SPECIFICS, PLEASE

The emerging field of Precision Turf Management will offer turfgrass managers unprecedented accuracy of inputs applied to a golf course.

BY CHRIS HARTWIGER

EDITOR'S NOTE: *This article summarizes a more detailed article written by Dr. Bob Carrow, turfgrass scientist at the University of Georgia. It is available at http://usgatero.msu.edu/.*

Most articles begin with an introduction and build to a conclusion. This article is going to begin with the conclusion and work backwards. The topic is Precision Turf Management (PTM). The conclusion is that in the not-too-distant future, golf course superintendents are going to base the application of course inputs — including water, fertilizer, and cultural practices such as aeration and soil salinity management — on computer-generated, color-coded maps that reflect thousands, if not millions of data points. This is going to happen because societal pressure and government-imposed mandates will incrementally improve a property's resource management. And it is going to happen because conservation of resources, without altering the end product to the golfer, will be better for the business of golf. That is the end of the story. Here is how the story is being written.

WHAT IS PRECISION TURF MANAGEMENT?

Precision Turf Management refers to the site-specific management of a golf course and the inputs needed to provide the desired turfgrass conditions. It assists superintendents in answering the age-old questions of where, when, and how much in regard to inputs. Precision Turf Management has its origin in Precision Agriculture, but for reasons soon to be discussed, the concept can be used more powerfully on a golf course.

Precision Turf Management would not be possible without the remarkable innovations in technology over the last two decades, including advanced soil sensor technology, mobile sensor platforms, GPS (Global Positioning Systems), and the application of GIS (Geographic Information Systems).

It is worthwhile noting what Precision Turf Management is not. PTM is not push-button agronomy or a replacement for the site-specific human decisions that must be made on an individual golf course. Turfgrass cannot be maintained by the push of a button, but excellent turf managers can improve performance and conserve resources with additional data to guide their decisions.

TOOLS TO MAKE PRECISION TURF MANAGEMENT HAPPEN

Several components must be in place before traditional turfgrass management evolves into Precision Turf Management.

- **Intensive Site-Specific Information:** To make precise applications of inputs, detailed, specific information is required.
- **Integrated Technology:** It is interesting to note that numerous technologies have come together to make Precision Turf Managment applicable today. Take out any of these technologies, and the power of this system would diminish greatly. If a site is going to be managed more precisely, sensors are needed that will enable us to accurately detect factors such as soil moisture, soil salinity, soil hardness, topography, and turfgrass stress. The Toro Company has developed a mobile mapping platform that can detect 1) soil volumetric water content, 2) turfgrass performance by normalized difference vegetative index (NDVI), 3) penetrometer resistance factor, and 4) topography through GPS. Technologies have come together that allow the spatial variability of a site to be more completely understood in a short period of time.
- **Development of Site-Specific Management Units (SSMUs):** SSMUs are groupings of areas that share the same characteristics. There may be four or five statistically significant soil types spread throughout a golf

We may see a day when turfgrass stress can be detected with digital scanners mounted on commonly used turfgrass equipment such as fairway mowers. The additional data collected will allow irrigation applications to be fine-tuned even more.

course that require different levels of inputs. The identification of SSMUs is a complicated statistical process that requires the use of specialized software to interpret the massive amount of data collected during mapping. SSMUs also have a crucial role in developing the location and number of soil sensors. Without an understanding of which areas on the golf course are similar, either the number of sensors needed will be overwhelming, or they will be placed in locations that are not optimal.

- **Visualizing, Characterizing, and Analyzing Mapping Results:** Information is great to have, but it must be presented to the end user in an easy-to-use form. To drive home this point, consider the organization of a dictionary. With alphabetical order, anyone can locate any word in a matter of seconds. Without alphabetical order, finding any desired word would be like finding a needle in a haystack. Geographical Information Systems (GIS) will provide order to data in a Precision Turf Management system in the way alphabetical order organizes dictionaries. Most likely, the end user is going to see overhead maps of the golf course with color-coded zones indicating differences in soil properties, such as soil moisture, compaction, turfgrass stress, and soil salinity.

HOW WILL PRECISION TURF MANAGEMENT BE USED IN THE FIELD?

Several field applications will be common.

Water Efficiency and Conservation: This topic is relevant in all parts of the country for a variety of reasons. Golf courses in the Southwest have been operating under annual irrigation quantity restrictions for many years. Golf courses in the Southeast have endured droughts and their accompanying governmental restrictions over the past few years. All golf courses will benefit financially from applying less water, as there is a cost associated with every drop of water sprinkled on the golf course.

Water efficiency improvements and conservation will manifest itself in a couple of ways. The first is through irrigation audits. This will begin by mapping the golf course at field capacity following a period of extended wet weather. Because volumetric water content is highly correlated to soil texture and water content, a map of soil types can be generated. This information will be valuable in creating SSMUs, determining where to place in-ground soil sensors, and in the next step below.

The second step is to map the golf course under drier conditions. If no irrigation was applied between the first mapping and the second mapping, any differences in soil moisture would be directly related to soil texture. However, golf courses are irrigated, and if the mapping took place after multiple irrigations, differences in soil moisture detected are due to a combination of soil texture, irrigation, and topography. The analytical software will be "smart enough" to take out differences in soil texture and topography. The result will be a sophisticated understanding of the distribution uniformity of the irrigation system. It is going to be vital to know when it's time to make a decision on how much water to apply in a given area. The software will

Experimental Salinity Monitoring Device (SMD) conducting salinity mapping of surface salinity, subsurface salinity, and plant NDVI at Old Colliers Golf Club, Naples, Florida. Data are GPS labeled, and the mapping grid is 5 by 10 feet. Photo courtesy of Toro.

make recommendations, based upon system coverage, to replenish the soil moisture in the rootzone to a level determined by the turf manager.

A third application is to use routine NDVI scanning to identify turf stress throughout the property. In simple terms, an NDVI scanner will be mounted on either a utility vehicle or ideally on mowers on the golf course, and it will take GPS-based readings when the machine is in operation. Upon completion, data will be downloaded and another color-coded aerial of the golf holes will show areas of turfgrass stress. This fantastic data will help fine-tune the turf manager's irrigation decisions.

Site-Specific Cultivation: Soil hardness is a function of soil moisture percentage, percentage of clay, type of clay, and degree of compaction. All of these characteristics will be captured through mobile mapping of the site. When mapping at field capacity, soil texture is determined and the soil moisture component is eliminated. The penetrometer resistance data then become key in determining the areas of greatest compaction. This will lead to recommendations for site-specific cultivation and further gains in water conservation. When soil is compacted, runoff is increased and irrigation effectiveness is diminished.

Site-Specific Fertilization: Although intensive and costly grid sampling can determine differences in soil characteristics and available nutrients, the development of SSMUs is going to make the process much less costly and time consuming. Once again, mapping at field capacity will generate important information regarding soil types on the golf course. Not only is volumetric water content highly correlated to soil texture, so is cation exchange capacity. There will be two approaches to this new protocol. The first is to sample within SSMUs on a given hole. This might be used on new golf courses or renovated courses where subsoil has been exposed and is now being used as a growing medium for turf. Another option is to sample within SSMUs across multiple holes. This will be useful on older golf courses that have had established turf for many years. Regardless of the option followed, there is an opportunity to fine-tune the application of nutrients.

Salinity Management: Mobile soil salinity mapping devices are under development in the turfgrass industry. Because salts in irrigation water are a leading cause of salinity problems and the distribution uniformity of an irrigation system affects how salts are deposited on a golf course, it is likely that different SSMUs for soil salinity will need to be generated. Once SSMUs for salinity are developed, the turf manager will be able to accurately 1) place salinity sensors, 2) evaluate the effectiveness of a leaching application, 3) more accurately schedule leaching events, 4) predict the areas most in need of gypsum if sodium is a problem, and 5) calculate site-specific leaching requirements for hot spots throughout the course.

CONCLUSION

There are sure to be many questions raised and details worked out in the emerging field of Precision Turfgrass Management. Be patient and be on the lookout.

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