

# Final Report: Segway GT Traffic Study (2005)

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**Note: This report has been amended to retain its publishing integrity. The full report is anticipated to be published in Spring 2006.**

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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<sup>®</sup> is a new personal transportation unit that is a possible replacement, or partner, to traditional golf carts. Our hypothesis was that the Segway<sup>®</sup> does not cause the significant wear associated with traditional golf carts.

**Objective:** To compare turfgrass wear caused by standard golf cart traffic versus Segway<sup>®</sup> traffic.

**Methods:** ***Experimental area.*** The proposed study was conducted on two sites maintained as golf course fairways. Site one was in Knoxville, TN. Site two was in 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<sup>®</sup> golf cart or a Segway<sup>®</sup> unit was used to traffic turf plots two days per week. On days when traffic was applied, 30, 60, or 90 passes were made with each vehicle. A traffic pass consisted of the golf cart or the Segway<sup>®</sup> pulling onto the plot and stopping at a fixed point, then starting rapidly and then 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, three times in Knoxville and four times in Fayetteville.

***Evaluations.*** The following evaluations were made on each plot at each fixed start/stop and turning point: 1) weekly visual or digital imagery to precisely quantify percent green turf cover, average turf color, and quality, 2) surface hardness using a Clegg Impact Soil Tester at the conclusion of the study, and 3) 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 of 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.*** There were significant vehicle and vehicle x traffic type interaction effects beginning at seven days after initial traffic treatments at the 90 passes rate and continuing throughout the duration of the study. In addition, there was a significant traffic type effect on 18 August. Vehicle x traffic type means are shown in Figure 1 below.

Turf trafficked with the Segway® in Fayetteville, AR maintained greater than 92% coverage throughout the study, whereas golf cart traffic reduced turf coverage below 76% by the end of the study. Turf trafficked in Knoxville, TN began with only 90% cover. At the conclusion of the study, Segway® start/stop traffic (82%) was significantly better than the start/stop golf cart traffic (73%). In addition, Segway® turning traffic (57%) was significantly better than the golf cart turning traffic (8%).

In Fayetteville, AR there were no significant differences in turf coverage between stop/go and turning traffic throughout the study for turf that was trafficked with the Segway®. In contrast, turf that was trafficked with the golf cart had significantly less green cover at the turning point (68%) compared to the start/stop point (75%) by the 9 September evaluation date.

In Knoxville, TN there were significant difference in turf coverage between traffic types on all five dates rated after traffic treatments were initiated. After 90 traffic passes, golf cart turning traffic had significantly less turfgrass cover (65%) than all other traffic types (82% – 90%). Unlike Fayetteville, AR, turning traffic type for both the golf cart and Segway® resulted in less turf cover. Start/stop golf traffic resulted in significantly less turf cover than Segway® start/stop traffic.

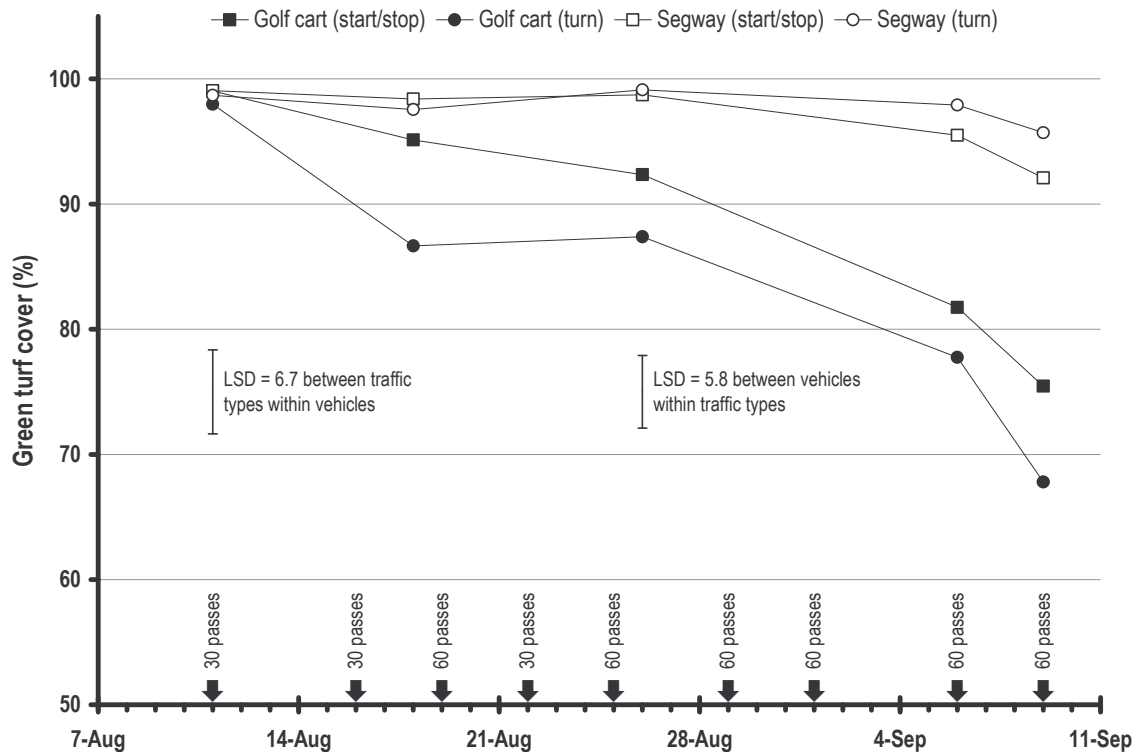


Figure 1. Percent green cover as affected by vehicle and traffic type. Arrows along the x-axis indicate dates of traffic application. Fayetteville, AR.

**Turf color.** There were significant vehicle and vehicle x traffic interaction effects on dark green color on all evaluation dates except 11 August. In addition, there was a significant traffic type effect on the 18 August and 9 September evaluations dates.

From 18 August through the end of the study, turf trafficked with the Segway® had significantly darker green color than turf trafficked with the golf cart.

On the final two color evaluation dates, turf at the turning point had significantly darker green color than the start/stop point when trafficked with the Segway®; however traffic type did not effect green color on these evaluation dates for golf cart traffic. In contrast, on 18 August turf trafficked with the golf cart had darker green color at the start/stop point compared to the turning point. Traffic type did not affect green color with the Segway® on 18 August.

**Surface hardness.** Following five weeks of traffic, for both locations, there were significant main effects of vehicle and traffic type on surface hardness.

When averaged across traffic types, turf trafficked with the golf cart had an average Gmax value of 117 & 97 (Fayetteville, AR & Knoxville, TN), whereas turf treated with the Segway® had an average value of 91 & 81 (Fayetteville, AR & Knoxville, TN).

When averaged across vehicles, start/stop traffic resulted in an average Gmax value of 113 & 94 (Fayetteville, AR & Knoxville, TN), which was significantly higher than turning traffic (95 & 84 (Fayetteville, AR & Knoxville, TN)).

**Turf quality.** For both locations, there were significant vehicle and vehicle x traffic interaction effects on all five evaluation dates throughout the study. In addition, there was a significant traffic type effect on the 12 August and 2 September evaluations dates in Fayetteville, AR and all dates in Knoxville, TN.

Throughout the study, turf trafficked with the Segway® had significantly higher average quality rating scores (5.6 & 6.4 (Fayetteville, AR & Knoxville, TN)) than turf trafficked with the golf cart (3.9 & 5.0 (Fayetteville, AR & Knoxville, TN)).

Throughout the study, start/stop traffic with had significantly higher average quality rating scores (5.1 & 6.6 (Fayetteville, AR & Knoxville, TN)) than turning traffic (4.4 & 4.8 (Fayetteville, AR & Knoxville, TN)).

In Fayetteville, AR, there were no significant differences in visual turf quality between traffic types throughout the study for turf that was trafficked with the Segway®. In contrast, turf that was trafficked with the golf cart had significantly lower average quality ratings at the turning point than the start/stop point on the 12 and 19 August, and 2 September evaluation dates. In Knoxville, TN, significant differences in visual turf quality occurred between golf cart turning and golf cart stop/go traffic.

**Conclusions:** Prior to traffic treatments, the bermudagrass at the Knoxville, TN location had lower green cover (less dense, 90%) than the Fayetteville, AR location (100%). As a result, turfgrass cover and quality ratings were much lower at the Knoxville, TN site. In addition, 120 passes were applied during the first two days of testing in Knoxville, TN versus 30 in Fayetteville, AR this resulted in more rapid decline in turf cover and quality in Knoxville, TN. However, regardless of location, golf cart traffic significantly decreased turfgrass cover and quality versus Segway® traffic. Golf cart traffic also increased surface harness (soil compaction) at both locations.