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Evaluating Small Unmanned Aerial Systems for Detecting Drought Stress on Turfgrass

Mu Hong
Kansas State University, mu2@ksu.edu

Dale Bremer
Kansas State University, bremer@ksu.edu

Deon van der Merwe
University of Utrecht, The Netherlands, d.vandermerwe@uu.nl

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Evaluating Small Unmanned Aerial Systems for Detecting Drought Stress on Turfgrass

Abstract

This study was conducted to evaluate early detection ability of small unmanned aerial systems (sUAS) technology for drought stress on turfgrass. Certain reflectances collected by sUAS and a handheld device declined more in less irrigated treatments before drought stress was evident in visual quality rating (VQ) and percentage green cover (PGC). The near infrared (NIR) band and GreenBlue vegetation index performed the best consistently for drought stress prediction among the other vegetation indices (VI) or bands from sUAS. Results indicate using ultra-high resolution remote sensing with sUAS can detect drought stress as well as, if not better than, a handheld device before it is visible to the human eye, and may provide valuable evidence for irrigation management in turfgrass.

Keywords

drought, prediction, drone, reflectance, vegetation index

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Evaluating Small Unmanned Aerial Systems for Detecting Drought Stress on Turfgrass

Mu Hong, Dale J. Bremer, and Deon van der Merwe[1]

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Summary

This study was conducted to evaluate early detection ability of small unmanned aerial systems (sUAS) technology for drought stress on turfgrass. Certain reflectances collected by sUAS and a handheld device declined more in less irrigated treatments before drought stress was evident in visual quality rating (VQ) and percentage green cover (PGC). The near infrared (NIR) band and GreenBlue vegetation index performed the best consistently for drought stress prediction among the other vegetation indices (VI) or bands from sUAS. Results indicate using ultra-high resolution remote sensing with sUAS can detect drought stress as well as, if not better than, a handheld device before it is visible to the human eye, and may provide valuable evidence for irrigation management in turfgrass.

Rationale

Recent advances in sUAS may provide a rapid and accurate method for turfgrass research and management with less labor and time consumption in an effort to provide resources for maximizing water use efficiency.

Objectives

This study was conducted to evaluate the early detection ability of ultra-high resolution remote sensing with sUAS technology for drought stress on turfgrass and compare it with traditional techniques.

[1]Department of Farm Animal Health, University of Utrecht, The Netherlands, d.vandermerwe@uu.nl.

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Study Description

This 3-year study was conducted under an automatic rainout shelter at the Rocky Ford Turfgrass Research Center, Manhattan, KS. 'Declaration' creeping bentgrass was mowed at 5/8-inch height and watered at several levels, from severe deficit irrigation to well-watered according to 15, 30, 50, 65, 80, and 100% reference evapotranspiration (ET) replacement. Airborne measurements with a modified digital camera mounted on a sUAS included reflectance from three individual bands (near infrared, green, and blue bands), from which eight VI were derived for evaluation. Traditional measurements included volumetric water content (VWC; soil moisture), VQ, PGC using digital image analysis, soil temperature, and reflectance with a handheld device.

Results

Declines in VWC in deficit-irrigation treatments were consistently detected with the NIR band (Figure 2, upper left and lower left) and six of the eight VI from sUAS (GreenBlue VI, for instance, shown in Figure 1), as well as the normalized difference vegetation index (NDVI), the NIR and red band from a handheld device (data not shown). Moreover, these bands and VI predicted drought stress at least one week before symptoms appeared in VQ and PGC in 2016 and 2017. For example, NIR closely matched measurements of VWC on July 15, 2016, and detected declines in visual quality (appeared on July 22) one week ahead (Figure 2, note the emphasis on differences between 100% evapotranspiration (ET) and 30 and 15% ET treatments. Bars with the same letter within each figure indicate no significant differences [$P = 0.05$]). For sUAS, NIR and GreenBlue VI [(green-blue)/(green+blue)] performed the best for drought stress prediction throughout three years. For the handheld device, NDVI and red band predicted drought events earlier than NIR.

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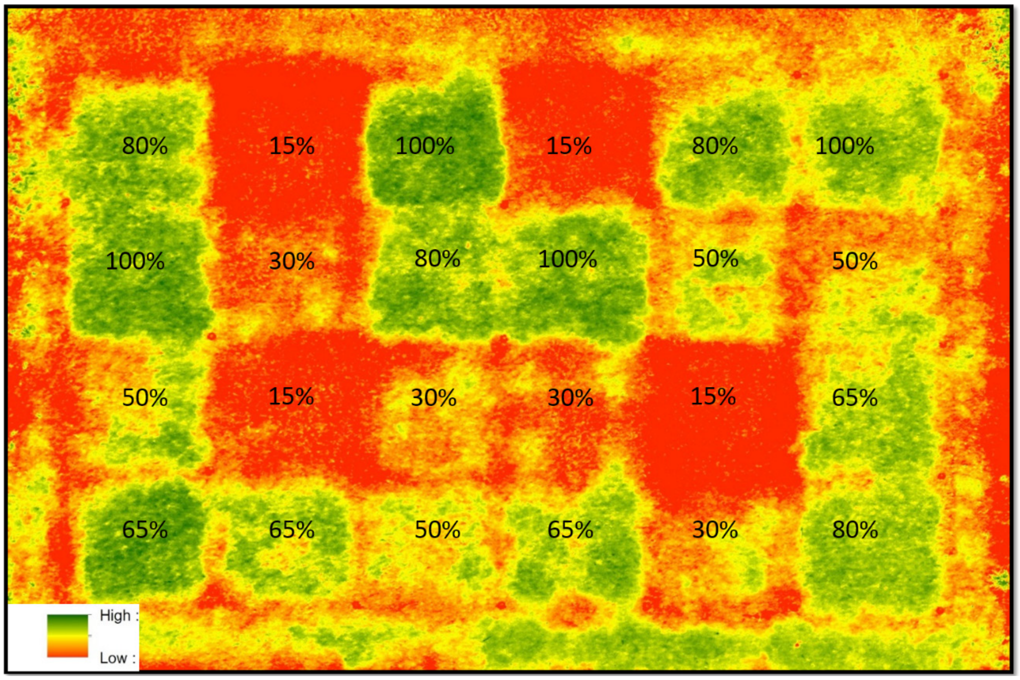

Figure 1. Color-enhanced image of plots in the GreenBlue Vegetation Index [(green-blue)/(green+blue)] from sUAS. August 31, 2015. Percentages denote evapotranspiration replacement irrigation treatments. Dark green (high) indicates more turfgrass biomass. Image created in ArcGIS.

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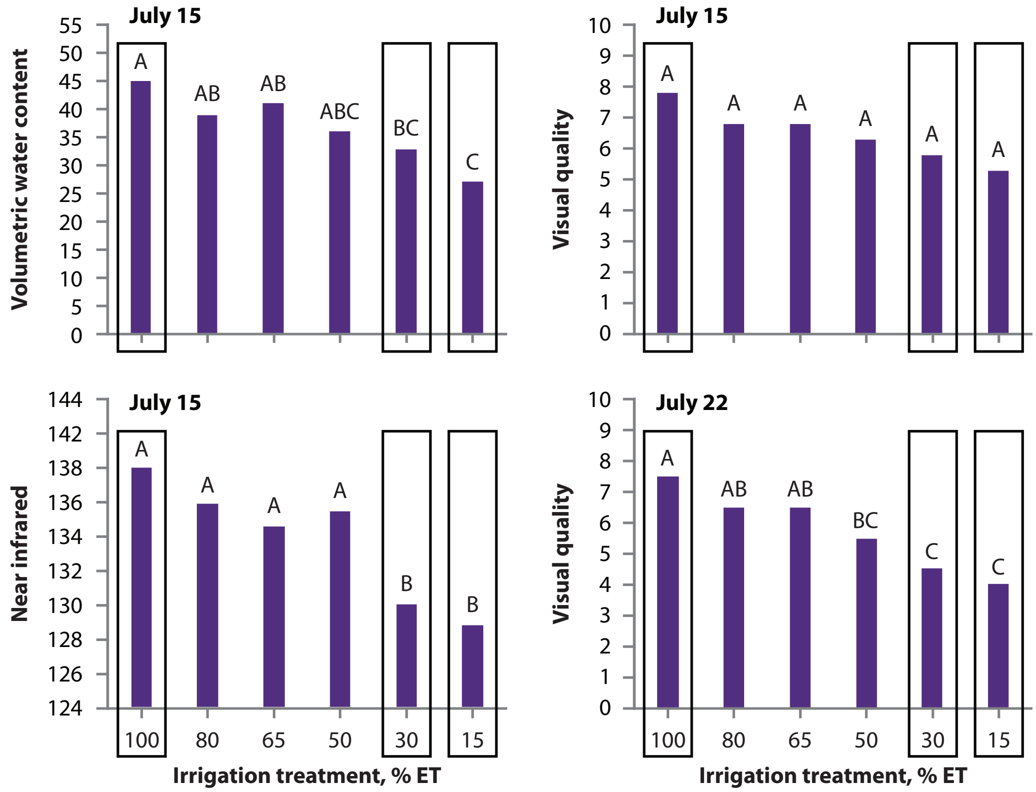

Figure 2. Volumetric soil water content (upper left), turf visual quality (upper right), and reflectance in near infrared band (NIR, lower left) on July 15, and visual quality one week later on July 22, 2016 (lower right). Data illustrate how measurements with NIR closely matched measurements of volumetric water content on July 15, and detected declines in visual quality one week before July 22; note emphasis on differences between 100% evapotranspiration (ET) and 30 and 15% ET treatments. Bars with the same letter within each figure indicate no significant differences (*P* = 0.05).

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Figure 3. Deficit to well-watered irrigation treatment according to 15, 30, 50, 65, 80, and 100% reference evapotranspiration (ET) replacement. Irrigation was applied three times a week by hand with a wand attached to a meter.

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