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Automating the Task of Evaluating Your Turf

Managing a golf course is a difficult task. Understanding how the ever-changing forces of nature will affect the appearance and playability of your turf is a constant challenge. Managing the effectiveness and efficiency of your employees can be equally daunting. Despite these obstacles, golf course superintendents are managing the highest-quality turf in history with unprecedented consistency. How is this possible?

This concept of precision or prescription management was first evaluated in agriculture over a decade ago. Like all new technologies, it is fraught with high costs, inconsistencies and many gaps in its applicability.

We now have the opportunity to use some of the best tools imaginable to assist with the task. Recent turfgrass cultivars mow better, grow better and resist a wide range of pest and environmental pressures. Modern equipment is easier to maintain, works harder and accomplishes tasks only dreamed of a decade ago. Many facilities have adequate budgets and staff. This allows a superintendent to focus almost unlimited resources to solve a problem. We currently have the luxury of taking a very conservative approach to turf management, applying management techniques to the entire course to minimize the expansion of small problem areas.

Will this situation continue? With the growing popularity of golf worldwide and a continued strong economy, it is anyone's guess. I think we should all be grateful for this "golden" era of turfgrass management. It might not last forever. Budgets are coming under increasing pressures to increase efficiency. Corporate management of turf is here to stay. Regulation of pesticides, fertilizers and those "turf enhancement" materials will probably only become stricter in the future.

What is needed to face these challenges?

I feel we need to continue to improve techniques and materials through research and education. This challenge will most likely continue for a very long time. I also feel that it is very important to evaluate the efficiency of all our operations. How can we do more with less? While many of my colleagues focus on the first challenge, I find the challenge of increasing the efficiency very interesting, but also very difficult.

I can certainly advise more students, improve my teaching techniques and conduct more research studies each day. You have your own set of daily effi-

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ciency challenges. Unfortunately, after many years of experience, you come to realize that the best way to increase your efficiency may be to declare a day 30 hours long. That's obviously not going to happen! What about considering a fundamental change in the way you do business? Could you somehow measure the potential risk for future problems for each area of turf and develop a response targeted only to that turf area?

This concept of precision or prescription management was first evaluated in agriculture over a decade ago. Like all new technologies, it is fraught with high costs, inconsistencies and many gaps in its applicability. Despite this, prescription fertilization is available at your FS dealer. Interest in applying this prescription technology to turf is beginning. Each of the major equipment suppliers in the turf industry is conducting some level of a precision turf development program.

Turf is a considerably different animal than annual row crops. As a perennial, it will require more sophisticated means of evaluation than simple soil tests. The **first** step in any precision management system is the accurate collection of meaningful data. With turf, the timing of data collection is also critical. You don't want to simply know that the turf is under stress, you need to know when there is a high likelihood that it may go under stress. This will require data-collection techniques beyond simple observation.

One technology that has shown considerable promise in assessing plant health is electromagnetic or light scanning. The leaves of turf are green because they absorb red and blue light while reflecting green light. Soil is dark brown or black because it absorbs almost all light wavelengths. Healthy plants reflect minimal quantities of light when measured by an instrument that is filtered to be sensitive to only a portion of the visible light spectrum. As plant health decreases and chlorophyll breaks down, greater quantities of light are reflected.

Healthy plants generally reflect greater quantities of electromagnetic energy with longer wavelengths than visible light (400-700 nm). Short-wave, near-infrared energy (750-1,000 nm) is not greatly absorbed by plants and is generally reflected. As plant health diminishes and chlorophyll breaks down, near-infrared reflectance decreases. Past research has shown that the ratio of red light/near-infrared light is one of the best indicators of increasing plant stress.

For the past three years, we have tried to evaluate this stress-measuring opportunity with a range of light-scanning devices. Initially, we tested scanning devices that measured near-infrared energy above 1,100 nm. While these instruments show great promise, there are currently no economical field scanners so we need to wait for further developments. We have also evaluated several photo diode-based scanners that have shown some promise. Several of these instruments are commercially available and marketed to golf course superintendents. (Spectrum Technologies, Inc., Chicago, IL)

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Current projects

Last year, with the generous support of John Deere Company and the Illinois Turfgrass Foundation, we began to evaluate sensors that capture images rather than simply providing an electrical readout. This technology has several important advantages. Portions of the image can easily be excluded to remove nonliving components from the field of view. Using image-analysis software, we can mea-

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sure components of the data, like uniformity, which is not possible with nonimaging systems.

Developing scanning technologies

Our current scanning system consists of a modified three-channel (red, green, near-infrared) digital video camera, several computer boards to capture images and a standard Windows-based laptop computer (Figure 1, Scanning Cart). Another critical component of the system is the controlling software that was developed in the Department of Agricultural Engineering at the University of Illinois (Figure 2, Computer Software). This software controls the camera, captures images and evaluates changing light conditions.

Figure 1.

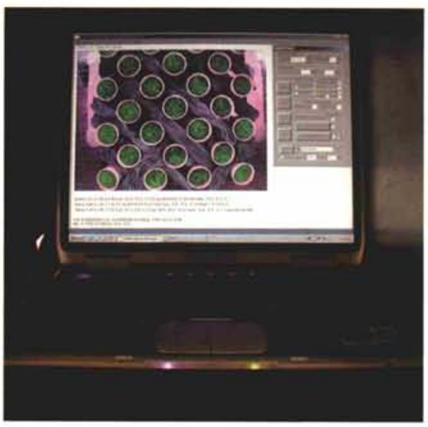

Figure 2.

The Ph.D. research of graduate student Mark Schmidt (also a turf agronomist with John Deere) has focused on measuring the accuracy of this system on turf under a wide range of conditions, both during the day and at night (Figure 3, Night Scanning).

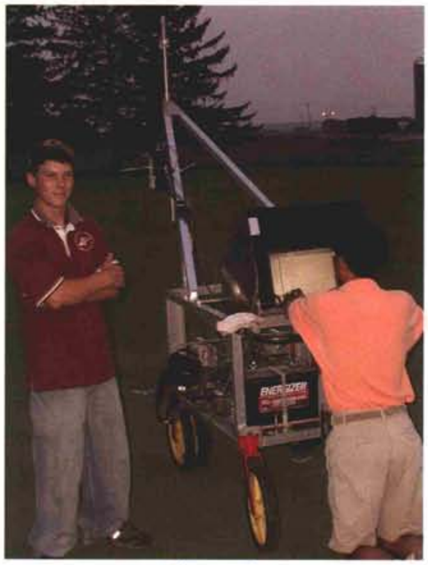

Figure 3.

Nutritional and moisture status of turf

Siddhartha Narra, also a Ph.D. student, is evaluating the capability of the imaging system to sense turf-tissue nitrogen and moisture in fairway-height creeping bentgrass and perennial ryegrass. Experiments have been designed on both species at the Landscape Horticulture Research Facility in Urbana to apply different quantities of either nitrogen or irrigation. Clippings samples are routinely removed from the plots to physically measure quantities of nitrogen or moisture in the laboratory (Figure 4, Collecting Clippings). The plots are scanned just prior to clipping collection in order to evaluate the accuracy of the images to predict nitrogen and water content. Preliminary evaluation of last year's data has indicated a moderate correlation between scanner output and chemical analysis.

Figure 4.

Due to the versatility of image analysis, there are many variables that can be modified to improve the current correlation values. This investigation is still underway, while we continue to collect new images. This research will again be presented at the annual University of Illinois Landscape Field Day in August. (We hope all MAGCS members will have an opportunity to visit our research facility on August 7 for the Field Day, when we will be showing a commercial variety—not yet released—of Roundup-Ready bentgrass from Monsanto along with a wide variety of new research studies.)

Disease detection

First-year M.S. graduate student, Zachary Anderson, is using the scanning equipment in a very different way. You can blame this one on Dave Ward, it was his idea. One day when we were reviewing scans of Olympia Fields' fairways and greens, Dave suggested, "While it is interesting to look at a map of current turf stress, it would be much better to know what areas might soon be stressed." Because near-infrared energy is invisible to the eye, there may be changes to turf reflective properties prior to visible changes. One stress that is imposed on turf where changes can be very rapid is the onset of turf disease.

With the help of Dr. Hank Wilkinson, we have developed a transparent turfgrass disease chamber to continuously scan seedling turf as it goes from a healthy state to a diseased condition (Figure 5, Growth Chamber—see page 27). Our main objective is to determine if we can detect the onset of disease prior to visual symptoms. We are currently testing a wide variety of camera and image-analysis variables to determine which ones will give us the optimum detection of disease. If we are successful, we plan to repeat these experiments in the field.

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Figure 5.

Remote evaluation of plant health

All of the previously described experiments have been conducted on plots of < 20 ft^2. This close observation has many advantages, mainly allowing each image picture unit (pixel) to represent a very small area. Each image, therefore, can detect changes to areas as small as a single blade of grass. While this is a tremendous advantage, there is the disadvantage of needing to take many images to cover a large area. The multispectral imaging system we are currently using is also used in remote or aerial scanning by airplane or satellite.

To evaluate the effectiveness of this scanning system on large areas, we contacted a local remote scanning company, Spectrum Vision, to develop a joint demonstration project. Last summer, we began weekly flyovers of Olympia Fields Country Club with the cooperation of course superintendent, Dave Ward. Dave was presented with a booklet of images of each of the 36 fairways and greens that were analyzed for levels of plant stress. Dave's insight into the information presented him has been invaluable in designing new studies. A limitation with this approach is that taking images from 2,000 feet makes each pixel represent approximately one square foot. This limits the types of discoveries we can view with an image.

Where is this going?

While we are involved in five separate projects examining data collection through imaging, we are only really starting this investigation. If any of the scanning techniques is successful, considerable additional engineering will be required to reduce the cost and simplify the use of the imaging system. The current camera system cost more than $20,000 to assemble and requires some understanding of the camera physics for correctly exposing images. Any resulting technology that is offered to golf course managers will need to be at a reasonable price and simpler to use. With "turnkey" systems mounted on mowers, superintendents might collect valuable data during routine operations. It might not be available soon, but I believe you will see some form of this technology in the next 10 years.