Stop #7a: Remote Sensing and Evapotranspiration (ET) Replacement Strategies for Turf Irrigation

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Background and Justification:

Irrigation scheduling is determining when and how much to irrigate. This is especially important in arid and semi-arid environments where rainfall is scarce and water resources are precious. The old adage of irrigating 10-15 minutes every night is often neither good for water conservation nor desirable for turf health and playability. Instead, most professional turf managers rely on evapotranspiration (ET), soil moisture, and or plant-based information (e.g., reflectance using NDVI) to schedule irrigation. At UCR, much of our turfgrass water conservation research is based on scheduling irrigation to replace a percentage of reference evapotranspiration (ETo) as determined by a California Irrigation Management Information System (CIMIS) weather station located at the UCR Turfgrass Research Facility.

EYEON18 is a technology service company that helps golf course management increase water efficiency and improve playing conditions. Their agriculture drone utilizes multi-spectral capabilities to deliver NDVI and high-resolution visible light images in unison. The dual imagery combined with soil moisture data allow turf managers to quickly evaluate turf growth habits and patterns over large areas. EYEON18 comprises 60+ years of turf management experience paired with a robust fixed-wing platform that can fly up to 800 acres per hour and the average golf course in 20 minutes.

This summer UCR teamed up with EYEON18 to help execute a grant from the Metropolitan Water District to study the water saving capability of their remote sensing system. EYEON18 flew a total of 8 flights over the entire UCR Agricultural Operations research station at the altitude of 300 feet with each mission lasting 19 minutes and covering 409 acres per flight. This study was conducted to help calibrate and compare data collected using EYEON18 technology as well as typical ground level data collected in our turfgrass research program. Three different irrigation strategies were employed to provide a range of irrigation amount (Table 1). The overall objective of this preliminary ongoing research is utilizing these irrigation scheduling technologies to produce the highest turf quality with the least possible consumption of water.

Materials and Methods:

The study was conducted on ‘Tifway II’ bermudagrass established from sod on 27 April 2017. Soil was a Hanford fine sandy loam. Turf received 0.5 lb N/1000 ft^2 every 6 weeks for a target of 5 lbs N/1000 ft^2/yr. Mowing height was 0.5 inches (3 days/wk). Irrigation treatments were initiated on 17 July 2017 and weekly irrigation budgets were divided into 3 events (days) per week by hand watering with a hose/nozzle with a known output (gpm).

Plots were evaluated at ground level for turf quality, volumetric water content (POGO), NDVI (Green Seeker), and using digital image analysis (DIA) every week. Experimental design was a randomized block with 3 replications of irrigation treatments. Individual plots were 20’ x 20’.

EYEON18 flew a total of 8 weekly flights over the entire research station at the altitude of 300 feet with each mission lasting 19 minutes and covering 409 acres per flight. Volumetric water content was recorded within each plot during each flight.

Results:

Table 2 shows the relative amounts of water applied to the turf relative to ETo over the course of an 8-wk period. Irrigating 1.5 inches of water/wk, analogous to frequent irrigation without much regard for irrigation scheduling technology, resulted in ca. 104%ETo replacement on average. In comparison to UCR recommendations of weekly replacement of 75%ETo for bermudagrass turf in Riverside, variable ETo replacement on a weekly basis resulted in ca. 78%ETo averaged over the 8-wk period.

Visual turf quality, volumetric soil moisture, and NDVI determined at ground level by UCR personnel revealed only a few minor differences among the three levels of irrigation (Tables 3-5). Although soil moisture increased and at times turf quality and NDVI were numerically higher in plots receiving the most irrigation, these results demonstrate that 75%ETo was sufficient to maintain turf quality.

With EYEON18 imagery, nuances in plant vigor are distinguishable to the sub-meter level across the entire area of interest (Fig. 1). EYEON18’s goal is to identify patterns from the imagery and assist turf managers with tuning their irrigation systems. Detailed analysis of NDVI results and comparisons to the UCR data is in progress.

Acknowledgments:

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Table 1. Irrigation treatments employed on bermudagrass turf. 2017. Riverside, CA.

No.	Irrigation Treatments
1	0.65-0.9% Variable ETo replacement (previous wk ETo)
2	75% ETo replacement (previous wk ETo)
3	1.5 inch of water/wk

Table 2. Previous weekly reference evapotranspiration (Eto) and weekly water consumption (inches and gallons) for the three irrigation treatments on bermudagrass turf. 2017. Riverside, CA.

Week	Week starting date	Previous weekly CIMIS ET_0	Variable ETo Replacement	75% ETo Replacement	1.5 inches of water / week	Variable ETo Replacement	75% ETo Replacement	1.5 inches of water / week
			---------- inches ----------			------------ gallons ------------		
1st	7/19/2017	1.7	1.3	1.3	1.5	322	322	374
2nd	7/27/2017	1.6	1.2	1.2	1.5	290	290	374
3rd	8/03/2017	1.1	0.8	0.8	1.5	201	201	374
4th	8/10/2017	1.4	1.0	1.0	1.5	252	252	374
5th	8/17/2017	1.6	1.3	1.2	1.5	323	307	374
6th	8/24/2017	1.4	1.2	1.0	1.5	304	258	374
7th	8/31/2017	1.2	1.1	0.9	1.5	270	224	374
8th	9/06/2017	1.5	1.2	1.2	1.5	286	286	374
Total		**11.5**	**9.1**	**8.6**	**12**	**2248**	**2140**	**2992**

Table 3. Visual turf quality (1-9, 9 = best) in response to three levels of irrigation on bermudagrass turf. 2017. Riverside, CA.

No.	7/19	7/27	8/3	8/10	8/17	8/24	8/31
1	7.0 A	7.3 A	7.7 A	7.0 B	7.0 A	6.3 A	6.7 A
2	7.3 A	7.3 A	7.3 A	7.3 AB	7.3 A	6.7 A	6.3 A
3	7.3 A	7.3 A	7.7 A	8.0 A	7.0 A	6.3 A	6.3 A

Means followed by the same letter in a column are not significantly different (P=0.05).

Table 4. Volumetric soil moisture (0-100%) as determined by a POGO instrument in response to three levels of irrigation on bermudagrass turf. 2017. Riverside, CA.

No.	7/27	8/3	8/10	8/17	8/24	8/31
1	19.9 A	24.5 A	18.3 B	24.0 A	22.4 A	21.1 A
2	21.3 A	24.7 A	21.0 AB	24.7 A	20.8 A	20.9 A
3	19.2 A	27.1 A	22.3 A	27.0 A	24.4 A	23.8 A

Means followed by the same letter in a column are not significantly different (P=0.05).

Table 5. NDVI spectral canopy reflectance (0-1) as determined by a Green Seeker instrument in response to three levels of irrigation on bermudagrass turf. 2017. Riverside, CA.

No.	7/27	8/3	8/10	8/17	8/24	8/31
1	0.75 A	0.74 AB	0.72 B	0.68 A	0.67 A	0.70 B
2	0.75 A	0.73 B	0.73 AB	0.67 A	0.67 A	0.72 AB
3	0.76 A	0.75 A	0.74 A	0.69 A	0.69 A	0.73 A

Means followed by the same letter in a column are not significantly different (P=0.05).

<u>Plot plan:</u>

12 E 10 S Plot Plan / Irrigation Map

↑**N**

101 Irrig. No. 1	102 Irrig. No. 2	103 Irrig. No. 3
201 Irrig. No. 3	202 Irrig. No. 1	203 Irrig. No. 2
301 Irrig. No. 2	302 Irrig. No. 3	303 Irrig. No. 1

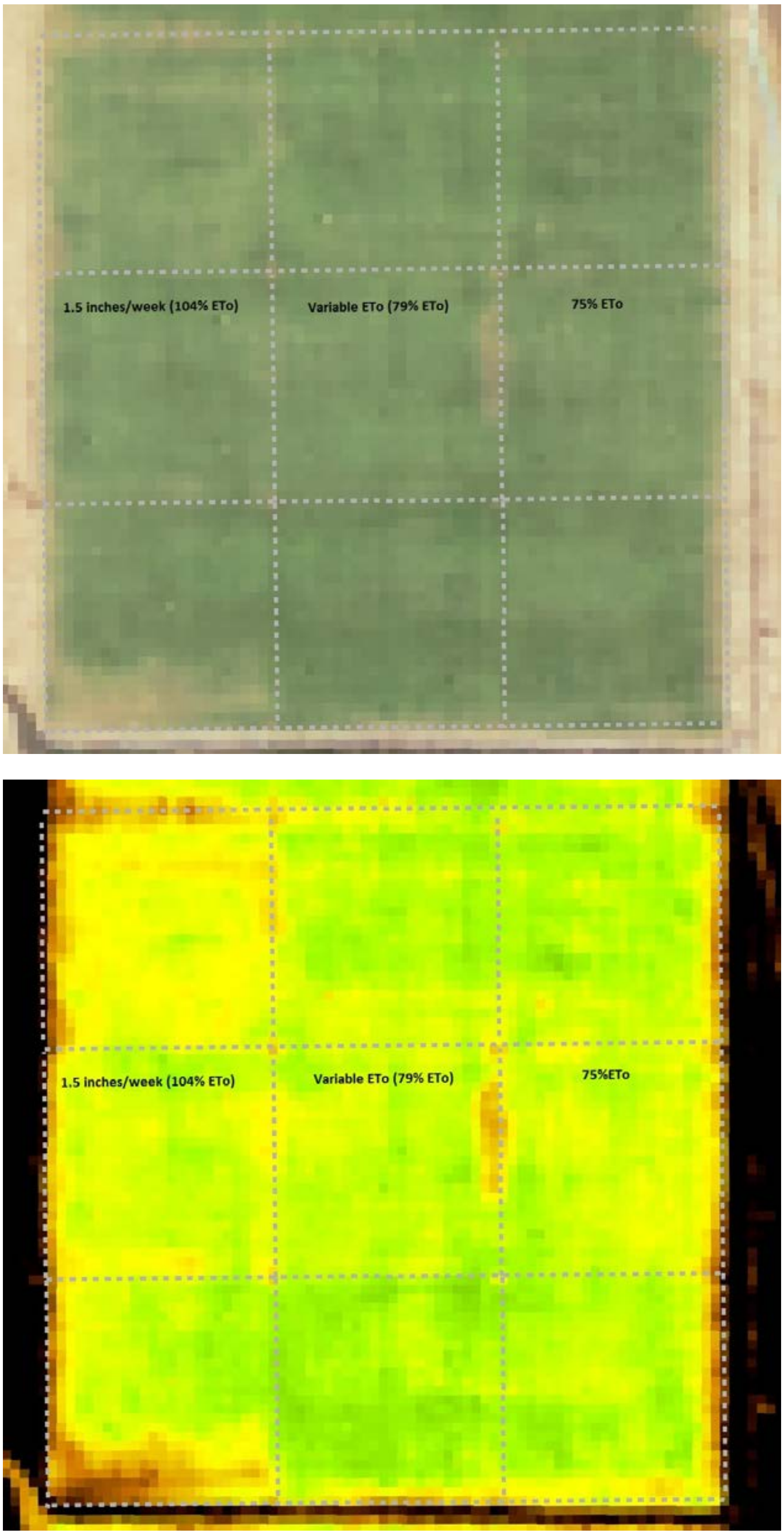

Figure 1. Visible red, green, blue (RGB) high density (HD) image (above) and Normalized Difference Vegetative Index (NDVI) image (below) of the irrigation study area at the UCR Turfgrass Research Facility in Riverside on 6 September 2017 captured by the EYEON18 drone at an altitude of 300 feet with a pixel size of 1.47 cm georeferenced.