Concentrating on Nutrient Loss Reduction: Analysis of the MANAGE database drainage concentration data

Allan Hertzberger[1]; Laura Christianson[1]; Daren Harmel[2]

[1]Department of Crop Sciences, University of Illinois, Urbana-Champaign, IL

[2]USDA-ARS Center for Agricultural Resources Research, Fort Collins, CO

Introduction

Much of the N applied to agroecosystems is transferred along the N cascade into aquatic, atmospheric, and natural terrestrial ecosystems. Nutrient pollution of ground and surface water through agricultural runoff and leaching is a major cause of eutrophication leading to hypoxia. A prime example is the seasonal hypoxic zone in the Gulf of Mexico, the largest of which ever recorded occurred in summer 2017, which is fed by N and P loads transported down the Mississippi River. A significant portion of these nutrients are sourced from agricultural areas in Upper Mississippi River Basin states, where subsurface agricultural drainage is a required component for high crop productivity. The transport of nitrate is affected by crop water and nutrient uptake and management practices. Controllable factors (e.g., crop selection, tillage, conservation practices, and fertilizer management) play a pivotal role in nutrient transport.

The “Measured Annual Nutrient loads from AGricultural Environments” (MANAGE) database is a compilation of field-scale surface and subsurface nitrogen and phosphorus loads from agricultural landscapes across the United States and Canada. Due to high variability in the results of research efforts, there was a need to better quantify the effect of controllable and uncontrollable factors on subsurface drainage N and P concentrations.

The **objectives** of this study were to:

- Update the MANAGE database to include agricultural subsurface drainage N and P concentrations.
- Conduct an analysis on the pooled data to better define the relationship between N and P management practices, water quality, and yield.

Methods

- Between May and December 2017, a literature review of more than 400 agricultural drainage publications yielded nutrient concentration (both annual flow-weighted and annual arithmetic means), cropping system, crop yield, nutrient application, precipitation, and drainage data from 79 “acceptable” drainage studies.
- Data were used to create a “Drain Concentration” table to complement the previously developed MANAGE Drain Load table
- Acceptable literature must: 1) have been peer-reviewed; 2) be from studies performed in the United States or Canada; 3) contain at least one full year of data (multiple years were divided into separate “site-years”); 4) have a drainage area ≥0.009 ha; 5) be for “free drainage” treatments only; 6) not be a rainfall simulation or lysimeter study

Results

Crop Selection

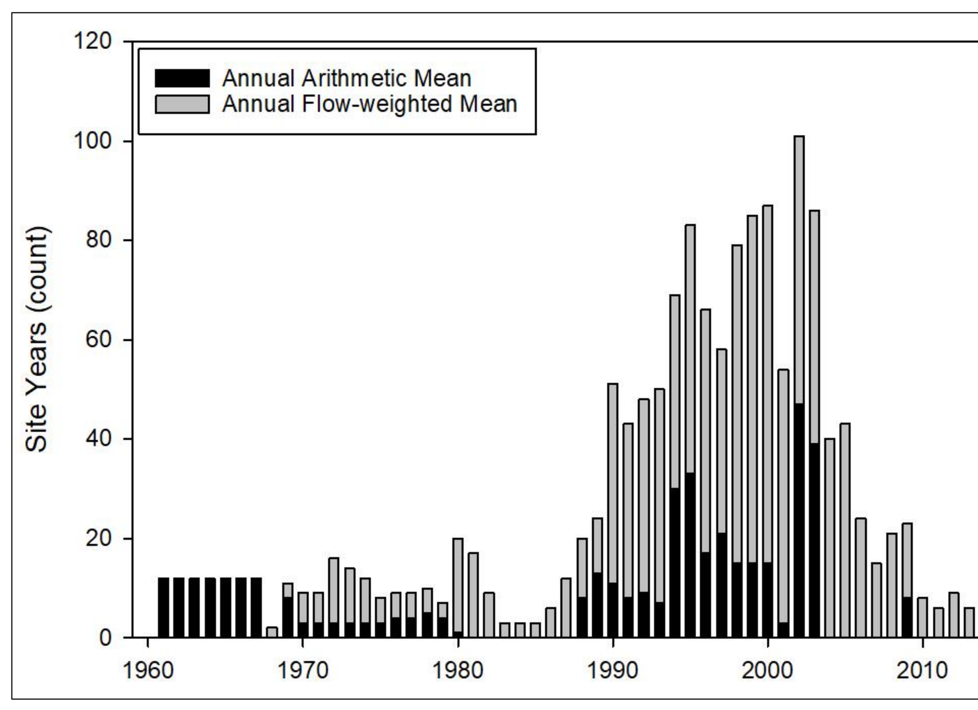

Figure 1. Histogram of MANAGE Drain Concentration table site-years by experimental year (i.e., not publication year) and mean type.

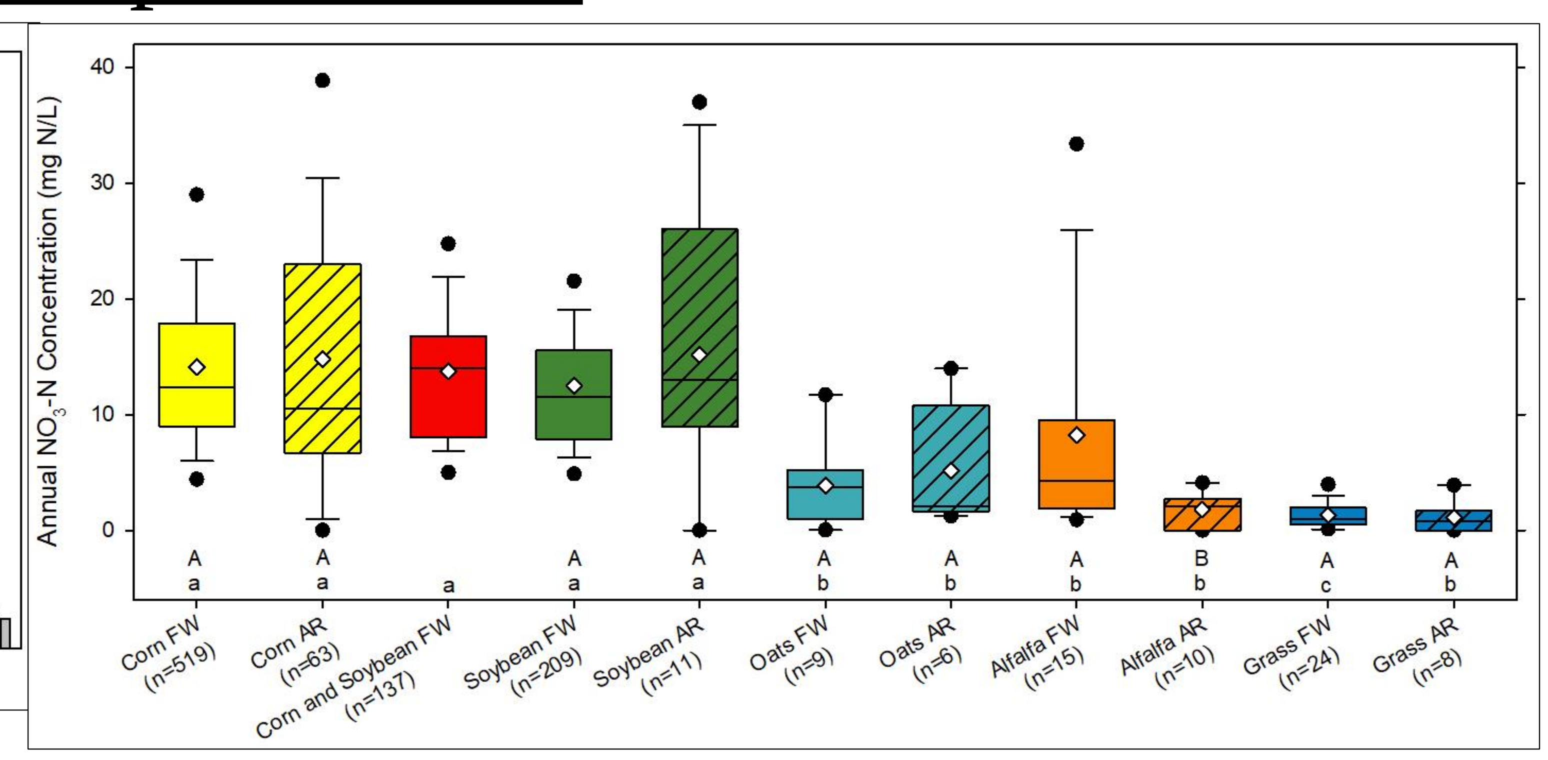

Figure 2. Crop type compared across annual flow-weighted (FW) and arithmetic (AR) mean nitrate concentration Boxes with the same uppercase letter for a given crop type are not significantly different at a= 0.05 (e.g., comparing the arithmetic vs. flow-weighted concentrations for corn). Boxes with the same lowercase letter for a given averaging type are not significantly different at a= 0.05 (e.g., comparing flow-weighted concentrations for corn vs. soybean vs. alfalfa, etc.)

- Annual flow-weighted concentrations made up 71% and arithmetic means totaled 27% of the database (fig. 1).
- The reporting of arithmetic means versus flow-weighted means seemed to reflect a change in water sampling technology over time.
- Arithmetic vs. flow-weighted nitrate concentrations were not significantly different for each specific crop type (fig. 2).
- The most common crops grown in the Midwest United States showed the highest annual nitrate concentrations (fig. 2).

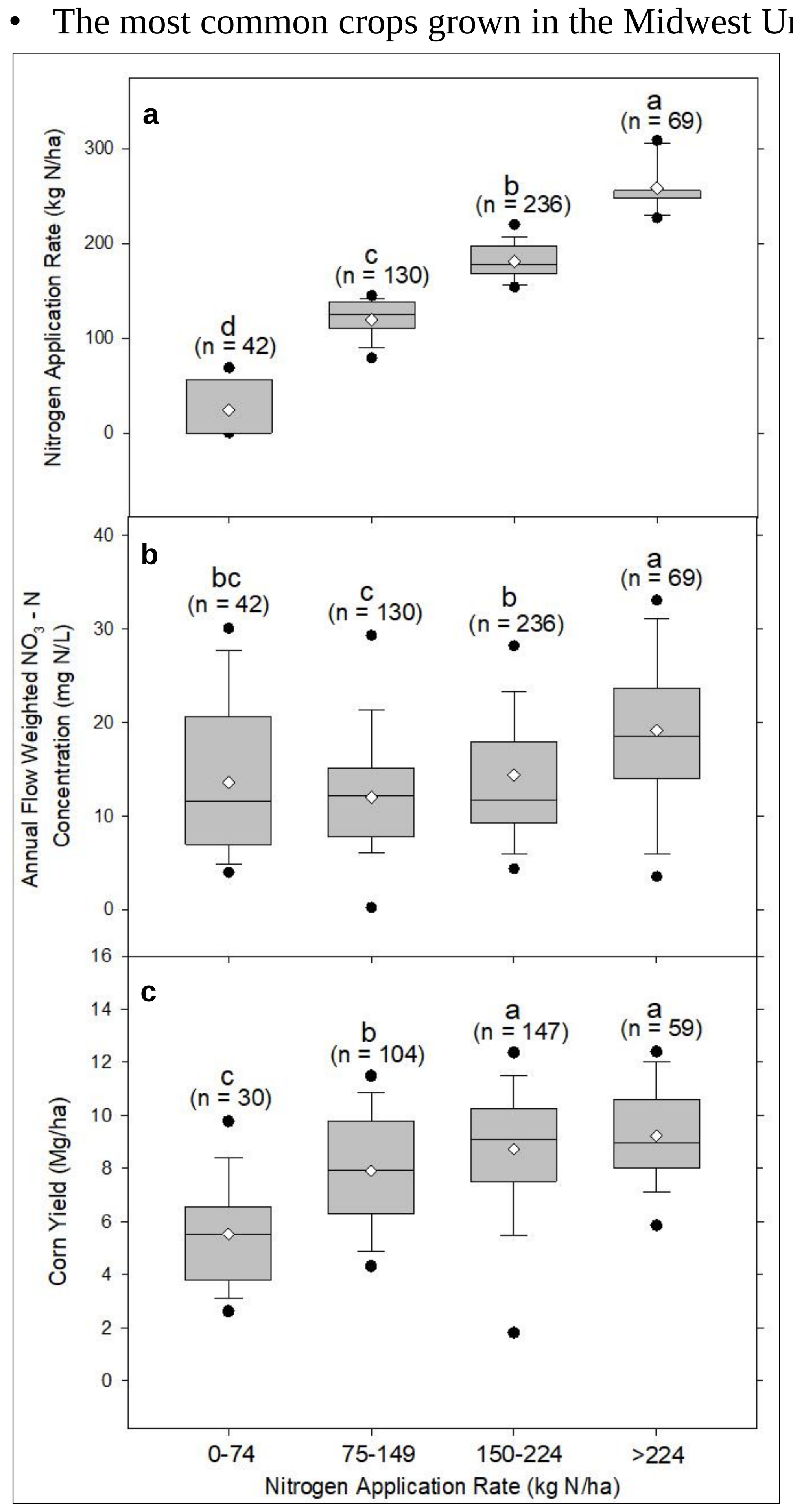

Figure 3. Grouped nitrogen application rates (kg N/ha) (a) compared across annual flow-weighted NO_3-N concentration (mg N/L) (b), and corn yield (Mg/ha) (c). Data reflects subsurface drainage and corn years only. Means with the same letter are not significantly different (α=0.05) based on a Student’s t-test.

Corn Nitrogen Management

- Increasing N application rate generally resulted in increased corn yield, with yield following a maximum return to nitrogen trend (figure 3a and 3c).
- Corn yields at N application rates of 150-224 and >224 kg N/ha were not significantly different with means of 8.7 and 9.2 Mg/ha, respectively (figure 3c), although these two yields were significantly greater than the yields from lower N application rates.
- While the three highest N application rate categories exhibited significant increasing flow-weighted concentrations, the 0-74 kg N/ha applied category highlighted the important point that a low N application rate does not necessarily equate with improved water quality (fig. 3b).
- Assessing these data across N rate, drainage N concentration, and corn yield (i.e., figure 3 a, b, and c) indicates that N-insufficient corn will yield poorly, potentially taking up less N from the soil, and leaving a relatively greater percentage to be lost in tile drainage.

Conclusions

Due to the large amount of variability in the results from agricultural water quality research, the MANAGE Drain Concentration Table satisfies the need to compile these data into one location to analyze the affects of multiple controllable factors on subsurface nutrient concentrations. The entire MANAGE database will help bolster the efforts of local, state, and federal organizations to mitigate the loss of nitrogen and phosphorus from agricultural systems.

Acknowledgments

- Funding for this work was provided by the Illinois Nutrient Research and Education Council.
- MANAGE Drain Load development was previously funded by the 4R Research Fund.