BY J. MARSHALL CLARK, PH.D.

Pesticide and nutrient removal

Study optimizes vegetative filter strips for treating turfgrass runoff waters

A joint greenhouse and field project is under way at the University of Massachusetts-Amherst to evaluate plant species for their effectiveness in removing pesticides and nutrients from turfgrass runoff waters that enter the rhizospheres of plants in vegetated filter strips acting as buffer zones. Initially, a greenhouse study screened plant species for their ability to remove pesticides from soil. The best arrangement of selected plants within vegetated filter strips to optimize their ability to remove pesticides is being evaluated.

Vegetated filter strips will be compared to turfgrass buffer strips to determine the relative effectiveness of each and will consider how these two systems would work in conjunction with each other. The fate of contaminants entering the vegetated filter strips will be evaluated by analyzing soil, plant tissue, soil water and runoff for parent pesticides and their major breakdown products.

GREENHOUSE STUDY

A greenhouse study was carried out to identify the most effective plant species for placement in a field run-on plot. A silt loam was amended with six pesticides (Table 1, below) at 5 percent of their application rates. While this is an overestimation of the amount of pesticides likely being lost, it will provide sufficient residues for screening plants for their ability to remove pesticides from soil at an amount that exceeds the detection limits for these pesticides.

The study objective was to screen 10 aesthetically acceptable plant species for their ability to remove four commonly used and degradable pesticides: chlorpyrifos, chlorothalonil, pendimethalin and propiconazole from soil in a greenhouse setting, thus providing invaluable information about the species composition that would be most effective for use in vegetated filter strips. Plant treatments examined were:

- Big blue stem (*Andropogon gerardii*);
- Black willow (*Salix nigra*);
- Blue flag iris (*Iris versicolor*);
- Eastern gama grass (*Tripsacum dactyloides*);
- Perennial rye (*Lolium perenne*);
- Prairie cord grass (*Spartina pectinata*);
- Rice cutgrass (*Leersia oryzoides*);
- Tall fescue (*Festuca arundinacea*);
- Tufted sedge (*Carex stricta*);
- Woolgrass (*Scirpus cyperinus*); and
- an unvegetated control.

Many of these plant species have been effective in previous buffer strip studies or have some other quality (salt tolerance, dense growth, increase soil infiltration) that makes them good candidates.

Blue flag iris, big blue stem, eastern gama grass, prairie cord grass and woolgrass enhanced the loss of one or more pesticides from the greenhouse soil. Blue flag iris (76 percent chlorpyrifos, 94 percent chlorothalonil, 48 percent pendime-

Table 1. Characterization and use of pesticides of interest

Pesticide class	Pesticide name	Pesticide mode	Maximum application rate (23.5%)	Active ingredient lost from 60 ft² at 5% loss	Concentration in soil if all lost in first square foot on VFS*
Insecticides	Chlorpyrifos	Nonsystemic	1 lb/acre	0.03 grams	0.2 mg/kg
	Imidacloprid	Systemic	8.6 oz/acre (75% ai)	0.01 grams	0.15 mg/kg
Herbicides	Pendimethalin	Nonsystemic	3.6 oz/1,000 ft² (37.4%) or 5lbs/acre (60%)	0.11 grams	0.81 mg/kg
	2,4-D	Systemic	1.1 oz/1,000 ft² (48.99%)	0.05 grams	0.37 mg/kg
Fungicides	Chlorothalonil	Nonsystemic	20 lbs/acre (82.5%) or 16 2/3 pints/acre (54%)	0.52 grams	3.85 mg/kg
	Propiconazole	Systemic	176 oz/acre (14.3%)	0.05 grams	0.37 mg/kg

* Calculation based on a bulk density of 1.6 g/cm³.

thalin and 33 percent propiconazole were lost from soil after three months of plant growth), eastern gama grass (47 percent chlorpyrifos, 95 percent chlorothalonil, 17 percent pendimethalin and 22 percent propiconazole were lost from soil after three months of plant growth) and big blue stem (52 percent chlorpyrifos, 91 percent chlorothalonil, 19 percent pendimethalin, and 30 percent propiconazole were lost from soil after three months of plant growth) were excellent candidates for the optimization of vegetated filter strips (Figure 1 on page 77). Blue flag iris was most effective in removing selected pesticides from soil and had the highest aesthetic value of the plants.

These five species were selected for use in the establishment of one of the two plant treatments. In the mixture treatment, each species will be mixed evenly throughout the plot. In the succession treatment, species will be arranged in order of increasing height from the front of the vegetated filter strips (blue flag iris, woolgrass, prairie cord grass, big blue stem, and eastern gama grass).

FIELD STUDY

Twelve vegetated filter strips in a run-on plot will be used to evaluate the ability of four planting treatments (unvegetated, mixture of selected plant species, succession of selected plant species and succession of different heights of turfgrass, with each treatment replicated three times) to remove pesticides and nutrients from runoff water generated in two simulated rain events (one year and five year). The first year of the study was primarily for site establishment; the second year was for plant establishment. The third year of the study and any subsequent years will have application of one of the pesticide groups in June with the other group applied in July.

CONSTRUCTING THE STRIPS

A run-on plot for the field study was constructed at the University of Massachusetts Turfgrass Research Center in Deerfield during the summer of 2006. Native sandy loam was used as the subsoil, and a silt loam was brought in from another location to be used for the surface horizon (0 to 6 inches). The 12 vegetated filter strips in the run-on plot were 3 feet by 15 feet by 6 feet each, lined with an impermeable 36-mil polypropylene liner and graded to a 5-percent slope.

At the end (bottom) of each strip, an aluminum sheet was placed under 3 inches of soil for the last 12 inches of the strip to collect runoff. Beneath the lip of the collector, a 5-gallon bucket was inserted to hold a 1-gallon brown bottle used during the collection of runoff water from each vegetated filter strip in the run-on plot. On the front (top) end of each filter strip, an aluminum manifold with holes drilled at 2-inch intervals was placed to ensure water would flow evenly onto the strips.

Stainless steel lysimeters were placed 5 feet below the soil surface and about 14 feet from the top of the vegetated filter strips to sample the subsurface water flow at the bottom of each filter strip (Figure 2 on page 76).

STORM/RUN-ON SCENARIOS

Several storm/run-on scenarios on the bare (preplanted) vegetated filter strips were evaluated. The volume of runoff water applied as run-on to each filter strips was based on a one-year rain event. The runoff water generated during a one-year rain event was calculated to be 25.4 gallons during 24 hours from a turfgrass area 3 feet by 20 feet with a 5 percent slope (obtained by calculating the amount of water loss with these rain events using the SCS Curve Number Method, Climate System Research Center, University of Massachusetts-Amherst).

This water volume is applied to the top of the filter strips as run-on water. A storm scenario was selected, which produced runoff that was measurable and manageable. Early storm event trials were spread over a 24-hour period. It was clear from these early trials the one-year rain event had to be condensed to six hours and the soil needed to be presaturated to produce measurable runoff.

Soil presaturation was achieved by adding artificial rain for 10 hours (0.4 inches per hour), followed by a 12-hour drying period (6 p.m. to 6

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a.m.) before the initiation of the storm event. The storm scenario selected for the one-year rain event and the initial bromide tracer studies were as follows: Artificial rain for six hours total (6 a.m. to noon, for 2 inches total rainfall) and run-on for two hours (11 a.m. to 1 p.m. at 12.7 gallons an hour).

BROMIDE TRACER STUDY

A bromide tracer study was conducted to determine hydraulic characteristics and runoff flows on the 12 vegetated filter strips before planting. This allowed us to evaluate the effects the plants have on the flow of water through each filter strip, and it will allow us to know any differences observed in runoff of the pesticides because of the plant treatments not the differences in the hydrology between the plots.

Artificial run-on containing the bromide tracer was applied to each vegetated filter strip by using a scaled-down version of previous run-on studies. A holding tank was used to mix the water and bromide together, and then run-on water was pumped to the manifold as previously described for a one-year rain event. Runoff water volume from the run-on event was measured by collecting in 1-gallon amber bottles at the bottom of the filter strips.

Grab samples were collected every two minutes in 2-ounce amber bottles for bromide analysis. Run-on was started at 11 a.m., and the first bromide grab sample was collected at 11 a.m. Grab samples were collected until the 2-ounce bottle was full so collection duration varied depending on the runoff flow rate. Between grab samples, the runoff was collected into the 1-gallon amber bottles to ensure the entire runoff volume was collected.

The results of the initial preplanting bromide tracer study are shown in Table 2 (below). Only the first six minutes of bromide tracer data is shown because the bromide tracer had reached the end of the vegetated filter strips by the six-minute grab sample for all 12 vegetated filter strips.

PLANT ESTABLISHMENT

Individual vegetated filter strips were planted in replicates of three (unvegetated, random mixture of plant species, succession of plant species and turfgrass rough mix). Greenhouse-reared plugs of blue flag iris, eastern gamma grass, prairie cord grass and woolgrass were planted at a density of 25 plants per 9 square feet. Big blue stem was seeded at a similar rate and was thinned in spring 2008. Three filter strips were planted with a golf course rough mixture (80 percent Kentucky bluegrass, 20 percent chewings fescue) at a rate of 4 pounds per 1,000 square feet. The rough mixture was maintained at three different heights (1, 1.5, and 2.0 inches, top to bottom) during the growing season.

The results of the bromide tracer study were used to block the plant-

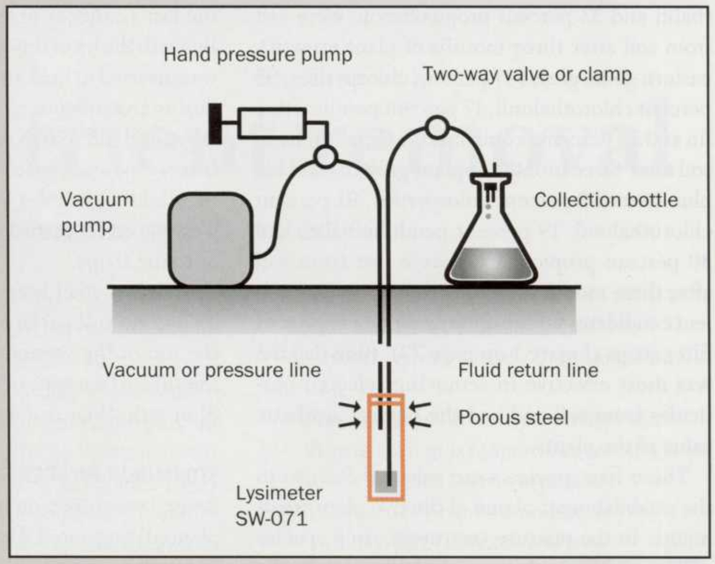


Figure 2. Lysimeters placed 5 feet below the soil surface and 14 feet from the top of the VFS allows subsurface water to be collected.

Table 2. Runoff rate, volume and bromide tracer concentrations

Strip	Runoff rate prerun-on (gal/hr)	Runoff rate with run-on (gal/hr)	Rainfall (inches)	Total volume (liters)	Run-on stop*	Runoff stop	Bromide (mg/L)** at 0 min	2 min	4 min	6 min	Planting
1	2.5	11.2	1.9 ± 0.60	58.4	1:16	1:25	0.27	600	2,060	1,900	Turf
2	0.9	7.6	2 ± 0.13	47.1	1:14	1:20	1.02	0.23	2,690	1,910	Succession
3	1	9.2	1.9 ± 0.19	49.2	1:18	1:42	0.7	95.1	1,450	1,890	Bare
4	1	9.2	2.2 ± 0.16	43.8	1:15	1:19	BDL	169	150	1,920	Random
5	3.8	10	2.5 ± 0.13	50	1:06	1:51	BDL	480	1,560	1,610	Bare
6	0.4	4.4	2.2 ± 0.10	22	1:09	1:31	BDL	660	1,820	1,620	Random
7	0.4	4.3	1.9 ± 0.10	19.7	1:14	1:21	BDL	BDL	BDL	3	Turf
8	1.7	8.7	1.9 ± 0.10	40.5	1:11	1:49	0.75	70	1,500	1,680	Succession
9	2.5	13	2 ± 0	77.3	1:09	1:33	2	1,360	2,230	2,430	Succession
10	1.9	9	2.2 ± 0	42.4	1:06	1:29	BDL	230	1,560	1,620	Turf
11	2.3	10.5	2.3 ± 0.11	54.5	1:05	1:37	BDL	140	1,170	1,360	Random
12	1	6.2	2.2 ± 0.22	26.5	1:05	1:36	0.12	0.11	0.1	470	Bare

*Time run-on delivery tank was empty. ** Bromide added at 4,000 mg/l. BDL = below detection limit ings in groups of three vegetated filter strips (fast, intermediate and slow flow rates). The individual vegetated filter strips were planted as shown in Table 2.

FUTURE RESEARCH PLANS

The six pesticides used in the greenhouse study, plus cyfluthrin, will be used in the vegetated filter strip run-on field trials. Pesticides will be applied with a water volume that would be generated for a one-year and five-year rain event. Bromide also will be added to the pesticide containing water at 4 grams per liter as a tracer.

Before applying the pesticide-containing water, the vegetated filter strips will receive a water volume that would occur in a one-year or five-year rain event (see storm scenario mentioned earlier). In the case of the five-year rain event, this would involve adding 3.8 inches of water as rain over 24 hours and 62.1 gallons of water as runoff over 24 hours. The expected runoff water coming from a vegetated filter strip is about 31 ounces for the one-year rain event and 36 gallons for the five-year rain event.

The mass of pesticide lost will be evaluated using the concentration of the pesticide and the volume of water collected during runoff. In addition to pesticides, runoff water will be monitored for losses of nitrogen and phosphorus from fertilizer inputs. Soil, soil water and plants within the vegetated filter strips also will be analyzed to determine if the pesticides lost from the runoff water are sorbing to the soil, being degraded in the soil, taken up by the plants or potentially lost to leaching or subsurface flow. These values will be compared against the bromide tracer, which will move freely with the run-on water.

Soil sampling will be conducted at three different depths at three locations within the vegetated filter strips (1 foot, 6 feet, and 11 feet from the top of each strip). The reason for sampling at multiple locations is half the pesticides of interest are water soluble. Also, many investigators have shown that even chemicals that sorb tightly to the soil can be found deeper in the soil profile than would be expected based on the physical and chemical properties of those chemicals because of preferential flow pathways established by earthworms and old root channels. Analysis will be conducted for parent compounds and expected metabolites based on existing literature.

Soil water will be collected with lysimeters and should include water that has passed through all the rhizospheres and soil in the upstream part

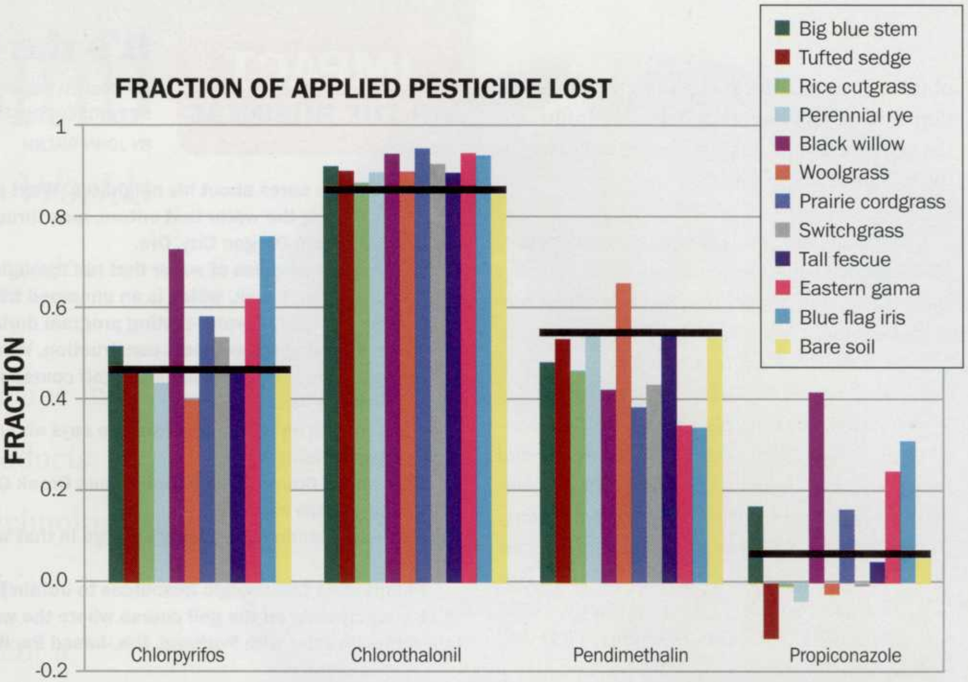
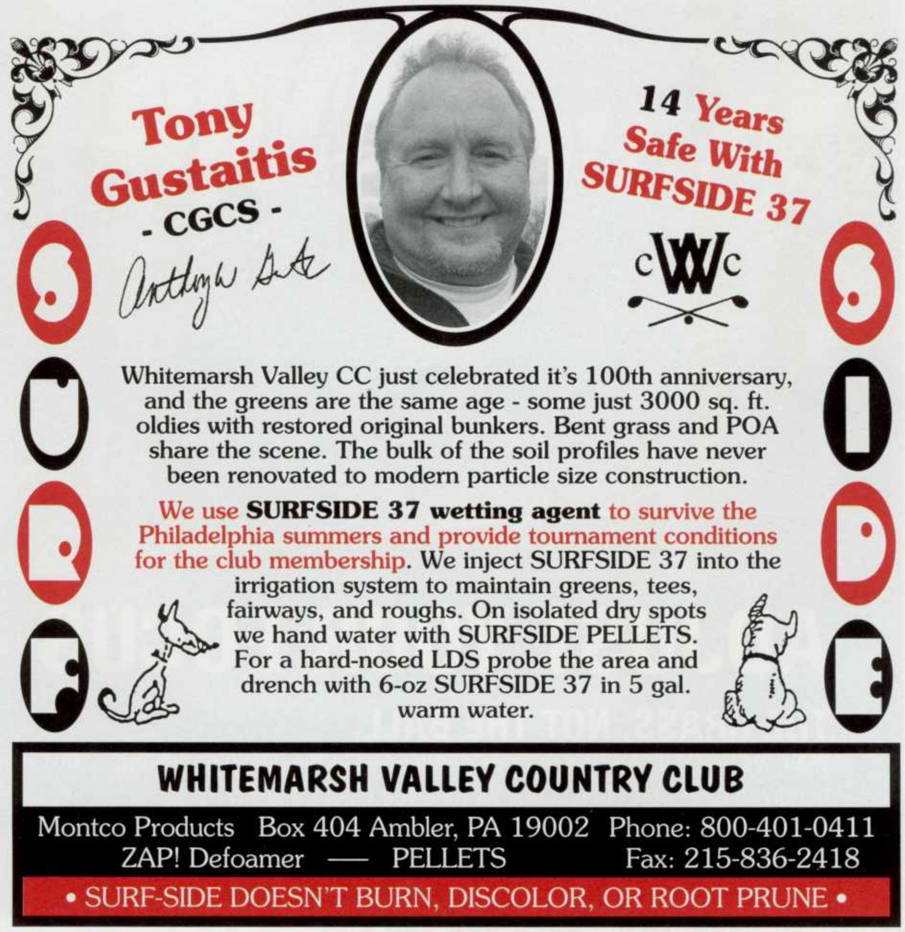


Figure 1. Fraction of applied pesticide lost from greenhouse soil for chlorpyrifos, chlorothalonil, pendimethalin and propiconazole. Horizontal lines represent unvegetated controls (bare soil).



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of the vegetated filter strips and give an indication of whether or not pesticides that infiltrated the vegetated filter strips are being lost to leaching or subsurface flow. GCI

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IMPACT ON THE BUSINESS

It's the neighborly thing to do

An Oregon superintendent regularly tests streams for pesticide contaminants

BY JOHN WALSH

David Phipps cares about his neighbors. Want proof? He's spent $65,000 throughout the past eight years testing the water that enters, runs through and exits the golf course he maintains – Stone Creek Golf Club in Oregon City, Ore.

There are two bodies of water that run through the golf course. Beaver Creek runs below the course, and Stone Creek, which is an unnamed tributary, runs through it.

Phipps started the water-testing program during the golf course's infancy, as soon as the grass was planted during the course's construction. When the golf course was being built, he knew some people in the area thought building a golf course was harmful to the environment. Phipps wanted to show them otherwise.

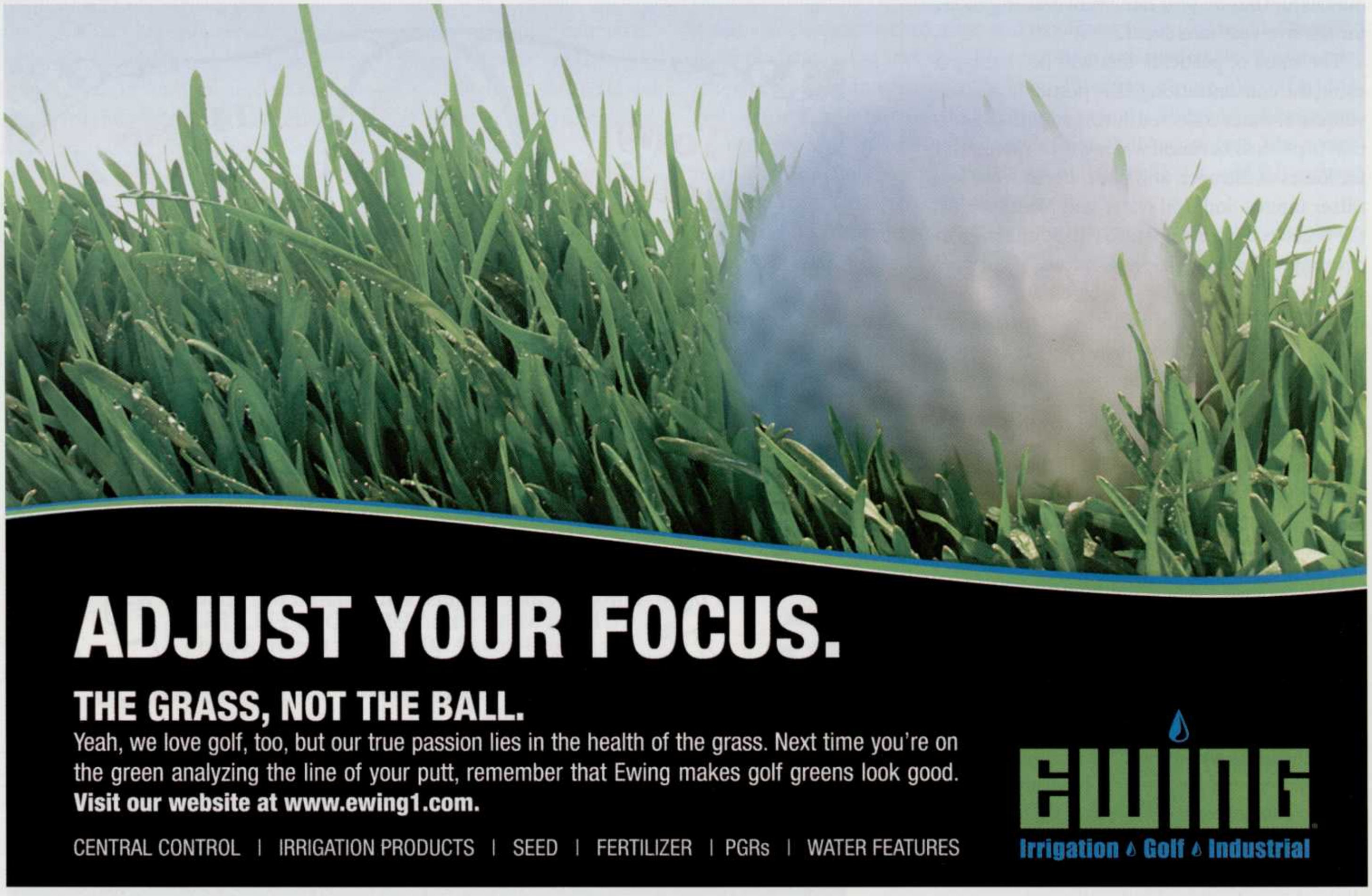
"I wanted all my ducks in a row," he says about backing up the fact that a golf course is beneficial to the environment.

Clackamas County, which owns Stone Creek Golf Club, bought into the water testing from the beginning, Phipps says.

"We're protecting the county's image in that we're looking to protect the neighboring properties," he says.

Phipps uses EnviroLogic Resources to obtain the water samples. The samples are gathered at strategic points on the golf course where the water enters and exits the property. Steve Thun, laboratory director with Portland, Ore.-based Pacific Agriculture Laboratory, performs the actual water

(continued on page 88)



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(Impact on the business *continued from page 78*)

testing. Each test, which includes a complete report from EnviroLogic Resources, costs as much as $5,000 and detects orthophosphates, nitrates and pesticides. Phipps determined what Thun's tests detect based on the chemical products he uses to maintain the turfgrass.

Overall, Phipps is following environmental stewardship guidelines published by the Oregon GCSA and his own integrated pest management program. When applying pesticides, Phipps considers using new products and whether he wants to introduce a new chemical class into his IPM program. If he did that, he would have to have the water tested for the new class of chemical, which would translate into additional costs.

"My IPM makes me think about what chemicals I use," he says. "It's a back-door way not to use additional pesticides because I might have to pay for the extra test."

In the past, the water tests detected a minute amount of the insecticide Sevin (carbaryl). Phipps applied three pounds of granular carbaryl to an approach (1.7oz. AI/1,000 sq. ft.) one time but stopped using it four years ago because of its tendency to move into the soil. He says sandy soil might have been one reason why the product moved so quickly through the soil and was detected in the adjacent pond. It also could have come from nearby treated residential lawns, which run onto the property. Regardless, there was no direct runoff from the golf course.

Since the testing started, Phipps has ceased using three pesticides: Sevin, Rubigan (but for reasons other than pollution) and Confront, which contains clopyralid, which also had a small detection in the tests. He tries to steer clear of insecticides, but Stone Creek has a crane fly nuisance, so he'll spot treat only the areas that have a history of infestation.

The county wants Phipps to reduce the amount spent on water testing because of the economy. Phipps and the county feel comfortable reducing the testing frequency to once a year because the tests have occurred twice a year for eight years and there haven't been any detections, which are measured in parts per million, in the past two years.

Generally, golf courses are better than many other industries when it comes to pesticide use, Phipps says. He cites Christmas tree growers who spray insecticides on trees with bare soil below them. There's nothing to filter the pesticide, unlike turf on golf courses.

"But nurserymen don't get fingers pointed at them like golf courses do," he says.

Phipps acknowledges many superintendents don't have the budget to implement these water tests. He estimates there are 24 golf courses in Oregon that test water like he does. There are even more testing just for nitrates and orthophosphates. Phipps says this approach is cheaper and probably costs in the hundreds of dollars, not thousands.

"It's a tough nut to crack," he says. GCI