interactions were observed. Interactions involving the cultivars indicated the cultivars that were affected under wear and/or compaction levels were more noteworthy than any change in the ranking of cultivars under wear and compaction. Thus, discussion of the interactive effects involving the cultivar factor on the effect of wear and/or compaction factors within cultivars is appropriate.

In the putting green study, turf quality generally decreased because of wear treatment, but response to compaction treatment was relatively small in 2000 (Table 2). Wear decreased turf quality of almost all cultivars at one or both levels of compaction except 7001, which didn't respond to wear in 2000 (Table 2). Also, wear didn't affect turf quality of SR 7200 and Southshore in uncompacted plots and Penncross in compacted plots. Compaction didn't affect turf quality of most cultivars; however, compaction decreased turf quality of Providence in no-wear plots and SR 7200, Providence and Southshore in plots receiving wear treatments.

In 2001, compaction decreased turf quality of only Providence (Table 2). Wear decreased turf quality of compacted and uncompacted plots, whereas compaction only reduced quality in the presence of wear. Vesper, 7001 and Penn A-4 had the best turf quality during the last year of the trial (2001) while Penneagle, Pennlinks and Penncross had the poorest turf quality (Table 2). Velvet bentgrass cultivars had better turf quality than most of the creeping bentgrass cultivars studied regardless of whether they received wear or compaction treatments.

Compaction didn't affect turf density in 2000. Wear decreased turf density of all cultivars except 7001, SR 7200 and Penn A- 4 (Table 1). An immediate reduction of turf density in 2000 caused by wear would be expected because wear damage is acute, causing immediate thinning of turf while compaction is a chronic stress. In 2001, wear continued to decrease turf density regardless of whether plots received compaction or not, while compaction treatments only reduced density in the presence of wear.

In 2001, Vesper was the most dense cultivar, followed by 7001 and Penn A-4. Pennlinks and Penncross were the least dense (Table 1). S.I. Sifers et al studied 12 bentgrass cultivars and reported similar observations for shoot density. They noted Penn G-2 had the highest shoot density at 3,547 shoots dm^{-2}, and Pennlinks and Penncross had the lowest at 1,353 and 1,369 shoots dm^{-2}. Beard et al reported Penn G-2 had the second highest density among the 13 creeping bentgrass cultivars studied, while Putter, Penneagle and Penncross had the lowest. Our data indicated cultivar differences in turf density exhibited under nontraffic conditions should also be evident under trafficked conditions.

In the fairway study, turf quality response was more varied than the putting green trial. Also, more cultivars were responsive to the compac-

Table 3. Soil physical properties of the 0-to-51-mm surface depth as affected by wear and compaction in a fairway trial grown on sandy loam; sampled in October 2001.

Main effects	Bulk density	Air-filled porosity†	Capillary porosity	K_{sat}
	$Mg\ m^{-3}$	---- $m^3\ m^{-3}$ ---		$mm\ h^{-1}$
No wear	0.97	0.229	0.404	92
Wear	1.07	0.197	0.401	74
No compaction	0.99	0.239	0.386	126
Compaction	1.04	0.188	0.419	40
Source of variation				
Wear	***	*	NS	NS
Compaction	**	**	**	**
Wear x compaction	NS	NS	NS	NS
CV (%)	1.9	7.5	3.6	38.5

* Significant at the 0.05 probability level. ** Significant at the 0.01 probability level. *** Significant at the 0.001 probability level. † Air-filled porosity was determined by subtraction of capillary porosity (measured as water retention at -10 kPa water potential) from total porosity. Total porosity was calculated from bulk density assuming a particle density of 2.65 $Mg\ m^{-3}$.

tion treatment as would be expected based on the greater extent of detrimental soil physical properties responses observed in the fairway trial (Table 3). Wear reduced turf quality of 10 cultivars in no-compaction plots and 12 cultivars in compaction plots in 2000. Pennlinks and Penncross were the only cultivars not affected by wear in compacted or noncompacted plots.

Compaction didn't alter turf quality of 12 cultivars in no-wear plots and nine cultivars in wear plots during 2000. However, compaction decreased turf quality of SR 7200 in plots receiving wear treatments and those receiving no wear treatments. Wear decreased turf quality of almost all cultivars in 2001. Only SR 7200 wasn't affected at both levels of compaction. Compaction didn't alter turf quality of 12 cultivars in no-wear plots and nine cultivars in wear plots in 2001. However, compaction reduced quality of SR 7200 at both levels of wear.

Wear reduced turf density of fewer cultivars (nine cultivars in no-compaction plots and seven in compaction plots) in 2000 than observed in the putting green trial (Table 1). Wear reduced density of Penn G-2, Penn G-1, Providence and SR 1020 in plots receiving compaction or not, whereas wear didn't affect SR 7200, Pennlinks, and Penncross at both levels of compaction.

Compaction decreased turf density of six cultivars in no-wear and wear plots in 2000. Compaction reduced density of Penn G-1 and SR 1020 at both levels of wear. Wear reduced turf density of nine cultivars in no-compaction plots and eleven cultivars in compaction plots in

IMPACT ON THE BUSINESS

Redirection, aerification help prevent traffic woes

By John Walsh

Superintendents who have a mix of *Poa annua* and bentgrass on their courses know *Poa* withstands foot and cart traffic better than bentgrass. Nonetheless, redirection and aerification help Ken Flisek, CGCS, prevent turf from taking a beating from golfers at the private, 18-hole Club at Nevillewood in Pennsylvania.

Flisek maintains *Poa* and bentgrass on the fairways, greens and tees with a $1.4 million budget. He tries to control the traffic on the greens as best he can by spreading it out via hole locations, which are rotated around the green daily.

The 400-member club generates about 24,000 rounds a year, 23,000 of which are with carts. The course features continuous cart paths. There also are signs that say "please park here" to help spread the traffic wear on turf. In particular, Flisek struggles with – and nurses – six greens that lack desired air movement. They sit low and are surrounded by trees.

"On two of those greens, we extended the cart path and brought it behind the green to give golfers two or three options to park and walk on and off the greens," he says.

Flisek is resurfacing the cart paths and widened them to 12 feet with curbs near the greens. Still, it's tricky to prevent traffic from negatively affecting the health of the turf.

"Golfers are creatures of habit," he says. "Some people park in the same spot no matter where the hole is. But our $15 'please park here' signs are worth their weight in gold because they help distribute foot traffic."

Flisek's crew members move the signs when they move the hole locations but the course doesn't have a sign on every green, just the six babied greens.

Compaction is another problem caused by traffic. All greens have it, and it's one reason why Flisek aerifies. He needle-tines the greens every three weeks throughout the summer (four to six times a year) and needle-tines some greens every two weeks. He core aerifies twice a year and might aerify additionally where carts exit and enter the fairway.

Flisek doesn't have traffic problems in the fairways. Rather, they're in the areas between the cart path and fairway – the rough areas, which tend to get concentrated traffic the most.

"We converted bentgrass to *Poa* because it withstood traffic better," he says. "The stands with a larger percentage of *Poa* withstand traffic better and are healthier."

Flisek distributes traffic in the fairways with the help of one-inch-diameter PVC posts painted black with white tops. The posts are moved every day to designate where golfers should exit the fairways.

"The effect of traffic is a huge issue in the rough," he says. "The turf would be down to dirt if we didn't direct the traffic with the posts. Ninety percent of golfers exit where they're supposed to."

Golfers at Nevillewood have a 50-yard area where they're asked to scatter carts. When the weather is dry and hot, the posts are moved closer to the greens.

"If it had a rope, everyone would drive right up to the rope," Flisek says. "With the post, everyone scatters naturally."

For Flisek, it's a simple matter of being proactive.

"We're trying to move traffic around before a problem develops," he says. **GCI**

2001. Penncross and 7001 weren't affected by wear at both levels of compaction. Compaction decreased turf density of seven cultivars in no-wear plots and only three cultivars in wear plots in 2001. SR 7200 and SR 1020 were affected by compaction at both levels of wear.

Table 4. Interaction effects of wear x compaction (comp) x cultivar on bentgrass populations (% area of plot) in a putting green trial grown on a sandy loam in 2000 and 2001.

	July 28, 2000				Aug. 13, 2001			
Bentgrass	**No wear**	**No wear**	**Wear**	**Wear**	**No wear**	**No wear**	**Wear**	**Wear**
cultivar	**No comp**	**Comp**	**No comp**	**Comp**	**No comp**	**Comp**	**No comp**	**Comp**
	(% cover)†							
Vesper‡	95.7	94.1	94.3	92.6	99.0	96.9	97.7	94.7
7001‡	95.3	95.6	93.5	93.1	99.0	96.7	96.2	93.7
SR 7200‡	94.3	93.3	92.7	89.3	96.7	93.7	92.9	85.2
Penn A-4	95.3	94.6	92.3	93.5	91.5	91.6	79.4	81.2
Penn G-2	95.6	95.6	91.7	90.2	90.3	90.8	75.9	79.8
Century	91.5	93.7	92.7	89.2	86.7	84.6	84.1	73.6
L-93	91.0	90.1	87.9	87.7	81.5	73.4	64.4	69.5
SR 1119	91.9	90.0	82.8	86.5	77.6	71.5	60.4	47.8
Providence	89.2	88.9	86.8	83.3	73.0	76.1	60.9	67.5
Southshore	89.6	91.5	87.4	85.4	81.5	70.7	53.1	55.4
SR 1020	89.5	90.0	84.8	83.3	80.1	70.7	65.0	54.1
Putter	92.7	85.9	85.9	90.7	82.7	74.6	64.7	68.4
Penneagle	89.5	88.6	85.8	83.3	78.0	74.6	68.9	53.1
Pennlinks	90.4	89.6	85.4	84.9	68.3	73.6	53.1	64.4
Penncross	88.8	86.1	86.4	84.1	64.0	66.1	54.1	48.4
$LSD_{0.05}$		3.8				10.7		

† Cover measured as the percent of 209 line-intersect observations of bentgrass (remainder was annual blue grass) over 1.35 m^2 of each plot. ‡ Denotes velvet bentgrass; all others are creeping bentgrass.

BENTGRASS POPULATION

Bentgrass population data (Table 4) for mid-season were presented because this time represents a key time of the growing season for golf course turf. Data were representative of populations measured at other times of the year. Generally, bentgrass population decreased as the study progressed and annual bluegrass encroached. Decreased bentgrass population was particularly evident for lower-density cultivars, as well as plots that received wear treatment (Table 4).

In the putting green study, wear decreased bentgrass population of five cultivars in no-compaction plots and seven cultivars in compaction plots measured on July 28, 2000. Wear decreased bentgrass population of Penn G-2, SR 1020 and Pennlinks at both levels of compaction (Table 4). Compaction decreased bentgrass population of only two cultivars: Putter in no-wear plots and SR 7200 in wear plots. Unexpectedly, compaction increased bentgrass population of Putter in wear plots. However, this response was not evident in 2001 (Table 4). Bentgrass populations in Vesper, 7001, Penn A-4 and L-93 didn't change regardless of the level of wear or compaction in 2000. And Vesper, 7001 and Penn A-4 maintained bentgrass populations of 92 percent or more over all levels of wear and compaction.

Bentgrass populations ranged from 48 to 99 percent on Aug. 13, 2001 (Table 4). Wear decreased bentgrass population of nine cultivars in no-compaction plots and seven cultivars in compaction plots and wear decreased bentgrass of Penn G-2, SR 1119, Southshore and SR 1020 at both levels of compaction (Table 4). Compaction decreased bentgrass population of only four cultivars: Southshore in no-wear plots and SR 1119, SR 1020 and Penneagle in wear plots. Interestingly, compaction increased bentgrass population of Pennlinks from 53 to 64 percent in wear plots in 2001 (Table 4). However, turf quality and density data didn't provide insight to explain this response in Pennlinks plots. Moreover, the practical significance of the increased bentgrass population of Pennlinks appeared to be limited since the bentgrass population (64 percent) was low compared to the best performing creeping

bentgrass (81 percent bentgrass for Penn A-4) at that level of traffic. Bentgrass population in Vesper and 7001 plots were 93 percent or greater and weren't significantly affected by the level of wear or compaction.

Beard et al reported Penncross creeping bentgrass had low shoot density (1,369 shoots dm^{-2}) and was less competitive against annual bluegrass encroachment in established nontrafficked turf compared to Penn G-2 and Penn A-1 that had shoot densities above 2,000 shoots dm-2. R.H. Cashel et al found that denser cultivars tolerated traffic stresses on a sand-based root zone and resisted infestation by annual bluegrass overseeding better than older, less dense cultivars.

More cultivars in the fairway trial responded to wear and compaction than in the putting green study with respect to bentgrass populations.

In the fairway study, wear decreased bentgrass populations of most cultivars measured on Aug. 7, 2000. Only 7001 and SR 7200 in no-compaction plots and SR 7200, Penn G-1 and Pennlinks in compaction plots didn't respond to wear. Compaction decreased bentgrass population of eleven cultivars in no-wear plots and five cultivars in wear plots. Compaction decreased bentgrass population of Penn G-2, L-93, Providence and Penneagle at both levels of wear. While all cultivars decreased in bentgrass population because of some level of wear and/or compaction, by Aug. 7, 2000, bentgrass population didn't fall below 90 percent for 7001, 89 percent for SR 7200, 88 percent for Penn G-1 and 87 percent for Penn A-4.

Wear decreased bentgrass populations of almost all cultivars by Aug. 22, 2001, except 7001 and SR 7200 in no-compaction plots and 7001 and Pennlinks in compaction plots. Compaction decreased bentgrass populations of 10 cultivars in no-wear plots and 12 cultivars in wear plots. Compaction decreased bentgrass in eight cultivars regardless of the level of wear: Penn G-2, Century, L-93, SR 1119, Providence, SR 1020, Penneagle and Penncross. 7001 was the only cultivar that didn't lose bentgrass population because of compaction at both levels of wear and maintained a population range of 93 to 99.8 percent across all traffic treatments. Of the creeping bentgrass cultivars, Penn A-4 and Penn G-1 maintained the greatest bentgrass population (83 and 79 percent, respectively) under the most stressful traffic level of wear plus compaction. **GCI**

H. Samaranayake, Ph.D., and T. J. Lawson are research technicians and James Murphy, Ph.D., is an associate extension specialist, all in the department of plant biology and pathology at Rutgers University, New Brunswick, N.J.

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BY MARISA PALMIERI

To the loo

A New York superintendent finds success with self-contained restrooms

Last fall, the staff at Anglebrook Golf Club in Lincondale, N.Y., surveyed its members for feedback about what improvements they sought for the 13-year-old golf course. Resoundingly, members had a common request: restrooms.

Because of the course's layout featuring returning nines, which theoretically allows golfers to use clubhouse restrooms mid-round, bathroom facilities weren't part of the course's original Robert Trent Jones design.

"But sometimes you can be out on that first nine for two hours before you make it back to the clubhouse," says Lou Quick, CGCS. "Members asked for restrooms, so last fall we started to look into options."

When it came time to procuring on-course restrooms, Quick was entering uncharted territory because he hadn't purchased bathrooms before and knew his search required research.

Though he considered it, hiring a contractor to construct a traditional restroom facility out of stone or wood would've been too expensive, Quick says, estimating it would have cost about $80,000.

"In the places where these needed to be, electricity, septic and sewage weren't readily available," he says. "And the cost to send water out there was extremely prohibitive."

Holes five and 14, where the restrooms are located, are hundreds of yards away from the nearest potable water source.

Though Quick considered a number of options, self-contained, composting restroom units were his first choice because they didn't need to be connected to utilities and they don't require extensive maintenance.

"I considered other types, but it came down to this style – the composting," he says.

A bonus was Quick and his maintenance staff were able to reduce costs by installing the units with help from the manufacturer, Clivus Multrum.

Anglebrook, which is corporate owned and not member driven in terms of decision making, didn't require member approval of the purchase.

"It was strictly a staff decision," Quick says. "The g.m. and executive director took my input, and that's how we made the decision."

The club purchased two M54 Trailhead units in April, and they were installed and operating by May in time for peak season. Anglebrook's Trailhead structures each feature a urinal, a foam-flush toilet, a built-in composting system, a waterless hand-washing station and a solar-powered ventilation system. The 3 ounces of water needed each time someone flushes the toilet comes from the course's irrigation system.

Anglebrook, a high-end private club, opted to upgrade its restrooms' facades with stonework and cedar shingles. Photos: Lou Quick/Clivus Multrum.

It was important to add amenities to the inside of the restrooms so they didn't feel like outhouses, superintendent Lou Quick says.

The two units, which were funded out of a capital expenditure budget, cost about $40,000, Quick says, adding the club didn't scrimp on upgrades.

"You can go lower – this was probably the high end," he says.

The Anglebrook staff opted for porcelain toilets instead of fiberglass and upgraded the exterior with a faux stone and cedar shank. Once installed, the restrooms also were appointed with wall art, plants, coat hooks and other extras to please the club's high-end clientele.

"For most of our male membership, it probably doesn't matter, but it's nice for our female members not to have it look like an outhouse," Quick says. "It's more homey."

DIY

Though the manufacturer offers prefabricated units with turnkey installation, Quick decided to assemble and install the units with his crew and manufacturer assistance.

"We're pretty handy around here," he says. "Most facility managers and golf course superintendents have the ability to do this type of thing. Clivus sent out two technical people to help us put together the first unit, and we assembled the second one ourselves."

Though installation required a foundation hole (6 feet wide by 12 feet long by 5 feet deep) to accommodate the waste collection tank, the units don't require a concrete foundation or digging trenches for septic or sewage line hookups. Two of Quick's crewmembers dug the hole in about six hours with a medium-size backhoe.

In all, installation took about two weeks, though the maintenance staff didn't work on

it every day. The foundation hole and basic construction, completed by Anglebrook's staff, took three days. The extra stone work and shingles took a week. The shingle roof and siding were installed by a contractor for about $5,000.

"The beauty of these units is they're self contained," Quick says. "Set up is very fast."

UPKEEP

In addition to the simplicity of installation, Quick selected the self-contained units for their low-maintenance requirements.

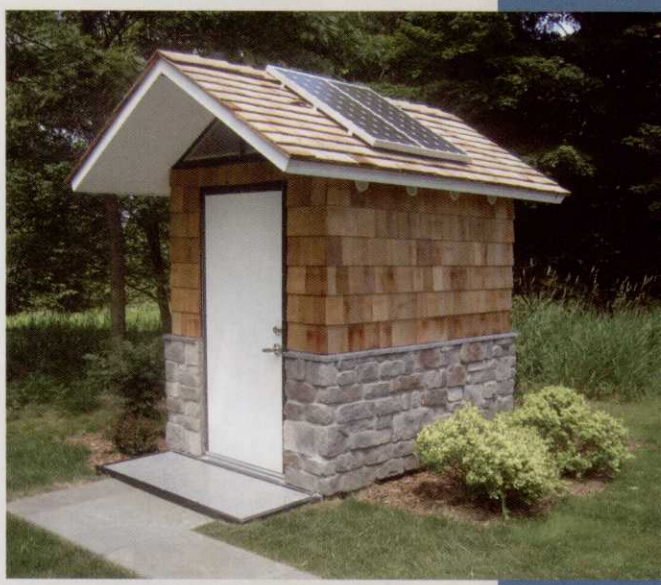
The units have underground containers that retain the liquid and solid waste in separate areas. The composting units require the solid waste be mixed with a bulking agent (any type of dried organic matter), such as mulch, which helps promote a colony of natural bacteria. The maintenance staff must occasionally turn over this matter with a garden fork.

"It's the same thing you'd do with any garden compost," Quick says. "Over time, the solid waste and bulking agent break down just like in nature."

The only other maintenance duty is monitoring the liquid tank. When it fills, a septic/sewage company will come and pump it out, according to the state's requirements. Though it's against New York state guidelines, some places consider liquid waste, which is essentially uric acid, to be a compost organic material and allow it to be redistributed as fertilizer, Quick says.

At this time, Quick can't cite actual upkeep costs because he hasn't had to maintain the units yet. But, based on Clivus Multrum's usage statistics, a course like Anglebrook, which generates 9,000 rounds annually, might not have to perform any maintenance for as long as two years.

"It's all based on the amount of people who use the unit," Quick says. **GCI**



A contractor installed the units' shingle roofs and siding for about $5,000.

BY MARISA PALMIERI

Weather watcher

A Web-based monitoring system serves the maintenance staff at Evanston Golf Club well

It's a bright, sunny morning in Skokie, Ill., one of the first days of fall. The maintenance staff at Evanston Golf Club has plans to seed part of the facility's nursery, but before superintendent Dan Charlton gives the go-ahead, he has to check the weather.

With seed prices rising along with everything else, Charlton's not going to OK preparations for an early afternoon seeding project if there's a chance of rain showers.

Charlton logs on to his Web-based weather-monitoring system, runs the radar and, sure enough, there's a storm coming in from Milwaukee.

"We need it to be dry so all the seed doesn't wash away," he says. "So I'll monitor this storm, and if it's going to come in, we'll find other things to do today."

There are a number of reasons Charlton swears by his weather-monitoring system, but the efficiency it creates in terms of scheduling is the No. 1 benefit to him.

"It's a great scheduling tool," he says. "Not only with our daily routines, but also with the forecast throughout the week. If it's predicting rain two or three days from now, we'll mow or fertilize before that."

Ultimately, a well-scheduled maintenance crew saves money in terms of labor, Charlton says. But savings don't stop at labor costs. Like in the nursery seeding instance, accurate weather-monitoring systems can pay for themselves in terms of materials, too.

"All it takes is part of an application to get washed away because you were unaware of a weather system coming in," he says. "Preventing that could pay for the weather-monitoring system for an entire year."

Evanston Golf Club uses the online version of DTN/Meteorlogix's WeatherSentry Turf Edition, the subscription for which Charlton estimates is $95 a month. Before

There are numerous reasons Dan Charlton swears by his weather-monitoring system, but the efficiency it creates in terms of scheduling is the No. 1 benefit to him.

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upgrading to the online version, the club had a stand-alone system, which required a monitor and an on-site satellite dish. Because Charlton wasn't working at Evanston when this unit was purchased, he's unsure about the initial hardware and set-up costs.

SHOPPING AROUND

Last year, when Charlton's subscription for the Meteorlogix system ended, he shopped around to see if he could find any free or cheaper services that provide similar results. Alternatives he considered included the National Weather Service, a free site called Intellicast and a local television station's weather page.

"I checked those out for about a month to see what I liked better," he says. "But I ended up renewing my subscription because I couldn't find anything that was better or equal for less."

At the time he renewed, Charlton also added the service's Lightning Manager feature. At first he was hesitant to add the lightning-protection upgrade because the facility already has a Thor Guard lightning prediction and warning system. But now he's glad he did – the systems complement each other well.

"My system is more of a check of Thor Guard," he says, noting the real benefit to that product is its sirens, which take the human element out of warning golfers and employees a lightning strike is possible.

The WeatherSentry lightning feature tells him if lightning strikes within a set radius and has tracking capabilities that allow him to see what direction the storm is coming from.

"If we got rid of Thor Guard, it would be my duty to sit in front of the computer and then run outside with a bull horn to warn people and hope they hear me," Charlton says. "But if I can predict a storm faster than Thor Guard and can get employees to a safe area, that's invaluable. You can't put a price tag on preventing someone from getting injured or killed because a storm came in."

Charlton's 17 maintenance employees appreciate the warnings, too – they keep them safe and dry.

"I always make sure to get them off the course before the heaviest rains come," he says.

Charlton can even check the radar from out of town on his smartphone and advise his staff about the weather. He recalls one instance when he was on the road for a long weekend and checked the weather at the course.

"I called my assistants and told them a storm was coming, but they argued it was a bright, sunny day," he says. "I told them I checked the radar and they better pull it in. Twenty minutes later they got hit with a huge storm. Later, someone at the club told me they made the comment, 'Here he is halfway across the country and he still knows the weather better than we do.'" GCI