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Pre-Game Agronomic Field Safety Assessment for Sports Fields: Future Implications for Risk Assessment

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Introduction

- One of the most difficult turfgrass areas to manage is sports fields due to the intense traffic they receive by players on a regular basis.
- Sports played on turfgrass athletic fields can easily result in injury to players, and there have been many cases where these injuries could be blamed on turf field conditions.

2

Introduction

- Due to high expectations regarding player safety by players and coaches, field safety and maintenance checklists need to be developed specifically for sports turf fields that ascertain agronomic properties of the turf.
- Currently, checklists consist mainly of facility-based questions regarding goals/goal posts, field markings, out of bound or transition areas, fencing, lighting, and rarely address turfgrass field conditions.

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STMA: Football/Soccer Field Safety & Maintenance Checklist

www.stma.org

Playing Surface – Natural Grass

Yes	No/Needs Attn	
❑	❑	There is at least 75 percent coverage of turfgrass on the field.
❑	❑	There are no bare spots with a hard soil surface exposed.
❑	❑	Soil is well drained with no standing water.
❑	❑	Turfgrass is uniform in color, height and density.
❑	❑	Turfgrass has strong root system, limiting "blow-outs."
❑	❑	There are no weeds with thorns, bristles or burrs.
❑	❑	There are no holes or mounds made by moles, gophers, or other animals.
❑	❑	There are no ruts or trenches caused by equipment use or field wear.
❑	❑	There has been communication between the maintenance staff and coach/ facility user.

4

Player Safety

- On sports turf, turfgrass quality is simply dependent on three characteristics:
- Traction
- Hardness
- Evenness

- Traction-
  - critical to generating and controlling player speed, making sharp turns, and stopping.
  - Poor traction can lead to muscle pulls and a variety of other injuries.

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Player Safety

- On sports turf, turfgrass quality is simply dependent on three characteristics:
- Traction
- Hardness
- Evenness

- Hardness-
  - affect player's ability to cut sharply.
  - increase injury from falls and tackles.

6

Player Safety

- On sports turf, turfgrass quality is simply dependent on three characteristics:
- Traction
- Hardness
- Evenness
- Evenness-
  - Influenced by turfgrass density, cover, and uniformity.

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Turf 3072: Turfgrass Science Course

Received complaints from Athletic Department on the quality of the football field.

Athletic Field Lab:

1. General Assessment
   - Soil Sampling (Soil Analysis, and Bulk Density
   - Soil Compaction Readings
   - Soil Moisture Readings
2. Dynamics between Athletic Department and Facilities.

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Pilot Study: Football Field Assessment

- A pilot field study was conducted on the University of Minnesota Crookston football field by undergraduates prior to each home game to assess field conditions (2016).
- There were six total home games during the season from September through October (3 games in September & 3 games in October).
- Soil compaction and soil moisture was measured prior to each home game to determine the agronomic field conditions of the turf and underlying soil.

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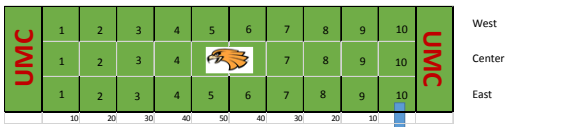

UMC Football Field

Data Collection:

*6 readings per plot taken diagonally across plot (3 rows, 10 plots per row=30 total plots)

Soil water content-VWC%

Soil compaction-psi

Game Field

10

Methodology

- Soil compaction was measured using a FieldScout SC 900 soil compaction meter (Spectrum Technologies)

PERCENTAGE OF MEASURING POINTS HAVING CONE INDEX > 300 PSI IN TOP 15 INCHES	COMPACTION RATING	SUBSOILING RECOMMENDED
< 30	Little to none	No
30–50	Slight	No
50–75	Moderate	Yes
>75	Severe	Yes

Adapted from: Lloyd Murdock, Tim Gray, Freddie Higgins, and Ken Wells, 1995. *Soil Compaction in Kentucky.* Cooperative Extension Service, University of Kentucky, AGR-161.

Table 1. Interpretation of soil compaction measurements.

11

Methodology

- Volumetric water content percentage was measured using a FieldScout TDR 300 (Spectrum Technologies) (Photo below).

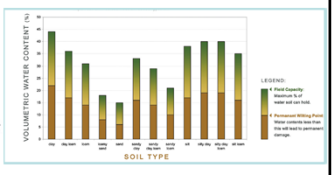

Figure 1. Water holding capacity by soil type in volumetric water content (%).

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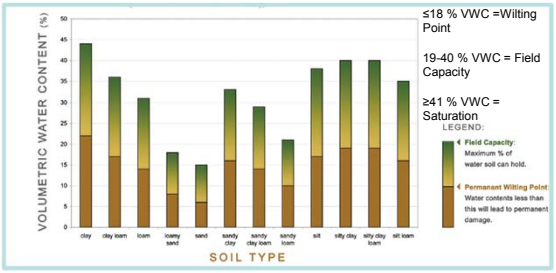
Figure 2. Water holding capacity by soil type in volumetric water content (%).



13

Results

- Soil compaction readings greater than 300 psi were measured on 50% of the field (moderate compaction) before the first home game.

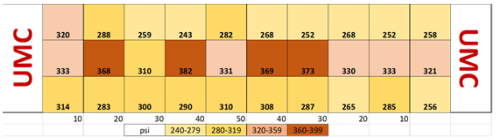


Figure 3. Prior to the first home game of the season, compaction readings indicated that 50% of the field (≥ 300 psi) had moderate compaction.

14

Results

- By the second home game, soil compaction readings greater than 300 psi were measured on 87% of the field.

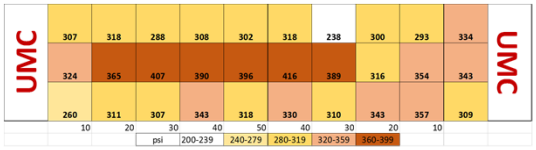


Figure 4. Prior to the second home game, compaction readings indicated that 87% of the field (≥ 300 psi) had severe compaction.

15

Results

- By the third home game, soil compaction readings greater than 300 psi were measured on 70% of the field.

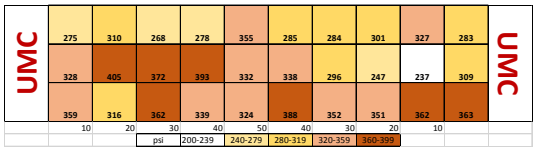


Figure 5. Prior to the third home game, compaction readings indicated that 70% of the field (≥ 300 psi) had moderate compaction.

16

Results

- By the fourth home game, soil compaction readings greater than 300 psi were measured on 80% of the field.

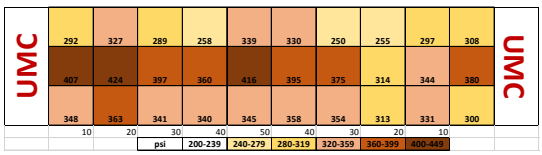


Figure 6. Prior to the fourth home game, compaction readings indicated that 80% of the field (≥ 300 psi) had severe compaction.

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Results

- The recommendation to aerify the field was made to the grounds crew and by the fifth home game of the season soil compaction readings greater than 300 psi were less than 10%.

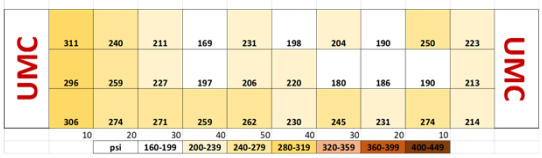

Figure 7. Prior to the fifth home game of the season, compaction readings indicated that less than 10% of the field (≥ 300 psi) had little to no compaction.

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Results

- By the sixth and last home game soil compaction readings greater than 300 psi had increased again to 50% (1 week later).

Figure 8. Prior to the sixth home game of the season, compaction readings indicated that 53% of the field (≥ 300 psi) had moderate compaction.

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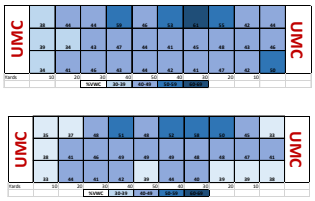
Results

- Field capacity (moisture content when downward water movement has ceased) for a silty clay loam is 19-40% volumetric water content.
- Soil moisture readings indicated that 70-90% of the field was saturated due to significant rainfall and over irrigation.

Figures 9-10. Prior to the first and third home game of the season (no data for second home game), soil moisture readings indicated that 70-90% of the field was saturated (≥ 40% VWC) .



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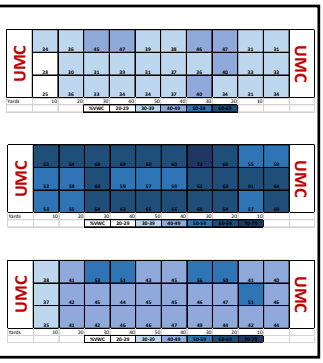
Figures 11-13. Prior to the fifth and sixth home game of the season, soil moisture readings indicated that 90-100% of the field was saturated (≥ 40% VWC) .



Results

- Soil moisture readings indicated that 90-100% of the field was saturated due to significant rainfall and over irrigation (exception prior to fourth home game VWC was 20%).

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Recommendations

- Aerate field every two weeks to reduce compaction on the football field.
- Decrease irrigation based on soil moisture content readings and precipitation.
  - Run uniformity test on irrigation system

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2017

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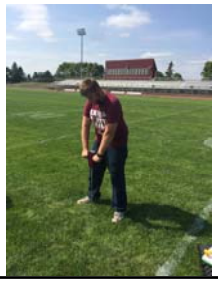
Pre-Game Agronomic Field Safety Assessment for Sports Fields



Aim of Research-Purpose

- Determine whether agronomic improvements made to the field indeed reduce player injury.
  - Athlete Injury Data from home games.
- Determine if coaches, players, and grounds staff found the pre-game assessment beneficial.
  - Survey

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Pre-Game Agronomic Field Safety Assessment for Sports Fields

Aim of Research-Purpose

- Develop an agronomic pre-game field safety assessment.
  - Includes:
    - Soil Compaction-psi
    - Soil Moisture-% VWC
    - Canopy greenness-NDVI
    - Turf Firmness-inches
  - Football and Soccer field

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UMC Football Field

Data Collection:

*6 readings per plot taken diagonally across plot (3 rows, 10 plots per row=30 total plots)

Soil Compaction-psi
Soil Moisture-% VWC
Canopy greenness-NDVI
Turf Firmness-inches

Game Field

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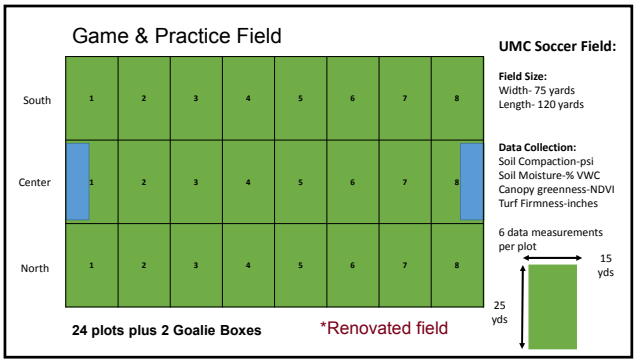

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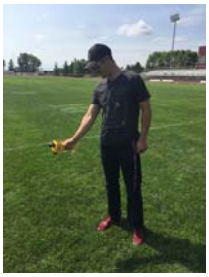
Methodology

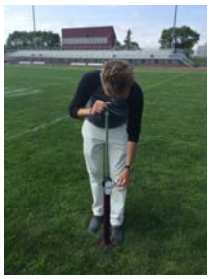
- NDVI FieldScout CM 1000 Chlorophyll meter (Spectrum Technologies):
  - Used to determine turfgrass color, quality, and overall health.



28

Methodology

- A FieldScout TruFirm Turf Firmness Meter (Spectrum Technologies)
  - The mass of the impact hammer is dropped from a consistent height and the maximum turf penetration value is recorded and correlated to the surface hardness, the lower the penetration value, the firmer the turf.



29

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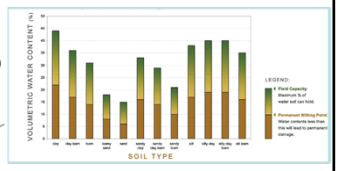

Figure 14. Water holding capacity by soil type in volumetric water content (%).

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SOCCER FIELD DATA

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Results

South	303	227	290	202	267	242	272	264
Center	267	220	234	204	211	255	242	234
North	231	237	196	230	237	267	263	276
	psi	160-199	200-239	240-279	280-319	320-359	360-399	400-449

Figure 15. Prior to the first home game, compaction readings indicated that only 4% of the field (≥ 300 psi) had little to no compaction.

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Results

South	43	39	44	53	46	48	41	44
Center	48	45	48	48	49	46	44	41
North	52	45	51	46	49	48	42	40
	%VWC	20-29	30-39	40-49	50-59	60-69	70-79	

Figure 16. Prior to the first home game, soil moisture readings indicated that 96% of the field was saturated (≥ 40 % VWC).

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Results

South	152	163	152	139	158	156	134	142
Center	164	155	141	117	129	132	157	132
North	156	177	131	129	133	146	132	144
	psi	< 199	200-239	240-279	280-319	320-359	360-399	400-449

Figure 17. Prior to the second (shown), third, and fourth home game, compaction readings indicated the field (≥ 300 psi) had little to no compaction.

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Results

South	65	68	69	73	71	69	69	63
Center	73	75	75	77	71	73	67	68
North	74	69	69	71	71	70	67	63
	%VWC	20-29	30-39	40-49	50-59	60-69	70-79	

Figure 18. Prior to the second (shown), third, fourth, and fifth home game, soil moisture readings indicated that 100% of the field was saturated (≥ 40 % VWC).

36

Results

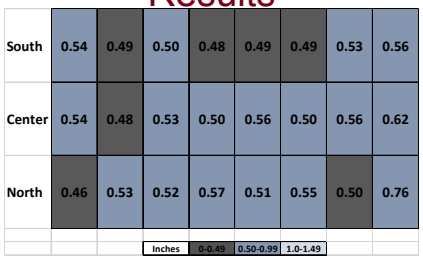

Figure 19. Prior to the third home game, turf firmness readings indicated that 30% of the field was firm (<0.49 inches).

37

Results

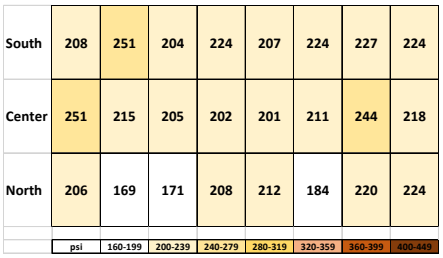

Figure 20. Prior to the fifth home game, compaction readings are increasing (≥ 300 psi severe compaction).

38

Compaction readings for both goals >300 psi indicating severe compaction.

Results

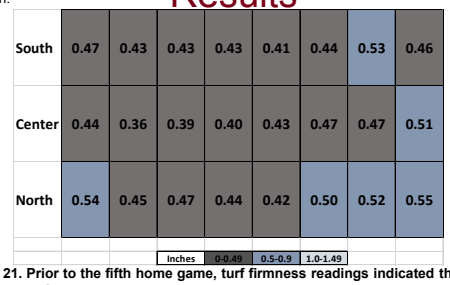

Figure 21. Prior to the fifth home game, turf firmness readings indicated that 75% of the field was firm (<0.49 inches).

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Results: Turf Firmness

	Game 1	Game 2	Game 3	Game 4	Game 5
	----------AVG inches----------				
South	0.6-0.7	0.6-0.7	0.5-0.6	0.5-0.6	0.4-0.5
Center	0.6-0.7	0.6-0.7	0.5-0.6	0.5-0.6	0.4-0.5
North	0.6-0.7	0.6-0.7	0.5-0.8	0.5-0.6	0.4-0.5
East Goal	0.6	0.7	0.5	0.5	0.4
West Goal	0.6	0.6	0.4	0.5	0.4

40

Results: Turfgrass Color & Health

	Game 1	Game 2	Game 3	Game 4	Game 5
	----------AVG NDVI----------				
South	.91	.90	.90	.91	.88
Center	.91	.91	.91	.89	.88
North	.90	.89	.89	.90	.89
East Goal	.92	.92	.85	.79	.85
West Goal	.92	.91	.87	.82	.85

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Soccer Injury Data

Injury	Game 1	Game 2	Game 3	Game 4	Game 5
Concussion	1				
Shin Splints	1				2
Stress Fracture	1				
Ankle Sprain				1	

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FOOTBALL FIELD DATA

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Results

UMC										UMC
	280	347	336	363	338	372	297	277	245	330
	328	306	394	399	402	396	402	396	331	323
	286	326	316	350	317	292	294	319	360	310
	10	20	30	40	50	40	30	20	10	

psi	160-199	200-239	240-279	280-319	320-359	360-399	400-449

Figure 22. Prior to the first home game of the season, compaction readings indicated that 77% of the field (≥ 300 psi) had severe compaction.

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Turf firmness values are firm (0.3-0.4 inches)

Results

UMC										UMC
	361	347	352	363	356	324	333	298	313	337
	351	349	339	360	339	327	328	337	307	288
	361	347	352	363	356	324	332	298	313	337

Figure 23. Prior to the fourth home game of the season, compaction readings indicated that 90% of the field (≥ 300 psi) had severe compaction.

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Results

	Game 1	Game 2	Game 3	Game 4	Game 5
	----------% VWC----------				
Football Field	77	100	100	100	100

Field is saturated (≥40 % VWC) for all home games in 2017. Drainage needs to be addressed.

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Results: Turf Firmness

	Game 1	Game 2	Game 3	Game 4	Game 5
	----------AVG inches----------				
West	NA	0.6-0.7	0.5-0.6	0.3-0.4	0.5-0.6
Center	NA	0.6-0.8	0.5-0.6	0.3-0.4	0.5-0.6
East	NA	0.7-0.8	0.6-0.7	0.3-0.4	0.5-0.6

90% of field is severely compacted

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Results: Turfgrass Color & Health

	Game 1	Game 2	Game 3	Game 4	Game 5
	----------AVG NDVI----------				
West	.90	.90	.93	.90	.85
Center	.89	.88	.92	.85	.81
East	.90	.92	.92	.90	.89

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Football Injury Data

Injury	Game 1	Game 2	Game 3	Game 4	Game 5
Concussion		1			1
Broken Wrist				1	
Knee Injury					1
Shoulder Injury				1	
Lateral Ankle Sprain	2	1			
Muscle Strains				2	

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2018

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Table 3. Soil Compaction, Soil Moisture, Surface Firmness, and Turfgrass Color for the UMC Football field before each home game in 2018.

Field Assessment	Game 1	Game 2	Game 3	Game 4	Game 5
Soil Compaction	0%	0%	ND	0%	ND
Soil Moisture	100%	100%	ND	100%	ND
Surface Firmness	0.6-0.9	0.5-0.7	ND	0.4-0.5 (40% Firm)	ND
Turfgrass Color	.91	.92	ND	.78	ND

51

Results

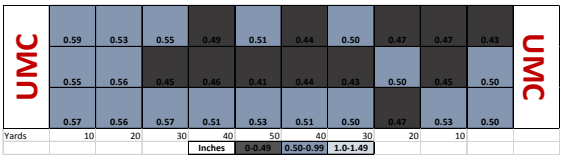

Figure 24. Prior to the fourth home game, turf firmness readings indicated that 40% (<0.49 inches) of the field was firm (60% of center field and 50% of west sideline was firm).

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Prior to Game 4-snow cover

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Football Injury Data

*No agronomic data due to weather.

Injury Type	Game 1	Game 2	Game 3*	Game 4	Game 5
Concussion					
Shin Splints					
Stress Fracture					
Ankle Sprain				1	
Ankle Bone Bruise			1		
Shoulder Sprain					1

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Table 4. Soil Compaction, Soil Moisture, Surface Firmness, and Turfgrass Color for the UMC Soccer field before each home game in 2018.

Field Assessment	Game 1 & 2	Game 3 & 4	Game 5 & 6	Game 7
Soil Compaction	0%	0%	ND	0%
Soil Moisture	100%	100%	ND	100%
Surface Firmness	0.5-0.7	0.5-0.7	ND	0.5-0.6
Turfgrass Color	.93	.89	ND	.66

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Prior to Game 7-snow cover

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Prior to Game 7-snow cover

57

Soccer Injury Data

*No agronomic data due to weather.

Injury Type	Game 1 & 2	Game 3 & 4	Game 5 & 6*	Game 7
Concussion				1
Shin Splints				
Stress Fracture		1		
Lateral Ankle Sprain	2		2	
Groin			1	
Knee Sprain			1	

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Survey

- 49 athletes (11 Soccer & 45 Football)
- 3 trainers
- 4 coaches

- Athlete perceptions of the fields:
  - 44 poor
  - 4 average
  - 1 good
- Did they notice a difference in playing conditions between 2017 & 2018
  - 17 No
  - 8 Yes
  - 24 had no basis for comparison

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Survey

- Suggestions for field improvement by coaches and athletes:
  - Improve drainage
  - Lower the mowing height
  - Clear fields more quickly after a snow
  - Install a heating system under the field
  - Level the field; re-crown field; resurface field
  - Decrease irrigation before practices
  - Improve turfgrass coverage
  - No high school football games
  - Practice field for soccer

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Implications

- Being able to quantify the relationship between the agronomic and risk assessments will lead to strategies intended to improve turfgrass field conditions.
- Identifying and implementing these strategies will be beneficial to facility managers by reducing the risk of player injuries.

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Recommendations

- Aerify at least every 2 weeks during the season.
  - Vary tine depth to prevent hard pans from developing when using solid tines.
- Use technology/gadgets for early detection of problem areas.

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What I didn't expect…..

- Using data for department agendas
  - Artificial turf
- Renovation needed to improve drainage on multiple fields.

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Importance

- 15 students
- 90 athletes
- 9 coaches
- 3 trainers
- 2 Departments (Athletics & Facilities)
- 2 Programs (Turf & SRM)
- All aware of player safety-goals met

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Baseball Field

65

Baseball Field

Field Assessment	Infield	Left Field	Center Field	Right Field
Soil Compaction (psi)	207.2	157.6	155.2	154.2
Soil Moisture (% VWC)	100	100	100	100
Surface Firmness (inches)	0.48	0.51	0.55	0.55
Turfgrass Color (NDVI)	0.76	0.77	0.81	0.83

66

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Thanks to…….

- Academic Affairs
  - Funded 4 students

MTGF
minnesota turf and grounds foundation

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