CORNELL UNIVERSITY TURFGRASS TIMES

CUTT

2008 Issue 2 • Volume 19 • Number 2

Can a Golf Course be Carbon Neutral? A Preliminary Assessment

Green house gases (GHG) are in the news and pressure is mounting in Congress to pass legislation to regulate GHG emissions. The Washington Post reported on March 10th that the Senate would vote on legislation in June that will set restrictions and ultimately cap US emissions of GHG. The legislation is expected to impose a cap-and-trade system similar to systems in other world markets where carbon offsets or emissions certificates must be purchased for any carbon emissions over an established cap. Many banks and other investors are scrambling to invest in carbon offsets as legislation is expected to boost the price of U.S. credits from \$2 to \$5 per ton of carbon to \$30 to \$50 a ton.

Clearly, major utility and industrial firms will fall within the scope of any regulations. How far will the mandates reach? What are the consequences if golf courses, sports fields, and public parks would be required to assess and control GHG emissions? Turf management has increasingly improved environmental stewardship through improvements in water quality protection, reduction in water use, and increased efficiencies in fertilizer and pesticide use. How does a golf course figure into the GHG discussion?

A project was undertaken by students enrolled in the Advanced Turfgrass Science Class at Cornell University to establish the carbon budget for the operation of a golf course in a northeast climate. The course was considered to be an average course from the GCSAA Environmental Profile Research with total golf course property of 150 acres with 100 acres or managed turf to calculate the energy or Carbon Equivalents (CE) for management factors including mowing, fertilization, pest control, and irrigation. (Table 1.)

Several months were spent to review available literature to establish the relative contribution of a golf course to carbon sequestration. Would a golf course be a better sink for atmospheric CO_2 than a parcel under agricultural management, a typical urban lot, or a forest system? In particular, is a woodlot a better carbon sink than turf? If so, can a golf course offset its carbon use by increasing the density of trees and total wooded area or simply pass along the cost of carbon offsets to the golfer through green or membership fees?

In the final summation, can a golf course be carbon neutral? How does the operation of the course affect the carbon balance? In our example we are using data generated from the Bethpage State Park Green Course that has been managed experimentally for eight years. This study has compared traditional management relying primarily on synthetic fertilizer and pesticides

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This Times

Proudly sponsored by the New York State Turfgrass Association.

CUTT, "CORNELL UNIVERSITY TURFGRASS TIMES" is published four times per year by the Turfgrass Science Program at Cornell University, Ithaca, New York 14853. Address correspondence to: CORNELL UNIVERSITY TURFGRASS TIMES, 20 Plant Science Building, Cornell University, Ithaca, NY 14853; phone: (607) 255-1629; email: fsr3@cornell.edu.

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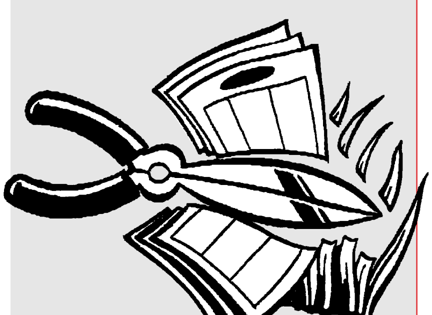
Design & Production: NYS Turfgrass Assn. Latham, NY

Clippings

With support from Senator Catharine Young, the 2008-2009 New York State Budget includes a $175,000 line item for the Turfgrass Environmental Stewardship Fund.



NYSTA Board Visits Geneva

The New York State Turfgrass Association Board of Directors met on Monday, March 17, at Cornell University's New York State Agricultural Experiment Station (NYSAES) in Geneva, New York. They had the opportunity to conduct their regular board meeting, hear presentations on NYSTA-funded projects, and tour the facilities.

Daniel C. Peck, Ph.D., Assistant Professor of Soil Insect Ecology and Turfgrass Entomology, presents an overview of the turfgrass research facility to the NYSTA Board during their March 17 meeting at the New York State Agricultural Experiment Station in Geneva.

Professor Daniel Peck presented updates on the work taking place in the Entomology Department. He was awarded a three-year (2006-2008) New York Turfgrass Foundation research grant for his project, "Alerting and Arming the Northeast against European Crane Flies, New Invasive Pests of Turfgrass." In addition, he received an Environmental Stewardship Fund Grant for his project, "Prospecting for Resistance to the Annual Bluegrass Weevil in Improved Cultivars of Poa annua."

NYSTA President, Owen Regan, said, "The NYSTA Board had the opportunity to hear dynamic presentations by the representatives from Horticultural Sciences, Plant Pathology, Entomology and Food Science and Technology departments. We are proud to be able to support the work being conducted by the New York State Agricultural Experiment Station and are committed to promoting awareness of the accomplishments taking place in Geneva."

In a quote published in the Station News, the campus newsletter of the New York State Agricultural Experiment Station, Dr. Thomas Burr said, "It was a great pleasure to host the New York State Turfgrass Association Board in Geneva. Our faculty in Entomology and IPM are recognized nationally for excellence in turf research and extension and this visit provided them an opportunity to show the Board our facilities and discuss important projects. The visit also allowed the Board to hear from faculty and staff about other research and extension programs that impact other segments of the agriculture and food industries of New York."

From left to right: NYSTA Executive Board members: Robert Sanderson - Secretary/Treasurer; Greg Chorvas - Vice President; Owen Regan – President; Dr. Thomas J. Burr - Station Director; Michael Maffei, CGCS, - Past President; and Dr. Jan Nyrop - Senior Associate Dean of the College of Agriculture and Life Sciences.

Environmental Stewardship Fund

With support from Senator Catharine Young, the 2008-2009 New York State Budget includes a $175,000 line item for the Turfgrass Environmental Stewardship Fund. This Fund makes research grants available that promote best management practices. These include studies that assist turf professionals in managing turf pests, invasive species and diseases using environmentally sound methods. A special thanks to Senator Young.

Fungicide Synergism Revisited

The management of fungal diseases is a primary concern for many turfgrass managers. For many years, conventional wisdom - mostly from data generated at Virginia Tech by the late Professor Houston Couch - suggested that low rates of fungicide could be tank mixed to produce a synergistic effect. (The two products work better at low rates combined than they would at the same rates applied individually.)

Experiments were designed to assess reports of synergism between propiconazole and other fungicides to control dollar spot in creeping bentgrass. In 2004 and 2006, two field experiments were conducted near Griffin, GA, and repeated near West Lafayette, IN. A third experiment was conducted at the Griffin site in 2007.

In each experiment, replicated treatments of commercial formulations of propiconazole, triadimefon, iprodione, vinclozolin, and chlorothalonil were applied to plots of creeping bentgrass at the sublabel rates of 0.12, 0.38, 0.57, 0.38, and 2.29 kg a.i. ha-1, respectively. In addition, each of the latter four fungicides was tank mixed with propiconazole at the rates given, and applied as treatments.

No synergistic interactions were detected at Griffin or West Lafayette in experiments 1 or 2. In the first trial of experiment 3, synergism was observed between propiconazole and iprodione on one of five ratings dates and between propiconazole and vinclozolin on two of five rating dates. However, no synergistic interactions were detected in the second trial. Results suggest that there is a low probability for turfgrass managers to take advantage of fungicide synergism to control dollar spot with the products and rates tested. *From Burpee ,L. and R. Latin. 2008. Reassessment of Fungicide Synergism for Control of Dollar Spot. Plant Disease, 92(4):601-606.*

Primo Effects Disease Control

Golf course superintendents are under regular pressure to reduce the use of fungicides for disease control. One aspect of reduction is simply treating less area. The largest area treated on golf courses are the fairways and therefore any methods that could be used to reduce overall reliance on fungicides in fairways would be welcome.

Research conducted at Purdue University investigated the effects of trinexapac ethyl on the development and control of dollar spot on creeping bentgrass fairways. In most cases trinexapac ethyl did not contribute to an increase or decrease in fungicide efficacy. There was an observed reduction in recovery from heavy infestations and the researchers question the continued use of trinexapac ethyl while disease levels remain high. Since we lack consistent evidence that trinexapac ethyl contributes to improved disease control, it may be prudent to suspend such treatments to fairways until turf has fully recovered from the disease-related damage.

Given that fungicide performance is influenced by numerous interacting factors including disease pressure, chemical deposition and depletion phenomena, and fungicide sensitivity of the pathogen population, neutral results associated with a single factor should not be unexpected. *From Stewart, J. M. and R. Latin, Z. Reicher, and S. G. Hallett. 2008. Influence of Trinexapac Ethyl on the Efficacy of Chlorothalonil and Propiconazole for Control of Dollar Spot on Creeping Bentgrass. Applied Turf. Sci. http://www.plantmanagementnetwork.org/sub/ats/research/2008/dollar/*

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Scanning the Journals

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If sod farmers were able to produce a crop that required less pesticides to maintain, they would be able to increase their marketing programs and overall pesticide use could decline.

Velvet bentgrass (Agrostis canina) has been shown in several studies to require significantly less pesticides, fertilizer and water than traditional turfgrass varieties. However, few sod farms are producing velvet sod and consequently golf course superintendents are not able to use this species.

New York State IPM Funded Project: Is Velvet Bentgrass a Viable Option for Sod Farmers and Golf Courses?

Abstract

Turfgrass disease management is a significant problem and rated the greatest challenge facing the turf industry based on the 2003 New York Turfgrass Survey. If sod farmers were able to produce a crop that required less pesticides to maintain, they would be able to increase their marketing programs and overall pesticide use could decline. This project was designed to investigate the production and management of two velvet bentgrass varieties for potential as a sod and develop management practices for golf course superintendents who desire to grow velvet sod. This is the second year of a two-year study. In year one, establishment studies indicated that lower seed rates were slower to reach adequate density (>85%) than normal or above normal seed rates and SR 7200 was less susceptible to diseases such as dollar spot and take-all patch than Vesper velvet bentgrass. Management factors such as low pH (5.3 or less), nitrogen fertility less than 2.0 lbs of nitrogen per 1000 ft2, and frequent grooming and topdressing provided the most desirable stand. In year two we introduced three traffic levels to determine the effects of traffic and pH on velvet bentgrass performance. SR7200 maintained higher turfgrass quality ratings than Vesper independent of pH or traffic treatment. Both varieties seem to perform best at pH 5 and neither provided acceptable quality when traffic exceeded 20,000 rounds of golf per year. This two year study suggest some important establishment, varietal, pest management and functional aspects of velvet bentgrass that will enable sod producers to more effectively market this species to the golf turf industry.

Justification

New York is one of the most restrictive regulatory environments in the US regarding pesticide use. IPM Focus Group sessions identified environmental regulations, pesticide use, and development of new varieties less dependent on pesticides and reduction of chemical use as major threats, opportunities and changes that could make a difference to sod farmers in NY.

If sod farmers were able to produce a crop that required less pesticides to maintain they would be able to increase their marketing programs into golf courses. Golf courses spent over $17 million dollars on fungicides for turf diseases, as compared to only $4 million by homeowners in 2003. Clearly turfgrass disease management on golf courses is significant problem and rated the greatest challenge facing the golf turf industry.

Velvet bentgrass (Agrostis canina) has been shown in several studies to require significantly less pesticides, fertilizer and water than traditional turfgrass varieties. However, few sod farms are producing velvet sod and consequently golf course superintendents are not able to use this important species.

This study is designed to determine important establishment, varietal, pest management and traffic tolerance of velvet bentgrass. This improved understanding will assist sod producers in effectively marketing this important golf turf species and reduce reliance on chemical pesticides.

Objectives

The objective of this project in 2007 was to:

1. Determine influence of pH and traffic on velvet bentgrass varieties.

Procedures:

1. Determine influence of pH and traffic on velvet bentgrass varieties.

Two varieties (vesper and SR 7200)of velvet bentgrass sod (donated by DeBuck Sod Farms) were delivered and installed at the Turf Center in Ithaca, NY in July 2005. The sod was planted on an Arkport fine sandy loam, pH 6.3. Immediately following successful rooting the sod was cored every month and heavily topdressed with sand. In addition, each variety was split into three 48 square foot subplots and elemental sulfur and ammonium sulfate applied regularly to two of the three plots to reduce the pH to about 4.0 and 5.0.

Mowing was performed daily with walk behind reel mowers at 0.130" and clippings collected. The research area was maintained to championship conditions with light frequent liquid fertilization applied weekly during the season. Total nutrient rates for the season was 1.75 lbs. N, 0.15 lbs. P and 0.50 lbs. K, 2 lbs. S, 0.5 lb Mn (reduce take-all patch) per 1000 square feet, with iron sulfate to improve turfgrass color.

Golf traffic is simulated daily during the season using a modified traffic device with two 0.5 meter diameter rollers that spin at different speeds to create slipping. The rollers are fitted with SoftSpikes. The amount of spikes and passes used are designed to simulate 20,000, 40,000 or 60,000 rounds of golf per year.

Data were collected for turf quality. Data analysis was conducted using linear mixed models with compound symmetric covariance structure to assess overall treatment effects when repeated measurements were made on the same experimental unit over time. Treatment differences at individual measurement events were evaluated using analysis of variance and Fisher's protected least significant difference (LSD). The MIXED and GLM procedures in SAS/STAT software version 9.1 (SAS, Cary, NC) were used to perform the analyses.

Results

pH

The first year of the study indicated that pH of 5.4 and below provided the highest quality turf and the least amount of disease suggesting that velvet bentgrass will perform well at low pH. In addition, the improved variety SR 7200 had significantly less take-all patch at similar pH levels compared to the older variety Vesper.

In year two there were no significant disease infestations. This supports two existing research findings. First, take-all patch infestations typically subside over time especially when treated regularly with light frequent applications of MnSO4. Second, velvet bentgrass is generally resistant to most major turfgrass diseases and therefore requires significantly less pesticide input than traditional creeping bentgrass and annual bluegrass species.

Turfgrass quality was significantly reduced in year two with only one date when acceptable turfgrass quality was produced. Furthermore, there was no significant difference between velvet bentgrass varieties averaged over the pH levels. This might be a result of the aggressive acidifying program conducted in 2007 to further reduce soil pH levels. Over time, as less aggressive acidifying programs are implemented, it is likely turfgrass quality will be improved.

Traffic

There were significant main effects for velvet bentgrass cultivar and a few dates when a significant interaction between pH and traffic level existed. In general, SR7200 provided higher turf quality ratings than Vesper independent of pH and traffic level.

These data suggest that more than 20,000 rounds of golf per year reduce turfgrass quality ratings below acceptable levels. SR7200 maintained acceptable quality on three of the five rating dates while Vesper produced acceptable quality on only one of five dates.

Implications

Velvet bentgrass production is a viable niche market for sod producers, however the long-term effect of seed rate on harvest interval could not be evaluated in this study. Still, as with most sod, the longer it remains on the farm the less profitable it will be, especially with velvet bentgrass that will require more intense maintenance.

Velvet bentgrass does have significant disease resistance but obviously it is not immune to disease as evidenced by the high levels of take-all patch observed at pH above 5.4 on the Vesper variety in 2006. However, no significant disease infestation occurred on either variety in 2007.

The first year suggested that selecting the best variety in combination with pH management leads to reduction in disease and reduced fungicide use. However the second year including MnSO4 in the nutrient management program seemed to suppress further infestation of take all patch independent of pH and traffic

Table 1. Effect of soil pH on quality rating of SR 7200

pH	Turf Quality*				
	17-Jul	6-Aug	20-Aug	30-Aug	8-Sept
4.0	5.8	5.5	5.4	5.8	5.8
5.0	5.6	5.3	4.9	5.8	6.1
6.0	5.6	5.4	5.2	5.8	5.7
LSD (p=0.05)	NS	NS	N/A	NS	0.2

** Turfgrass quality rated on sacle of 1 to 9; 1=dead turf, 9=perfect turf, 6=acceptable turf*

Table 2. Effect of soil pH on quality ratings of Vesper

	17-Jul	6-Aug	20-Aug	30-Aug	8-Sept
4.0	5.2	5.2	5.1	4.5	5.1
5.0	5.5	5.3	4.6	4.7	5.7
6.0	5.5	5.4	4.8	4.8	5.3
LSD (p=0.5)	0.2	NS	N/A	0.2	N/A

** Turfgrass quality rated on sacle of 1 to 9; 1=dead turf, 9=perfect turf, 6=acceptable turf*

continued on page 6

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It appears there are important limitations to using velvet bentgrass such as traffic and nutrient management. Clearly, velvet bentgrass offers significant opportunities for reducing reliance on chemical pesticides. Further research is required to more fully elucidate successful management strategies.

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Table 3. Traffic effects on turfgrass quality of SR7200 velvet bentgrass

Traffic	**Turf Quality***				
Rounds per yr.	17-Jul	6-Aug	20-Aug	30-Aug	8-Sept
20,000	6.1	5.4	5.7	6.6	6.6
30,000	5.5	5.6	5.2	5.7	5.8
60,000	5.5	5.2	4.7	5.1	5.1
LSD (p=0.05)	0.2	NS	N/A	0.1	0.2

** Turfgrass quality rated on sacle of 1 to 9; 1=dead turf, 9=perfect turf, 6=acceptable turf*

Table 4. Traffic effects on turfgrass quality of Vesper velvet bentgrass

Traffic	**Turf Quality***				
Rounds per yr.	17-Jul	6-Aug	20-Aug	30-Aug	8-Sept
20,000	5.7	5.6	5.4	5.3	6.1
30,000	5.3	5.3	4.8	4.6	5.4
60,000	5.1	5.0	4.3	4.2	4.6
LSD (p=0.05)	0.2	0.2	N/A	0.2	N/A

** Turfgrass quality rated on sacle of 1 to 9; 1=dead turf, 9=perfect turf, 6=acceptable turf*

level. This would be a viable recommendation for sod producers to make to prospective clients.

There appears to be traffic limits that can be imposed on velvet bentgrass. Turfgrass quality was significantly reduced above 20,000 rounds per year independent of variety and pH. In fact, there were no dates when acceptable quality was achieved when traffic levels above 20,000 rounds per year.

This traffic finding is not consistent with previous research from Murphy et al. (2001) who indicated that velvet bentgrass was more traffic tolerant than other creeping bentgrass varieties and a perennial biotype of annual bluegrass. In that study, wear was separated into abrasive stress and compaction, whereas in our study we used actual golf spike traffic to impose the wear treatment.

It appears there are important limitations to using velvet bentgrass such as traffic and nutrient management. Clearly, velvet bentgrass offers significant opportunities for reducing reliance on chemical pesticides. Further research is required to more fully elucidate successful management strategies.

Frank S. Rossi, Ph.D.

New York State Turfgrass Association

Calendar of Events

2008

August 19 — **CNYGCSA Poa Annual**
Tuscarora Golf Course, Marcellus, NY

August 20 — **Sullivan County Challenge**
Grossinger Golf and Country Club, Liberty, NY

September 15 — **FLAGCS Poa Annual**
Country Club of Rochester, Rochester, NY

September 18 — **AdkGCSA Poa Annual**
TBD

September 22 — **NEGCSA Poa Annual**
Mohowk Golf Club, Schenectady, NY

September — **METGCSA Poa Annual**
TBD

2009

January 7-9 — **Empire State Green Industry Show**
Rochester Riverside Convention Center, Rochester, NY

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applied without restriction to a bio-based IPM management system choosing reduced risk pesticides and overall reduced fertilizer use.

Table 1. Average 18-hole golf course profile based on 2007 GCSAA data.	
GCSAA Survey Typical Course	**150**
Greens	3
Tees	3
Fairways & Turf Nurseries	31
Rough	51
Driving Ranges & Practice Area	7
Clubhouse Grounds	3
Acres Managed Turf	98
Forest/Woodland (38.2% of 24)	9.0

Calculating Carbon Budgets

The energy consumed for agricultural production was summarized extensively in the 1970's and 80's with an emphasis on fuel consumption. The first USDA benchmark study was immediately after the oil-price shock of 1973-74 and the oil embargo of 1973. (Dovring, 1985). The figures presented in a number of journals and reports were criticized as representing only the direct energy of operating equipment or as direct (factory) energy inputs into the production of materials. Dovring (1985) contends that many reports neglected to account for the indirect or "embodied" energy implicit in the material components particularly with regard to the manufacture of fertilizers and pesticides. While the emphasis may still be on the accounting of limited oil resourses, the focus now is also on the carbon (C) consumed and/or emitted as a greenhouse gas.

To assess the carbon inputs in golf, consideration was given to the direct energy that was expended such as the gas to operate the mowers and the electricity to power the irrigation system. The direct energy could also be obtained by totaling the fuel consumed over the year and power metered for battery charging, irrigation and shop operation.

It is not clear how legislation will assess carbon use and emissions. Therefore, all energy embodied in the fertilizers and pesticides are counted including the manufacturing inputs, direct energy, formulation, packaging and transport. There is considerable data for the embodied energy in agricultural inputs reported in the Energy in Agriculture report. (Fluck, 1992). This report is a synthesis of the available information on energy use in farm operations, and its conversion into CE units; that a principal advantage of expressing energy use in terms of carbon emission as kg CE lies in its direct relation to the rate of enrichment of atmospheric concentration of CO2. (Lal 2004). (Table 2.)

Equipment Energy

The direct energy inputs on the golf course were based on course management over an eight-month season. Greens and tees were hand-mowed; fairways were cut with lightweight five-plex mowers and the rough was cut with a 20-foot wide area mower. Calculations were made for weed trimming and rotary mowing edges around the rough once each week. A boom sprayer was used for fertilizer and pesticide applications except for a small amount of manual spreader applications. The energy input calculated from available fuel consumption statistics is shown in Table 3.

Table 2. Carbon emission coefficients, different fuel sources and the energy conversion units (Fluck, 1992) (Lal,20)	
Equivalent carbon emission (kg CE)	
Diesel	0.94
Gasoline	0.85
Oil	1.01
LPG	0.63
Natural Gas	0.85
Energy Units	
Million Calories (Mcal)	93.5 x 10
Gigajoule (GJ)	20.15
BTU	23.6 x 10
Kilowatt hour (kW h)	7.25 x 10
Horsepower	5.41 x 10

Irrigation Energy

The energy for irrigation depends on the pumps used, the distribution system, the pressure and the lift required. The 100 acres of maintained turf averaged 0.5" of water per week over the entire season (32 weeks) or a total of 47,357,012 gallons. Assuming ideal distribution and 70% pump efficiency, 1.46kWh are needed to lift 325,851 gallons of water one vertical foot. (Peacock, 1998) With 200 feet of lift from a deep well or pond, 42,437 kWh or 3.1 metric tons

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How to be smart about carbon:

#1

Use the most efficient equipment to minimize hours of operation and fuel efficient engines. Most engines are rated on gas consumption per hour on the basis of the horsepower of the engine. Check your suppliers. Wider cutting widths will have a significant impact. (Suppliers need to get on board with published data)

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How to be smart about carbon: #2

Nitrogen has the highest embodied energy of all the fertilizers and that energy varies by the form of nitrogen fertilizer. Choose carefully. All fertilizer elements, N, P and K, each have significant energy formulations as do micronutrient packages. Design a suitable fertilizer program based on your turf requirements. Anything more is costly.

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of CE per year is required to pump the needed water for the entire season.

Farm irrigation was reported as 125-285 kg ha-1yr-1. (Lal, 2004) This equates to a range of 5.5 - 12.6 t of CE for the 109-acre course. Metering the pump house will provide a more accurate number for the irrigation system.

Fertilizer and Pesticide Energy

Most fertilizers are reported as the production energy equivalent per pound or kilogram of N, P2O5, K20 and active ingredient (AI) for the pesticides. Dovring (1985) reported that many of these reports do not report all of the direct and indirect energy associated with the product manufacturing. (Dovring, 1985) The values reported vary considerably (Lal 2004).

In the absence of a standard convention, the selection of data appropriate for a turf application is difficult at best. The assessment for this study is based on weighted averages for agricultural applications. (West and Marland 2002). This data included energy of formulation into emulsifiable oils, wettable powders or granules for the pesticides. However they did not include them in the fertilizers. An additional 0.4 kg CE/kg is required for formulation. (Green, 1987). A summary of fertilizer and pesticide applications relative to carbon emission and cost comparing two management systems is shown in Table 5.

Carbon Sequestration from Turfgrass

In general, any activity that increases plant growth will increase carbon sequestration. Carbon will be stored in the biomass of the plant or within the soil matrix. Photosynthesis will convert CO2 and transfer carbohydrates to stems, branches and roots. Carbon will also be deposited on and in the soil in the form of litter; detritus and soil carbon will increase notably as soil organic material (SOM). There is a soil respiration affecting Soil Organic Carbon (SOC), which is really the respiration of microorganisms and the decomposition of biomass. Respiration is a function of temperature, water and nitrogen. (Kimble et al. 2003)

SOM and SOC will have an initial loss after tillage or disturbance. After conversion to urban use, the SOM and SOC will increase over time. The greatest increases have been observed in the most highly managed soils. For example, SOM in a golf course fairway was 1.76% one year after turfgrass planting, 3.8% after 20 years, and 4.2% after 31 years (Qian & Follet, 2002). Work by Monsieur et al (2005) and Robertson et al (2000) concluded that highly managed urban soils such as irrigated turfgrass are better than urban soils at net removal of greenhouse gases. Their calculations included net CO2, N2O and CH4 emissions associated.

Qian and Follet (2002) report that turfgrass carbon sequestration is 1 ton C ha-1yr-1. The measurements were taken in the west, an arid

Table 4. Production energy equivalent per pound or kilogram of N, P_2O_5, K_2O and active ingredient (AI) for the pesticides

N	0.86	+0.4	=1.26	Kg CE/Kg N
P_2O_5	0.17	+0.4	=1.57	Kg CE/Kg P_2O_5
K_2O	0.12	+0.4	=0.52	Kg CE/Kg K_2O
Herbicide	4.7			Kg CE Active Ingredient
Insecticide	4.9			Kg CE/Kg AI
Fungicide	5.2			Kg CE/Kg AI

Table 3. Energy input calculated from available fuel consumption statistics

Operational Carbon Input	Total Hrs/Yr Machine Operation	Gals/hr	Fuel Consumed (Gal)	Fuel Consumed (kg)	kg CE per kg fuel	Carbon Equivalent (kg CE)	Carbon Equivalent (t ce yr1)
Mowing							
Mowing Rough-Batwing	611	4.5	2748.8	9367	0.94	8805.3	8.8
Mowing Rough - Rotary	121	1.5	182.2	517	0.85	439.8	0.4
Line Trimming Rough	146	0.5	72.9	207	0.85	175.9	0.2
Mowing Fairways	903	3.8	3385.1	9613	0.85	8171.0	8.2
Mowing Greens	1032	1.5	1547.3	4394	0.85	3735.0	3.7
Mowing Tees	754	1.5	1130.3	3210	0.85	2728.3	2.7
Fertilizer & Pesticide Application							
Greens	99.0	3.8	371.3	1265	0.94	1189.2	1.2
Fairways & Tees	140.3	3.8	525.9	1792	0.94	1684.7	1.7
Total Fuel			**9963.8**			**26929.1**	**26.9**

climate that would show lower SOC and SOM. They noted that turfgrass was on par with land placed in the Conservation Reserve Program (CRP). This program was set up in the 1985 and 1990 Farm Bills to convert highly erodible land (HEL) to permanent vegetative cover. Additional information on CRP is available (Lal, et al., 1999).

Additionally, Qian (2003) further specifies contributions from various golf turf features for 12 golf courses in the Denver area and one in Wyoming. Greens were reported to sequester an average of 0.4 t C ha-1yr-1(0.99 t C ha-1yr-1) and fairways at 0.44 t C a-1yr-1 (1.09 t C ha-1yr-1). Furthermore, Qian indicates fairways constructed from previous agricultural land had 24 percent less SOM than fairways converted from grasslands.

Pouyat et al (2006), in a study of urban soils of several cities across the United States, confirmed that SOC in residential lawns are relatively high and of low variability compared to other non-wetland soil types in urban areas. The SOC of Northeastern cities is higher than other cities due to the cooler and wetter climate

Table 5. Summary of fertilizer and pesticide applications relative to carbon emission and cost comparing two management systems.

Traditional Mgmt.		**kg ce**	**t ce yr-1**	**cost**
Fertilizer	Greens	459	0.5	3,863
	Tees	494	0.5	3,958
	Fairways	2,520	2.5	13,609
	Rough	4,716	4.7	12,810
	Total	8,189	8.2	$34,240
Pesticides	Greens	482	0.5	10,407
	Tees	532	0.5	8,789
	Fairways	1,288	1.3	33,403
	Rough	211	0.2	610
	Total	2,513	2.5	$53,209
Grand total		**10,702**	**10.7**	**$87,449**
Bio-Based IPM Mgmt.		**kg ce**	**t ce yr-1**	**cost**
Fertilizer	Greens	583	0.6	7,527
	Tees	272	0.3	3,579
	Fairways	2,703	2.7	8,029
	Rough	1,415	1.4	3,843
	Total	4,973	5.0	$22,978
Pesticides	Greens	507	0.5	13,488
	Tees	318	0.3	8,340
	Fairways	1,798	1.8	39,418
	Rough	0	0.0	0
	Total	2,623	2.6	$61,246
Grand Total		**7,596**	**7.6**	**$84,224**

and the inherent SOC from pre-urban soils that were heavily forested lands.

The relevance to golf courses is that managed turf is better at carbon sequestration than other urban (suburban) developed areas. Therefore, using 0.4 t C a-1yr-1, the 109 acres of managed turf in the example for this paper will sequester 44 t C yr-1.

Carbon Sequestration from Trees

There is some controversy on the measured net contribution of agroforestry to carbon sequestration. For example, younger, faster growing trees sequester more carbon than older mature trees. The differences are partly in the measurement methods. Studies show that factors such as stand density, water availability and fertilization are significant factors. Sequestration is also a function of species and mixed stands may be better than monostands. (Kimble et al 2003)

Most studies are done on tropical forests. Watson et al, (2000) report carbon sequestration at rates of 0.2 to 3.1 t C ha-1yr-1. In a review by Pataki, annual sequestration rates identified by Nowak and Crane (2002) ranged from 0.26 x 10-9 MtCm-2 (2.6 t C ha-1yr-1) for average forest cover in Atlanta to 0.12 x 10-9 MtCm-2 (1.2 t C ha-1yr-1) cover in New York, with a median value of 0.2 x 10-9 MtCm-2 (2.0 t C ha-1yr-1) cover. (Pataki, D., et al, 2006).

At the median level 2.0 t C ha-1yr-1, trees are much better at carbon sequestration than turfgrass. Any course with a significant portion of the property as woodland, will have an advantage in their carbon balance.

Calculation Results

For the purpose of this class exercise we totaled the direct and indirect carbon energy for machine operations, irrigation, fertilizer and pesticides. For the course evaluated, a total of 40.7 t of carbon was used in a year. Fuel accounts for between 66 percent and 72 percent of the total carbon emission.

The golf course used in this exercise offset the carbon emitted between 115 and 125%. Surprisingly there is little difference between the two management systems with both systems by our calculations and our assumptions indicating the course used in our example is in fact carbon neutral and likely to a provide significant sequestration.

Discussion

The carbon assessment provides an interesting perspective for shaping the activities

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CUTT

How to be smart about carbon: #3

Based on calculation methodology, pesticides are based on the percentage of active ingredient. Use chemicals with the lowest % AI per acre for recommended effectiveness.

How to be smart about carbon: #4

Managed turf is a carbon sink. Trees are an even greater carbon sink. Native vegetation and grassland is neutral.

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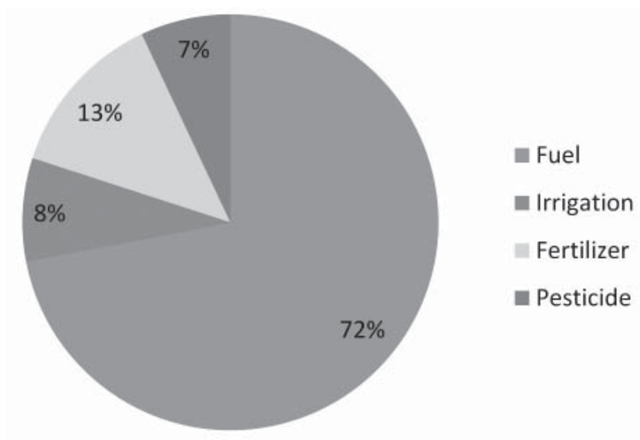
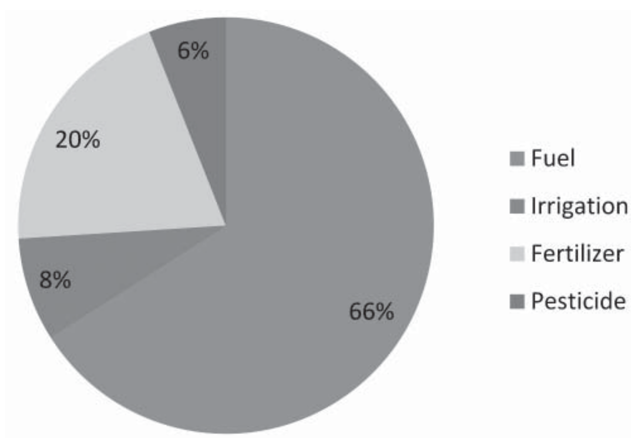
Carbon Input

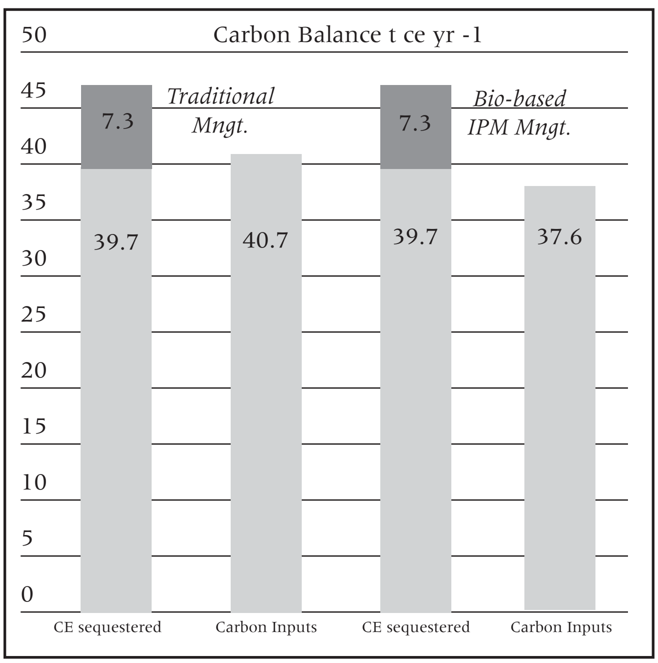
Bio-based IPM Mgmt. T ce yr-1



Carbon Input

Traditional Mgmt. t ce yr-1





and the choices made in managing a golf course in a climate sensitive world. For example, when selecting a mower, fuel-efficient equipment may be measured in hrs per gal or in terms of the gals per acre managed for that particular piece of equipment. Wide area mowers are larger pieces of equipment but can get they get the job done faster and with less overall fuel. What is the carbon efficiency?

From our calculations it appears that fuel use is the most important aspect of management. From a product perspective the bio-based IPM programs can help reduce the dosage as well as the number of applications. Alternative products can be selected to be equally effective while reducing the overall carbon input. As the industry is already selecting chemicals with lower environmental risk, selection of pesticides might also be made on a "Carbon Index". Perhaps, legislation will lead to developing such carbon indexes as part of the EPA labels so that we can make informed decisions on the proper selection of chemical inputs.

Truly there is one aspect of this work to consider: the "Carbon Footprint" that is made in operating a golf course. The greater question is on managing a golf course to minimize its Greenhouse Gas Emission.

It is imperative that we identify this issue in our work and discussions. Golf operations are significant emitters of greenhouse gases. Carbon dioxide may be the least of the GHG's. Emissions standards at SETAC included all environmental outputs to the air, the soil and the water. The largest of these is nitrous oxide. Other NOx, POx and SOx oxides are also important factors. Given the degree of fertilization and volatility of some nitrogen fertilizers, nitrous oxide may be a greater contributor to GHG.

The studies referenced in our readings have a range of values for embodied energy. All that data is outdated. There is a lack of information for modern day pesticides and there is question to the methodology that researchers used to determine their values. The chemical manufacturers have to step up and provide the information.

Robert Portmess, Nicholas Pettinati, Christopher Miller, Brett Hochstein, Thomas Condzella and Frank S. Rossi, Ph.D.

Healthy Ecosystem

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regarding the presence of toxic chemicals in the crumb rubber infill. There appear to be two primary issues; the potential for chemicals to leach out of the field and the exposure of the athletes to potential carcinogenic hydrocarbons. Leachate studies are currently focusing on zinc, sulfur, cadmium and lead being conducted at UConn. Exposure studies with toxic hydrocarbons are more substantiated claims. A 2007 CA study found cancer risks 1.2 in 10 million, well below the 1 in 1 million risk from a single one time ingestion. Another estimate from handwipes indicated that regular playground use and contact with rubber (more than would be expected on a field) created a slightly higher risk (2.9 cancers in 1 million).

Summary: Much more work is needed in these areas to better understand the risks and benefits associated with synthetic turf systems. Clearly many natural turf systems cannot sustain the same high traffic as synthetic turf, however improved natural turf management and regular re-sodding could be viable options for a comparable investment in synthetic turf.

Andrew McNitt, Penn State University
and Frank S. Rossi, Ph.D.

Sports Turf Manual Now Available

The New York State Turfgrass Association (NYSTA) is pleased to announce that a practical guide to sports turf maintenance is now available. "Sports Field Management," written by Joann Gruttadaurio, is a hands-on manual for turf professionals who manage scholas-tic and community high-use sports fields. She received a grant for the project in 2005 from the New York Turfgrass Foundation, an endowment fund established between NYSTA and Cornell University to ensure the future of the turfgrass industry. It provides valuable information on how to maintain safe sports fields to maximize player safety and performance. This educational guidebook is a culmination of Gruttadaurio's 33 plus years experience as a former Senior Extension Associate at Cornell University. It includes information on routine maintenance practices, management programs, turf challenges and decisions, frequently asked questions, and sport turf management resources. In addition, a useful sports field assessment sheet is provided with a rating system to help sports turf professionals decide if they should continue current management prac-tices or reassess their management programs. Illustrations, photos and tables provide clear and concise information on best management practices for sports field maintenance. "Sports Field Management" can be purchased for $15 plus shipping and handling: http://www.nysta.org/sportsmanual/orderinfo.html. Orders of two or more qualify for the discounted rate of $10 each. It is also available at no cost for sports turf professionals who are members of the New York State Turfgrass Association. For more information, contact NYSTA at (518) 783-1229.

NYSTA President, Owen Regan (left) and Sports Field Managment author Joann Gruttadaurio

CUTT

Healthy Ecosystem

Much more work is needed in these areas to better understand the risks and benefits associated with synthetic turf systems. Clearly many natural turf systems cannot sustain the high traffic as synthetic turf, however improved natural turf management and regular re-sodding could be viable options for a comparable investment in synthetic turf.

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Healthy Ecosystem

A study conducted by the Center for Disease Control showed that although the synthetic infill does not harbor MRSA, the greater number of turf burns due to the abrasive nature of the surface and combined with poor personal and wound hygiene as well as chronic misuse of anti-biotics has lead to increased incidence.

Environmental Aspects of Synthetic Turf

As an example of the growing popularity of synthetic turf, in NYC alone there are 4000 parks that currently have replaced asphalt with synthetic turf at 35 locations. Over the years the original single pile "carpet-like" Astro-Turf gave way to the in-filled system with long polyfilament fibers that are filled with various amounts of rubber and sometimes sand. The combination of the rubber infill and the padded backing underneath the field provide the resiliency. More recently, the infill industry is moving to the monofilament fibers that appear to have more durability, possibly increasing the lifespan of the system. There is little question that infill synthetic turf has revolutionized the industry, allowing for substantial increases in field use without (at least to date) significant increases in head and neck injury (a common indicator of player injury). With more than 3500 of these fields now installed in the US some questions are beginning to be raised regarding the use of synthetic turf; surface temperature, injury surveillance, MRSA Methicillin-resistant Staphylococcus aureus (a penicillin-resistant strain of Staph), and potential health hazards of the crumb rubber infill.

Surface Temperature: Temperature monitoring studies have found surface temperatures of synthetic infill systems to be as high as 160F on a 78 F day, while an adjacent grass field was 85F. There is some medical evidence that suggests temps above 122 F can cause skin injuries. Some have suggested irrigation as a means of reducing surface temperatures however studies have shown that while there might be an initial reduction of 10-15 degrees it does not last more than 45-60 minutes. Also measurements from Iowa State University suggest that relative humidity levels are as important as temperature measures.

Injuries: A 2007 study published in the British Journal of Sports Medicine indicated there were no differences in incidence, severity, or cause of injuries in soccer teams who played on grass versus infilled systems. A 2004 study likely looking at single pile carpet turf indicated 10% more injury compared to natural grass, yet head and neck injuries were greater on natural turf. The NCAA maintains an injury surveillance program that explores the risk of playing surfaces and monitors injuries.

MRSA: There has been an increase in concern over the spread of MRSA (a bacterium responsible for difficult-to-treat infections in humans) and some have associated it with synthetic infill systems. A study conducted by the Center for Disease Control showed that although the synthetic infill does not harbor MRSA, the greater number of turf burns due to the abrasive nature of the surface and combined with poor personal and wound hygiene as well as chronic misuse of anti-biotics has lead to increased incidence. The recommendation then would be to be sure to treat abrasions as any other wound with topical disinfectants. There does not appear to be a need for regular disinfecting of field surfaces however granular Tide and Snuggles fabric softeners (8 gallons per field) can provide some benefit.

Crumb Rubber Chemicals: There has been significant concern expressed in the last year

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