How sports turf helps reduce **the carbon footprint**

IT MIGHT TURN OUT THAT GOLF FAIRWAYS, football fields and other sports turf areas are the "good guys" when it comes to the earth's carbon footprint.

Although sports turf has been much maligned in the general press recently, researchers at Colorado State University, Fort Collins have proved that established turf does great things for carbon sequestration. The next step in their research is to develop metrics that predict the impact of carbon sequestration in turfgrass.

Early results are eye-opening. For starters, undisturbed turf will lock up one metric ton of carbon per hectare per year. In English, that is about 0.44 tons of carbon per acre annually.

"The strength of this research is that it covers multiple years and is based on very good data," says Yaling Qian, professor of horticulture and landscape architecture at Colorado State. She notes that some other studies, a few of which do not have nice things to say about recreational turf, are based on far fewer data sets.

Recent global concerns over increased atmospheric CO_2, which can potentially alter the earth's climate systems, have resulted in rising interest in studying soil organic matter (SOM) dynamics and carbon sequestration capacity in various ecosystems.

WHAT IT IS

Carbon sequestration is simply the long-term storage of carbon dioxide. CO_2 storage is necessary as a part of controlling climate change. CO_2 can be stored either geologically or in terrestrial ecosystems, according to the National Energy Technology Laboratory. NETL is part of the U.S. Department of Energy's national laboratory system and is operated by the DOE. NETL supports DOE's mission to advance the national, economic, and energy security of the United States.

"This is the kind of information turf managers need to broadcast," says Tony Koski, professor and extension turf specialist at Colorado State.

Determination of carbon pools in urban turfgrass soils will shed light on the role of turfgrass systems in contributing to terrestrial carbon, Koski says.

Koski says the results of this research support a better understanding of the roles carbon sequestration and carbon emissions play in the management of sports turf and what impact operational activities have on the environment.

At present, Qian is looking for research funding to support graduate students who will establish models for determining carbon sequestration. "We need to be able to project the impact of land use," she says.

The models would weigh climate, soil type, management style and prior land use—among other variables—in a database file. The results would not only help turf managers see the impact of what they do but also would help lawmakers determine the value of keeping open green areas open and green.

A one-acre soccer field removes carbon equivalent to driving a car OVER 3,000 MILES.

Qian notes there was no hard data for turf when the Colorado State group started its research in 2000. It was tough even to find carbon data on farmland. "On turf, there was no data at all," she says.

Golf courses figure most heavily in the Colorado State research. That is because turf management records were available for years, even decades on the sites the CSU researchers studied. Critical benchmarks identified during the project provide information that will allow the golf course management community to improve resource use efficiencies and bolster environmental performance.

"Carbon sequestration as only one side of the equation. The other side is carbon emissions." – Qian

One reason the CSU study focuses so heavily on golf courses as a function of sports turf is the number of acres golf courses keep green. According to the World Golf Foundation's "The Golf 20/20 Industry Report," there are about 15,000 golf courses in the United States. The GCSAA (Golf Course Superintendents Association of America, www.gcsaa.org) puts the size of a typical 18-hole golf facility at 150-200 acres total, including water bodies, hard structures, and out-of-play areas. A typical urban golf course might be only 110-120 acres, and courses in resort areas may be 170-190 acres. While not all of this is managed turf, all of the green areas can absorb carbon.

On the other hand, a typical soccer or football field is about one acre in size. Even a college complex with a dozen or more fields would represent only a fraction of the managed turf area of the typical golf course. But keep in mind that all sports turf can contribute positively to carbon sequestration.

The Colorado State study is only one of many studies that point up the value of sports turf for carbon sequestration. The biology departments at such diverse spots as Cornell University; Bradley University, Peoria, Illinois; and Missouri Southern State University in Joplin have done similar work on a somewhat smaller scale. No matter the geography, these studies point in the same direction.

Because of high productivity and lack of soil disturbance, turfgrass may be making substantial contributions to sequester atmospheric carbon. To determine the rate and capacity of soil carbon sequestration, Yaling Qian and Ronald Follett at the USDA-ARS, Soil-Plant-Nutrient Research Unit in Fort Collins compiled historic soil-testing data from parts of 15 golf courses that were near Denver and Fort Collins, and one golf course near Saratoga, WY.

In addition, they compiled 690 data sets on previous land use, soil texture, grass species and type, fertilization rate, irrigation, and other management practices. The oldest golf course was 45 years old when the project was initiated, and the newest golf course was just over a year old. Nonlinear regression analysis of compiled historic data indicated strong pattern of SOM response to decades of turfgrass culture.

"The strength of our project was based on having 690 data points," Qian notes.

The study shows that total carbon sequestration continued to increase for up to 31 years in fairways and 45 years in putting greens. However, the most rapid increase occurred during the first 25 to 30 years after turfgrass establishment. Past land use imparted a strong control of SOM baseline: in fact, fairways converted from farm lands exhibited 24% lower SOM than fairways converted from native grasslands.

That led the researchers to conclude that carbon sequestration in turf soils occurs at a significant rate that is comparable to the rate of carbon sequestration reported for land that was placed in the Conservation Reserve Program.

Translated into everyday terms, the typical fairway (between 1.5 and 2 acres) will sequester three-quarters of a ton of carbon each year. That is the rough equivalent of removing the carbon caused by driving a car 6,500 miles.

A one-acre soccer field removes carbon equivalent to driving a car over 3,000 miles.

Disturbing such soil for any reason will add more oxygen to the soil, Qian notes. "The more disturbance the more you degrade the organic matter," she says. A renovation will put some carbon back into the atmosphere. But tearing the golf course up and building on the land will release great quantities of carbon to the atmosphere and destroy the valuable carbon sink.

This is one of the first studies of turfgrass that received strong cooperation from USDA-ARS. While USDA did not provide financial support, the research was a collaborative effort. Sports turf is less competitive when it comes to grabbing a part of the USDA research-dollar pie. This usually is credited to the fact that sports turf is seen as non-essential when compared to food and fiber research. So the big money normally goes to grasses like corn and wheat – and not Kentucky blue or turf-type fescues.

This time, USDA-ARS was interested in the carbon sequestration work. The reason has roots in the need to establish just what is happening to carbon in the environment in an era when the term "climate change" has gone well beyond research labs and into the halls of Congress and the front pages of the New York Times.

The Colorado State study is doubly important to the sports turf industry because sports turf got slammed in reports, some done in California, which painted a bleak picture of the value of sports turf when it comes to carbon sequestration.

Terrestrial carbon sequestration is defined by NETL as the net removal of CO_2 from the atmosphere by plants and microorganisms in the soil and the prevention of CO_2 net emissions from terrestrial ecosystems into the atmosphere.

"There is significant opportunity to use terrestrial sequestration both to reduce CO_2 emissions and to secure additional benefits, such as habitat and water quality improvements that often result from such projects," NETL scientists say.

In principle, terrestrial sequestration is the enhancement of the CO_2 uptake by plants that grow on land and in freshwater and, importantly, the enhancement of carbon storage in soils where it may remain more permanently stored. Part of NETL's interest in terrestrial sequestration is that it provides an opportunity for low-cost CO_2 emissions offsets.

Early efforts had included tree plantings, no-till farming, and forest preservation. More-advanced research includes the development of fast-growing trees and grasses and deciphering the genomes of carbon-storing soil microbes.

Rather than sports turf, NETL's terrestrial sequestration R&D is focused on reforesting and amending mine lands and other damaged soils and analyzing various land management techniques, including no-till farming, reforestation, rangeland improvement, wetlands recovery, and riparian restoration. There is a heavy agricultural and forestry bent to the NETL program. While ag research is important, it leaves out the contribution of sports turf. Taken together, however, natural areas will help reduce CO_2 emissions.

This is no easy task. Roughly speaking, NETL figures it would take about 220,000 acres to offset emissions from a single, average-sized coal-fired power plant. That is a lot of soccer fields, golf courses and baseball diamonds. The NETL figure assumes an average coal power plant from the existing fleet and a forest uptake rate of three tons of carbon per acre per year. Terrestrial sequestration is conceptualized for use in conjunction with CO_2 capture and storage to provide fossil-fired power generation with zero net greenhouse gas emissions. It is expensive to capture the last 5-10% of CO_2 emissions from a fossil fuel conversion plant, due to the law of diminishing returns.

Sports turf and trees are not the final answer. NETL figures a cost-effective approach for zero emissions is to capture 90% of emissions and offset the remaining 10% with terrestrial sequestration. NETL does point out the many collateral benefits of this kind of program, including flood protection, wildlife/endangered species habitat, restored ecosystems, and the like.

Soil carbon is both organic and inorganic carbon contained in soil. During photosynthesis, plants convert CO_2 into organic carbon, which then is deposited in the soil through their roots and as plant residue. Organic carbon is found in the top layer of soil, the A horizon. Inorganic soil carbon comprises carbonates that form through non-biological interactions. They are a minor amount compared with organic carbon, but are considered more permanent. Large plant roots, such as those of trees, are considered biomass and not part of the soil, but the organic matter, if you look closely, includes many fine root hairs, where much of the CO_2 exchange from the plant to the soil occurs.

But Qian sees ways sports managers can help with carbon in ways that go beyond carbon sequestration. "Turf managers should look at carbon sequestration as only one side of the equation," Qian says. "The other side is carbon emissions."

By this, she means managers have to look at ways to minimize their carbon footprint…whether from chemical use, from vehicle use, or other carbon-generating uses.

"Some vehicles are more fuel-efficient," she says. "It's another area of the carbon question that needs work." ■

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>> **SAND SLITTING** can increase percolation and break up compacted layers.

Tips from David Frey

David Frey has more than 45 years of experience in maintaining, renovating, designing and building all types of fields. He should be considered a "founding father" of STMA; Frey succeeded the legendary Harry C. Gill as STMA president from 1983-1985 when he was the head groundskeeper at the old Cleveland Stadium. He was involved in developing new types of mound clay, a powered device for field tarps, and using geotextiles for bench tarps and field protection. He currently owns Field Specialties, which builds and renovates natural grass fields. Here are some tips from the master:

THE BEAUTY OF A NATURAL GRASS surface is that with maintenance, it can last forever. I spend a great deal of time fixing and improving surfaces and I have been asked how I develop a plan to evaluate them. Grade and consistency come first, followed by drainage and then grass cover.

You may notice that I like to use the word "surface" rather than field. A field is an area, be it level and true or not, that is used for pasturing and raising crops. A surface is a specific area that is designed for a particular activity, with defined dimensions, grades and variations.

Some surface changes are a matter of time and/or use. Changes to the requirements of particular sports have required the surfaces to change size, position of the goals, and room around the outside of the playing surface. Incorporation of other sports to be played on the same surface requires other considerations.

For example, NFL fields have changed dramatically. In the beginning the teams basically would play anywhere they were allowed. Fields were not even the correct length (Tiger Stadium and Wrigley Field). Practice areas were totally different than the training centers you see today. Many teams practiced on only a field and a half and the indoor work was done in a warehouse.

But times have changed, and grasses and soil mediums have changed too. Better varieties and higher sand/soil mediums make for better wear and drainage. High sand profile baseball fields have improved the use of grass fields in competition with artificial surfaces. Of course, separate facilities for each discipline have been the greatest change in baseball and football.

Most surfaces that I review are those that have been used for many years and hopefully have some good basic structure. Baseball requires good drainage, particularly from the infield area. Fields that are built backwards are those where the grades run toward the infield. They are not easy to fix without lots of changes and cost.

In most cases for baseball, I find the first thing I change is to raise the height of home plate, usually about 4 inches. Home plate and the mound are where everything starts. If they cannot drain the game is over. Do not get carried away with the idea that the plate and the bases have to be at the same height. Good plan, but does not always work unless you are in Florida. Raising home plate will raise the mound and the increases the grades on the infield grass, therefore providing better drainage.

GRADE AND CONSISTENCY

My approach to a football or soccer surface starts with the grade and consistency. Hopefully the surface was built with enough height to help the surface to drain. One rule of thumb is that you should be able to run at full speed and look over your shoulder and know the footing is consistent. Therefore, the grade might not be to specifications, but it should be consistent. The center of the field must not be lower than the sidelines. Bad or uneven grades would be reasons to rebuild the field. This

Home plate illustration ©istockphoto/XonkArts

In most cases for baseball, I find the first thing I change is to raise the height of home plate, usually about 4 inches.

has to do with safety and playability. If the grade is within reason both the drainage and grass cover can be fixed without rebuilding.

I like to see the grade slope to be about 1% from the center line at the most. Less than a ½% slope will develop low areas and there is not enough slope to move water through the grass. I do not like the surface to be lowered at the ends. It changes corner kicks and goal play in soccer and end zone play in football.

Let's say the basic grades are good, but there are depressions or holes. Another possibility is to true up an existing surface using a sandy mix of more than 85% sand and a laser box to spread the material over the entire surface. Do not use topsoil as it will seal off the drainage. Straight sand is okay, but tougher to get the new seed to germinate. The grass from below will come through at some point if the layer is not too deep.

PERCOLATION

Okay, the grades are acceptable, but the field is worn and the complaint is poor drainage. There are several methods to increase percolation in a sports surface. Installation of sand slitting, or several of the new thin pipe materials serve to move water, and break up the compacted layers.

In my opinion, a drainage pipe installation in existing grass is not a good plan. Look at the process. First you trench the surface every 15 or 20 feet. Then you install pipe and backfill with either a sand or stone. The two problems that happen will be to get grass established over the trench and keep the grass during drought situations. If you add soil to establish the grass, the soil acts to seal off the drain. French drains along the perimeter are great to capture water off the surface. The same drains in foul territory can greatly solve water runoff problems from the surrounding areas of the diamond. I do not put drains under clay infields as the clay will not percolate and if you backfill with sand the ball bounce is inconsistent.

I am always amazed that schools balk at strong overseeding and fertilization programs. It is a low cost method to improve a surface. Compare that to the cost to seal the old parking lot each year. And do not forget the practice surfaces. Football players spend almost every day on the practice field and 1 day every 2 weeks on the playing surface.

Grass cover not only improves the surface appearance, it improves playability. Grass needs to be grown aggressively which means a good fertilization program needs to be in place. Compare that cost with the renovation cost. Do not try to seed into a well-established stand of grass, as the germination rate is very low. Remember that seed count is important. There is a big difference between ryegrass and the bluegrasses. My suggestion is 20% to 30% ryegrass in a blended mix in new seeding to help the bluegrass to get established. I do not recommend seeding any bluegrass into a stand that has rye as it cannot compete. Do not forget annual ryegrass for those seedings that have to happen now. ■

Converting a field from Kentucky bluegrass to hybrid bermudagrass

>> **A NEW CAMBRIDGE DRAINAGE SYSTEM** was installed before the inter-sprigging of the bermudagrass into the bluegrass playing surface. One-inch perforated drain tiles were installed on 10-foot centers across the entire field and then backfilled with gravel and sand.
>> **Inset Image: THE KENTUCKY BLUEGRASS** playing surface of Thompson Field at Virginia Tech in Fall 2008.

STRESSFUL, TIME CONSUMING, PROBLEMATIC, EDUCATIONAL, EXPENSIVE…from a sports field manager's position, these are all words that can be associated with the process of renovating an athletic field. A renovation might encompass anything from a simple re-sodding to the complete reconstruction of a field from the ground up, but the end result is hopefully an enhancement of the safety and playability of a field.

During Spring 2009, the Virginia Tech athletic department initiated a unique renovation project of their competition soccer field. Thompson Field is home to the Hokie men's and women's soccer teams in the fall, as well as the women's lacrosse team during the spring. It was originally completed in Fall 2003 as a native soil, Kentucky bluegrass playing surface with a sand-slit (Cambridge) drainage system to enhance water removal from the field. One inch perforated drain tiles were installed in the sand slits on 10-foot centers across the entire playing surface along with an in-ground Toro irrigation system.

When I arrived at Virginia Tech in Fall 2007, I was fortunate enough to be entrusted with the management of the soccer facilities. I quickly learned the difficulties of managing a field for multiple teams and the high expectations of the coaches for their field. While the coaches were always satisfied with the playing surface, I was always under constant pressure to increase the

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speed (and therefore decrease the mowing height) of the field.

Eventually, we reached a point where we felt we could no longer decrease the mowing height and ensure the safety of the field so we began "planting" the idea for a possible renovation of the field surface to bermudagrass. By switching we felt we could provide a more dense, uniform, and faster playing surface than what we had on the original bluegrass field.

Unfortunately, while the suggestion was welcomed by the coaching staffs, there were limited financial resources available to allow for stripping the old and installing the new. For this reason, we continued to play on the Kentucky bluegrass surface, but continually kept the idea of a field conversion alive by discussing it with our coaches and administrators.

TIME TO ACT

During Fall 2008, I began to notice some drainage issues with the field in the fact that it became spongy and remained wet for days after a rain event. At one point a game had to be cancelled due to unsafe playing conditions 2 days after a half-inch rainfall event. This caught the attention of our administrators. While the financial situation hadn't really changed, we had reached a point where definite action had to be taken on the drainage system.

We began to make plans to install a new Cambridge drainage system into the field following the completion of the spring lacrosse season. Knowing that we would have a fair amount of field disruptions with the new drainage trenches, but that we still could not afford a complete re-sodding of the field from bluegrass to bermudagrass, I began to explore other options. Through my work as a graduate student with Dr. Mike Goatley, I learned of a process of converting a cool-season athletic field into bermudagrass by sprigging directly into the existing playing surface. Dr. Goatley had conducted several successful research trials and had been involved with similar conversions at other schools.

After multiple questioning sessions with Dr. Goatley about the process, I began presenting the idea to my supervisor to be presented to the athletic department administration. The biggest selling point of this approach was that by using sprigs instead of sod, the overall cost of resurfacing the field could be drastically reduced. In order to fully educate and prepare our coaches for the process, Dr. Goatley was brought in for a meeting to present them with the process and answer their questions.

PLAY MUST GO ON

The primary difference between our renovation plan and the previous successful conversions at other schools was that we had to take a 2-year approach as the field would still be used for the fall playing season instead of being allowed to develop and mature for a year without any activity. The upfront education process for our coaches and administrators was the key to the success of this project. By explaining to them what would happen and preparing them for how the field would look, there were no surprises or unmet expectations throughout the renovation process.

The coaches' primary concern was that the field would still play consistent and true during the conversion process and the aesthetics

>> **THE CUSTOM SPRIGGING MACHINE** used by Carolina Green in action. The Patriot bermudagrass was inter-sprigged into the existing bluegrass at the approximate rate of 800 bushels per acre.

>> **Above: THIS PHOTO** was taken 1 month after initial sprigging and shows a close-up of some bermudagrass patches growing within the Kentucky bluegrass.

>> **Above: TWO MONTHS** after sprigging, at the beginning of the fall playing season. Notice that the drainage lines are completely covered with bermudagrass and are still distinguishable. Other than looking a little odd aesthetically, the field functioned very well as a two grass system during the first year. The field was successfully converted to 100% bermudagrass the following summer.

in between were of little consequence to them. When asked by the coaches and administrators what might happen in a worst-case scenario for the bermudagrass conversion (i.e. a cool Blacksburg summer where bermudagrass would not thrive), Dr. Goatley told the group that field safety and playability would not be compromised by the introduction of the bermudagrass sprigs into the bluegrass sod, but that the playing surface might look a little strange as cooler temperatures arrive and the bermudagrass entered dormancy.

As mentioned, this renovation was undertaken with the intention of it hopefully being a 1-year conversion, but realizing that it likely would be a 2-year process in our climate. Following the conclusion of the women's lacrosse season in late April, we began making preparations for the conversion from Kentucky bluegrass to bermudagrass, which would begin in late May/early June which is the most appropriate time to sprig bermudagrass in the Blacksburg climate.

The mowing height of the bluegrass was lowered to ¾ of an inch and a one and a half times label rate of Primo (Trinexapac ethyl) was applied 1 week before sprigging to slow the growth of the Kentucky bluegrass.

Contractor Carolina Green arrived during the first week of June and installed new 1-inch drainage lines on 10-foot centers across the entire field, backfilled with gravel and sand to the surface, and then sprigged Patriot bermudagrass directly into the existing bluegrass stand at the approximate rate of 800 bushels per acre. Patriot was selected for its cold hardiness and because of previous success on the Virginia Tech football field.

Following the inter-sprigging, the entire field was topdressed with ¼ - ½ inch of the same sand used to fill the drainage trenches. Additional bermudagrass sprigs were placed over the drainage trenches by hand in an effort to improve the establishment and fill-in rate of the bermudagrass. Finally, to complete the installation process, we set an irrigation schedule to ensure that the sprigs remained moist for the first 7-10 days; watering frequency and amounts were then scaled back to a more typical maintenance irrigation schedule.

Mowing was reconvened at ¾-inch on the field approximately 2-3 weeks after the sprigs were installed and continued throughout the rest of the year in order to provide the bermudagrass a competitive growing advantage but still allow the bluegrass to survive for playability. The fertility program was adjusted to resemble a typical warm-season nutrient program except for the fall when it was treated very similar to an overseeded situation.

Summer 2009 turned out to be one of the coolest, wettest summers on record in the Blacksburg area and the bermudagrass didn't spread as aggressively as had previously been shown in research trials at the Virginia Tech campus, and the Kentucky bluegrass continued to thrive even at the ¾-inch mowing height. At the conclusion of 2009, the field was between 30-40% bermudagrass and had a

Not only did we deliver a cost effective renovation process that has reduced our annual maintenance costs (seed, herbicide, and fungicide), but we improved the speed and quality of our playing surface without removing the field for use for weeks/months at a time.

unique two grass appearance to it. While the field maintenance crew and administration did receive a fair amount of questioning regarding the appearance of the field, the first year was considered a relative success given the weather.

During the winter months, we covered the field with protective growth tarps and managed in the same fashion in the spring as it was in the fall. Following the women's lacrosse season in April 2010, we fully committed to the bermudagrass establishment and sprayed the entire field with Monument (Trifloxysulfuron-sodium) in an effort to kill off the Kentucky bluegrass and provide the bermudagrass with a competitive advantage. Due to the lower than expected bermudagrass stand, we sprigged an additional 300-400 bushels per acre of Patriot into the field in order to speed up the conversion process.

The mowing height was adjusted to ½-inch and we focused the fertility and irrigation programs solely on growing and developing the bermudagrass. Revolver herbicide (Foramsulfuron) was applied a month after sprigging to control any rogue bluegrass plants. Fortunately, Summer 2010 was one of the warmest on record in the Blacksburg area and the bermudagrass thrived. At the start of the fall soccer season in August 2010, we had 100% bermudagrass coverage and our coaches, players, and administrators were thrilled with the results.

This renovation process was a very challenging and educational experience. While it might not fit the needs of all facilities, it does provide an affordable alternative to completely resurfacing a field and the strategy has been used successfully in what turned out to be essentially "single season"' conversions for fields at Bridgewater College (Bridgewater, VA) and the University of Louisville. Not only did we deliver a cost effective renovation process that has reduced our annual maintenance costs (seed, herbicide, and fungicide), but we improved the speed and quality of our playing surface without removing the field for use for weeks/months at a time. ■

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