Evaluation of a Geonics EM38 and NTech GreenSeeker Sensor Array for use in Precision Turfgrass Management

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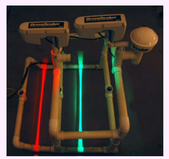
Summary

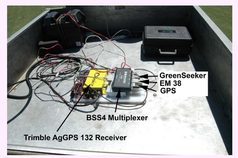
The use of sensors holds great promise for implementation of improved precision turfgrass management. In this study, we evaluated two pieces of equipment (the EM38 soil electrical conductivity (EC) sensor and the GreenSeeker normalized difference vegetation index (NDVI) sensor array) for their ability to serve as decision-making tools for turf managers. We first evaluated the sensor's accuracy by comparing its performance with that of hand-held sensors, whose utility had been previously determined. We found that the EM38 EC values were closely correlated with soil moisture, as determined with a Spectrum Technologies TDR300 soil moisture meter (r^2=0.85, p<0.0001). The GreenSeeker NDVI values were correlated with chlorophyll index values as determined by the Spectrum CM1000 (r^2 0.91, p<0.0001). When we conducted sensor scans at southern California turfgrass sites, the sensor array was able to detect moisture variation and turfgrass quality over large areas.

Although the array provided reasonable sensitivity, data management and interpretation were complex, and are the primary barriers to practical use of remote sensing arrays for precision turfgrass management. With improvements in data processing, a soil moisture and turf performance sensor array will provide a significant advance in precision turfgrass management.

The sensor array and data acquisition equipment consisted of:

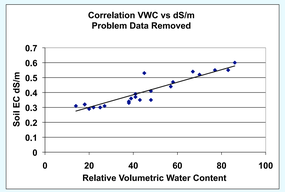
- Trimble AgGPS 132 sub meter GPS receiver and TDS400 Trimble Recon handheld computer (www.trimble.com)
- HGIS-pro GIS software from Starpal (www.starpal.com)
- 232BSS4 buffered smart switch from B & B Electronics (www.bb-elec.com)
- Geonics EM38 provided for evaluation by Simon Boniwell (www.geonics.com)
- Ntech GreenSeeker provided for evaluation by Ted E. Mayfield (www.ntechindustries.com)
- Power was provided by a 12 VDC deep-cycle RV battery.
- Sensors were mounted on a sled constructed of 2-inch PVC pipe that was towed behind a utility cart.



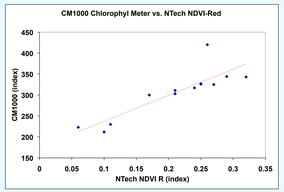


Calibration

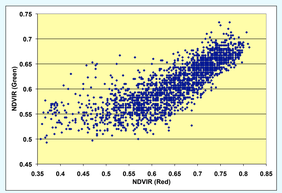
Soil moisture readings collected using a Spectrum Technologies TDR300 soil moisture meter were compared to EM 38 values. The correlation was significant (r^2=0.85, p<0.0001).



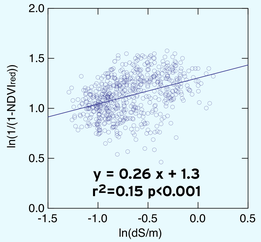
The GreenSeeker NDVIred sensor was compared to the chlorophyll index value provided by a Spectrum Technologies CM1000. The correlation was significant (r^2=0.91, p<0.0001). Evaluation conducted on Tifway bermudagrass.



The GreenSeeker NDVIred and NDVIgreen sensors provided similar turf quality estimates. Data plotted below represents the results from a Tifway bermudagrass fairway scanned simultaneously using both meters. The GreenSeeker NDVIred may provide greater sensitivity than the NDVIgreen sensor.



Soil moisture values, as measured by the EM38, were compared to turf quality, as determined by the GreenSeeker NDVIred and NDVIgreen sensors. There is a significant correlation between ln(EC) and logit(NDVI). However, the regression is weak indicating that there are likely many factors influencing turfgrass quality.



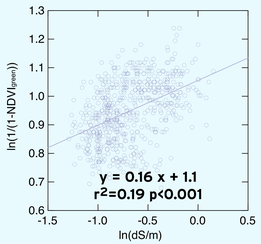
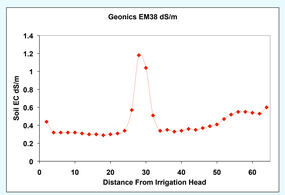


Illustration of spurious EM38 data caused by detection of an underground metal pipe. Spurious data will have to be removed before management decisions can be based upon sensor results.

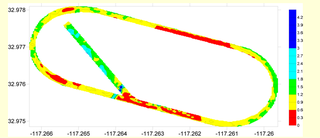


Before and after effects

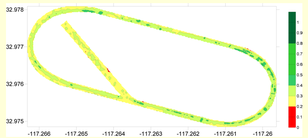
The sensor array was useful in evaluating the impact of irrigation on variability of soil moisture and turfgrass performance at the Del Mar Thoroughbred Club, Del Mar, California. Uniform soil moisture is a critical safety component of thoroughbred horse racing. The EM 38 shows promise for monitoring soil moisture in a rapid and non-destructive manner. GN-1 bermudagrass, Leif Dickinson, Superintendent.

Before 2.5 cm irrigation 5/2/2005

Geonics EM 38 dS/m (soil moisture)

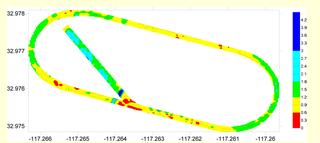


NTech GreenSeeker NDVIred (turfgrass quality)

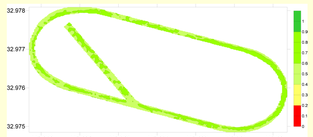


After 2.5 cm irrigation 5/9/2005

Geonics EM 38 dS/m (soil moisture)

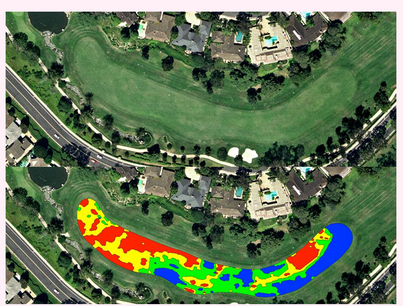


NTech GreenSeeker NDVIred (turfgrass quality)



Mapping and Quantifying

The GreenSeeker NDVIred provides a rapid method for mapping and quantifying turfgrass quality. The higher the NDVI value, the better the quality. Tifway bermudagrass on Fairway 18 at Big Canyon Country Club, Newport Beach, California, Jeff Beardsley, Superintendent.

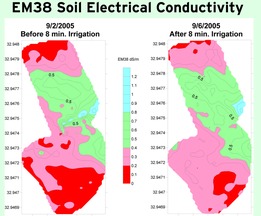


GreenSeeker NDVI (red)	
Red	0.68 - 0.79
Yellow	0.79 - 0.81
Green	0.81 - 0.82
Blue	0.82 - 0.87

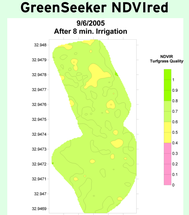
Evaluating management practices

The plots on the left below illustrate the changes in soil moisture following irrigation using 56%, 70%, and 84% of reference ET. Soil moisture increases (illustrated by a shift from red to blue on the map) were easily detected using the Geonics EM38. The plots on the right illustrate turfgrass quality measured using the NTech GreenSeeker NDVIred. The correlation between electrical conductivity and turfgrass quality was weak. This is due to the presence of confounding factors such as soil type, soil salinity, and traffic patterns. Even though neither sensor provides a complete picture of turfgrass quality and soil moisture conditions, when this data is combined it can lead to improved water management, and overall precision management. Tifway bermudagrass at Barona Creek Golf Club, Lakeside, California, Sandy Clark, Superintendent.

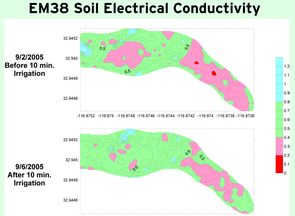
56% ETo
EM38 Soil Electrical Conductivity



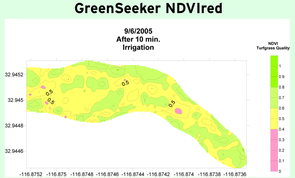
56% ETo
GreenSeeker NDVIred



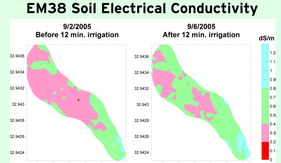
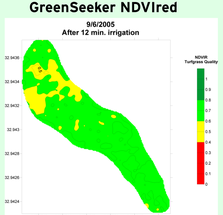
70% ETo
EM38 Soil Electrical Conductivity



70% ETo
GreenSeeker NDVIred



84% ETo
EM38 Soil Electrical Conductivity



84% ETo
GreenSeeker NDVIred