

The Importance of Managing Soil Moisture on Athletic Fields

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Athletic Field Safety Concerns

- Over 40 million athletes participate in organized sports annually (Micheli, 2000)
- More than 8,000 sports related injuries that require emergency room visits for youth daily (Wier et al., 2009)



Athletic Field Safety Concerns

- There are over \$1.3 billion each year in medical expenses for sports related injuries each (Hergenroeder, 1998)
- 5.7% of high school football injuries were definitely related to field conditions, 15.2% were possibly related to field conditions (Harper et al., 1984)



Athlete-to-surface interactions
(Bell, 1985; Nigg et al., 1984)



Ground Reaction Forces

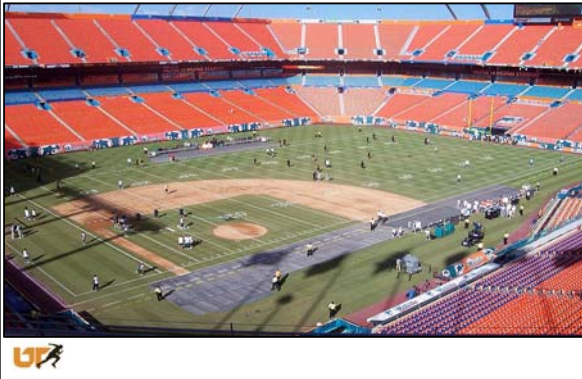


What is playing quality?

Safety and Playability



Consistency & Reliability



Surface Hardness



Athletic Fields

- Poor athletic field playing quality can negatively impact player performance and safety (Cockerham et al., 1993)
- Reduced turf cover
 - Increases surface hardness
 - Reduces traction (Holmes and Bell, 1986)



Characteristics of a good athletic field

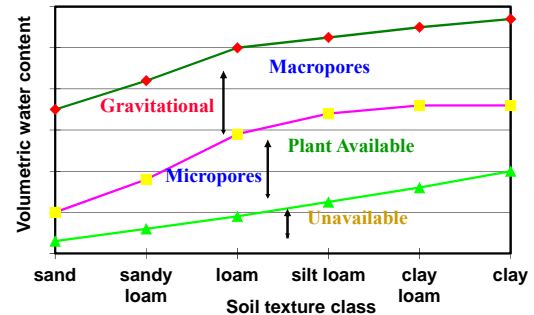
- Maintain adequate
 - Traction
 - Surface hardness
 - Turfgrass cover
- Consistent and safe regardless of weather conditions (Henderson et al., 2009)

Played under different soil water content (SWC) conditions

- Athletic events take place across a variety of field conditions



General Relationships Between Soil Moisture Characteristics and Soil Texture



Previous Research

- Native soils are higher in silt plus clay content than sand based root zones, resulting in higher soil water content (SWC) and lower infiltration rates

(Pitt et al., 2008)

- Too much rain can create unstable soil conditions due to excessive SWC

(Antunes et al., 2011)



Previous Research

- Bermudagrass under high levels of SWC exhibited greater loss of GTC subjected to traffic compared to lower levels of SWC

(Carrow et al., 2001)

- Green turfgrass cover loss was greater for higher SWC levels on *Poa pratensis* (L.) subjected to traffic events

(Minner and Valverde, 2004)

- Surface hardness and SWC have an inverse relationship

(Rogers and Waddington, 1989 & 1992)



Objectives

- Determine the impact of varying SWC levels for turfgrass performance characteristics and soil physical properties in silt loam and sand root zones
- Create a predictive model for loss of GTC due to SWC



Silt Loam Root Zone

Materials and Methods

- Treatments**
 - 4 soil water contents
 - 10% (+/- 3.5)
 - 17% (+/- 3.5)
 - 26% (+/- 3.5)
 - 35% (+/- 5.0)
- All Plots hand watered**
 - SWC checked daily
- 12 ft x 6 ft plots**
- Tifway Hybrid bermudagrass (*C. dactylon* (L.) Pers. x *C. transvaalensis* Burt-Davy)**
- Silt loam root zone**
 - (28% sand, 48% silt, and 24% clay)



Data Collection

Field Performance Evaluations

- Percent Green Cover Damage (DIA, Richardson et al., 2001)
- Surface Hardness (Clegg, F1702)
- Shear Resistance (Shear Vane, Goddard et al., 2008)
- Vertical and horizontal forces (TAFT, Thoms et al., 2013)

Turfgrass Measurements

- Internode length (Caliper, Roche and Loch, 2005)
- Leaf Texture (Caliper, Roche and Loch, 2005)
- Clipping Collection (Bucket, Turgeon et al., 1979)
- Percent Green Cover Recovery (DIA, Richardson et al., 2001)
- Spring Recovery (DIA, Richardson et al., 2001)
- Turfgrass cover (Visual estimate, Skogley and Sawyer, 1992)

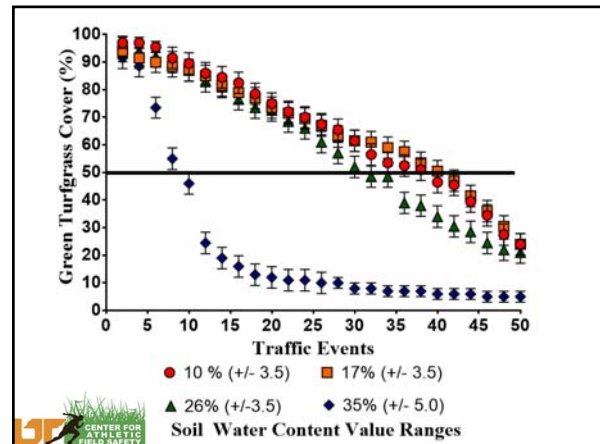
Soil Physical Properties

- Soil Bulk Density (Core method, Grossman and Reinsch, 2002)
- Air-filled Porosity (Gravimetric method with water saturation, Flint and Flint, 2002)
- Water-filled Porosity (Water desorption method, Flint and Flint, 2002)
- Organic Matter (Loss on ignition, F1647)
- Soil Moisture (Gravimetric method, Topp and Ferré, 2002)
- Soil Moisture (Time Domain Reflectometry, Topp and Ferré, 2002)
- Infiltration (Double ring Infiltrometer, Burgly and Luthin, 1956)

Traffic Simulation

25 Traffic Events

Baldree Traffic Simulator
(Kowaleski et al., 2013)



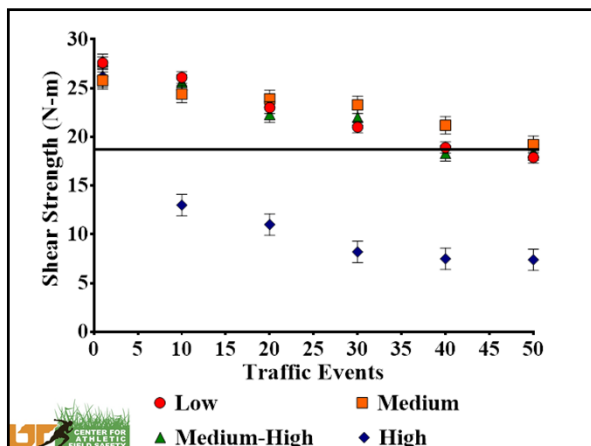
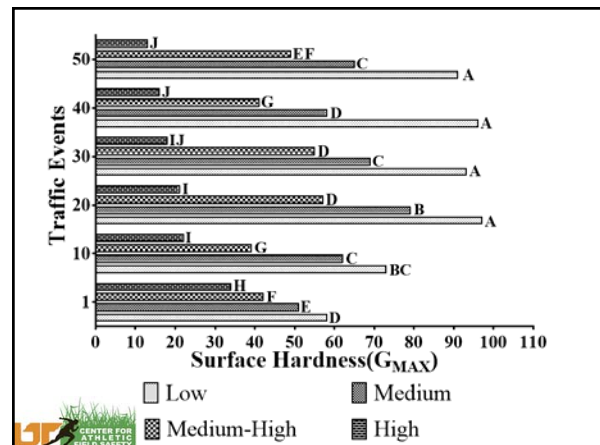
Soil Water Content Comparison Through 10 Traffic Events



17% SWC



35% SWC



Conclusions

- Athletic field performance was best between 7% to 20% SWC
- 30% SWC or above negatively impacts athletic field performance
- As soil water increases surface hardness decreases

Sand Root Zone

Materials and Methods

- **Treatments**
 - 3 soil water contents
 - 8% (+/- 3)
 - 16% (+/- 3)
 - 25% (+/- 5)
 - 12 ft x 6 ft plots
- Tifway Hybrid bermudagrass (*C. dactylon* (L.) Pers. x *C. transvaalensis* Burt-Davy)
- **USGA specification root zone**
 - (0.7% very coarse, 14.3% coarse, 61.4% medium, 18.1% fine, 5.1% very fine, and 0.4% silt and clay)

Data Collection

Field Performance Evaluations

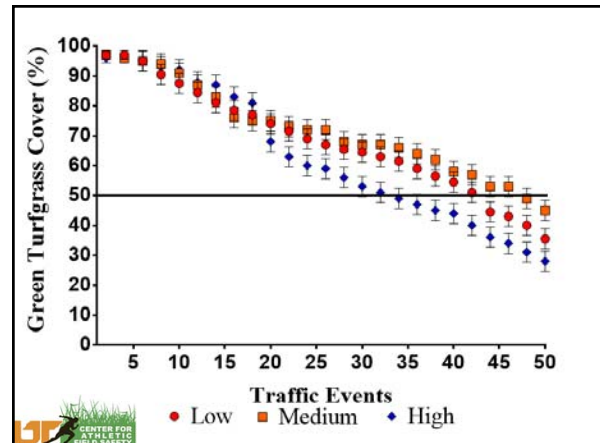
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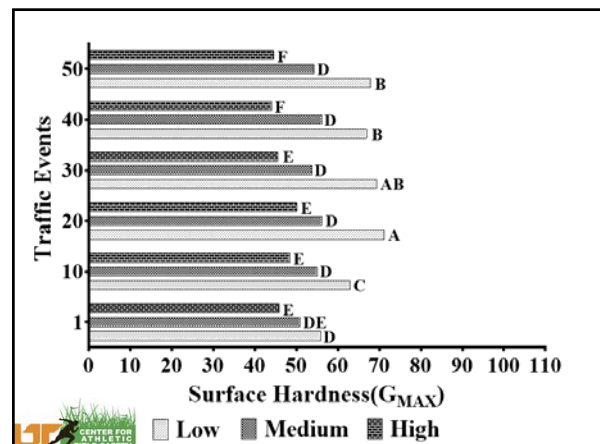
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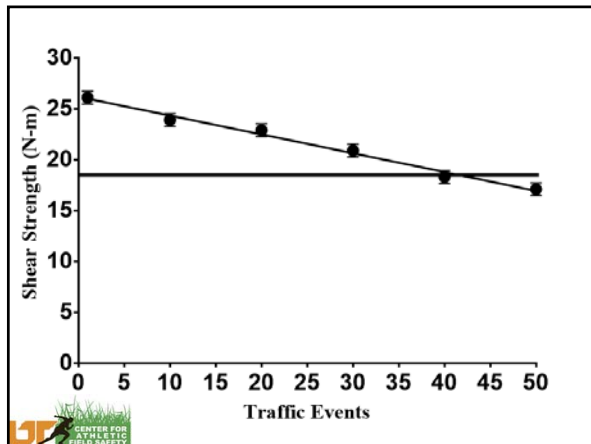


8% SWC



25% SWC



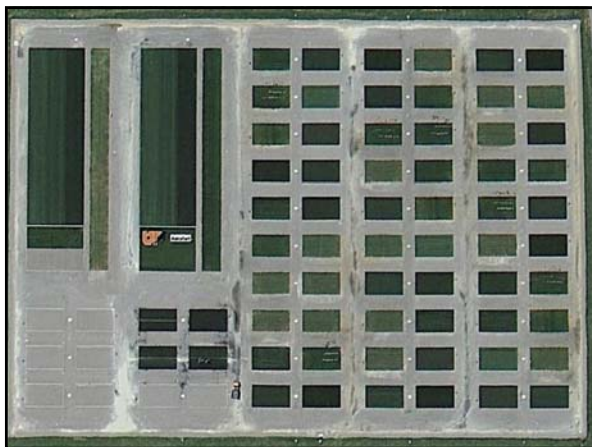


Conclusions

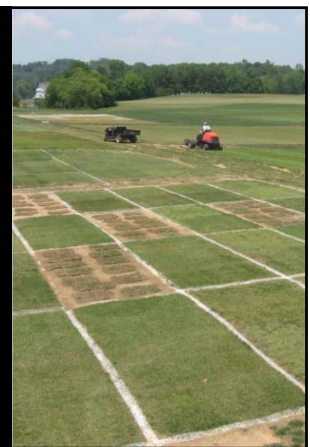
- Soil moisture had minimal impact on athletic field performance
- A predictive model was created for the loss of green turfgrass cover due to SWC and traffic events

Take Home Message

- In higher clay content soils moisture management is key
- Soil moisture has minimal impact on sand based root zone performance



ENSURE PLAYING SURFACE
DOESN'T AFFECT
THE OUTCOME OF
A GAME OR SAFETY
OF A PARTICIPANT



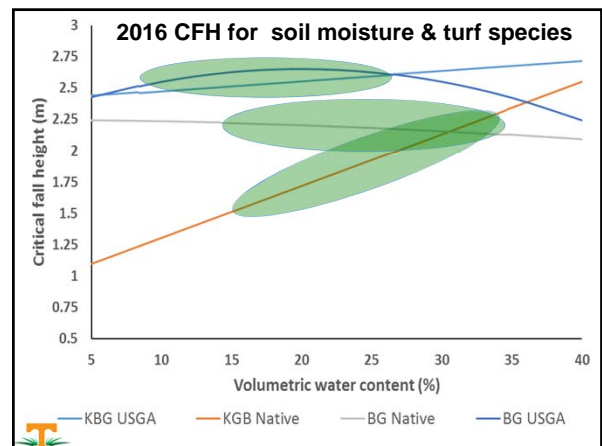
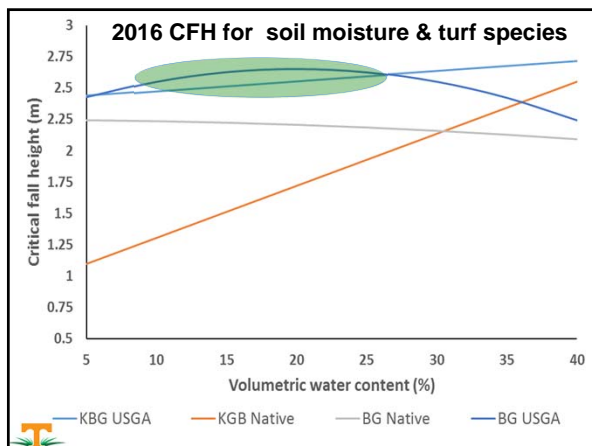
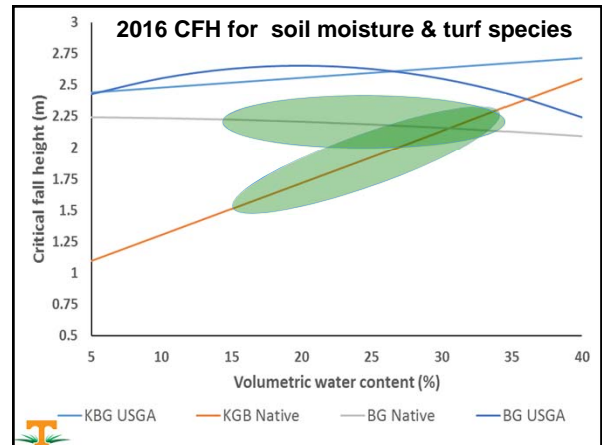
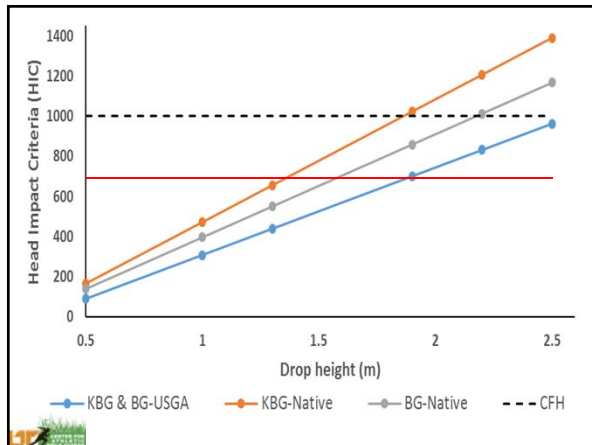
Playground Head Drop Device

Curved projectile mimics head shape

- 4.6 kg (10 lbs.) curved missile
- 1.3 m (51") drop height
- HIC must be less than 1000



ASTM F355 E 4.3 ft drop on synthetic turf



Thatch



Summary

Consolidated averages – ASTM F355-2016, Missile E

- KBG / BG USGA HIC 700 at ~6.2 ft / HIC 1000 at ~8.5 ft
- BG NATIVE HIC 700 at ~5.2 ft / HIC 1000 at ~7.2 ft
- BG NATIVE HIC 700 at ~4.5 ft / HIC 1000 at ~6.2 ft

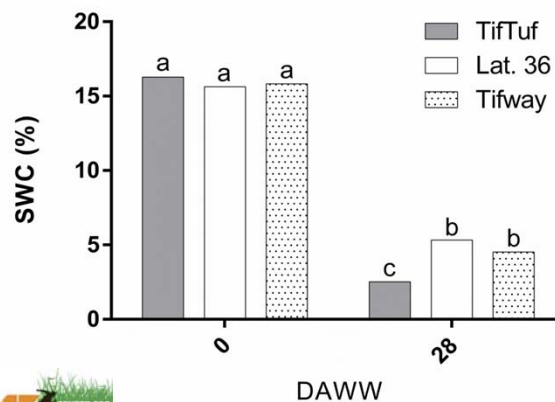


Conclusion

- Critical fall height is more of a function of soil texture than soil moisture for sand root zones
- Critical fall height is impacted by soil water content in silt loam soil root zones



Variety Selection



Cultivar	Root and Rhizome Dry Mass (g)					Root Length (cm)
	Soil Depth (cm)			Total	Rhizomes	
	0-15	15-30	30-45			
TifTuf	1.07	0.56 a	0.18 a	1.82 a	2.56 a	42.8
Latitude 36	1.04	0.27 b	0.02 b	1.33 b	1.62 b	34.8
Tifway	1.00	0.32 b	0.03 b	1.35 b	2.02 ab	35.8
<i>P</i> value summary	NS	*	**	*	*	NS

* and **, significant at $P \leq 0.05$ and 0.01 , respectively. NS, not significant



Conclusion

- TifTuf had higher quality after withholding water
- TifTuf produced the most root surface area

National turfgrass evaluation program (NTEP) – NTEP.org

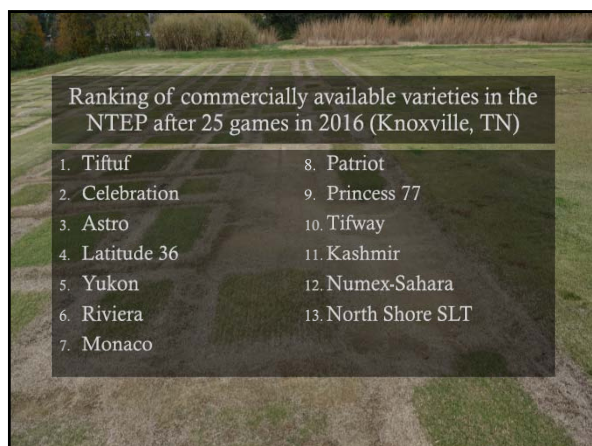
- 2013 National bermudagrass test
- 35 seeded and vegetative varieties
- Only 13 are commercially available
- Test includes traffic to test for wear tolerance (sports field use)

NTEP Varieties

Commercially available Varieties

- Tifway
- Latitude 36
- Patriot
- Celebration
- NuMex-Sahara
- Princess 77
- Monaco
- Riviera
- Yukon
- North Shore SLT
- TifTuf
- Kashmir
- Astro

Entry No.	Name	Type	Supplier
41	Tifway	Vegetative	Standard Earth
42	Latitude 36	Vegetative	Standard Earth
43	Patriot	Vegetative	Standard Earth
44	Celebration	Vegetative	Standard Earth
45	NuMex-Sahara	Vegetative	Standard Earth
46	Princess 77	Vegetative	Standard Earth
47	Monaco	Vegetative	Standard Earth
48	Riviera	Vegetative	Standard Earth
49	Yukon	Vegetative	Standard Earth
50	North Shore SLT	Vegetative	Standard Earth
51	TifTuf	Vegetative	Standard Earth
52	Kashmir	Vegetative	Standard Earth
53	Astro	Vegetative	Standard Earth
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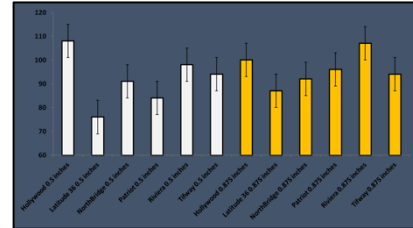
Clegg Surface Hardness

(ASTM F1702)

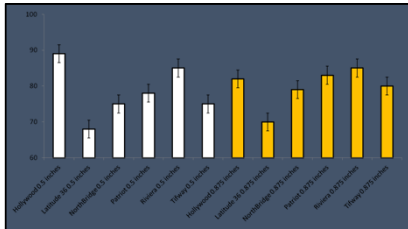


2.25 kg (5 lb) missile
45 cm (18") drop height

Mowing height by variety Clegg values (Gmax) after 0 games



Mowing height by variety Clegg values (Gmax) after 24 games



Tools

Turfgrass Evaluation



Surface Hardness Measurements



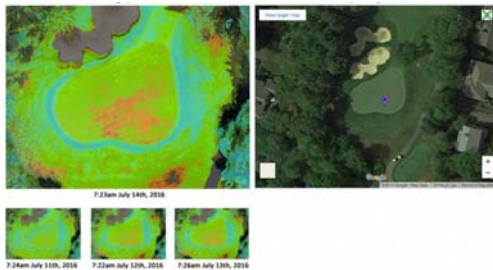
Irrigation Audit



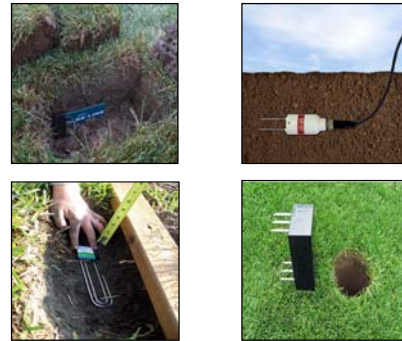
Soil Moisture Sensors



Software for Data Maps



Buried Ground Soil Moisture Sensors



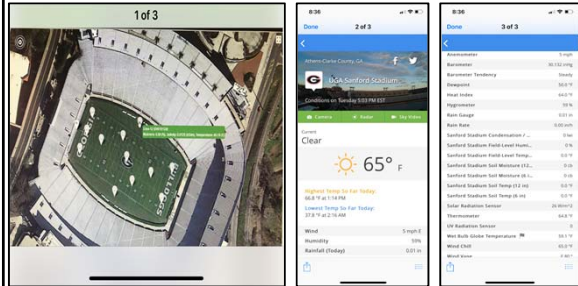
In Ground Sensors

Maps	Quick View	Programs	Devices	Water Sources	LiveView
Zone Status					
1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30
31	32	33	34	35	36
37	38	39	40	41	42
43	44	45	46	47	48
49	50	51	52	53	54
55	56	57	58	59	60
61	62	63	64	65	66
67	68	69	70	71	72
73	74	75	76	77	78
79	80	81	82	83	84
85	86	87	88	89	90
91	92	93	94	95	96
97	98	99	100	101	102
103	104	105	106	107	108
109	110	111	112	113	114
115	116	117	118	119	120
Controller: BL-3200 3K90229 BaseStation 3200					

In Ground Sensors



In Ground Sensors

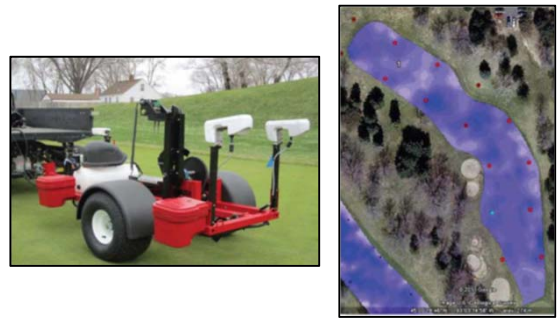


Record Keeping

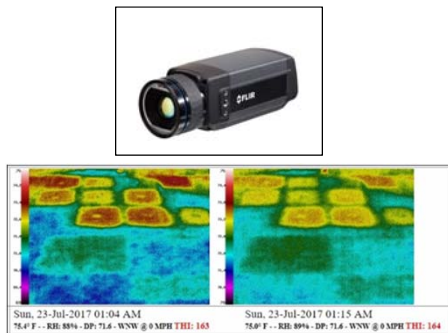


The Future

Precision Sense



Thermal Camera



App

- Goal to create an app for to help make game decision



Take Home Message

- Soil moisture management is key to the safety and playability of athletic fields
- Soil moisture impacts each soil texture differently
- Variety selection is important
- There are many traditional and new tools available to manage soil moisture

