It is well known from experimental research that grasses such as tall fescue and perennial ryegrass will produce a lot more biomass, about 40% more aboveground and 80% more root mass, over the course of a growing season under elevated carbon dioxide. The challenges for turf applications will be that it's not only turfgrasses that respond positively to extra carbon dioxide, weed species will too. The question is: "will grasses or weeds benefit more from the extra carbon dioxide?" We don't know the answer to that question with any degree of certainty. One exception is probably that leguminous weeds (like clover and black medic) that are able to fix atmospheric nitrogen, will probably be more competitive than they are now, compared to turfgrasses.

As plants fix more carbon from increased photosynthesis, they become even more nitrogen limited, and legumes have the ability to overcome that limitation themselves. Management implications of these kind of changes might mean, all other things being equal, that turfgrass will require more frequent mowing to maintain height, and might need heavier or more frequent applications of nitrogen fertilizer to compete with leguminous weeds.

So weeds might, or might not, be a bigger problem in the future. However there are opportunities as well. In crop agriculture, researchers are looking at selecting cultivars that can make better use of the extra carbon dioxide in the atmosphere. Turf

Table 1: Carbon costs accrued by maintaining whole golf courses in central Ohio, USA.

Product Use	Carbon Costs Per Year (kg Carbon or Carbon Equivalents)
Diesel fuel	6,557
Gasoline	3,618
Nitrogen fertilizer	1,498
Fungicides	1,377
Irrigation	626
Insecticides	353
Herbicides	206
Potassium fertilizer	138
Phosphorous fertilizer	96
All sources	**14,469**

Source: Selhorst & Lal (2012) Carbon Sequestration in Golf Course Turfgrass Systems and Recommendation for the Enhancement of Climate Change Mitigation Potential. In: Lal & Augustin (eds.) ***Carbon Sequestration in Urban Ecosystems***. Springer. DOI: 10.1007/978-94-007-2366-5_23.


Elevated carbon dioxide experiment on tall fescue plants conducted at the University of Guelph. (Photo: J. Newman)

researchers too might like to explore this trait as a target of selection as well. In crop production selecting for increased biomass or yield in the presence of elevated carbon dioxide makes sense. For turf applications, this choice is less clear-cut. On the one hand, one might select for enhanced growth because it would increase the turf's ability to recover from the damage common in many applications. On the other hand, one might want to select for slower growth in the presence of higher concentrations of carbon dioxide, so as to keep maintenance costs low, particularly mowing costs.

We have been talking about how to adapt our management to cope with climate change; the flip side of adaptation is called "mitigation" and it deals with how we can change our management practices to reduce our impact on climate change. There are two aspects of turf management that impact mitigation: increasing carbon sequestration and decreasing carbon emissions. Carbon sequestration refers primarily to how much carbon gets stored in the soils of various ecosystems. Turf applications affect sequestration primarily through land use. Turf applications occupy a relatively small amount of land compared to other types of land use. For example, in Ontario, crop agriculture occupies more than 20 times the land area occupied by turf. Hence turf will tend to have a small impact, positively or negatively, on carbon sequestration. Nevertheless, turf applications can have a positive impact on carbon sequestration by converting depleted agricultural soils, which hold very little carbon, into turf dominated soils which can, relatively speaking, hold large quantities of carbon.

PERHAPS THE LARGER IMPACT THAT TURF SYSTEMS CAN HAVE IN MITIGATING CLIMATE CHANGE IS IN THE "CARBON COSTS OF MAINTENANCE".

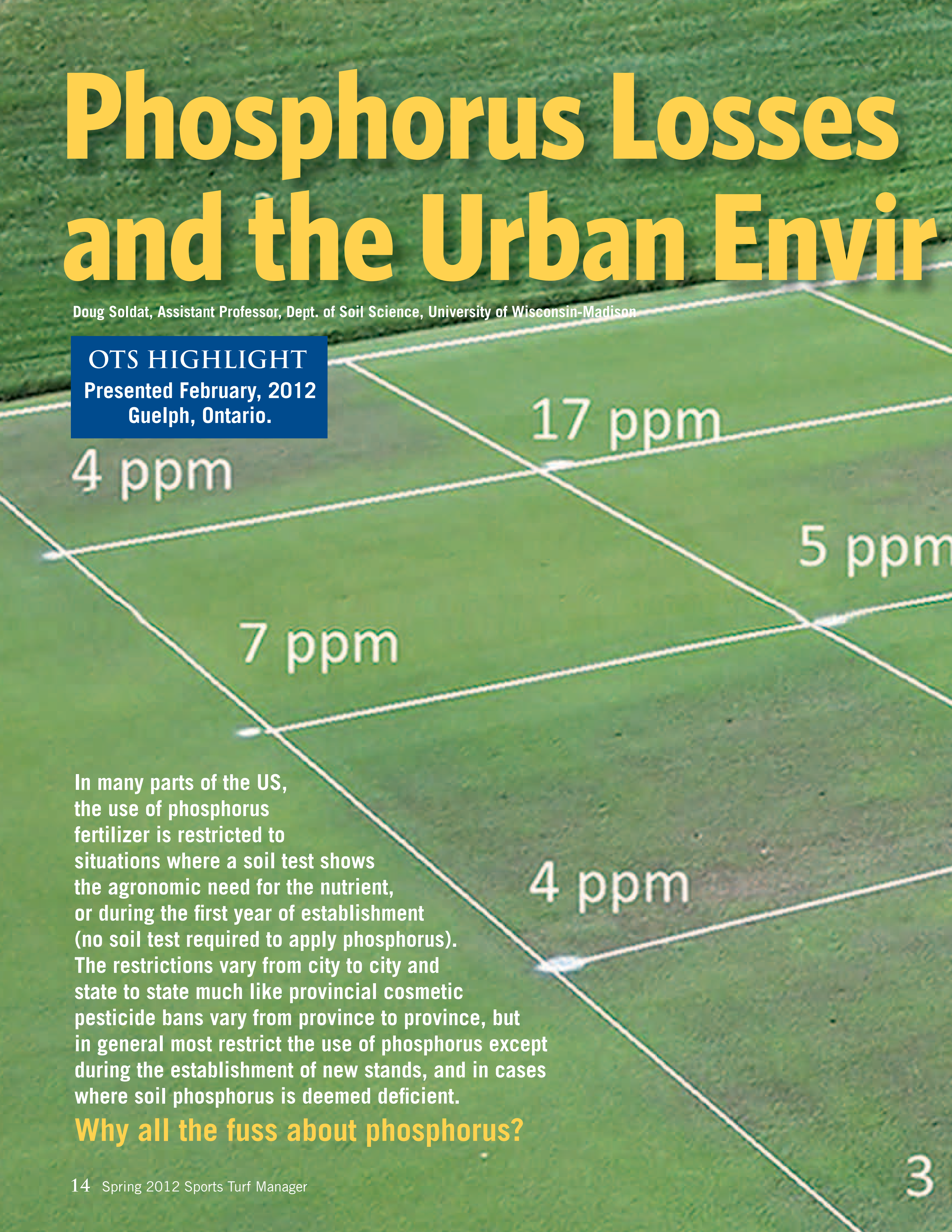
Perhaps the larger impact that turf systems can have in mitigating climate change is in the "carbon costs of maintenance". Maintenance costs for golf courses in central Ohio are illustrated in Table 1. We see that the largest potential carbon savings are from reducing nitrogen fertilizer use, and cutting back on both diesel and gasoline uses. If some maintenance operations can be powered with renewable energy, the overall impact of turf systems on climate change can be significantly reduced.

That's a very quick look at some of the issues surrounding climate change and turfgrass. There is still a lot of research to be done in this area. Turf systems have received far less attention than production agriculture systems and pasture systems. Readers interested in finding out more about climate change science might be interested in reading: *The Discovery of Global Warming* by Spencer Weart (Harvard University Press). It provides a fascinating history of the discovery and development of this area of science, but it reads more like a mystery than a science or history book. Readers who want to learn more about the biological and ecological impacts of climate change might be interested in reading my new book: *Climate Change Biology* (CABI publishing).

Phosphorus Losses and the Urban Envir

Doug Soldat, Assistant Professor, Dept. of Soil Science, University of Wisconsin-Madison

OTS HIGHLIGHT
Presented February, 2012
Guelph, Ontario.



In many parts of the US, the use of phosphorus fertilizer is restricted to situations where a soil test shows the agronomic need for the nutrient, or during the first year of establishment (no soil test required to apply phosphorus). The restrictions vary from city to city and state to state much like provincial cosmetic pesticide bans vary from province to province, but in general most restrict the use of phosphorus except during the establishment of new stands, and in cases where soil phosphorus is deemed deficient.

Why all the fuss about phosphorus?

from Turfgrass
onment

Figure 3. Mehlich-3 soil test phosphorus levels below 7 ppm negatively affected turfgrass quality on this sand-based putting green. There were no differences in turf quality above 7 ppm.

Excessive phosphorus can be a major detriment to water quality, especially in fresh water ecosystems. In many lakes, streams, and rivers, phosphorus is the most growth limiting nutrient. Therefore, additions of phosphorus are usually accompanied by increases in algal growth. Increased algal growth decreases the recreational value of the water body, depletes oxygen in the water which harms aquatic life, and increases the need for chemical treatment of the water.

Phosphorus is often a limiting nutrient in turf and agricultural systems too, so farmers and turf managers apply phosphorus fertilizer to maximize yield or turf quality. However, when excessive phosphorus is applied, it builds up in the soil and eventually finds its way to a water body. Phosphorus is very insoluble in soil and tends to bind tightly with soil particles in the upper few inches. In agricultural areas where phosphorus-rich manure is continually applied, soil phosphorus levels often vastly exceed what is required for optimum growth. Once phosphorus is built up in the soil, the primary way it finds its way to water bodies is by soil erosion (Figure 1). Large rains or snow melt events cause a process called runoff where water flows over the land until it reaches a body of water. If the soil is poorly protected, runoff will also carry away the phosphorus-rich topsoil – once the topsoil is detached from the land, we call it "sediment".

So far, this has been a story about agriculture. But research has shown that urban areas actually contribute as much or more phosphorus to water bodies than agricultural areas. Urban areas don't seem to have a manure spreading problem or an apparent issue with topsoil washing away, so where is the phosphorus coming from? The average politician or citizen has reasonably concluded that lawn fertilizer must make up a large portion of this amount, and therefore banning turfgrass fertilization will likely solve the problem. However, there is much more than meets the eye with urban phosphorus pollution.

First, it's clear that sediment losses actually are a serious issue in urban environments. Scientists at the United States Geological Survey examined the phosphorus and sediment losses urban and rural watersheds in Southeastern Wisconsin. They found that the phosphorus losses from urban areas were slightly greater than from the rural areas, but that the sediment losses from urban areas were four times greater than from rural areas (Corsi et al., 1997). Controlling the sediment loss from urban areas would presumably also reduce the phosphorus losses from these areas. So where does the sediment from urban areas come from? Building and road construction are major culprits. David Thompson maintains a blog called *The Contractor Report* (contractorreport.blogspot.com) which attempts to document the impact of construction practices in and around Madison, WI. The collage in Figure 2 was taken from that blog.

Figure 1. Two of the best ways to keep phosphorus from entering water bodies are to not let phosphorus build up to excessive levels in the soil, and to protect the soil from being washed away – usually by maintaining a dense ground cover. While these practices sound relatively simple, scores of scientists continue to study ways of reducing phosphorus losses from agricultural areas as it remains a very important environmental issue. *Photo: Webster's Online Dictionary.*

Areas that have dense turfgrass cover are notoriously low in sediment losses (Soldat et al, 2008). However, when the ground is bare, the exposed soil can be quickly washed away. In rural areas, top soil may be carried away from the farm but eventually be caught in a grassed buffer strip and never reach a body of water. But urban areas have well-connected networks of impervious surfaces. Sediment that is deposited on these surfaces can be quickly washed away into a storm sewer and find its way to a water body. The Wisconsin Department of Natural Resources estimates that 50 to 100% of eroded top soil in urban areas reaches a body of water compared to less than 10% from rural land uses (Johnson and Juengst, 1997).

Controlling sediment losses from urban areas should become a top priority if reducing phosphorus losses from these areas is a major goal. However, the focus in the US has been disproportionally on reducing phosphorus fertilizer applied to lawns and other turf areas. Will this approach work? The research suggests that the restrictions are not likely to have a large impact on urban water quality. Dr. Wayne Kussow (2008) at the University of Wisconsin measured phosphorus losses from three turfgrass management systems: 1) non-fertilized control, 2) Scotts Turf Builder (with phosphorus) and 3) organic fertilizer (with phosphorus). Even though no fertilizer was applied to the control treatment, more phosphorus (0.54 kg/ha/yr) was found in the runoff than the other two treatments receiving phosphorus (0.34 and 0.36 kg/ha/yr). The non-fertilized treatment had poorer density and therefore greater exposed soil and greater amounts of

Figure 2. Everyday images of sediment losses from construction sites in urban environments. Images: contractorreport.blogspot.com

runoff during storms than the two fertilized treatments. Similarly, researchers in Minnesota found no signification differences or significantly less phosphorus in runoff from plots receiving fertilizer than non-fertilized control plots during a three-year period (Bierman et al., 2010). They also found greater phosphorus losses when phosphorus was applied at three times recommended rates, but similar losses to no phosphorus at all when the recommended rate of phosphorus was used. These and other studies (see Soldat et al., 2008) clearly demonstrate that dense ground cover reduces phosphorus losses.

However, often soil phosphorus levels are sufficient to sustain healthy turf without additional applications. In these situations, adding phosphorus fertilizer is wasteful economically and environmentally. Soil testing is an effective technique to determine if phosphorus fertilizer should be applied. Fertilizer prices are at nearly all-time highs, and are unlikely to drop if a global demand for fertilizer continues to rise. Additionally, phosphorus is mined in only a few locations worldwide, and phosphorus reserves are critically low. For these reasons, it pays to be miserly with phosphorus fertilizer.

WHEN ESTABLISHING TURFGRASS FROM SEED, APPLYING PHOSPHORUS FERTILIZER NEARLY ALWAYS ENHANCES ESTABLISHMENT.

Figure 3 (pages 14-15) shows a picture of a phosphorus soil test calibration study recently completed (Kreuser et al, 2012). When soil phosphorus levels were at or above 7 ppm (Mehlich-3), the turf quality was excellent. Below 7 ppm, classic phosphorus deficiency symptoms appeared. Most soil testing labs will use 30 ppm as the cut-off for optimum soil P – a fairly conservative number. I strongly recommend not applying phosphorus fertilizer unless soil test levels indicate a potential problem, and keep in mind that every plot in Figure 3 would come back from the lab with a "low" or "very low" for every single plot, even though true deficiency symptoms only showed up on plots with less than 7 ppm phosphorus.

When establishing turfgrass from seed, applying phosphorus fertilizer nearly always enhances establishment. Hamel and Heckman (2006) found that turf establishment was enhanced when phosphorus was applied to soils with less than 200 ppm Mehlich-3 P, above 200 ppm yield was usually not increased further. In my experience, it's fairly rare to find soil test phosphorus levels exceeding 200 ppm. Applying phosphorus to speed establishment is an environmentally friendly practice because the shorter amount of time bare ground is exposed, the lower the potential for sediment loss.

In conclusion, turf fertilization is a component of phosphorus coming from urban areas, but pales in comparison to the phosphorus that is lost from urban building and road construction practices. Legislation restricting the use of phosphorus fertilizer is likely to have a limited effect on urban water quality. However, application of phosphorus when soils already contain a sufficient supply is a wasteful use of a precious resource.

References:

Bierman, P. M., B. P. Horgan, C. J. Rosen, A. B. Hollman, and P. H. Pagliari. 2010. Phosphorus runoff from turfgrass as affected by phosphorus fertilization and clipping management. J. Environ. Qual. 39:282-292.

Corsi, S.R., D.J. Graczyk, D.W. Owens, and R..T. Bannerman. 2007. Unit-area loads of suspended sediment, suspended solids, and total phosphorus from small watersheds in Wisconsin. USGS Factsheet FS-195-97: Washington, D.C.

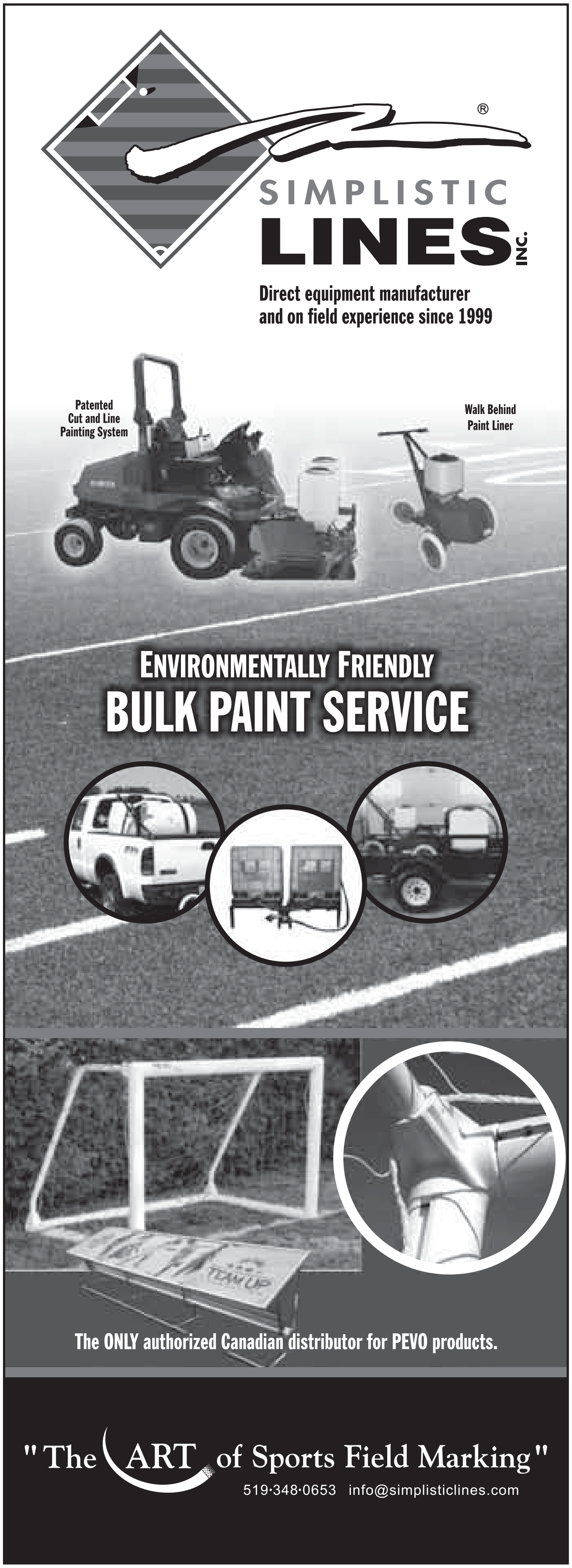
Hamel, S. C., and J. R. Heckman. 2006. Predicting need for phosphorus fertilizer by soil testing during seeding of cool season grasses. HortScience. 41:1690-1697.

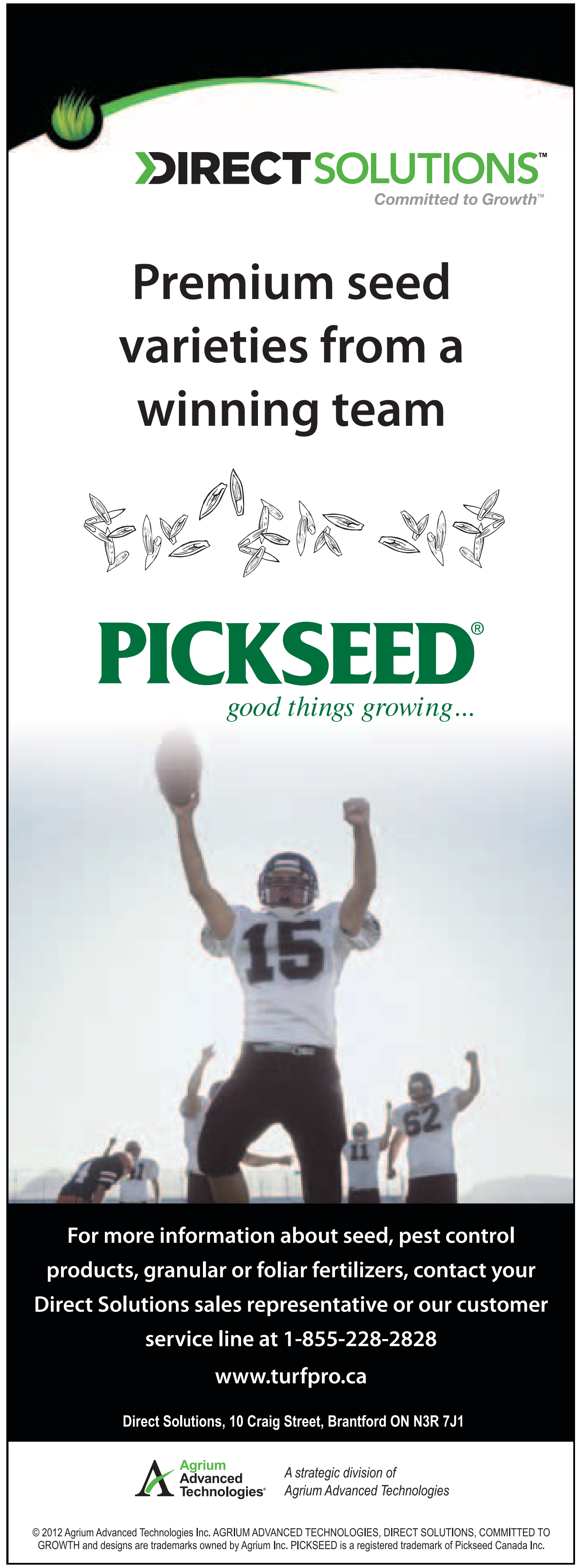
Johnson, C.D., and D. Juengst. 1997. Polluted urban runoff - A source of concern. Publication GWQ020 University of Wisconsin-Extension: Madison, WI.

Kreuser, W.C., P.H. Pagliari, and D.J. Soldat. 2012. Creeping bentgrass putting green Mehlich-3 soil test phosphorus requirements. Crop Sci. 52: In Press.

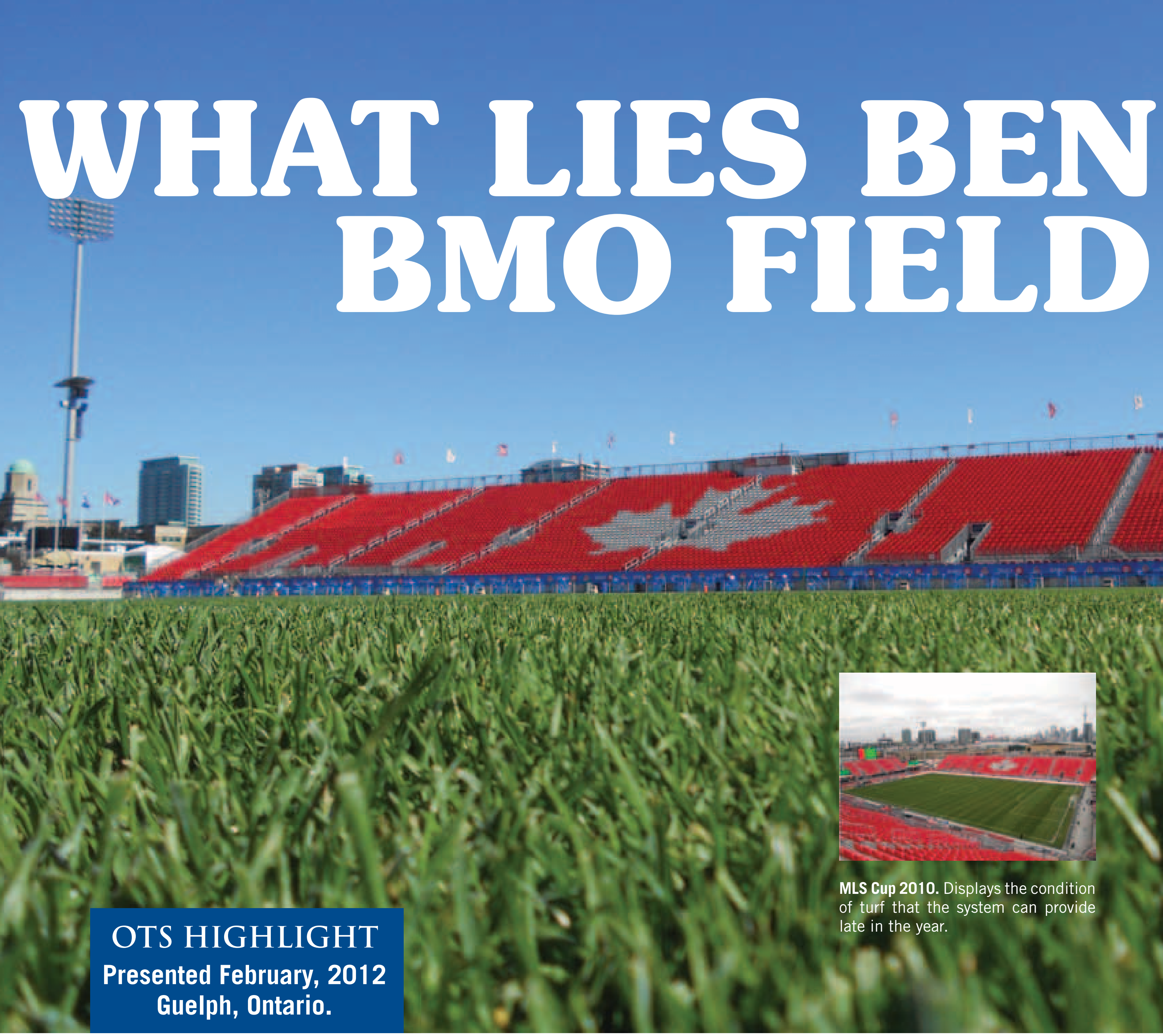
Kussow, W.R. 2008. Nitrogen and soluble phosphorus losses from an upper Midwest lawn. P 1-18. In M. Nett et al. (eds.) The fate of turfgrass nutrients and plant protection chemicals in the urban environment. American Chemical Society, Washington, DC.

Soldat, D. J., and A. M. Petrovic. 2008. The fate and transport of phosphorus in turfgrass ecosystems. Crop Sci. 48:2051-2065.


®
SIMPLISTIC
LINES INC.
Direct equipment manufacturer
and on field experience since 1999
Patented
Cut and Line
Painting System
Walk Behind
Paint Liner
ENVIRONMENTALLY FRIENDLY
BULK PAINT SERVICE
The ONLY authorized Canadian distributor for PEVO products.
"The ART of Sports Field Marking"
519·348·0653 info@simplisticlines.com


DIRECTSOLUTIONS™
Committed to Growth™
Premium seed varieties from a winning team
PICKSEED®
good things growing...
For more information about seed, pest control products, granular or foliar fertilizers, contact your Direct Solutions sales representative or our customer service line at 1-855-228-2828
www.turfpro.ca
Direct Solutions, 10 Craig Street, Brantford ON N3R 7J1
Agrium Advanced Technologies®
A strategic division of Agrium Advanced Technologies
© 2012 Agrium Advanced Technologies Inc. AGRIUM ADVANCED TECHNOLOGIES, DIRECT SOLUTIONS, COMMITTED TO GROWTH and designs are trademarks owned by Agrium Inc. PICKSEED is a registered trademark of Pickseed Canada Inc.

WHAT LIES BEN BMO FIELD



MLS Cup 2010. Displays the condition of turf that the system can provide late in the year.

OTS HIGHLIGHT
Presented February, 2012
Guelph, Ontario.

It's a chilly overcast day in mid March and the Toronto Football Club is playing their home opener at BMO Field. Over 22,000 people are in attendance sitting and watching the game live with even more on TV, yet very few pay any attention to the pitch and the fact it's actively growing and healthy in March. When you look at the grass, you wouldn't suspect what is happening below BMO Field. There are many systems in place to produce a high quality pitch in less than ideal weather conditions. In February I spoke at the Ontario Turfgrass Symposium in Guelph and was asked to recap it for the *Sports Turf Manager* magazine.

BMO Field is about to start its 6th season, its 3rd season with a natural turf field. It was originally constructed with FieldTurf, however after a few years of use it was in rough shape creating a serious need for a better solution. Artificial turf was viewed as a negative by coaches, players and officials. Not only is it not favoured to play on but it also makes scouting difficult in attracting high quality players. In many instances players will not sign with a club that plays on artificial turf. At BMO Field, for a Real Madrid game a few years ago, natural turf had to be brought in and installed over the artificial turf so that the teams would come and play an international friendly. With this strong desire and requirement from professional levels to play on natural turf, the decision to convert from artificial turf was made in the winter of 2009.

BMO Field was constructed as a two acre USGA style green that is planted with 4 different types of Kentucky bluegrass: 35% Impact KBG, 25% Skye KBG, 15% Cheetah KBG, 25% SR 2284 KBG. There