GDD based PGR applications

Precise PGR applications on greens

To suppress turfgrass yield throughout the season, use growing degree days to schedule Primo Maxx applications.

Over the past two decades, repeated applications of plant growth regulators (PGRs) have become a staple of putting green management. Golf course superintendents use products such as Primo Maxx (trinexapac-ethyl, Syngenta), Trimmit (paclobutrazol, Syngenta) and Cutless (flurprimidol, SePro) to reduce clipping yield, increase ball-roll distance and enhance turfgrass visual quality through increased color and stand density (3). Although use of plant growth regulators is widespread, superintendents employ a variety of application rates and reapplication frequencies, especially on cool-season greens.

Suppression, rebound and efficacy

Plant growth regulators alter clipping yield in two distinct phases: the suppression phase followed by the rebound phase (4). The suppression phase occurs after a PGR application and is associ-

weather. This means that calendar-based reapplication intervals are not an efficient way to sustain yield suppression.

Growing degree day models

The alternative to imprecise, calendar-based applications is to apply PGRs based on plant metabolism or rate of PGR breakdown. Growing degree day (GDD) models provide a simple way to estimate plant metabolism since PGR degradation is enhanced as temperature increases. To calculate GDD, the daily high and low air temperatures are averaged together, subtracted from a base temperature where metabolism is minimal, and added to values from the previous GDD total. The objective of this research was to determine whether a GDD model could predict trinexapac-ethyl degradation on creeping bentgrass (*Agrostis stolonifera*) greens. The ultimate goal was to determine

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GDD based PGR applications

The rates presented in the **Application Rate Table** provide approximately 50% growth inhibition over a 4-week period with little or no discoloration of turf growing under favorable conditions.

Application Near and Around Monuments and Hardscape Materials:
Primo MAXX, at normal dilution rates, will not stain brass, bronze, concrete, marble, granite, or other types of stone. Before using Primo MAXX around other materials, test on a small scale basis first.

NOTICE TO USER: Plant tolerances to Primo MAXX have been found to be acceptable for the grasses listed on this label. Due to the large number of species and cultivars of grasses, it is impossible to test every one for tolerance to Primo MAXX. Neither the manufacturer nor the seller has determined whether or not Primo MAXX can be used safely on grasses not specified on this label. The professional user should determine if Primo MAXX can be used safely prior to commercial use. Before using Primo MAXX for grasses not listed in the application table, test Primo MAXX on a small scale first. Apply the lower rate for the turf setting (lawn, fairway, etc.) and evaluate for phyto-toxicity and growth inhibition to widespread use.

Notes: (1) Areas treated with Primo MAXX should continue to receive regular maintenance practices, including irrigation; fertilization; and weed, disease, and insect control when necessary, and as recommended for quality turf. Because some herbicides can injure turf, tank mixes with Primo MAXX should be tested on a small scale before widespread use. (2) Primo MAXX may cause temporary yellowing. This usually disappears about one week after application. To minimize yellowing and to enhance the green color of turf, apply readily available nitrogen at 0.2-0.5 lb of actual nitrogen per 1,000 sq ft. If desirable, rates of iron per 1,000 sq ft can also be used. (3) Full growth regulation by Primo MAXX begins at about 3-5 days after application.

APPLICATION PROCEDURES / RESTRICTIONS

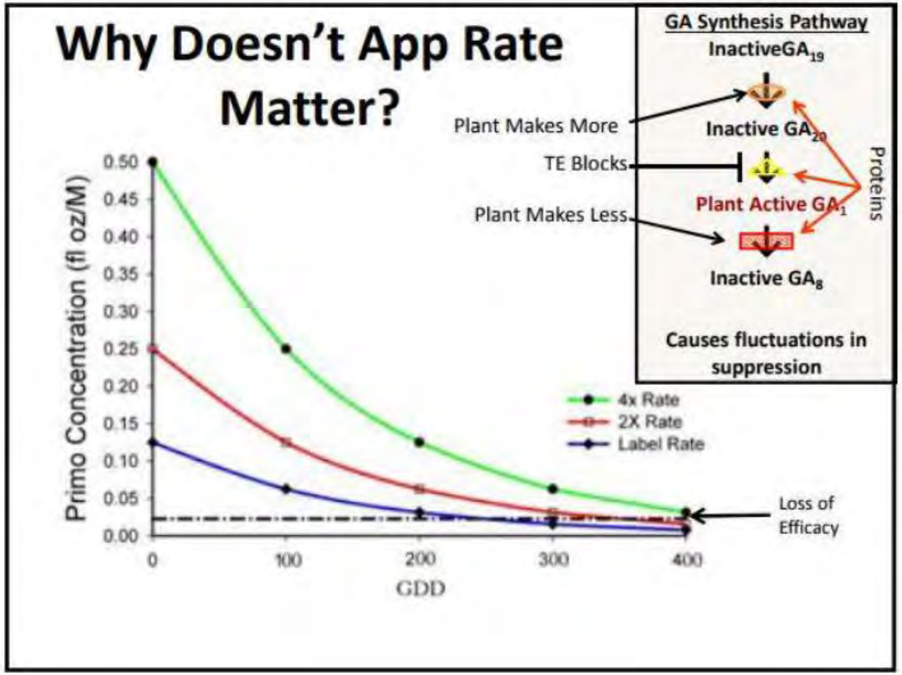
Applications of Primo MAXX can be made as frequently as weekly during the growing season, however, **DO NOT exceed a total of 7.0 fl oz/1,000 sq ft (305 fl oz/A; 19.0 pt/A) per year.**

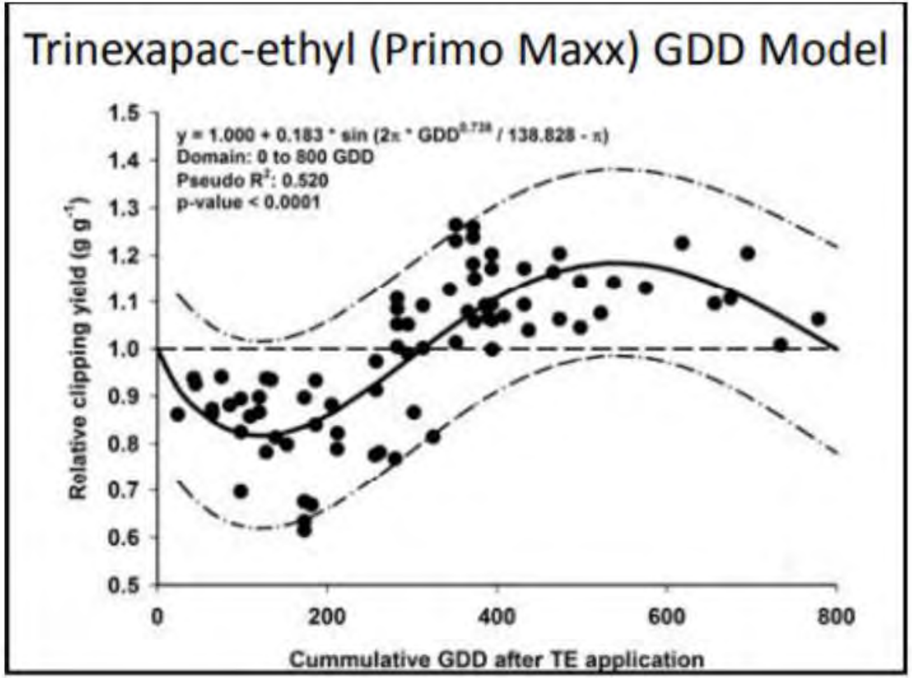
GDD calculations – Base 0 degrees Celsius

1. Add high and low temperature for the day
2. Calculate the average
3. Keep a running total

4. Example – High temp 30; low 20 = 25 GDD

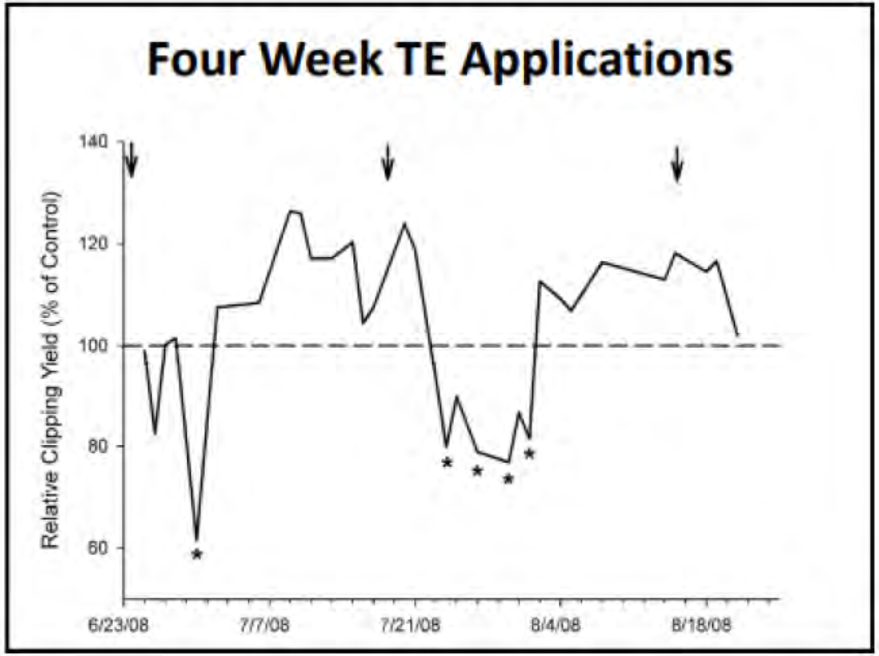
GDD based PGR applications: T-ethyl

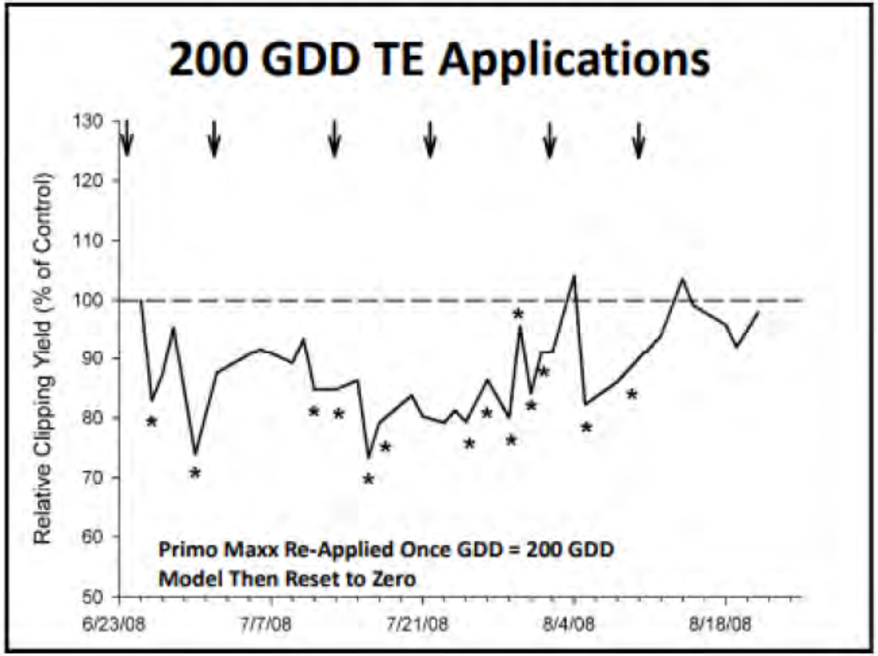




Dr. Kreuser, Univ. Nebraska

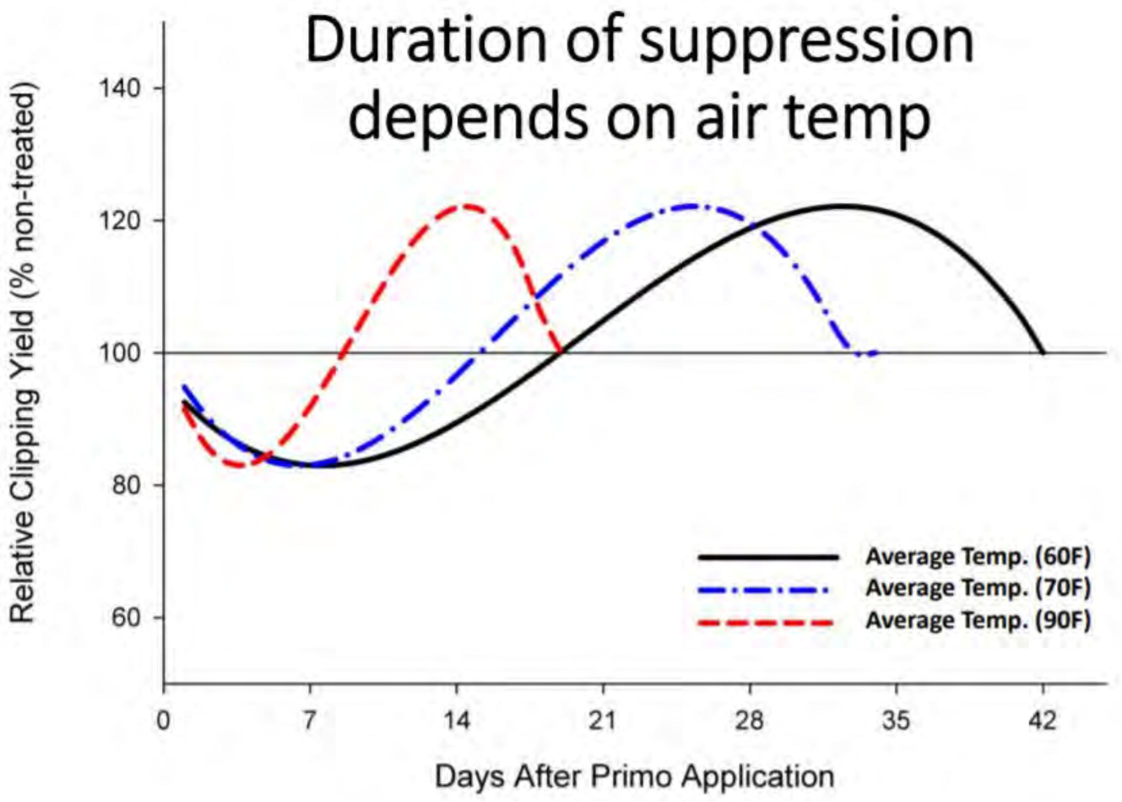
GDD based PGR applications





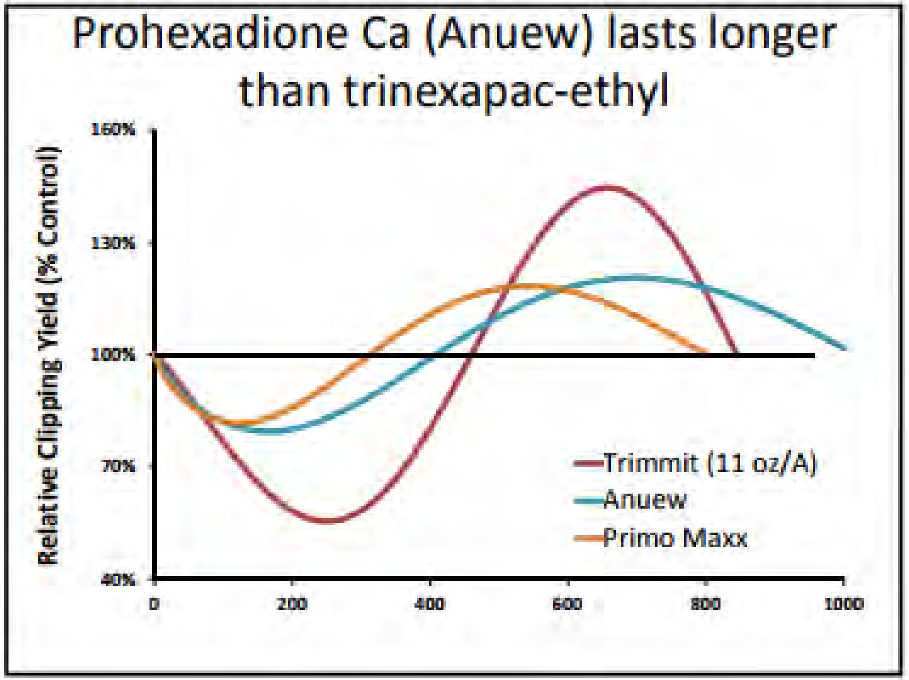
Dr. Kreuser, Univ. Nebraska

GDD based PGR applications



Anuew – Class A

- 300 GDD vs. 200 GDD (t-ethyl)
- Used on ultradwarf greens to regulate off types
- Longer regulation means less spraying
    - Can overregulate with weekly applications



https://turf.unl.edu/Presentations/2014NEConference/GDD-Presentation-Slides.pdf

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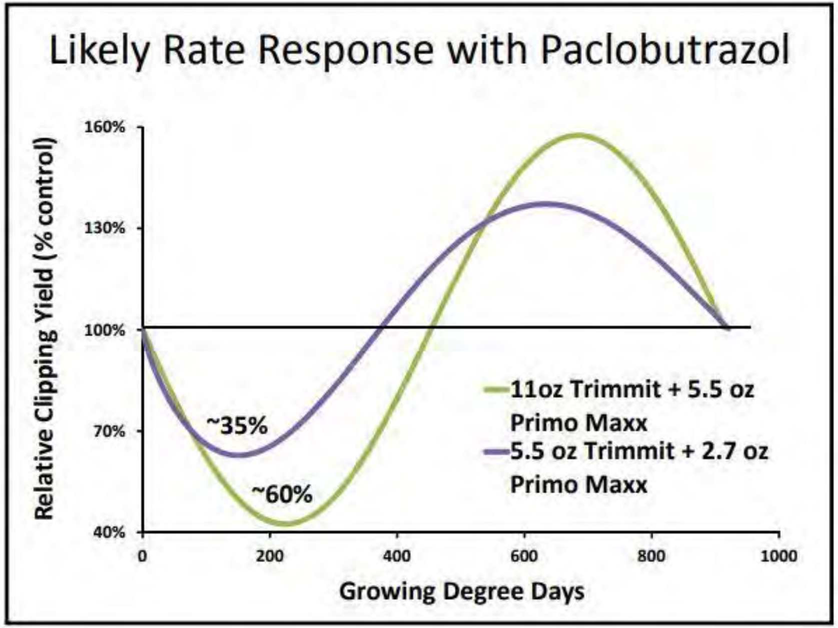
What about Class B regulators?

- Longer regulation
- Trimmit (Cultar)
  - Rate affects duration
  - 16 oz/A (1170mL/ha) = 310 GDD
  - 5.5 oz/A (400mL/ha) = 280 GDD



https://turf.unl.edu/Presentations/2014NEConference/GDD-Presentation-Slides.pdf

HOC impacts reapplication interval

Active Ingredient	Common Name	PG ideal GDD	FWY ideal GDD
Trinexapac-ethyl	Primo Maxx	200	350-380
Paclobutrazol	Trimmit	280-310	480-640
Flurprimidol	Cutless	210-270	380-410
Prohexadione-Ca	Anuew	280	350-380
Flurprimidol+ Trinexapac-ethyl	Legacy	270-300	320-390
Flurprimidol+ Trinexapac-ethyl+ Paclobutrazol	Musketeer	290	350-400

Avoid excessive growth during “rebound” phase

Avoid overregulation during spring, fall and winter

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Reduces overregulation of collars

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Reduces overregulation of collars

Dr. Bill Kreuser – Univ. Nebraska

Collar Decline Research

PGRs Applied at Green Rates/Intervals on a Creeping Bentgrass Fairway

- Primo Maxx – 5.5 fl oz/M @ 200 GDD
- Trimmit 2SC – 8.0 fl oz/M @ 260 GDD

These intervals typically suppression bent greens by **20 and 35%**, respectively.

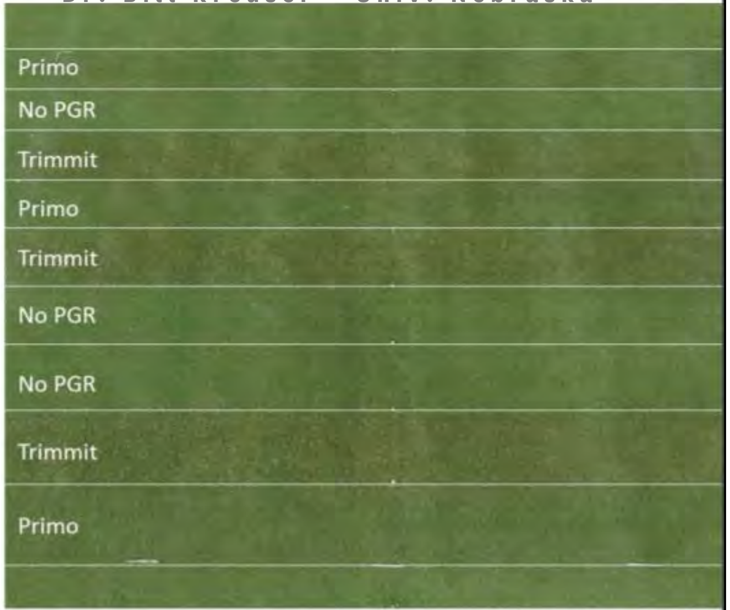
Picture Date:	6/5/17
Primo Maxx	Trimmit 2SC
5/10	5/10
5/22	5/26

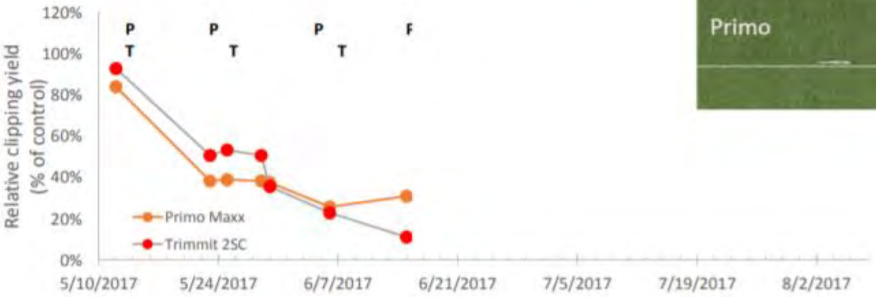
Reduces overregulation of collars

Dr. Bill Kreuser – Univ. Nebraska

One week later, phytotoxicity is becoming more apparent

Suppression 70-90%





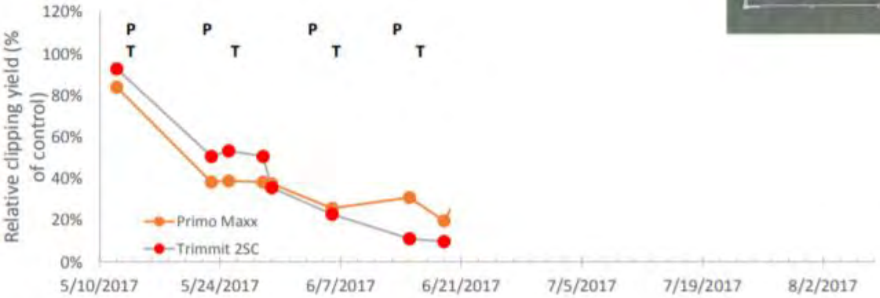
Picture Date:	6/14/17
Primo Maxx	Trimmit 2SC
5/10	5/10
5/22	5/26
6/5	6/7

Reduces overregulation of collars

Dr. Bill Kreuser – Univ. Nebraska

Six weeks of greens PGR rates and intervals causes severe phytotoxicity on collars

Suppression 80-95%



Picture Date:	6/21/17
Primo Maxx	Trimmit 2SC
5/10	5/10
5/22	5/26
6/5	6/7
6/14	6/16

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Potential solutions for overregulation of collars

1. Reduce HOC
2. GPS sprayer with individual nozzle control
3. Wash off collars after application
4. Turn booms off before they reach collar, not after they exit

Greenkeeper App to track GDD

GREENKEEPER

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Product Tracking & Alerts

The GreenKeeper App automatically keeps track of product efficacy, including PGR breakdown with GDD models, and notifies you when control has expired for one of your products.

Nutrient Management

Use GreenKeeper to track your fertilizer applications and monitor changes in soil and tissue test results over time. We have partnered with Rock River Labs to provide full integrated testing experience. Select a test type, enter the site information, print a label, and view your results directly in GreenKeeper a few days after they are received by the lab. Prices range from $20 to $50 and Premium members receive a 10% discount.

Performance Tracker

Turfgrass managers record a lot of data to help make management decisions. Managing that data manually can sometimes be challenging. With the Performance Tracker, managers and maintenance crew members can directly enter green speed, clipping volume, average soil moisture, color, etc. Crew entered data is approved by the course managers to ensure quality before it is then displayed graphically within GreenKeeper. This is a Premium feature and will improve your management precision.

Pest Outbreak Models

GreenKeeper uses hyper-local weather data to help predict pest outbreaks. The Smith-Kerns dollar spot model is now fully integrated into the site. Set your risk threshold and see what cool-season turfgrass areas are protected or at risk of a dollar spot outbreak.

Product Applications Log

You can select an area of your course to treat and choose products and application rates from an extensive turf product database. Then, watch the GreenKeeper App calculate how much product goes into a sprayer tank, the number of tanks needed, and the number of gallons in the mix. When you are done, you can print off an easy to read report with mixing instructions!

Multiple Users

Turf management professionals need to work together and the GreenKeeper App makes it very easy! Just give the App an email and it will add that professional to your course!

Pest Reports

You can tag a target pest (curative or preventative) to the products you add to your turf or report pest outbreaks directly to help other turf managers prepare for potential problems. Then, the GreenKeeper App (with the help of it's users) compiles maps showing the relative locations of recently reported pests.

Desktop & Mobile Friendly

Designed to efficiently function on both desktop computers and mobile devices, the GreenKeeper App allows users to quickly reference prior applications and monitor pest control while on the course. Have confidence that your mixing calculations are correct and know your turf is covered at any time by simply looking at your phone!

Weather Reporting

The GreenKeeper App monitors the weather so that you don't have to. It's unique tools takes into account local weather conditions and gives you a hyper-local view of how your product application is doing and when it is time to reapply.

Excel file to track GDD

Temperature Unit	Fahrenheit
Select PGR	Primo Maxx
Enter Rate (oz/acre)	8
Default GDD Interval	200
Use the Default GDD Interval?	Yes
[illegible]	
User Defined GDD Interval (0 to 600 GDD)	250

Date	Observed High Temperature	Observed Low Temperature	PGR Applied	Daily GDD	Cummulative GDD	Approximate Relative Yield	Required Action	Forecasted Temp High	Forecasted Temp Low
8/25/2016	91.0	74.0	No PGR Applied	28.1	28.1	96%	None		
8/26/2016	89.0	73.0	No PGR Applied	27.2	55.3	92%	None		
8/27/2016	89.0	74.0	No PGR Applied	27.5	82.8	88%	None		
8/28/2016	91.0	72.0	No PGR Applied	27.5	110.3	86%	None		
8/29/2016	92.0	74.0	No PGR Applied	28.3	138.6	84%	None		
8/30/2016	91.0	72.0	No PGR Applied	27.5	166.1	83%	None		
8/31/2016	90.0	73.0	No PGR Applied	27.5	[illegible]	84%	None		
9/1/2016	89.0	71.0	No PGR Applied	26.7	[illegible]	85%	Re-apply PGR		
9/2/2016			No PGR Applied			100%			
9/3/2016			No PGR Applied			100%			
9/4/2016			No PGR Applied			100%			
9/5/2016			No PGR Applied			100%			
9/6/2016			No PGR Applied			100%			
9/7/2016			No PGR Applied			100%			
9/8/2016			No PGR Applied			100%			
9/9/2016			No PGR Applied			100%			

Instructions | High-Low Temp Option | Mean Temp Option | Sprayer Calculator

Emerging Trends and Technologies

MLSN vs. SLAN

Sufficiency Level of Available Nutrients (SLAN)

- Developed for agriculture crops
- Fertilize to bring soil nutrient content to an optimum range
- Then sustain that level for the long run
- MAXIMIZE PLANT GROWTH

USGA®

MLSN


PACE TURF
INFORMATION CENTER
Member Login
Username
Password
Login
Remember me
Forgot password?
Not a member?
Take a Tour | Sign Up
Home
Super Journal
Tour
Gallery
Updates
Weather
Highlights
Insights
Reference
Clubhouse Editions
Minimum Levels for Sustainable Nutrition Soil Guidelines (MLSN)
Soil,
Reference
Minimum Levels for Sustainable Nutrition Soil Guidelines
Increased economic and environmental pressures have caused many of you to re–assess the way you manage turf. With fertilizers as one of the bigger inputs, we felt that it was time to review and revise our current soil guidelines to reflect these changes. The result is the "Minimum Level for Sustainable Nutrition" (MLSN) soil guidelines, a new, more sustainable approach to managing soil nutrient levels that can help you to decrease inputs and costs, while still maintaining desired turf quality and playability levels. Used in conjunction with Climate Appraisals and Growth Potential, annual fertilizer needs can be estimated.
Working together with Dr. Micah Woods of the Asian Turfgrass Center, the guidelines were produced through review of key soil nutrient data from thousands of turf soil samples. Based on our evaluations, we determined that in many cases, guidelines could be safely lowered without a dramatic impact on turf quality or playability.
Search PACE Turf
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MLSN

- Not designed to maximize turf growth

Reference

September, 2014

Minimum Levels for Sustainable Nutrition Soil Guidelines

The Minimum Level for Sustainable Nutrition (MLSN) Guideline is a new, more sustainable approach to managing soil nutrient levels that can help you to decrease fertilizer inputs and costs, while still maintaining desired turf quality and playability levels. The MLSN guidelines were developed in a joint project between PACE Turf and the Asian Turfgrass Center. All soil analyses were conducted at Brookside Laboratories, New Bremen, OH.

	MLSN Soil Guideline
pH	>5.5
Potassium (K ppm)	37
Phosphorus (P ppm)	21
Calcium (Ca ppm)	331
Magnesium (Mg ppm)	47
Sulfur as sulfate (S ppm)	7

Nitrogen requirements are best determined based on **turf growth potential**, which incorporates site-specific weather and turf type to calculate nitrogen demand (Gelernter and Stowell, 2005. Golf Course Management, p. 108-113, March, 2005).

Contrasting MLSN guidelines with SLAN categories

	MLSN	SLAN Categories†	
	Soil Guideline*	Very Low	Low
	---------------------- ppm ----------------------		
Potassium (K)	37	0-20	21-40
Phosphorus (P)	21	0-12	13-22
Calcium (Ca)	331	0-307	308-503
Magnesium (Mg)	47	0-22	22-41
Sulfur	7		< 15 ‡

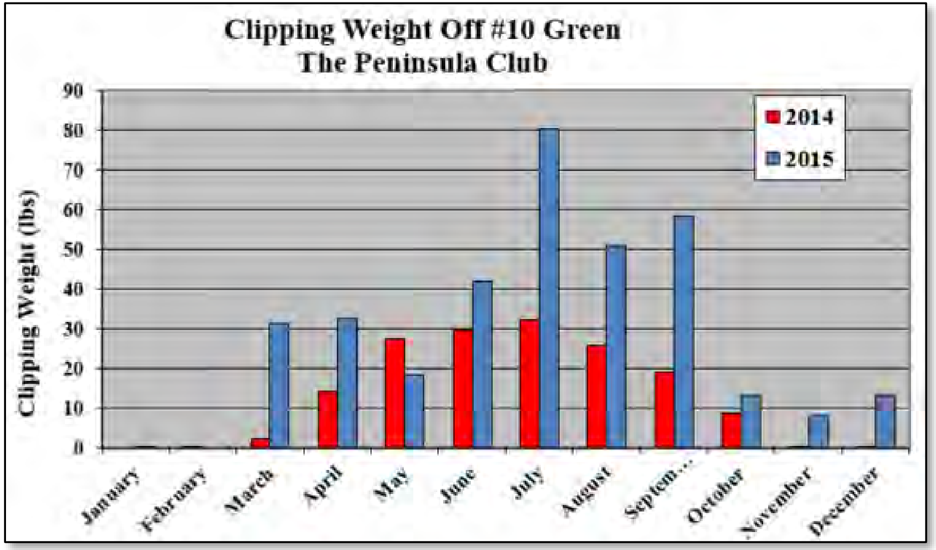
* Data applies to soil with pH between 5.5 and 8.5

† Rutgers Soil Testing Lab.

‡ Carrow, Waddington & Rieke. 2001.

Measuring Clipping Yields from Greens

- Data is better than a visual assessment
- Green speed, topdressing, mowing, rolling, verticutting, PGR apps and soil conditions
- Clippings from the 10th green daily
- Weight or volume can be measured quickly
- Compare clipping data with cultural practices
- START SLOW



Measuring Clipping Yields from Greens

- Measure volume with 5 Gal bucket, or use measuring cups

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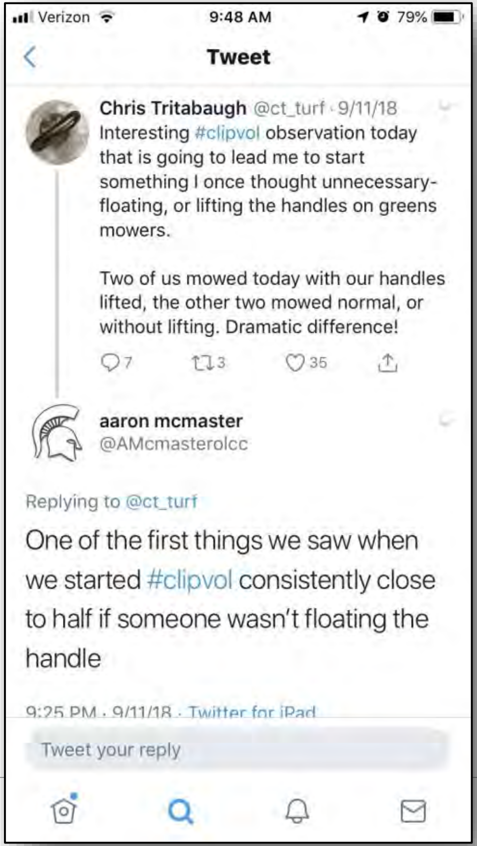
Clipping Yield – Using the data

- Understand relationship between performance and growth.
  - Fert rates, growing environments, PGR rates, TD rates, mower setup, etc.
  - Adjust maintenance according to growth
- Operator error (heavy hands)
- The future…



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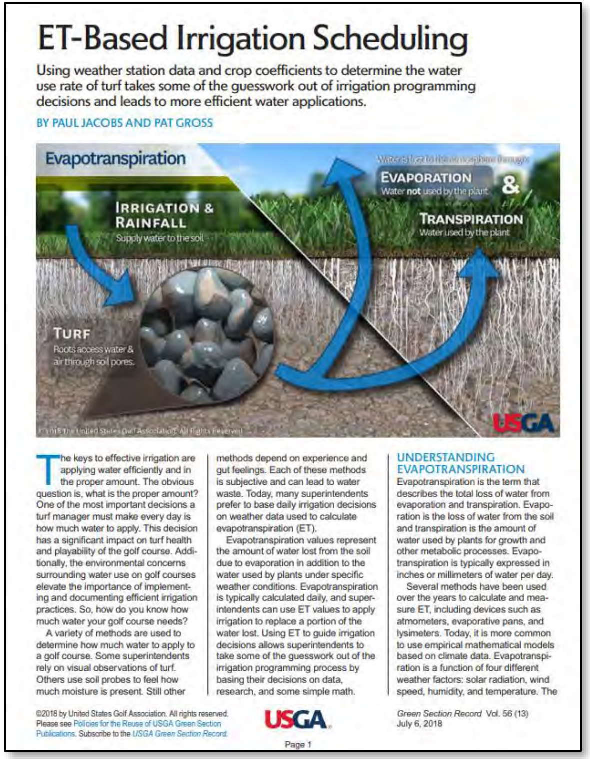
Water Management

- Managing for playing conditions, not color
- ET-based water management
  - Reference ET from a weather station
  - Crop coefficient – e.g., 60%, 70%, 80%

<u>Example</u>

- Hot, windy summer day results in ET 0.23 inches
  - 0.23 inches x 0.8 = 0.184 inches of irrigation



ET-Based Irrigation Scheduling

Using weather station data and crop coefficients to determine the water use rate of turf takes some of the guesswork out of irrigation programming decisions and leads to more efficient water applications.

BY PAUL JACOBS AND PAT GROSS

The keys to effective irrigation are applying water efficiently and in the proper amount. The obvious question is, what is the proper amount? One of the most important decisions a turf manager must make every day is how much water to apply. This decision has a significant impact on turf health and playability of the golf course. Additionally, the environmental concerns surrounding water use on golf courses elevate the importance of implementing and documenting efficient irrigation practices. So, how do you know how much water your golf course needs?

A variety of methods are used to determine how much water to apply to a golf course. Some superintendents rely on visual observations of turf. Others use soil probes to feel how much moisture is present. Still other methods depend on experience and gut feelings. Each of these methods is subjective and can lead to water waste. Today, many superintendents prefer to base daily irrigation decisions on weather data used to calculate evapotranspiration (ET).

Evapotranspiration values represent the amount of water lost from the soil due to evaporation in addition to the water used by plants under specific weather conditions. Evapotranspiration is typically calculated daily, and superintendents can use ET values to apply irrigation to replace a portion of the water lost. Using ET to guide irrigation decisions allows superintendents to take some of the guesswork out of the irrigation programming process by basing their decisions on data, research, and some simple math.

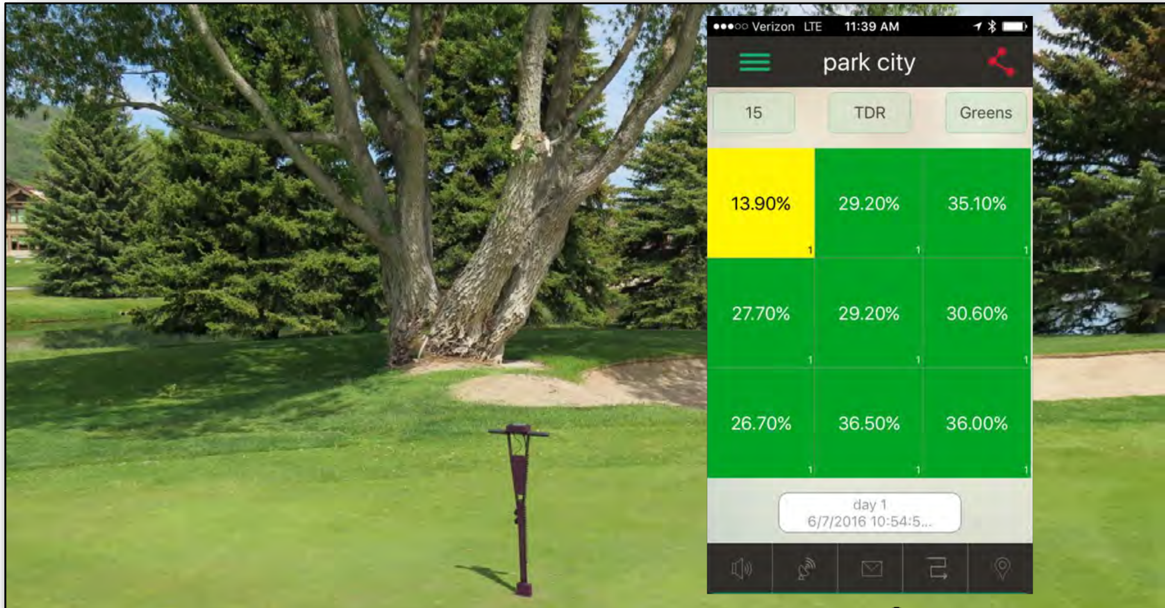
UNDERSTANDING EVAPOTRANSPIRATION

Evapotranspiration is the term that describes the total loss of water from evaporation and transpiration. Evaporation is the loss of water from the soil and transpiration is the amount of water used by plants for growth and other metabolic processes. Evapotranspiration is typically expressed in inches or millimeters of water per day.

Several methods have been used over the years to calculate and measure ET, including devices such as atmometers, evaporative pans, and lysimeters. Today, it is more common to use empirical mathematical models based on climate data. Evapotranspiration is a function of four different weather factors: solar radiation, wind speed, humidity, and temperature. The

Water Management

- Most are using portable moisture meters to guide IRR decisions.
  - Measuring what's actually there vs. theoretical.
  - Weather stations – a thing of the past?



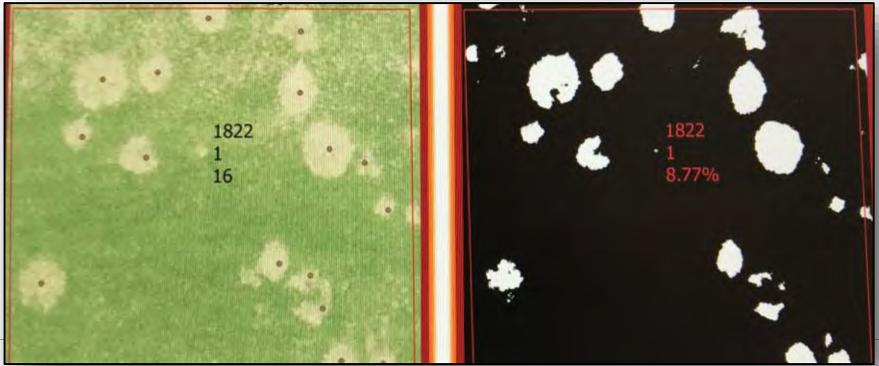
Spectrum TDR 300® Moisture Meter

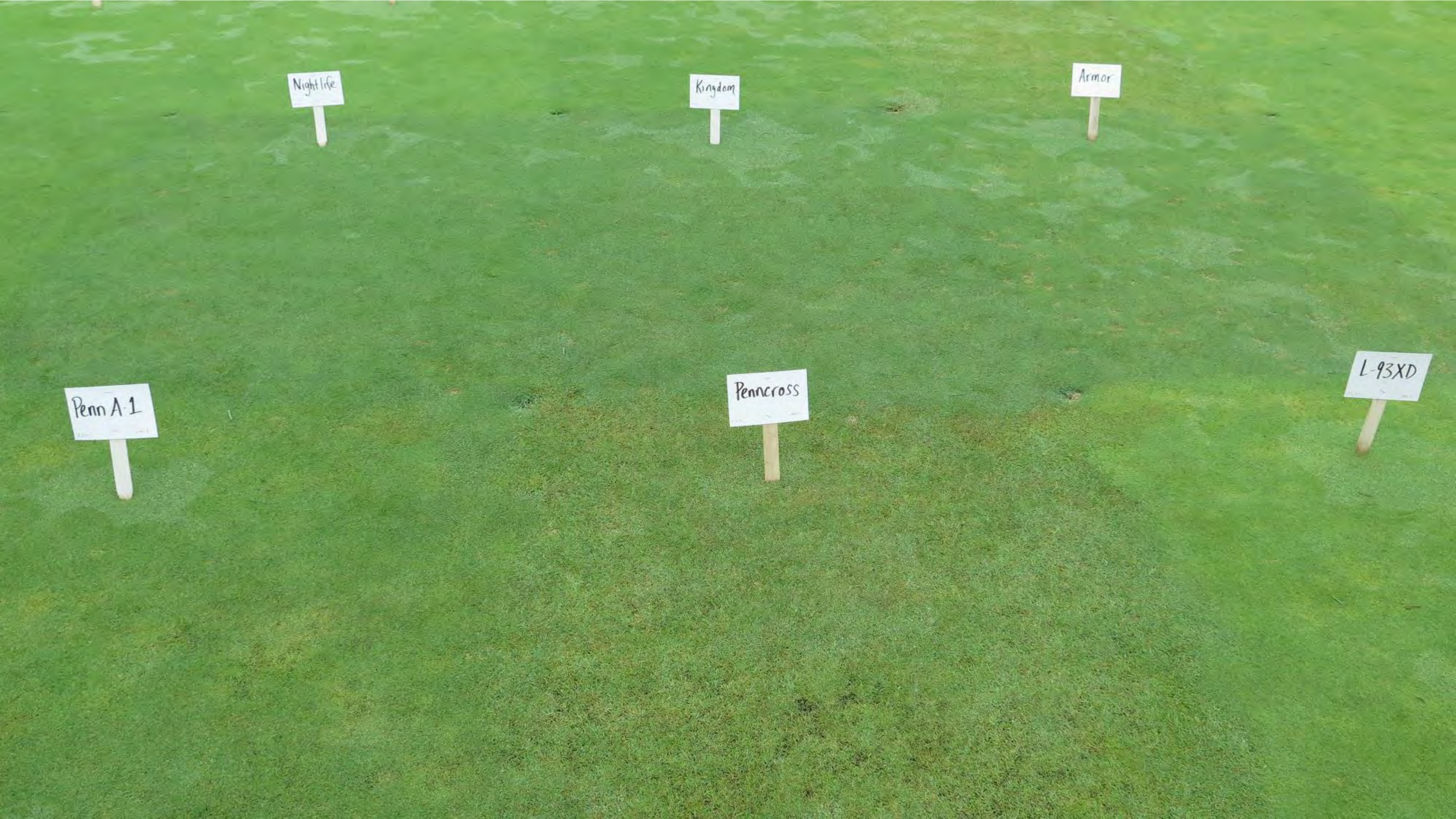
Drones for Turf Performance Monitoring

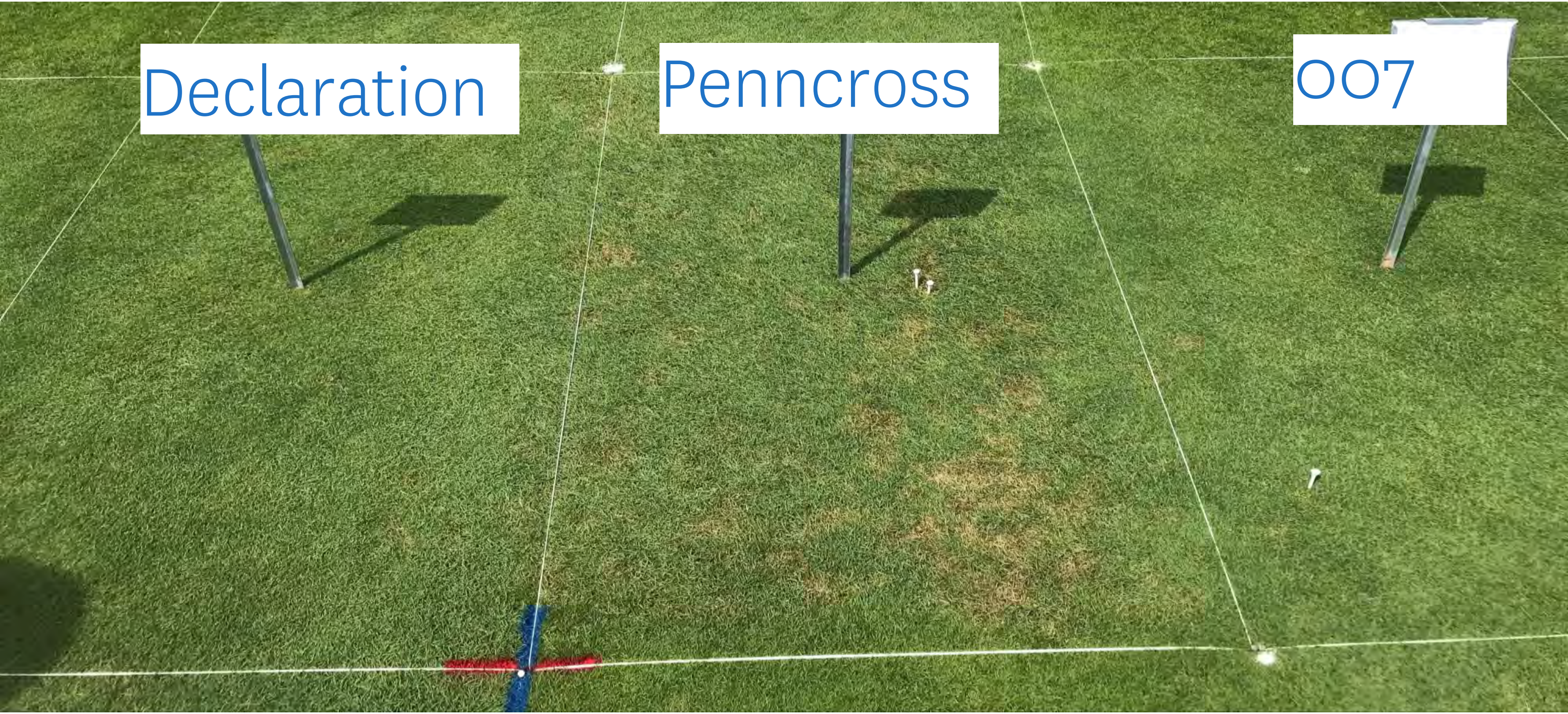
- Unique perspective
- Monitor turf stress and performance
- Troubleshoot problems
    - Moisture?
    - Cart traffic?
    - Disease?
- Logistical challenges with location, weather, pilot license, etc.

Future of Drone Use

- VA Tech research – mapping spring dead spot on bermudagrass and applying preventatively only where disease is present. (Combines GPS sprayer + Drones)
- Sensors to PREDICT moisture stress before it happens




Nightlife
Kingdom
Armor
Penn A-1
Penncross
L-93XD


Declaration
Penncross
007

Summary

- Managing turf begins with sound fundamental practices.
  - Environment, Drainage and OM management.
- New technology improving efficiency and quality of turf surfaces.
  - Robotic mowers
  - GPS sprayers
  - GDD PGR models
- Emerging trends focus on science and technology.
  - MLSN, ClipVol, Moisture meters, Drones/sensors

Questions?

Paul Jacobs

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