

Then was the summer of our discontent

Despite the use of respected spray and fertility programs, as well as what should've been efficient topdressing and cultivation programs, some of the best courses and superintendents suffered turf loss last season. Industry consultant Michael Vogt crunches the numbers to find out why.

The 2010 golf season wreaked havoc on greens surfaces from the eastern seaboard all the way to the Rockies in the United States and Canada. Granted, the sustained hot, humid conditions coupled with untimely downpours created an unsustainable environment for bentgrass and *Poa annua* turf maintained for golf greens. Some of the finest courses and superintendents succumbed to turf loss, with what would be considered bullet-proof spray and fertility programs along with topdressing and cultivation programs that followed the best known practices.

While these significant turf losses received a good deal of press, their actual causes or remedies will in all likelihood not be mentioned in the Wall Street Journal or your hometown newspaper. After the fact, diagnoses were made and the subject of the catastrophic turf failures became a forgotten memory. In my 30-plus years in the golf course maintenance business, I have not witnessed such a large-scale disaster with green turf loss.

No one can point to any one physiological or pathological process that devastated green conditions, but these are some of my observations in no particular order:

- Sustained low mowing heights throughout the summer put extra stress on turf;
- High organic matter in the top 3 inches of the root-zone held too much moisture;
- SBI (sterol biosynthesis inhibitors) - DMI (demethylation inhibitor) fungicide use;
- High temperature in the root-zone (> 90 F);
- Poor drainage and gas exchange on sand-based greens;
- Blue-green algae or cyanobacteria after

some turf thinning;

- Winter damage – turf never recovered;
- Reduced maintenance budgets;
- Bacterial wilt;
- Fairy ring; and
- Sand and soil thermal properties.

This past summer, I attempted to discover several main causes for greens failure. One commonality was the unusually high temperature in the root-zone of thinning turf. Soil, soil with sand root-zones and some types of sands tended to have lower root-zone temperatures than most straight sand-based greens and fared better having increased rooting and more turgid green leaf tissue. Of course, total turf coverage was the best insulator from the sustained high ambient air temperature. After looking into high-percentage sand greens as opposed to soil greens, I launched a short survey. More severe turf loss was experienced on sand-based root-zone green construction than all others in both occurrence and severity.

My totally unscientific conclusion was that sand-based root-zones retained and transmitted heat more efficiently than the soil-based or soil/sand root-zone mix contributing to a more severe turf loss.

It is difficult to say something general about the soil thermal properties at any location because these are in a constant state of flux from change from angle of sun exposure, organic fraction and, most importantly, the entire water fraction in soil's capillaries. Air is a poor thermal conductor and reduces the effectiveness of the solid and liquid phases in the root-zone to conduct heat. While the solid phase of sand has the highest conductivity, it is the variability of soil moisture that largely



determines its heat retention. As such, the green's root-zone moisture properties and root-zone thermal properties are very closely linked. It comes as no surprise that temperature variations are most extreme at the surface of the root-zone and these variations are transferred to sub-surface layers but at a highly reduced rate as depth increases.

Generally speaking, heat capacity indicates the ability of a substance to store heat energy; the greater its heat capacity, the more heat it can gain (or lose) per unit rise (or fall) in temperature. The heat capacity of dry soil is about 0.20 BTU per pound-per degree Fahrenheit of temperature change, which is only one-fifth the heat capacity of water. Therefore, moist or saturated root-zones have greater heat capacities, typically in the range of 0.23 to 0.25 BTU per pound-per degree Fahrenheit. Light, dry, sandy soils experience greater seasonal temperature swings than most wet soils.

This is because their lower heat capacity

causes their temperature to rise or fall more than wet soils for a given amount of heat energy gained in the spring or lost in the fall. Thus, moisture-laden sandy soil or dry sand root-zones have the ability to conduct greater amounts of heat faster and in high moisture cases longer than soil type root-zones.

Creeping bentgrass root growth ceases at temperatures above 77 F, and most cool season turf plants are subjected to indirect heat

the original root-zone, and on a regular basis to dilute organic matter accumulation and a timely cultivation program incorporating heavy topdressing.

WHAT KIND OF SAND?

Calcareous sand – which is composed primarily of calcium carbonate – is predominantly debris from once-living marine organisms. Plants and animals used calcium carbonate

sands are easily obtained and often used for construction of golf course putting greens and other sand-based root zone media. However, their use is in question because of possible problems with their long-term stability. It is suspected that calcareous sands may break down, resulting in restricted or plugged pore space. The result could be poor drainage, restricted rooting due to root-zone saturation, and eventually thinning or turf death.



Left: Aerification remains the single most important cultural practice for a functional root-zone. Right: A dead green. High organic matter in upper three inches of root-zone caused turf to decline and die.

stress above 86 F. Bentgrass root death occurs after five days of 90 F temperatures.

AGING GOLF GREENS

In the recently published research study by R.E. Gaussoin, Ph.D., University of Nebraska, aging sand greens is noted for the changes in physical properties. After the 10th year infiltration rate decreased 75 percent. In years one through eight, the decreases were the most significant. As infiltration rates decreased, so did large capillary space (critical for root gas exchange and root-zone temperature change). Also of note, total capillary space increased over the years, meaning that small capillary space was more inclined to hold additional water. The number one cultural practice to keep aging greens functioning properly, according to the research, is a sand topdressing program that closely matched

(CaCO³) to form their skeletons and shells. When the organisms died, these pieces became part of the soil and sand.

Non-calcareous sand, in inland continental settings and non-tropical coastal settings, is silicon dioxide (SiO²) usually in the form of quartz, which, because of its chemical inertness and considerable hardness, is the most common mineral sand resistant to weathering. Non-calcareous sands are not saturated with excessive calcium, making it easier to maintain a balanced fertility program.

The absence of excessive calcium leads to slower nitrogen breakdown which helps prevent disease in susceptible turf. Due to lower pH levels, applied nutrients are more available to the plant.

The physical properties of calcareous sand can be defined as any sand that contains at least 1 percent CaCO³ by weight. These

Laboratory experiments have been conducted using small PVC columns to simulate putting green profiles. The columns were filled with sands of varying calcite content.

Dilute acid was added to the columns on five day intervals, with water added on the days in between. The addition of acid simulates some of the reactions that occur following fertilization. Chemical properties of the drainage water were measured, as well as physical and chemical properties of the sand at the conclusion of the experiments. These studies confirmed that calcium carbonate does break down in response to acidification of the soil.

Unfortunately, the study needs to be continued to arrive at a solid conclusion regarding the fate of high-calcium sands. I would be interested in seeing a more complete study of these occurrences in the future.

GAS EXCHANGE IN THE ROOT-ZONE

A misleading fact is that the leaves of a turf-grass plant are the only portion of the plant that accumulates air and disposes carbon dioxide for transpiration. The roots are an important gas-exchange medium also. In fact, roots are the primary source of a grass plant's mechanism to capture oxygen. The roots gather oxygen from the soil matrix and release the carbon dioxide waste product into the soil. Carbon dioxide will gradually increase in the soil, and the oxygen content will decline, unless air circulation or soil permeability permits the release of carbon dioxide-rich soil gases with the atmosphere and the replenishment of the oxygen supply. Venting the root-zone with solid tines throughout the summer months helps balance the soil-gas ratio and evaporate moisture to cause a cooling effect to control high temperatures.

AERIFICATION, ORGANIC MATTER DILUTION AND GAS EXCHANGE

The golf maintenance industry has not found a superior cultural program to replace regular hollow core aerification. In an effort to increase play days this important cultural program has been neglected or reduced to increase rounds and revenue. Hollow core aerification relieves compaction, aerifies and removes organic material.

Historically, aerification relieves compaction and permits air to permeate into the root zone. With several hollow core aerifications annually it has been found to control and manage organic material build-up.

Organic material is removed with cored plugs. Removing organic material and filling the cavities with straight sand reduces the amount of organic material in the upper root zone. In addition, organic material gets

diluted and migrates through sand-filled aerification cavities and dissipates into the lower root zone.

Green root-zones with high organic concentrations (>2.5 percent) will contaminate the sand-air macro pores and seal off these larger cavities. Organic concentrations in the upper three inches of the root-zone less than 2 percent generally do not have this sealing effect. Organic material continues to migrate through the sand with the percolating water, but the lesser amount of migrating organic material does not materially inhibit the cavity's air permeability.

It is a common phenomenon of hollow coring that the turf initially responds positively to the aerification. Unfortunately, the turf eventually returns to its original condition. On some greens the decline is rapid while slower on other greens. It is believed the phenomenon is explained by the organic sealing off the sand-filled cavities. The difference observed between turf systems is primarily attributable to differences in the upper root zones' organic content. While the cavities remain open, the turf thrives. Once the cavities are sealed off, the grass reverts to its former condition. As a common observation, it will take four to six hollow core aerification applications, with at least a $\frac{5}{8}$ -inch tine, before the observed positive changes to the turf will appear permanent. Some root zones require less applications, many root zones require more applications.

At minimum it is recommended that US-GA-specification greens receive, on average, twice-annual aerification to merely maintain their physical condition. That is, twice-annual aerification is needed to merely remove the organic material deposited by the roots. This general rule, however, has its exceptions.

If twice-annual hollow core aerification applications are required with $\frac{5}{8}$ -inch tines or similar equipment to maintain a root system, an accelerated program is required to reduce the organic concentration. On grossly organically-affected root-zones the recommendation is an accelerated aerification program consisting of at least four aerification applications per year.

An accelerated aerification program is not intended to be permanent. In time, the greens will achieve optimal visual and physiologic properties which are capable of being maintained, due to the changes in the root-zone's physical properties, during periods of stress. It is possible to over-aerify a green; however,

(continued on page 80)

Hitting the Re-do button

The following are write-in responses to the question: "If you had a re-do button, what would you have changed for turf to better survive the summer of 2010?"

- Mowing practices ranged from using smooth front rollers sooner, skipping mowing, raising heights of cut and rolling less and rolling in place of mowing.
- Add drainage
- Added more fans for air movement
- Better-timed fungicide
- Changed tournament scheduling
- Cooled my irrigation water
- Drainage in greens
- Drainage was the key, surface, sub-surface and air
- Flush greens more
- Go to smooth rollers sooner
- Had covers available
- Hand water
- Have roots checked for pythium infection
- I did all the rest of the items on the list
- If I had them, run sub-airs and fans
- Improve air circulation
- Improve winter drainage
- Increased watering
- Just not mowed at all
- Less mowing when wet
- Less verticutting
- Listen less to the members,
- do what is necessary
- playability be damned
- Managed wetting agents more carefully
- More fans
- More fans installed
- More hand watering and wetting agent use
- More roll, less cut
- Mowed less often
- Possible snow removal to reduce freeze thaw cycles from day to night.
- Push it harder with fertilizers in the spring and use more wetting agents in the spring when it was wet
- Put up more fans
- Raise height of cut earlier than I did.
- Raise it sooner
- Reduce applications of growth regulators
- Reduced rolling
- Reduced traffic on greens
- Remove tree canopies
- Shoveled all the snow
- Skip mowing greens on days of extreme heat
- Solid tine aerify
- Solid tine and then vent the same
- Stop growth regulator applications on greens sooner
- Switched to smooth rollers quicker, most importantly on cleanup mower
- Tree removal
- Used fans on pocketed greens
- Use different wetting agent
- Used more wetting agents
- Use impermeable covers
- Water a bit more. I was too conservative during the most extreme periods
- Watered more
- Tree removal
- Switch to solid rollers
- We aerified greens pretty aggressively on June 8-9 thinking we had plenty of time to recover. This year the heat hit early and never let up causing thin stressed turf by late June, with the whole rest of the summer to go. In hind sight, we would have been better served if we had not been so aggressive (heaving surface and tearing roots).



1



2



3

By Kyle Brown

Ready to go

An unpredictable winter means broadleaf weeds are ready to start showing up. Is your program prepared?

Winter might be toying with parts of the country with sudden changes in warm and cool weather, but eventually, spring will show up. With it will come broadleaf weeds, eager for their day in the sun as turf is coming around from a tough season.

Dealing with broadleaf is a top priority this time of year, but the best plan for doing so sounds different from course to course. Is it better to use preemergent or postemergent? What's the best way to determine the right chemical mix?

Regardless of how broadleaf is dealt with, Trey Anderson, superintendent of Hickory Ridge Golf Course in Carbondale, Ill., says it takes a sharp eye early in the season to keep ahead of the weeds.

"We'll go scout out areas in spring to see where broadleaves are going to be a problem," says Anderson. "Then we'll get a good three-way mix and go down and clean those up. Once the summer comes along, it's not really conducive to putting anything on those leaves."

Anderson's transition-zone, zoysiagrass course sees some knotweed and clover, with some broadleaf plantain showing up from year to year. Each year, he and his crew watch for the weeds to start showing up, noting where trouble spots might be and where it might pay off to give a little more attention to a section of turf.

Aside from early recognition, taking notes from year to year will also pay off, according to Patrick McCullough, extension turfgrass weed specialist at the University of Georgia.

Know the enemy:

Be on the lookout this spring for these golf course invaders

- 1 Buckthorn plantain
- 2 Common chickweed
- 3 Corn speedwell
- 4 Dandelion
- 5 Hairy bittercress
- 6 White clover
- 7 Purple deadnettle
- 8 Sticky chickweed

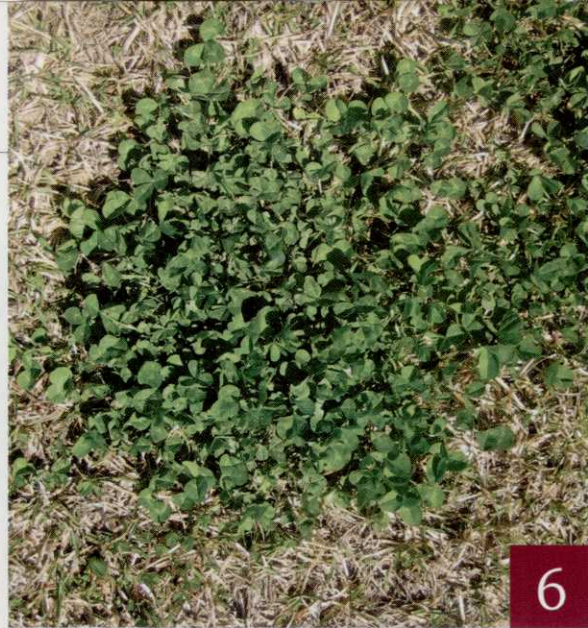
PATRICK MCCULLOUGH



4



5



6

“Scouting turf in winter and early spring is recommended to identify broadleaf weeds that warrant control,” he says. “Turf managers should also note weeds that were present in previous years and pay particular attention to new species that may have become established.”

Be especially aware of sections of turf that thinned or were weakened from traffic, disease or injury during fall and winter, as well as turf grown in shade, compacted soils, or with poor drainage, since all of these scenarios are prime situations for broadleaf weeds to show up, says McCullough.

For Anderson, it’s about dealing with the weeds as they show up.

“When I see what kind of catch we got through the winter, we’ll start getting ready for the season,” says Anderson. March means the use of preemergent for Anderson, and his crew follows up in later March and early April with postemergent as needed.

“Although we’ve used some preemergent, it works better for us to use post,” he says. “We’ll go out there with it and we know about how much we’ll need because of seasons prior. We try to spray as little as we have to. If we don’t have to go out and spray wall-to-wall, we won’t.”

Knowing where the weeds are likely to turn up and what he’s likely to tangle with gives Anderson the edge to clear out problem areas with small doses of FMC Professional Solutions’ Solitare without doing big, costly applications, he says.

“We’re just trying to clean everything up, trying to get a nice, clean look for spring,” he says. “If we can do that when we’re putting down postemergent and three-way in spring, that sets us up for a really good start going into the summer golf season.”

The mixed pre and post strategy feels like too much for Ken Mangum, director at the Atlanta Athletic Club in Johns Creek, Ga.

“I’ve always been a big proponent of just not letting it be seen,” he says. “If you let even a couple weeds out there, the amount of seed it produces, it just spreads.”

Mangum just didn’t have regular trouble with broadleaf weeds until a resod of the course with Champion ultradwarf in 2006.

“When you solid sod your golf course, you bring in weeds from other areas,” he says. “Once we covered the golf course with sod from who knows where, we had some hitchhikers.”

Mangum started seeing knotweed and crabgrass appearing throughout the course, and that was not going to over well with members.

“Our weeds just multiplied,” he says. “It had really become a notice-



7



8

A line in the grass

Methods for taking out broadleaf weeds are specific to each course, and even to the preferences of each superintendent. Beyond the battle of preemergent and postemergent herbicide is the argument of weed tolerance.

When cost is high and repeated applications get in the way of course play, it might be time to loosen the iron grip on turf, says Trey Anderson, superintendent of Hickory Ridge Golf Course.

"We're pretty clean throughout the year, but we can live with a little bit," says Anderson. "Sometimes we can be our own worst enemies. It might be good sometimes to maybe just try to decide if that's okay for your place. Everyone's program is a little different."

A municipal course, Hickory Ridge runs on a moderate budget, so when just one weed or so is spotted, he takes a moment to decide whether it's worth the money and interruption to play, and possibly bringing more attention to a dead weed stalk on the turf.

To Ken Mangum, director at the Atlanta Athletic Club, it's about cost and dealing with the weed, and all the seeds it will produce, later.

"What's your threshold for pain?" asks Mangum. "It's a question of management."

Mangum runs a tight course with a high standard on weed control, but with the Atlanta Athletic Club listed as the site for the 2011 PGA Championship, it's a standard worth upholding to him.

With a decreased budget, it might make more economic sense not to always try to play up to tournament levels, says Anderson.

"Sometimes we choose to just leave a few weeds if they're not going to have an impact on playing conditions," he says. "It's so tough to keep up to those conditions, and costly to go out with the spray repeatedly. It's a choice you have to make for your course."

Players understand and generally haven't complained to Anderson, he says. Mangum also has never heard from his players about it, but for a different reason.

"If you never see a weed, you'll never get a comment," he says.

able problem, so we wanted to get it before it even started growing."

After dealing with the weeds, he started use of Bayer Environmental Science's Specticle to get control of the knotweed, and started a regular program of Dow AgroScience's Dimension and Gallery herbicides to hold that line against the weeds. The battery of preemergents is Mangum's way of fighting off the need to do postemergent application.

"It's because of the visual, and you can typically do preemergent easier in the off-season rather than spraying during the summer when the course is busy," he said. "Not only do you have dead weeds then, your turf is off-color around where you spray sometimes. It's better if the weed is never seen at all."

Early spring is a key time of year for dealing with broadleaf, as many broadleaf weeds will start to show up alongside healthy turf. In the warming climate, growing weeds are most vulnerable to herbicide. Though it's important to get a jump on broadleaf, knowing when to attack keeps costs down.

"Broadleaf herbicides applied under cool weather in early spring often have reduced efficacy and require sequential treatments to control weeds," says McCullough. "Efficacy of broadleaf weed herbicides generally improves when temperatures are consistently in the 70s compared to cooler weather."

This is especially important with the irregular warm-ups happening as spring starts to come around this year, bringing temperatures up and giving broadleaf weeds a little bit of a jump start on superintendents.

"The timing of things is always important, especially with the crazy weather in this past year," says Mangum. "We're very warm right now. We're scrambling to get things down and get ahead of the weeds."

Anderson tries to set up his course as best he can in March and bulk out the program with aerification after.

"The best defense is a good offense," says Anderson. "The best way to deal with broadleaf is just to have a really great stand of turf. We find that if we take off that early and work in aerification, it gives the turf a chance to go into spring and summer strong."

Spring and fall applications round out a broadleaf program, but not all broadleaf decisions come down to setting up a schedule. Choosing the right product is a balancing act between finding the correct coverage for specific weeds at an application price that fits.

"In today's economy, it's trying to take your economic ability and find something that



No Water? No Sewer?

No Problem.

The Clivus Multrum M54 Trailhead is an odorless composting toilet system with handicapped accessible bathroom structure. Ideal for mid-course, the Trailhead structure is available in single or double-stall configurations and a variety of finishes. And like all Clivus systems, the Trailhead is odorless and does not pollute.

Call Clivus today to learn more about why the Trailhead is the Natural Solution for your golf course restroom.

GSA Schedule # GS-07F-0361V

clivus multrum
INCORPORATED

800-425-4887

www.clivusmultrum.com

matches your weeds," says Mangum. "You always have to evaluate the cost of control per acre and the number of applications."

The mix of chemicals used in the main preemergent application is worth the cost to Mangum, since it covers his course's needs before paying for postemergent as well. For Anderson, being able to fall back on the single product makes a huge difference to his crew, since he'll only use very small amounts in postemergent applications.

"It's just simple for my guys," he says. "We're a municipal golf course. We've got an average-sized budget. It's great to have something in the shed to know that you don't have to worry about mixing, or mixing well."

More important than just finding a chemical that works is continuing to try to find a better herbicide. As technology has improved, chemicals have evolved through the years, changing the game almost every season.

"It used to be about pounds of it in every application," says Anderson. "Now it's just ounces. It's much less product than it used to

be. Sometimes we get so busy you might not know what's out there. Some of the chemistry, the way it's grown in the last four to five years, now there's just so much more available. If you keep up on it, you might find you can take care of something with one spray.

"We do as much as we can education-wise," he adds. "We want to put the spray rig out the minimum number of times we can. Some chemicals have changed, and the amount of herbicides that are available now; it would be easy to just get stuck in buying the cheapest three-way without looking to see if there's something else that covers the weeds you have better."

Mangum continues to research new mixes and herbicides. "Even though you've got something that works, always be looking for something better," he says. "You have to start looking at everything. We're fortunate to have products that are actually cheaper to work with now. Look for plenty of help, staying up on all the new things. Look at trade publications and read articles."

Mangum takes the time to test new mixes before using them throughout the course.

"I tend to test things," he says. "Most everything we spray new has been tested somewhere on the golf course until we get a feel for it, see how the turf reacts to it and what kind of control it gives us."

When a superintendent finds the right application setup for their course and the right herbicides after research, dealing with broadleaf weeds is easy after all, says Anderson. "A super today is pulled in so many directions, it's helpful to just have that ready to fall back on," he says. "The less you have to worry about that the better." **GCI**

Kyle Brown is GCI's associate editor.

Dealing with broadleaf weeds?

Patrick McCullough, extension turfgrass weed specialist at the University of Georgia, covers winter broadleaf weed control in our Online Extras.

Durability. Reliability. Playability.

With Princess-77, we offer a pro turf as determined as you. Drought tolerant, and reliable in high traffic areas, it is the only hybrid seeded bermuda that is ready to play — any time, any day.

Pennington . . . a trusted brand since 1945.

Learn about our selection of professional turfgrass products at:

www.penningtonseed.com



TURF MANAGEMENT

(continued from page 52)

the more common mistake is to reduce the number of annual applications too soon. Regular monitoring, consisting of at least annual testing, is essential to ensure the success of the program year after year. Eventually, the program will be modified to maintain the physical properties you have achieved.

WHAT CAUSED WHOLESALE TURF LOSS?

I have had conversations and have observed more devastation on golf greens than I care to talk about. I am by no means a scientist but I have been around golf turf for more than 30 years. What I have is evidence that nighttime temperatures never dropped in some cases below 80 F for extended periods, never allowing drier sand-based root-zones to cool.

Fans at green sites have a substantial benefit in aiding the cooling effect due to the evaporative effect on the turf canopy. Fans surrounding the putting surface are a distraction to the aesthetics. With the ongoing cost to operate, you'll soon discover over a period of several years a small fortune can be spent to keep bentgrass turf healthy with artificial wind. Why must greens be designed and built in depressions with large trees blocking natural sunlight and air circulation? Many superintendents responded in a write-in portion of the survey that increased air circulation would have improved turf conditions.

Older sand greens have problems with drainage and gas exchange. Whether from a high percentage of organic material in the upper portion of the root-zone, poor topdressing sand, not enough topdressing applications or perhaps a degradation of calcareous sand, the take away here is water and gas exchange in most cases were severely compromised. Second only to air circulation; superintendent's sited drainage was the limiting cause for healthy turf on greens they managed.

Organic material was the culprit in many situations. Superintendents are being placed under increased pressure to skip or curtail vital core aeration procedures and routine topdressing to increase playable days and in turn maximize revenues.

In normal, less stressful summers, the impact of accumulated organic material in the upper 3 inches of the root-zone was not a critical factor. In 2010, golf course turf roots cooked in the soupy, low-oxygen mess of thatch and organic matter.

High content or straight sand greens suf-



A sand green root-zone after multiple heavy topdressings.

fered significantly more because the physical ability of sand to transfer temperature is greater than soil on mostly push-up type greens. Even sand greens that have limited amounts of organic material to buffer temperatures were affected. Greens that have a soil component or had limited sand topdressing on top of soil base fared better, in my opinion, due to the temperature buffering ability of the soil fraction if the green was well drained.

WHAT NEXT?

There are some fundamental questions that need be asked:

- Could maintenance and construction methods be changed to regulate/moderate the temperature in the root-zone?
- In older sand greens, do calcareous sands cause a reduction of drainage and air exchange?
- Can new bentgrass varieties be bred to withstand higher root-zone temperatures?
- Could a soil fraction in the root-zone be incorporated to create an environment to increase decomposition of organic matter and perhaps buffer soil temperature?
- Is the sand size specification optimum to support drainage and gas exchange as the green ages?
- With just several minor changes during the last 50 years, can new research improve sand-based root-zone systems?

We all know, and the research bears it out, that the sand-based root-zone green begins to change dramatically with age, and the hanging water column (perched water table)

system begins to be non-functional after the onset of organic material accumulation. The American Society of Golf Course Architects recommends replacing greens at an interval between 15-30 years. With aggressive and proper care I have witnessed sand-based as well as soil greens last more than 20 years and sustain great turf stands.

Sand-based root-zones are not for every golf course, the sand root-zone is very costly to build and maintain and the benefits of these greens diminish substantially if not cultivated and topdressed religiously. Less expensive sand/soil blends can be built and maintained for far less money and perform nearly as well.

The surveys point out that fundamentally, if not aggressively managed, the root-zone is the area that failed during the summer of 2010. And, expensive sand-based greens designed and built to enhance root-zone management have performed less than adequately, actually reducing water and gas exchange in the all important root-zone if not managed to a high level.

A new look needs to be taken to engineer and or manage a more stable root-zone that can sustain an environment for optimum root growth and function without the high cost and down-time of the current sand root-zones. **GCI**

Michael Vogt is a consultant with the McMahon Group and a frequent contributor to GCI.