BY JOHN C. STIER AND WAYNE R. KUSSOW

Buffer Strips, Runoff, and Leachate

Research compares nutrient loading in runoff and leachate when buffer strips are used alongside golf course fairways.

Federal mandates to decrease nutrient pollution of water supplies are resulting in various local and state regulations aimed at reducing phosphorus (P) movement into surface waters and nitrogen movement into groundwater. Some regulations aim to reduce nutrient and sediment loading into surface waters based on the idea that "native" or prairie vegetation should be used as buffer strips between mowed turf and natural areas or surface water.

Some research indicates that dense turf vegetation is more effective at reducing runoff and nutrient leaching than other strategies, including mulched landscaped beds. Data are just starting to be published that report on the effectiveness of prairie buffer strips to reduce nutrient loading in water runoff and leachate relative to turf. Also unknown is the size requirement of buffer strips relative to the area they are to be buffering.

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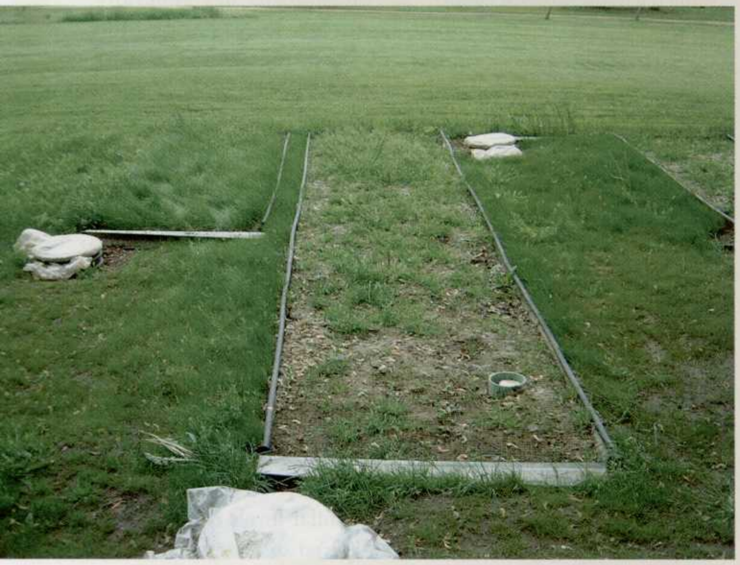
Turf is often used as a ground cover throughout inhabited areas including golf course roughs because it is relatively easy to establish and maintain, provides contiguous ground cover throughout the year under traffic and mowing, and the low mowing height facilitates human activity while discouraging vermin and insect pests. The turf species allow some type of turf to be established across a diversity of situations, including moist or dry soils, and moderately shaded to full-sun conditions.



Prairie planting takes less care, but can cost more to get started.

Prairie plantings are being increasingly promoted as a low-cost alternative to managed turf. They are also seen as "native," while most cool-season turf species were introduced from Eurasia. Although management is usually much less intensive than turf, establishment of prairie vegetation is not necessarily less expensive than turf, as prairie seed may cost considerably more. Prairie establishment may take years, during which time weeds, especially noxious weeds, must be regularly controlled. Lastly, prairie plantings are not necessarily suited for many habitats, such as wooded golf courses. A number of courses utilize fine fescues as low-maintenance roughs, which receive almost as little attention as prairie areas, yet establish quickly and easily. Generic regulations that require the installation of prairie buffer strips can be costly, reduce valuable golf turf areas, and promote the assumption that turf has inherently negative environmental consequences.

Data from various projects suggest that annual nutrient loading from mowed turf may be similar to that from prairies, as most of the nutrient loss occurs when nutrients are leached from dead foliage. When we began the study in 2003, there were no data that directly compared the efficiency of turf to prairie vegetation for its ability to minimize runoff and leachate pollution, particularly during the establishment phase, which can last for two to three years.

The project goal was to compare the relative amount of nutrient loading in runoff and leachate when prairie and fine fescues were used as buffer strips alongside golf course fairways. We also wanted to determine the effect of three different ratios of buffer strips relative to the fairway area draining into the buffer strips. The information will be useful for predicting effectiveness of different vegetation types and buffer strip sizes on golf courses.

GROWING BUFFER STRIPS AND INSTALLING WATER SAMPLERS. Research plots were constructed in 2003 at the Wisconsin River Golf Club (WRGC) in Stevens Point, Wis. The golf course is adjacent to and drains into the Wisconsin River. Two large natural areas exist within the course and the course is surrounded primarily by forest with a small amount of agricultural land. The plots were developed in the roughs that drain fairways 4, 8, and 9. Fairways were approximately 85 feet wide and crowned in the middle with 1-2 percent slopes. Fairway turf was predominantly annual bluegrass (*Poa annua L.*).

Buffer strip plots were installed at the edge of the fairways and had slopes ranging from approximately 1 to 4 percent. Plots on fairway 9 were in full sun, plots on fairway 8 were in slight shade, while plots on fairway 4 were moderately shaded. Treatments included 2:1, 4:1, and 8:1 fairway-to-buffer-strip ratios, with one ratio each of prairie or fine fescue mixtures. A seventh treatment in each replicate was a no-buffer-strip plot.

Runoff collection flumes (1-meter width) were installed at the lower end of each buffer strip plot. Each collection flume had a cover to prevent debris from falling into the flume, while a screen-covered slit at the soil surface allowed runoff water to enter. Leachate was collected in each buffer strip, using a low-tension lysimeter installed just upslope of the runoff collection weir.

Plots were dormant-seeded in October, as recommended for prairie plantings, and they were covered with a biodegradable wood fiber erosion control blanket. Prairie plots were planted with a commercial prairie seed mixture that included flowers and grasses. Fine fescue plots were seeded to a commercial seed mix containing Chewings, creeping red, blue and hard fescues.

None of the plots were irrigated, treated with pesticide, or fertilized during the study. Plots were mowed (clippings returned) at 30-inch height in early spring 2004 and 2005 to encourage new growth in accordance with recommendations for prairie establishment. Fairways received 108 to 216 lb. N acre-J annually in one or two applications (spring and fall), with approximately 5.5 to 11 lb. P acre-1 each year. Fairways received little to no irrigation, so snow melt and rainfall provided the source of runoff water. The 9th fairway remained flooded from excessive rainfall throughout most of 2004 and part of 2005 and was dropped from the study.

ANALYZING WATER QUALITY AND VEGETATION. The leachate water samples were analyzed for nitrate- and ammoniacal-N and soluble phosphorus. Runoff samples were analyzed for three P types: soluble P, biologically active phosphorus (BAP), and total phosphorus (TP), which were extracted from both sediment in the water as well as the water itself. Sediment in runoff was collected and quantified. Turfgrass and prairie plant stands were analyzed two to three times each year by determining the percentage of desirable plants (turf or prairie), weeds and bare soil.

RESULTS AND DISCUSSION. Fine fescues covered nearly 40 percent of the ground by early May 2004, while weed seedlings were the only vegetation on the prairie plots. Fescue cover was excellent by August, while annual weeds covered 80 percent of the ground in prairie plantings. A few prairie plants were present, but they comprised less than 1 percent of the ground cover. By June 2005, fescue cover remained dense and prairie vegetation had increased to 18 percent, though weeds still covered more than three quarters of the plot area. Several of the prairie flower species were evident by summer 2005, though few bloomed that year. None of the prairie grasses were ever observed, consistent with several of our other establishment projects using similar prairie seed mixtures. Prairie plots on fairway 4 had more weeds, especially *Poa annua*, than plots on fairway 8 that were less shaded. Regulations requiring native vegetation for buffer strips in situations where climatic conditions are not favorable are likely to result in unwanted vegetation and/or exposed soil that will not necessarily decrease nutrients in runoff or leachate.

In our study, less than 5 percent of the total rainfall during the sampling period in 2004 ran off fairway and buffer strip surfaces, while less than 1 percent of rainfall ran off during 2005. The minimal slopes of the fairways (1-2 percent) likely helped infiltration to occur by reducing speed of runoff despite periods of heavy rain. The nearly complete ground cover was likely just as, if not more, important for reducing runoff by slowing its rate and allowing it to infiltrate into the soil.

None of the buffer strips changed runoff or phosphorus loading compared to the fairway alone, indicating fertilizer was not an important source of phosphorus. Total phosphorus losses on a land area basis were similar, or less than, the annual 0.1 kg P ha-1 loss reported for native prairie in Minnesota when rainfall-induced runoff averaged 6 mm per year, and similar, or less, than the 0.18 to 7.04 kg P ha-1 in surface runoff from a variety of Oklahoma grazing lands.

Editor's note

A more complete version of this report can be found at USGA Turfgrass and Environmental Research Online: http://usgatero.msu.edu/v05/n22.pdf

Phosphorus runoff in our study was more than 20 times less than that reported for wheat production, probably due to greater vegetative cover in the golf course system. Phosphorus sources in our study likely included natural sources such as vegetation, soil, and precipitation. We've found similar results when comparing Kentucky bluegrass (*Poa pratensis*) and prairie buffer strips for controlling urban runoff.

A growing body of evidence indicates that when ground is well covered by vegetation (e.g., 70 percent), total P losses may be much reduced compared to predominantly exposed soil. In exposed soil situations, sediment bound P is often the primary type of P. Vegetation greatly reduces total P runoff by reducing both runoff volume and sediment, though soluble P may increase as it leaches from vegetation and organic P-containing particles move in runoff Prairie plants may be especially prone to P loss from vegetation, as they are predominantly C4 plants with foliage that dies in early autumn, while C3 turf foliage may survive the winter and has a steady but low turnover rate coupled with less abundant above-ground biomass than prairie vegetation.

In our study, about 25-50 percent of the total P in runoff was bio-available P (BAP). This is the type that stimulates algae blooms in ponds, lakes, and rivers. Values in our study were at least 20 times less than BAP in wheat field runoff and similar to BAP runoff from native grassland. Our data are important because they represent natural background levels of phosphorus. Consequently, regulations to limit phosphorus fertilization would in this case be ineffective at reducing phosphorus loading. Ultimately it is impossible to achieve zero P runoff.

Buffer strips did not affect phosphorus or nitrogen leaching below the soil surface. Nitrogen is the most important nutrient contaminant in leachate water because excessive levels in drinking water may have adverse human health effects, such as blue baby syndrome. The U.S. EPA sets the drinking water limit at 10 ppm nitrate-nitrogen. In our study, this level was exceeded in 2004 under the fine fescue plots, but the results were not statistically different from leachate under prairie plots or fairway alone. The higher concentrations in 2004 were likely due to soil disturbance effects from the establishment process and lack of vegetative cover until May 2004. In 2005, all nitrogen concentrations were below 10ppm and were likely lower than 2004 because more vegetation existed in the second year.

Phosphorus has generally been regarded as having little movement in soil and so most leaching studies do not measure phosphorus. However, increasing awareness of ties between ground and surface water may soon require additional knowledge of phosphorus leaching. Easton and Petrovic reported more than 50 percent of P applied to turf from swine compost leached below the surface, while synthetic fertilizer sources had significantly lower leachate losses. Our study indicates that an unfertilized prairie stand has similar levels of P leachate compared to unfertilized fine fescue turf and fertilized *P. annua* fairways. Phosphorus and nitrogen contamination of runoff and leachate water from golf course fairways was similar to natural background levels reported for nonfertilized native prairies and was not affected by buffer strip type or size. **GCI**

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