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Project Title: Examining the Response of Golf Course Lentic Ecosystems to Insecticide and Nutrient Additions Using Survey and Experimental Approaches

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Objective: The objectives of this research are to: 1) conduct a survey to quantify water quality and biotic communities of lentic turfgrass ecosystems across 25 courses within the Chicago Metropolitan area, and 2) use data from survey efforts to inform an experimental design to mechanistically examine whether additions of pesticides and/or nutrients (nitrogen and phosphorus) have measurable impacts on turfgrass lentic water quality and ecosystem communities.

Start Date: 2017

Duration: 3 years

Total Funding: \$82,053

Summary:

Golf courses in the United States have long been considered to play a significant role in maintaining and enhancing local biodiversity – particularly when the adjacent landscape is dominated by anthropogenic land-use (e.g., urbanization, agriculture). In the face of global change, managed areas that can harbor native biodiversity are crucial for supplying source populations to adjacent areas and for maintaining ecological processes and ultimately, ecosystem integrity. During the first year of our study, we quantified water quality and chemistry, algal concentrations, and micro- and macroinvertebrate and amphibian diversity and density across 25 golf course lentic ecosystems (herein ponds) and compared those to the same parameters found in ponds located within adjacent forest preserves (n = 30; 15 permanent ponds with fish and 15 fishless ephemeral ponds). To date, we collected over 550 water quality/chemistry measurements per analyte/compound and over 600 samples each of micro- and macroinvertebrates and amphibians. *These data will help elucidate the degree to which golf course ponds harbor biodiversity compared to adjacent systems considered more natural.*

Water quality/chemistry and algae: We examined concentrations of 10 analytes (name, minimum detection limit [ppb]) within each of the 25 course ponds and seven accessible course inflows (e.g., courses with accessible wells or lotic systems filling course ponds): Azoxystrobin (0.50), Bifenthrin (0.20), α -Chlordane (0.20), γ -Chlordane (0.20), Chlorpyrifos (0.20), Cypermethrin (1.00), Oxadiazon (0.50), cis-Permethrin (1.30), trans-Permethrin (1.30), Fenvalerate (0.30). Azoxystrobin, α -Chlordane, and Oxadiazon were the only compounds detected above the detectable limit in any of the 25 courses or course inflows in August (Table 1), and no detections occurred in April samples. Nearly 30% of course inflows we examined (3/7) had detectable compounds that were likely contributing to the concentrations found in course ponds. Concentrations of chlorophyll *a* were only significantly different between ephemeral ponds and forest preserve/golf course sites in August (Fig. 1), whereas concentrations of phycocyanin (blue/green algae) were not measurably different between any pond type. Water quality variables taken with a YSI multi-probe meter show variation between golf course and

ephemeral wetlands, but not between golf courses and forest preserve ponds (Fig. 2). Water chemistry values, i.e., nitrate, ammonium and phosphorus, are currently being analyzed. These data suggests golf course ecosystems function similar to adjacent permanent, fish-containing forested lentic systems in managed forest preserves.

Biotic assessment: We collected 9 or 15 samples per pond from April to August (3 or 5 each month) to quantify micro (zooplankton) and macroinvertebrate diversity and density. Organisms are currently being identified. Amphibian diversity was low across all ponds (golf course or nature preserve). From April to August, both golf course and permanent ponds with fish harbored an average of 0.4 (0-3 total species) amphibian species per pond whereas diversity at ephemeral, fishless ponds was just 0.31 (0-3 total species) species per pond.

Future expectations: By summer 2018, we expect to submit a peer-reviewed manuscript detailing the comparison of water quality and chemistry of golf course and adjacent forest preserve ecosystems. We expect to have all micro-and macroinvertebrate samples enumerated and will begin construction of a manuscript detailing the biodiversity comparison of invertebrates and vertebrates across golf course and forest preserve (permanent and ephemeral) ponds by late summer 2018. In addition, as discussed in our proposal, in spring 2018 and 2019 we plan to utilize measures of Azoxystrobin, nitrogen and phosphorus to design and conduct mesocosm experiments investigating the response of biofilms (e.g., algae), zooplankton, Odonata nymphs and amphibians (American toads).

Summary Points:

- Concentrations of analytes (pesticides, fungicides, and herbicides) measured in golf course ponds were low and infrequently detected for 8/10 analytes examined. Azoxystrobin was the most widespread analyte measured.
- Amphibian diversity was low across the region and was similar in golf course ponds versus ponds located in forest preserve habitats.
- Concentrations of algae (both green [Chlorophyta and Charophyta] and blue-green [Cyanobacteria] algae) were similar across golf course and forest preserve ponds.
- Water quality measures were measurably different between golf course ponds and ephemeral wetlands, but not between golf course ponds and permanent forest preserve ponds containing fish.
- These results suggests golf course ponds provide similar aquatic ecosystems to more natural, forested ecosystems. Further examination is required to fully examine the degree to which these ecosystems are similar or different.

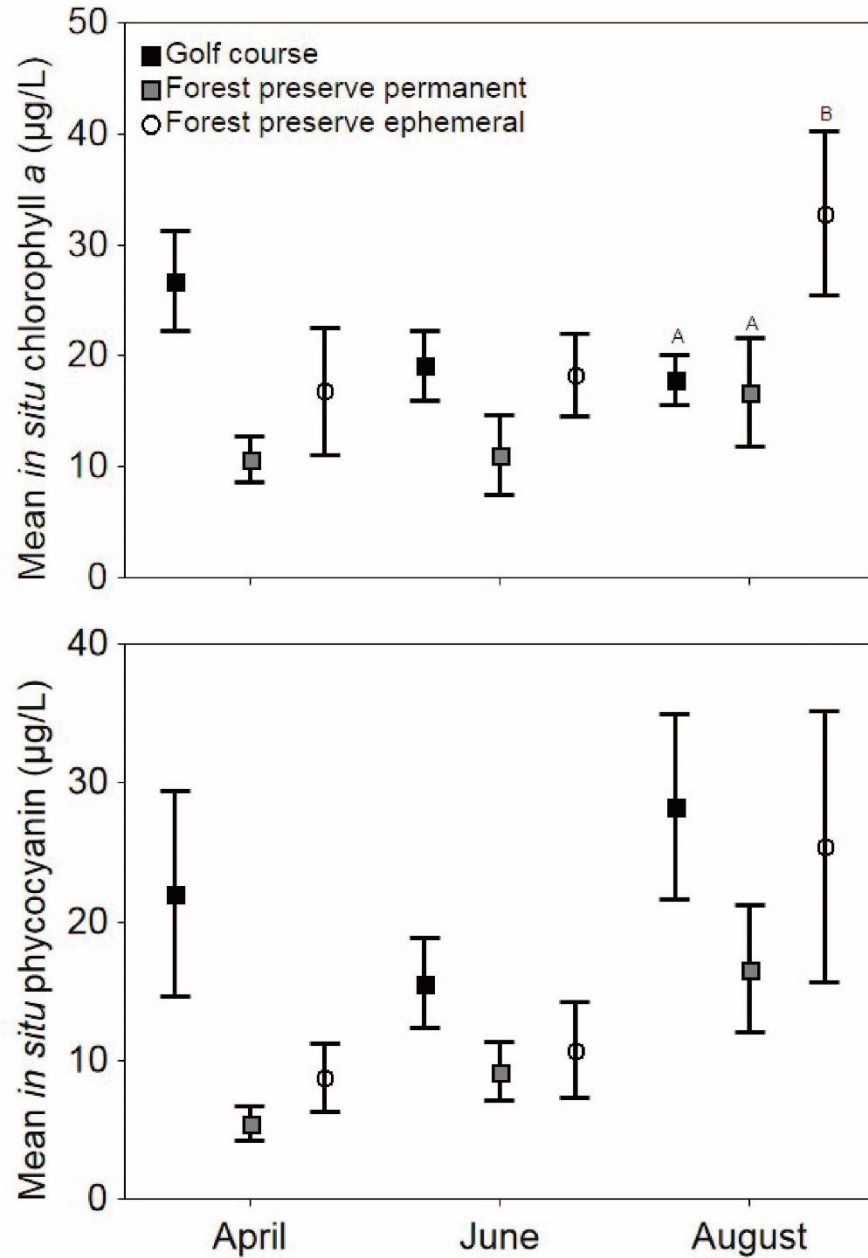


Figure 1. Mean (SE) *in situ* chlorophyll *a* and phycocyanin concentrations within sites across months. Different upper case letters suggest statistical significance ($p \leq 0.05$) within months using one-way ANOVAs and Tukey multiple comparison tests.

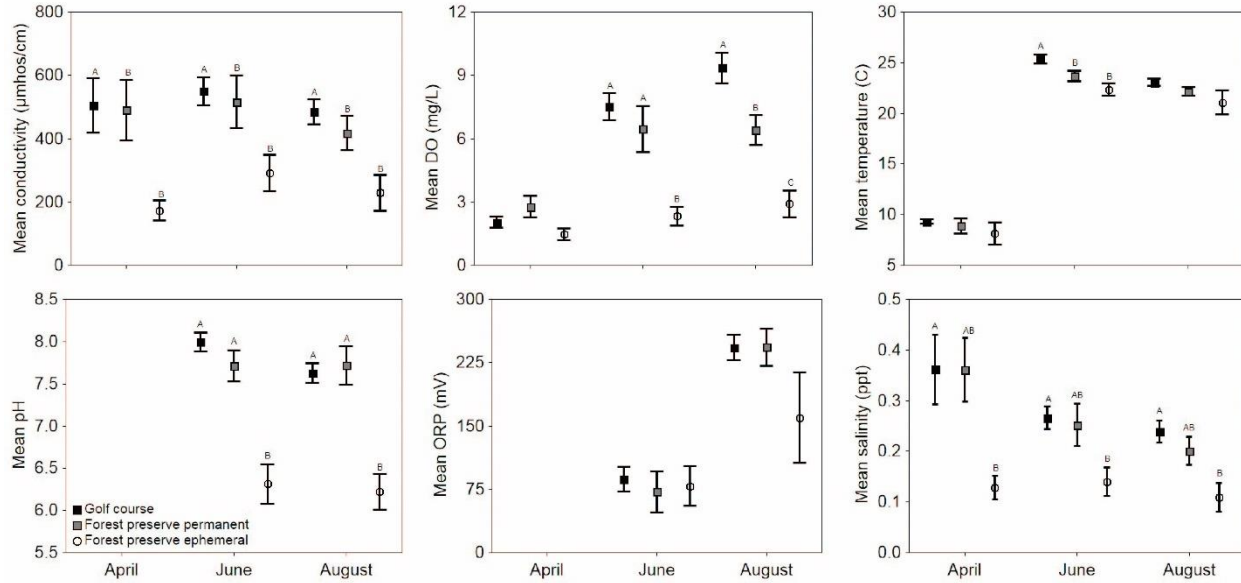


Figure 2. Mean (SE) values for water quality parameters within site types and across months (DO = dissolved oxygen, ORP = oxidation reduction potential). Different upper case letters represent statistical significance ($p \leq 0.05$).

Table 1. Concentrations of analytes within golf course ponds and course inflows. Mean, range, and sample size (n = number of courses where each analyte is found).

Analyte	Within course ponds				Course inflows			
	n	Mean	Std. error	Range	n	Mean	Std. error	Range
Azoxystrobin	11	2.21	1.05	0 – 24.39	2	0.45	0.90	0 – 2.29
Bifenthrin	0	0	–	–	0	0	–	–
α-Chlordane	2	0.14	0.12	0 – 2.81	1	0.09	0.47	0 – 0.63
γ-Chlordane	0	0	–	–	0	0	–	–
Chlorpyrifos	0	0	–	–	0	0	–	–
Cypermethrin	0	0	–	–	0	0	–	–
Oxadiazon	2	0.16	0.11	0 – 2.22	1	0.11	0.52	0 – 0.77
cis-Permethrin	0	0	–	–	0	0	–	–
trans-Permethrin	0	0	–	–	0	0	–	–
Fenvalerate	0	0	–	–	0	0	–	–