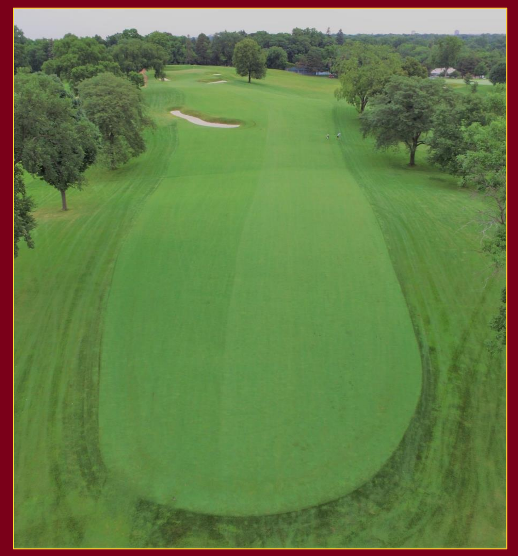

Golf Course Superintendents' Knowledge of Variability within Fairways

TURFGRASS SCIENCE

Chase Straw and Brian Horgan

Department of Horticultural Science, University of Minnesota, St. Paul, MN

Introduction

Precision turfgrass management (PTM) relies heavily on mapping technologies (e.g. drones, GPS-equipped sensor devices) for identifying variability within turfgrass systems to implement variable rate or site-specific applications that can reduce management inputs. Despite recent advancements of mapping technologies in turfgrass, a number of factors have inhibited widespread adoption amongst managers; for example, cost and training associated with obtaining, analyzing, and interpreting spatial data. While focus continues towards improving mapping technologies, turfgrass managers' knowledge of variability may be an overlooked and underutilized tool for PTM. Demonstrating the extent of knowledge that turfgrass managers encompass regarding variability, and how they can apply this knowledge to management practices, could offer a practical, low cost starting point for PTM implementation.

Objectives

1) Gain understanding of golf course superintendent's perceptions and knowledge of soil moisture and turfgrass quality variability within their fairways.
2) Identify golf course superintendent's perceived value and possible use of soil moisture and turfgrass quality interpolated maps.

Materials and Methods

- Twelve golf course superintendents (nine head and three assistant) from Minnesota participated in the study. Participants ranged in age, experience level, and course type. Four of the participants had used some form of mapping technologies at their course, but only one was using the maps for PTM.

Initial interviews

- Initial interviews were conducted in situ June and July 2018 on one randomly selected, predetermined fairway at each participants' golf course (fairways were primarily *Agrostis stolonifera* or *Poa pratensis*, with some *Poa annua* invasion, on native soil). They involved having a semi-structured discussion (utilizing an interview guide) regarding participants' perceptions and knowledge of variability within the fairway.
- Participants were provided a paper copy of their fairway's boundary (digitized from a basemap in ArcMap) to illustrate variability. They were asked to hand-draw and describe perceived areas of "high" and "low" soil moisture and turfgrass quality.

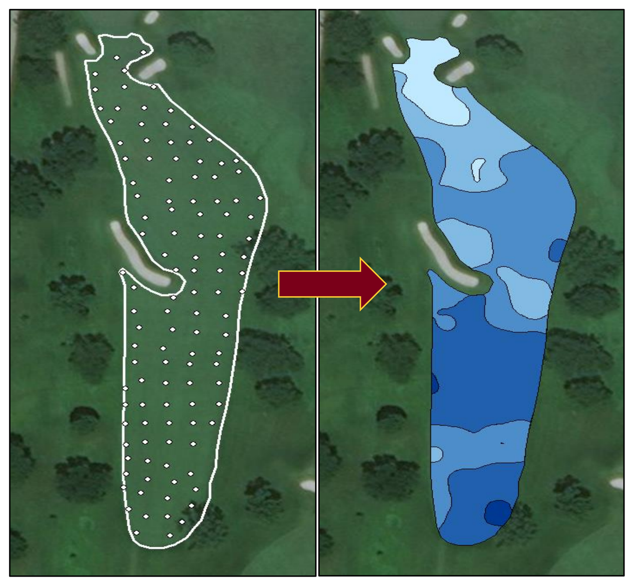

Figure 1. Example of a sampling grid (left; dots represent sample location) and interpolated soil moisture map.

- Soil moisture (volumetric water content) and turfgrass quality (normalized difference vegetation index; NDVI) were measured [using a HydroSense II Soil Moisture Meter (Campbell Scientific, Inc., Logan, UT) and FieldScout TCM 500 NDVI Turf Color Meter (Spectrum Technologies, Inc., Aurora, IL), respectively] from fairways immediately following initial interviews using a sampling grid. A GPS in the HydroSense II georeferenced all sample locations within the fairways (Figure 1; 101-119 samples, depending on fairway).
- Georeferenced data were interpolated via ordinary kriging in ArcMap to create spatial maps (Figure 1; color scales are used to represent high and low valued areas). Interpolated maps were used in follow-up interviews.

Follow-up interviews

- Follow-up interviews were conducted in each participants' office July 2018. They involved having a semi-structured discussion (utilizing an interview guide) regarding their comparison of hand-drawn and interpolated maps, as well as their perceived value and possible use of interpolated maps.

Data analyses

- Audio recordings of interviews were transcribed verbatim and imported into ATLAS.ti, where they were coded to facilitate qualitative analysis. Word clouds were generated to visually present key words describing participants' perceptions of factors that influence soil moisture and turfgrass quality variability within fairways. Thematic analysis was conducted to identify themes deriving from participants' comparison of hand-drawn versus interpolated maps, and perceived value and possible use of interpolated maps.
- Hand-drawn maps were digitized into ArcMap (Figure 2). Participants' digitized hand-drawn maps were overlaid with their respective interpolated maps and the zonal statistics tool was used to calculate mean soil moisture and turfgrass quality within their perceived "high" and "low" areas. To determine if their perceptions matched reality, paired t-tests (one-tailed; $\alpha = 0.05$) were applied in RStudio to compare the means of hand-drawn "high" and "low" areas to the means of entire fairways.
- Interview transcripts, fairway data, and maps were triangulated to further explore and validate findings.

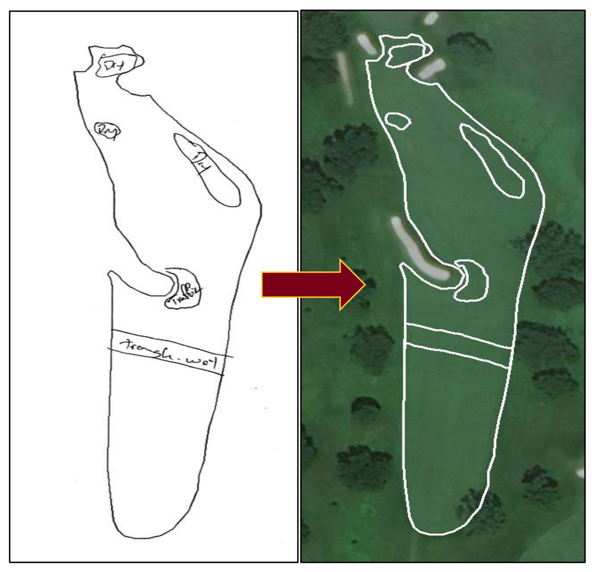

Figure 2. Example of a hand-drawn (left) and digitized hand-drawn (right) soil moisture map.

Results

- Perceived soil moisture variability within fairways was primarily a result of topography, irrigation efficiency, and soil characteristics, while perceived turfgrass quality variability was primarily due to cart and foot traffic patterns and topography (Figure 3).

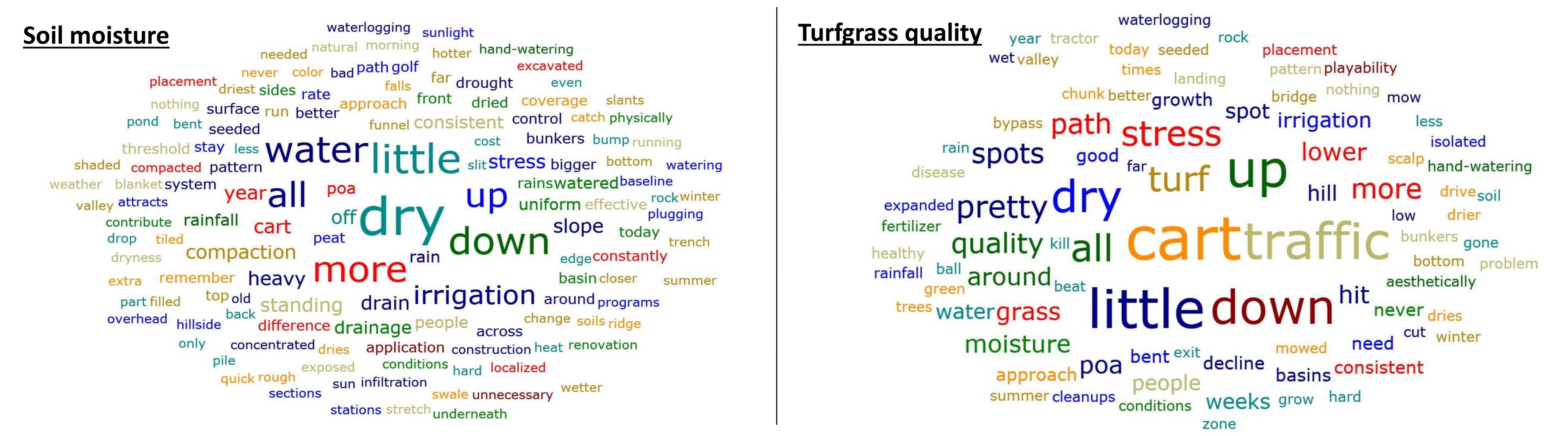

Figure 3. Word clouds representing key words used to describe participants' perceptions of factors that influence soil moisture (left) and turfgrass quality (right) variability within fairways. Larger sized words were used most frequently.

- Participants were generally not surprised when comparing hand-drawn and interpolated maps. They described that interpolated maps reconfirmed their perceptions and provided greater detail of variability. Irrigation programming, regulating equipment and cart traffic, and site-specific aerification or chemical applications were examples of how interpolated maps could be utilized (Figure 4 and 5).

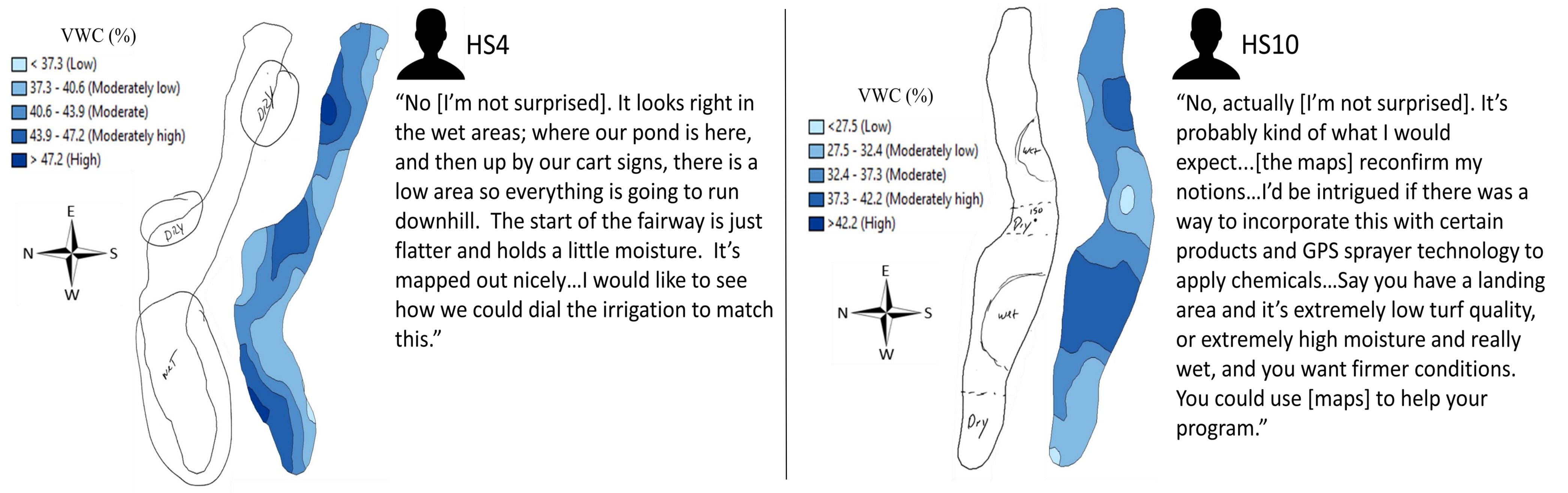

Figure 4. Two participants' soil moisture hand-drawn maps (black and white) next to interpolated maps [volumetric water content (VWC); color scale, where light blue indicates drier areas and dark blue indicates wetter areas within a fairway], as well as exemplar quotes about map comparisons and possible use and value of interpolated maps.

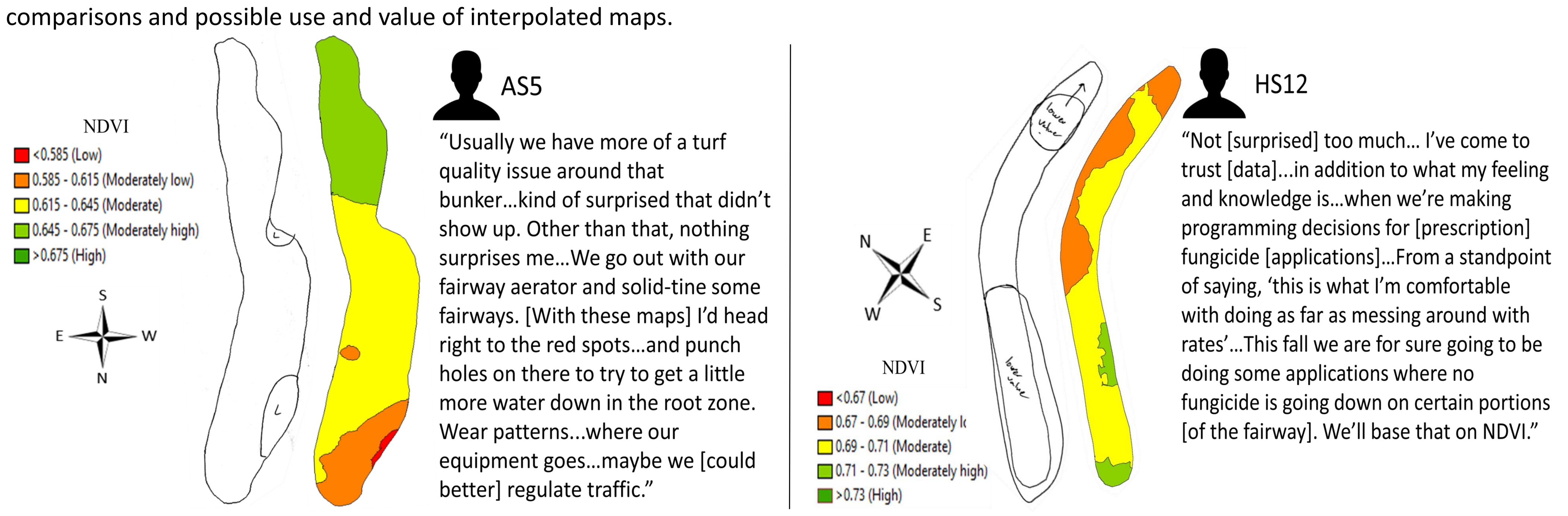

Figure 5. Two participants' turfgrass quality hand-drawn maps (black and white) next to interpolated maps (NDVI; color scale, where red indicates lower quality areas and green indicates higher quality areas areas within a fairway), as well as exemplar quotes about map comparisons and possible use and value of interpolated maps.

- Means of hand-drawn "high" and "low" soil moisture areas were significantly higher ($P < 0.05$) and lower ($P < 0.05$) than means of the fairways, respectively. This indicates that participants' knowledge of these areas were correct; however, in their drawings they typically over- or underestimated the size of an area, or left other "high" and "low" valued areas within fairways unaccounted for (Figure 4).
- Means of hand-drawn "high" and "low" turfgrass quality areas were not significantly higher ($P = 0.19$) or lower ($P < 0.18$) than means of the fairways, respectively. Participants' knowledge of these areas were incorrect, but it should be noted that the vast majority explained moisture stress was a factor in drawing "low" turfgrass quality areas when there was no apparent moisture stress on any of the participants' fairway at the time of NDVI sampling (Figure 5).

Conclusions

Golf course superintendents had a general understanding of variability within their fairways. Therefore, their knowledge of variability can be an applicable tool for initiating some PTM strategies; for example, programming an irrigation system to irrigate less frequently in perceived wet areas, or aerification of only high cart traffic areas. Interpolated maps reconfirmed perceptions and provided addition detail that could be useful for more precise management input applications.