Turf's Carbon Footprint:
What Size Is It?

By VAN CLINE, Ph.D.
The Toro Company

There is a growing public discussion about the environmental footprint of urban landscapes, particularly maintained turf including golf courses, sports fields, home lawns and city parks. Water use, chemical use and now greenhouse gas emissions are all being scrutinized. Much of this discussion has been sparked by careless interpretations of scientific research by the popular media. Research continues to show that efficiently managed turf grass is an environmental asset in all respects including a net sequesterer of carbon.

This article is a commentary on turf's "carbon footprint" based on a research paper published on Jan. 22, 2010, in Geophysical Research Letters, a scientific journal of the American Geophysical Union. The paper titled, "Carbon sequestration and greenhouse gas emissions in urban turf" was authored by two postdoctoral researchers in the Dept. of Earth System Science at the University of California Irvine. The paper which attempted to quantify the carbon balance of maintained turf contained an unfortunate math error that skewed the author's conclusions and resulted in misleading stories released to the public through a number of media outlets characterizing maintained turf as a detriment to the environment.

First, some background in the science of carbon flux in turfgrass systems. Turfgrass plants capture carbon dioxide (CO2) from the atmosphere and convert it to carbohydrates and ultimately to plant tissue through the process of photosynthesis. As plant tissues die and are decomposed by micro-organisms a portion of the carbon tied up in the tissue is stored or "sequestered" in the soil as stable soil organic carbon (SOC). As a result, soil becomes a "sink" for carbon derived from plant tissue that originated as atmospheric CO2. This is a good thing. At the same time, however, greenhouse gases (GHG) including CO2 and nitrous oxide (N2O) are emitted to the atmosphere in the process of maintaining turf. Mowers and other equipment burn gas and diesel releasing CO2. Electricity used in turf irrigation results in CO2 emissions during its production in coal or petroleum-fired power plants. When fertilizers are applied to turf, a certain amount of the nitrogen is converted by natural microbial processes into N2O which is lost to the atmosphere. N2O is a powerful greenhouse gas. Turf maintenance as a result is a source of greenhouse gases. The question then is whether the amount of carbon sequestered by the turf system and stored in the soil exceeds the CO2 and N2O emitted back into the atmosphere during routine maintenance.

UC Irvine Study Objective

The objective of the UC Irvine study was to quantify greenhouse gas (GHG) contributions from turf maintenance based on city parks in Irvine, CA, in order to calculate a net "global warming potential" (GWP) balance between soil carbon sequestered and GHG's emitted in turf maintenance.

Study Background

1. The study was based on turf maintenance practices for city parks in Irvine, CA.
2. General park turf and sports field turf were considered separately.
3. Soil organic carbon and N2O emissions were measured onsite from four parks built at different times between 1975 and 2006, and within a 4.4 mile radius. These two factors were the only data collected directly by the scientists.
4. CO2 produced in electricity generation for irrigation pumping was estimated using previously published data from agricultural irrigation research. Specific water use rates and irrigation practices for turf in Irvine parks were not considered.
5. CO2 from fuel consumed in turf maintenance was calculated from data given to the scientists by the Irvine park maintenance contractor. Fuel used was reported as a monthly average

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only and was not broken down by maintenance activity. The scientists assumed that all fuel was used for turf maintenance. Their calculations were based on total park acreage, not turf acreage.

6. Fertilizer application rates were considered at two extremes specified by the City of Irvine: 2 lb. N/1000ft2/yr and 15 lb. N/1000ft2/yr. The assumption was that the 2 lb. rate was used on general park turf, and the 15 lb. rate on sports fields.

7. CO2 produced in fertilizer manufacturing was estimated using previously published data and was calculated for the 2 lb. and 15 lb. fertilizer rates.

Original Study Conclusions:

1. General park turf sequestered carbon over time based on a linear trend in soil carbon data from the four Irvine parks of different ages.

2. No carbon was sequestered in sports field soils based on what the scientists concluded to be a lack of a trend in soil carbon data.

3. CO2 emissions from fuel combustion dominated turf's net contribution to GWP according to the scientists original calculations.

4. N2O emissions were influenced strongly by fertilizer application rates (2 lb. N and 15 lb. N).

5. CO2 emissions from fertilizer manufacturing represented a significant GHG contribution.

6. CO2 emissions from electricity generation for irrigation pumping also represented a significant GHG contribution.

Analysis & Critique by Toro:

1. Based on Toro fuel use research the study's reported fuel contribution to GWP appeared to be very high. Recalculating the study's results using the data presented in the paper revealed a 12X error (conversion error from month to annual) in the study's results which was acknowledged by the authors. (The authors have submitted a correction to Geophysical Research Letters for publication.) Toro calculations indicated a 92% reduction in CO2 emissions from fuel combustion. This correction alone indicated a significant net sequestration of carbon in general park turf. *(see Figure 1)*

2. We recalculated fuel use based on Toro research data, which more accurately represented actual fuel use for turf maintenance, and a turf acreage estimate of 60% of total park area which reduced the CO2 emission estimate for fuel use an additional 11%.

3. CO2 emissions in electricity generation for irrigation pumping were recalculated based on turf water use reflecting ET for Irvine's climate during the study period, and energy calculations reflecting basic pumping physics which resulted in a 24% reduction in the CO2 emissions estimate for irrigation.

4. Based on the SOC data presented in the study for sports turf, we concluded that there was an apparent trend in carbon sequestered over time even though the trend was less predictable than for general park turf. We estimated the carbon sequestered in sports field soils in this study to be approximately half that in general turf soils. Specific data for an accurate calculation was not available in the paper, however.

5. The 15 lb. N/1000ft2/yr fertilizer rate was unreasonably high. The turfgrass extension specialists at the University of

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Figure 1:
Carbon sequestered vs. GHG's emitted in park turf maintenance in Irvine, CA

Townsend-Small, A. and C.I. Czimczik. 2010. Carbon sequestration and greenhouse gas emissions in urban turf. Geophysical Research Letters, vol. 37.
UC Irvine Dept. of Earth Systems Science

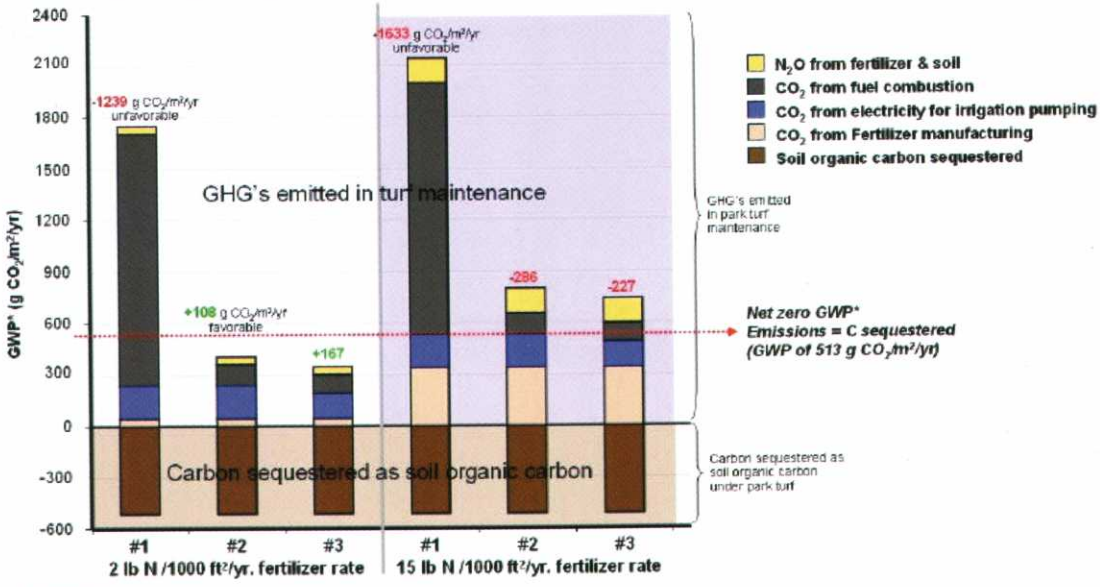

Figure 1:

#1 Original UC Irvine calculations with fuel error
#2 UC Irvine calculations with only fuel corrected
#3 Calculations with fuel use adjusted based on Toro data, and electricity use for irrigation adjusted based on Irvine ET

* Global Warming Potential (GWP) is expressed as grams of CO_2 equivalent emitted or sequestered per square meter of turf per year

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California Riverside recommend 4 lb. N/1000ft2/yr for both cool and warm season lawn and park turfs. We, therefore, calculated CO2 and N2O emission impacts using 4, 6 and 8 lb. N/1000ft2/yr in addition to the 2 lb. N rate to elucidate net GWP results at different fertilizer rates. Using the SOC value for general park turf the net zero GWP would occur at 6-8 lb N/1000ft2/yr. (see Figure 2)

Figure 2:
Carbon sequestered vs. GHG's emitted at different fertilizer rates in park turf maintenance in Irvine, CA

Townsend-Small, A. and C.I. Czimczik. 2010. Carbon sequestration and greenhouse gas emissions in urban turf. Geophysical Research Letters, vol. 37.
UC Irvine Dept. of Earth Systems Science

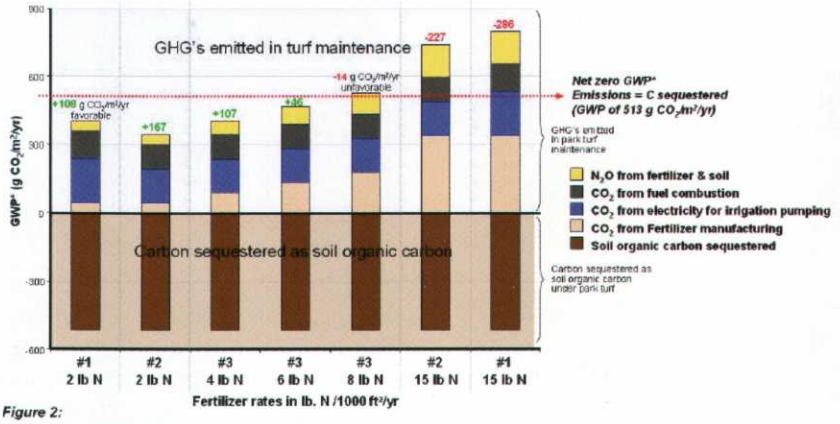

Figure 2:
#1 UC Irvine calculations with only fuel corrected
#2 UC Irvine calculations with fuel use adjusted based on Toro data, and electricity use for irrigation adjusted based on Irvine ET
#3 Calculations with fuel use adjusted based on Toro data, and electricity use for irrigation adjusted based on Irvine ET at additional fertilizer rates
* Global Warming Potential (GWP) is expressed as grams of CO_2 equivalent emitted or sequestered per square meter of turf per year

Lessons from this experience

The authors and the University continue to stand by the conclusion that turf is an "unlikely" sink for GHG's based on their range of results for management using 2 lb. N/1000ft2/yr and 15 lb. N/1000ft2/yr. At 2 lb. N their corrected results show a significant net sink or benefit. At 15 lb. N the results show turf to be a large emitter. Their study did not examine controlled applications of fertilizers. They simply used the range given to them by the City of Irvine. But, because of the results for 15 lb. N/1000ft2/yr, they concluded that it is "unlikely" that turf can be a net sequesterer of carbon because of the emissions produced at this high rate. The flaw in their logic of course is that 15 lb. of nitrogen for that climate is an irresponsible use of fertilizer! No one experienced in turf management would promote the use of 15 lb. of nitrogen. Again, the turfgrass extension specialists at UC Riverside recommend the application of 4 lb. N/1000ft2/yr for both cool and warm season lawn and park turfs. The published conclusion that it is "unlikely" that turf is a net sink for carbon is based on an unreasonable assumption for nitrogen fertilization. There are two important lessons here: first, turf managed responsibly is a net sequesterer of carbon; second, researchers lacking expertise in a specific discipline should learn about the subject being studied and should validate their assumptions with experts before publishing broad conclusions.

It is worth noting that the UC Irvine scientists apparently had limited background in research related to cropping systems including turf, and that the journal, Geophysical Research Letters, does not normally publish research in this area. Not only did the authors miss the fuel error, but the journal reviewers failed to question the extent of the fuel contribution to emissions as well. They also failed to question the appropriateness of the 15 lb. N/1000ft2/yr. fertilizer application rate, and failed to recognize the need for more specific water use rates for turf in Irvine, CA. This raises a question about expertise. Scientists better versed in agronomics publishing in a journal focused on agricultural or horticultural topics would have produced a different outcome.

This study illustrates the danger in translating results from research conducted under a specific set of conditions and in a specific climate to all situations in all climates. In the case of this study, we would all expect that results in Minnesota or Florida would likely differ from results in Irvine, CA. The turf system is complex. The authors may not have intended their conclusions to be generalized, but without being specific in their communications with the media they were.

There is also a lesson in the use of generalized assumptions to make specific calculations. The UC Irvine study only measured soil organic carbon and nitrous oxide evolution. Calculations of emissions from fuel use for mowing, electricity use in irrigation and fertilizer manufacturing which make up the bulk of the GHG emissions were based on previously published information or general estimates in the case of fuel and fertilizer use. Based on our knowledge of turf management, the water and fuel inputs were overstated in the study. "Information out" is only as good as "information in." When drawing important conclusions it is important to know that your data is as good as it can be. Studies like this should measure actual inputs under best management practices if the objective is to measure carbon sequestration potential.

An issue that requires serious discussion as the industry clarifies turf's carbon footprint is what emission costs can or should logically be assigned to turf management on a specific site. In other words, how far down the production chain should the environmental impact be counted in the calculation of a footprint? In this study, CO2 resulting from fertilizer manufacturing was included. Should it be? If the answer is yes, then should CO2 from manufacturing the turf maintenance equipment be included? If that answer is yes, should CO2 from mining the iron ore to produce the steel to manufacture the equipment be included? Should the CO2 from mining the coal to produce the electricity to pump the irrigation water be included? The point is that fair boundaries need to be established in assigning greenhouse gas emission costs whether it's turf management or any other commercial endeavor.

Turfgrass' carbon footprint is an emerging issue that warrants serious research. There are many biological

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Musing the Minutes

By MATT McKINNON
MGCSA Secretary

The MGCSA Board met at Golden Valley Golf and Country Club on March 9, 2010.

Treasurer Paul Eckholm, CGCS, reported that projections for this year are on track. The Board needs to look at committee budgets and report any changes for the year at the next meeting.

There also was some discussion if we should send out the *Hole Notes* publication electronically and possibly reduce it down to six times per year. MGCSA board will need to survey the membership before anything could possibly be done.

Scott Turtinen reported that the Hospitality night in San Diego made $1,000 profit this year. The March Mega Seminar made $4,300 but there are some travel expenses that still have to be paid. The March Mega Seminar had 78 attendees on Wednesday and 98 on Thursday. Fifty-eight people signed up for both days. MGCSA dues are coming in. We have received 416 paid Superintendents and 186 have not paid. Affiliates have 88 paid and 44 have not. MGCSA has received $2,600 from the dues for Research.

Eric Counselman and Jeff Ische reported that they are working on the 2011 Green Expo. For the 2011 Expo there will only be eight sessions offered where we have had more in the past. On Thursday MGCSA will have one additional session, which was not offered to the other Associations. The 2010 Green Expo was down 20% from the eight-year average. MGCSA was down 6% from the eight-year average, and the Vendors were down 12% from the average.

Paul Diegnau, CGCS and Jeff Ische reported that Dave Oberle is the new Vice President of the MTGF and Brian Horgan is the Secretary. Since Kathy Aro is no longer with MTGF, Turtinen Communications, Inc. will take on some administrative responsibilities. MNLA will also take on some responsibilities.

Scottie Hines, CGCS reported that the MGCSA would continue to advertise for the Turf Tourney. Since we have started advertising for this event participation has increased. Since attendance was down at the Expo the MTGF has less money to give out. The Research Committee recommended that the MGCSA donate $25,000 to the TROE Center and the TROE Center may need some more help before the year is over.

I hope everyone's spring has gotten off to a good start. As I look outside on March 15th it has been a few years since we have had almost zero snow cover in Brainerd.

- Respectfully Submitted,
Matt McKinnon, Secretary

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components (plants and soils) as well as management components that are not well understood. Further research is needed in several areas including:

- The potential for sequestration is influenced by soil conditions, climate, turf species, management practices and turf use. The influence of these factors on carbon dynamics needs to be sorted out. A range of locations across the U.S. should be studied to understand the influence of geography on carbon dynamics in turf management as well.
- Methodologies that accurately measure resource inputs and gases emitted in management need to be refined to deter the use of borrowed and unrepresentative estimates.
- Machine choices and management practices that influence fuel consumption must be studied and improved.
- Ultimately research must define best management practices for specific climate and soil conditions, turf species and uses that maximize carbon sequestered for the most efficient use of irrigation, nutrients, chemicals and fuels.

Turfgrass is an important component of our landscape. It is an environmental asset at many levels. Life without turf for sports, relaxation, environmental cleansing and stabilization is hard to imagine. Our responsibility is to make turfgrass the strongest contributor to environmental quality and sustainability that it can be. We have momentum. We need to keep pushing.