Are You Under-Irrigating Your Trees?©

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INTRODUCTION

To maintain high growth rates, plants need to stay fully hydrated. Yet over-irrigation results in nutrient leaching and can promote root diseases. Water management is especially important for container production, where soil volume is limited. For woody shrubs, there are several examples available to estimate irrigation need (Beeson, 2004; Burger et al., 1987; Knox, 1989; Reagan, 1997). However for trees, examples are few (Beeson and Brooks, 2008; Edwards, 1986; Steinberg et al., 1990). In Florida, nurseries and tree farms are often required to justify their request for water-use permits when renewed. This project was initiated to quantify water use of three tree species up to 13-cm (5-in.) caliper. This paper is a brief summary of some of the results.

MATERIALS AND METHODS

In March 2001, rooted cuttings of 'Florida Flame' red maple (*Acer rubrum*) and 'Nellie R. Stevens' holly (*Ilex* 'Nellie R. Stevens'), and seedlings of live oak (*Quercus virginiana*) were transplanted into #7 containers. Substrate was a composted pine bark, Florida sedge peat and coarse sand (7 : 3 : 1, by vol) amended with micronutrients and dolomite limestone. These containers were painted on the inside with a copper hydroxide mixture (Spin-Out™, Griffin Corp. Valdosta, Georgia) and covered on the outside with aluminum foil to reduce heat load and evaporation of water. Tops of each container were covered to exclude most rainfall and reduce evaporation. Trees were micro-irrigated using one spray stake per container (yellow, Netafilm, Fresno, California). Each container was suspended in a tripod lysimeter, consisting of a metal basket suspended from a load cell held up by a 2.1-m (7-ft) tall tripod. The load cell (SSM-100, Interface Force, Scottsdale, Arizona) was connected to a data logger system that recorded lysimeter mass and controlled irrigation for each species (Beeson, 2006). Trees were supplied controlled-release fertilizer and staked as needed. Pruning was judicial prior to spring growth.

In April 2002, lysimeter trees were transplanted to #25 containers, enhanced as described for #7 containers, with each placed in one of nine large tree lysimeters. These were similar to the tripod lysimeters, except the basket was a 3.1 m (10 ft) equilateral triangle which was suspended at each apex. Data collection and irrigation control was similar to that described above. Additional trees were transplanted to serve as border trees around each lysimeter. Thereafter each February trees were transplanted into larger containers in the sequence of #25, #95, #200, and #300. Data was collected a second year for hollies in #25 and oaks in #300 containers. Tree measurements consisted of height, widest canopy width and the width perpendicular to this width; and trunk circumference at 15 and 31 cm (6 and 12 in.) above the substrate and just below the collar of the first major branch. To account for variations in microclimate, reference evapotranspiration was calculated for each day of the experiment using a modification of the Penman-Monteith equation.

RESULTS

Although there were three tree replications per species, the results presented are an example of only one tree per species.

Holly. Initially the tree was 0.3 m (1 ft) tall, with average canopy width of 10 cm (4 in.) and caliper at 15 cm (6 in.) of 0.3 cm (1/8 in.) (Fig. 1). Average evapotranspiration (ET_A) was around 148 ml (5 oz.). By early fall (Day 255) tree height had doubled. Canopy width and caliper had increased three-fold. Daily water use also increased three-fold to 503 ml (17 ounces)/day. Maximum water use occurred during late summer in July and August, yet rarely exceeded 0.5 L (0.14 gal)/day. By early November (Day 305) tree water use was generally less than 0.4 L (0.1 gal)/day. Cumulative water use over the 257 days was 87 L (23 gal).

In 2003, cumulative water use was 1306 L (345 gal). Daily ET_A increased only 40% while tree height increased 0.8 m (2.5 ft) and width increased 0.2 m (0.5 ft) for the year (Fig. 2). This was similar to tree height increases in 2002, but a smaller percent increase in ET_A than the 2 previous years. From mid-May (Day 135) until December (Day 335) ET_A was generally between 4.7–5.7 L (1.3–1.5 gal)/day. There was little reduction in ET_A in early winter as observed in previous years.

The last year, 2006, ET_A peaked around 45 L (12 gal)/day in mid-August when tree was 4.3 m (14 ft) tall with an 2.4 m (8 ft) wide canopy (Fig. 3). There was a 2-fold increase in ET_A from winter to late summer. At its peak, ET_A frequently varied about 50% over periods as short as a week. Similar variability can be seen thorough all graphs. For 2006, cumulative ET_A was 10,247 L (2,707 gal) from this tree in a #300 container. Total ET_A to produce this tree from rooted liner to a tree caliper of 13 cm (5 in.) and height of 4.5 m (14.6 ft) was 21,963 L (5,802 gal) over a 5-year, 8.5-month period.

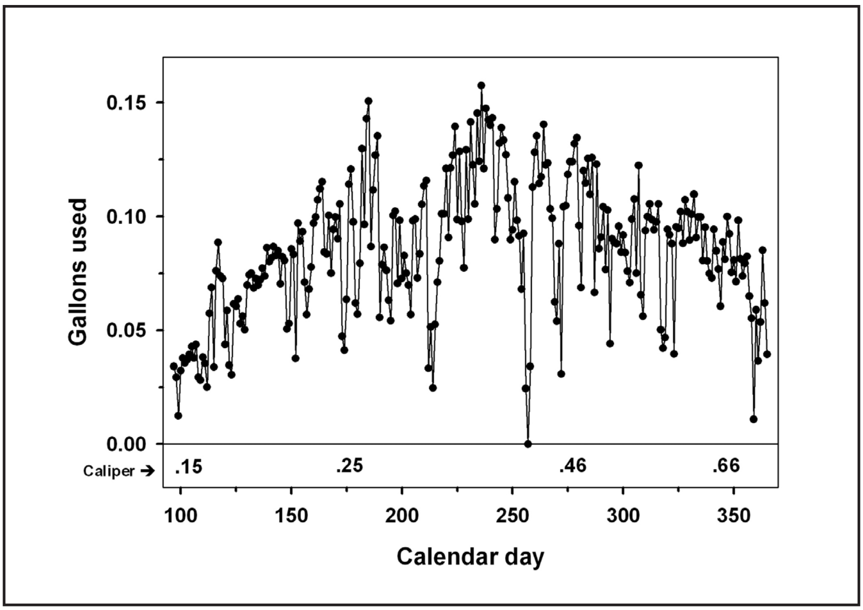

Figure 1. Daily ET_A of 'Nellie R. Stevens' holly in a #7 container.

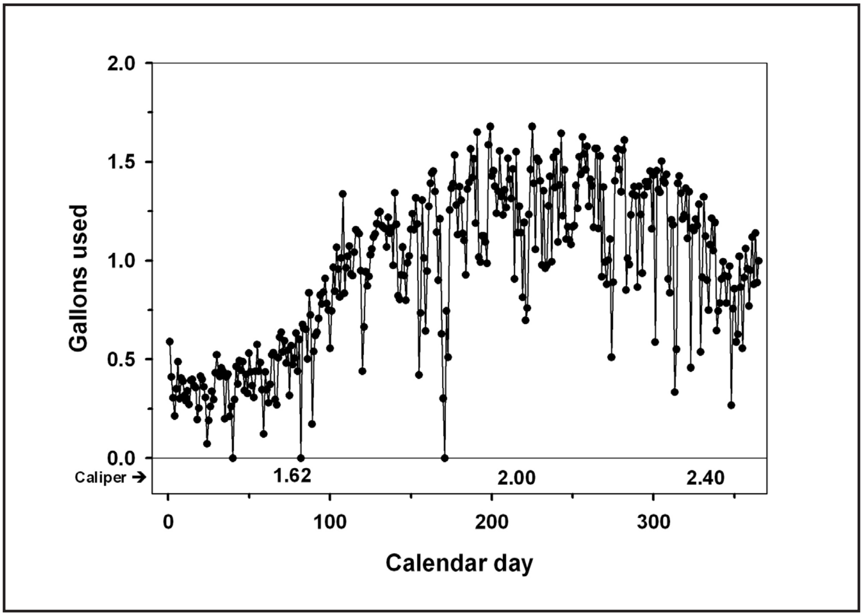

Figure 2. Daily ET_A of 'Nellie R. Stevens' holly in a #25 container.

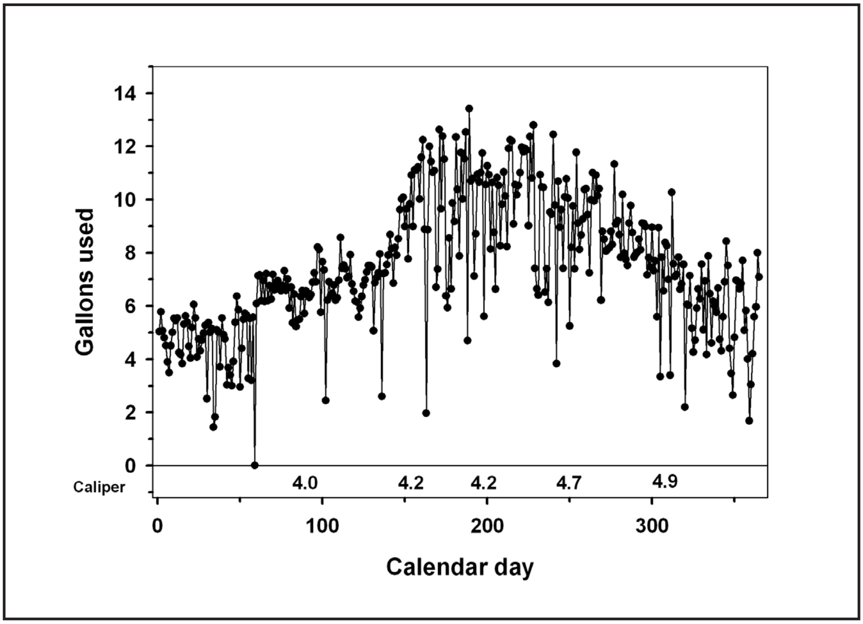

Figure 3. Daily ET_A of 'Nellie R. Stevens' holly in a #300 container.

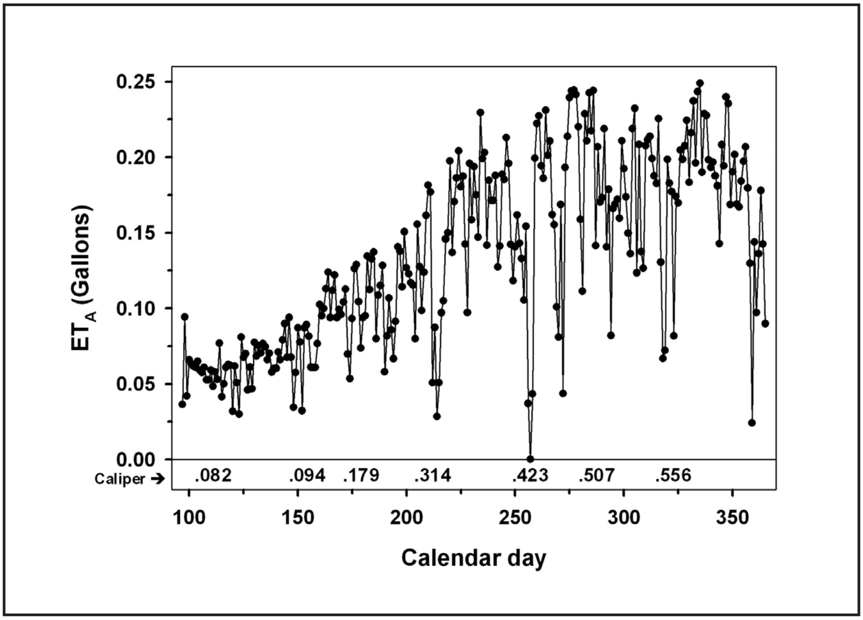

Figure 4. Daily ET_A of Live oak in a #7 container.

Live Oak. In 2001, this tree started at 23 cm (9 in.) in height, with a stem caliper at 15 cm (6 in.) of 0.3 cm (0.10 in.) (Fig. 4). The first year, both height and trunk caliper increased 6-fold. Initial ET_A was similar to that of the holly, but ET_A of oaks increased more rapidly, obtaining a four-fold increase to 0.9 L (0.24 gal)/day by early October. Unlike holly, ET_A did not decline as much late in the year. ET_A of live oak continued to occasionally reach its peak rate into mid- December (Day 348). Cumulative ET_A for 2001 was 136 L (36 gal).

In 2003, leaf drop in late February resulted in daily ET_A of less than 3.8 L (1 gal)/day (Fig. 5). ET_A peaked at 36 L (9.6 gal)/day in mid-September (Day 256) as the tree grew in height from 2.6–3.9 m (8.5–12.8 ft). Daily ET_A rates between 19–34 L (5–9 gal.) persisted from early July (Day 182) through late September (Day 264). Thereafter ET_A generally ranged from 18.9–28.4 L (5-7.5 gal)/day through early December. Cumulative ET_A for this live oak in 2003 was 5,727 L (1,513 gal).

In 2006, leaf drop occurred from mid-February (Day 45) through early March (Day 70) (Fig. 6). During this transition, ET_A fluctuated between 26–45 L (7–12 gal)/day. This was the tree's second year in a #300 container. The tree obtained its previous summer's peak ET_A [121 L (32 gal/day)] in early April (Day 96). ET_A was generally around 132 L (35 gal)/day until June, when 151–170 L (40–45 gal)/day was the norm. ET_A peaked at 178 L (47 gal)/day until the tree blew over in mid-June and was harvested. Cumulative ET_A for this live oak to increase from 17.5–18.8 cm (6.9–7.4 in.) in caliper over 6.5 months was 13,703 L (3,620 gal). Tree height when it blew over was 6.8 m (22.3 ft), with a mean spread of 5.4 m (17.7 ft). Cumulative ET_A for this live oak from seedling through mid-June 2006 was 57,795 L (15,268 gal).

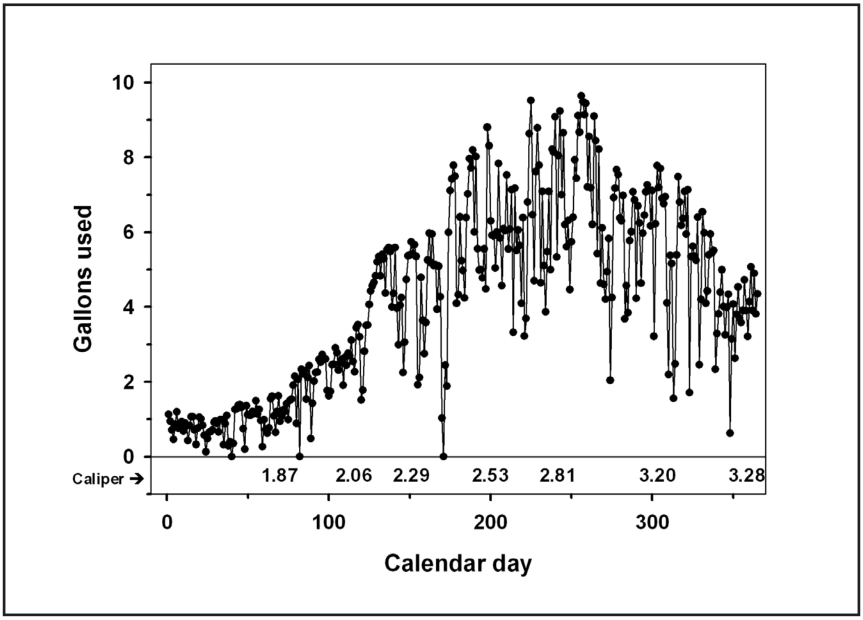

Figure 5. Daily ET_A of Live oak in a #95 container.

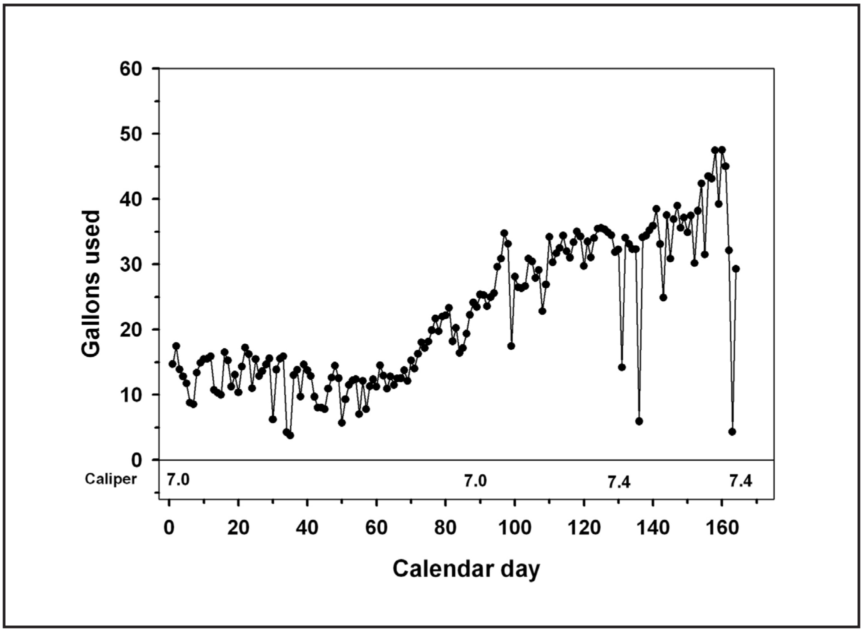

Figure 6. Daily ET_A of Live oak in a #300 container.

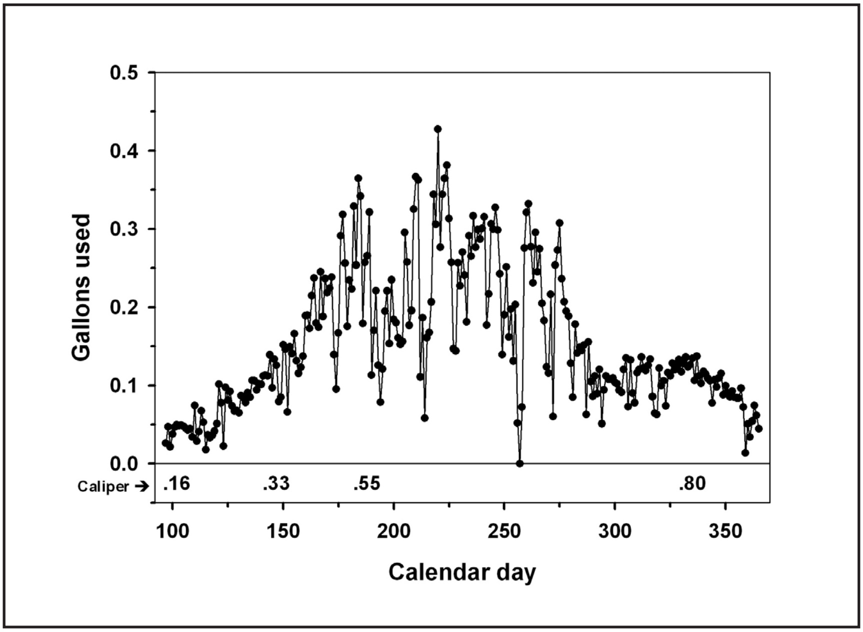

Figure 7. Daily ET_A of red maple in a #7 container.

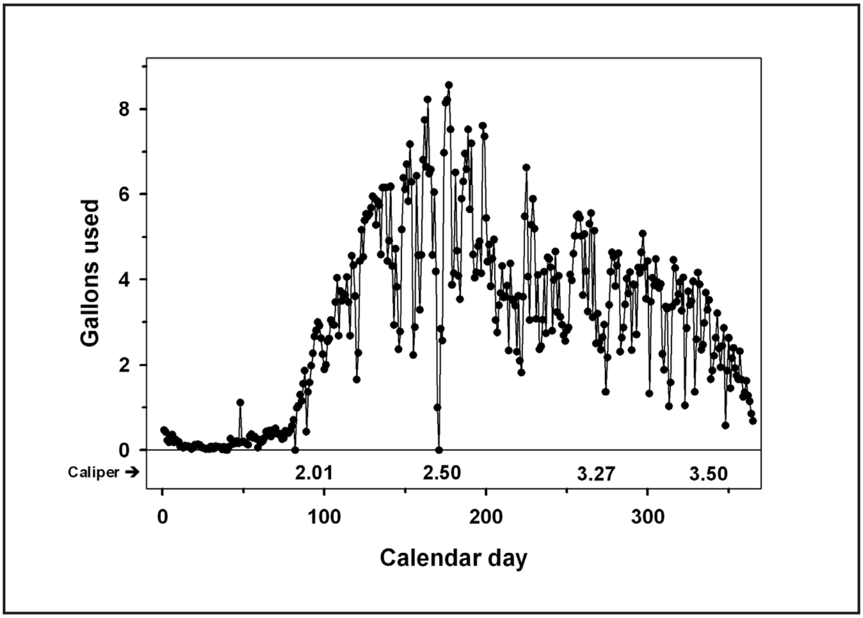

Figure 8. Daily ET_A of red maple in a #95 container.

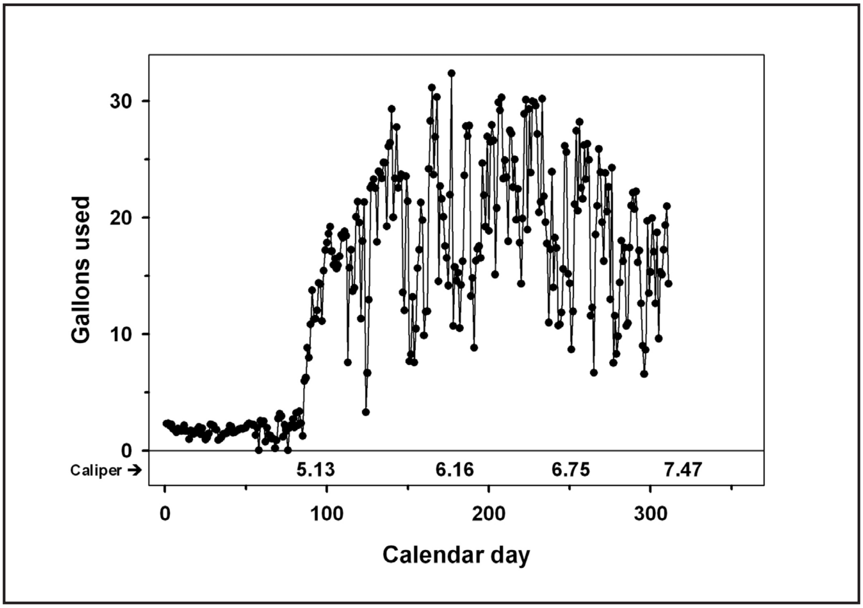

Figure 9. Daily ET_A of red maple in a #300 container.

Maple. In 2001, ET_A was similar to other species initially at around 0.2 L (0.05 gal)/ day (Fig. 7). The tree grew from 0.4–2 m (1.4–6.6 ft) in height the first season, with ET_A peaking above 1.5 L (0.4 gal)/day in early August. This ET_A was twice as much as measured for oaks and three times that of hollies. ET_A began declining in mid-September (Day 260) and was quite low by early October (Day 280). This corresponded with a bacterial infection of leaves that caused leaf senescence. By October, most leaves had fallen. In latter years, foliar sprays of Kocide and Dithane were applied biweekly from June through Oct to prevented leave loss. Cumulative mean ET_A for 2001 was 156 L (41.1 gal).

In 2003, flowering occurred in mid-February before leaf expansion (Day 45; Fig. 8). Leaf and shoot growth did not begin until late March (Day 80). Though there was little photosynthesis and no shoot or leaf growth, ET_A more than doubled with flowering, but was less than 1.9 L (0.5 gal)/day. Increase in ET_A was rapid with leaf bud break, going from 1.9–20.8 L (0.5–5.5 gal)/ day in 45 days. ET_A peaked over 30.3 L (8 gal) /day in late June (Day 175) and ran generally between 20–27 L (5–7 gal)/day through the first week of July. A dramatic drop in shoot elongation dropped ET_A by 50% the second week. Shoot growth and ET_A remained anemic the rest of the year.

In 2005, ET_A was 3.8–7.6 L (1–2 gal)/day through flowering (Fig. 9). With onset of shoot elongation (Day 80), tree water use rapidly increased from 7.6–56.8 L (2–15 gal)/day over a 2-week period. From mid-June until late August (Day 225), ET_A was generally 75.7–113.6 L (20–30 gal)/day. As in previous years, slowing of shoot elongation reduced ET_A for remainder of the fall, though not as dramatically as in 2003. The tree was harvested beginning the first week of November before leaf senescence began. During this last year, this tree increased in height by 1.1 m (3.5 ft) and average canopy width by 15 cm (1.5 ft). At harvest, trunk caliper was

18.5 cm (7.3 in.) measured 15 cm (6 in.) above substrate level. Mean cumulative ET_A for 2006 was 16,463 L (4,349 gal). To grow this maple from 35.6 cm (14 in.) tall to one 7.9 m (26 ft) tall required 4.8 years and 31,930 L (8,435 gal) of ET_A.

DISCUSSION

Tree water use varied substantially among species, even when compared with similar trunk circumference. Day to day variation in ET_A was due to differences in microclimate, principally differences in the amount, thickness, timing, and duration of cloud cover. Because of strong influence of microclimate and its daily variability, actual volumes of water used by these trees provide only a coarse approximation, especially outside of Central Florida. Total volumes should be similar for the same size tree. Quantifying effects of microclimate through daily calculation of reference evapotranspiration accounted for most day-to-day variability. When tree species and size were factored in, a simple linear equation predicted measured ET_A with a better than 93% accuracy over entire production periods. For more information and complete daily water use graphs, please access: <http://www.mrec.ifas.ufl.edu/rcb/Tree_Lysimeters/>.

Acknowledgement. This project was funded by grants from the Horticultural Research Institute and the Southwest Florida Water Management District in conjunction with the Hillsborough River and Alafia Basin Boards.

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