Performance Testing of Community Sports Fields:
----Current Status
----Future

(our focus is on natural grass fields)

Drs. Bob Carrow and Gerald Henry
University of Georgia
Dr. Van Cline
The Toro Company
Jan. 2013

Performance Testing

"Performance testing" -- broad term that denotes assessment of the sports field surface conditions for one or more purposes.

- **Started in the 1960's with introduction of first artificial grass fields – but, natural grass fields were tested as the standard of comparison. Core driving forces were: *a) player-surface interaction* – i.e. safety, especially surface hardness and traction/shear resistance; *b) ball-surface interaction* – i.e. field playability.**
- **Evolution of performance testing continues to depend on type of field (artificial, natural grass) and purpose or motivation for testing.**

References

- Bartlett, M. D., I. T. James, M. Ford, and M. Jennings-Temple. 2009. Testing natural turf sports surfaces: the value of performance quality standards. J. Sports Engineering Tech. 222(2): 1-11.
- Caple, et al. 2012. Spatial analysis of the mechanical behavior of natural turf sports pitches. Sports Eng 15: 143-157.
- Carrow, R. N. and V. Cline. 2011. Precision turfgrass management for athletic fields. SportsTurf 27(7): 16-21.
- Holmes, G. and M. J. Bell. 1987. Standards of playing quality for natural turf. The Sports Turf Res. Inst., Bingley, West Yorkshire, UK.
- James, L. T. 2011. Advancing natural turf to meet tomorrow's challenges. J. Sports Engineering and Tech. 225: 115-129.
- Miller, G. L. 2004. Analysis of soccer field surface hardness. Acta Hort. (ISHS) 661:287-294 http://www.actahort.org/books/661/661_36.htm
- Twomey, D. M., C. F. Finch, D. G. Lloyd, B. C. Elliott, and T. L. A. Doyle. 2012. Ground hardness and injury in community level Australian football. J. Sci. Med. Sport. On-line 16 Jan. 2012. http://dx.doi.org/10.1016/j.jsams.2011.12.003.

Performance Testing:
Some Background

- **Spatial and temporal variability**
- **Sample numbers and spacing**
- **Devices**

Surface Variability on Sport Fields

Spatial variability in surface conditions-function of:

- **Traffic patterns (wear, compaction) and effects on turf coverage and soil conditions;**
- **Surface drainage (slope, unevenness);**
- **Subsurface drainage (soil conditions);**
- **Irrigation system design (uniformity of application) and scheduling;**
- **Uniformity of soil characteristics across a field;**
- **Light/shade patterns in stadiums.**
- **Management of the above factors.**

Temporal variability (overtime) in spatial conditions results for weather, management, and use effects.

Performance testing can be on a limited number of sites with 3-15 selected locations – with hand-held devices. Or, it can be intensive to define spatial variability over the whole area of a field (hundreds of samples per field) – with mobile devices.

Measuring Surface Variability on Sport Fields

Testing schemes to determine spatial variability.
(American football field; 360 x 160 feet = 57,600 ft^2)

- **98 x 98 ft grid = 6 sample sites = 9600 ft^2 per sample**
- **85 x 85 ft grid = 8 sample sites = 7200 ft^2 per sample**
- **20 x 20 ft grid = 144 sample sites = 400 ft^2 per sample**
- **8 x 10 ft grid = 720 sample sites = 80 ft^2 per sample**

Athletic Fields: Sensor Devices

1. Hand-devices for single parameters (infiltration soil water content, hardness, traction, penetrometer resistance, etc.)
2. Hand-devices coupled with GPS (Global Positioning Systems)* and GIS (Geographic Information Systems)* technologies for single or multiple parameters. Intensity/spacing can vary. Problems – time and penetration of devices into soils.
3. Mobile devices coupled with GPS and GIS with intensive mapping (close spacing; i.e. < 10-12 feet for most measurements) for multiple parameters.
4. In-situ (in-place) soil sensors – soil moisture and soil salinity.

*Allows detailed spatial maps to be developed and relationships to be analyzed; but interpretation is important.

Performance Testing

--- Categories (purposes)

--- Current and Future Status

Performance Testing: *Purposes*

Barlett et al. (J. Sports Eng. Tech. 222-2: 1-11. 2009) reviewed performance testing research/practice and defined 4 categories of purposes or motivations:

1. **Category 1. -- to develop standards, compare a field to standards accepted by a sport's governing body; or to compare fields or a field overtime.**
2. **Category 2. -- to determine an "overall quality" score or rank prior to a field use.**
3. **Category 3. -- to obtain information for "decision-making".**
4. **Category 4. -- to examine surface design, function, or injury risk in sport injury/medicine studies.**

Performance Testing: *Purposes*

Category 1. – test to: a) develop standards; b) compare a field to standards accepted by a sport's governing body; or c) to compare fields. Most common and longest term. Initially, "benchmarking" of fields is used develops the standards. Test locations are 3 – 12. Examples are;

- **Performance Quality Standards (PQS) for Natural Turf Fields -- Holmes and Bell, 1987. Standards of Playing Quality for Natural Turf, Sports Turf Res. Institute, UK.**
- **FIFA Quality Concept for "Football Turf" (artificial grass surfaces) – FIFA. 2012. FIFA Quality Concept - Handbook of Requirements for Football Turf. FIFA, Geneva, Switzerland.**


PAT PURCELL
SCORE BOARD

Performance Testing: *Purposes*

Category 2. -- to determine an "overall quality" score or rank prior to a field use. Examples;

- **Used prior to play/use for cricket fields, grassed horse racing (GoingStick – penetrometer and shear resistances), NFL fields.**
- **Provides a quality score or rank.**
- **Test locations are 3- 12.**

Performance Testing: *Current and Future*

1. Category 1. -- to develop standards, compare a field to standards accepted by a sport's governing body; or to compare fields or a field overtime.
2. Category 2. -- to determine an "overall quality" score or rank prior to a field use.

Comments:

- Both of these testing purposes are based on hand-held testing devices and limited number of test locations (usually 6).
- Both types of performance testing are well developed and used in the UK, AU, NZ, Europe.

Performance Testing: *Current and Future*

1. Category 1. -- to develop standards, compare a field to standards accepted by a sport's governing body; or to compare fields or a field overtime.
2. Category 2. -- to determine an "overall quality" score or rank prior to a field use.

Comments:

- Category 1 testing can be refined for American sport fields relatively rapidly for sports common to the UK. Other sports (i.e. American football, baseball) require development of standards, especially with the diversity of grasses, climates, soils in the US.
- New testing devices will evolve.
- Provides only limited or general information on how to improve a specific field due to limited test locations per field.

Performance Testing: *Current and Future*

1. Category 1. -- to develop standards, compare a field to standards accepted by a sport's governing body; or to compare fields or a field overtime.
2. Category 2. -- to determine an "overall quality" score or rank prior to a field use such as cricket, grassed race courses, NFL fields.

Comments:

- Should act as an incentive to improve community sport fields and awareness of role of management and inputs in fostering safer, more playable fields.
- May foster Category 2 testing -- to determine an "overall quality" score or rank prior to a field use for some situations, but most likely not for routine use on community sport fields.

Performance Testing: *Purposes*

Category 3. -- to obtain information for "decision-making".

- **Develop "Decision Support Systems" (DSS).** Barlett et al. (2009) stated "In theory the testing of sports surfaces should facilitate the better management of facilities by identifying deficiencies and the response of playing quality in intervention in category 3 type approaches to surface testing".
- **Requires intensive spatial mapping grid to define spatial variability and testing over time to define temporal variability.**

Category 3. – relationship of "decision support systems" (DSS) and "sustainability"

"There is a critical need to assess and reduce resource consumption to enable sustainability of sports surfaces under the pressure of climate change, increased population, increased urbanization, and reduced resource availability" (James, 2010).

- **Maintenance of sustainable sports facilities will be greatly assisted if more comprehensive site-specific information is available to investigate input (irrigation, cultivation, topdressing, etc.) efficiencies and implications on sports field surfaces relative to safety, playability, economics, and aesthetics.**

Performance Testing: *Purposes*

Category 4. -- to examine surface design, function, or injury risk in sport injury/medicine studies.

- **To-date field assessment has been by 6-15 test locations and may include empirical statements on surface conditions by officials.**
- **Twomey et al. (2012) "To insure an accurate interpretation of the link between ground hardness and injuries, future studies need to report the ground hardness at the specific location of injury."**
- **Thus, similar to Category 3 testing for development of DSS, Category 4 performance testing required more intensive mapping and geospatial analysis.**

Category 3 and 4 Testing:
Anticipated Developments

- **Moving to more intensive mapping grids; reliance on mobile, multiple sensor platforms; development of new senors**
- **Development of DSS specific to sport fields that inter-relate surface hardness, traction, soil moisture, and other surface conditions.**
- **Using DSS information to enhance sustainability -- development of a better understanding of inputs, field design, and field construction on spatial surface characteristics.**

Measuring Surface Variability on Sport Fields

Testing schemes to determine spatial variability.
(American football field; 360 x 160 feet = 57,600 ft^2)

- **98 x 98 ft grid = 6 sample sites = 9600 ft^2 per sample**
- **85 x 85 ft grid = 8 sample sites = 7200 ft^2 per sample**
- **20 x 20 ft grid = 144 sample sites = 400 ft^2 per sample**
- **8 x 10 ft grid = 720 sample sites = 80 ft^2 per sample**

Site Assessment Technology

Toro Precision Sense 6000

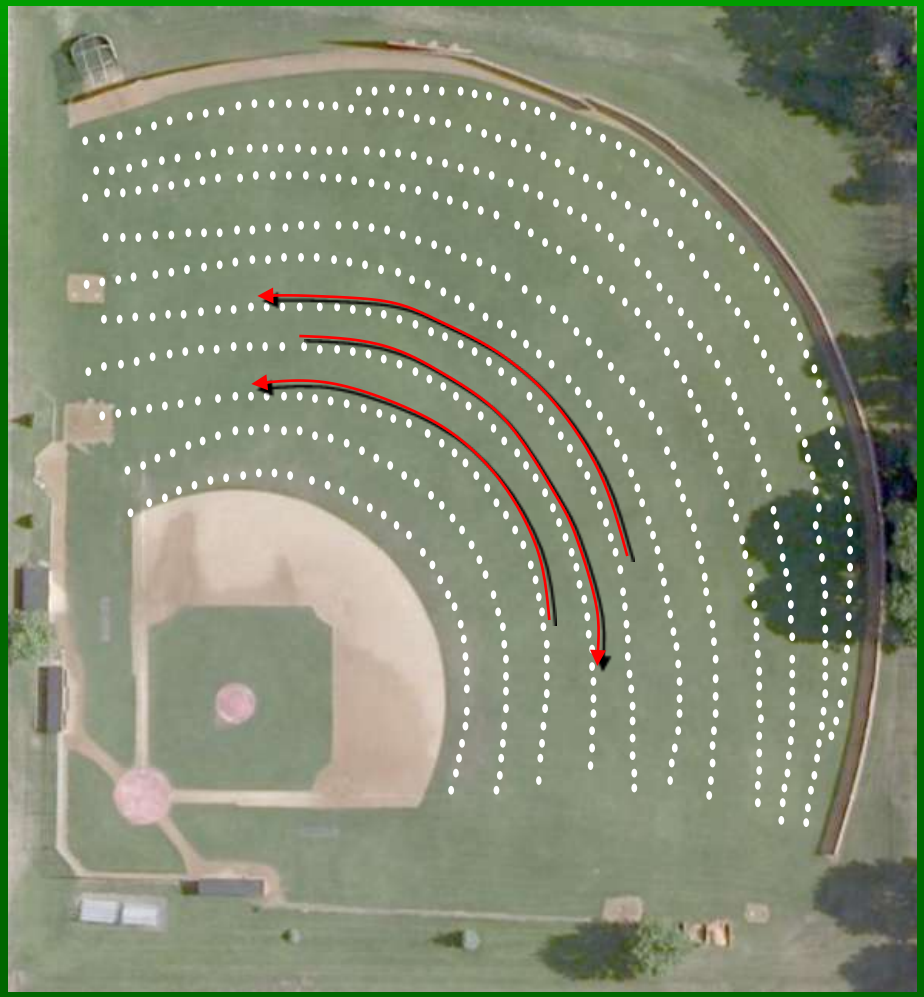
- Soil moisture (TDR)
- Soil salinity (conductance)
- Soil hardness (penetrometer)
- Turf quality (reflectance sensors)
- Topographic relief (GPS elevation)

Turf Mobile Accelerometer – Prototype.

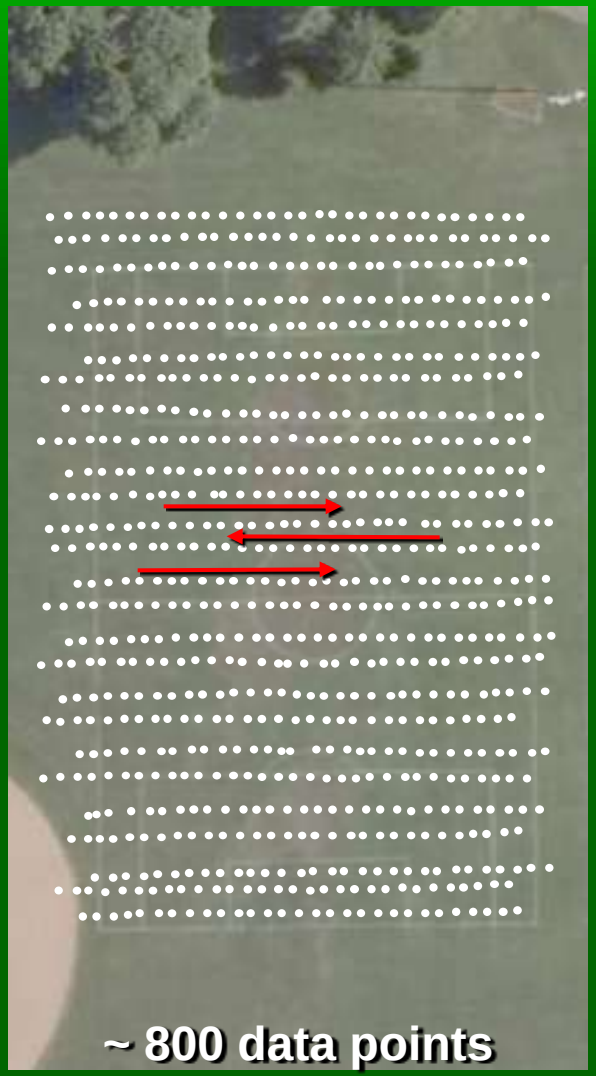
- Soil hardness (Clegg type accelerometer)

700 VWC Readings and 1500 NDVI per acre – multiplied by 5 to 10 fold by GIS autocorrelation methods.

Sampling pattern – 8 x 10 ft grid



~ 600 data points
~ 30-45 min.



~ 800 data points
~ 45- 60min.

Toro Precision™ Sense 6000 - Example of a "Total System" Approach

1. Mobile device --rapid data collection, close grid spacing
2. Protocols for Different DSS Field Applications.
3. Multiple sensors to obtain data of key soil and plant parameters.
4. Data integration by software programs. Data from the multiple sensors must be integrated together along with GPS location tagging.
5. Analyses and Data-mining by Proprietary software --- by descriptive statistics and geostatistical (i.e. GIS) approaches to provide mathematical metrics.
6. Presentation in a Decision-Support System Format. A combination of hardcopy plus Google Earth formats, the software program for analyses and data-mining also creates the final product for the end user is a decision-making report with practical recommendations.

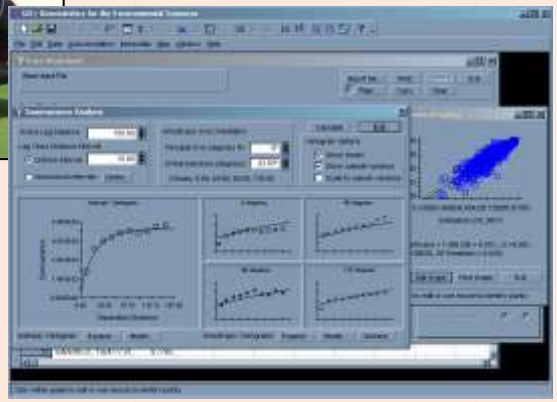
Precision™ Sense process: data collection, analysis & implementation

← On-site | At Toro →

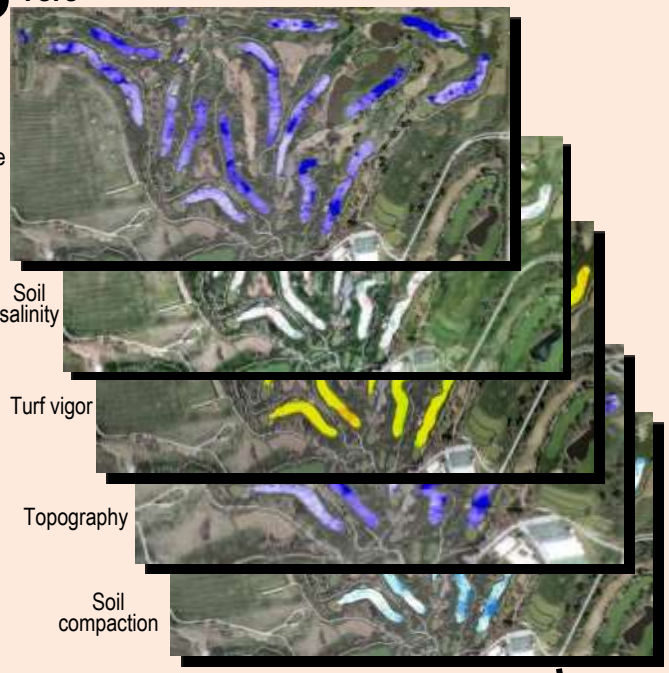
1 Data collection
On-site – Distributor

Data transmitted electronically to Toro

2 GIS ArcView processing & analysis
Toro

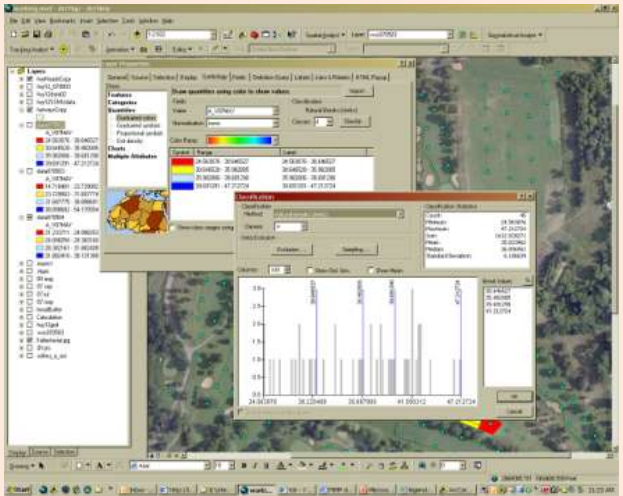


3 Primary Data Products (Google Earth format)
Toro



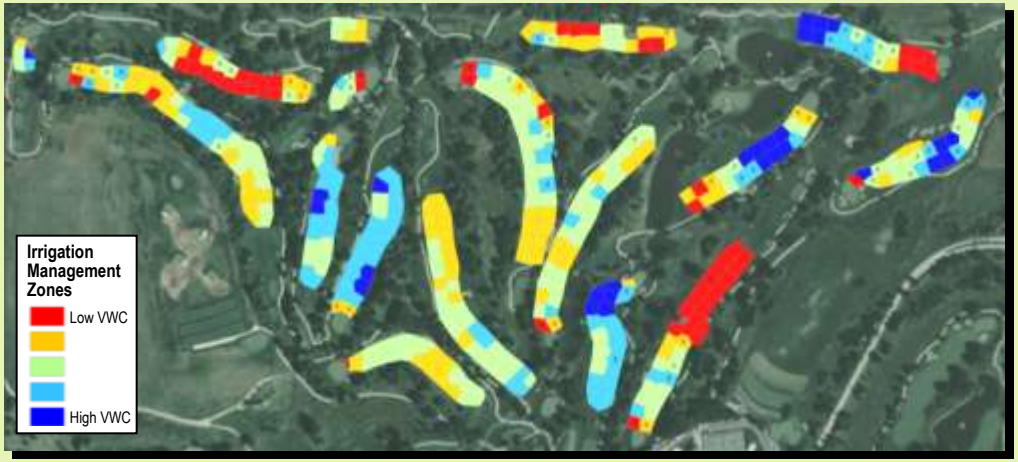
4 GIS application analysis & products, Interpretation & recommendations
Toro

Analysis products delivered back to customer electronically



5 Field Implementation
On-site – Distributor consultant

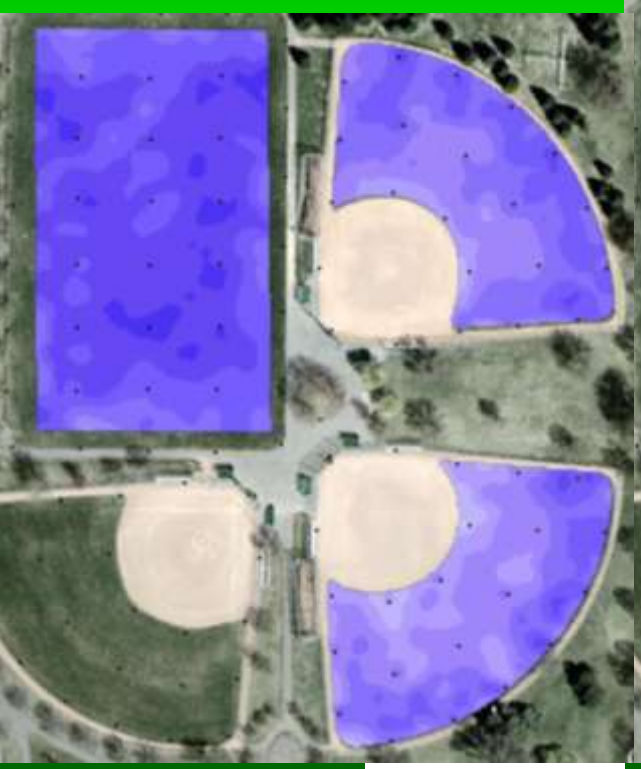
- Irrigation corrections made from audit
- Irrigation management zones defined
- Turf Guard sensors located & installed
- SitePro/Lynx customization
- Etc.



DSS Applications

1. **New Water Audit Approach*** – wall to wall, mapping under drier conditions. Includes a head by head assessment; individual head analysis
2. **Water Conservation/Efficiency**** – improved irrigation scheduling. Includes: a) a head by head assessment, b) defining SSMUs based on soil VWC, slope, slope aspect
3. **Soil Salinity Audit****
4. **Performance Testing for Sports Fields*, ****
5. **Performance Testing for Grassed Race Tracks***.

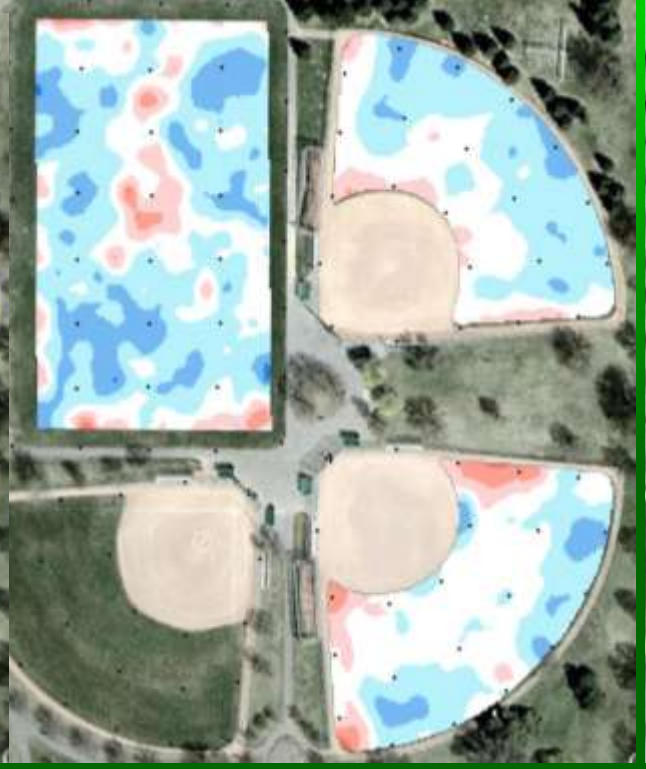
Mapping at drier than field capacity ** Mapping at field capacity



Soil Moisture
TDR

VWC Legend

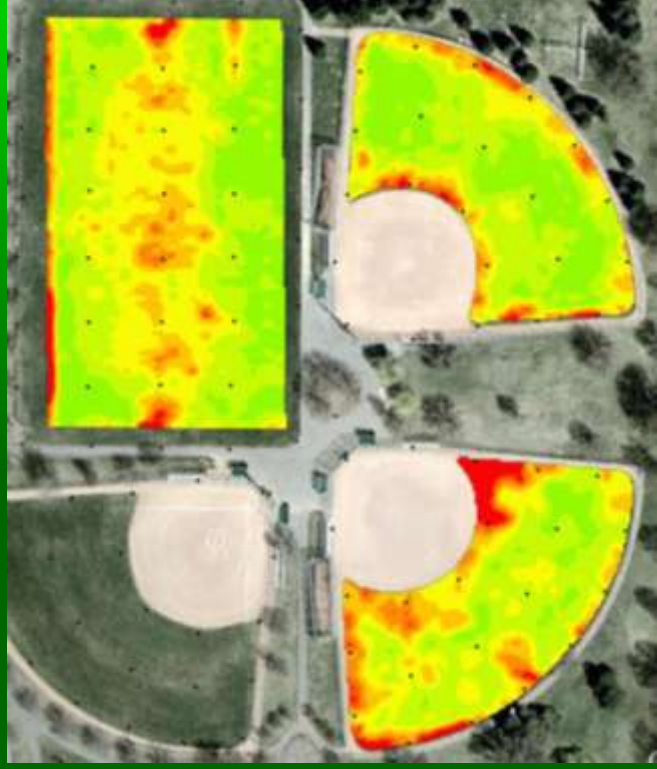
Values (%)
<10
10-15
15-20
20-25
25-30
30-35
35-40
40-45
45-50
>50



Soil Compaction
Penetrometer

Compaction

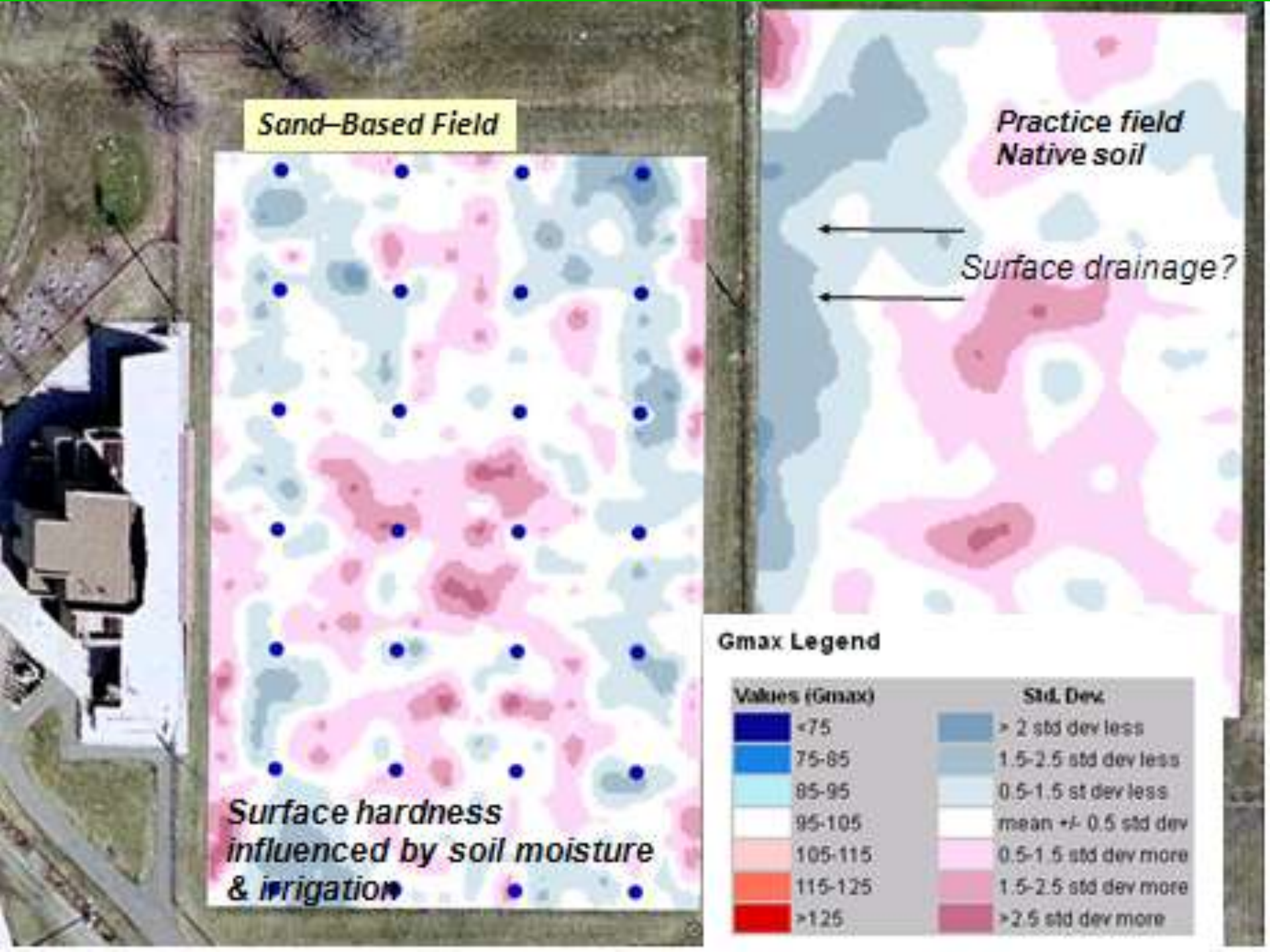
Values (lbs Force)
<70
70-140
140-210
210-280
280-350
350-420
420-490
490-560
560-630
630-700
>700



Turf Vigor
Spectrometer

NDVI Legend

Values
<0.65
0.65 - 0.69
0.69 - 0.73
0.73 - 0.77
0.77 - 0.81
0.81 - 0.85
0.85 - 0.89
0.89 - 0.93
>0.93


Sand–Based Field
Practice field
Native soil
Surface drainage?
Surface hardness
influenced by soil moisture
& irrigation
Gmax Legend
Values (Gmax)
<75
75-85
85-95
95-105
105-115
115-125
>125
Std. Dev.
> 2 std dev less
1.5-2.5 std dev less
0.5-1.5 st dev less
mean +/- 0.5 std dev
0.5-1.5 std dev more
1.5-2.5 std dev more
>2.5 std dev more

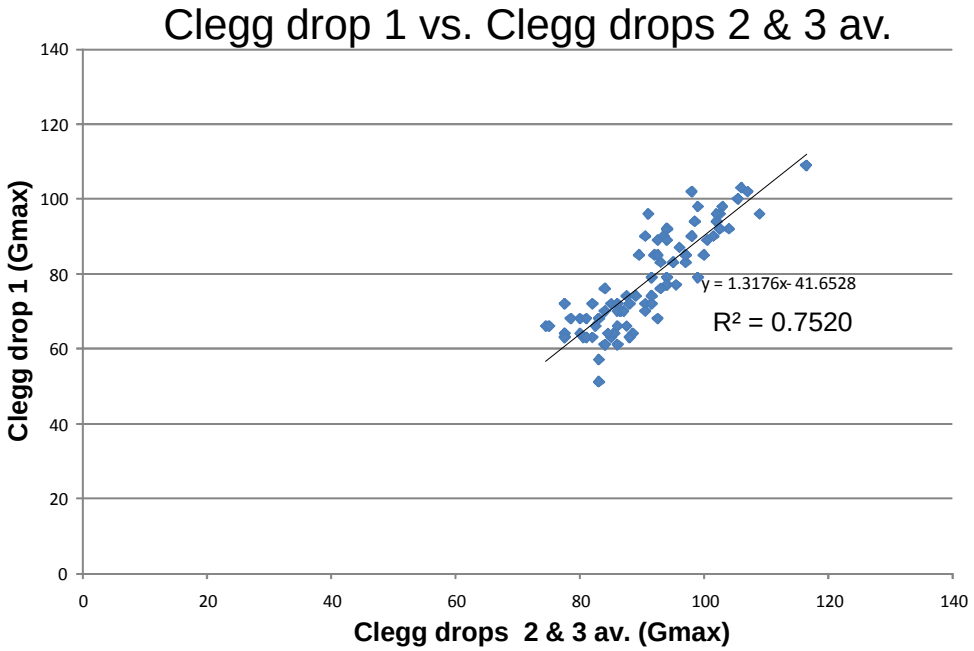
Sensor Development

- An increase in Performance Testing of Category 1 and 2 will stimulate hand-held sensor development.
- Performance Testing for Category 3 and 4 purposes will stimulate sensors for mobile platforms and those related to sport injury research.
- Example, mobile Clegg device and testing protocols.

Questions:

- *Are the Gmax values for the mobile accelerometer and Clegg comparable?*
- *How does a single drop compare to the three drop standard?*

Can a single drop replace the three drop standard?



3 Clegg drops in the same spot.

Toro drop and Clegg drops offset ~ 6-12”.

We are testing ways of conditioning the turf in advance of the first drop to replicate the three drop method.