

# Applied Thermography<sup>(@ Golf Courses)</sup>

Autonomously distill **tons of data** from multiple sites everywhere that you need to know about,  
into **actionable information**

And solve the labor shortages and budget squeezes by making using the tool that makes money back!

**Jim Etro**

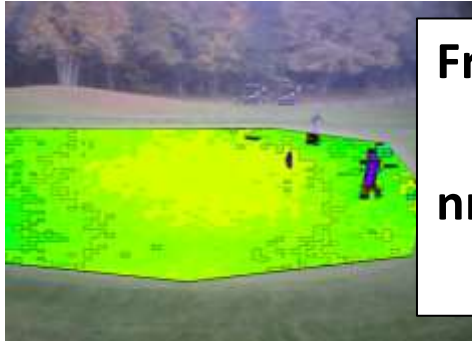
[j.etro@turf-vu.com](mailto:j.etro@turf-vu.com)

+1 703 489 8507 on WhatsApp



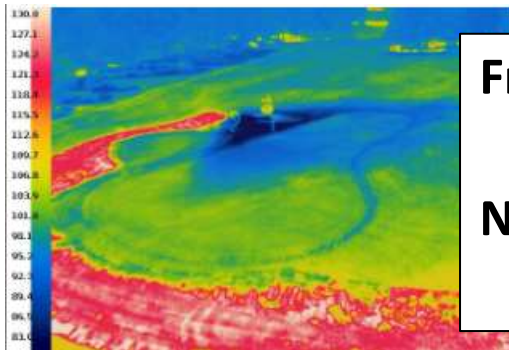
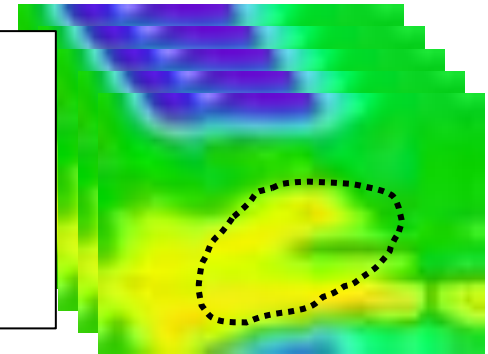
Turf-Vu  
a Division of ItriCorp

Autonomously distill **tons of data** from multiple sites everywhere that you need to know about,  
into **actionable information**



From: Hawk-Eye  
To: e-mail and/or phone @ 1:15 PM  
nr15green **Color** is declining toward yellow  
Look at it & consider N

From: Hawk-Eye  
To: e-mail and/or phone @ sunset  
Nr13 Fairway Zone 3 & 4 **IRRIGATE** Daily Stress >0.70  
Add a turn to sprinkler



From: Hawk-Eye  
To: e-mail and/or phone @ 1:25 PM  
Nr03green Turn **FAN ON**  
Turf Temp GTR 94 deg

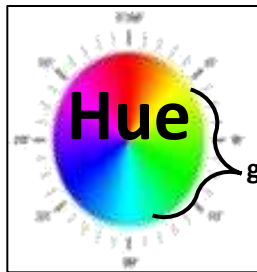
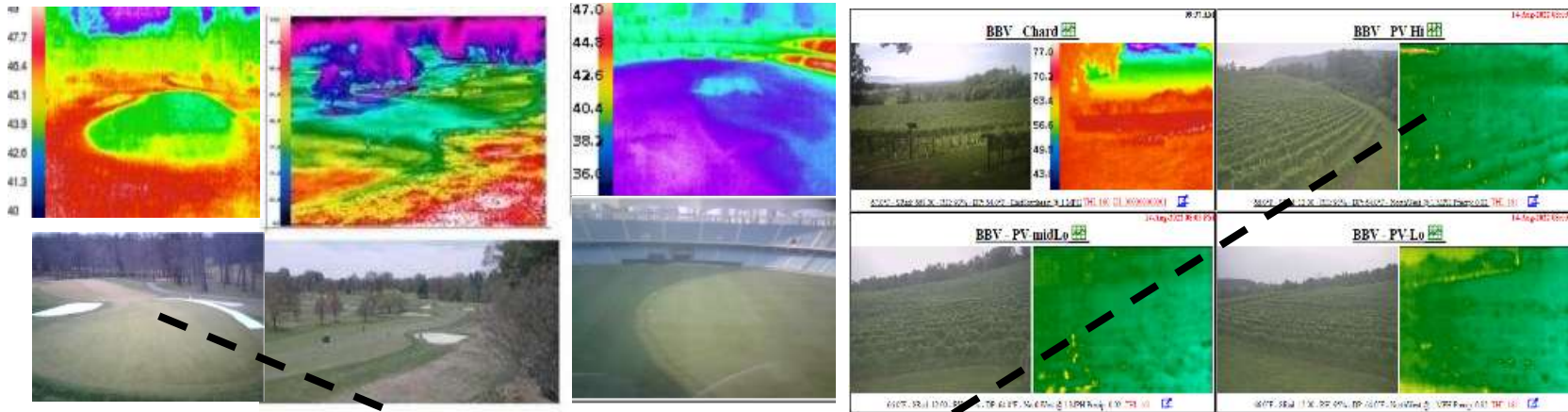
**jim etro**

703-489-8507

j.etro@turf-vu.com

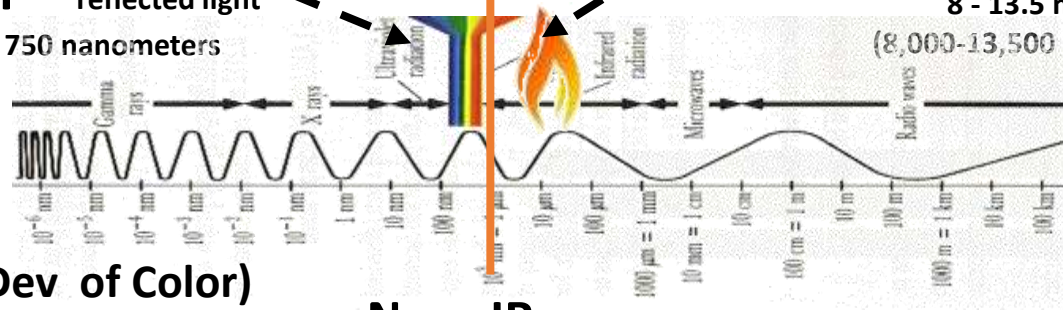


# The Agricultural Imaging Spectrum

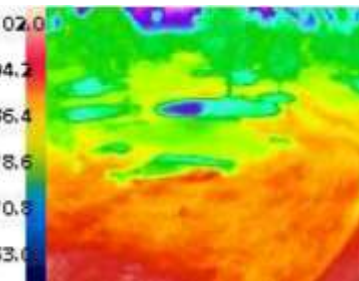


**Color** — reflected light  
430 - 750 nanometers

**Temperature** — emitted heat  
8 - 13.5 microns  
(8,000-13,500 nanometers)



**Near-IR** — chlorophyll fluorescence  
Approx 850 nanometers



**Color (Hue°) & Uniformity (Std-Dev of Color)**  
= **QUALITY (1-9) & Infers N,P,K**



**Temperature** Infers  
Photosynthesis  
Respiration  
Evaporation/Moisture  
Plant Water Status

It makes for a ton of data

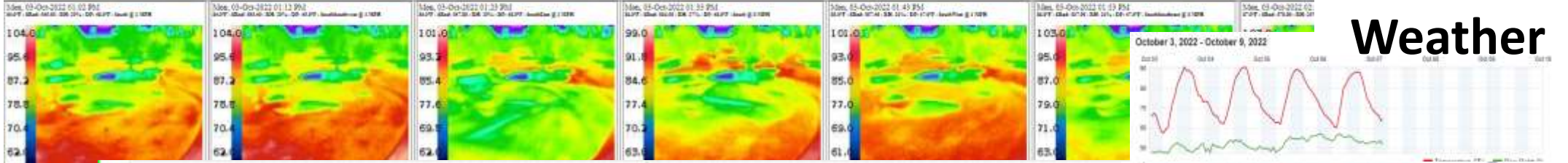


# Persistent Imagery & Data

Images



Weather



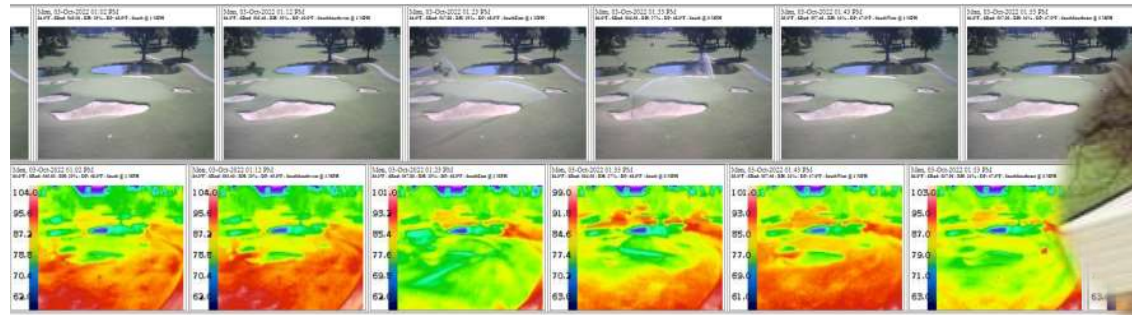
Data



**But, it's Lots of Pictures & Data**



# Distill Lots of Pictures & Data



## Into Actionable Information

From: Hawk-Eye

To: e-mail and/or phone @ sunset

Nr13 Fairway Zone 3 & 4 **IRRIGATE** Daily Stress >0.70

Add a turn to sprinkler

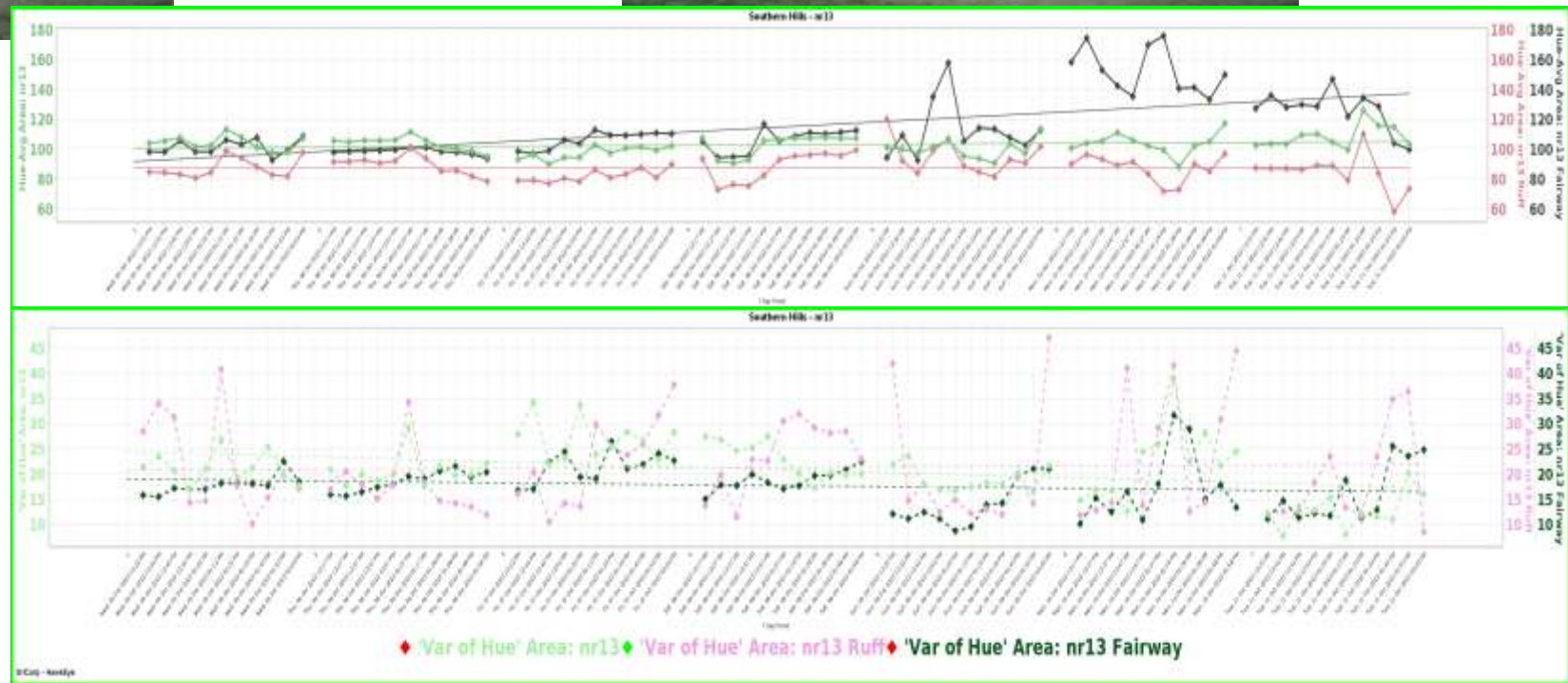
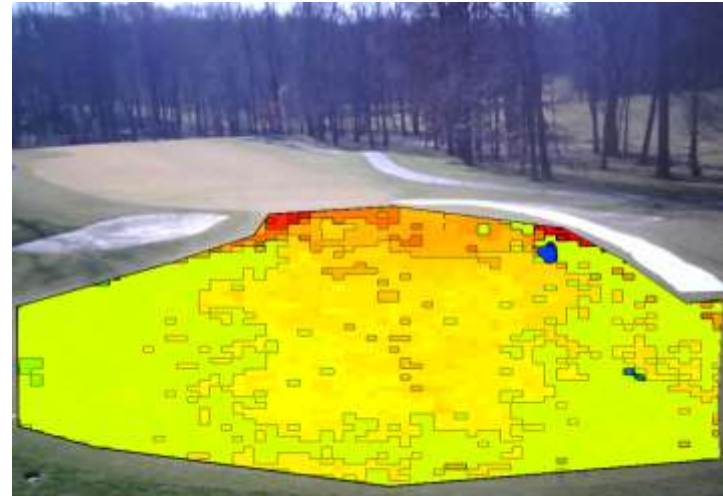
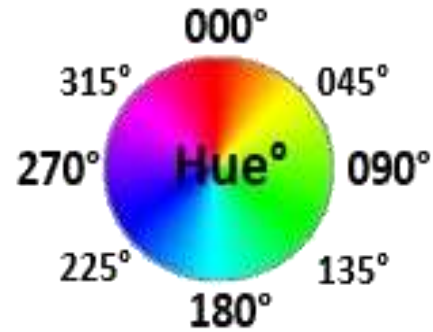
From: Hawk-Eye

To: e-mail and/or phone @ 1:15 PM

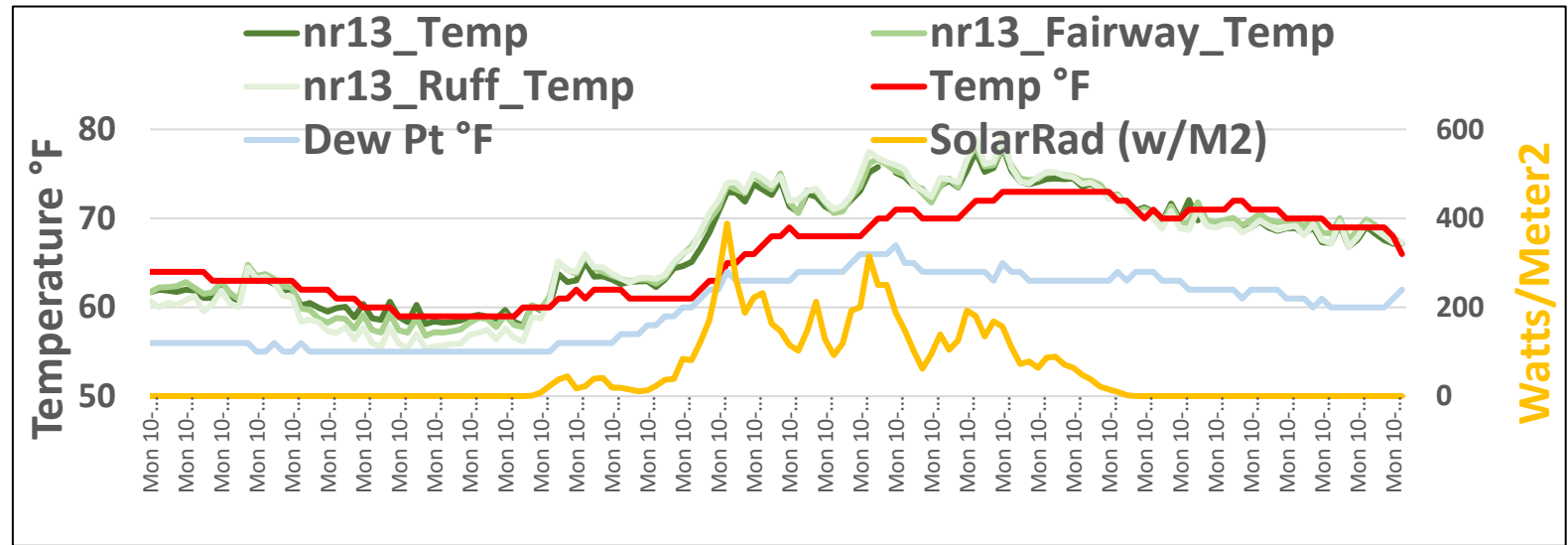
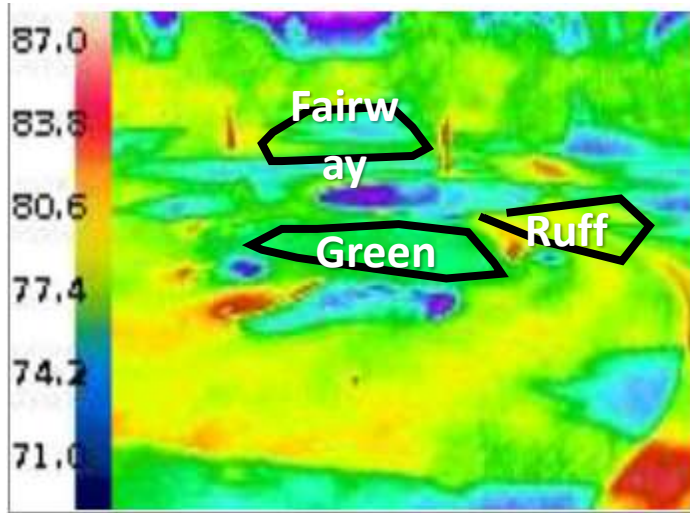
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Look at it & consider N

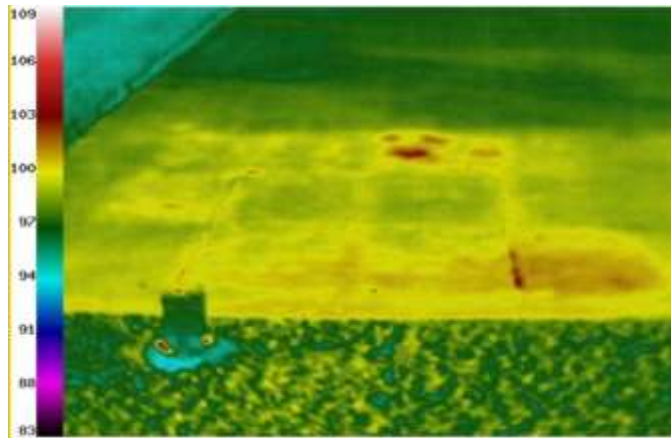
# Using Visual Images & Quality Indices



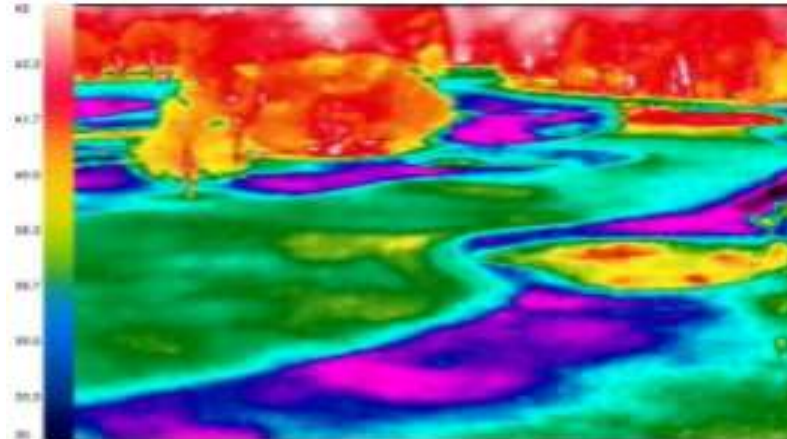
# Using Thermal Images Day & Night



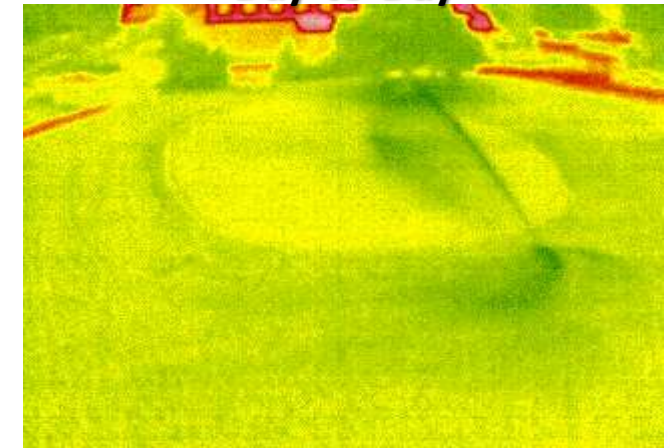
Research



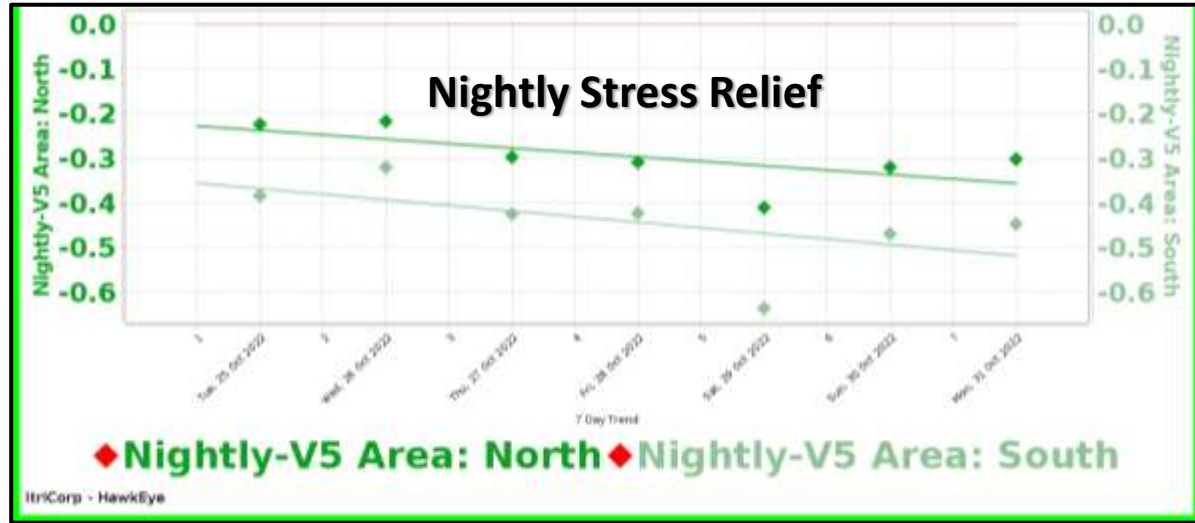
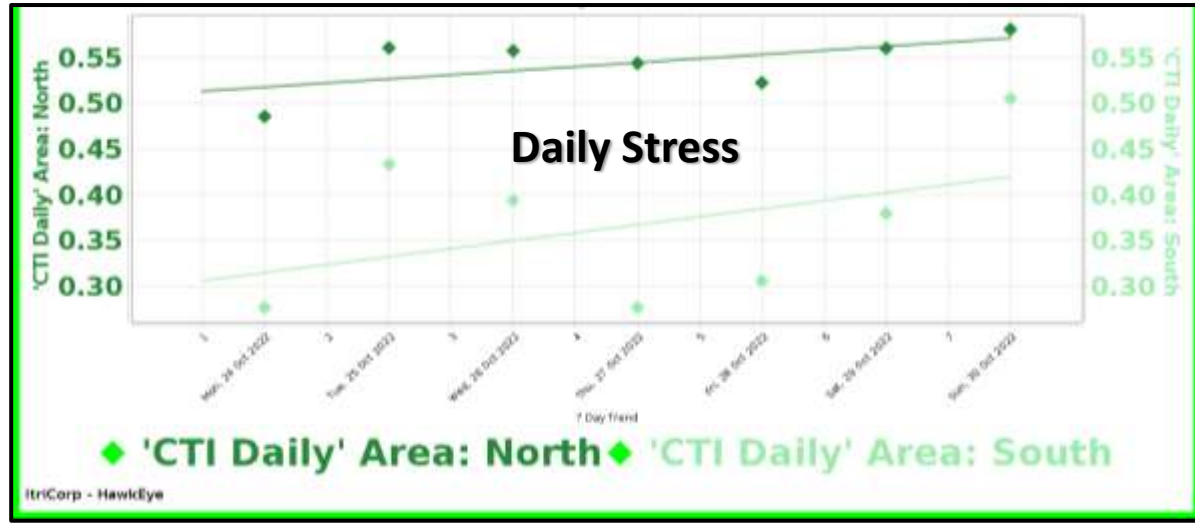
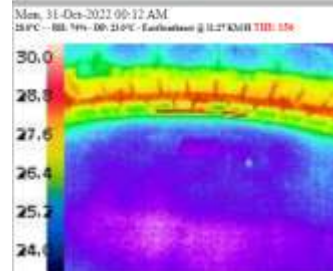
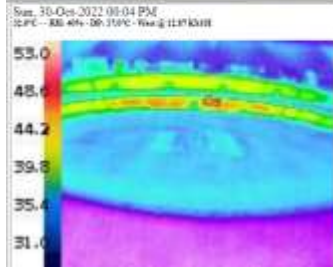
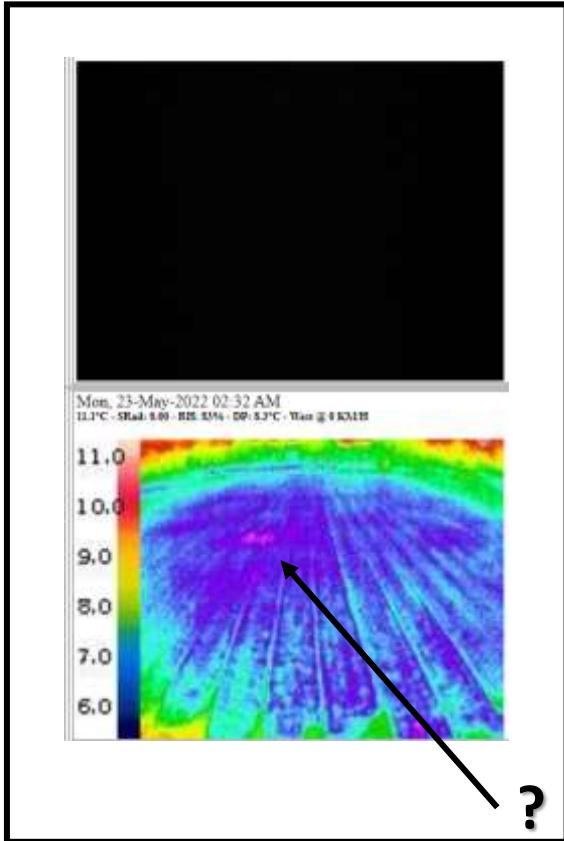
Maintenance



Day-to-Day

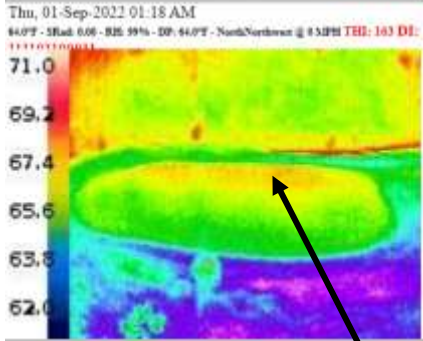


# Turf Thermography Night and Day

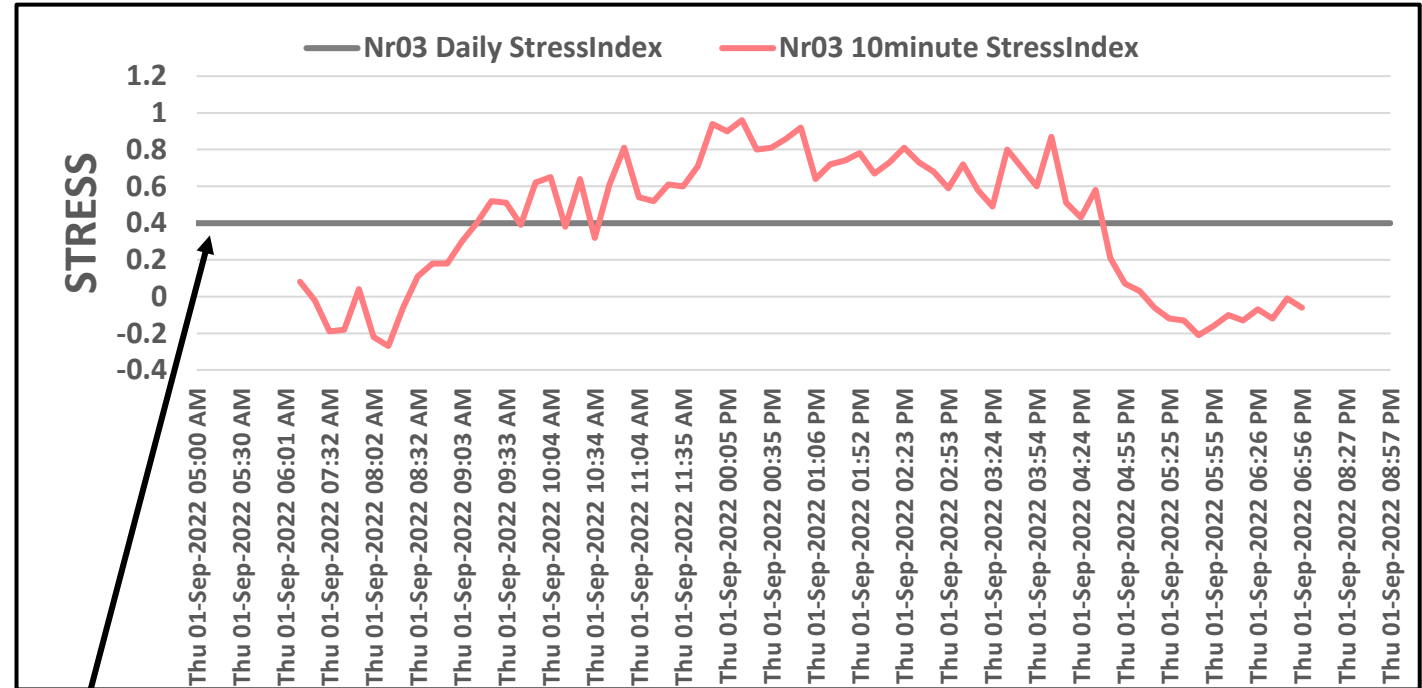
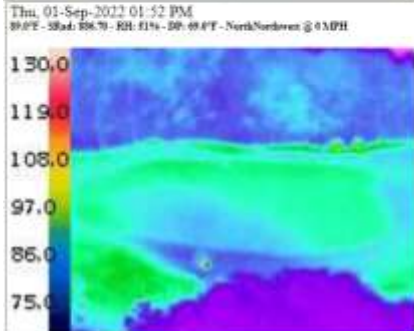




# Turf Thermography Night and Day

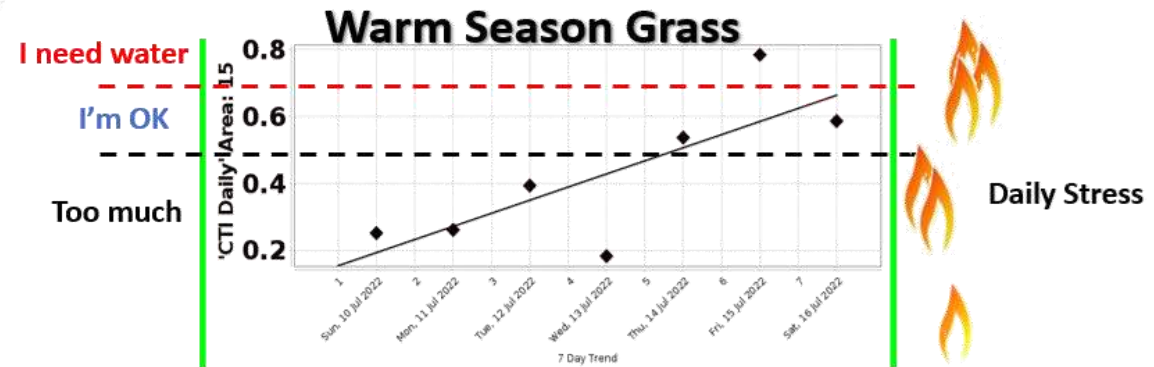
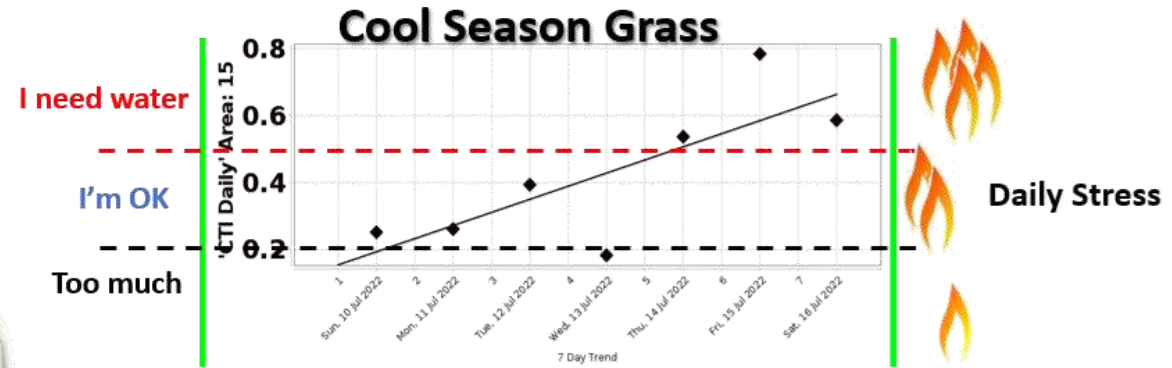


?



Add a turn to sprinkler when daily reaches .5 or more.

# Using Temperature Stress Indices



**Irrigation = Water + Electricity + Pump Hours**

# Use Cases

# Getting Ahead of Winter Kill

Locate Dead Spots to Remediate Early



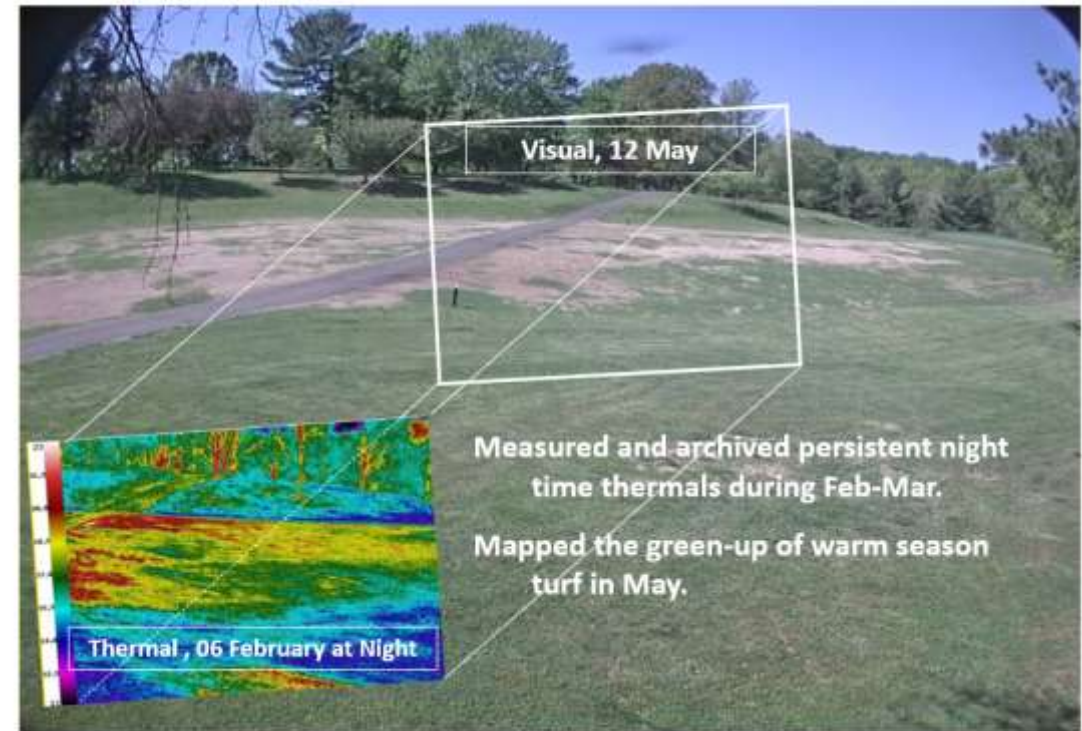
Poor drainage.

Persistent wet areas.

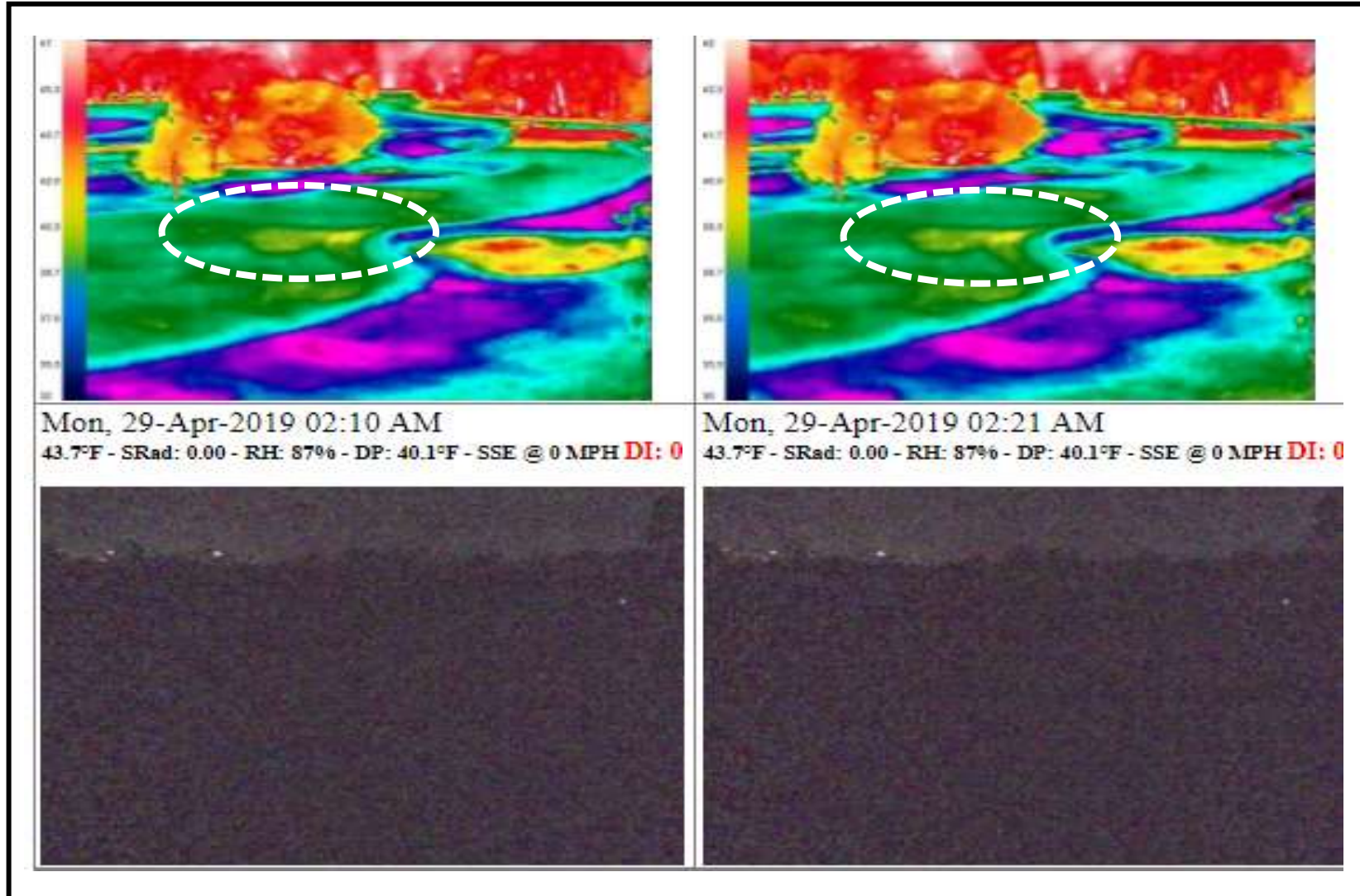
Persistently well below freezing temperatures (more than 3 days in a row)

Frozen roots = winter kill

Green-Up,  
The Movie: <https://vimeo.com/269639967>



# Identifying Need for Better Drainage

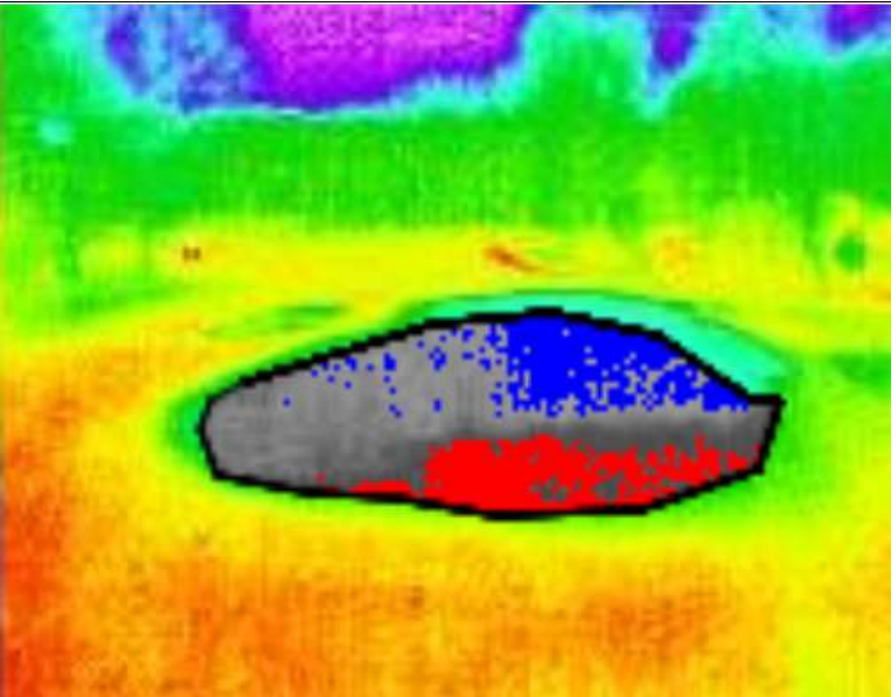
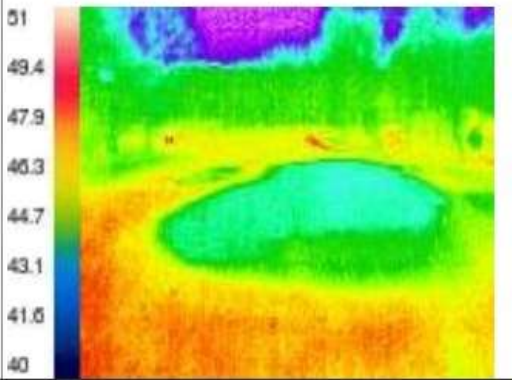


# Assessing Compaction & its Remediation

## Tine &/or Adjust Irrigation

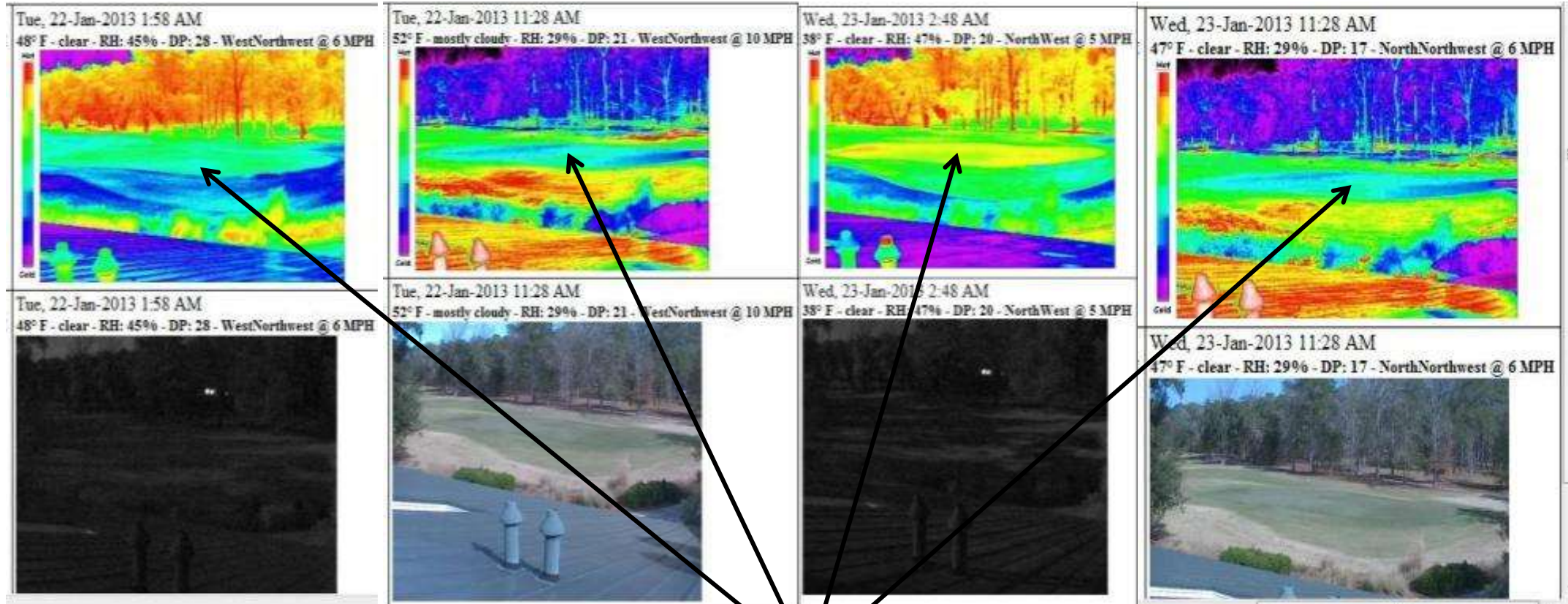


Mon, 25-Jan-2021 01:20 PM  
36.0° F - SRad: 88.00 - RH: 53% - DP: 20.0 - East @ 0 MPH



36.0° F - SRad: 79.30 - RH: 53% - DP: 21.0 - EastSoutheast @ 1 MPH

# Identifying Nematodes



**Persistent Pattern**

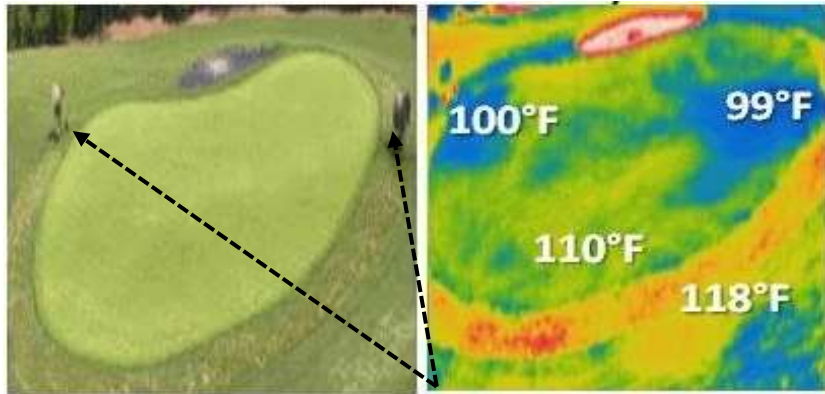
Cooler during night  
Warmer during day



# a Fan is Effective for Cool Season Grass

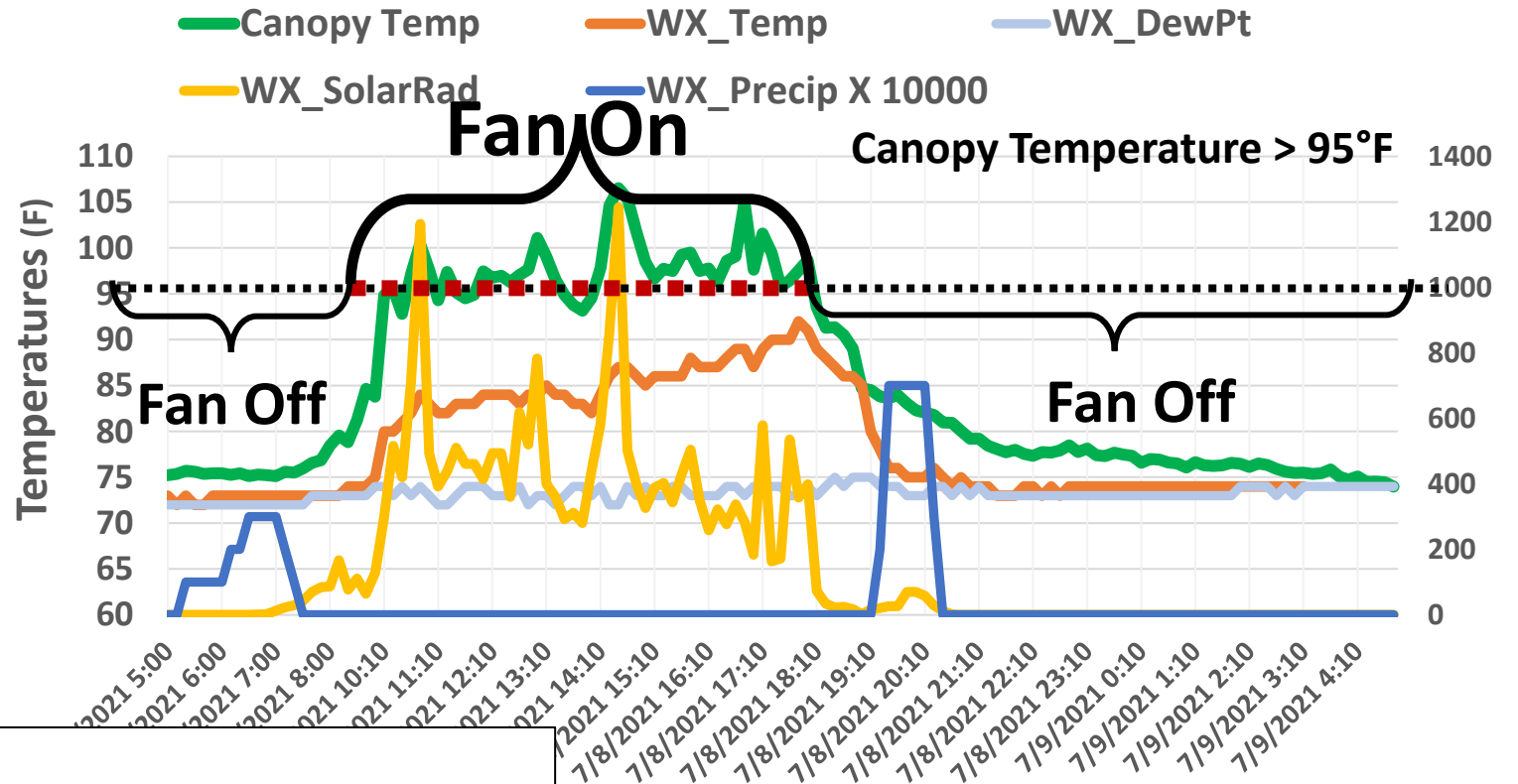
Set-Up Your System and know ...

When the Fan is aimed well.

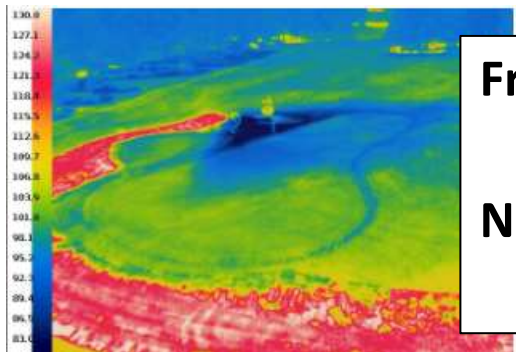


*These fans could be aimed better.  
or Add a fan?*

When the Canopy Temperature is > 95 °F.



SolRad (w/M<sup>2</sup>) & Precip (in X 10000)



From: Hawk-Eye  
 To: e-mail and/or phone @ 1:25 PM  
 Nr03green Turn **FAN ON**  
 Turf Temp GTR 94 deg

Only use Fans when needed.





# Guiding Irrigation



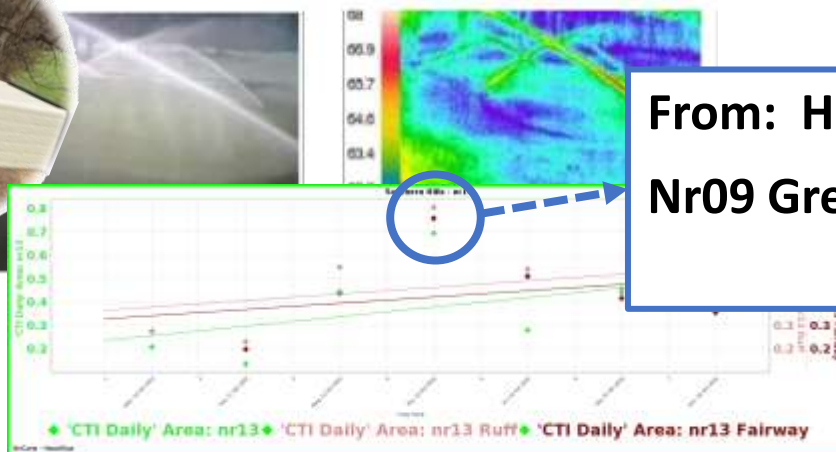
Use your regular irrigation schedule.

When you irrigate today, let the System tell you if you should:

add a turn

or

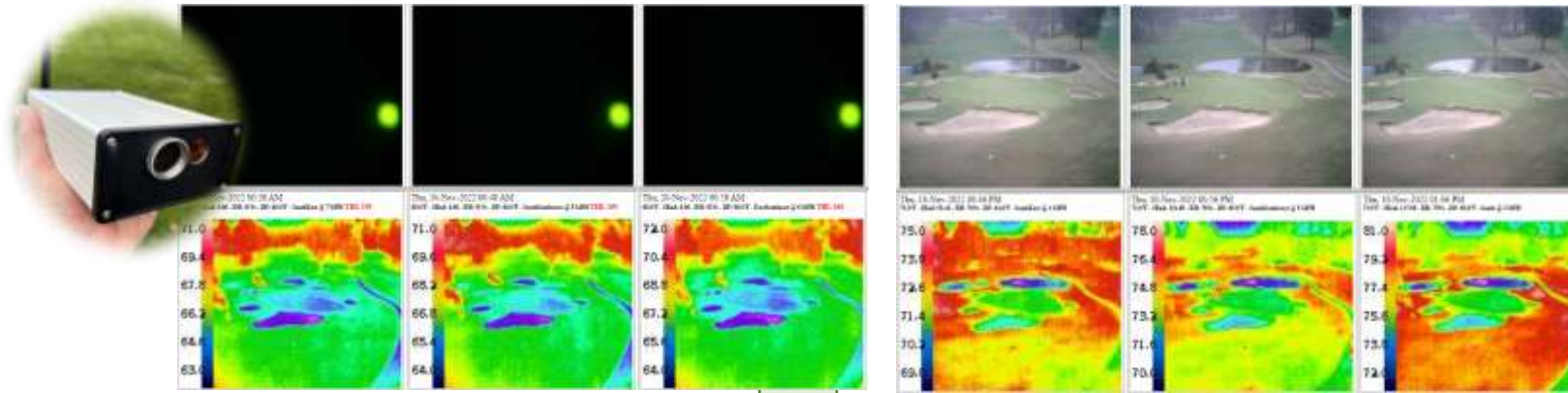
take one away



From: Hawk-Eye

Nr09 Green **IRRIGATE**

Add a turn to sprinklers



**It's not how the picture looks.**

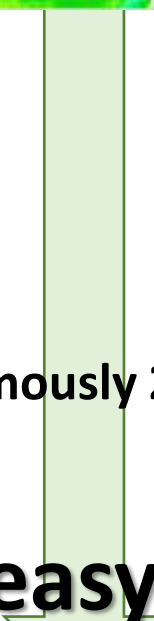
**It's about the information in it.**

Measuring HUE°

Measuring Turf Temperature

Autonomously 24/7/365

**And how easy it is to use.**



**Hawk-Eye™**  
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[http://itricorp.com/our\\_business/Why\\_and\\_How\\_it\\_works.html](http://itricorp.com/our_business/Why_and_How_it_works.html)



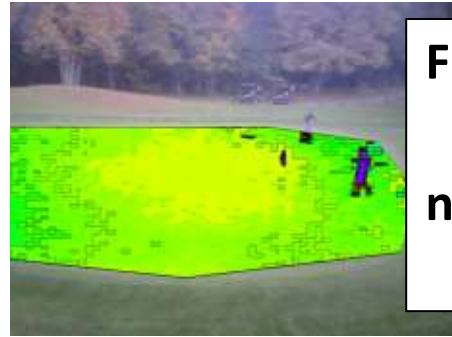
**From: Hawk-Eye**

**To: e-mail and/or phone**



# We are Working On

- Using Hue° Measurements to Guide Fertility Applications.
  - Applying by Fertigation (or not).



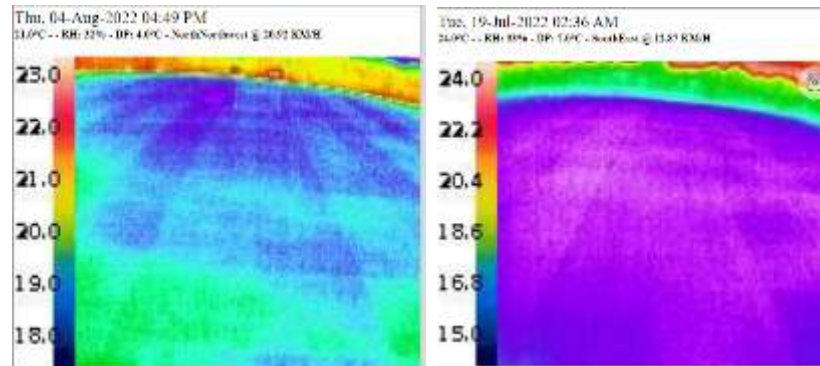
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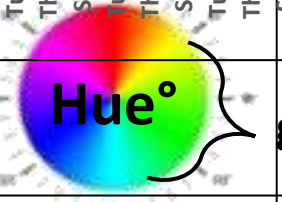
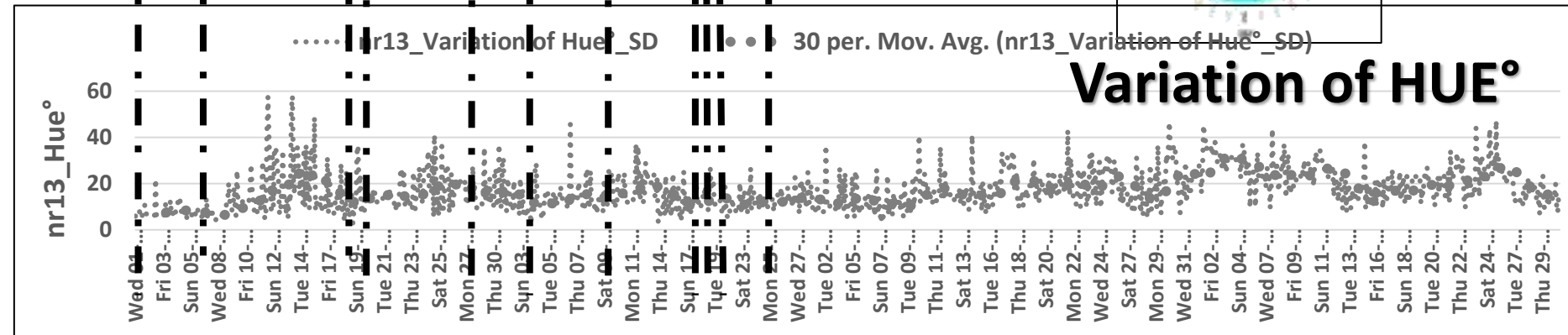
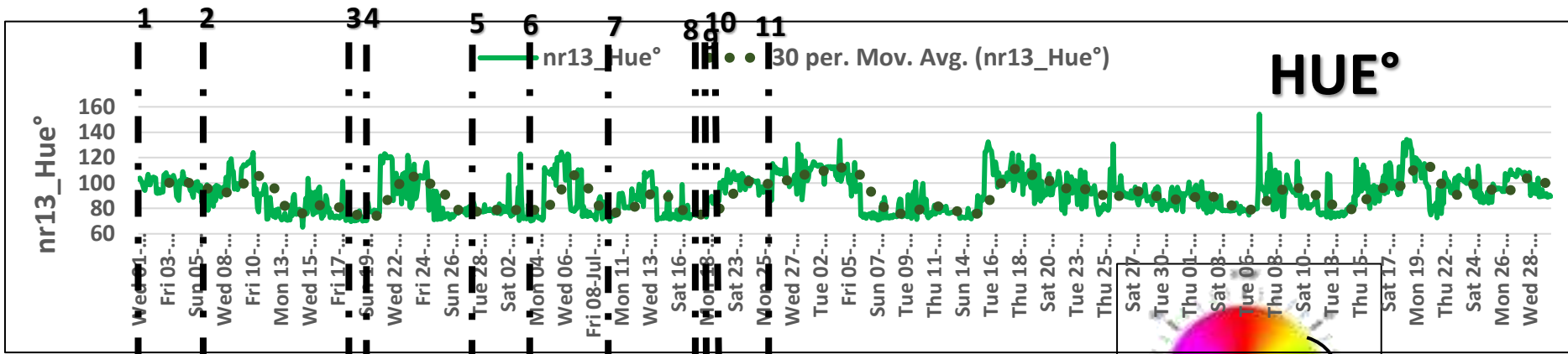
Look at it & consider N

- Relationship of Mowing Pattern to Disease Control and Irrigation.



- Understand the Daily Stress & Nighttime Recovery Relationship.

# Guiding Fertility Applications



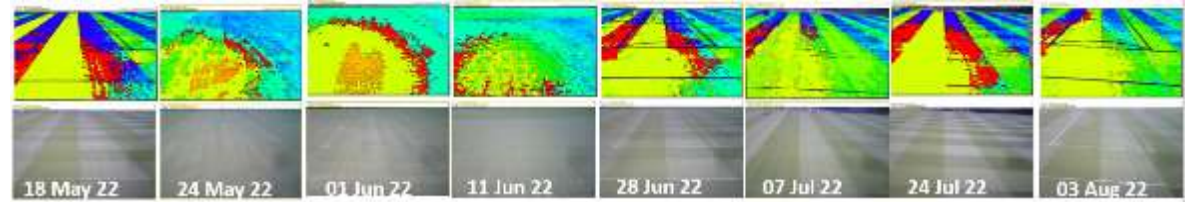
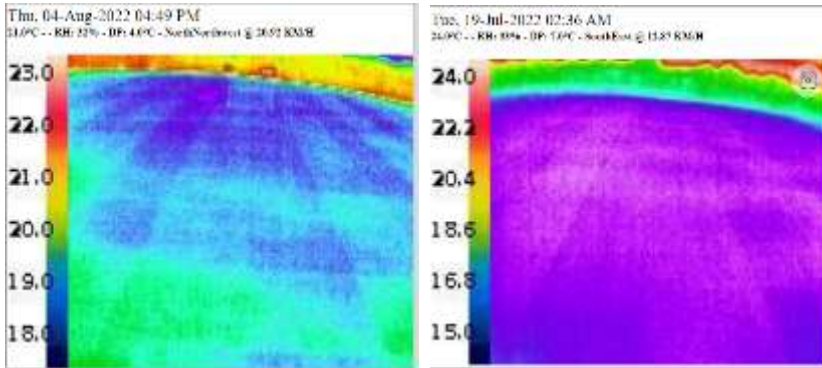
In Progress



GreenSeeker from Trimble

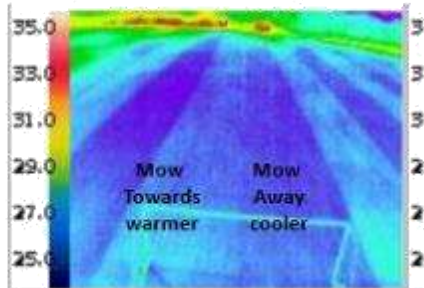


# Health Impact of Mowing Patterns?

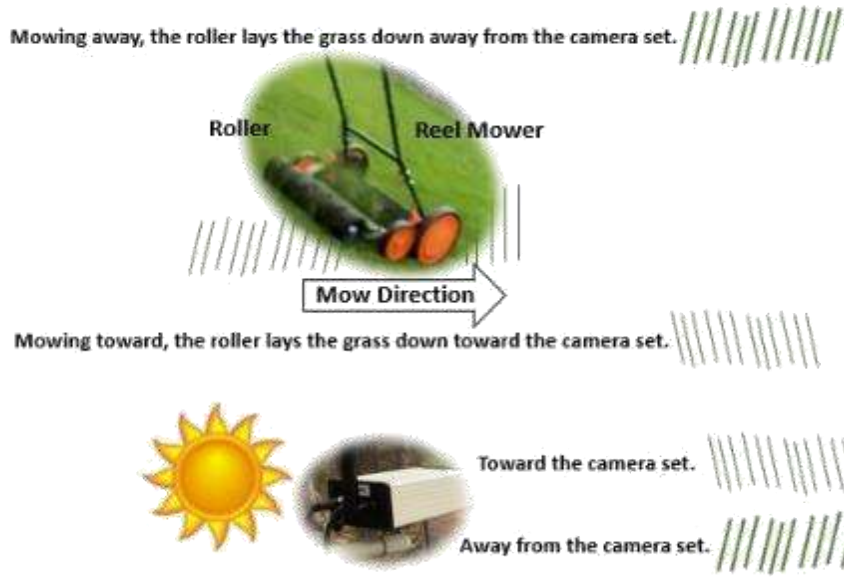


The canopy in the NNW end of the field (nearest the camera) consistently warmer than the SSW end, day and night?

If you stand on the end line at the end away from the cameras, the visual pattern reverses. Not the temperature pattern.



The Sun is behind the camera all day. The temperature difference is most pronounced between 11h and 16h. It goes away after sunset.



Mowing away, between 11h and 16h, some visible light is reflected off the Epicuticular wax away from the grass. That energy is not absorbed to be radiated as heat, but it is plenty for photosynthesis.

## “So What”

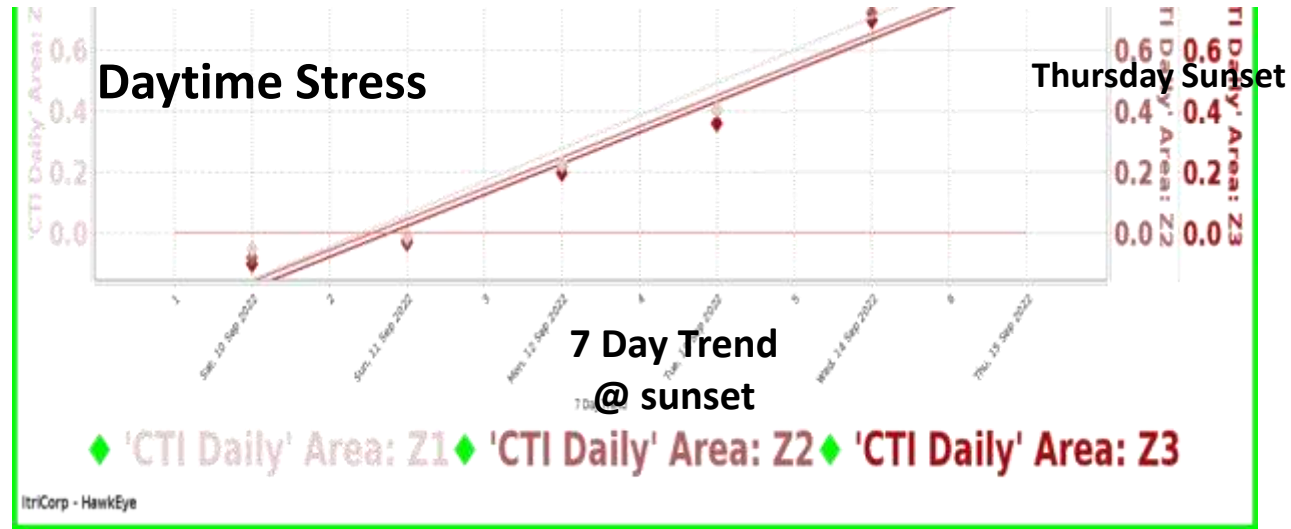
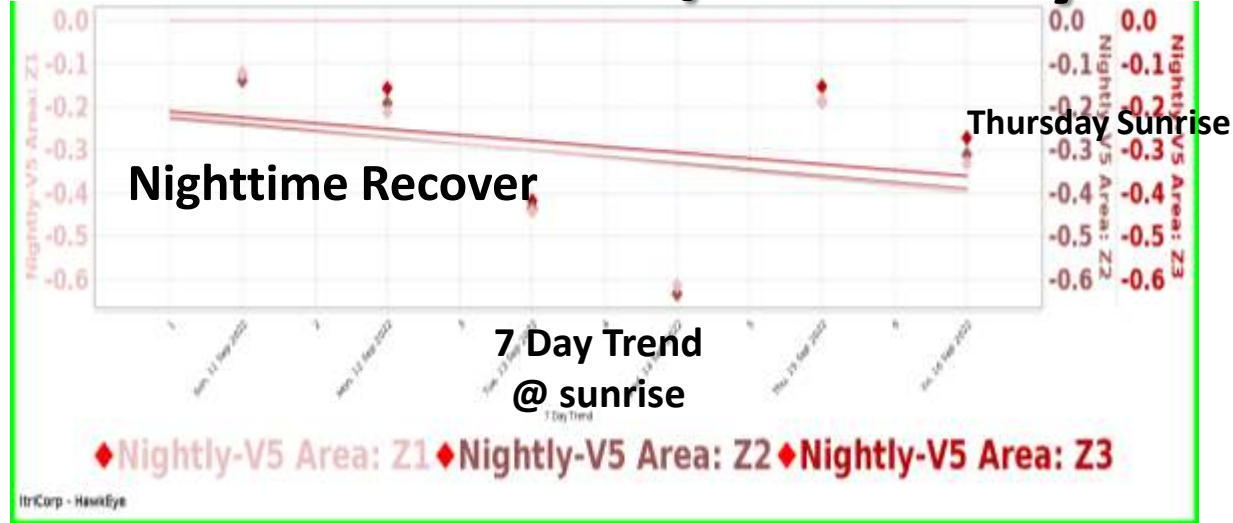
Mowing patterns are cool and have an aesthetic value. But does it matter that half a field may be a degree warmer during the afternoon?

- ? Does it have an impact on stress and irrigation demand?
- ? Does it open a door to disease in the cooler/moister part of the pattern?
- ? Does it impact player safety?

In Progress

# Understand the Stress/Recovery Relationship

In Progress



Index the Stress/Recovery Relationship