Carbon Footprint and Agronomic Practices to Reduce Carbon Footprint of Golf Courses

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Start Date: 2012
Project Duration: 3 years
Total Funding: $75,000

Turfgrass and Environmental Research Online
Volume 14, Number 1 | January—February 2015

Objectives:

1. *To evaluate fuel and electricity uses associated with golf course maintenance activities (electricity used for irrigation, fuel and energy used for mowing, spraying, and aeration, vehicle and golf cart uses); and b) fuel and electricity use associated with clubhouse operations.*
2. *To measure trace gas fluxes on golf course fairways, roughs, native areas, and putting greens.*
3. *To evaluate the impact of different types of fertilizers on trace gas fluxes.*
4. *To determine the carbon sequestration rates for golf course native areas, roughs, fairways, and greens by computer modeling.*
5. *To identify agronomic practices that will increase carbon sequestration, reduce carbon foot print, and minimize greenhouse gas emissions using calibrated and validated CENTURY and DAYCENT models as a management support system.*

Research has been conducted at Colorado State University and with the GRACEnet (Greenhouse Gas Reduction through Agricultural Carbon Enhancement Network) program of USDA-ARS to evaluate golf course carbon footprint. The project consists of 5 objectives as stated above.

To address Objective 1, a survey was conducted to evaluate fuel, electricity, and natural gas uses associated with 22 clubhouse and golf course operations in Colorado for over 3 years. Golf courses reported electricity and natural gas use from clubhouse and maintenance facilities, electricity for irrigation, and fuel usage. Management and land use information regarding fertilization rates per managed section of turf, annual irrigation water use, and hectares of alternative land use types such as native areas or wetlands were also provided. To calculate carbon footprint, CO_2 source contributions from fuels, electricity, natural gas, and fertilizers were converted to carbon dioxide equivalents (CO_2e) by using conversion factors from published journals and government websites. Soil N_2O emission was based on the emission factor suggested by the International Panel for Climate Change. Soil carbon sequestration from greens, tees, and fairways was estimated based on our previous results. Carbon sequestration from native, urban forest, and wetland was based on published data from this region.

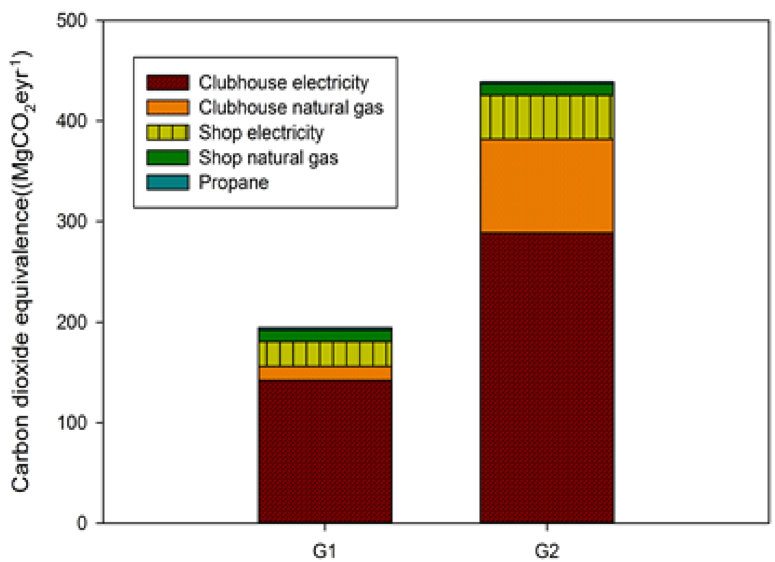

Figure 1. Clubhouse and maintenance shop energy uses in metric ton of carbon dioxide equivalents (CO_2e) per golf course.

The results showed that electricity consumed at clubhouses (including electrical charge for golf carts) and electricity used for pumping irrigation water were the major sources of CO_2e emissions from Colorado golf courses, with natural gas and fuel use making up other important CO_2e emission sources (Figures 1 and 2). This is true for both statistical groups of courses (G1 and G2) which differed in emission sizes. Soil organic sequestration from fairway and rough together with other alternative land use types such as native and forests areas were important sinks that offset approximately 38-44 % of total CO_2e emissions from golf courses. This study suggested that: 1) increasing energy use efficiency at clubhouses and irrigation pumping systems, 2) using best turfgrass management practices, and 3) increasing areas that have low inputs costs such as forests or native areas will con-

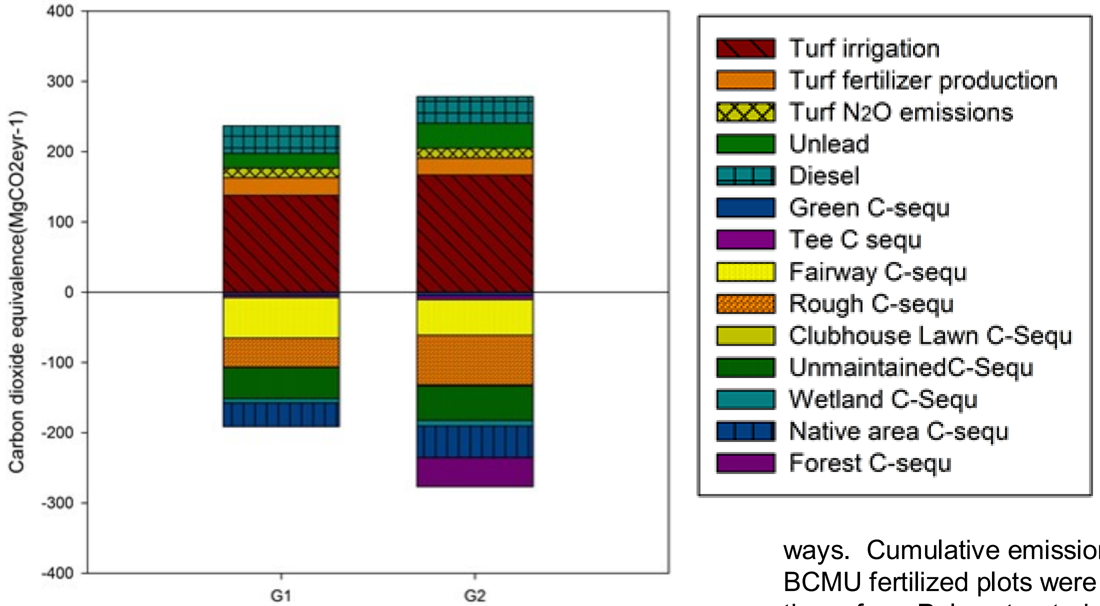

Figure 2. Carbon dioxide equivalents of golf courses. Positive numbers represent emissions from golf course land management. Negative numbers represent carbon sequestrations (C sequ) from the various land use types of golf courses studied.

tribute to mitigating CO_2e emission from golf courses.

To address Objectives 2 and 3, graduate student, Katrina Gillette has measured N_2O and CH_3 fluxes. Cumulative annual N_2O emission from the fairway site was significantly higher than the rough site. N_2O emissions from the putting green and native sites were only about 10% of the emissions from fairways. Cumulative emissions from UMaxx and BCMU fertilized plots were significantly greater than those from Polyon treated plots (Figure 3). This study clearly showed that Polyon-coated fertilizer can reduce N_2O emission from cool-season turf during summer when soil conditions are warm and wet, favoring denitrification. Applying UMaxx and BCMU materials when soil is cool and dry was effective in mitigating N_2O losses from fairways. Our study also revealed that highly managed turfgrass exhibited reduced soil oxidation of methane.

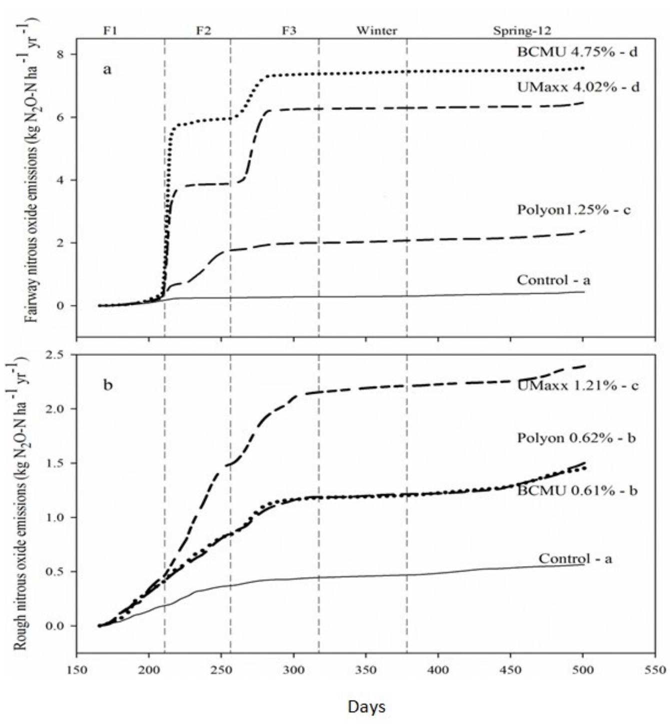

Figure 3. Cumulative nitrous oxide (N_2O-N) emissions reported in kilograms (kg) of nitrogen (N) per hectare per year from the fairway (plot a) and rough (plot b) for three fertilizer treatments, UMaxx, BCMU, Polyon, and one control (zero fertilizer) treatment. The F1, F2, F3 fertilizer applications, and winter and spring correspond to five measurement times during the year-long study. Letters indicate significant differences (P<0.05) between treatments, and percentages indicate losses of total N applied for the season. Percent loss of total N applied is relative to the difference of emissions from the control. The X axis is in day of year (DOY).

Summary Points:

- The objectives were addressed using a multifaceted approach that included survey, ecosystem modelling, and a two-year field study measuring trace gas fluxes from a golf course using different fertilizers.
- Energy consumption from clubhouse and maintenance facilities and irrigation pumping stations were the largest sources of emissions, therefore increasing energy efficiency may significantly reduce annual emissions from golf courses;
- Soil organic sequestrations of golf courses offset approximately 38-44 % of total CO2e emissions from the golf courses studied.
- N_2O emissions were greatest from the fairway site.
- Compared with BCMU and UMAXX fertilizers, POLYON with advanced coated technology had the lowest loss of N_2O.
- Highly managed turfgrass exhibited reduced soil oxidation of methane.