Buffer Strips, Runoff, and Leachate at Wisconsin River Golf Course:

UW-Madison Research Aims at Smart Legislation

By Dr. John Stier, *Professor and Department Chair, Department of Horticulture and*
Dr. Wayne Kussow, *Professor Emeritus, Department of Soils, University of Wisconsin-Madison*

The Wisconsin DNR (WDNR) rule to reduce non-point source pollution of surface waters, NR151, went into effect last March. Golf course superintendents may remember the original draft of the rule required buffer strips of "native plants" (i.e., prairie) to be planted between any impervious surface or mowed turf areas and surface waters. Many members of the turf industry, along with University of Wisconsin researchers, provided input at public hearings during vetting of the original NR151 draft, questioning the lack of science to support the buffer strip requirements. The WDNR acceded to the lack of buffer strip data, and at least temporarily removed the buffer strip requirement until scientific data could be developed to properly guide future regulation.

Fig. 1. Prairie buffer strip (left) and fine fescue buffer strip (right) plantings alongside the eighth fairway at Wisconsin River Golf Course, Stevens Point, WI, in spring 2004. Note the fine fescue has already established vegetative cover.

The UW-Madison response and research protocol

In order to help create sound, scientifically-based regulations to protect the environment and the golf course industry, Dr. Wayne Kussow and I initiated a study to research the usefulness of buffer strips on golf courses. Both the Northern Great Lakes Golf Course Superintendents Association and the United States Golf Association provided funding to conduct the research. Because regulations tend to be inflexible and treat the entire state equally, we sought to conduct the research on a northern golf course, outside the historic range of prairie, on relatively poor soils. The ownership of the Wisconsin River Golf Course in Stevens Point, WI, agreed to let us conduct the research on the golf course; two superintendents over the course of our study assisted us (Tod Blankenship and Troy Jastal).

We chose to test fine fescues alongside prairie plantings for the buffer strips because fine fescues are already used in rough areas of many golf courses and they were suited to the relatively low pH soil (< 6). Since the initial NR 151 draft would have required a certain size of buffer strip without regard to size of the fairway, even though common sense and research data indicate buffer strip sizes should be based on the area they drain, slope, etc., we tested buffer strip lengths of one-eighth, one-fourth, and one-half the size of the fairway area. The soil type was a relatively well-draining sandy loam. Runoff collectors were installed at the downslope end of each buffer strip plot (Fig 1). Lysimeters to monitor leachate (i.e., water draining into the groundwater) were placed just upslope of the runoff collectors.

The plots were seeded in October 2003 because this would favor the prairie plantings and is acceptable for fine fescue. Plots were seeded along three different fairways: number 4, 8, and 9. Fairway 9 was relatively open, 8 had some sparse tree cover, and 4 had relatively denser tree cover. We covered the freshly-seeded plots with a biodegradable,wood fiber-based erosion control mat (Futerra®) that facilitates germination and prevents seed from moving in the case of runoff.

Runoff was collected and measured each time sufficient rainfall occurred between early spring 2004 and autumn 2005. The initial couple of years after establishment is a critical time because phosphorus contamination of surface waters, which causes algal blooms, is well-correlated with sediment loss which occurs primarily when there is insufficient vegetative cover. We collected leachate on average once each month (Fig. 2). Runoff water samples were assayed for sediment and total phosphorus (TP) because these are the two contaminants most typically regulated in runoff water from vegetated areas. Leachate samples were assayed for nitrate (NO3-) as this is a regulated contaminant in drinking water.

Fig. 2. Graduate student Jake Schneider pumps a lysimeter sample from below-ground of a buffer strip plot at Wisconsin River Golf Course, Stevens Point, WI.

What we found

Runoff. The rough along the 9th fairway where we'd placed our plots was flooded during 2004, preventing that site from providing any useful data. Statistical analysis of sample data collected from the other two sites showed runoff volumes and TP amounts were not affected by any of the buffer strip treatments (Table 1). In 2004, 5% of the precipitation was collected as runoff, and in 2005 about 9% of the total precipitation was collected as runoff. These results were about what we'd expected, based on previous research that shows vegetated sites typically allow less than 10-20% of precipitation to run off-site. The runoff that did occur happened primarily during snowmelt and intense rainfalls when precipitation rate (i.e., amount of rainfall per hour) exceeded the capacity of the ground to absorb rainfall. Such events occurred primarily in the spring of 2004 and 2005, and again in late summer 2005 (Fig. 3).

Total phosphorus in runoff was less than 0.2 kg ha^{-1} in 2004, and

Table 1. Runoff and total phosphorus (TP) in runoff from buffer strip plots at Wisconsin River Golf Course, Stevens Point, WI.

	Runoff water (mm) †		TP (kg ha^{-1})	
Treatment	**2004**	**2005**	**2004**	**2005**
No buffer	35	37	0.10	0.02
Fine fescue 1:8	45	65	0.19	0.06
Fine fescue 1:4	38	86	0.16	0.04
Fine fescue 1:2	45	77	0.22	0.04
Prairie 1:8	41	59	0.17	0.05
Prairie 1:4	49	85	0.16	0.05
Prairie 1:2	34	66	0.12	0.04
P-value	0.99	0.79	0.98	0.95

† Total precipitation during the monitoring periods was 827 and 739 mm in 2004 and 2005, respectively.

‡ Buffer strips were one-eighth, one-fourth, or one-half the width of the fairway area which could potentially drain into the buffer strips.

most of this occurred in spring before vegetation was established in the plots. The amount of phosphorus would have been much greater if we hadn't used the wood fiber mats to control erosion. In 2005, after the wood fiber had degraded and plants were established, TP leaving the site in runoff was about one-third to one-fifth that which occurred in 2005. Total phosphorus is a combination of sediment-bound phosphorus and water-soluble phosphorus. In 2004, most of the TP was in the form of sediment-bound phosphorus (Stier and Kussow, 2009). In 2005, only about half of the TP was sediment-bound because the increased amount of vegetation inhibited sediment movement, however, the amount of soluble phosphorus increased. Soluble phosphorus increases in runoff as vegetative cover increases because it leaches from plant leaves, however, a well-vegetated surface will still have significantly less TP than an area with little or no vegetation (Steinke et al., 2007).

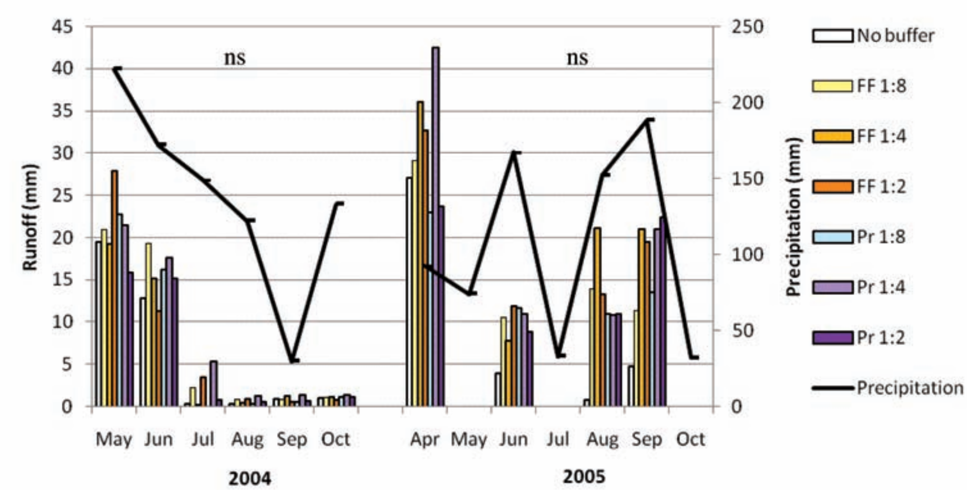

Fig. 3. Runoff from fairway buffer strip treatments at Wisconsin River Golf Course, Stevens Point, WI. Black lines indicate the precipitation (note the different order of units compared to runoff).

Phosphorus concentrations in runoff exceeded the U.S. Environmental Protection Agency (EPA) limit of 0.1 mg P L^{-1} for waters entering rivers in 93% of the 454 samples we collected. This is not unusual for water samples collected from land surfaces as phosphorus is picked up from soil, vegetation, and even enters from atmospheric deposition. Reporting concentration alone gives a false indication of the potential pollutant entering a body of water, as concentrations often increase in runoff as runoff volume decreases. Consequently, we reported TP in terms of kg ha-1 because ultimately the amount of phosphorus entering a surface water is more important than the concen-

Table 2. Annual leachate amount (mm), during the growing season, resulting from different types of vegetated surfaces at Wisconsin River Golf Course, Stevens Point, WI.

Buffer strip treatment	2004†	2005
No buffer	339	342
Fine fescue 1:8‡	442	548
Fine fescue 1:4	313	289
Fine fescue 1:2	536	372
Prairie 1:8	480	348
Prairie 1:4	390	339
Prairie 1:2	354	261
P-value	0.89	0.86

† Total precipitation during the monitoring periods was 827 and 739 mm in 2004 and 2005, respectively.

‡ Buffer strips were one-eighth, one-fourth, or one-half the width of the fairway area which could potentially drain into the buffer strips.

tration (to convert to lb per acre, simply divide by 1.12).

All treatments had equal water infiltration and returned about 50% of precipitation as potential groundwater (Table 2). The difference between runoff plus leachate and precipitation was likely returned to the atmosphere as evapotranspiration, which was about 40-45% of precipitation during the growing season. Nitrate levels in leachate from the fine fescue and prairie buffer strip treatments exceeded U.S. EPA guidelines for drinking water during spring 2004 (Fig. 4). The excessive nitrate levels were likely due to existing N being released from soil following tillage operations in spring 2003 as no N fertilizer was ever applied to the buffer strip plots. The fairway treatment without buffer strip was the only treatment at this time to not have excessive N in leachate despite being fertilized with 45 to 90 lb N acre-1 annually. In 2005, nitrate levels from the fairway treatment briefly rose above the EPA guidelines in the spring but were not statistically different from the buffer strip treatments. Nitrate levels also rose above drinking water guidelines at the last sampling event in autumn 2005 in the smallest buffer strip treatment composed of fine fescue, but again, data were not statistically meaningful compared to other treatments.

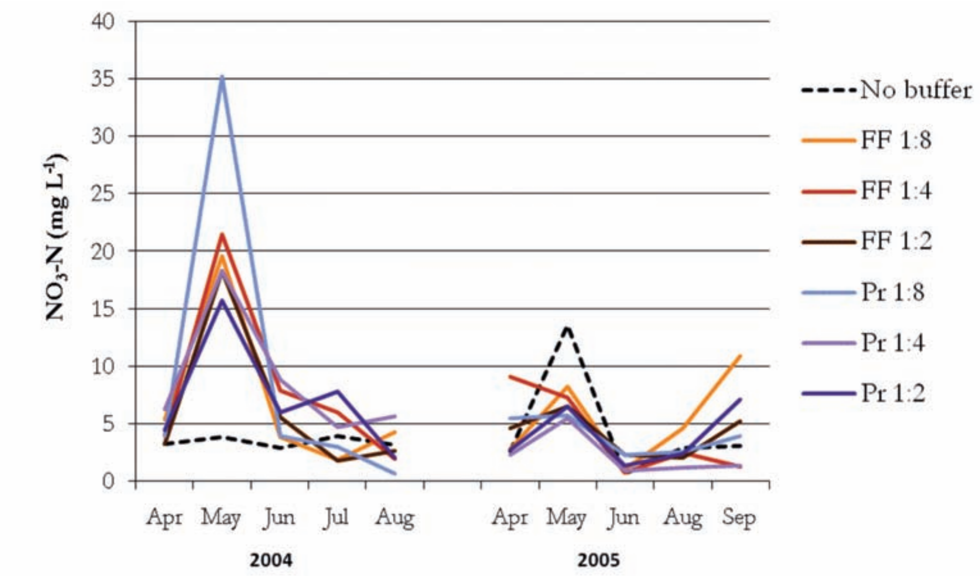

Fig. 4. Nitrate leaching from golf course fairway and buffer strips alongside fairways at Wisconsin River Golf Course, Stevens Point, WI. The legend indicates buffer strips as fine fescue (FF) or prairie (Pr), in ratios of 1/8, 1/4, or 1/2 the width of the fairway. The U.S. EPA drinking water limit is 10 mg NO3-N L-1.

One of the additional things we noted during our study was that the prairie plants failed to establish very well, particularly along the 4th fairway which was more heavily shaded than the 8th fairway. Instead, annual weeds and *Poa annua* provided soil cover, and did a fair job of controlling runoff. Regulations require a particular type of vegetation at a site to which it is not adapted will potentially cause more harm than benefit.

The lack of difference between buffer strip treatments could be surprising to some persons as native plants (i.e., prairie) are often thought of as somehow being inherently better for the environment in all respects than turfgrasses, however, this is simply not the case. Data from our studies show that it is impossible to achieve zero phosphorus in runoff or nitrate in leachate as both of these minerals are often naturally abundant and play an important role in healthy ecosystems (Steinke et al., 2007; Steinke et al., 2009). In the current study, our data did not indicate golf course fairway management to be a significant source of either phosphorus or nitrogen.

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