Soil Temperature and Related Fairway Management Practices-Northern Turfgrasses

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

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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.

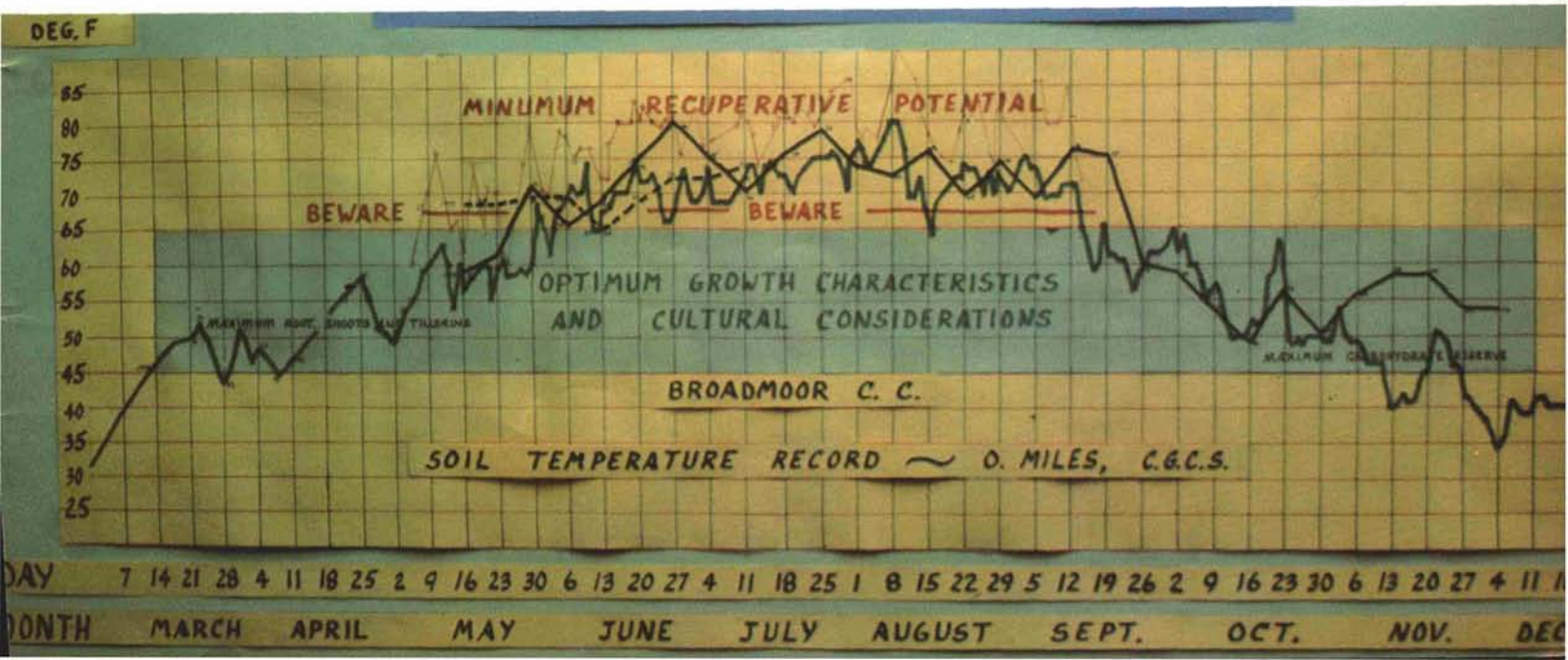
REFERENCES:

(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.