Water–Use Efficiency and Carbon Sequestration Influenced by Turfgrass Species and Management Practices

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Objectives:

1. *Estimate carbon balance of golf course carbon flux and soil carbon pools.*
2. *Determine associations between water use efficiency and carbon dynamics within turfgrass system.*
3. *Identify effects of reduced water and nutrient inputs.*

Our study addresses a need for improved data and understanding of turfgrass carbon dynamics especially under reduced inputs of water. In meeting this need we have conducted experimental varietal trials under optimum and reduced water conditions for two years at the University of California Riverside campus. We have expanded upon these findings through the installation of six new environmental sensor systems to continually measure carbon and water fluxes in turfgrass. Together these studies are providing new data describing turfgrass carbon dynamics for a large number of varieties and environmental conditions. We have found high rates of carbon fluxes and large stores of carbon in turfgrass systems. Water use efficiency is highly variable and depends on plant characteristics, timing of irrigation, amount of irrigation, seasonality, and recent weather conditions. While reducing water caused reduced visual appeal, it also led to some improvements in carbon uptake and varying effects on water use efficiency. Our results confirmed that warm–season turfgrasses are the most appropriate species for water conservation in regions where they are adapted.

In our experimental studies we examined annual dynamics of seven cool–season and six warm–season turfgrass species and various cultivars of each in a field experiment, surveys of turf in common land management, regional patterns along a strong coastal to inland gradient, and high resolution sensing and modeling to describe physiological responses to drying and wetting events. Carbon fixation was measured and calculated as gross ecosystem production (GEP) along with WUE using an open–path infrared gas analyzer.

Figure 1. Optimal and deficit irrigation experiments designed to determine associations between water use efficiency and carbon dynamics within turfgrass system.

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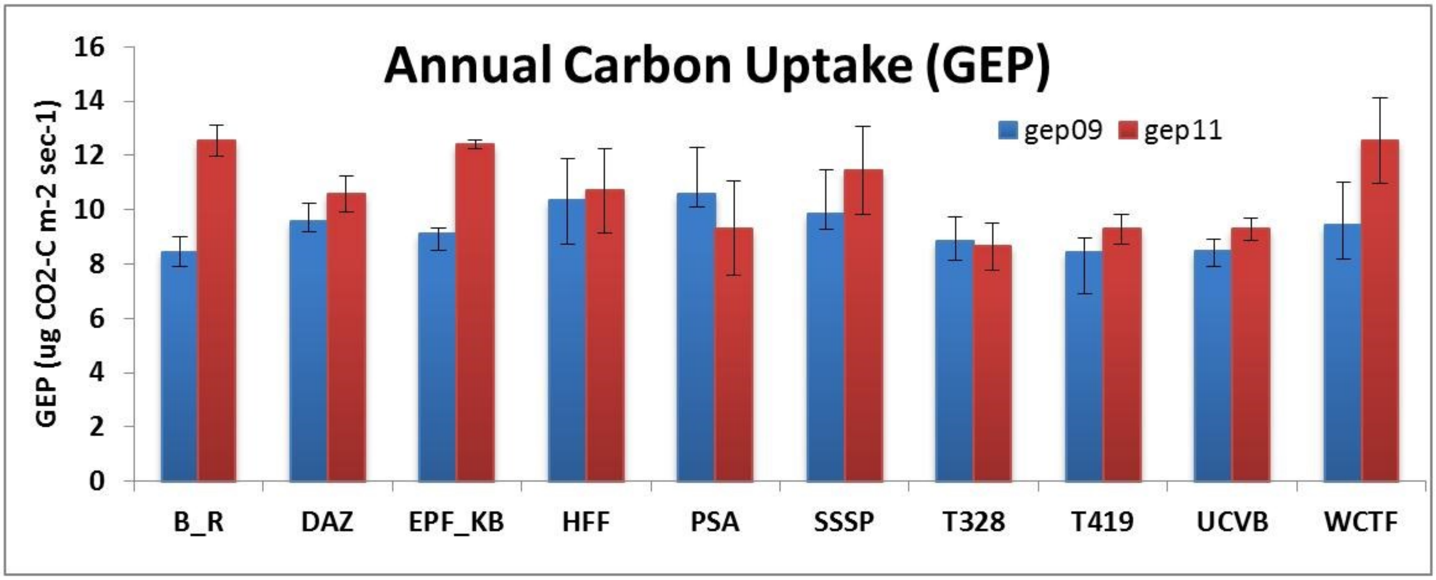
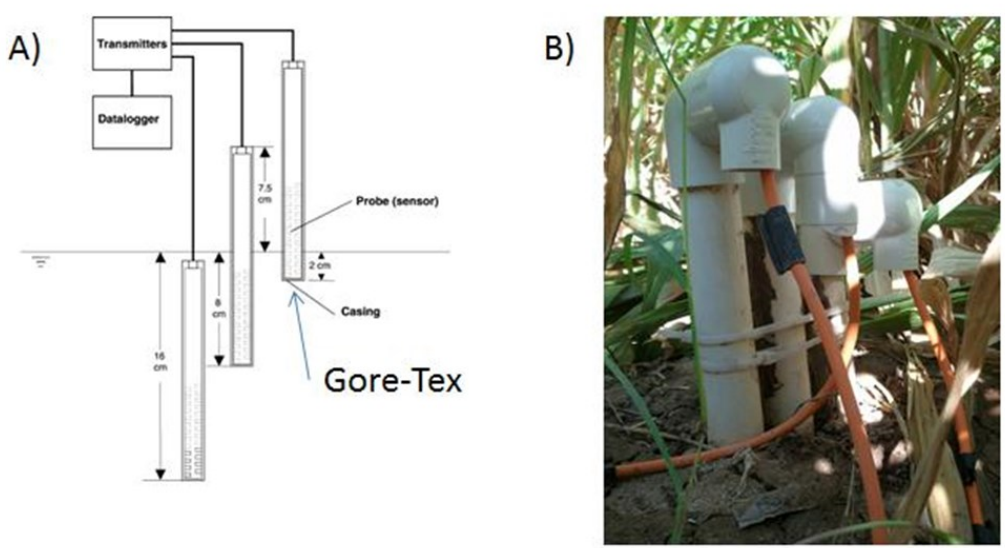
Figure 2. Differences in carbon uptake, Gross Ecosystem Production (GEP) between optimal watering (2009) and deficit irrigation (2011).



When grouped, GEP was significantly higher during recovery under deficit irrigation ($p<0.0001$) for cool-season compared to warm-season turfgrasses, indicating that cool-season photosynthesis is labile and warm-season photosynthesis is stable during recovery. Overall, WUE for warm-season grasses was higher than cool-season grasses ($p<0.0001$). However, species did not differ in WUE during recovery between optimal and deficit irrigation, suggesting that WUE is conserved when water is limited.

We expanded our study to a regional sampling of turf soils from golf courses through collection across a climate gradient extending from moderate coastal to desert inland. We have installed environmental sensors in golf courses located in Westwood neighborhood of Los Angeles, Riverside, and Palm Springs, CA and in turfgrass research plots in Irvine, Riverside, and El Centro, CA. Instrumentation at each site includes continuous measurements at a 5 minute resolution of local weather and most critically soil CO2 fluxes. These fluxes have a critical role of carbon sequestration rates we are currently acquiring data across all seasons. In addition to these sensors, we have also installed eddy covariance towers that are measuring total carbon and water fluxes at the three research sites. These above ground sensors will provide information on both plant and soil dynamics and will continuously provide measurements of water use efficiency. The new sensors systems have only begun acquiring data, but already differences between sites are evident.

Figure 3: Soil respiration CO_2 flux instrumentation system. The system features fast response CO_2 concentration sensors buried at three depths in conjunction with soil temperature and moisture measurements. A) system schematic (from Tang et al. 2004). B) aboveground portion of sensor system deployed at test facility.



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Summary Points

- Deficit irrigation reduces maximum water use efficiency across all turfgrass species.
- Species varied significantly in sensitivity to deficit irrigation.
- Total photosynthesis increased following irrigation events – such measurements may help improve irrigation frequency plans.
- New instrumentation systems have been deployed and are measuring soil and whole ecosystem CO2 fluxes across a network of golf courses in southern California from mild coastal to extreme inland environments.

Figure 5: Whole field eddy covariance systems for measuring water and CO_2 installed above turfgrass. Three turfgrass sites were established in 2013.

Figure 4: One month of continuous data from soil CO_2 flux system located on a golf course in Riverside, CA. Data are currently being collected with using standardized instrumentation systems at three golf courses and three additional turfgrass sites.