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Measuring Nitrogen Loss from a Floating Green

A unique opportunity to assess nutrient losses.

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Environmental concern by the turfgrass industry and the public has promoted the development and implementation of best management practices (BMPs) for golf courses. A major area of concern on golf courses is the application of fertilizer to potentially highly leachable sand-based putting greens.

Several nitrogen leaching studies have been conducted. However, except for the work of Johnston et al. (5) and Rummele (10), many leaching studies tend to be conducted at small-scale university research plots under very controlled conditions, and they may not accurately represent golf course conditions of management and play.

WHY THIS STUDY WAS DIFFERENT

Our research was unique because no study had monitored leachate flow and nutrient concentration on an entire golf course green receiving play. In addition, the green received its normal maintenance by the golf course superintendent throughout the three years of the study. By accurately monitoring flow through the rootzone and sampling the leachate to obtain nitrogen concentrations, the total quantity of nitrogen being leached could be determined.

The overall goal of this study was to provide scientific data for the development of best management practices for sand-based turfgrass systems. To accomplish this goal, the objectives were to measure flow through a sand-based putting green under golf course management and play, and determine the nitrogen concentration and quantity in the leachate and grass clippings.

After installing the drainage system, polystyrene-filled concrete cells staggered in two layers provided the buoyancy of the floating green.

THE FLOATING GREEN — A MASSIVE FIELD LABORATORY

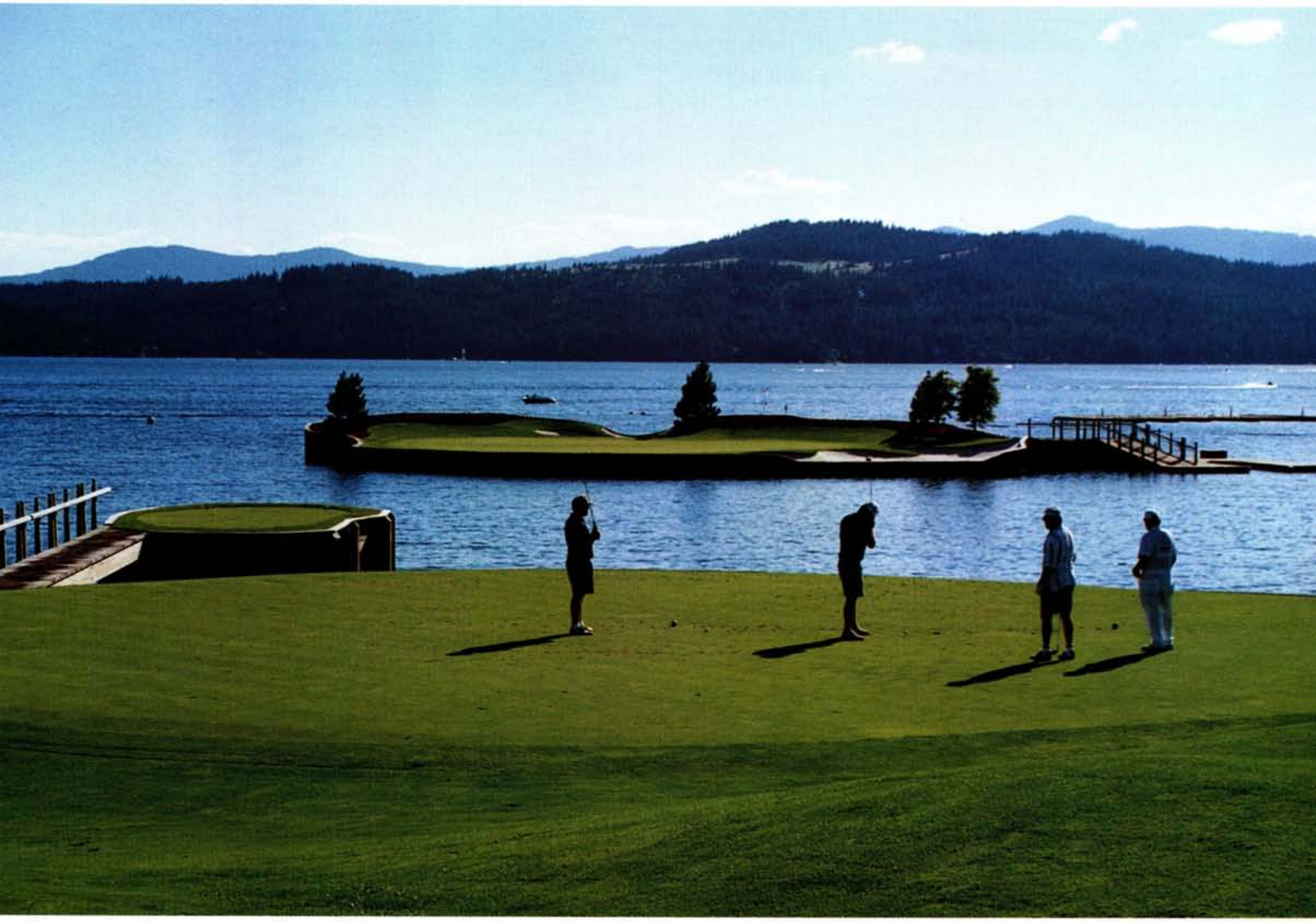
The 15,000 ft.^{2} floating island green used in this study was constructed in 1990 at the Coeur d'Alene Resort Golf Course, Coeur d'Alene, Idaho. Buoyancy was provided by approximately 100 polystyrene-filled concrete cells (30 ft. × 10 ft. × 3.5 ft.) staggered in two layers. To minimize weight, the green contours (subsurface grade) were constructed of Styrofoam sections.

The 7,000 ft.^{2} putting green has a USGA-recommended rootzone with 14 in. of sand above a 4 in. layer of pea gravel. The putting surface was sodded to Penncross creeping bentgrass (*Agrostis stolonifera* L.). The green was irrigated with water pumped directly from Lake Coeur d'Alene. Since Lake Coeur d'Alene is a large body of water (approximately 25,000 acres), as expected, there was negligible fluctuation in lake water NO_3-N and NH_4-N concentrations during the study. NO_3-N and NH_4-N were 40 and 80 ppb, respectively (0.04 mg L^{-1} and 0.08 mg L^{-1}, respectively).

MONITORING FLOW AND SAMPLING LEACHATE

Downward flow of leachate into the Styrofoam was prevented by an impermeable liner placed above the Styrofoam sections and beneath a herringbone drainage system connected to two 850-gallon storage tanks located under the front and rear bunkers. The putting green drainage was isolated from the surrounding area by a vertical liner. All leachate passing through the putting green soil profile flowed through a small trapezoidal flume attached to the main drain prior to flowing into the rear storage tank. When the rear tank was nearly full, leachate was pumped via a 4 in. flexible tube to a drainage field on shore.

From the flume a leachate sample was collected daily and flow was recorded every 30 minutes. Leachate samples were stored within an automatic sampler at 34°F (1°C) to insure sample stability, transported to Washington State University, and frozen until nitrogen analysis was performed with a flow solution analyzer. A weather station was installed at the site to record environmental parameters. Soil moisture potential and temperature probes were placed 39 in. onto the green and 5 in. below the surface. Data were collected every 30 minutes to correspond to the collection of the flow sample.



Using a unique floating green at Coeur d'Alene Resort Golf Course (Idaho), Washington State University researchers were able to track nitrogen leachate after nitrogen fertilizer applications.

FERTILIZER APPLICATIONS

A foliar fertilizer, 24-0-24 Nitro-K Plus II at 0.1 lb. N per 1,000 ft.² (1.75% ammoniacal N, 3.0% nitrate N, 19.3% urea N), was applied by the golf course superintendent every 7 to 10 days during the growing season. In addition, Ferromec (15% urea N) was added to the foliar fertilizer at a rate of 1 oz. per 1,000 ft.² The total nitrogen applied annually to the green ranged from 3.4 to 4.2 lb. per 1,000 ft.²

Nitrogen was increased to 0.3, 0.6, 0.7, 0.9, or 1.2 lb. N per 1,000 ft.², one application at each rate, to observe the effects of higher N rates. Nitro-K Plus II was applied at 0.3 or 0.6 lb. N per 1,000 ft.² on August 5 and September 4, respectively. Scotts 26-4-13 with minor elements (0.6% ammoniacal N, 9.9% urea N, 10.8% water-soluble organic N, and 4.7% water-insoluble N) was applied at 0.9 lb. N per 1,000 ft.² on April 8, 1999, and 0.7 lb. N per 1,000 ft.² was applied September 17, 1999, as Scotts Starter Fertilizer 19-25-5 (4.3% ammoniacal N, 7.4% urea N, 6.3% water-soluble organic N, and 1.0% water-insoluble N). In 2000, 1.2 lb. N per 1,000 ft.² was applied on May 2 as Scotts 17-3-17 (3.3% ammoniacal N, 6.9% urea N, 3.9% water-soluble organic N, and 2.9% water-insoluble N).

Grass clippings were collected from the green daily during the growing season by the golf course superintendent, weighed, sub-sampled, and frozen. The clipping samples were later dried in a 60°C oven for three days and weighed. Clippings were separated from top-dressing sand and analyzed for nitrogen using a combustion auto-analyzer.

Annual precipitation during the study was 25 inches, with more than two-thirds occurring from late October to early March, a period when the golf course generally was closed (the golf course was open April 1 to October 31). Precipitation and flow through the green were related, i.e., as precipitation increased, the flow through the green increased. Low-flow during winter occurred when the soil profile was frozen. When soil temperatures increased and snow melt occurred, there was a notable increase in flow. Mean flow rate through the green over the three-year study was 1,151 gallons per day. Peak flow rates can be attributed to rainfall events, e.g., during the week of August 4, 1999, when a 2 in. rainfall occurred during a 24-hour period.

N CONCENTRATION IN LEACHATE

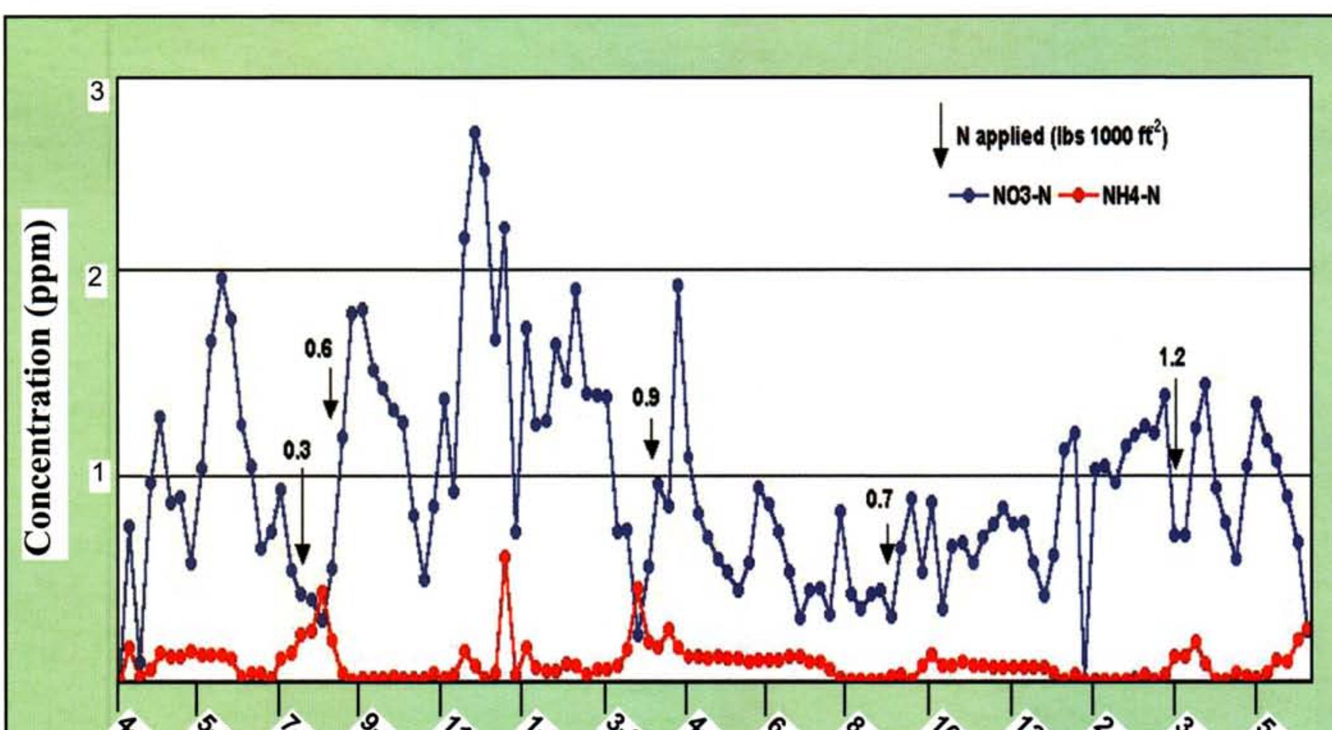
Analysis for NO_3-N and NH_4-N indicated low levels of N in the leachate. NO_3-N ranged from 0 to 3.1 ppm, well below the U.S. Environmental Protection Agency limit of 10 ppm. NH_4-N levels ranged from 0 to 0.6 ppm. There is no EPA standard for NH_4-N in groundwater. Low concentrations of NO_3-N in the leachate may be attributed in part to light, frequent foliar N applications, periods of high leachate flow, and rapid turfgrass growth with high nitrogen uptake.

Increased nitrogen fertilizer rates increased leachate NO_3-N concentration during the 7- to 21-day period following application. Others have reported higher NO_3-N leaching as N fertilization rates increased. However, at no time during an 8-week post-application period were NO_3-N concentrations excessive (i.e., greater than 1.9 ppm).

The highest quantity of nitrogen was leached during late fall and late winter/early spring when water flow and nitrogen leachate concentrations were high and grass growth was minimal. An increase in the amount of nitrogen leached occurred 7 to 14 days following fertilizer applications, but results were confounded by increased flow that also occurred during this period. Since, in general, concentration decreases as flow increases, which as noted above did not occur, there was an increase in the amount of nitrogen leaching following fertilizer applications.

Clipping dry weight variation can be attributed to mowing height variation, periodic mowing of cleanup lap, and environmental factors. The daily bentgrass clipping nitrogen content ranged from 2.4% to 7.3% and reflected increased nitrogen applications. Mean nitrogen content of the clippings was 4.6%. This is within the range of 3% to 6% N on a dry weight basis reported for turfgrass. The amount of bentgrass clippings removed from the green was a less accurate predictor of when nitrogen was applied than percent N in the clippings. Low leachate concentrations combined with high nitrogen content of the clippings suggests efficient nitrogen uptake by the grass.

Over the three years of this study, total recovered N was 59% (11% in leachate, 48% in clippings). Non-recovered nitrogen could be present in non-available forms in both the soil and thatch, with some potential loss due to volatilization (13, 14). However, it is believed not to be an environmental concern (6, 12).



Leachate nitrogen concentrations from a golf green at Coeur d'Alene, Idaho, 1998-2000. Arrows indicate timing of nitrogen applications (lbs of N per 1000 ft.²).

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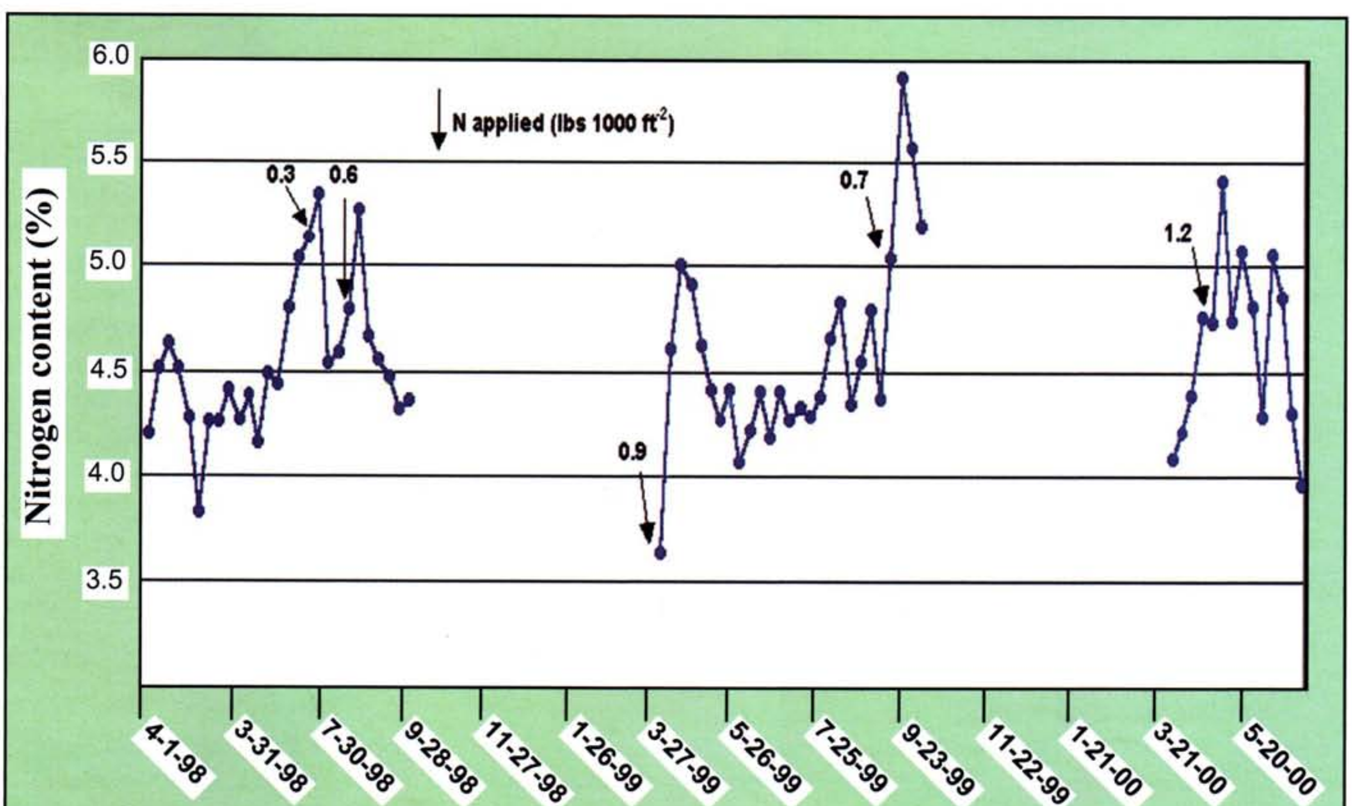

Nitrogen content (%) of clippings from a golf green at Coeur d'Alene, Idaho, 1998-2000. Arrows indicate timing of nitrogen applications (lbs of N per 1000 square feet).