance staff or by an outside contractor? Who will plan and design the drainage system?

The Soil Conservation Service (SCS), an agency of the U.S. Department of Agriculture, is a source of expert planning assistance. The SCS provided us with a soils map of the course, along with a description of each major soil type and provided a comprehensive design of a drainage system for the entire course. It must be recognized that the Soil Conservation Service people are specialists in farm drainage and are not accustomed to working with fine turf. While their advice must be modified to fit golf course conditions, the basic engineering principles will be the same. For us at Mayfield, they produced a design from a topographic map that would drain every square foot of fairway without consideration for actual conditions on the course. We therefore had to modify the plan significantly because many areas needed very little or no drainage at all. Any plan should make use of all existing drainage pipe that is functional. We had no plans of any of the existing pipe and we knew of very little that was functional. During our installation process, we did discover a considerable amount of drain tile, and we were able to use some of it. We found that at first we followed the modified version of the SCS plan rather closely. As we gained experience with installation and observation of the course through varying moisture conditions, we began to disregard the formal plan and to develop a plan right on the site to custom-fit the situation.

After the drainage system has been designed and approved, it is important to decide who will do the job. Each club must decide whether it will be contracted out or done by the golf course staff. We decided to do the work ourselves with additional personnel. We felt that it was absolutely necessary that we not borrow personnel from the regular maintenance operation and sacrifice routine course maintenance. A contractor was hired for a short period to install some main lines to expedite the program.

Since our soil was a very heavy clay and impervious to water movement, we decided to remove all soil and to backfill to the surface with gravel. This would also provide for removal of excess surface water. With the gravel backfill, we have followed the theory used in the USGA putting green construction system of keeping the particle diameter sizes of layers within a ratio of one to seven. Theoretically, this restricts downward movement of the finer aggregates. We used one to three inches of ⅜″ gravel under the tile, then filled the ditch to within three or four inches of the top with ¾″ gravel and capped it off with ⅜″ gravel to the surface level. After a few months, the gravel will settle an inch or two, and then we level it off with a layer of sand of 0.25 to 1.00 mm range. This allows faster covering of turf than is possible if grown over the gravel.

THE FIRST PHASE of implementation is to lay out a part of the system on the ground where it is to be installed. Begin at the outlet where the water is to terminate. This might be a pond, creek, existing tile line or a ravine. The proposed pattern should be marked with stakes or paint. If there is any question about grade, shoot some points with a transit level. Decide the depth of drain needed. This can be determined from experience and information available from the Soil Conservation Service. We used an average depth of close to three feet. We try never to be shallower than two feet, but sometimes the shale bottom was as close as 15 inches below the surface. In such cases the lines had to be closer together. We provided additional surface drainage

Ditching frame tapered at bottom to provide fall of 2.34 inches in 100 feet. Bubble on carpenter's level immediately tells if drain ditch fall is correct.

Equipment used to remove soil from ditching site.

by putting surface risers with grates in many of the low spots. These risers also provide good visual checkpoints. We use a double tee or cross clay pipe in the line for the riser, because the basin below the flow line provides a trap for sediment which can be cleaned out periodically.

When the tile installation requires removal of the soil, it means a tremendous amount of material handling. Soil spoilage must be hauled away and gravel hauled in. Disposal of the soil can sometimes be a problem. Proper equipment is necessary to make the operation as efficient as possible. We purchased a large trencher with a conveyor to move the soil away from the ditch. Another conveyor was added which would then take the soil up into a dump truck. We also experimented with conveyor attachments on the dumptruck for backfilling the gravel, but we found that dumping from small trucksters was just as fast. Since there was some soil and gravel spillage and occasional damage to the turf surface by equipment, we found it best to lay 4′ x 8′ panels of ½″ plywood on each side of the line before digging. After the ditch is filled and the work completed in that section, the panels are lifted, and the turf will still be in good condition.

We also have a smaller trencher which is used in confined areas and in bunkers. We have found a cast-iron pipe and tile cutter to be very useful. It helps to determine correct riser heights, and the correct length when connecting to existing clay tile lines. We also built a gadget that we call a ditching frame. It is a wooden frame eight feet long with two horizontal surfaces that are 3/16 of an inch out of parallel from one end to the other. This provides 2.34 inches of fall in 100 feet. By setting it on the bottom of a ditch or on the tile in a ditch and checking with a carpenter's level, it can be readily determined if minimum grade has been obtained.

Since we began our program in 1969, we have installed nearly seven miles of drain pipe. We found that short lateral lines of under 20 feet worked satisfactorily with gravel backfill only. We have mainly used the perforated-corrugated plastic pipe with a section of rigid plastic or steel outlet pipe to a creek. We prefer clay tile in bunkers because it can be more easily flushed in case sand accumulation becomes a problem.

INSTALLING A DRAINAGE system is no simple task; it requires a great amount of supervision. It is probably the nastiest, messiest and dirtiest job on the golf course. This can create morale problems and it takes a constant effort to instill a sense of pride of accomplishment among those involved. One of the ways we found to improve morale was by encouraging the development of a rivalry between the regular crew and the drainage crew through the challenges of softball and touch-football games.

Once the drainage system has been installed, it will require periodic maintenance. Grass and debris must be cleaned off of riser grates, and traps at the bottom of risers must be inspected and cleaned as sediment deposits accumulate.

Finally, it should be understood that even though an area seems to be thoroughly drained, underground water flow patterns are subject to change, and new wet spots can always develop. This does not necessarily mean that the drainage line was improperly installed. Drainage on silt clay soils is not only difficult, it often is an endless task too.

Infrared Photography

by **GERALD L. FAUBEL**, Golf Course Superintendent
Saginaw Country Club, Saginaw, Michigan

THE SPECTRUM OF electromagnetic radiation includes visible or white light which can be readily recorded on film. The length of the light wave determines its visibility and its ability to be recorded on film. The visible light spectrum includes a band of color ranging from violet through blue, green, yellow, orange, red and deep red. The visible wavelength range is about 400 nm (nanometers — one millionth of a millimeter) at the violet end to about 700 nm at the extreme red end. At each end of the visible spectrum there is invisible radiation.

Extending beyond the violet end of the spectrum is ultraviolet radiation that has shorter wavelengths. On the other end of the spectrum beyond the red is infrared, which has longer wavelengths. Extending beyond infrared, the radiation merges into heat waves. The spectral range of infrared photography is between 700 nm and 900 nm.

In doing infrared photography, Kodak Ektachrome Infrared 35 mm film can be used in a regular 35 mm camera with a lens filter. A Kodak Wratten filter No. 12 should be used over the lens; however, a No. 8, 15, or 21 can also be used. If color balance is desired, a No. 12 is preferred. Other infrared films and filters may be used; some of them are especially designed for aerial photography.

The camera's ASA setting can vary depending upon the amount of light falling on the image and its reflection. An ASA setting of 100 is a good starting point. Because most cameras and light meters are designed to measure visible light, determining the appropriate shutter speed and lens opening may be difficult. Read the instructions in the film box and talk to the professional at your local camera shop for some useful ideas.

When photographing an image, it is best to keep in mind that the film is

Natural photo (left) and infrared photo (right) of No. 18 green taken the same day at ground level during the Walker Cup Match in August, 1977. Notice that in infrared photography, healthy green plant tissue is recorded as red, whereas tissue under stress photographs in other hues. Note wilting areas on front left portion of this green.

recording reflected light. Infrared radiation and visible radiation often are reflected and transmitted quite differently by natural and man-made objects. For example, chlorophyll in live green foliage and grass absorbs a large percentage of the visible radiation which falls on it, but it transmits most of the infrared. We do not fully understand what mechanisms are involved within the living plant tissue which cause healthy tissue to reflect the infrared spectrum. Qualitatively though, healthy plant tissue has a greater capacity to reflect infrared radiation than does unhealthy plant tissue. This phenomenon therefore can be recorded on Ektachrome Infrared film.

BY USING INFRARED film to photograph the golf course, one can detect various pathological and physiological occurrences not only to plant life, but to the entire recreational facility as well. The method used to photograph the golf course was to fly over the golf course in a single-engine plane at approximately 1,000 feet while photographing through a side window of the plane.

The transparent slides have to be interpreted after the photograph has been completed. Color infrared photos have been effective in locating drain tile lines. This is possible due to the fact that Ektachrome Infrared film has a high degree of sensitivity and the turf growing over the tile line has less stress on it, especially if the moisture in the soil is at or exceeds field capacity.

Fertilizer distribution patterns are easily evaluated and irrigation distribution patterns are observed easily. Both the lack of adequate water and the overapplication of irrigation water is quite apparent. Weed infestations, the quality of herbicide applications and effectiveness of the herbicides are recordable on film. Disease and insect infestations are sometimes apparent, and the total area affected is more easily seen with infrared photography than by the naked eye. The amount of silt which has become mixed with the sand in the bunkers is seen easily and provides a clue to the playing condition of the sand bunkers. Golf cart traffic patterns can be observed before either redirecting them or placing cart paths. The health of deciduous and evergreen trees can be studied for small or large areas. Problems can be dealt with before they become disasters.

By using infrared photography as a tool of management, one can gain knowledge about the challenges and problems at hand. For those interested in pursuing the opportunities afforded by infrared photography, the following publications are recommended. Both are available at your local camera shop.

1. Applied Infrared Photography. Kodak Publication M-28.

2. Photography from Light Planes and Helicopters. Kodak Publication M-5.

Topdressing Putting Greens

A Panel Discussion

Moderator: **Stanley J. Zontek**
Director, Northeastern Region, USGA Green Section

Panelists: **John Berarducci**, Golf Course Superintendent,
Skokie Country Club, Glencoe, Illinois

Raymond P. Knapp, Golf Course Superintendent,
Tuckaway Country Club, Franklin, Wisconsin

James T. Snow, Northeastern Agronomist, USGA Green Section

Charles B. White, Southeastern Agronomist, USGA Green Section

Douglas T. Hawes
Director, Mid-Continent Region, USGA Green Section

Donald D. Hoos
Director, Western Region, USGA Green Section

Moderator: Gentlemen, our panel today will deal with one of the most important management operations that can be performed on putting green turf. Our panelists represent the entire country. Their comments on topdressing are of national significance.

The first question therefore is, why are putting greens topdressed?

Hoos: There are many reasons to topdress greens:

1) Fresh topdressing encourages new growth of grass shoots and stems to form a dense, fine-bladed turf.

2) Thatch control. Under heavy fertilization or high or infrequent mowing, thatch becomes a major problem. Topdressing checks dense thatch accumulation by mixing soil particles with plant materials which, in turn, encourages microbial activity that breaks down thatch and converts it into valuable soil humus.

3) Reduced disease and insect activity.

4) Alleviate compaction. Topdressed greens usually have better holding qualities for the golfer. The material props the grass plant and helps it to absorb compacting forces. It develops resiliency when a high quality topdressing is being used. This point is of particular importance on heavily-played greens.

5) Weed control. Most weed seeds require light to germinate. Regular topdressing buries the seed and thus reduces the potential for weed invasion.

6) Protection against winter injury. In regions where this is a problem, topdressing applied late in the fall helps to insulate the turf against winter desiccation and helps to reduce the severity of winter turf diseases.

These benefits are in addition to the improved putting green quality usually achieved because of the smoothing, firming and speeding of the putting surface that topdressing provides.

Moderator: To the Golf Course Superintendents on the panel, please explain the topdressing program you use on your course.

Knapp: At Tuckaway Country Club we are presently topdressing our greens with 100 percent sand. During the first year of our program, the greens were topdressed five times during the year. Now they receive applications during June, August and late October. We have been applying a total of 20 cubic feet of sand through the season with the heaviest application in late October. Under our conditions, three heavier applications seem to do the best job of truing the putting surface. This is something the golfers want and appreciate, even though there are some complaints for a time after the topdressing has been applied.

Until this year, we have been using a drop spreader to apply the sand. In 1980 we plan to use a centrifugal spreader because of increased efficiency.

After five years of 100 percent sand topdressing we have noticed a tremendous reduction in thatch and a general increase and improvement in the water infiltration rate of the greens. In fact, last year there was only one day when we could not mow after a rainfall. This program is working well for us.

Berarducci: When I came to Skokie Country Club two years ago, I inherited a situation where three different topdressing mixtures were used. Twelve greens received a 6-2-2 blend of sand, soil and peat, three greens built to USGA Green Section specifications received the same 80-20 sand/peat mixture as was their original construction blend, and three problem greens located next to the woods were on 100 percent sand topdressing. After some study I found that in our situation all three topdressing materials were unsatisfactory for various reasons.

The 6-2-2 blend created an impervious layer on the surface of the greens due to the high silt content of the mixture, and the grass suffered no matter what amount we applied.

The 80-20 topdressing material was supposed to be the same mixture that the greens were constructed with origi-

A rotary broadcast spreader in process of applying topdressing.

nally, but over the years this material (delivered by an outside supplier) varied to a point that laboratory testing proved it contained unacceptable amounts of silt and clay. This silt and clay formed an impervious suface layer that caused problems.

Our three greens near the woods received sand topdressing for three years and, during this time, one of them, a long, uphill par 3 became too firm for the type of golf shot required to hold the green. We experienced *Poa annua* loss over the winter on the second hole, while the third, built entirely of clay, tended to accumulate water during the summer in the upper, sandier soil profile.

These greens, located in shade, were not well constructed initially, and our sand program simply did not work well for us. None of the materials were entirely satisfactory.

We are now developing our own topdressing mixture to achieve what we feel are the properties we want for all greens. We are looking for good infiltration rate, resiliency and moisture retention. We feel this can be achieved, under our conditions, with a laboratory tested 70-30 sand/peat topdressing mixture. We believe we now have the right blend.

Moderator: Topdressing programs are designed to meet specific criteria so there are some differences in topdressing programs. We will now call on our Green Section Agronomists who, as a result of their concentrated schedule of Turf Advisory Service visits, observe many topdressing programs.

White: Sand alone has recently emerged as the primary topdressing material in the Southeast. Sand topdressing has been most successful in improving the rootzone structure and in increasing the uniformity and playability of the playing surface. We generally see light, frequent vertical mowings followed by a light topdressing of approximately ⅛ to ¼ cubic yard per 1,000 square feet. This practice encourages upright growth, minimizing grain on bermudagrass, bentgrass or winter overseeded greens.

Hawes: The number of golf course superintendents on a light, frequent sand or high-sand content topdressing program similar to that reported by Dr. Madison in the May, 1974, issue of the GREEN SECTION RECORD is increasing. In the Mid-Continent Region, golf courses are noted for fast, relatively firm greens with decreasing problems maintaining good turfgrass on greens through the summer stress period. This applies mainly where good materials for topdressing exist.

Unfortunately, in areas of my region, suitable materials are difficult to find. Quality topdressing materials are expensive to import from other parts of the country, so the frequency of topdressing is often twice per year in conjunction with regular spring and fall aeration. Regrettably, the decision is based primarily on costs rather than on soil and agronomic requirements.

Hoos: In the Western Region we see a wide variety of topdressing programs. They vary from twice yearly with aeration, to more frequent programs of applying light amounts of material on two- to three-week intervals for a total of up to 15 to 18 topdressings per year using high percentages of sand.

In the arid and semi-arid regions, rainfall occurs only during the winter. This creates a less-than-favorable condition for the natural breakdown of thatch. For this reason, the light, frequent topdressing program has been very effective in helping to reduce thatch by creating better air exchange and more favorable environment for good turfgrass growth. The popularity of this program is increasing each year.

Most golf courses that follow this program apply topdressing every three to four weeks during the active growth periods. Approximately 1/4 to1/3 cubic yards of topdressing is applied for average size greens. The cartster mounted topdressing machines or rotary fertilizer spreaders are the most common methods of application.

Many golf courses still use prepared topdressing mixtures. In the Western states, we have a problem finding good sources of organic matter. Often, decomposed bark products are used. Many courses now use a mixture of sand and organic matter. When organic matter is used, it is best to compost the mix for several months before spreading it.

Coupled with the lack of good organic amendments is the lack of quality sands. Many sands contain too high a percentage of very coarse sand and gravel. These sands do not work into the thatch layer well at all, and they are objectionable to the players because of the need to putt through gravel and to the golf course superintendents because of the need to regrind bedknives frequently. I'm sure this is one reason why golf course superintendents avoid topdressing if they are forced to use subquality material.

Courses using 100 percent sand for topdressing now pay a premium price for high quality sand imported from other states. Now the standard application rate is in the neighborhood of 1/13 to 1/9 cubic yard per 1,000 square feet on a three- to four-week interval.

Snow: In the Northeast, quite a few clubs use commercial topdressing blends or their own mixtures, ranging from 60-90 percent sand with the remainder made up of soil and peat. These mixtures vary greatly in quality, especially the home-brew blends. We attempt to encourage tests of these mixtures so that they conform to the Green Section specifications for putting green construction. In our position paper on topdressing (November, 1977, issue of the RECORD), the Green Section recommends that materials used for topdressing should meet the same vigorous specifications for soils used in new construction because, after all, topdressing is the addition of a new well-structured soil on top of an existing soil. Therefore, it is sensible to have these topdressing mixes correspond to the same high quality specifications that you would use to build a new green. Response has been gratifying, including reactions from companies that offer commercially blended products that meet or very closely match our specifications. This offers the superintendents a choice of quality materials.

As in other regions, topdressing with sand is becoming increasingly popular. As with any topdressing, these sands need testing to make certain they fall in the proper particle size ranges. This can be done locally or at a nominal charge through our USGA soil testing laboratory at Texas A&M University, Soil Physics, Soil and Crop Sciences Department, Texas Agricultural Experiment Station, College Station, Texas 77843. We are fortunate in our area to have many good sands available, usually at reasonable cost.

Moderator: Up to now we've talked about topdressing mostly in positive terms. When have you seen topdressing *not* work well?

Hawes: We sometimes see it in Kansas, in the spring when the fields are being worked and it is windy. Nature topdresses the greens with a silty windblown material forming a problem layer on the putting green surface. One course we know improved its problem by reducing the cultivations of adjacent fields and erecting a hedgerow as a windbreak.

Berarducci: In my case, too much silt and clay was in our topdressing mixtures. This created a surface layer problem. Where the sand was used on one of my clay-based greens, there understandably arose a situation where too much water began to accumulate at the surface. This should correct itself in time as more quality topdressing is applied.

Snow: When the wrong material is used, when there is too much silt and clay in the mix, when too coarse a sand is used, when topdressing is applied too heavily or infrequently, when topdressing mixes are continually changed; these are examples where topdressing will work against you.

White: Tifdwarf bermudagrass will not tolerate heavy applications of topdressing as well as Tifgreen will. Therefore, a more controlled program must be exercised on those courses growing Tifdwarf.

With the tremendous differences in sand sources, it is important to have the sand laboratory tested. The wrong sand will cause problems.

Knapp: The principal negative aspect of my sand program is the slow recovery of greens damaged by vandalism or winter injury. Seed germinates very slowly in a high sand topdressing due to its low moisture retention capacity. We use sod now to repair such damage.

Hoos: Let me add that the amount of topdressing that is applied should match the growth rate of the grass, always striving to maintain enough cushion to reduce the impact of wear on heavily played greens.

Moderator: What do you all feel is the future of topdressing in the 80s?

Knapp: In the 1980s I feel the future looks bright for sand topdressing. When good high-quality tested sands are used, the overall greens maintenance program can be simplified and yet still give the golfers a fine playing surface.

Hoos: I believe more and more golf course superintendents will adapt and use the light frequent technique of applying topdressing and will move away from the old practice of heavy applications in conjunction with aeration, even though this practice is still effective on some golf courses. As pesticide and fertilizer costs escalate, more emphasis will be placed on management programs that get the maximum benefits from the material used. Topdressing, with its recognized benefits in disease, insect and weed reduction will be a part of future programs. The major drawback in the West may be in finding suitable materials at a reasonable cost. If they were more readily available, I'm certain that Western courses would topdress more frequently.

Hawes: I agree that the future of topdressing is bright where good topdressing materials are available. The successful programs that have been properly carried out are well-documented. As new, more efficient methods of applying topdressing are used, more superintendents will be encouraged to use topdressing more frequently.

White: As renovation and rebuilding costs escalate, topdressing to amend problem soils should remain popular.

Preferred sand to use for topdressing greens — with particle size distribution ranging from 0.11 mm to 1.0 mm.

A time and labor saving method of filling the spreader.

Soil amendment through topdressing can be effective over a period of years, but it can never be as effective as totally rebuilding a poor rootzone.

Snow: In the future, we should know more about the long-term effects, if any, of straight sand topdressing. Every attempt should be made to use a tested sand that meets USGA specifications for particle size distribution and infiltration rate, preferably one that contains a small percentage of silt and clay. Apply it lightly and frequently, and never again go back to a heavier type of topdressing material.

Berarducci: Topdressing should continue to be an important part of progressive golf course management in the 80s when playability and soil needs are taken into account. The information on what to use is available. The turf manager must decide which topdressing will perform best on his course, then use it wisely. It is a decision that requires a lot of study.

Moderator: Thank you panelists for an interesting and informational discussion of "Topdressing Putting Greens."

NOW AVAILABLE

A Literature Review on Sewage Utilization for Turfgrass Purposes with Annotated Bibliography

by

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Soil Temperature and Related Fairway Management Practices-Northern Turfgrasses

Soil thermometer in position. Golf cart sign protects it from players and equipment.

by **OSCAR L. MILES**, Certified Golf Course Superintendent, Broadmoor Country Club, Indianapolis, Indiana

OVER THE NEXT 10 YEARS it will be tremendously important to the golf course superintendent and the clubs for us to make a sincere effort to conserve our resources. Resolve to be better managers of people, equipment and supplies that the industry has made available to us. Collectively, we must share ideas and experiences so that we may learn together. I want to share with you an experience in fairway turf management using the daily soil temperature as a forecaster of the dos and don'ts in the culture of turfgrasses.

Could soil temperature be as important a factor as air, sunlight, water and soil? Dr. Donald V. Waddington, Professor of Soil Science, Pennsylvania State University, (1) must feel it is very important because in *Turfgrass Science* he states, "Soil temperature influences plant growth and microbial activity, and Troughton (1957) compiled a list of optimum temperatures for root growth for various species as follows: bermudagrass 80° to 100° F., ryegrass 44° to 63° F., Kentucky bluegrass 55° to 73° F., and bentgrass 59° to 72° F."

Dr. C. Y. Ward, Agronomist, Auburn University, on the subject of "Soil Temperature and Turfgrass Growth" (2) states: "Temperature at the soil surface may be more important than air temperature in determining turfgrass adaptability. This is because the growing points of turfgrasses, especially those of rhizomes and stolons are at or near the soil surface. The knowledge of turfgrass response to variation in soil temperature is limited. Beard and Daniel (1966) found root growth of creeping bentgrass correlated with the soil temperature at a depth of six inches. In their investigation, new root growth always followed a sharp drop in soil temperatures." Well, everyone knows you must have roots to have grass. Many years ago, a wise greenkeeper somewhere gave me a phrase that has always stuck with me: "Understand and manage what's below the turf and you will have turf to manage."

BEFORE WE GET INTO the substance of soil temperature, I believe it is important to understand the environment of the Broadmoor Country Club. It will then be easier to understand why we use soil temperatures to assist us in fairway management. Broadmoor Country Club is an 18-hole course designed by Donald Ross. The club is 60 years old with a membership of 330. It is located in the northwest section of Indianapolis. Of the 17,000 rounds played there each year, one third of them are played in electic carts. The membership desires maximum turf conditions on the greens and tees, above average results from the fairways and the adjacent rough and bunkers, and average conditions in the rough and other playing areas. These objectives serve as a plan to understand our overall priorities and budget limitations.

Climate — Because of our location, it is very difficult to grow consistently high quality golf turf. The growing season is only 192 days. We are in the southern edge of the transition zone. We average 40 inches of rain per year, but from March through August we average 3.58 inches per month. The average July air temperature is 76° F.; humidity average at 8 A.M. is 80% and at noon 50%. Mean average temperature during December through February is 30° F.

Soil Conditions — Generally speaking, our soil is a moderately fine-textured, brown silty loam, low in organic matter, having high moisture capacity, with slopes of 0 to 2 percent for slow surface runoff.

Turfgrass and Cultural Considerations — The fairway turf consists of 30% to 50% annual bluegrass, 10% to 30% elite bluegrasses, 10% to 20% creeping bentgrass, and 0% to 10% improved turf-type ryegrasses. Each fairway has a different percentage of these grasses. With the high population of annual bluegrass we are forced into two separate turf management regimes. One program favors the bluegrasses, bents and ryegrasses during the spring and fall, while the second is geared to keep the annual bluegrass from dying out during the hot and humid summers. The surface mass consists of a ¼ to ½ inch of live mat and below this, a ½-inch layer of thatch intermixed with soil from frequent aerifications the past five years. Root penetration is vigorous in late fall, early winter and spring. Roots begin to turn gray in late May.

We are very fortunate to have a cooperative membership and board of directors that understands the problems of maintaining good fairway turf.

When Ross designed and constructed Broadmoor, he built a marvelous drainage system for the fairways. Every fairway has three to four 4-inch lines running the length of the fairway, on 30- to 40-foot spacings. This drainage system removes excess water very quickly, and so our heavy soil dries and firms up rapidly in the spring. Also, we now enjoy rapid surface drainage after heavy rains since we installed surface drains in the low areas in recent years. The biggest single factor that keeps us from having above average fairways by holding annual bluegrass through the summer is an inadequate manual watering system. Because of this inferior system, we overwater some areas and underwater others. Either way the turf is weakened. Our board is aware of this problem and plans to correct it when funds become available.

Fusarium blight was so severe on the fairways during the early and mid-'70s that much of the Merion bluegrass has been replaced by annual bluegrass.

IN 1966 I BEGAN looking for a technique that would help me forecast when *Fusarium* blight might be active so that we could time the fungacide application to control this disease better. By keeping soil temperature data we learned that we could expect blight symptoms at 65° F. when the soil was dry. When I attempted to understand the relationship between soil temperature and *Fusarium* blight, I became interested in soil temperatures as they might relate to other turf problems.

In 1977, I selected the 10th fairway as the typical problem fairway. Fortunately it is only 50 yards from the maintenance headquarters, and it gave us excellent access to perform and observe tests. It is ideal for investigating fairway turf stress because it has: (1) slight southern slope and, therefore, adequate direct sunshine; (2) 50% annual bluegrass population; (3) 20% improved turf-type ryegrass population; (4) high water table and poor internal drainage; (5) soil compaction and mower injury from mowers and tractor; (6) electric cart crossover in front of the green; (7) under- and overwatering from sprinklers; and (8) annually gets all the pest problems.

In this project, we used the Taylor soil thermometer. It is a very simple instrument. The probing stem is 6 inches long and a quarter inch in diameter. It has a sealed weather-resistant glass face with degree Fahrenheit reading from 20 to 220. It was inserted into the ground to a depth of two inches. It remained in the soil in this area for 24 hours every day. A cart directional arrow is placed in front of it to keep it protected from golf carts, golfers, grounds equipment and golf balls. It is noticeable but not objectionable to the golfers. It has sparked an interest in the labor force to observe conditions and to attempt to correlate turf problems with the temperature. This instrument has also stimulated questions and conversations from members.

On May 16, 1977, we began recording the daily low soil temperature. Within eight weeks we had gone through three thermometers. One was wrecked by the gang mowers, another was vandalized, and the third was stolen. So our study was terminated at the end of June 1977. During the winter of 1977-78, I purchased more thermometers and renewed my determination to read, record and study soil temperatures during 1978. The 1978 season proved more successful and provided us with the data and turf condition problem observations that were needed in formulating a program for the next year. During the winter of 1978-79, I searched for scientific supporting information. The publications that were most helpful were *Turfgrass Science and Culture* (4) by Beard, *Turfgrass Science* by Hanson and Juska, "Proceedings from the First and Second International Conferences," various magazine articles, and the "Michigan State University Research Report No. 352 on Annual Bluegrass," by Beard, Rieke, Turgeon and Vargas, sponsored by the USGA Green Section.

At last I was able to put together the information that would serve as my guide for a chart.

This chart is set up for turf highly populated with annual bluegrass with its inherent difficulties of survival. If we were maintaining turf favoring the elite bluegrass or improved bents, I would raise the high Optimum Soil Temperature about five degrees. These parameters, as general as they may appear, provided organization and meaning which then allowed me to prepare a basic line graph.

This chart (Figure 1) shows the temperatures on the sides, the month and day at the top and is overlaid with a piece of blue paper in the 45°-65° range to illustrate the zone for optimum growth and cultural considerations. The area above or below the blue reminds me to BEWARE. If I am contemplating any cultural practice

Optimum Soil Temperature (deg. F.) Growth Characteristics Chart

1. Roots — Max. 50°-65°; Med. 40°-50°; Min. 40°-30° and 70° and above.
2. Shoots and Tillering (stems, buds and leaves) — Max. 50°-65°; Min. 70° and above and 50° and below.
3. Carbohydrate Reserve — More documentation needed. My estimate: Max. 40°-60° (when roots and shoots are most active).

*4. **Seed Germination:**	**Weed Science**	**Northrup King Seed Co. (3)**
Cultivar:	**Optimum**	**Minimum**
a. Annual Bluegrass	68°-86°	37°-40°
b. Bentgrass	50°-86°	50°
c. Kentucky Bluegrass	59°-77°	50°
d. Perennial Ryegrass	59°-77°	50°
e. Hairy Crabgrass	68°-95°	50°
f. Goosegrass	68°-95°	59°

*Temperature separated by a dash indicates an alternating temperature — the first numeral for approximately 16 hours and the second for approximately 8 hours.

that might disturb the soil or cause mechanical or chemical stress on the plant, I proceed with extreme caution. From this experience we have put together our soil temperature turf management guide.

I realize the parameters established for this guide are not so exact that they can be used by all turf managers. My intention is to get you to think about it and possibly develop a soil temperature forecasting planning system of your own.

Could this soil temperature record also be used to determine which grasses should be encouraged? The record over the past two years indicates that we have had 15 consecutive weeks with the minimum soil temperature above 65° F. I feel this is above the annual bluegrass range of adaptability. The soil temperature was above the 70° F. line for only nine weeks during this same period. The bluegrasses and bentgrasses have an optimum range up to 72° F. This poses an agonizing question. Are we encouraging the right grasses? Maybe we should consider a herbicide renovation and reseeding program to more desirable grasses, which in the long range may conserve our resources and be less expensive to maintain.

Immediately outside my office is my "1980 Soil Temperature and Weather Record Information Board." On this board I keep the following data:

1. The daily soil temperature, air temperature, precipitation record.
2. The three-month permanent record soil temperature graph.
3. Chart of Optimum Growth Considerations.
4. The 1977 to 1982 Monthly Average Soil Temperature Record.
5. Original Soil Temperature Record Chart.
6. Cultural Practice Soil Temperature Turf Management Guide.
7. Monthy, Day-by-Day Weather Record and Condition of Grass Canopy, Thatch, Soil and Management Variables.

Number 7 is a new record to be maintained in 1980 which includes two sections. The first section records weather data as follows:

a. Air temperature at 6 and 10 A.M. and 2 P.M. and daily lows.
b. Atmospheric pressure at 6 A.M. and 2 P.M.
c. Relative humidity at 6 and 10 A.M.; 2 and 6 P.M.
d. Wind direction and speed at 6 and 10 A.M.; 2 and 6 P.M.
e. Rate of evaporation — transpiration, using key symbols of H — high, AA — above average, A — average, and L — low.
f. Day precipitation — in inches.
g. Night precipitation — in inches.

The second section records observations of the conditions of the grass canopy, thatch and soil.

a. Day irrigation — in inches.
b. Night irrigation — in inches.
c. Thatch moisture: S — saturated, M — moist, D — dry.
d. Soil moisture: S — saturated, FC — field capacity, M — moist, D — dry or permanent wilting point.
e. Soil temperature at 6 A.M. and maximum.
f. Dew and guttated water: H — heavy, M — moderate, L — light, N — none.
g. Condition of roots: W — white active, G — gray inactive, B — brown deteriorating.
h. Vigor of grass: H — high, M — moderate, L — low, SD — semi-dormant.

MY INTENTION for this expanded record system is to better document the day-to-day and hour-to-hour environmental conditions. This should help us do the right thing at the right time. Hopefully, it will help us keep

Soil Temperature Turf Management Guide

Cultural Practice	Parameters	
	anticipate at degree F.	to do at degree F.
Mowing		
As needed at ¾ inch	45	45-60
Every other day at ⅞ inch	55	61-65
Every other or third day at 1 inch	62	66-70
Infrequently, in evening, after soil temperature drops below 74° F. at 1⅛ inch	67	71-74
No mowing	72	75 & higher
Irrigation		
.50 inch on Monday and Friday	45	45-60
.30 inch every other day	60	61-65
.25 inch every day	65	66-70
.10 to .20 inch before 10 A.M. and again before 2 P.M. — daily	70	71-75
.05 to .10 inch before 9 A.M. and again at noon and at 3 P.M.	70	75 & higher
Wilt Control — Non-infectious Diseases		
Physiological Condition Syndrome — excessive evapotranspiration rate, high temperature — low humidity phenomenon (see 5th procedure under irrigation)	70	75 & higher
People Pressure — carts and equipment traffic — restrict them to roughs only	70	74 & higher
Fertilizer or chemical applications — don't take any chances with applications that burn turf or encourage rapid lush growth	65	65 & higher
Weeds		
Soft — Hairy Crabgrass	45	45-55
Silver Crabgrass	45	50-60
(2nd. half rate pre-emergent)	60	65-75
White Clover	50	55-60
Knotweed	45	45-55
Plantain	50	55-65
Dandelion	45	50-60

		anticipate at degree F.	to do at degree F.
Cultivation and Thatch Control			
Aeration	spring		45-55
	fall		65-50
Slicing or Spiking	early summer only		50-65
Verticut or Thinning	spring		50-70
	fall		65-50
Thatching	spring		50-65
	fall		65-50
Establishment or Reseeding			
Creeping Bentgrass	only fall		65-50
Kentucky Bluegrass	only fall		70-55
Perennial Ryegrass — turf-types	spring		50-60
	prefer fall		65-50
Infectious Diseases			
Pythium Blight		72	74 & higher
Pythium Blight of Ryegrass		70	72 & higher
Brown Patch		68	70 & higher
Dollar Spot	late spring	60	60-75
Dollar Spot	late summer and fall	70	70-50
Helminthosporium — Melting Out		40	45-75
Helminthosporium — Leaf Spot		65	70-85
Fusarium Blight		60	65-75
Snow Mold — Typhula	early winter	55	55-35
Surface Insects			
Cutworms		60-85	65-85
Frit-fly and Leafhoppers		60-85	65-85
Soil Insects			
Annual White Grub (Cyclocephala)		65	70-80
Black Turfgrass Beetle (Ataenius)			
first adults flying		58	55-60
first generation larvae		60	65-75
second adults flying		70	70-75
second generation larvae		75	75-55
Common White Grubs — damage noticed in late summer and fall		75	75-55

from making a cultural management mistake. The additional data, I believe, will help us set up a program that a data processor or computer can maintain for us. I feel it is inevitable that mini-computers will make their way into golf course management systems. This is not as far-fetched as you might think. Recently, I received a letter from Elliot Lapinsky, a manager in Or Akiva, Israel. He requested this soil temperature information for a program he is formulating for the computer he is presently using in his management.

I am looking forward to the challenge of the 80s with confidence and enthusiasm, knowing that soil temperatures play an important part in turf management for golf.

REFERENCES:

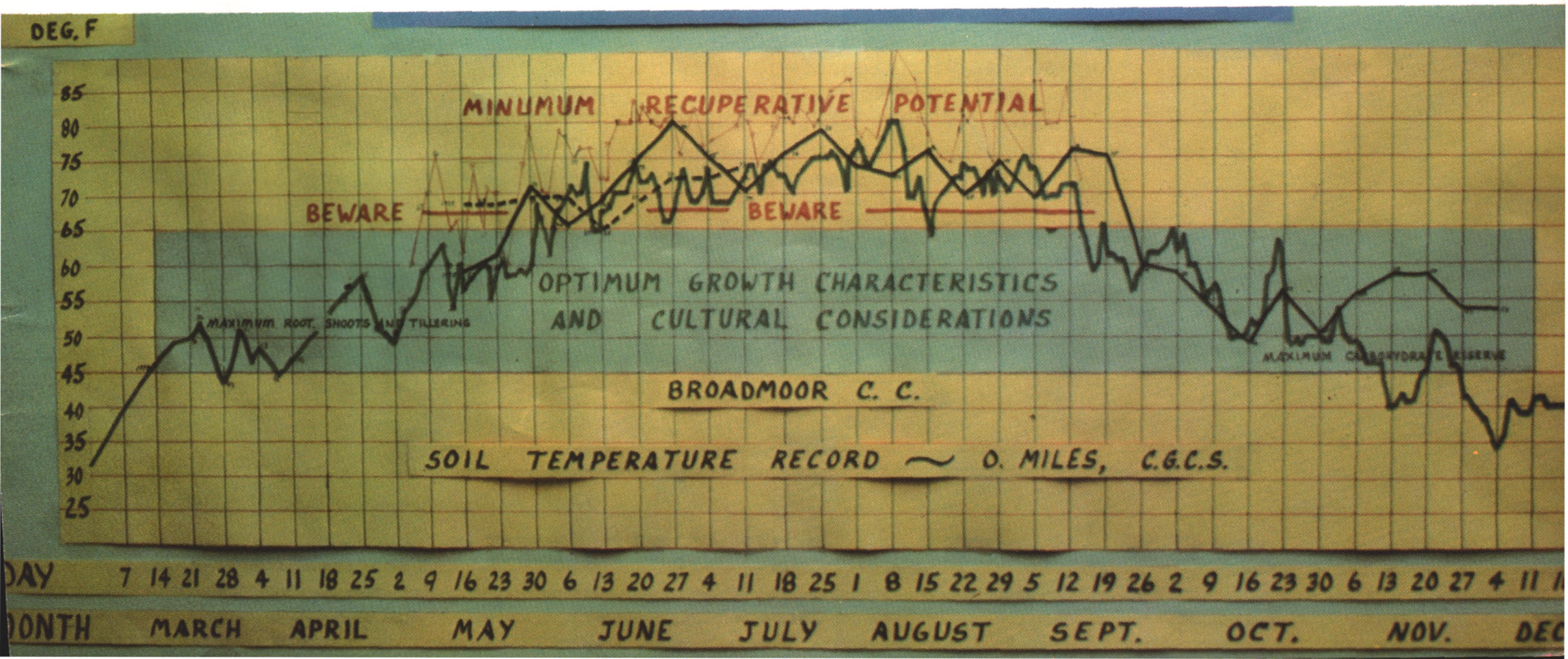
(1) Waddington, *Turfgrass Science* — American Society of Agronomy, Soil Temperature, page 97.

(2) Ward, *Turfgrass Science* — American Society of Agronomy, Soil Temperature & Turfgrass Growth, page 46.

(3) Information provided by Mr. Keith Ahti, Northrup King Seed Co., Minneapolis, Minnesota.

(4) Beard, *Turfgrass Science and Culture*, Temperature, Table 7-3, page 225.

Soil temperature graph set up for ready reference.



TURF TWISTERS

RESOLVED IN 1980: BREAK THE HABIT

Question: I have been brought up to irrigate early in spring. A superintendent from a course nearby says I'm wrong. What's your opinion? (Pennsylvania)

Answer: Your neighbor is right. It's advisable to hold off with irrigation as long as you can in your state and in states having similar climate. Remember that once you begin, you must continue to irrigate. Living things are creatures of habit, and grasses are no exception. Spring is the time of the year to toughen your turf, not baby it!

GROW A GRASS LIP

Question: What is the correct way to edge a bunker to create a lip at green side? (Oregon)

Answer: Most bunkers are constructed with a slope facing up to the putting green. A bunker lip is created by growing a grass overhang to the required depth and not by use of an edging tool. The thatch and turf should overhang the top of the slope, three inches or more, so that players cannot putt out of the bunker. If no lip is present, rake several inches of sand away from the top to allow the turf and thatch some growing room. It will form a grass lip in time. Edging tools are used mainly to edge the rear and sides of bunkers and should be very sparingly used on the forward side of the bunker, the side facing the green, so that the grass lip is not destroyed.

AND CUT A FAIR CUP!

Question: What is USGA policy with respect to hole location on a mound or slope of a putting green? (Connecticut)

Answer: An area two to three feet in radius around the hole should be in good condition without any steep slopes or, if possible, any changes in the degree of slope. In other words, the green in the holing-out area should be as nearly level as possible and of uniform grade, but it need not be exactly level. In no case should holes be located in tricky places, or on sharp slopes where a ball can gather speed. A player above the hole should be able to putt with a reasonable degree of boldness, and not purely defensively.