Developing Variable-Rate Prescription Maps for Precision Nitrogen Management on Golf Course Fairways

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Introduction

- Increasing pressure to reduce nitrogen fertilizer application has prompted exploration of precision turfgrass management, shifting from conventional blanket to site-specific variable-rate approaches.
- While fairways exhibit significant spatial and temporal variability in turfgrass and soil characteristics, limited literature exists on this topic.
- Although the normalized difference vegetation index (NDVI) is widely used in assessing turfgrass nitrogen status, its efficacy weakens in real-world scenarios due to additional stresses. Thus, there is a need for another robust approach that integrates secondary data to create prescription maps.
- This novel concept in turfgrass management aims to visualize seasonal variation in site-specific management units (SSMU) and guides on selecting between static versus dynamically updated nitrogen prescription maps for integration into GNSS spreader for nitrogen fertilizer applications.

Objective

To delineate variable-rate management zones based on two approaches (NDVI- and Model-Based) and visually inspect the seasonal variation within these zones.

Materials and Methods

Location: The Bearkat Course in Huntsville, TX, with hybrid bermudagrass and native soil fairways.

Figure 1. Fairway 1 (left) and Fairway 5 (right) used in the study

Data Collection:

- Four surveys using the Precision Sense 6000 (PS6000) in May, July, Sept, and October 2022.
- Ground soil moisture (% volumetric water content; VWC), penetration resistance (PR), and NDVI were collected using the PS6000 from hundreds of georeferenced locations within each fairway. These data underwent ordinary kriging to create raster maps.
- Similarly, aerial images were captured from 120 m using a Dragonfly Commander 2 UAV equipped with a MicaSense Altum-PT multispectral camera in the same months of 2022. These images were processed using Pix4D to create orthomosaic maps of NDVI and Digital Elevation Models (DEM) to extract slope data. NDVI used in both approaches were based on aerial images (UAV).

Delineation of Management Zones:

- Fairways 1 and 5 were divided into 91 and 65 polygons respectively. Each polygon represents a management unit equivalent to the size of the Texas A&M GNSS spreader's width (12.2 x 11.5 m).
- **NDVI-Based**: Three zones—low (0-0.38), medium (0.39-0.58), and high NDVI (0.59-1)—from UAV processed images, with NDVI thresholds set based on historical data collected in October 2021.
- **Model-Based**: Secondary data—Slope, VWC, and PR be integrated into NDVI (UAV) through a K-means clustering approach. Model validation and management zone (cluster) appropriateness was performed using historical data from October 2021.

Figure 2. Image of the Precision Sense 6000 (left), GPS Trimble Geo7x (center), and Draganfly Commander 2 with MicaSense Altum-PT (right)

Results

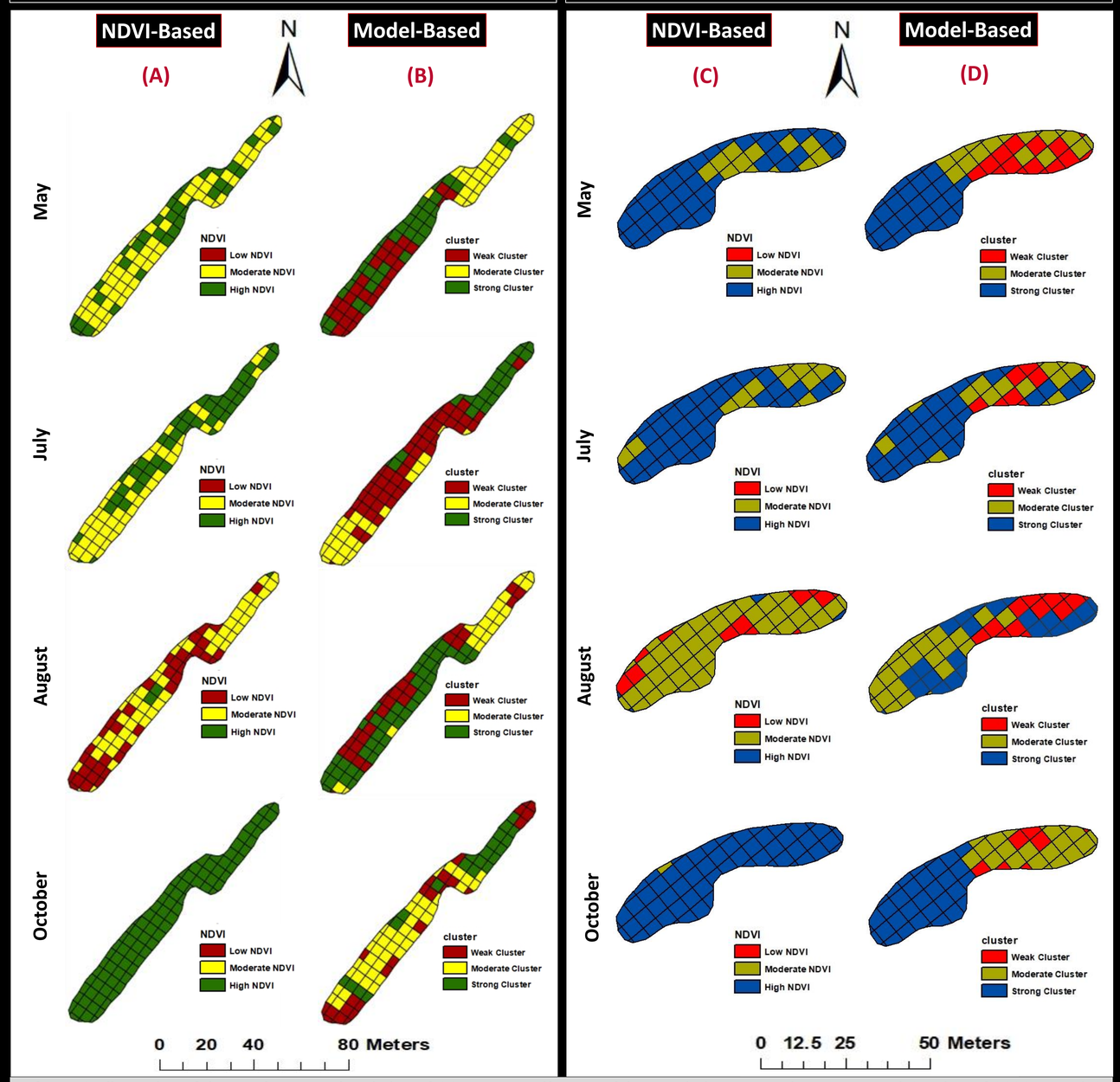

Figure 3. Illustration of the spatiotemporal variation of SSMUs on golf course fairways during May, July, August, and October of 2022. A and C represent the seasonal variation in the SSMUs categorized into three regions: low, medium, and high based on NDVI value in fairway 1 and 5, respectively. Similarly, B and D represent the seasonal variation in the SSMUs categorized into three clusters as weak, medium, and strong based on the cluster's centroid values. In above variable-rate maps, low NDVI and weak clusters indicate a need for high rate of fertilizer, moderate NDVI and moderate clusters suggest a moderate rate of fertilizer, while high NDVI and strong clusters imply a low rate of fertilizer.

Conclusions

- The range of values for NDVI and clusters fluctuated over the seasons, indicating clear seasonal variation in SSMUs within each fairway both spatially and temporally.
- The variable-rate prescription map should be periodically updated during each fertilizer application, as the SSMUs were observed changing over season, likely due to the combined effects of moisture stress, topography changes, soil compaction, and overall turf quality.
- These visualizations can be valuable for determining the optimal timing of fertilizer applications considering climatic and turfgrass conditions.

Future Research

- Implementing variable-rate N prescription maps with GNSS spreader.
- Comparing conventional and variable-rate approaches to assess their effectiveness in enhancing N use efficiency during fertilizer applications.

Acknowledgments

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