Final Report: Segway X2 Traffic Study (2007)

Doug Karcher & John Sorochan
University of Arkansas University of Tennessee

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Introduction: Regular traffic on golf course turf will decrease turfgrass quality over time, particularly in areas used to enter and exit the fairway. The Segway X2 is a specialized model that is a possible alternative to traditional golf carts. Our hypothesis is that the Segway X2 does not cause significant wear compared to traditional golf carts.

Objective: To compare turfgrass wear caused by standard golf cart traffic to Segway X2 and GT traffic.

Methods: ***Experimental area.*** The proposed study was conducted on two sites maintained as golf course fairways in Knoxville, TN and Fayetteville, AR. The experimental areas were 15 ft. long plots of established 'Tifway' bermudagrass (the most commonly used golf course fairway species in the southern U.S.). Plots were mown three times per week at a 0.5 in. height.

Treatments. A standard Club Car® golf cart or a Segway® unit was used to traffic turf plots two days per week. On days when traffic was applied, either 30 or 60 passes were made with each vehicle. A traffic pass consisted of either the golf cart or Segway pulling onto the plot and stopping at a fixed point, then starting rapidly and finally turning sharply at another fixed point to exit the plot. Traffic treatments were discontinued when significant wear damage was present on the experimental area. Each treatment was replicated four times.

Evaluations. The following evaluations were made on each plot at each fixed start/stop and turning point: 1) bi-weekly digital imagery to precisely quantify percent green turf cover, average turf color, and quality, 2) surface hardness using a Clegg Impact Soil Tester three times throughout the study, and 3) bi-weekly visual quality ratings using a 1 to 9 scale with 9 representing no visual wear and 1 representing no turf cover.

Data analysis. For each evaluation, a repeated measures two-way analysis of variance was computed to determine if the effects of the vehicle (Segway vs. golf cart), traffic type (turn vs. start/stop), and their interaction were significant ($P < 0.05$). When effects were significant, treatment means were separated using Fisher's Protected Least Significant Difference test (alpha = 0.05).

Results:

Percent Green Cover. Green turf coverage was significantly affected by vehicle type, traffic type, and evaluation date. In addition there were significant vehicle x date and traffic type x date interactions.

The vehicle x date interaction is summarized in Figure 1. In Arkansas, the golf cart treatment resulted in significantly lower turf coverage than the Segway treatments on all but the initial evaluation date and the 9 July evaluation date. No traffic had been applied on the initial evaluation date, so no differences were expected. Between 9 July and the previous traffic application, weather conditions were ideal for recovery (hot temperatures and judicious rainfall). However, wet soil conditions during the next treatment date resulted in substantial differences in turf coverage on the 13 July evaluation date. These results suggest that the Segway vehicles cause much less damage to turf when soil conditions are relatively wet.

On average turning traffic resulted in significantly lower turf coverage than start/stop traffic, regardless of vehicle type. On average, turn traffic had 4% lower turf coverage than start/stop traffic.

In Tennessee, the golf cart treatment resulted in significantly lower turf coverage than the Segway treatments on all but the initial two evaluation dates. No differences between Segway treatments occurred. These results suggest that the Segway vehicles cause much less damage to turf when than a golf cart.

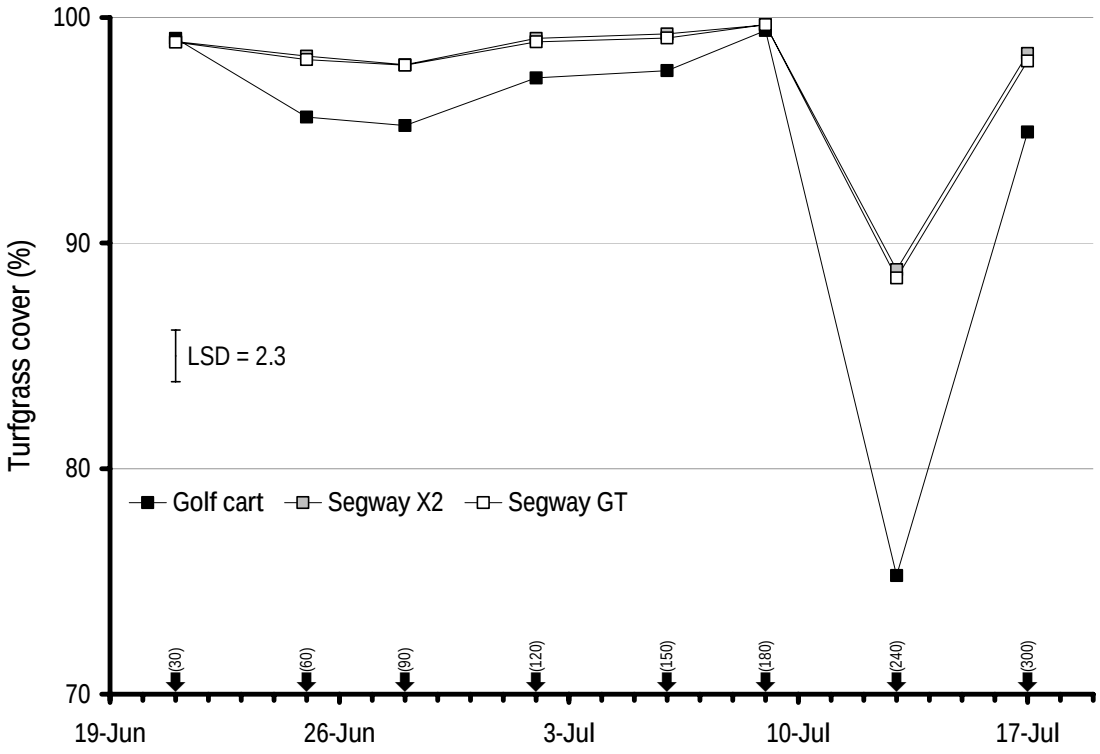

Fig 1A.

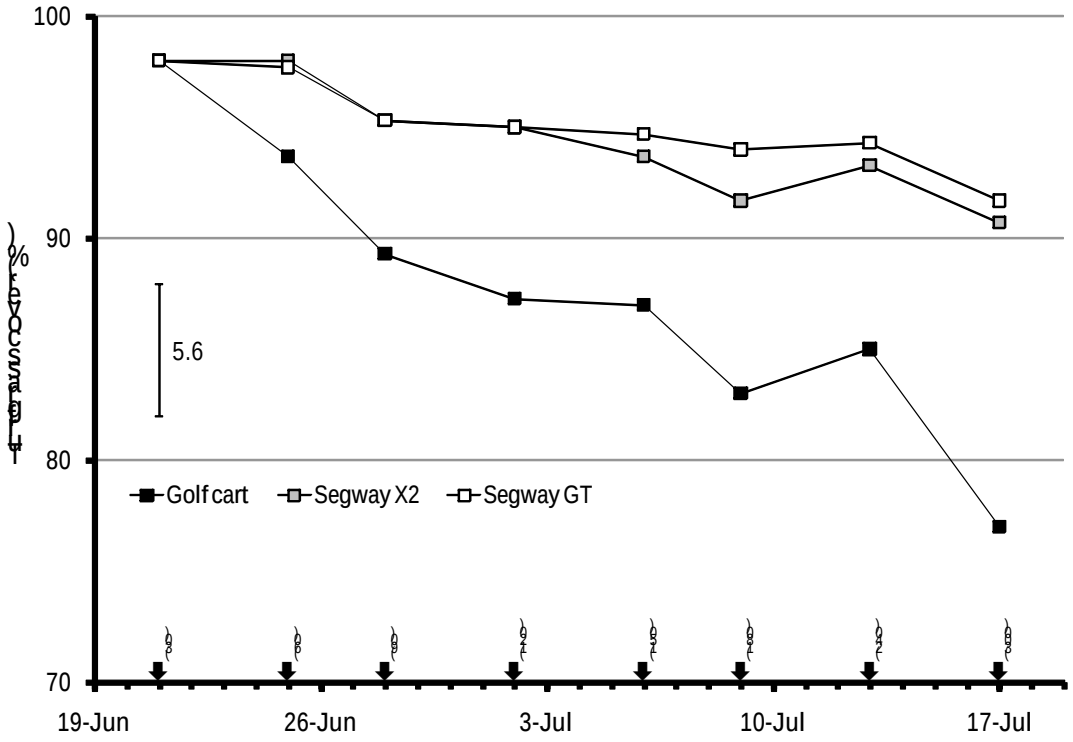

Fig. 1B.

Figure 1. Percent green turf cover as affected by vehicle type and evaluation date. Arrows along the x-axis indicate dates of traffic application and cumulative number of passes applied. 1A. Fayetteville, AR. & 1B. Knoxville, TN

Turf color. The average turf color was significantly affected by vehicle type, traffic type and evaluation date. In addition there were significant vehicle x date and traffic type x date interactions. Figure 2 illustrates the average color for each vehicle on each evaluation date. On average the turf became darker green during the first two weeks of the study due to a fertilizer application just prior to the beginning of the study and judicious rainfall. However from 6 July through 12 July, turf green color decreased due to increasing traffic stress. Turf color was lowest on the 12 July evaluation date. Each Segway vehicle had significantly more desirable green color than the golf cart treatment on 6 of the 8 evaluation dates. In addition, turning traffic resulted in significantly less desirable green turf color compared to start/stop traffic, regardless of vehicle type.

	21 June	25 June	28 June	2 July	6 July	9 July	12 July	17 July
Golf cart	A	B	B	B	B	B	B	B
Segway GT	A	A	A	AB	A	A	A	A
Segway X2	A	A	A	A	A	AB	A	A

Figure 2. Average turf color as affected by vehicle and evaluation date. Within evaluation dates, treatments not sharing letter have significant different ideal green color values (ideal green color decreases from "A"). Fayetteville, AR.

Surface hardness. Treatment effects that were significant with regard to surface hardness in Fayetteville and Knoxville were vehicle x date and traffic type.

For both locations, surface hardness was not affected by vehicle type during the first two evaluation dates, corresponding to 2.5 weeks and 150 traffic passes. However, at the end of the study, following 4 weeks and 300 passes of traffic, vehicle type significantly affected surface hardness. At that time the golf cart treatment had a significantly harder surface than either Segway treatment. Increasing the number of traffic events from 30 to 60 resulted in a more rapid increase in surfaces hardness, regardless of location.

In Arkansas, when averaged over vehicle types and evaluation dates, start/stop traffic resulted in a harder surface compared to turning traffic (Gmax values of 59 and 54, respectively).

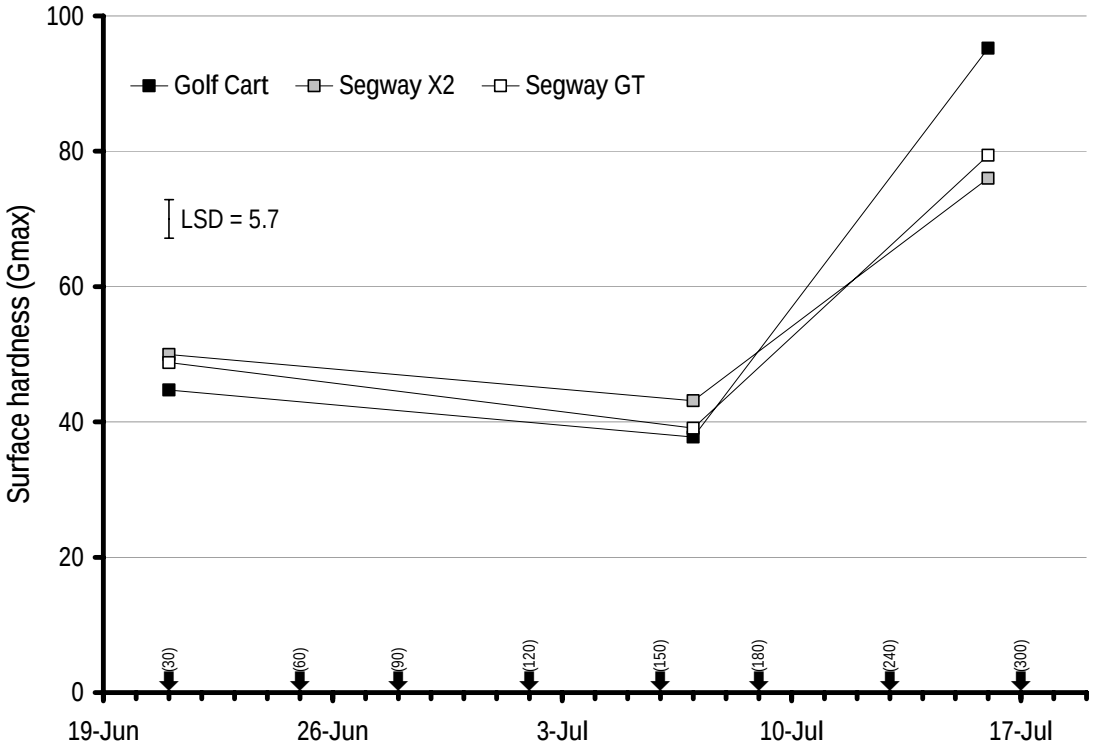

Fig. 3A.

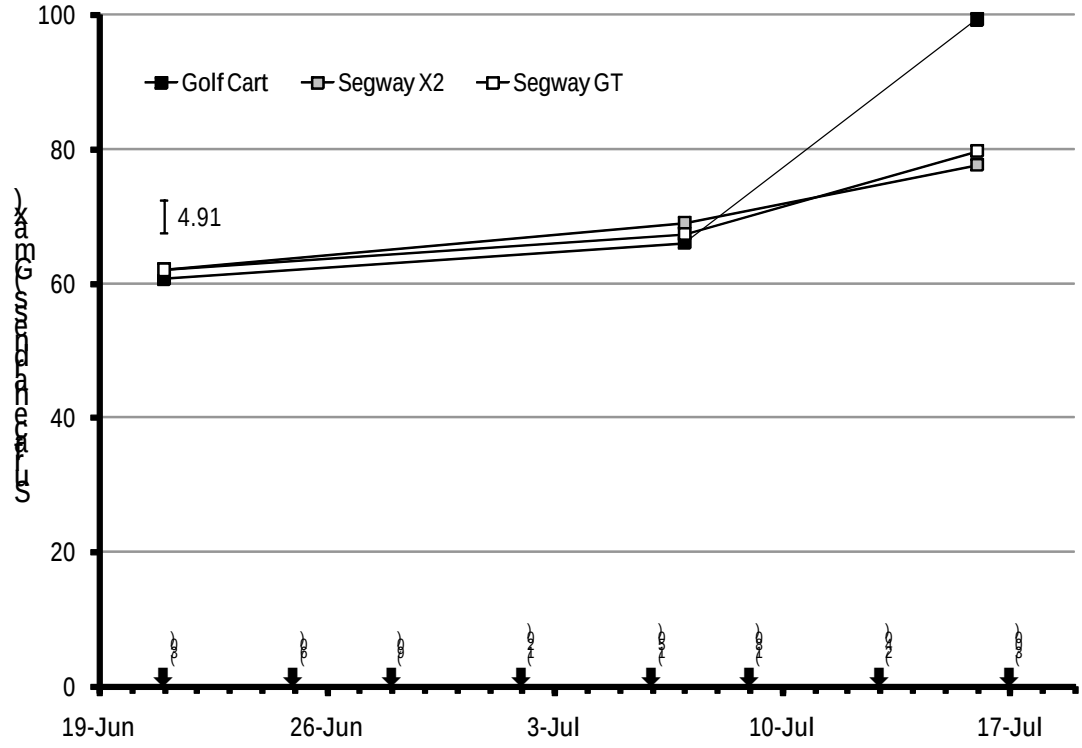

Fig. 3B.

Figure 3. Vehicle x date effect on surface hardness in 3A. Fayetteville, AR and 3B. Knoxville, TN. Within each main effect, bars not sharing a letter are significantly different. Arrows along the x-axis indicate dates of traffic application and cumulative number of passes applied.

Turf quality. There was as significant vehicle x traffic x date interaction with regard to turf quality in Fayetteville. At the beginning of study there were no significant difference in quality among treatments; however, once traffic applications began there were quality differences among treatments on all subsequent evaluation dates.

As the study quality generally decreased with increasing number of traffic passes with the exception of start/stop traffic with the Segway vehicles. Throughout most of the study, the golf cart plots had the lowest quality. There were no consistent differences in turf quality between the two Segway models; however, at the conclusion of the trial turf treated with the X2 had higher quality than the GT where start / stop traffic was applied.

In Tennessee, as traffic increased turfgrass quality for all traffic treatments gradually decreased. Both traffic types for the golf cart traffic had significantly lower quality levels than the two Segway models and their respective traffic type (start/stop and turning traffic). No significant differences for turfgrass quality occurred between the Segway models; however, July 2nd and 5th the turning traffic for both the X2 and GT was significantly less than the start/stop traffic.

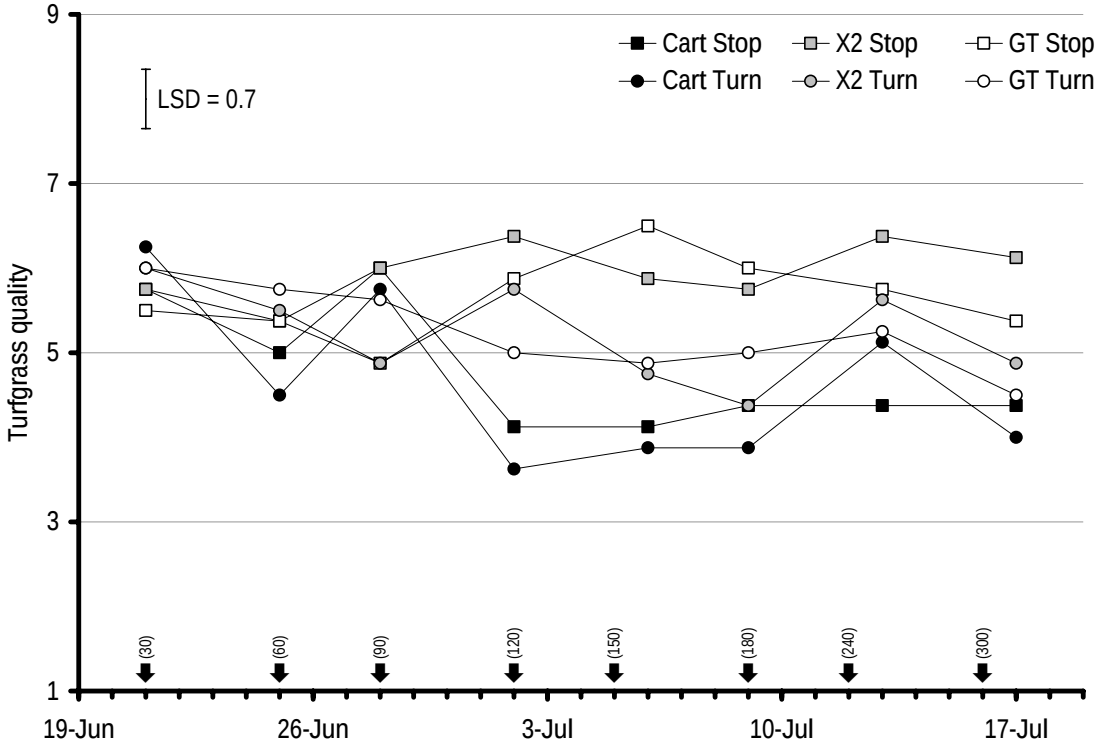

Fig. 4A.

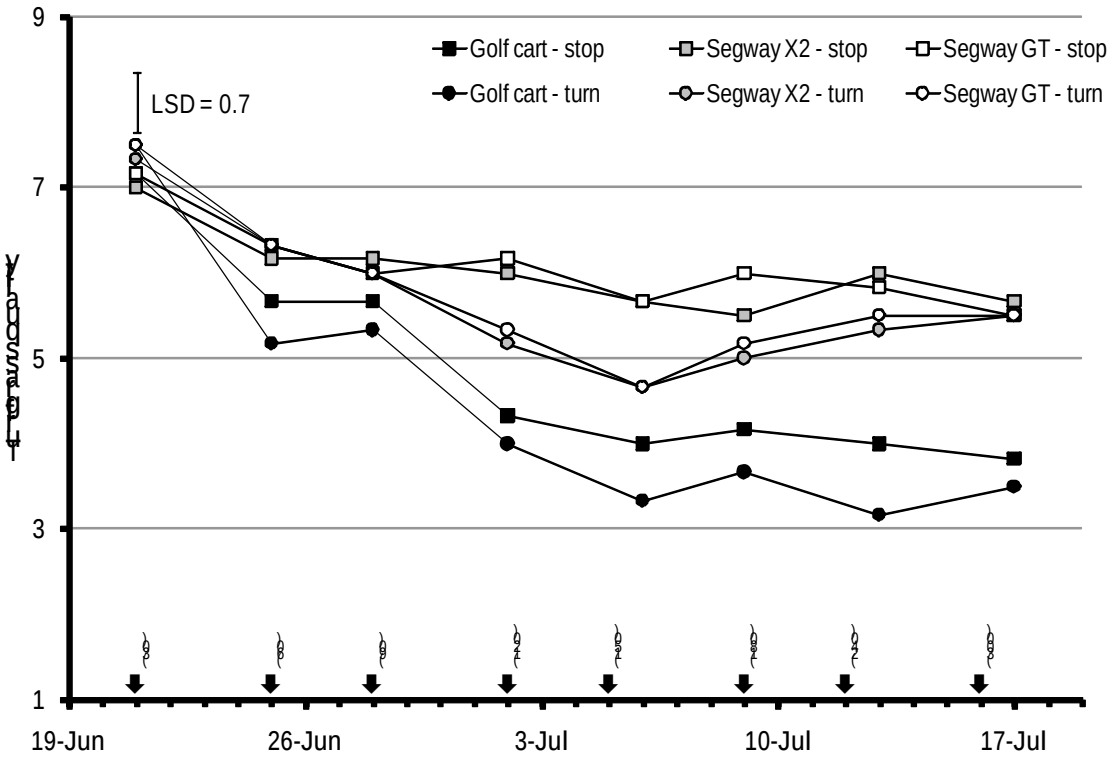

Figure 4. Visual turf as affected by vehicle and traffic type. Arrows along the x-axis indicate dates of traffic application. 4A. Fayetteville, AR & 4B. Knoxville, TN.

Conclusion. Results from the study determined that both the Segway X2 and Segway GT do less damage to the turfgrass than a traditional golf cart. No significant differences between the two Segway models were noticed; thus, both would be considered ideal for golf course use compared to a golf cart with respect to turfgrass wear damage.