

Summary of IFAS Turf and Landscape Irrigation Recommendations ¹

Michael D. Dukes²

Introduction

Turfgrass and landscape irrigation recommendations from the University of Florida/IFAS are provided in a number of publications (Table 1). Two basic recommendations emerge for sprinkler irrigated turfgrass and are summarized below:

1. Irrigating "deep and infrequently" (0.5 inches to 0.75 inches) is recommended for wilting turf growing in a sandy soil where vertical root growth is not limited.
2. Irrigation frequency and run times are recommended based on irrigation application rate, month of the year, and different climate areas within the state.

Irrigation recommendations for ornamental plant material are less prevalent. This lack of recommendations is due to the wide range of landscape plant material and the lack of scientific study of water requirements for each plant type. Further complicating a science-based irrigation recommendation is the fact that typically many types of plant materials are mixed in the landscape. It is

often assumed that irrigation levels satisfying turfgrass water requirements will satisfy ornamentals, but this situation may result in over-watering of ornamental plants. Recent research has been used to develop recommendations for irrigation of shrubs and trees as reported in *Fertilization and Irrigation Needs for Florida Lawns and Landscapes* (<http://edis.ifas.ufl.edu/EP110> (Trenholm et al. 2002))

The first recommendation is based on the concept of replacing the soil water deficit at some threshold and is simple and easy to communicate. However, this generalized recommendation is not applicable to all soil conditions in Florida. For example, many soils in South Florida and coastal areas do not have sufficient depth to retain 0.5 to 0.75 inches of water. In addition, it ignores the fact that most new homes in Florida have in-ground irrigation with time clock controllers that must be programmed with minutes of irrigation per zone to apply a given amount of water. Therefore, Dukes and Haman (2002) developed recommendations which convert depth of irrigation required to controller run times and presented them in an online publication: *Operation of Residential Irrigation Controllers* (<http://edis.ifas.ufl.edu/AE220>).

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2. Michael D. Dukes, associate professor, Department of Agricultural and Biological Engineering, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611.

The depth of irrigation application is based on the calculation of full evapotranspiration (ET) replacement for the turfgrass using historical rainfall data and calculated ET for various parts of the state as presented by Augustin (1983).

The two recommendations summarized above are inherently different in that the first is aimed at a user manually controlling the irrigation application; whereas, the second recommendation methodology provides guidelines on how to program time clock irrigation controllers for unattended operation based on historical irrigation needs (plant demand minus rainfall input). There is a need to review these recommendations and, if possible, define a single recommendation that can be given to stakeholders.

Objectives

1. Review current turfgrass and landscape irrigation recommendations and determine if they are consistent, accurate and reasonable.
2. Produce a coordinated science-based turf and landscape irrigation recommendation.

Irrigation Recommendations Literature Review

The "fixed amount" recommendation probably stems from the idea that the soil holds a fixed amount of water and needs to be refilled after it has been depleted (Dukes, 2007). However, without knowing site characteristics, this recommendation could lead to overirrigation as much as 78% (Dukes, 2007). Turfgrass and landscape irrigation recommendations for a fixed amount can be found in numerous extension documents from across the country and seem to be targeted for the manual (i.e. hose and sprinkler) irrigator.

More sophisticated approaches for landscape irrigation scheduling exist. North Carolina State University (NCSU) has a turfgrass irrigation management system (TIMS) based on real-time weather data and user inputs such as sprinkler application rate and type of grass. The site can be found at <http://www2.turffiles.ncsu.edu/tims/>. The calculations within the TIMS system are a daily soil water balance or water budget (described later).

Despite the availability of this resource, fixed depth recommendations still exist in various extension turfgrass publications from NCSU. There is a weather network in California known as the California Irrigation Management Information System (CIMIS) that provides real-time and archived evapotranspiration (ET) data from the website, <http://www.cimis.water.ca.gov/cimis/welcome.jsp>. The water budget approach is recommended and is used widely by consultants in California and throughout the western states. It is considered the most accurate method for irrigation scheduling and water resources planning where weather data are available. In Arizona a system exists that gives general guidelines for watering via the web (<http://cals.arizona.edu/azmet/phxturf.html>). This system is connected to the Arizona Meteorological Network, AZMET which uses real-time weather data for its recommendations. In addition, a newer tool exists for the Phoenix area that is similar to the TIMS system where irrigation system information can be specified and saved online in a user account.

The AE220 UF/IFAS publication (Dukes and Haman, 2002) was used to develop a simple Web-based guideline for turfgrass irrigation, http://fawn.ifas.ufl.edu/tools/urban_irrigation/. This online tool simplifies the information in AE220, so that within two clicks of entering the Web site, users can determine how many minutes to set their time clock for a particular time of year. This site is intended to give users a rough estimate for irrigation amounts. This schedule is essentially the approach used by Haley et al. (2007) to reduce applied water by 30% on homes in a Central Florida research study.

Irrigation Scheduling Research in Florida

Turfgrass irrigation research has been ongoing in Florida since the 1950s. Typically, research has been driven by prolonged drought conditions such as those that happened in the drought of 2000-01.

Augustin and Snyder (1984) found that tensiometer-controlled turfgrass irrigation reduced water applied by 42% to 95% compared to a daily irrigation schedule. The tensiometer-controlled irrigation plots approximated the turfgrass ET

demand during dry periods ranging from 3.2 to 3.3 inches/month in the cooler months of November through February and 5.1 to 5.7 inches/month in the warmer months of March through May. These values were slightly higher than the values of turfgrass consumptive use reported by Stewart and Mills (1967) ranging from 1.9 to 2.5 inches/month in the cool months and 3.3 to 5.2 inches/month in the warmer months. Annual water consumption in South Florida was reported for St. Augustinegrass and bermudagrass as averaging 42.8 inches over five years using drainage lysimeters and three water table depths of 12, 24 and 36 inches (Stewart and Mills 1967).

Haley et al. (2007) applied the scheduling outlined in AE220 (Dukes and Haman, 2002) to a home lawn and irrigation study. They found that by using the 100% irrigation replacement approach over a 30-month period, an average monthly irrigation reduction of 30% was realized. Visual quality ratings for turf on this schedule were no different than other irrigation treatments in the study. However, these homes still overirrigated with respect to theoretical requirements for several reasons:

1. The actual irrigation systems were inherently inefficient. About 25% more water than the target amount needed to be applied to adequately water all areas of the landscape. Although the distribution uniformity of these homes averaged 0.45 (where 1.0 is perfect uniformity; Baum et al., 2005), the actual uniformity of soil moisture was not negatively impacted by sprinkler low quarter distribution uniformity (DU_{lq}). It has been shown that soil moisture uniformity is not negatively impacted until catch can-measured DU_{lq} falls below 0.4 to 0.5 (Dukes et al., 2006). Thus, even though some gains in water conservation could be made by increasing the efficiency of the irrigation application, the amount of gain is overstated as estimated by low quarter distribution uniformity (DU_{lq}).
2. The 100% ET replacement schedule in AE220 is intentionally conservative (i.e. with intentionally high irrigation estimates). This built-in inefficiency is an artifact of the McCloud ET methodology used by Augustin (1983) in BUL200, which typically overestimates plant ET

(except for the climate of Gainesville, Fla. where the empirical formula was developed). Jacobs and Satti (2001) found that the McCloud formula overestimated reference ET (ET_o) by 7% for Daytona Beach and 5% for Gainesville on an annual basis. However, daily estimates were overpredicted by more than 40% in some cases. Temperature-based ET methods, such as McCloud's, typically overestimate ET in the summer and underestimate in the winter because they do not account for the cloud cover of humid climates (Amatya et al. 1995; Irmak et al. 2003; Jacobs and Satti 2001; Jacobs and Satti 2001; Jensen et al. 1990). Additionally, McCloud readily admits that the above-ground lysimeters used to develop this estimate probably overestimated ET due to the oasis effect. The lysimeter tanks were surrounded by a dry environment which leads to increased ET from advective heat transfer (McCloud 1955). The McCloud (1955) method is presented as, $ET_p = KW^{T-82}$ where ET_p is potential ET, analogous to crop ET (ET_c) in well-watered environments (inches/d), $K = 0.01$ (Gainesville), $W = 1.07$ (Gainesville) and T is mean daily air temperature (degrees F). McCloud (1955) also indicated that this formula is limited to temperatures between 45°F and 80°F.

3. In any given year, the historical data used by Augustin (1983) will not necessarily match the particular weather that year.

Soil Water Budget Approach

In the irrigation industry, it is standard practice to calculate theoretical irrigation requirements based on a soil water budget (SWB), also called a soil water balance. Sometimes this technique is referred to as "the checkbook method" where the soil water storage is the bank account. ET_c represents withdrawals, while irrigation and rain represent deposits. Other withdrawals include deep percolation below the root zone (i.e. drainage) or surface runoff.

There are several simplifying assumptions that make this method well adapted for conditions in Florida. It is typically assumed that there is minimal runoff due to relatively high infiltration rates and flat

slopes. This technique assumes one-dimensional flow vertically, steady state (i.e. drained to equilibrium) conditions at each time step or interval, and no contribution from a shallow water table. Again, permeable soils such as the sands that are prevalent in most of Florida are thought to make these assumptions appropriate for much of the state. In cases where a high water table exists, capillary flow upward from the root zone should be taken into account. The SWB can be calculated on a daily, weekly, or monthly basis depending on input data availability.

This approach is used by the Florida water management districts to allocate water for irrigation purposes. The SWB is commonly accepted by irrigation practitioners and industry as the standard approach for calculating irrigation water requirements as well as scheduling irrigation (IA 2005; Jensen et al. 1990).

If real-time weather data are available, the SWB approach can be used for irrigation scheduling and if historical data are available, the SWB approach can be used to determine long-term average irrigation requirements.

The SWB balance approach was described by Smajstrla (1988) and later became the Agricultural Field Scale Irrigation Requirements Simulation (AFSIRS) model (Smajstrla 1990) which was adopted by the St. John's River Water Management District for irrigation permitting. The Northwest Florida Water Management District uses this model for permitting, while the Southwest Florida Water Management District uses a similar approach but a different model. The South Florida Water Management District references this model for consumptive use permitting.

Example of Calculated Water Requirements, Jacksonville, Fla.

In a study conducted by Dukes (2007), weather data were gathered for Jacksonville. The data were carefully quality checked and adjusted as necessary to represent data from a well watered site for calculation of ETo by the ASCE standardized method (Allen et al. 2005). Assumptions used in this analysis were a 50% allowable deficit of the soil water storage

(the difference between field capacity and permanent wilting point) and an 8-inch root zone (representative for lawn turfgrass) on a sand with field capacity (FC) = 10% and permanent wilting point (PWP) = 3% by volume. Crop coefficients for warm-season turfgrass developed in Florida (Jia et al. 2007) were used to convert ETo values to ETc. The following comparisons were set up (Dukes et al., 2007):

- OPT, irrigation to refill the soil reservoir when 50% of available water is depleted;
- FIX, 0.75" of irrigation when 50% of the available water is depleted;
- FIX-RS, addition of a rain sensor at 0.25" to FIX schedule;
- HIST, 100% replacement schedule from AE220;
- HIST-RS, addition of a rain sensor at 0.25" to HIST schedule.

Figure 1 gives the average annual cumulative irrigation required by the irrigation schedule comparisons. The "FIX" and "FIX-RS" schedules are 0.75 inches of irrigation when significant turfgrass wilt occurs. The fixed schedule without a rain sensor overestimates irrigation required by 78% and with a rain sensor by 60%.

Subsequent research projects on turfgrass have been conducted in Gainesville, Citra, and Wimauma, FL based on the time schedules recommended in AE220. It appears that 60% of the net irrigation requirement (shown in the irrigation recommendations within AE220) is an adequate amount even in drought conditions. Figures 2 through 4 show the actual irrigation applied based on the 60% replacement schedule in the tables of AE220. In the warmer months, seen as April and May in Figure 2 and September through November in Figure 3, the AE220 schedule for South Florida (used for the research site at Wimauma) slightly over predicts irrigation requirements or closely matches the soil water balance predicted by a SWB. However, in the winter months irrigation is over-predicted (Figure 4).

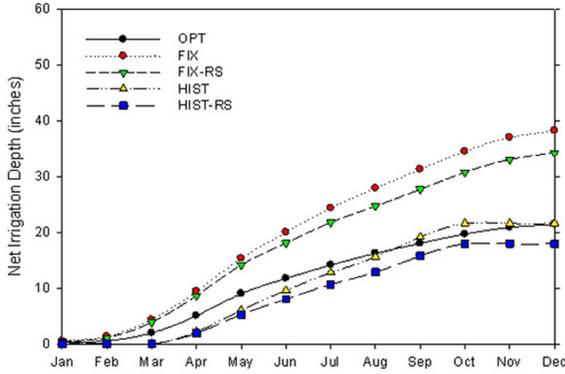


Figure 1. Average annual cumulative irrigation required for Jacksonville based on a daily soil water balance and 30 years of weather data on a fine sandy soil. Note the following: OPT, irrigation to refill the soil reservoir when 50% of available water is depleted; FIX, 0.75" of irrigation when 50% of the available water is depleted; FIX-RS, addition of a rain sensor at 0.25" to FIX schedule; HIST, 100% replacement schedule from AE220; HIST-RS, addition of a rain sensor at 0.25" to HIST schedule. After Dukes (2007).

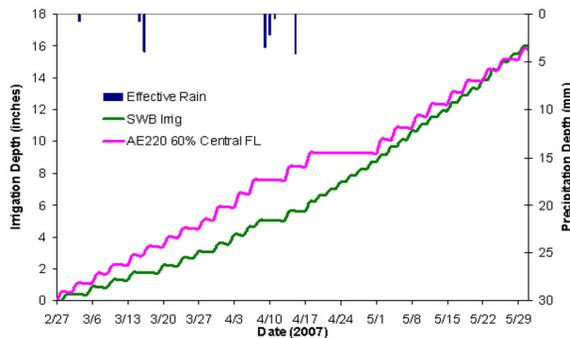


Figure 2. Spring 2007 example of 60% time-based irrigation schedule (AE220 60% Central FL) compared to theoretical irrigation requirements based on a daily soil water balance (SWB Irrig). Irrigation system had a rain sensor set at 0.25" threshold. Note that from 4/15 through 5/1 a broken rain sensor resulted in no irrigation application.

The 60% replacement schedule in AE220 was adequate during the warm months. However, the edges of the plots required hand watering due to incomplete coverage of the irrigation system. This lack of uniformity is common, thus the 80% recommendation would be conservative with respect to providing adequate water across a range of irrigation system qualities. A well-designed and maintained irrigation system could likely use the 60% replacement for maximum water conservation potential.

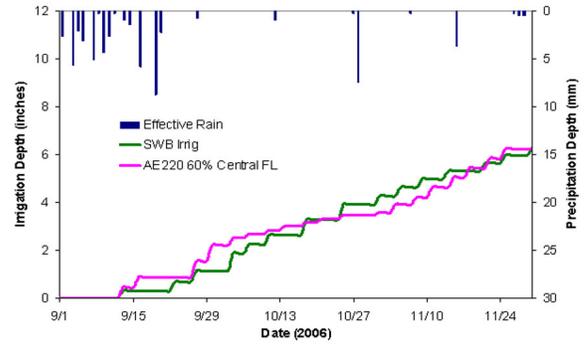


Figure 3. Fall 2006 example of 60% time-based irrigation schedule (AE220 60% Central FL) compared to theoretical irrigation requirements based on a daily soil water balance (SWB Irrig). Irrigation system had a rain sensor set at 0.25 inches threshold.

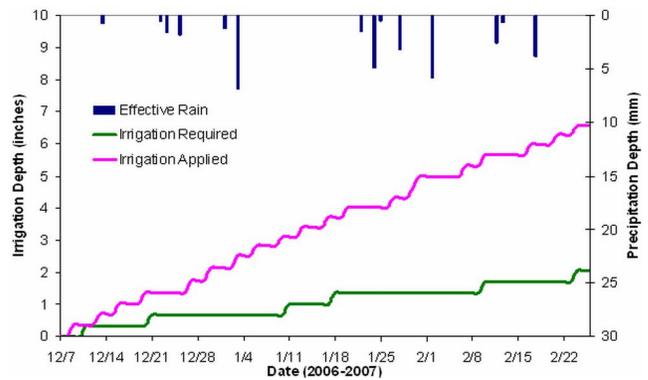


Figure 4. Winter 2006-2007 example of 60% time-based irrigation schedule (AE220 60% Central FL) compared to theoretical irrigation requirements based on a daily soil water balance (SWB Irrig). Irrigation system had a rain sensor set at 0.25 inches threshold.

Conclusions & Recommendations

Although the fixed-depth irrigation recommendation is simple and easy to communicate, it could lead to overirrigation. This is because of the tendency for this depth to exceed the water holding capacity of many sandy Florida soils. In addition, many homeowners set irrigation amounts and do not readjust properly for seasonal changes. This tendency is reinforced by water restrictions which mandate specific day-of-the-week schedules. Day-of-the-week water restrictions have been shown to reduce municipal water use 15% to 20% in SFWMD during the spring and summer of 2007 (data not shown), but this amount is far below the 50% reduction expected from a 2 day/week to a 1 day/week transition. Recommendations, such as SFWMD's winter "Skip a Week" campaign, encourage users to adjust their time clocks. However, the challenge with such

recommendations is getting homeowners to follow through on them.

Unification of the various UF/IFAS landscape irrigation recommendations can be expressed as follows: "UF/IFAS recommends irrigation when plants show visual cues of water stress (Trenholm and Unruh, 2003). When using a time clock for irrigation scheduling, run times based on historical weather data can be found in *Operation of Residential Irrigation Controllers* <http://edis.ifas.ufl.edu/AE220>. If an automatic controller is used, it is recommended that irrigation schedules be changed each month according to recommendations outlined in AE220. An easy, user-friendly version, the Urban Irrigation Scheduler, can be found at http://fawn.ifas.ufl.edu/tools/urban_irrigation/.

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Table 1. IFAS Turfgrass and Landscape Irrigation Recommendations Published in EDIS.

Reference	Title	Irrigation Requirement or Scheduling Recommendation
Augustin 1983 No longer available in EDIS.	Water Requirements of Florida Turfgrasses	Net irrigation requirement ranging from 19.0 to 34.6 inches per year.
Trenholm et al. 1991 http://edis.ifas.ufl.edu/LH010	<i>St. Augustinegrass for Florida Lawns</i>	Irrigate 0.5 to 0.75 inches when lawn show signs of wilting. Vary watering frequency and not amount according to season and rainfall.
Smajstrla and Zazueta 1995 http://edis.ifas.ufl.edu/AE078	<i>Estimating Crop Irrigation Requirements for irrigation system design and Consumptive Use Permitting</i>	Daily soil water balance using historical data to determine mean annual irrigation requirement.
Zazueta et al. 1995 http://edis.ifas.ufl.edu/AE144	<i>Turf Irrigation for the Home</i>	Provides general guidelines on water holding capacity for sandy Florida soils. Gives allowable depletion of 0.50 inches per foot not including irrigation efficiency. Guidelines are also given on days between irrigation events. Recommends tensiometers to automate irrigation scheduling.
Smajstrla et al. 1997 http://edis.ifas.ufl.edu/AE111	<i>Basic Irrigation Scheduling in Florida</i>	Describes water budget irrigation scheduling. Recommends tensiometer/soil moisture sensors to assist with scheduling.
Zazueta et al. 2000 No longer available in EDIS	<i>Reduced Irrigation of St. Augustinegrass in the Tampa Bay Area</i>	Describes a study that evaluated turfgrass quality under deficit irrigation conditions where acceptable quality turfgrass was maintained with 60% of crop water requirement replacement. Recommends applying only the amount of water that can be stored in the root zone at each irrigation event and a general value of 0.75 to 1.0 inches is given for Florida soils. Gives irrigation intervals based on root depth ranging from 2.7 to 11.6 days, 2.2 to 9.3 days, and 1.7 to 7.5 days for high, medium, and low water savings (6" root zone in Tampa Bay); 6.1 to 27.8 days, 5.2 to 21.6, and 4.4 to 20.2 days for a (12" root zone).
Trenholm and Unruh 2003 No longer available in EDIS.	<i>Let Your Lawn Tell You When to Water</i>	Recommends irrigating when turf wilts. Encourages deep rooting by watering only when stressed and by mowing at highest recommended height. Apply 0.5 to 1 inches of water per application. General required watering frequencies are given for three geographic areas of the state.
Garner et al. 2001 http://edis.ifas.ufl.edu/EP079	<i>A Guide to Environmentally Friendly Landscaping: Florida Yards and Neighborhoods Handbook</i>	Water early morning between 4 am and 7 am. Apply 0.5" to 0.75" when turfgrass shows signs of distress. Water less in cooler months.
Trenholm et al. 2001 No longer available in EDIS	<i>Watering your Florida Lawn</i>	Over watering results in a less developed shorter root system. On average we receive over 60 inches of rain each year. Water when grass shows signs of wilt; apply 0.75" of irrigation. Each week, 2-3 irrigation events are adequate in the summer rainy season; one irrigation every 10-14 days in the winter.
Trenholm et al. 2002 http://edis.ifas.ufl.edu/EP110	<i>Fertilization and Irrigation Needs for Florida Lawns and Landscapes</i>	For established lawns, when 50% shows wilt, irrigate with 0.75" of water. Irrigation intervals are 1-3 events per week in the summer and every 10 to 14 days in the winter.

Table 1. IFAS Turfgrass and Landscape Irrigation Recommendations Published in EDIS.

Reference	Title	Irrigation Requirement or Scheduling Recommendation
Tichenor et al. 2004 http://edis.ifas.ufl.edu/EP235	<i>Using the Irrigation Controller for a Better Lawn on Less Water</i>	Recommends setting irrigation controller to water 0.75" and adjusting number of watering days according to climate demand.
Dukes and Haman 2002 http://edis.ifas.ufl.edu/ae220	<i>Operation of Residential Irrigation Controllers</i>	Controller run times suggested based on historical ET and rainfall data for three regions in the state. Assumptions include 60% efficiency and two d/wk irrigation. Net irrigation requirements were taken from Augustin (1983).