"The quality of education and the trade show has grown significantly," Pinsonneault says. "Daytona was a good example of that. The people who put the program together have done an outstanding job with educational selections and networking opportunities."

Pinsonneault also plans to follow a strategic plan he helped develop for the association, which calls for focus on education, environmental programs, membership growth and conference expansion.

No one possesses more confidence in Pinsonneault's upcoming year as leader than the man who originally appointed him to the board.

"David has no ego, no hidden agenda and he will work his tail off to ensure the board is highly productive and responsible to the membership," Andresen says. "With David, we're going to get a very unselfish leader, and one that I want representing us as president, knowing he brings an understanding and work ethic to the office as strong as any that have served."

STMA CEO Kim Heck agrees. "When David speaks, his comments always have the best interests of STMA at heart. As a leader, David's honesty and integrity are front and center in everything he does," she says. "He has respect for everyone, and as a result is given respect in return. David has a unique ability to bring clarity to issues. He can look at an issue and give a 360-degree assessment of it that really helps discussions in our board meetings."

PASSION IN WORK AND PLAY

As for Pinsonneault, he'll tell you he couldn't have accomplished any of this if it weren't for his family.

He and his wife, Robin, a kindergarten teacher, raised their two children to follow in their footsteps of careers in public service. Their daughter, Noelle, 24, is a special education teacher; and son, David, 21, is studying public service and political science at Providence (RI) College.

Working for the public takes a particular passion, Pinsonneault says, and if you've got it, you're in for a rewarding career. "You've got to like what you do, but you've also got to like making a difference. It's certainly true in teaching, and it's certainly true in the sports turf world."

The rewards? Like Pinsonneault's practice jersey from a high school football team on a late night, they come unexpectedly and they're 100% worth all the work.

"The thing I like about parks and rec, you can see your results," Pinsonneault says. "You maintain the field well, you happen to see the 10-year-olds out there playing a ball game, or swimming at the pool, and you know that you helped to make that happen. That's part of the job, too. That's part of the appeal." ■

Darcy DeVictor Boyle is a free lance writer based in Lawrence, KS.

DRONES OFFER *UNIQUE PERSPECTIVE* TO TURFGRASS MANAGERS

New technology can bring a unique perspective to turf management. Unmanned aerial vehicles, or "drones," can provide valuable information to aid sports turf managers. As part of a management program, drones can save time, labor, and money.

Drones are semi-autonomous aircraft that come in a variety of shapes and sizes (see photo). Drones are capable of fully automated flight via GPS-based navigation or manual flight via radio-controlled transmission. They are available as multi-rotor helicopters and fixed-wing aircraft. Companies including Quadcopter, LLC, Lehmann Aviation, Pixobot, LLC, MicroPilot, Inc., and senseFly, Ltd. manufacture and sell drones for public use or provide drone-related services. They can be relatively small, about the size of a large pizza, to several feet in diameter or length. Drones require little technical training and do not require a pilot license for operation. They can operate in a wide range of environmental conditions. Drones can fly in hot or cold temperatures, humid or dry air, and sunny or cloudy skies. Although Federal Aviation Administration regulations currently prohibit drone flights for commercial operations, rule changes could come as early as 2015. Recently, farmers were granted permission to operate drones over their own property for personal use, in accordance with guidelines established by the Academy of Model Aeronautics.

WHAT DRONES DO

In a turf management program, drones are best used as a platform for collecting aerial imagery. Digital cameras collect visible light reflected from surfaces. Visible light is the portion of the electromagnetic spectrum "visible" to the human eye; it ranges from 400-700 nanometers (nm) in wavelength. Digital cameras record visible light information into three channels—red, blue, and green (RGB)—that make up each pixel in an image. Imagery can provide real-time information on many aspects of turf quality important to turf managers.

Images can be analyzed with computer software and used to quantify turf status through a process called digital image analysis (DIA). The DIA method is recognized for its ability

▼ **A custom-made** unmanned aerial vehicle, or "drone," is shown flying over turf. Drones are used as a platform for digital image analysis, enabling quick and efficient quantification of turf quality and stress. *Image by Keenan L. Amundsen.*

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to objectively quantify many turf quality parameters, including percent green cover, turf color (via a dark green color index, or DGCI), fertility, chlorophyll index (i.e., "greenness"), and others. The objective nature eliminates variability associated with subjective visual ratings.

In addition to their impact on visible light reflectance, many turf stresses largely impact reflectance in the near-infrared (NIR) region of the electromagnetic spectrum. Near-infrared is the portion of radiation just beyond that visible to the human eye, ranging from 700-1300 nm in wavelength. The NIR provides the ability to "see" stressed areas otherwise invisible. Near-infrared radiation can be detected and recorded using a modified digital camera. Modification costs are relatively inexpensive, costing about the same price of a new mid-grade digital camera; pre-modified digital cameras are also commercially available.

Research at the University of Nebraska-Lincoln John Seaton Anderson (JSA) Research Facility near Mead, NE, in 2010-12 has shown RGB and NIR information in digital images can be extracted with computer software and used to quantify turf quality and stress. Two commonly used agronomic measurements include chlorophyll index (CI) and the normalized difference vegetation index (NDVI). Although computed somewhat differently, each is an objective measurement of turf "greenness," calculated by mathematical manipulations of red and NIR reflectance data. Other methods based on analogous principles involve handheld sensors. Handheld sensors are commercially available that measure visible and NIR reflectance from turf and quantify a value. Researchers have demonstrated high correlations among multiple turfgrass quality parameters with handheld CI and NDVI, making them robust, objective measurement tools. However, no attempts have been made to correlate these sensor data with a DIA system that incorporates NIR reflectance.

A dual-camera (regular + NIR) DIA system may be a convenient, reliable, low-cost alternative to handheld sensors for collecting turf quality data. Regular and NIR-modified digital cameras used in tandem can record RGB and NIR reflectance data for each image. These data could provide CI and NDVI information, as well as percent cover, DGCI, and traditional DIA measurements.

Furthermore, by combining DIA with drone technology, efficiency of collecting turf information increases dramatically. Drones provide the ability to image large areas, common in sports turf, in short time spans. For example, entire football fields can be imaged in minutes. By comparison, collecting imagery of equivalent area by hand would take several hours. Turf affected by various stresses, including water, fertility, disease, and insect damage, could easily be detected. In addition, because drones can collect information on entire areas in one image, effects of changing sunlight and cloud conditions are eliminated, increasing accuracy.

Research conducted at UNL in 2012 investigated effectiveness of a drone-based, dual-camera (regular + NIR) DIA system for measuring CI and NDVI compared to handheld sensors. An ongoing deficit irrigation field study established in 2009 was used. Deficit irrigation was applied via a linear gradient irrigation system, such that turf closest to the sprinkler line source received 80% evapotranspiration (well-watered) and turf farthest received no irrigation (rain-fed); plots were divided into eight equal sub-plots that differed in irrigation and replicated four times. This design provided a broad range of turf qualities for analysis. Plots were mowed twice weekly at 2.5 inches, fertilized at 3 lbs N·1000 ft-2·y-1, and received regular pre- and postemergence herbicide applications.

Aerial imagery was collected using a custom-built, GPS-controlled hexacopter equipped with a digital camera (Pixobot, LLC, Lincoln, NE). Aerial imagery of Bowie buffalograss (*Buchloe dactyloide*), 4-Season Kentucky bluegrass (*Poa pratensis*), Apple GL perennial ryegrass (*Lolium perenne*), and Spyder tall fescue (*Festuca arundinacea*) was collected on 6 days approximately every 4 weeks from early April through late September. Imagery was collected in full sun between 1200 and 1400 hr. The NIR imagery was collected immediately following regular image capture. A CI and NDVI were calculated for each image using the RGB and NIR data. The CI was calculated as (NIR / Red) – 1 and NDVI calculated as (NIR – Red)/(NIR + Red), based on equations developed by previous researchers. Traditional DGCI (which does not use NIR) values were also calculated for comparison against CI and NDVI.

Turfgrass	Handheld CI vs:		Handheld NDVI vs:	
	Drone-CI	Drone-DGCI	Drone-NDVI	Drone-DGCI
Buffalograss	0.78	0.75	0.71	0.71
Kentucky bluegrass	0.87	0.80	0.80	0.79
Perennial ryegrass	0.84	0.73	0.82	0.72
Tall fescue	0.87	0.74	0.82	0.75

▲ **Correlations** of handheld chlorophyll index (CI) and normalized difference vegetation index (NDVI) sensors among drone-based CI, -NDVI, and -dark green color index (DGCI). (n = 184 each; all results were statistically significant at the 0.001 level)

Chlorophyll index and NDVI data were also collected using handheld sensors. The CI and NDVI were measured using a Spectrum Technologies FieldScout CM 1000 chlorophyll meter and FieldScout TCM 500 NDVI turf color meter, respectively. Scores were averages of three random measurements taken in the center of each plot. Handheld sensor data were collected the same days as aerial imagery.

Our results showed strong correlations between drone-based CI and NDVI and handheld sensor data (Table 1). On average, drone-based CI data were highly correlated (R ≈ 0.84) with handheld CI values across turfgrasses. Similarly, drone-based NDVI values were highly correlated (R ≈ 0.79) with handheld NDVI values across turfgrasses. The

Future implications of drones in sports turf management are ongoing. Drones could be programmed to take off, fly routine routes, and land at specified time intervals, providing automated turf data over time.

drone-CI and -NDVI values were better correlated with handheld sensors than DGCI in all but one case.

These results suggest drone-based imaging using regular and NIR-modified digital cameras can provide information equivalent to handheld sensors. This allows CI and NDVI data to be collected in a fraction of the time required for handheld collection. Though our study used water-stressed turf, many other stresses and cultural practices have been correlated with handheld CI and NDVI, suggesting other stresses can be equally detected with drone-based DIA. These results also show addition of an NIR component to DIA increases ability to measure "greenness," illustrated by the stronger correlations with handheld CI and NDVI sensors than DGCI, which does not use NIR data.

MONITORING CHANGES OVER TIME

Drones can provide additional information valuable to sports turf managers. By using drones, changes in turf can easily be monitored over time. Furthermore, using drones to create GPS-based maps can easily pinpoint areas of turf stress. This information can then be used by sports turf managers to address the problem, whether it is increasing an irrigation zone run time to alleviate localized drought stress or increasing nitrogen fertility to correct chlorotic turf. With DIA, it is possible to model and calculate corrective measures (i.e., nitrogen rate must be increased by 0.20 lbs N·1000 ft-2 to alleviate turf chlorosis) with little error and simple mathematics, minimizing waste.

Future implications of drones in sports turf management are ongoing. Drones could be programmed to take off, fly routine routes, and land at specified time intervals, providing automated turf data over time. Drones could automatically detect turf problem areas with onboard software and generate GPS-based maps on the fly. If networked wirelessly to irrigation controllers, drones could trigger site-specific irrigation events to correct for localized dry spots detected during flight in real time. Drones also can be used to gather information other than imagery. Thermal-infrared imaging or infrared thermometers can measure turf canopy temperatures, which can indicate water stress. At UNL, preliminary work has begun on engineering drones for weed-control technology. The goal is to program drones to automatically seek, detect, and spray weeds with onboard herbicides.

By providing a birds-eye view of turf, drones can quickly and efficiency gather useful information regarding turf status that can aid in management. Through DIA, drones can provide quantitative information about turf in a timely and efficient manner. Turf parameters such as "greenness" (via CI and NDVI), color, percent green cover, and various stresses can be detected quickly and easily. The information from drones can lead to better-informed decisions. Thus, drones offer many advantages to sports turf managers that ultimately save time, reduce labor, and lower costs. ■

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Make use of preemergence herbicides this spring

Summer annual weeds such as crabgrass and goosegrass commonly invade athletic field turf. The stress of foot traffic from athletic competition can leave athletic field turf susceptible to annual weed invasion (Figure 1). Crabgrass and goosegrass complete their life cycle in one year, germinating from seed in spring, growing throughout summer, and setting seed in fall. Summer annual weeds invading athletic fields need to be controlled in order to maximize field quality and safety.

An effective means for controlling summer annual weeds is the use of preemergence (PRE) herbicides in spring. A list of preemergence herbicides labeled for use on warm- and cool-season turfgrasses commonly found on athletic fields is presented in **Table 1**.

Weed control programs centered on the use of PRE herbicides offer many benefits to athletic field managers compared to eradicating these weeds with postemergence (POST) herbicides after they become established. For example:

• Athletic field managers have more herbicide options to control summer annual weeds PRE than POST.

• PRE programs are often more economical than POST programs that can require numerous sequential applications.

• Several PRE herbicides are available on fertilizer carriers allowing for granular applications to be made instead of liquid sprays.

Active Ingredient	Trade Name†	Formulations‡,¶	Labeled Species
prodiamine	Barricade	FL, WG	Bermudagrass Seashore Paspalum Tall Fescue Kentucky Bluegrass Perennial Ryegrass
dithiopyr	Dimension	EW, WP	Bermudagrass Seashore Paspalum Tall Fescue Kentucky Bluegrass Perennial Ryegrass
prodiamine + sulfentrazone	Echelon	SC	Bermudagrass Seashore Paspalum Tall Fescue Kentucky Bluegrass Perennial Ryegrass
pendimethalin	Pendulum	FL, G, EC	Bermudagrass Seashore Paspalum Tall Fescue Kentucky Bluegrass Perennial Ryegrass
pendimethalin + dimethenamid-P	FreeHand	G	Bermudagrass Seashore Paspalum
oxadiazon	Ronstar	G, FL, WSP	Dormant Bermudagrass (FL, WSP only) Bermudagrass (G only) Seashore Paspalum (G only) Tall Fescue (G only) Kentucky Bluegrass (G only) Perennial Ryegrass (G only)
indaziflam	Specticle	WSP, FL, G	Bermudagrass

† Active ingredients may be available under multiple trade names. Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the University of Tennessee Institute of Agriculture. The omission of a particular trade name is not intended to reflect adversely, or to show bias against, any product or trade name not mentioned.

‡ FL = flowable; WG = water dispersible granular; EW = concentrated emulsion; WP = wettable powder; WSP = water soluble powder; SC = soluble concentrate; G = granular (not on fertilizer).

¶ Many preemergence herbicides are sold on granular fertilizer carriers. Be sure to follow label instructions to ensure that the correct rates of active ingredient and nutrients are supplied to turf when using these materials.

▲ **Table 1.** List of herbicide active ingredients labeled for preemergence (PRE) control of annual grassy weeds in warm- and cool-season turfgrasses commonly used on athletic fields.

• Likelihood for undesirable turf injury with PRE herbicides is low compared to applying POST products to remove established weeds such as crabgrass and goosegrass.

THINGS TO REMEMBER WHEN USING PREs

#1- Application Timing: Be sure to apply PRE herbicides before weeds have emerged from soil (i.e., before they are visi-

John Mascaro's Photo Quiz

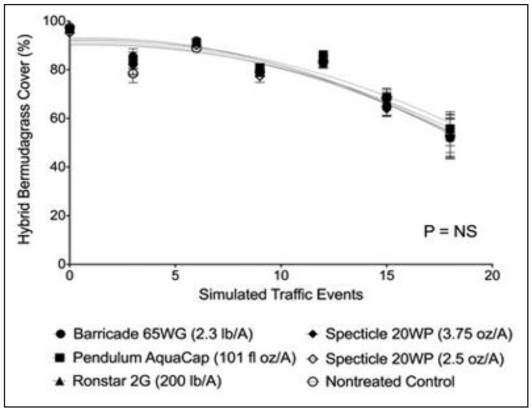
John Mascaro is President of Turf-Tec International

Can you identify this sports turf problem?

Problem: Cement pad on sideline
Turfgrass area: College football practice field
Location: Columbus, OH
Grass Variety: Perennial ryegrass and Kentucky bluegrass

Answer to John Mascaro's Photo Quiz on Page 33

Background illustration courtesy of istockphoto.com ble). These herbicides do not prevent weed seed germination; rather they prevent germinated seedlings from developing into mature plants. Considering that the timeframe between weed seed germination and weed emergence can be quite short, it is often recommended that PRE herbicides be applied once soil temperatures are favorable for crabgrass seed germination. Athletic field managers should make their first PRE herbicide application as soon as soil temperatures (at approximately 2 inches) measure ≥ 55°F for a minimum of 3 days in spring.



▲ **Left: Figure 1.** Effect of simulated traffic on weed encroachment into hybrid bermudagrass in Knoxville, TN during 2013. **Right: Figure 2.** Effect of PRE herbicide treatments in spring on hybrid bermudagrass cover after being subjected to simulated traffic events in fall in Knoxville, TN in 2012 and 2013. Data were combined to present the effects of single and sequential application regimes at the rates tested in both years. Standard error bars presented as a means of statistical comparison.

Researchers studied how the blooming of 74 different ornamental plants in spring corresponded with the emergence of crabgrass in turf. They concluded that blooming of border forsythias is a helpful indicator of when to apply PRE herbicides for crabgrass control. Border forsythias produces distinctive yellow blooms at soil temperatures similar to those that facilitate crabgrass seed germination and emergence. Thus, athletic field managers should be sure to apply PRE herbicides before forsythia plants have completed flowering each spring.

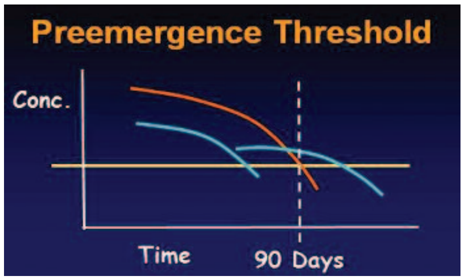
#2- Irrigation: A key to effectively controlling weeds with PRE herbicides is to water them into the soil after application. Most labels require that 0.25 to 0.50 inches of irrigation or rainfall be applied within 24 to 48 hours after application. These her-

Crabgrass plant's developmental stages

▲ **Forsythia** is in full bloom. The yellow petal drop has not started. *Photos and figure courtesy of Jeff Borger, Penn State*

▲ **Forsythia** yellow pedal drop has begun. About this time crabgrass will start to germinate.

▲ **Newly germinated** crabgrass in the spring of the year.



▲ **A visual** representation of the preemergence herbicide concentrations in the top ¼ inch of the soil profile following an application in the spring of the year.

bicides are absorbed by germinating weed seedlings in the soil, so moving them into the rootzone is critical. Failure to irrigate after application can also lead to material being lost due to volatilization. On fields without irrigation, try to time PRE herbicide applications around a period of rainfall.

#3- Split Applications: Split (also referred to as "sequential") application programs of PRE herbicides tend to provide more consistent control of summer annual weeds throughout a growing season, particularly in southern climates. These programs typically apply the total amount of active ingredient for the season in two equal rate applications spaced 8 to 10 weeks apart. A single herbicide application in spring for PRE control of crabgrass will slowly be broken down by soil microbial activity over the course of a summer often leading to crabgrass breakthrough by fall. Split application programs delivering active ingredient two times throughout a season tend to provide a longer period of control. Additionally, split application programs will control species germinating later in the year than crabgrass (e.g., goosegrass, etc.).

NO EFFECTS ON TRAFFIC TOLERANCE

Research has been conducted at the University of Tennessee Center for Athletic Field Safety (Knoxville, TN) evaluating the effects of four preemergence herbicides on Tifway hybrid bermudagrass traffic tolerance and recovery. Over the course of a 2-year study, no differences in smooth crabgrass control were detected among herbicide treatments after being subjected to athletic field traffic in spring; control measured 95 to 99% by 5 months after application. Additionally, these PRE herbicide applications for smooth crabgrass control had no effect on Tifway hybrid bermudagrass traffic tolerance to spring traffic.

Follow-up research at the University of Tennessee Center for Athletic Field Safety investigated the effects of PRE herbicide applications in spring on hybrid bermudagrass tolerance to traffic during the fall of the year. Similar to the initial study, PRE herbicide applications for summer annual weed control in spring had no effect on hybrid bermudagrass traffic tolerance in fall **(Figure 2).**

CONCLUSIONS

Numerous PRE herbicides are available for controlling annual grassy weeds on athletic fields. Always refer to the product label for specific information on proper use, tank-mixing compatibility and turfgrass tolerance. Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the University of Tennessee Institute of Agriculture. For more information on turfgrass weed control, visit the University of Tennessee's turfgrass weed science website at www.tennesseeturfgrass weeds.org.

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Field Science | By Stacie Zinn Roberts

From high school to the big leagues: ZOYSIAGRASS FOR SPORTS TURF

▲ **Dan Bergstrom** of the Houston Astros in action last season. *Photo courtesy of Houston Astros.*

At Rangers Ballpark in Arlington, TX home of the Texas Rangers, Dennis Klein, Director of Major League Baseball grounds, says he "would recommend zoysia." For several seasons, even during Word Series Games, the Rangers infield was grassed with Zeon Zoysia, and then Y2 Zoysia, both developed by Bladerunner Farms in Poteet, TX.

"It did great," Klein says. "Zoysia is a little slower to establish than bermudagrass, and slower for the seams to lock together, but once it's in there and established it's really hard to hurt. We put it in in June and wouldn't replace a piece of grass on it until after the season. We went through a couple of World Series with it. The cutout at first and third base, and in front of the pitchers mound, you could beat balls into it and it wouldn't divot. It's really tough grass."

Klein says the Rangers installed the zoysiagrass infield at the request of the pitching coach. "We had been putting zoysia every year on the infield grass because we were able to maintain it at a taller height of cut to slow the ball down. The pitching coach wanted it tall and the zoysia offers installing the power cords runs across that hill. Concerts are a tough week for that hill and it stands up. We've been really happy with the zoysiagrass in that role," he says. "There was one time at a concert, a forklift fork was shoved into the hill and tore the grass. We replaced the divot and it healed back over the winter. I wouldn't expect to grow warm season grass in the winter but even some November damage healed."

▲ **Opening Night** at Minute Maid Park in Houston, March 31, 2013. *Photo courtesy of Houston Astros.*