1988, respectively. In most months, the models' results were a reasonable match to observations. A although the tests are not conclusive, it appears that these models are capable of describing turf runoff.

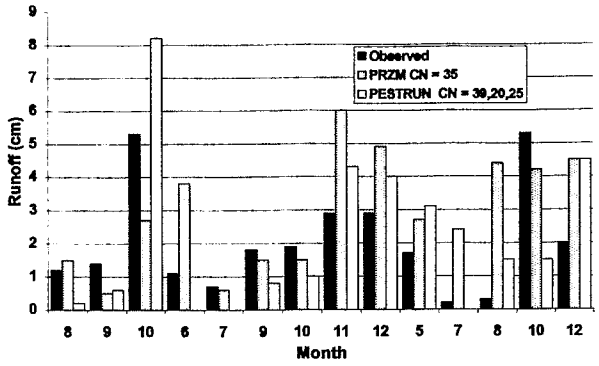

Figure 12. Comparison of calibrated model estimates with observed runoff - Pennsylvania State University Classic Seed Mixture Turf Plots 1986-88.

Characterization of Leaching at the Coeur d'Alene Golf Course Floating Green

Washington State University

William J. Johnston

Start Date: 1998
Number of Years: 3
Total Funding: $32,000

Objectives:

1. *Quantify water flow and movement of NO_3 and NH_4 through a large-scale sand-based putting green under actual golf course conditions.*
2. *Demonstrate the effect of nitrogen fertilization and application methods on sand-based putting greens to promote environmental safety and support the highest level of turfgrass quality.*
3. *Explore monitoring root growth and water movement utilizing computerized mesorhizotron technology newly developed at Washington State.*
4. *Monitor movement of nutrients (other than N) and pesticides.*
5. *Develop water movement models and calibration in sand-based greens.*

The objective of this project is to determine whether modern management practices provide adequate prevention of nitrogen leaching while maintaining the high level of playability required on modern golf facilities. The unique research site at the floating 14th green at the Coeur d'Alene Resort Golf Course allows for complete leachate collection from the green surface due to its self-contained design. This permits an accurate determination of concentration and quantity of leachate.

An automated flow meter with a sampler line is located in a storage tank beneath the green surface. As water is leached through the soil profile and collected by the drain lines located within the green, the flow meter monitors flow rate and total flow. Every 24 hours, a leachate sample is automatically taken from the drainage water prior to its entering the storage tank. The leachate sample is then stored within the refrigerated sampler until removal for analysis.

Currently a soluble 20-0-20 fertilizer is being applied at 0.1 lb N/1000 ft^2 every 7 to 10 days throughout the growing season. For research purposes, nitrogen rate was briefly increased to 0.3 and 0.6 lb N/1000 ft^2 to observe leaching at higher fertilizer rates. Future objectives include the use of a granular fertilizer to observe the effect of form on nitrate and ammonia leaching.

To date, leachate data indicate very low concentrations of ammonia and nitrate. Nitrate levels range from 0.11 to 1.79 ppm, well below the EPA limit of 10 ppm (Figure 13). Ammonia levels ranged from 0.18 to 0.47 ppm. Following closure of the green to play in November 1998, six micro-lysimeters were placed in the rootzone to allow for additional sampling.

To develop a nitrogen balance, soil and clipping samples are being taken to determine the concentration and form of nitrogen present. Clipping samples are taken from daily mowing, weighed, sub-sampled, then frozen for later analysis. Currently clipping samples range from 3.3 and 6.1 percent

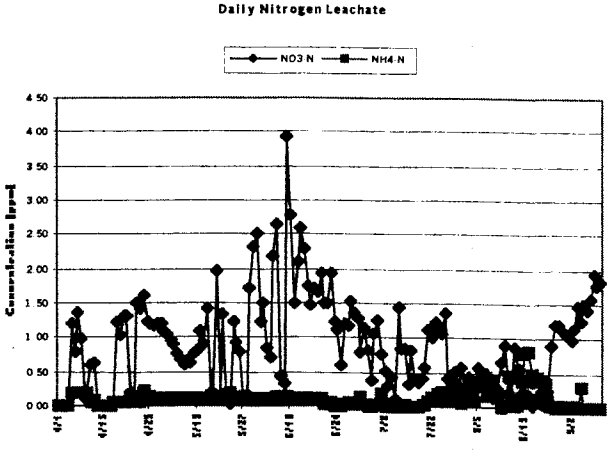

Figure 13. Nitrogen concentrations (NO_3 and NH_4) found in leachate recovered from the floating green located at Coeur d'Alene Resort.

nitrogen on an oven dry-weight basis.

Future research includes the formation of a nitrogen balance. In addition, construction of a water balance can be made leading to a better understanding of water use efficiency in the turfgrass environment. The findings of the project will provide a clearer understanding of how golf course management practices affect the environment. It will allow the public to directly view how management practices on sand-based greens affects groundwater and the environment. It will demonstrate to the public the high level of effort being placed on insuring that the environment is preserved through current golf course practices.

Gaseous Losses and Long-Term Fate of Nitrogen Applied to Kentucky Bluegrass Turf

University of Illinois

Bruce Branham

Start Date: 1998
Number of Years: 5
Total Funding: $124,270

Objectives:

1. *Detemine the quantity and form of gaseous nitrogen losses from turf.*
2. *Develop long-term (20+ years) field plots examining the fate of nitrogen applied to a mature turf.*

The objectives of this project is to determine how nitrogen is lost from fertilized turf stands, which is being conducted at the University of Illinois; and to determine the long-term fate of nitrogen at Michigan State University (MSU). The project at MSU includes the development of long-term turfgrass plots that will be treated the same every year for an indefinite period. We envision these plots as a kind of "Morrow" plots for turf. The Morrow plots are an experimental field at the University of Illinois that has continually produced corn since 1868. The plots at MSU will be continually under turf management for the indefinite future at the same, known level of management inputs. These plots will be an invaluable resource for future researchers long after this study is over. The project at MSU consists of establishing the long-term plots on a site that contains four large lysimeters that will be monitored for nitrogen leaching under two fertility regimes. The high maintenance plots receive 5 lbs nitrogen per 1000 square feet per year while the low maintenance plots receive 2 lbs. nitrogen per 1000 square feet per year. The lysimeters will be monitored continuously for nitrate leaching under these two fertility programs. Beginning in 2000, a study will be initiated to monitor the fate of labeled fertilizer nitrogen in these plots.

The results from monitoring the leachate of the two nitrogen regimes in 1998 indicate slight increases in nitrogen leaching compared to the baseline levels established in these same plots during a study conducted from 1991 through 1993. Average nitrogen losses ranged from 1.83 to 2.85 mg N L^{-1} for the 2 lbs. N/1000 ft^2/Yr treatment and 2.37 to 4.61 mg N L^{-1} for the 5 lbs. N/1000 ft^2/Yr treatment. While these values are well below the drinking water standard of 10 mg N L^{-1}, they are above the levels detected by Miltner et al. (1996) in a similar study. Values detected by Miltner et al. were generally below 1 mg N L^{-1} with a maximum detection of 3.8 mg N L^{-1}

Research at the University of Illinois is focused on gaseous losses of nitrogen from fertilized turf stands. Turfgrasses are fertilized yearly but lose insignificant amounts of nitrogen to leaching. Yet, turfgrass systems must be losing nitrogen or fertilization could be stopped without any loss in turfgrass growth or quality. Since nitrogen leaching appears negligible, the only other avenue for loss of nitrogen from the turf is through nitrogen volatilization. Nitrogen volatilization losses can occur by two different pathways. Ammonia volatilization and denitrification will both be studied in these experiments.

Most of our time in 1998 was devoted to developing the systems needed to study nitrogen volatilization under field conditions. In particular, denitrification is very difficult to study under field conditions. One of the most vexing problems encountered was a method to measure the volume of the lysimeters to be used in the field measurements. The lysimeters, plastic tubes inserted into the turf, must protrude above the turf surface so that a cover can be placed over the lysimeter and a sample of the air inside the lysimeter taken to determine gaseous nitrogen loss. Determining the head space volume inside the lysimeter is critical to getting an accurate estimation of the total nitrogen gasses volatilized. While many easy approaches were considered, none of them provided acceptable results. The method developed introduces a known volume of neon gas into the lysimeter prior to sampling, after equilibration, a sample is withdrawn and the concentration of neon gas is determined by mass spectroscopy. The dilution of the neon gas can be used to accurately determine the head space volume of the lysimeters.

Our field system has been tested and is ready for our first field studies which will begin in May of 1999. These trials should be sufficiently sensitive to determine nitrogen volatilization losses from fertilized turf stands.