

FOUNDATION NEWS

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PRESIDENT'S MESSAGE



*Ken Lochridge, President of
Tri-State Turf Research Foundation*

2026 Research Priorities: Strengthening Golf and Environmental Stewardship

The Tri-State Turf Research Foundation exists to support independent, science-based research that strengthens golf while protecting our environment. For more than three decades, the foundation has served as a critical link between academic research and practical, on-course application—ensuring superintendents have access to regionally relevant data they can trust.

As I begin my term as president, I am honored to build on the strong leadership, collaboration, and shared commitment that have guided the foundation and advanced meaningful research across the tri-state area.

RESEARCH PLANS FOR 2026

Golf course superintendents across our region face growing pressures—from emerging turf diseases and increased water-use scrutiny to evolving maintenance practices and environmental stewardship. The foundation remains committed to funding practical, regionally relevant research that delivers real-world solutions superintendents can apply with confidence.

With the completion of a study conducted at Cornell, the Tri-State board approved a focused and forward-looking research portfolio, including four new studies

designed to deliver value across a wide range of facilities and management strategies.

NEW RESEARCH PROJECTS

Management of Yellow Ring Disease on *Poa* Greens

University of Connecticut – Dr. John Inguagiato

This project seeks to identify effective chemical and cultural strategies to manage an emerging and poorly understood disease threatening annual bluegrass putting greens throughout the Northeast.

Remote-Sensing Guided Precision Irrigation

Rutgers University – Dr. Bingru Huang

This research will use drone-based, multispectral remote sensing to improve irrigation efficiency, reduce water use, and provide data-driven tools to support BMP compliance and regulatory discussions.

Yellow Bumble Bee (*Bombus fervidus*) Conservation Study

University of Rhode Island – Dr. Steven Alm

This three-year study will evaluate how golf courses can provide meaningful habitat for a species of greatest conservation need, offering practical guidance on pollinator-friendly management and environmental stewardship.

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TURF RESEARCH FOUNDATION

Stepping Up the Game, Year Two

Cornell Researchers Investigate the Influence of Golf Footwear and Maintenance Practices on Putting Surface Quality

Golf course superintendents continue to pursue championship-level playing conditions, yet golfer foot traffic remains an unavoidable source of putting surface disruption (PSD). As traction systems in golf footwear evolve, questions persist about how these designs—along with maintenance practices—influence surface performance.

With support from the Tri-State Turf Research Foundation, Cornell's Dr. Frank Rossi and his team of agronomists and data scientists completed the second and final year of a two-year investigation into how modern golf footwear interacts with putting surface types and management programs throughout the Tri-State region.

Year One established foundational relationships between footwear type and surface disruption. Year Two expands this work by:

- » Increasing the number of facilities examined
- » Incorporating enriched USGA GS3 data
- » Modeling how maintenance practices influence traffic tolerance
- » Evaluating objective measures alongside golfer perception

Putting surface types included creeping bentgrass (*Agrostis spp.*), *Poa annua* (*Poa annua L.*), and mixed stands, all managed under peak growing-season conditions.

OBJECTIVES

- 1:** Quantify putting surface disruption associated with modern golf footwear designs.
- 2:** Identify maintenance and surface characteristics that influence traffic tolerance and playability.

METHODOLOGY

TRAFFIC TRIALS

Traffic trials were conducted at 16 championship-level golf facilities:

- 1:** Four in **Connecticut** (Connecticut Golf Club, Fairview Country Club, The Country Club of Darien, The Stanwich Club)
- 2:** Four in **New Jersey** (Arcola Country Club, Edgewood Country Club, Paramus Golf Course, The Ridgewood Country Club)
- 3:** Six in **New York** (Bethpage Black, Glen Oaks Club, Meadow Brook Club, Westchester Country Club, Wheatley Hills Golf Club, Winged Foot Golf Club)
- 4:** One in **Minnesota** (Hazelton National Golf Club) during the United States Amateur Championship

At each facility:

» **Participants were asked the following questions:**

1. What is the height of cut?
2. How many times per week are greens mowed?
3. Is the surface walk-mown or triplexed?
4. How many times per week are greens rolled?
5. What type of roller is used?
6. How often and at what rate is Nitrogen applied?
7. How often and at what rates are growth regulators applied?
8. How often is the surface irrigated?
9. Do you measure clipping volume? If so, what are typical clipping volumes?
10. When was the surface last verticut?
11. When was the surface last topdressed?
12. When was the surface last aerated?

» Five footwear treatments were applied.

» A test subject known for aggressive walking completed 140 simulated rounds per footwear type, circumnavigating the hole location (where 85% of foot traffic occurs).

» Nontrafficked control plots were measured for comparison.

Footwear Categories

- 1: Replaceable Traction Elements (RTE):**
Traditional spiked shoes
- 2: Fixed Traction Elements (FTE):**
Spikeless shoes
- 3: Combination (FTE + RTE):**
Hybrid traction systems

DATA COLLECTION

SURFACE PERFORMANCE METRICS

The researchers assessed the impact of footwear on the putting surface through various tests.

1: Visual Spike Damage (VSD): Visually assessed on a scale of 1 to 5 where 1 = extreme disruption, 2 = severe disruption, 3 = moderate disruption, 4 = mild disruption, and 5 = no visible disruption.

2: The Bobble Test: Assessed according to Linde et. al, (2017) where 1 = many bobbles and much snaking, 5 = some bobbles and snaking, 9 = one bobble or snake, and 10 = no bobble or snaking.

3: USGA GS3 Ball Measurements:

The GS3 ball measured surface disruption by tracking green speed (stimp measurement), smoothness (vertical disruption), and trueness (lateral disruption). Smoothness and trueness values are both more desirable when they are lower.

» The ball was rolled six times in each plot after traffic was imposed (three in one

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direction, three in the opposing direction), with the average for each metric taken across the six rolls.

USGA GS3 ENRICHED DATA ACQUISITION

Through collaboration with USGA Green Section Data science staff, raw accelerometer data were obtained, allowing calculation of:

- » Bump count (part of smoothness estimate)
- » Bump magnitude (part of smoothness estimate)
- » Snake count (part of trueness estimate)
- » Snake magnitude (part of trueness estimate) (Figure 1)

SUPPORTING SURFACE DATA

- » **Volumetric water content:** VWC was measured using a TDR 350 soil moisture meter to a 3-inch depth
- » **Firmness:** measured in nontrafficked plots using the GS3 ball dropped from USGA housing
- » **Poa percentage:** visual estimate in each trafficked and nontrafficked plot
- » **Soil Sample:** OM2 method involves combusting the entire soil sample to determine total percent, by weight of organic material in the top 2 centimeters of soil

RESULTS

1: Visual Spike Damage

Most golfers begin to form a perception of putting surface disruption (PSD) through a visual assessment of the surface. The visual spike damage (VSD) rating used in this study approximates that subjective evaluation from a golfer. Testing showed:

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Trueness and Smoothness

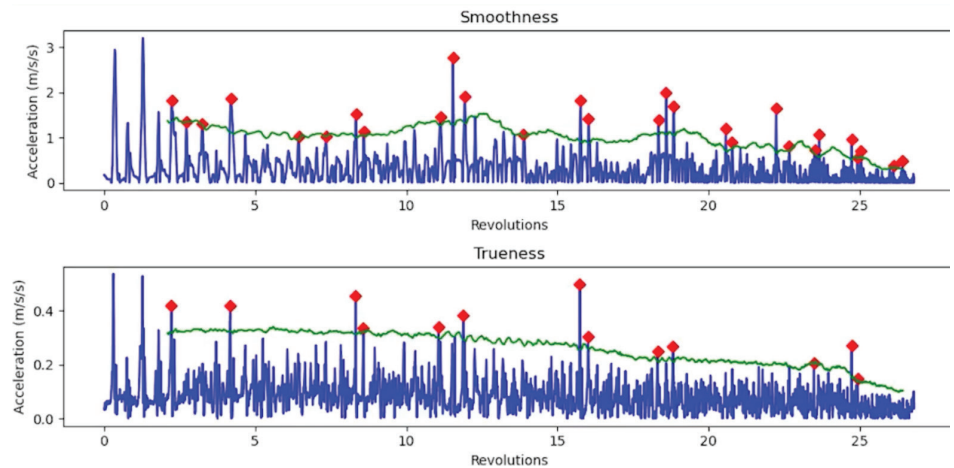


FIGURE 1

Enriched data from a single roll, visualized by Wes Stewart (USGA Data Scientist). Red dots indicate events during the roll that are outside the normal band of disruption experienced that are marked as Bumps (top graph) or Snakes (bottom graph). The magnitude of those events is measured by an accelerometer in units of m/s².

Spike Damage by Shoe type

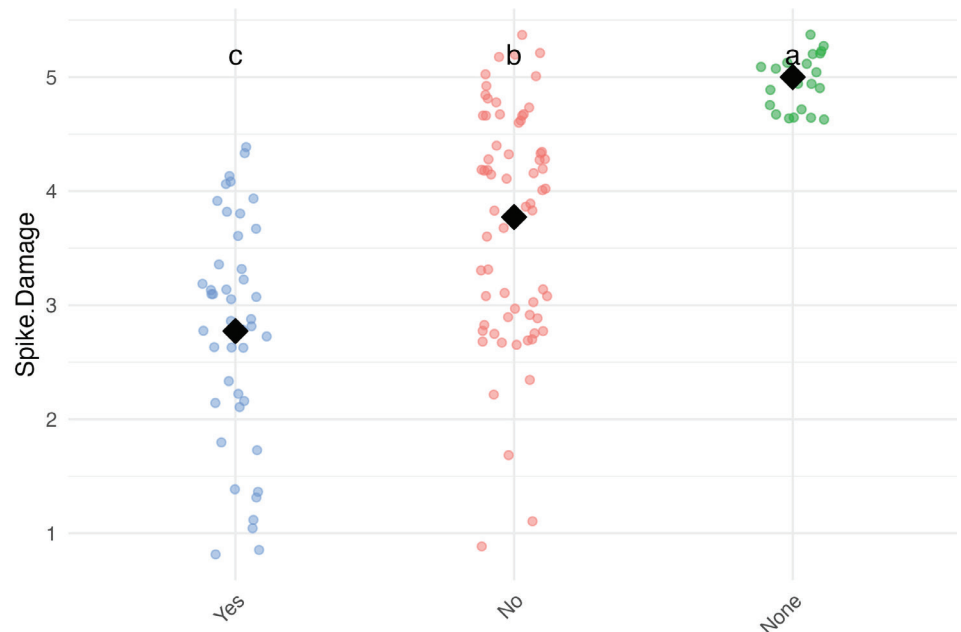


FIGURE 2

Spike damage ratings by spike type.

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- » Spiked footwear (RTE) produced significantly greater visible spike damage than spikeless (FTE) designs.
- » On average, spikeless shoes were 36% less visually disruptive than traditional spikes (Figure 2).

Maintenance Effects

Multiple linear regression (MLR) models to predict VSD from spikeless shoes were poor, indicating there were no significant relationships identified between maintenance variables and VSD from spikeless shoes. However, MLR models to predict VSD from spiked shoes were found to be relatively powerful ($R^2 = 0.64$), identifying significant relationships between maintenance and VSD from spiked shoes.

- » **As surfaces became softer, VSD improved.**

Hypothesis: Softer surfaces allow for more cushioning in the spike/turf interaction, potentially mediating VSD.

- » **As the amount of *Poa annua* increased, VSD improved. Models suggest that** for every 10% increase in *Poa*, VSD will improve by 0.14 points.

Hypothesis: Prior research at Cornell has shown *Poa*-dominated surfaces have improved VSD compared to bentgrass-dominated surfaces, suggesting canopy architecture has some effect. The upright growth of the *Poa* appears less affected by spikes compared to the lateral growth of bentgrass, which can pock or lift during interactions with spikes.

- » VSD improved as time from last aeration increased. Models suggest that **for each additional 10 days since last aeration**, VSD will improve by 0.06 points.

Hypothesis: The longer putting surfaces have to recover from aeration, the less VSD they reveal.

- » As mowing frequency increased, VSD decreased. Models suggest that **for each additional mowing per week**, VSD will decline by 0.09 points.

Hypothesis: Increased mowing creates a more uniform surface, which improves ball roll characteristics and golfer satisfaction, but reveals spike damage more readily.

The dominant factor, however, remained **footwear type**, which superintendents cannot directly control.

2: Bobble Test (Golfer Perception of Roll Quality)

The bobble test indicates golfer perception of how smoothly the ball rolls across the green (Figure 3).

- » Traffic reduced bobble ratings (more bobbles) by 25% overall.

- » Spikeless shoes rated 14% better than spiked shoes after traffic.

Again, MLR models showed poor ability to predict bobble from spikeless shoes, but showed more predictive power for spiked shoes ($R^2 = 0.42$).

Important findings:

- » **As the amount of *Poa* increases, bobble improves. Models suggest that for every 10%**, bobble will improve by 0.08 points.

Hypothesis: Similar to the relationship with *Poa* and VSD, it's hypothesized that the vertical growth habit of *Poa* allows it to be less disrupted by spiked shoes, resulting in less disruption in the bobble test. This has been demonstrated during prior studies at Cornell's research center across a decade.

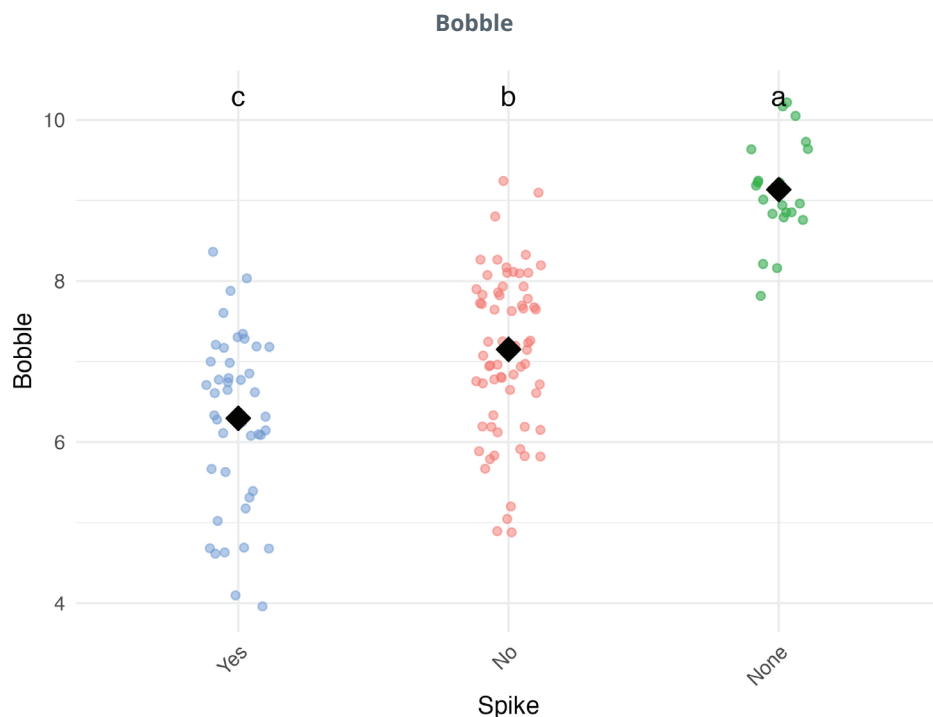


FIGURE 3
Bobble test ratings by spike type.

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» As mowing frequency increased, bobble decreased. **Models suggest that for each additional mowing per week**, bobble scores drop by 0.29 points.

Hypothesis: Just as VSD declines with additional mowings, bobble tests decline as the cumulative maintenance intensity from mowing increases.

» **As nitrogen rates increase (after accounting for growth regulator use), the bobble test improves.** In simple terms, when turf is allowed to grow more, ball roll tends to be slightly more affected after traffic.

Hypothesis: Greens with more active growth (less suppression or higher effective nitrogen) tend to show higher bobble test readings after traffic. There might be a cushioning effect created

by more vigorous grass that reduces perceived imperfections in ball roll.

» **Use of a growth regulator containing prohexadione calcium (Anuew) is associated with** increases in the bobble test by 1.16 points.

Hypothesis: It is not clear what mechanism might drive improved ball roll specifically from Anuew. Other growth regulators were used on golf courses in this study but did not have significant effects on ball roll. It is possible this effect is an artifact of a relatively small dataset, but the strength of this relationship does warrant further investigation.

Although the MLR models for both the bobble test and visual surface disruption (VSD) provide useful guidance for management decisions, they were only

accurate with respect to spiked shoes. **In the end, shoe type had a bigger influence on ball roll and surface disruption than mowing frequency, nitrogen rates, or growth regulator use.**

3: Stimpmeter Readings (GS3 Ball)

The GS3 ball calculates green speed by measuring how fast the ball spins (revolutions per second) as it rolls across the surface. A built-in gyroscope tracks the roll, and an algorithm converts that data into an estimated Stimpmeter reading.

In 2025, the USGA improved the GS3 algorithm. The ball used in this study was verified against traditional Stimpmeter readings at the Cornell Bluegrass Lane Turf & Landscape Research Center, where side-by-side testing confirmed its accuracy (Figure 4).

Effect of Traffic on Green Speed

» Traffic reduced green speed by about 4%, which was not statistically significant.

» The difference between spiked and spikeless shoes was small: about 2%.

To put that into perspective:

» A green running at 12 feet that slows by 4% would lose about 5.8 inches of roll distance.

» However, post-traffic speed is heavily influenced by how fast the green was to begin with (mowing height, rolling, etc.). So instead of focusing on raw green speed after traffic, the researchers looked at how much traffic slowed a green relative to its own baseline.

This metric, Stimp Relative-to-Control (RTC), measures how well a green maintains its speed compared to a nontrafficked area on the same green.

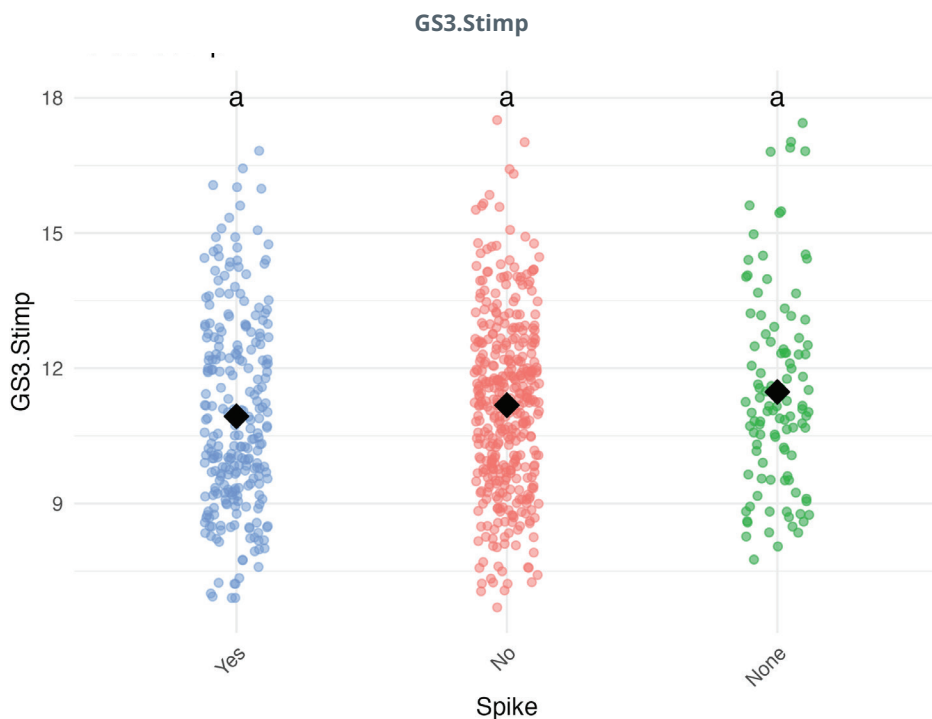


FIGURE 4
GS3 Stimp readings of spiked, spikeless, and nontrafficked plots

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Influences of Traffic on Green Speed Retention

The regression model explained about 60% of the variation in how well greens maintained speed under traffic. That is considered to be a reasonably accurate model.

Here's what mattered most:

1. Days Since Aeration (Strongest Effect)

- » For every 10 days after aeration, green speed retention improved by about 1%.
- » Greens perform more consistently under traffic as they recover from aeration.
- » **This was the single strongest relationship to maintenance practices in the entire study.**

2. Prohexadione-Calcium (Anew)

- » Use of a PGR containing prohexadione calcium (Anew) improved speed retention by about 9%.
- » This aligns with earlier findings that this PGR is associated with improvements in the bobble test.
- » More research is needed, but results are promising.

3. Mowing Frequency

- » Each additional mow per week reduced speed retention by 0.7%.
- » More frequent mowing was consistently linked to greater performance loss after traffic. In other words, when greens begin faster (mowed more frequently), they lose a greater percentage of green speed after traffic is applied.

4. Volumetric Water Content (VWC)

- » For every 2% increase in VWC, speed retention improved by about 1.1%.
- » Slightly wetter greens appeared to maintain speed better after traffic.

Key Takeaway on Speed Modeling

Green speed (an objective measurement) was easier to predict than golfer perception measures, like bobble or visual surface disruption (VSD). In practical terms, speed changes are easier to model than what golfers "feel."

4: GS3 Enriched Data (Smoothness & Trueness)

The GS3 ball also measures surface quality using three accelerometers. It detects two disruption events during the roll:

- » **Bumps** or vertical disruption, which indicates a smoothness metric

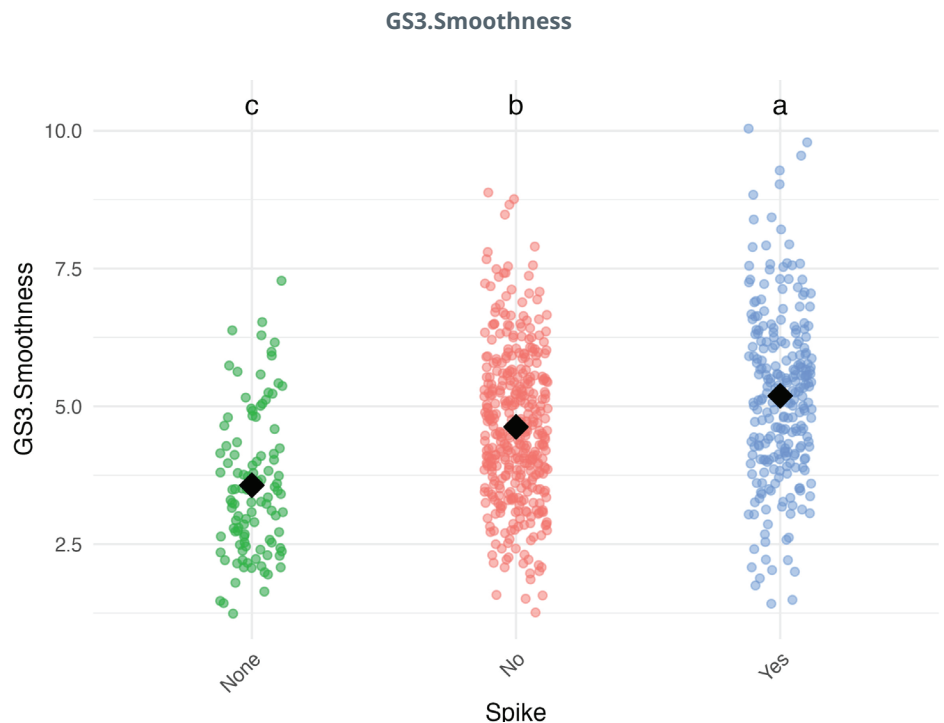


FIGURE 5
GS3 Smoothness by spike type.

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» **Snakes** or lateral movement, indicating the trueness metric

The lower the number, the smoother and truer the surface (Figures 5 & 6).

Effect of Shoe Type on Surface Disruption

Results clearly showed:

- » Spiked shoes caused more disruption than spikeless shoes.
- » Nontrafficked plots had the best smoothness and trueness.

Interestingly:

- » Spiked and spikeless shoes caused similar *numbers* of bumps and snakes.

» Spiked shoes, however, created *larger magnitude* disruptions.

So the issue might not be how often disruption happens, but how severe each disruption event is.

GS3 vs. Golfer Perception (Important side benefit to the USGA)

On nontrafficked plots:

- » GS3 detected 60-plus disruption events per roll.
- » The visual bobble test showed less than one noticeable disruption per roll.

This suggests:

- » The GS3 may be detecting very small events that golfers do not perceive.
- » The threshold for what GS3 considers a “disruption” may be too sensitive.

Also:

- » Bump magnitudes were 5 to 8 times greater than snake magnitudes.
- » Lateral forces (which knock putts off line) were relatively small.

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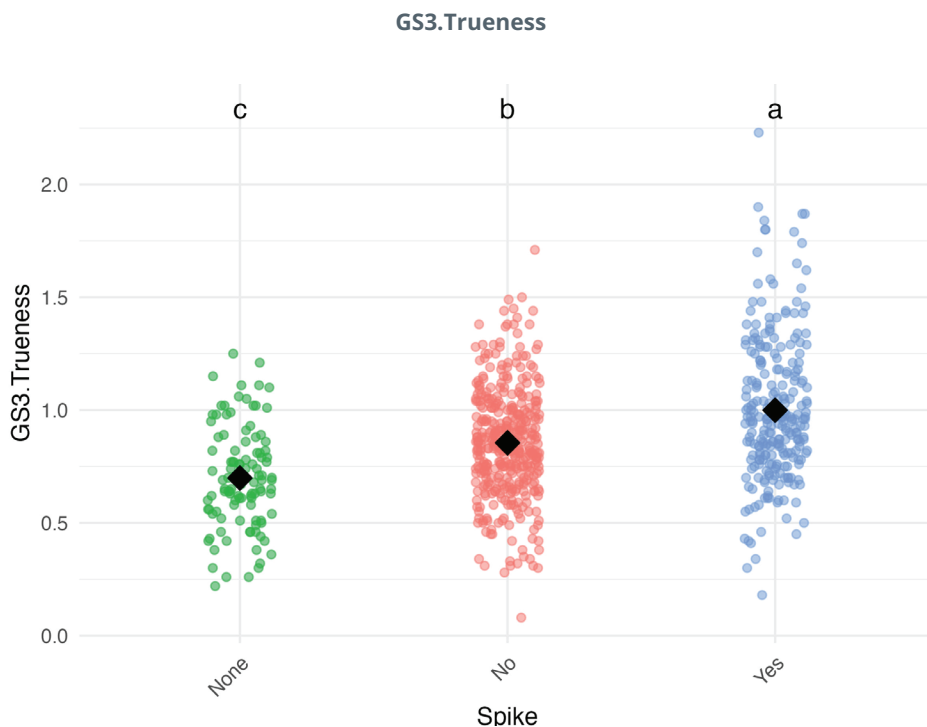


FIGURE 6

GS3 Trueness by spike type.

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Average Putting Surface Performance Before and After 140 Rounds of Simulated Traffic Across All Courses Tested

Putting Surface Performance Metric	Nontrafficked	After 140 rounds	Difference
<i>GS3 Stimp (ft)</i> ^b	11.4	11.0	4%
<i>Bobble Test (1-10)</i> ^b	9.1	6.8	25%
<i>Visual Spike Damage (1-5)</i> ^b	5	3.4	33%
<i>GS3 Smoothness</i>	3.5	4.9	29%
<i>Bump Count</i> ^c	27.5	31.7	14%
<i>Bump Magnitude</i>	0.15	0.18	19%
<i>GS3 Trueness</i>	0.70	0.91	23%
<i>Snake Count</i> ^c	33.7	39.5	15%
<i>Snake Magnitude</i>	0.026	0.028	10%

^a Compared to nontrafficked, the percent of performance that is retained after traffic. 100% = no different than the nontrafficked

^b Non-GS3 metrics are more desirable when numerically higher

^c Normalized per 10 ft. of ball roll

THE TAKEAWAY

Year Two expands understanding of how footwear and management interact to influence putting surface performance.

While superintendents cannot control footwear selection, they can influence traffic tolerance through:

- » Aeration timing
- » Growth regulator programs
- » Nitrogen management
- » Surface moisture management

The most consistent finding across both years is that putting surface canopy architecture strongly influences resilience to traffic.

This research provides actionable insight for turfgrass managers while also informing footwear manufacturers and the USGA about traction-system impacts on high-performance putting surfaces.

**For further information, contact
Dr. Frank Rossi at fsr3@cornell.edu.**

Rutgers Research Team Seeks Precision in Fairway Irrigation Management

Irrigation management remains one of the most complex and resource-intensive responsibilities for golf course superintendents. Increasing water costs, tighter allocations, and sustainability expectations require courses to do more with less, while still delivering consistent, high-quality playing conditions. Although tools such as weather-based evapotranspiration (ET) scheduling, soil moisture sensors, and timer-based irrigation programs are widely used, each has limitations when applied across large, variable fairway landscapes.

Fairways often include slopes, low-lying areas, differing soil textures, and microclimates that influence how turf uses water. Applying the same amount of irrigation across an entire fairway can result in overwatering some areas while under-irrigating others. As a result, superintendents frequently rely on experience and visual scouting to make adjustments—an approach that is effective but time-consuming and increasingly difficult under water-use constraints.

Recognizing that superintendents could benefit from more accurate, site-specific irrigation guidance based on actual turf conditions, the Tri-State Turf Research Foundation will support Rutgers University's Dr. Bingru Huang and her research team in evaluating a remote-sensing-driven support system (DSS) for turfgrass precision irrigation management (PIM).

OBJECTIVES

Dr. Huang's research will evaluate a remote-sensing DSS for PIM compared to three conventional irrigation methods:

- 1: Weather ET-based scheduling
- 2: Soil moisture sensor-based irrigation
- 3: Traditional timer-based irrigation

Effectiveness will be measured by:

- » Total water savings
- » Turfgrass performance
- » Spatial uniformity
- » Superintendent usability

More specifically, the researchers will:

- 1: **Determine spatial irrigation needs** using multi-sensor remote sensing tool (drone)
- 2: **Compare DSS recommendations** against standard superintendent practices
- 3: **Quantify improvements** in water-use efficiency, turf quality, turf stress reduction, and uniformity
- 4: **Evaluate operational feasibility** for routine golf course management

EXPECTED OUTCOMES

Dr. Huang and her research team anticipate that the PIM-DSS will reduce total irrigation volume by 20% to 40% while maintaining or improving turf quality, without requiring modifications to existing irrigation infrastructure.

The project is expected to demonstrate that:

- » Remote sensing can detect turf stress earlier than visual scouting
- » Spatially explicit irrigation prescriptions improve alignment between water application and actual turf water demand
- » Improved water distribution uniformity reduces localized dry spots, disease pressure, and compaction-related stress

Beyond direct water savings, this project will deliver:

- 1: A validated, field-tested workflow for integrating drone-based remote sensing into golf course irrigation management
- 2: High-resolution turf stress maps and decision-support tools scalable across diverse course types and irrigation systems
- 3: Structured user feedback to refine PIM-DSS usability and improve compatibility with commercial irrigation controllers

Collectively, these outcomes will provide a science-based pathway for adopting precision irrigation technologies in golf course management. By reducing water consumption while maintaining high-quality playing surfaces, the project supports both economic sustainability (through reduced water and labor costs) and environmental stewardship.

■
For further information, you can reach Dr. Bingru Huang at huang@sebs.rutgers.edu.

Special Thanks to Our 2025 Contributors

We'd like to thank our contributors for their generous show of support to the Tri-State Turf Research Foundation. Your contributions go a long way toward helping the foundation continue its mission "to provide turfgrass research for better golf and a safer environment." We hope those of you on the list will continue to support the foundation's work. We also hope you will encourage more of your fellow turfgrass professionals to add their names to the growing list of contributors.

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LANDSCAPING

How Topdressing Sands and Solid-Tine Cultivation Affect Putting Green Performance

Topdressing—the routine application of sand to putting greens—is one of the most important practices used to keep greens smooth, firm, and playable. Over time, organic material builds up near the surface of turf, creating a layer that can hold too much water and reduce firmness. Applying sand helps dilute this layer, improve drainage, and maintain consistent playing conditions.

However, not all sand behaves the same way. Sands with finer particles tend to blend into the turf more easily and interfere less with play, but they may also hold more water. Coarser sands drain better but can be more disruptive on the surface. Golf course managers also rely on cultivation practices—punching holes in the turf with hollow or solid tines—to help manage this surface layer, though these practices temporarily disrupt play.

Rutgers researchers have been studying how sand size and cultivation methods work together to influence putting green conditions, especially firmness, moisture, and recovery from traffic.

Recognizing that superintendents could benefit from understanding the best management practices for topdressing and cultivating golf course putting greens, the Tri-State Turf Research Foundation has agreed to offer one year of support to Rutgers' Dr. James Murphy and his team of researchers to further their studies with the ultimate goal of developing technologies and management strategies that improve resource efficiency, mitigate stress, and optimize maintenance efficiency by reducing golf course disruption and reliance on resources.

WHAT RESEARCHERS HAVE LEARNED SO FAR

Long-term research at Rutgers has shown that medium-fine sands can be applied frequently and effectively without causing major disruption to play or mowing

equipment. These sands perform similarly to coarser sands in controlling organic buildup, but they integrate more smoothly into the turf canopy.

The studies also found clear differences in how sand size affects surface moisture. Greens topdressed with very fine sand tend to stay wetter, while those receiving slightly coarser sands are firmer and drier. Importantly, cultivation practices—especially traditional hollow-tine aeration followed by sand backfilling—can largely eliminate these differences by physically mixing coarser sand into the surface layer.

More recently, the research shifted from hollow-tine to solid-tine cultivation, which creates less surface disruption and heals faster. Early results suggest solid tines improve turf recovery and surface quality, but it is still unclear whether they provide the same long-term benefits for managing the surface layer as hollow tines.

THE CURRENT STUDY OBJECTIVES

The Rutgers team is continuing its work to answer several practical questions:

- » Can putting greens be effectively managed using topdressing alone, without relying heavily on disruptive hollow-tine aeration?
- » How well does solid-tine cultivation modify the surface layer over time compared to traditional methods?
- » Do different sand sizes and application rates affect how well putting greens hold up under foot traffic and how quickly they recover?
- » Is long-term use of sands finer than current industry standards a sound and sustainable practice?

Ultimately, the research team's goal is to provide science-based guidance that helps golf courses maintain high-quality greens with less disruption and greater efficiency.

METHODOLOGY

The research is being conducted on a “Shark” creeping bentgrass putting green seeded in September 2014 on a sand-based rootzone built to USGA construction standards and grown-in during 2015. To answer practical questions faced by golf course superintendents, the study includes two complementary field trials that examine how sand topdressing and cultivation practices influence putting green performance and recovery.

FIELD TRIAL 1: TOPDRESSING SAND AND SOLID-TINE CULTIVATION

This trial, begun in 2023, examines how different sands and cultivation practices work together to affect putting green conditions (*Table 1*).

- » Three different sand types are used for topdressing: medium-coarse, medium-fine, fine-medium.
- » Each sand is applied at 50 or 100 lb. per 1,000 sq. ft. per application from May through September.
- » Plots either receive no cultivation or solid-tine cultivation twice per year, with coarse-medium sand brushed into the holes.
- » Topdressing is applied regularly throughout the season to reflect common golf course maintenance practices.
- » Researchers measure how these treatments affect:
 - Surface firmness and moisture
 - Organic matter buildup in the surface (thatch/mat layer)
 - How well the surface tolerates and recovers from golf shoe traffic
- » Putting green playability is evaluated repeatedly during the season using a GS3 USGA device before and after simulated foot traffic.

How Topdressing Sands and Solid-Tine Cultivation Affect Putting Green Performance

Factors in the Experiment

Treatment No.	Sand Size [†]	Topdressing Rate during the Growing Season [‡]	Cultivation	
			Levels 2023 to 2026 [¶]	Pre-existing Levels 2016 to 2022 [§]
lb. / 1,000 sq. ft.				
1	Medium-coarse	50	None	None
2	Medium-coarse	50	Solid Tine + Backfill	Core + Backfill
3	Medium-coarse	100	None	None
4	Medium-coarse	100	Solid Tine + Backfill	Core + Backfill
5	Medium-fine	50	None	None
6	Medium-fine	50	Solid Tine + Backfill	Core + Backfill
7	Medium-fine	100	None	None
8	Medium-fine	100	Solid Tine + Backfill	Core + Backfill
9	Fine-medium	50	None	None
10	Fine-medium	50	Solid Tine + Backfill	Core + Backfill
11	Fine-medium	100	None	None
12	Fine-medium	100	Solid Tine + Backfill	Core + Backfill
13	None	0	None	None
14	None	0	Solid Tine + Backfill	Core + Backfill

† First mentioned size class represent the predominant size fraction in the sand.

‡ The frequency of application during the growing season will be once every 10 to 14 days from May through September. The 50 lb. per 1,000 sq. ft. represents a “dusting” quantity of topdressing.

¶ Cultivated plots received hollow-tine cultivation during 2016 to 2022. Since 2023 all cultivated plots were treated with solid-tine cultivation twice a year (April and October) using 5/8-inch diameter tines spaced to disturb ~10% of the surface area per year. Plots were topdressed with 600 lb. per 1,000 sq. ft. of medium-coarse sand before solid-tine cultivation, then brushed into solid-tine holes. Noncultivated plots will continue; plots will be topdressed with the respective sand size at a rate matching the topdressing effect between holes in solid-tine plots (400 lb. per 1,000 sq. ft.).

§ Pre-existing cultivation levels were no cultivation or cultivation performed with hollow tines twice a year (April/May and October) using 1/2-inch i.d. tines spaced to remove ~10% of the surface area per year. Coring holes were backfilled with medium-coarse sand and noncultivated plots were topdressed with the respective sand size at 400 lb. per 1,000 sq. ft., which matched the topdressing effect between holes on coring+backfill plots.

TABLE 1

Topdressing and cultivation treatments arranged as a 3 × 2 × 2 factorial experiment on Shark creeping bentgrass grown on a sand-based root zone in North Brunswick, NJ. Nontopdressed controls included for comparison purposes.

(continued on page 14)

How Topdressing Sands and Solid-Tine Cultivation Affect Putting Green Performance



Dr. Murphy and his research team prepare to begin sampling of the mat layer to measure physical properties: bulk density and air-filled and capillary porosity among the treatments.

FIELD TRIAL 2: COMPARING HOLLOW-TINE AND SOLID-TINE CULTIVATION

This companion trial, initiated in 2023, focuses specifically on how different cultivation methods affect the “Shark” creeping bentgrass putting green surface.

» Three cultivation treatments are compared:

- No cultivation
- Traditional hollow-tine cultivation
- Solid-tine cultivation

» All cultivated areas are backfilled with medium-coarse sand to maintain consistent surface conditions.

» At the same time, noncultivated plots will be topdressed with medium-coarse sand at 400 lb. per 1,000 sq. ft., which will match the topdressing effect that occurs between holes on cultivated and backfilled plots.

» The entire trial will be topdressed every two weeks from May through September with 50 lb. of sand per 1,000 sq. ft., representing a “dusting” quantity, reflecting typical putting green management.

» Researchers assess:

- Changes in surface firmness and water movement
- Organic matter accumulation near the surface
- Speed of turf recovery following cultivation
- Overall playability and surface consistency

ONGOING MEASUREMENTS

Across both trials, turf quality and recovery are tracked throughout the growing season using visual ratings and electronic sensors. Data collected from these trials

allow researchers to compare surface performance over time and determine which combinations of sand and cultivation produce the best balance of playability, durability, and reduced disruption.

WHY THIS MATTERS

This work is expected to benefit most golf courses, especially those looking to reduce disruption from aeration while maintaining fast, firm, and consistent greens. The results will help superintendents choose the right sand, decide how much to apply, and better understand when solid-tine cultivation can replace more aggressive practices—all while preserving the playability golfers care about most.

■
For further information, you can reach Dr. Jim Murphy at jamurphy@njaes.rutgers.edu.

Managing a New Yellow Ring Disease on Putting Greens

UConn Researchers Delve Into a Growing Problem for Golf Course Superintendents

Golf course superintendents across New England are facing a new and frustrating problem on putting greens: yellow rings that appear in early spring and fall, intensify as temperatures warm, and in severe cases turn into dead, blighted turf. First observed in Connecticut in 2023, this problem expanded rapidly during the 2024 growing season, with confirmed cases now found across New England and even the Chicago area. Many more courses have reported similar symptoms.

What makes this issue especially challenging is that it looks like familiar diseases—such as brown ring patch or yellow patch—but does not respond to the fungicides typically used for those problems. Most confirmed cases have occurred on annual bluegrass putting greens, while creeping bentgrass appears to be less affected in the region.

Recognizing the urgency of the situation, the Tri-State Turf Research Foundation has agreed to fund new research headed by Dr. John Inguagiato at the University of Connecticut to help superintendents better understand this disease and, more importantly, learn how to manage it effectively before significant damage occurs.

WHAT THE RESEARCHERS KNOW ABOUT THE DISEASE

The disease typically begins in March or April as thin, pale-yellow rings ranging from a few inches to two feet in diameter. As spring progresses, the rings often become brighter yellow, expand outward, and in some cases collapse into brown, dead turf. Symptoms usually subside during the hot summer months of June and July, but in some locations, they return again in the fall, generally October or November.

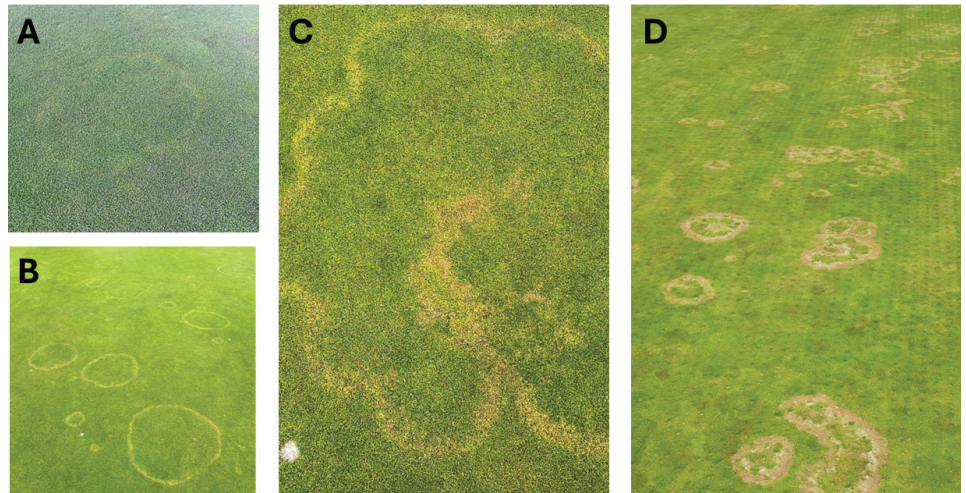


FIGURE 1

A: Faint yellow ring typical of early onset in March. B: Intensification of chlorotic rings during moderate May temperatures. C: Collapse of tillers in severe ring during May. D: Severe blighting of rings in slow-growing turf during April.

Laboratory work at UConn has shown that the disease is caused by a previously undescribed fungal pathogen, likely related to fungi in the genus *Burgoa* or *Sistotrema*. The fungus grows best in cooler temperatures with growth occurring from 45° to 82°F and optimal temperatures between 63° to 73°F. These results correspond well with the spring and fall appearance of symptoms observed on golf courses. Unlike many known turf diseases, this pathogen has proved difficult to control with standard fungicide programs.

Because this pathogen is new, there is still much to learn about how it infects turf and survives between seasons. While those questions are being investigated, superintendents need immediate, practical guidance. That need is the driving force behind this research.

This project focuses on one central question: *How can golf course superintendents manage yellow ring symptoms effectively using available fungicides and everyday putting green management practices?*

To answer that question, researchers will evaluate both chemical controls (fungicides) and cultural practices (fertility, growth regulation, and seedhead management) to identify strategies that reduce disease severity and turf damage.

METHODOLOGY

All studies will be conducted on an annual bluegrass putting green at UConn's Plant Science Research and Education Facilities in Storrs, CT. This site has exhibited consistent yellow ring symptoms during spring and fall since 2023. The pathogen isolated from symptomatic turf at this location is consistent with isolates recovered from affected golf courses throughout the region.

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Managing a New Yellow Ring Disease on Putting Greens

The following studies were initiated in autumn 2024 and are designed to run through the summer of 2026.

TEST 1. Seasonal Efficacy of Demethylation Inhibitor (DMI) and DMI Premix Fungicide Applications for Yellow Ring Patch Control

Preliminary field trials conducted by UConn researchers at a West Hartford golf course indicate that very few fungicides provide curative control of this disease.

» Among eight fungicides tested, representing QoI, SDHI, DMI, and contact fungicide classes, only Maxtima (mefentrifluconazole; 0.6 fl. oz./1000 ft² applied every 14 days) effectively controlled symptoms.

» Torque (tebuconazole; 1.1 fl. oz./1000 ft² applied every 28 days), another DMI fungicide, did not provide symptom control.

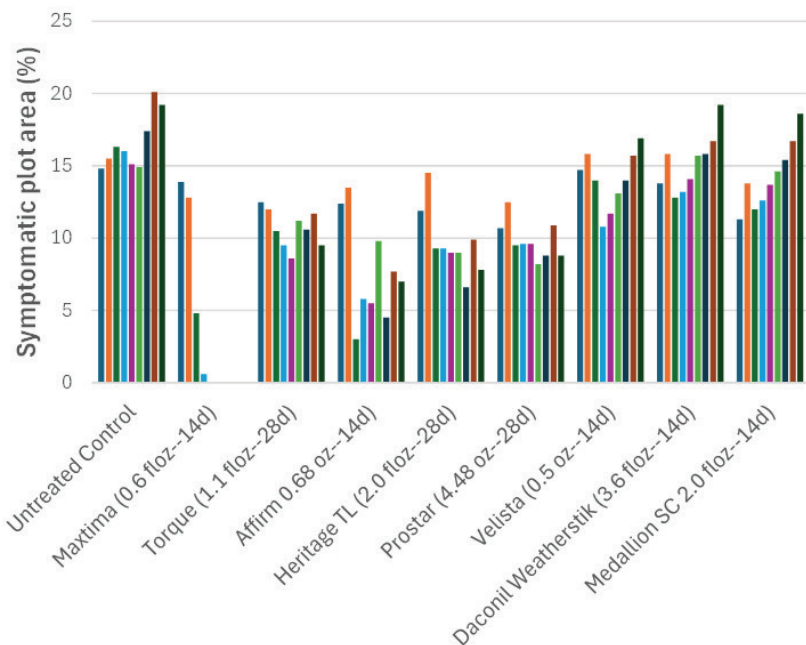
» These results suggest that differences in efficacy may exist between first-generation DMIs (e.g., tebuconazole) and second-generation DMIs (e.g., mefentrifluconazole).

» In addition, empirical reports from golf course superintendents indicate that second-generation DMIs, such as Densicor (prothioconazole), Rayora (flutriafol), and the DMI/SDHI premix Kalida (flutriafol + fluindapyr), have provided symptom suppression under field conditions.

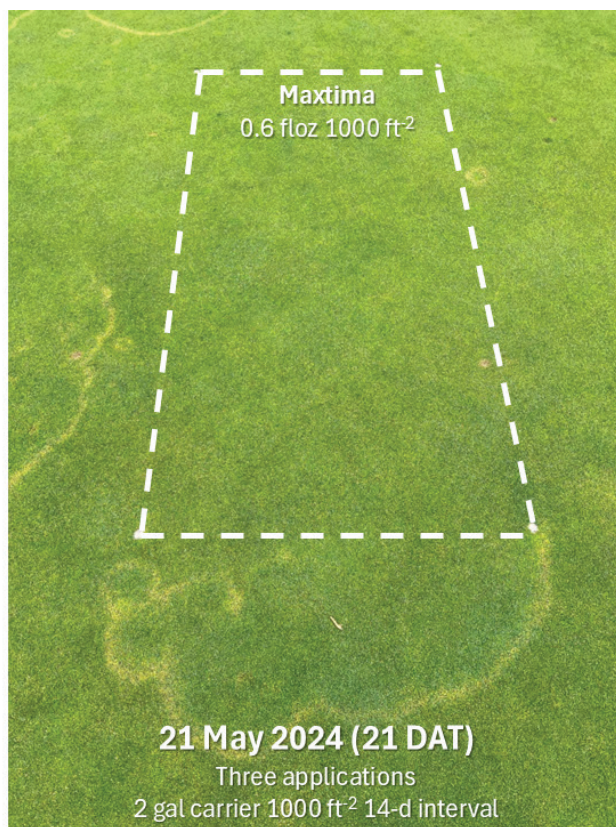
This study will:

- » Evaluate all commercially available DMI fungicide active ingredients, along with DMI/SDHI premix products
- » Determine whether newer DMI chemistries provide improved control compared to earlier-generation products
- » Assess application timing, including fall-only, spring-only, and fall plus spring programs, applied on a 21-day interval

Application timing is of particular interest because spring symptom expression may result from infections initiated during the preceding fall.



Curative control of yellow ring symptoms on an annual bluegrass putting green. Initial application on 2 Apr 2024. Plots were rated every 7-d from 2 Apr to 28 May. Bars represent rating dates for each treatment. Maxtima was the only treatment to reduce disease compared to untreated control.



Managing a New Yellow Ring Disease on Putting Greens

TEST 2. Influence of Seasonal Nitrogen Fertility and Seedhead Control Programs on Yellow Ring Patch Severity

Field observations from affected golf courses indicate that disease severity ranges from thin, faint yellow rings to wider, completely blighted dead rings in some locations.

- » More severe symptoms were often observed on greens exhibiting reduced turf color and vigor.
- » These observations suggest that nitrogen could be an important cultural control for managing the severity of this disease.

This study will evaluate:

- » The effect of fall (October) versus spring (April) granular nitrogen applications on disease severity
- » Whether fall nitrogen fertility improves turf tolerance to, or recovery from, yellow ring symptoms during early spring
- » The influence of annual bluegrass seedhead control programs using fall and spring applications of ethephon (Proxy)
- » Granular nitrogen treatments will be applied at 0.5 lb. N/1000 ft² using a 14-0-4 fertilizer with a portion of slowly available nitrogen.
- » Seedhead control treatments will consist of a fall application of ethephon (Proxy; 5.0 fl. oz./1000 ft²) followed by two spring applications. Trinexapac-ethyl (Primo MAXX; 0.125 fl. oz./1000 ft²) will be tank-mixed with Proxy for the final spring application, consistent with industry practices.

Although ethephon has not been identified as a causal factor in disease development, its use coincides with periods of pathogen activity. Therefore, understanding whether seedhead control programs influence symptom severity—either positively or negatively—is critical for managing annual bluegrass putting greens affected by this disease.

TEST 3. Influence of Nitrogen Source, Nitrogen Rate, and Spring Plant Growth Regulators on Yellow Ring Patch

Turf growth rate appears to be closely associated with the severity of yellow ring symptoms, particularly during the cool spring conditions when pathogen activity is highest. However, limited information exists regarding how frequent spring fertility programs and plant growth regulators may affect disease development.

This study will evaluate:

- » Nitrogen source, including urea, ammonium sulfate, and calcium nitrate
- » Two soluble nitrogen application rates (0.1 and 0.2 lb. N/1000 ft²) applied at 14-day intervals during April and May
- » The influence of commonly used plant growth regulators, including trinexapac-ethyl (Primo MAXX at 0.125 fl. oz./1000 ft²) and prohexadione-Ca (Anuew EZ at 2.2 increasing to 4.5 fl. oz. /1000 ft²) applied every 14 days during April and May

Nitrogen treatments will be applied alone and in combination with plant growth regulators, along with an untreated control. This approach will allow UConn researchers to determine whether specific fertility strategies or growth regulation programs exacerbate disease severity or can be used as part of an integrated management approach to reduce symptom expression.

WHAT RESEARCHERS WILL MEASURE

- » How much of each plot is affected by yellow ring patch
- » Severity of symptoms, from faint discoloration to complete turf death
- » Overall turf quality and color
- » Seedhead production, where applicable

Assessments will be made weekly during active disease periods in spring and fall.

WHY THIS RESEARCH MATTERS

For superintendents, this new disease presents a series of challenges:

- » It is easily mistaken for a known disease: brown ring patch or yellow patch.
- » Fungicide options providing effective control are limited and expensive.
- » Symptoms persist when turf growth is slow.
- » Repeated applications may be needed.

» Cultural practices may unknowingly contribute to the severity of the disease.

Without research-based guidance, courses risk wasting resources on ineffective treatments—or worse, suffering prolonged damage to putting greens during peak playing seasons.

■
For further information, you can reach Dr. John Inguagiato at john.inguagiato@uconn.edu.

A Conservation Plan for the Golden Northern Bumble Bee

URI Researchers Seek Ways to Save a Declining Pollinator Population

Golf courses are increasingly recognized as more than just places to play golf: They are large, managed landscapes with enormous potential to support wildlife. At a time when pollinators are declining across North America, golf course superintendents are in a unique position to be part of the solution.

One species in urgent need of help is the Golden Northern Bumble Bee (*Bombus fervidus*), also known as the Yellow Bumble Bee. Once common throughout the Northeast, this native pollinator has experienced steep population declines and is now listed as a *Species of Greatest Conservation Need or State Assessment Priority Species* in many states, including Connecticut, New York, New Jersey, Maine, Vermont, and New Hampshire, and is proposed for the same status in Rhode Island. Without targeted conservation efforts, URI researchers estimate this bee could disappear within the next 70 to 80 years. One of New Hampshire's recommendations for this bee is to **"Create 1000 acres of pollinator habitat in the state each year."**

Recognizing the importance of halting the decline of the Golden Northern Bumble Bee and possibly other pollinators, the Tri-State Turf Research Foundation has agreed to offer University of Rhode Islands' Dr. Steven Alm and undergrad student Fiona Dell'Antonio three years' support in their pursuit of a plan for preserving the bumble bee populations.

BEHIND THE BUMBLE BEE DECLINE

Bumble bees are among the most effective pollinators of native plants and flowering shrubs. Their decline threatens not only biodiversity but also the resilience of surrounding ecosystems. While agriculture often dominates discussions about



Andrew C. CC BY 2.0, via Wikimedia Commons

pollinator conservation, golf courses offer something equally important: large areas of open space that can be managed intentionally to provide food and shelter for bees.

Surveys across New England show just how rare *Bombus fervidus* has become. In Rhode Island, fewer than 40 observations were recorded during a three-year statewide survey, representing less than one percent of all bumble bee sightings. Similar trends have been documented in neighboring states, even as overall pollinator monitoring has increased.

The causes of decline are familiar to many superintendents: loss of flowering habitat, fragmentation of open space due to land development, pesticide exposure, disease, and climate stress. The good news is that many of these pressures can be reduced through thoughtful course design and management.

METHODOLOGY

FLOWERS AND NESTING HABITAT STUDY

Bumble and other bees require two basic things:

1: Season-long floral resources

Flowers provide pollen (protein) and nectar (energy), but not all plants bloom at the right times or offer the same nutritional value. Bumble bee colonies depend on early-season flowers to get started, mid-season blooms to grow, and late-season flowers to produce the next generation of queens. These plants also need to be located close enough to nesting sites—generally within a few hundred meters.

2: Safe nesting areas

Nesting habitat is equally important. Bumble bees often nest underground or along field edges, forest margins, and

unmanaged roughs—areas commonly found on golf courses but not always recognized as valuable habitat. Dr. Alm and his team are also investigating irrigation boxes as nesting sites for bumble bees with support from the New England Regional Turfgrass Foundation. On the University of Wyoming campus, they found hundreds of queen bumble bees trying to use them as nesting sites. In 2025, we had a *Bombus fervidus* nest occupy one of our modified irrigation boxes all season long.

THE FIELD TESTS

Researchers at the University of Rhode Island are developing a conservation plan for the Golden Northern Bumble Bee that aligns well with golf course management practices.

Using iNaturalist data from New York, New Jersey, and Connecticut, the project will identify the flowers most frequently visited by *Bombus fervidus* throughout the season. From this, regional seed mixes will be created and tested in replicated field plots in Rhode Island.

Two key tests are being conducted:

Test 1. Planting Design: Randomly arranged plants versus plants grouped by species

- » Does the *Bombus fervidus* prefer plots where plants are grouped together? In other words, is floral frequency important with these planting plans?
- » Which designs are easier to maintain over multiple seasons (i.e., fewer lost species) and more resistant to weeds?

Test 2. Plant Selection: Inclusion of a nonnative “lure plant” like zinnia in some plots versus just plants that are native to the region

- » Do zinnia plots show higher *Bombus fervidus* presence?

» Does the presence of zinnia increase or decrease *Bombus fervidus* visitation on the native plants in the plot?

» Do the zinnia compete for *Bombus fervidus*'s attention to the detriment of the native plants?

Plots are monitored morning and afternoon three times per week to track *Bombus fervidus* activity and plant performance, data that will translate directly into practical recommendations.

At the same time, land-cover data around past bee sightings are being analyzed to better understand what types of habitats support nesting. This information can help superintendents identify which out-of-play areas, roughs, or buffer zones are most valuable to conserve or enhance.

PLANNED OUTCOMES

The goal of this work is simple: to provide superintendents and other turf and nursery industry professionals and organizations with clear, tested guidance. To help increase *Bombus fervidus* and other pollinator populations, the research team will produce:

- » State-specific fact sheets outlining recommended favored host plants
- » Planting designs
- » Solid data on the land cover types needed for *Bombus fervidus* nesting

These resources will be shared with golf course superintendents, extension services, nurseries, conservation groups, and land managers.

Many courses are already leading the way through programs such as Audubon International, Operation Pollinator, Bayer's Bee Health Program, and USGA-supported sustainability initiatives. This project builds on that momentum by focusing on a single,

at-risk species and identifying actions that can be implemented without disrupting play or increasing maintenance demands.

WHY IT MATTERS

Golf courses collectively manage millions of acres nationwide. Even modest changes—adding pollinator plantings in roughs, naturalized areas, or unused corners of the property—can have an outsized impact. By supporting the Golden Northern Bumble Bee, courses also benefit a wide range of other native pollinators. By-the-way, there are an estimated 450 native bees in New York State, 380 in Connecticut, and 350 in New Jersey. These bees and other pollinators did all of the pollination of the native plants prior to the introduction of the honey bee in 1622.

Too often, species are listed as “at risk” without a clear plan for recovery. This research aims to change that by offering a roadmap that works at the ground level. With the help of engaged superintendents, golf courses can become part of a regional effort to prevent the loss of a native pollinator—and demonstrate once again that the golf industry can be a leader in environmental stewardship.

■
For further information, you can reach Dr. Steven Alm at stevealm@uri.edu.



2026 Research Priorities: Strengthening Golf and Environmental Stewardship

Topdressing Sands and Solid-Tine Cultivation Practices

Rutgers University – Dr. James Murphy

This project will examine topdressing materials and cultivation methods to better understand their effects on putting surface performance, playability, and long-term turf health.

RESEARCH UPDATE

Investigating the Impact of Golf Footwear on Putting Surface Quality

Cornell University – Dr. Frank Rossi

Having completed his two-year commitment to the foundation, Cornell's Dr. Frank Rossi reports on the outcome of his research examining golf footwear's effect on putting surface quality.

Together, these projects address immediate agronomic threats, long-term water and regulatory pressures, environmental stewardship, and core cultural practices—ensuring meaningful value for every superintendent in our region.

GRATITUDE FOR YOUR CONTINUED SUPPORT

None of this work is possible without your continued support. We ask clubs and industry partners to maintain their annual \$350 contribution—an investment that directly funds research benefiting golf courses, golfers, and the broader environment.

To those who have already contributed, thank you. If you have not yet sent in your donation, please visit www.tristateturf.org or contact our office at 914-347-4653.

LOOKING AHEAD

The strength of the Tri-State Turf Research Foundation has always been rooted in collaboration—among superintendents, researchers, allied associations, and industry partners who share a commitment to progress through science.

On behalf of the Board of Directors, thank you for your continued support and engagement. I look forward to working together to advance research that not only addresses today's challenges, but also positions golf for a sustainable and successful future.

Ken Lochridge

President

Tri-State Turf Research Foundation

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