Turfgrass Management Influence on Water Quality
Part 3: Leaching and Hydrology

Editor’s Note: This is the third of a three part series on the current status of water quality research as it relates to turfgrass management. Part 1, Pesticides, was published in CUTT Winter 2004, while Part 2, Nutrients, appeared in 2004 Issue 2 (Spring 2004).

Much highly managed turf is grown on a sand-based rooting mix, which provides rapid—and in some cases excessive—drainage, preventing adequate time for chemical removal and attenuation. Nutrient and pesticide leaching is by far the largest contributor of chemicals to ground water. However, sand profiles allow relatively unimpeded turf growth, avoiding many of the problems found in turf grown in other soil.

In sand, root growth and density are increased, allowing for an increased growth rate which increases thatch formation, and organic carbon deposition which increases microbe activity. These all increase the remediation potential of nutrients and pesticides in the soil. Yet, in some cases increased soil organic matter (OM) may actually increase NO3 leaching by increasing soil N mineralization. However, in general, increased OM has a positive affect on water quality, as it provides a greater buffer for contaminant capture.

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Dilution and Mobility
Dilution is important in terms of reducing NO3 concentrations in leachate. Greater precipitation entering the profile will dilute soil solution N, but will also increase the speed at which it moves, reducing possible attenuation. Once past the root zone (15-30 cm) compounds tend not to be further attenuated, and can move to the ground water table relatively unimpeded. Compounds mobility in the soil is a function of both the compound and the soil. Soils high in OM and cations will have increased nutrient and pesticide leaching.

Nailed by Specs
USGA specs are used as a guide to “ensure” success, but they can easily double as a hammer with which to nail blame should greens fail. In general, it is widely agreed that the specs focus on drainage with little regard for chemical properties.

The increased number of sand-based rootzones has raised questions on proper fertility that are understood by researching soil chemistry. Private soil chemical testing companies have a network of consultants that promote testing, interpret the numbers and make recommendations.

Though soil chemical analyses often are informative and accurate, consultants sometimes complicate the data with their interpretations, or opinions, in an effort to help turf managers better understand the research. By putting “spin,” as it’s referred to in political parlance, on the data, leaps of faith are taken without supportive research that calibrates plant response to soil nutrient levels.

Favoring the Emperor
When I ask turf managers what they know about certain agronomic practices and chemical treatments, they often regurgitate what they have been told by consultants—though they don’t understand the information. When this happens I am reminded of the story entitled “The Emperor’s New Suit” by Hans Christian Andersen. In the story, written in 1837, two swindlers persuade an emperor with an obsession for fine clothing that “they could manufacture the finest cloth to be imagined, but the clothes made of their material possessed the...
Turfgrass Management and Water Quality

Macropores

Leaching via macropore flow represents the most probable pathway for nutrients and pesticides to reach groundwater. Shipitalo and Gibbs measured macropores created by earthworms extending >1 m into the soil profile, and some were directly connected to tile drains allowing for rapid water movement. Burrows may increase leachate and soil infiltration rate, reducing runoff, but they have been shown by Binet and Le Bayon to increase sediment and dissolved phosphorus runoff from castings left on the soil surface.

Macropores clearly have the ability to affect the transport of contaminants. Their presence in the soil profile can be both beneficial in that they will increase the infiltration rate, reducing runoff, and increasing aeration, but they will also speed the transport of contaminants to groundwater supplies. The effect of macropores on preferential flow can vary with soil type and management, or large microbe populations can be both beneficial in that they will increase the infiltration rate, reducing runoff, but they have been shown by Binet and Le Bayon to increase sediment and dissolved phosphorus runoff from castings left on the soil surface.

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Macropores and fingers only contribute to solute movement when the soil is close to saturation. As the soil wets, more of the macropores will contribute to flow.

In the end this is a cautionary tale. I must be careful not to let my skepticism blind me to important innovations. At the same time, turf managers need to open their eyes to see if the empirical evidence they’re presented with is the naked truth.

Frank S. Rossi, Ph.D.
I often feel like that young child, saying: “I don’t understand the soil test information.” As I inquire further, I find a cult-like theology of soil testing, with no basis in turfgrass science.

In spite of research showing that most soils with a pH above 6.5 do not need calcium and findings saying that applied potassium has no measurable effect on soil, turf managers continue to apply them.

In contrast, well-managed turfgrass landscapes perform better, with reduced disease pressure and greater profitability. The key element is soil health: the biological, chemical, and physical properties of soil that determine its capacity to support plant growth.

Soil Health

Apart from the physical and chemical aspects of soil, the biological components are equally important. Bacteria, fungi, and other microorganisms play a crucial role in nutrient cycling and organic matter decomposition. Healthy soil is “all the rage” in turf management, but the biological aspect remains a black box. However, the concept of proper soil health is emerging in the industry. I hear it touted in organic farming circles, but it is often difficult to see the magnificent suit worn by their ruler.

One would think that the golf turf industry, with its high pesticide use, would be particularly interested in soil health. Yet, many of the soil tests that confuse me often include tests for calcium and potassium. Furthermore, I am surprised at how many times I see specious fertilizer recommendations from persons aligned with fertilizer companies based on the feed-the-weather approach. I often feel like that young child, saying: “I don’t understand the soil test information.” As I inquire further, I find a cult-like theology of soil testing, with no basis in turfgrass science.

I, therefore, establish a cult of turfgrass where microorganisms and microbes are venerated, and the soil matrix and microbial activity are worshiped. In this cult, healthy soil is “all the rage” in turf management systems. My critical nature shapes my initial thoughts of skepticism. I explore the concept and find that we have been studying soil biology for many years in turf science. For example, several USGA-funded turfgrass research studies found no meaningful effect of soil on microbial activity. Microbial populations during sand-based construction increase and diversify until turf is established, then they stabilize. Beyond this we know very little.

The “emperor” factor in the soil health movement is the promotion of production practices to manipulate soil microbes. Organic agriculture will accomplish this by incorporating large amounts of compost (a large source of microbes and microbe food [carbon]). This is wonderful and is the widespread application of these nutrients; in fact, most studies argue against their application in most cases.

I can’t help but wonder why we, as turfgrass scientists, haven’t embraced soil health as a cult in our research. The emperor’s cult is currently more of a religion than a science. The emperor’s cult is a religion because it is based on faith, not evidence. The emperor’s cult is a religion because it is based on tradition, not innovation. The emperor’s cult is a religion because it is based on mythology, not science. The emperor’s cult is a religion because it is based on ignorance, not knowledge. The emperor’s cult is a religion because it is based on convenience, not necessity. The emperor’s cult is a religion because it is based on wishful thinking, not reality. The emperor’s cult is a religion because it is based on ideology, not facts.

For instance, a random check of the preceding sections contained soils that were screened and repacked into the lysimeters. This practice effectively removes the macropores from the soil. Flow in these lysimeters would be assumed to be flowing uniformly through the soil matrix. Greater interaction of solutes with the soil matrix allows adsorbed solutes to be bound or retarded much more quickly. This explains the low concentrations of nutrients and pesticides seen in drainage from these lysimeters.

Water moving through the soil profile utilizes multiple pathways. Movement pathways include finger flow, macropore flow, and matrix flow. Fingers form following initial infiltration of water and are responsible for transporting contaminants very deeply into the soil profile. Macropores can form as a result of root growth and die back, worm movement, or the swell/shrink, freeze/thaw cycle in soils with clay.

The Benefits of Turf

Turf clearly has the ability to attenuate harmful nutrients and pesticides. The high evapotranspiration rate, rapid growth, and wide ecological range make them ideally suited for remediation. Best management practices to reduce nutrient and pesticide runoff, explored by Bandy et al., determined that vegetative buffers would reduce nutrient and chemical concentrations in runoff and that taller buffers worked better than shorter buffers. In addition, excess application of water-soluble fertilizers and pesticides by over-irrigated soils should be avoided.

The use of turf and grass filter strips to reduce N, P, and sediments was studied by Daniels and Gilliam who found that a grass filter alone was more effective at reducing nutrients and sediments than a wider grass and riparian filter, but that removal rates for filters varied widely depending on the antecedent moisture.

Conversely, Tate et al. discovered that a turfgrass buffer reduced pesticide runoff through a number of factors, including dilution, reduced runoff velocity, physical filtering, and increased infiltration.

Baird et al. discovered that a turfgrass buffer reduced sediment runoff through a number of factors, including dilution, reduced runoff velocity, physical filtering, and increased infiltration.

Soils containing macropores can function as a natural drain for excess water. Macropores form in sandy soil due to an instability in the wetting front from increased hydraulic conductivity with depth, water repellent soils, and air entrapment. Finger and macropore flow are very similar, and ultimately both have the potential to transmit nutrients deep into the soil profile, beyond the reach of the roots, and microbes, to attenuate them. Fingers allow solutes to bypass the soil matrix, reducing attenuation. Macropores and fingers only contribute to solute movement when the soil is close to saturation. As the soil dries, more of the macropores will contribute to flow.

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Comparatively, Casey and Klime found that riparian wetlands were effective at removing both NO3, by 80% and PO4, by 74% from runoff off golf courses. However, they do mention that PO4, attenuation may be reduced due to P saturation in the wetland, leaving only plant uptake as the primary means of P removal.

Conversely, Tate et al. found that buffers were ineffective in removing NO3 from runoff.

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Nitrogen Uptake in Kentucky Bluegrass

Nitrate leaching into ground water is a major concern for the turfgrass manager. The nitrate uptake rate (NUR) for Kentucky bluegrass plants is a key factor in selecting those turfgrass species that can reduce the amount of nitrate leached into ground water. Since nitrate leaching is of particular concern during establishment, researchers at the University of Rhode Island studied six cultivars of Kentucky bluegrass at the seedling, as well as mature plant, stage.

In addition to comparing NURs among and within the cultivars, the study also investigated the relationship between seedling NUR and mature plant NUR. The ability to select cultivars with high mature plant NUR based on seedling NUR would decrease the amount of time required for selection and development. The six cultivars (Blacksburg, Barzan, Conni, Dawn, Eclipse, Gnome) were screened for NUR beginning at 30 days after seeding. Seedling NUR was positively correlated with total length and total area of leaves and roots of the seedlings. There were significant differences in seedling NUR both among and within the cultivars. The removal of shoot tissue significantly and immediately reduced NUR, but rates generally increased to initial levels within a week.

For the most part, however, the results did not show a significant correlation between seedling NUR and mature plant NUR. Therefore, seedling NUR may not be a good predictor of mature plant NUR in all cases. This is likely due to the fact that mature plants have characteristics that the seedlings do not, such as the ability to protect the rhizomes, both of which would influence NUR.

With the issue of water quality being such a high priority in this industry, growing turfgrass cultivars that are genetically programmed with high NURs is an important tool in reducing the risk of leaching.

From: Jiang, J., W.M. Sullivan. 2004. Nitrate uptake of seedling and mature Kentucky bluegrass at the seedling, as well as mature plant, stage.

Residential Fertilization Practices Surveyed

The scarcity of data on residential lawn care practices makes it difficult to evaluate fertilizer, pesticide and water use. With concern growing throughout the United States over surface and ground water contamination from both nutrients and pesticides, this information is critical for establishing sound turf management guidelines and educational outreach programs.

In an effort to characterize how turf fertilization practices in residential areas may contribute to water pollution, researchers at North Carolina State University conducted a survey in five North Carolina communities. Homeowners and lawn care companies were asked specific questions about how they fertilize lawns.

More than half of urban homeowners surveyed use fertilizer on turf. Some households used lawn care services, with the highest frequency of use occurring in the community with the highest median income. High and medium income households had significantly higher fertilizer rates than low-income households. Fertilization was based on soil testing for only 20% of the households, and none of the lawn care companies surveyed used soil tests on a routine basis. Generally, fertilizer rates for tillage lawns were appropriate, but for grasses with low N requirements, such as centipede grass, excess fertilizer was often applied. Both homeowners and lawn care services tended to fertilize during the wrong season. On average, only 52% of households removed fertilizers from impervious surfaces such as driveways and sidewalks.

The results of this study indicate areas of concern that can be addressed in order to reduce negative environmental impacts of fertilizer use. Surveys in other areas of the country would no doubt yield information necessary for educating people about safe lawn care practices in their own communities.

**Cornell University Turfgrass Times**

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**Clippings**

Ph.D. candidates Zachary Easton and Micah Woods were winners in the Crop Science Society of America graduate paper contest.

Frank Rossi was named the 2004 outstanding young alumnus from SUNY Cobleskill.


Nathan Rudgers named 2004 "Friend of the Green Industry" by NYSTA.

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**NY Turf Survey Released**


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Send your comments to Cornell University Turfgrass Times, 134A Plant Science Building, Cornell University, Ithaca, NY 14853, or via email to fsr3@cornell.edu.

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**N.Y. Turf Survey**

The newly released survey, which has been in the planning and implementation stages for the past five years, is the first of its kind to evaluate the magnitude and economic importance of the turfgrass industry in New York State. This important data will position the turfgrass industry as a growing agricultural commodity in New York State and enable the public, industry and government to work together to ensure its continued growth.

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**Ag & Markets Commissioner Chosen as “Friend”**

The New York State Turfgrass Association (NYSTA) has awarded Nathan Rudgers, Commissioner of the New York State Department of Agriculture and Markets, with the "Friend of the Green Industry" award. This award is given to individuals who have excelled in support of the turfgrass industry.

Commissioner Rudgers was recognized for pledging his department’s support of the New York Turfgrass Survey in 2001 and his foresight in recognizing the importance of documenting the economic value of the turfgrass industry. The award was presented at NYSTA’s annual Turf & Grounds Exposition, “Economics and the Environment—Surveying the Landscape,” at the Rochester Riverside Convention Center in Rochester, NY.

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Frank Rossi was named the 2004 outstanding young alumnus from SUNY Cobleskill at the 2004 New York State Turf and Grounds Exposition in Rochester, NY on November 17. Rossi graduated from Cobleskill in 1982 with an AAS degree in Agronomy under the tutelage of long time Cobleskill professor Bob Emmons. SUNY Cobleskill’s president noted that, “Frank embodies all that is unique about Cobleskill and has regularly given back to the school with his time and expertise.”

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