Golf Course Water Use Efficiency in the Western U.S.

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Introduction

One of the most important issues facing the game of golf is water use (USGA, 2001). As members of the golf industry address water use issues, a multi-faceted approach is being employed by superintendents and turfgrass managers. New grass varieties that use less water or lower quality water, new irrigation technologies, the use of alternative water sources, improved course design concepts, irrigation technologies and educational efforts are all being employed to improve stewardship of water resources (USGA, 2001).

In the state of Utah, periodic drought is a common occurrence. These conditions, coupled with a growing population and its demands for water resources, have brought irrigation and water use efficiency to the forefront of water conservation efforts in the state. In 2000, as the state entered a drought period, Utah's Division of Water Resources (UDWRe) collaborated with the Intermountain Golf Course Superintendent's Association (IMGCA) on a study of golf course water use efficiency. Because many citizens of the state had observed golf courses irrigating during the drought, sometimes during the day when many communities did not allow residential irrigation, the perception formed that the golf courses were wasting water. This study sought to evaluate and characterize golf course water use efficiency in the state.

Materials and Methods

Thirty-nine golf courses (Figure 1) in the state were surveyed at the end of the 2001 and 2003 irrigation seasons, collecting data for the 2000, 2001, 2002, and 2003. Some courses did not meter irrigation deliveries at the time the study was conducted, and estimated all or part of their water usage. However, only courses that metered their irrigation deliveries for all four years of observation are included in this study.

Survey questions included general course identification and contact information as well as property area, which was broken down into subareas (tee boxes, fairways, greens, irrigated rough, practice areas, landscaped areas). Other survey questions addressed water source (purchased/culinary, well, surface) and water delivery (automatic irrigation, manually valved in place/moveable heads, hand irrigation) as well as water conservation practices (irrigation system maintenance, weather-based irrigation scheduling, reductions in irrigated area).

Weather data was collected to determine potential evapotranspiration (ET_o) of the study courses. Evapotranspiration was calculated using the American Society for Civil Engineers (ASCE) standardized reference ET equation (EWRI/ASCE, 2005). Turfgrass ET (ET_c) was calculated by multiplying ET_o values by monthly crop coefficients in the state, averaging 0.7 over the course of the growing seasons considered. Water use efficiency (WUE) was calculated as:

$$WUE = (\text{Net } ET_c) / (\text{Metered Irrigation Delivery}) \times 100.$$

Course location (region of the state), course area (ha), water source, water delivery method and water conservation practices were analyzed using a mixed model with repeated measures. Golf course was treated as a subject effect with a compound symmetric error structure. The procedure MIXED in SAS/STAT (v. 9.4) was used for all analyses.

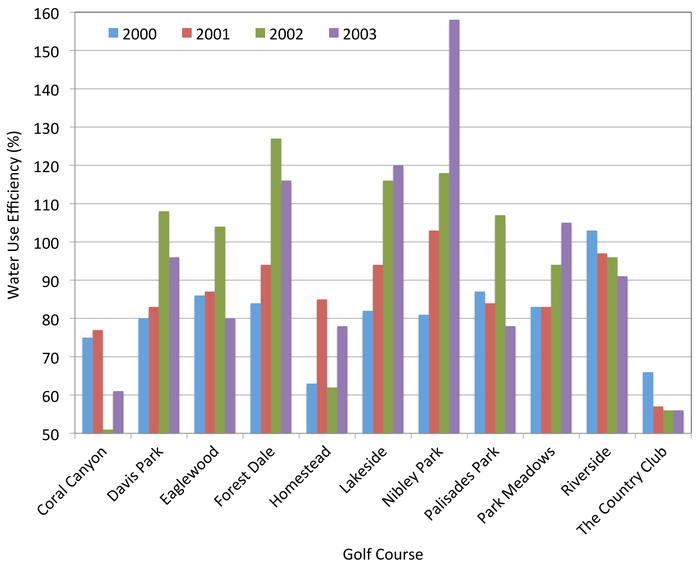

Figure 2. Water use efficiency (%) of eleven Utah golf courses (2000 – 2003).

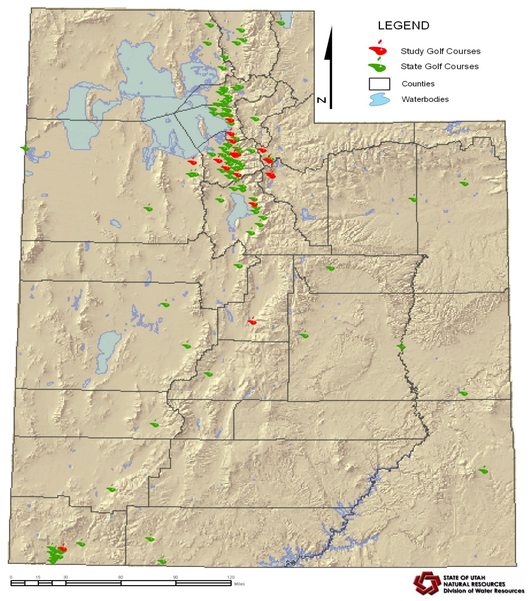

Figure 1. Golf course locations in the state of Utah (study courses are noted in red).

Figure 3. Annual average high temperature (˚C) and precipitation amounts (cm) in the North, Central, and South regions of Utah.

Table 1. Summary of analyses of variance indicating significant source effects on golf course water use efficiency in Utah.

Source	df	F Value	Significance
Year (Y)	3	22.6	***
Region	2	22.5	***
Course Area (A)	1	42.3	***
Conservation Practices (CP)	1	28.4	***
A × Y	3	29.5	***
CP × Y	3	13.1	***

References

Environmental and Water Resources Institute of the American Society of Civil Engineers. 2005. The ASCE Standardized Reference Evapotranspiration Equation Final Report. Allen, Walter, Elliott, Howell, Itenfisu, Jensen and Snyder (*eds.*). ASCE/Irrigation Association. Reston, VA.

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Results and Discussion

Annual course WUEs were widely ranging over the course of the study. In 2000, course WUEs ranged from 66 to 103%. In 2001, course WUEs ranged from 57 to 103%. In 2002, course WUEs ranged from 51-127%. And in 2003, course WUEs ranged from 56-158% (Figure 2).

Average irrigation depths for the courses were 76, 81, 76 and 76 cm in years 2000, 2001, 2002, and 2003, respectively. Corresponding, average turfgrass ET_c depths were 61, 67, 64 and 65 cm, resulting in average course WUEs of 81, 85, 94, and 94%.

Significant effects on WUE were attributed to year, region, total course area, and the water conservation practice of reducing irrigated area (Table 1). Water source and delivery method did not significantly effect WUE. Course WUE generally increased over the years of the study (Figure 2) and was higher in the northern and central regions of the state than in the southern region where annual average high temperatures are higher and precipitation amounts are lower (Figures 3 and 4).

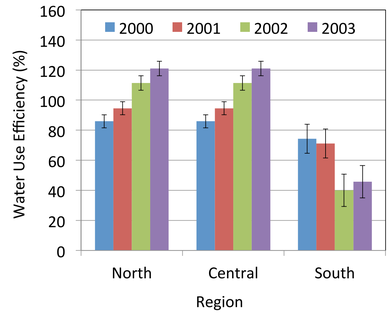

Figure 4. Water use efficiency (%) Utah golf courses by region (2000 – 2003).

Significant interactions between course area and year and conservation practices and year were also observed (Table 1) and, during the study, smaller courses tended to have higher WUEs than larger courses (Figure 5). This finding may be attributed to the fact that smaller course areas allow for more careful and frequent observation of irrigation systems and irrigation system maintenance. Smaller course budgets for irrigation water may also be a factor.

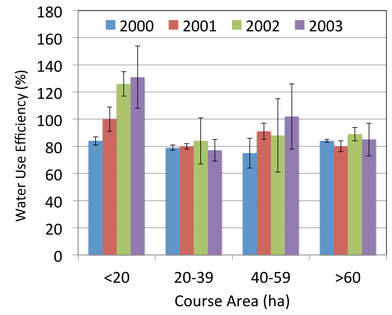

Figure 5. Water use efficiency (%) of Utah golf courses by course area (ha) (2000 – 2003).

Water conservation practices utilized by the courses included improving irrigation system maintenance practices, implementing ET-based irrigation scheduling, and reducing the overall amount of irrigated area. Of these practices, reducing the amount of irrigated area had the strongest effect on WUE, and surprisingly reduced irrigated area correlated to reduced course WUE (data not shown).

Conclusions

From 2000 to 2003, average golf course WUEs in Utah were 81, 85, 94, and 94%, respectively. These are excellent levels of efficiency for sprinkler irrigation systems and indicate that under watering of some areas likely occurred. In comparison, during the same time period, USU Extension's Slow the Flow™ irrigation auditing program found average residential WUEs of 50%, indicating that homeowners typically applied twice as much water as their landscapes required. The perception of golf courses as "water-wasters" in the state is incorrect based on the results of this study.

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