Research Proposal

Stormwater pond plantings: Testing the effectiveness of a proposed Best Management Practice on water quality

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by

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Stormwater pond plantings: Testing the effectiveness of a proposed Best Management Practice (BMP) on water quality

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Project Description

According to World Bank, in 2020 about 82% of the total global population lived in cities and urban areas (Aaron, 2022), causing urban development to encroach upon natural ecosystems. Alig et al. (2004) predicted that U.S. urban land cover will increase from 5.2% to 9.2% in the next 25 years, increasing the amount of impervious surfaces and subsequent stormwater runoff into nearby natural water bodies (McDonald, 2008). Natural waterbodies such as lakes and streams are particularly susceptible to increased stormwater runoff, as it leads to flooding and water quality issues, that latter being due to in part by nutrients that runoff of urban landscapes. According to summary statistics of the EPA (2000), over 7090 lakes and streams, and over 6,600 waterbodies are threatened or listed as impaired due to nutrient loading. To alleviate these impacts, engineered ecosystems like stormwater ponds have been constructed. Most parts of North America have adopted stormwater ponds to manage urban stormwater runoff. Stormwater ponds have become a common feature in urban landscapes in Florida. According to University Florida researchers there are over 76,000 stormwater ponds in Florida alone (Figure 1a), which take up considerable amount of urban land cover (Figure 1b).

Stormwater ponds are designed to prevent flooding and treat urban runoff. The pollutants in urban runoff can be removed in stormwater ponds in several ways; settling, plant adsorption, assimilation, sedimentation, bacterial degradation, decomposition, and percolation into ground (Weiss et al., 2006). It has been found that stormwater ponds achieve the goal of flood control, but rarely achieve the goal of nutrient removal (Harper & Baker, 2007). Stormwater ponds are accredited by the Florida Department of Environmental Protection to remove 80% of total nitrogen and phosphorous from urban runoff. However, studies show that current nutrient removal is occurring at about half, or even less, of the expected rate (Harper & Baker, 2007), thereby failing to protect urban aquatic plant communities (Hess et al., 2019). These findings suggests that stormwater ponds need different management measures to enhance their intended functionality on nutrient removal.

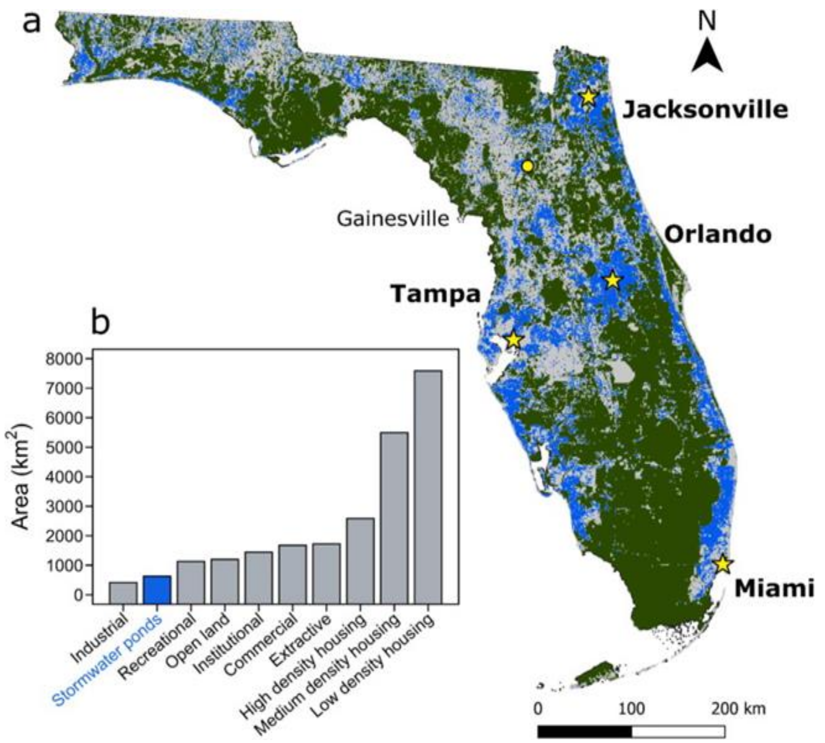

Figure 1. (a) Over 76,000 stormwater ponds (blue) withing expanding areas of urbanization (grey) in Florida, USA and (b) areal coverage of stormwater ponds relative to other urban land cover types. Figure from Sinclair et al., (2020). Figure shows that not only are there a lot of stormwater ponds, but they also occupy a significant amount of space in urban landscapes.

Stormwater pond planting could work as a better strategy for nutrient removal (Hess et al., 2019 and Nighswander et al., 2022). They can improve water quality via bank stabilization, direct uptake of nutrients by plant roots and by microbes living on plant roots, and by acting as a buffer that limit excess fertilizers and grass clippings from entering the pond (Jacoby et al., 2017, Yang et al., 2019). Added benefits of stormwater pond plants include, improving the quality of aquatic habitat and ecological value by maintaining biodiversity and attraction of wildlife (i.e., wading birds and fish that encourage nutrient cycling process by stirring up the pond) (Noble & Hassall, 2015).

Most of the conventional stormwater pond banks are planted with turfgrass. Turfgrass banks allow nutrients to run into stormwater ponds though they stabilize the banks and prevent soil erosion (Lusk & Chapman, 2021). Establishment of a no-mow buffer zone is a management strategy to reduce the nutrient loads entering stormwater ponds (EPA, 2009). Addition of plants on the banks and littoral shelves could be a potential BMP to improve nutrient removal efficiency of stormwater ponds (UF/IFAS). However, there are limited amount of published data on the efficiency of stormwater pond plantings on reducing nutrients, thereby hindering the adoption of this potential BMPs in Florida and elsewhere.

In a preliminary study conducted in Lakewood Ranch, FL by the University of Florida, researchers compared stormwater ponds with planted banks and littoral shelves to those having only turfgrass planted banks. They found a 20% reduction in phosphorus in areas of ponds that had plants relative to areas of the same pond that did not have plants (Iannone, personal communication). However, only 30%-50% of the pond bank and littoral areas were planted, raising the question of if great plant abundance would benefit water quality.

Therefore, our study will be carried out to test the efficacy of stormwater pond plantings as a potential BMP to improve downstream water quality. Our project integrates water quality monitoring and educational workshops to promote stormwater ponds plantings. We predict that stormwater ponds having planted banks and littoral shelf are more efficient in nutrient removal than stormwater ponds having turfgrass banks and the degree to which water quality is improved can be affected by the types of plants present in stormwater ponds.

Objectives

1. Estimate the difference in nutrient removal between planted stormwater ponds and conventional stormwater ponds having banks planted with turfgrass.
2. Determine the effects of three different planting styles (i.e., Stormwater ponds with littoral plantings and no mow buffer zones, Stormwater ponds with banks and littoral plantings, and conventional ponds having turfgrass planted banks) on nutrient removal and water quality.
3. Determine if nutrient removal efficiencies vary in relation to plant abundance and/or plant community composition.

Hypothesis of the study

H1: We hypothesize that stormwater ponds with planted banks and littoral shelf are more efficient in nutrient removal than conventional stormwater ponds with turfgrass banks.

H2: We hypothesize that ponds with planted banks and littoral plantings will improve stormwater pond water quality more than stormwater ponds with littoral plantings and no mow buffer zones.

H3: We hypothesize that there is a positive correlation between nutrient removal efficiencies and plant abundance and nutrient removal will vary in relation to plant community composition.

Methodology

Study Location: Manatee County and Sarasota County, FL, USA

The study will be done on three treatment levels (stormwater ponds with three planting styles) (Figure 2).

1. Stormwater ponds with traditional turfgrass banks (Figure 2a)
2. Stormwater ponds with littoral plantings and no-mow buffer zones (Figure 2b)
3. Stormwater pond with banks and littoral plantings (Figure 2c)

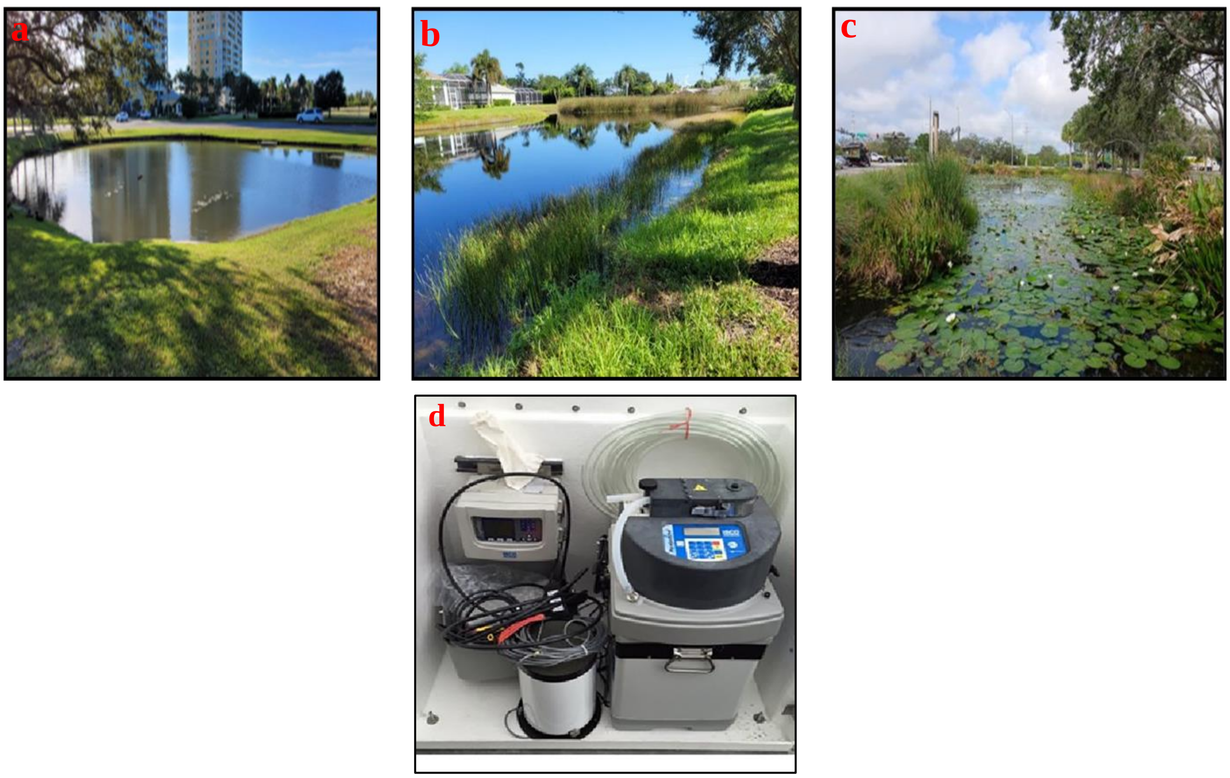

Figure 2. (a) Stormwater ponds with turfgrass banks, (b) Stormwater ponds with littoral plantings and no-mow buffer zones, (c) Stormwater Pond with banks and littoral plantings. (d) Autosamplers used to collect water samples at pond inflows and outflows.

Three of stormwater ponds with traditional turfgrass banks, three of stormwater ponds with littoral plantings and no-mow buffer zones, and a stormwater pond with banks and littoral plantings will be assessed for nutrient removal efficiency, vegetation cover, and internal water quality. Planting banks and littoral plants (e.g., Figure 2c) is a newer practice limiting the number of ponds we can sample of this planting style.

Water sampling

Water sampling will be done throughout the year during 14 storm events (ten samplings during Florida's wet season and at least four samplings during Florida's dry season) using autosampler and GatorByte technology (Figure 2d). GatorByte sensor is a water quality monitoring platform developed by Dr. Eban Bean from University of Florida. The difference in total nitrogen and total phosphorus at inflows and outflows of each stormwater pond will be measured during each storm event. Seasonal internal samplings will be done (five water samples taken along a transect extended from the inflow to the outflow) to quantify the levels of different nutrients (total nitrogen, total phosphorous, nitrate, nitrite). In addition, internally, dissolved oxygen, conductivity, temperature, and secchi depth will be measured as other indicators of water quality.

Vegetation sampling

The vegetation sampling will be done seasonally. The pond will be divided into 4 equal sections and an average areal coverage by six vegetation vertical strata following the US national Vegetation classification system will be measured using the Daubenmire cover class method. The six vertical strata are,

- Ground cover: 0-0.5m (including all turfgrass)
- Field cover: all plants in 0.5-1m including all herbaceous plants
- Shrub cover: 1-5m (woody plants)
- Tree cover > 5 m in height and with a diameter at breast height ≥ 2 cm
- Floating aquatic plant cover
- Submerged aquatic plant cover

In each site visit, the presence of wildlife (e.g., dragon flies, wading birds) will be recorded to assess the attraction of wildlife to stormwater pond plantings.

Data analysis

ANOVA style analysis will be used to model water nutrient levels as a function of 3 treatment levels (test hypothesis 1 and 2). A linear regression style analysis will be used to model the effects of plant abundance on overall pond water quality and nutrient removal (test hypothesis 3). Multivariate statistical approaches also will be used in the study to show how plant community composition relates to variation in nutrient removal.

Our findings will be made publicly available through my lab's website, as well as through the UF|IFAS Electronic Data Information Source (https://edis.ifas.ufl.edu/). Data from our study will be available through Institutional repository of University of Florida (https://ufdc.ufl.edu/collections/ufir).

Budget Justification

The Florida Department of Environmental Protection has allocated funding for the majority of this project. The initial budget was planned for sampling three types of stormwater ponds in Manatee County, FL, and Sarasota County, FL. Recently, we partnered with the city of Alachua, FL who have just completed a stormwater pond planting project. Alachua city officials have reached out to us, as they want to test out their approach for the better management of stormwater ponds in their city planning. Having this opportunity, we wanted to expand our study network to include this newly planted stormwater pond project. Should I receive this award, I will use the funding to incorporate the stormwater pond in Alachua, FL into my research project. An itemization of how I would use $3,000 if funding is provided in Table 1.

Table 1. Proposed itemized budget for sampling the new stormwater pond project in Alachua, FL.

Item	**Details**	**Estimated cost**
Autosamplers	Installation and maintenance of 3 auto-samplers.	$900
Autosampler accessories	Batteries ($75 each), solar panels ($85 each), and protective cover ($100 each) for 3 autosamplers	$780
Water sample analysis: Storm events	Water quality testing for 14 storm events from two inflows and one outflow of the pond.	$700
Water sample analysis: Internal sampling	Internal sampling conduct four time.	$320
Water sample collection and preserving	Filters and syringes and chemicals for the preservation of water samples.	$100
Project travel	From Gainesville to Alachua County for sample collection.	$200
	Total estimated Budget	**$3,000**

Project Deliverables

This project is cost effective in terms of methodology and project deliverables. Regarding methodology, the autosampling and GatorByte technologies. We propose to collect samples are cost-effective, as they reduce travel costs. Regarding deliverables, we will use multiple inexpensive approaches including workshops, live and recorded webinar, factsheets, and PowerPoint presentations to educate stakeholders, public and private pond management companies about the benefits of stormwater pond plantings.

Significance and benefits to the industry

Given their potential importance to the management of urban stormwater runoff, stormwater ponds are long-overlooked research priority of national importance in the U.S. This study will benefit the pond industry in addressing this challenge in five key ways. First, this study will help the industry identify strategies to manage stormwater pond nutrient and improve stormwater pond health and functionality. Second, the findings will help to promote stormwater pond plantings as a BMP, allowing the industry to charge their clientele for planting and plant maintenance as a service. Third, the study will help urban landscape managers for better decision making. It will be useful for the industry to serve as a foundation to build future outreach and research collaborations among stakeholders, county governments, and private pond management companies. Fourth, this project will yield many valuable educational and scientific products. These products will be useful for the industry as tools for the stormwater pond management, as well as for educating clientele. Fifth, it can help the industry lead in protecting water quality using new stormwater pond management practices.

Quality of coursework

I am a master’s student (started in Fall 2022) interested in studying in ecological restoration, hydrologic science, and wetland ecology, all in the context of urban landscapes. For this semester, I am taking a class for applied statistics focusing on basic statistical analysis in the programing language R and a class on Research Planning where I am developing my research proposal. I am planning to take diversity of courses pertaining to experimental design, statistics, hydrology, wetland ecology, water chemistry, and human behavior change in the context of ecosystem conservation. My study plan is listed below in Table 2. In addition to the courses below I'm also going to be working as a Teaching Assistant for two semesters.

Table 2. The relevant courses I will be taking throughout my master's degree.

Semester	Course	Description
Fall 2022	Research Planning	History and philosophy of science, scientific method, development of a research proposal.
	Introduction to Applied Statistics for Agricultural and Life Sciences	Basic statistical analysis and data management skills using the R statistical language.
Spring 2023	Plant Water Relation Methods	Focus on instruments and techniques used to quantify water balance and status in plants in the field.
	Ecological Statistics & Design	Focus on real-world sampling design and data analyses. Topics include applied regression, mixed models, ANCOVA, and repeated-measures analysis non-linear modeling, indices assessment, and capture-recapture methods.
Summer 2023	Freshwater Ecology	Focus on physical and chemical aspects of freshwater ecosystems, major groups of freshwater organisms, and the ecological processes that affect freshwater communities and ecosystems.
	Scientific Thinking in Ecology	Philosophical foundations of science, the nature of scientific disputes, and the relevance to ecology.
Fall 2023	Ecosystem Restoration Principles & Practice	Focus on history, structure, importance, ecology, restoration and management techniques, ownership patterns and policy implications.
	Science Communication & Public Education	Focus on strategic message framing and how to convey scientific research to the public.
Spring 2024	Environmental Biogeochemistry	Overview of biogeochemical processes affecting elemental cycling (carbon, nitrogen, phosphorus, sulfur) in global environmental systems.
	Global Change in Freshwater Ecosystems	Focus on understanding human impacts in freshwater ecosystems and challenges and approaches for conserving freshwater diversity and ecosystem services.
Summer 2024	Urban Soil and Water Systems	Focus on issues and opportunities related to soil and water quality in urban systems.
	Ecohydrology	Focus on field of ecohydrology via targeted examples drawn from model systems, continental-scale ecological (and agro-ecological) control over the hydrologic cycle, and analytical models of watershed rainfall-runoff response.

Statement of career goals and interests

Ever since I was young, I really enjoyed learning new scientific methods. I want to use my passion for science to learn how to solve real world problems pertaining to the protection of aquatic ecosystems. I like to do research particularly in urban landscapes because urban landscapes involve human and environmental interactions. I enjoy learning new techniques in lab and fieldwork, data analysis and modelling and as a part of my career I want to lead a research lab on water quality and urban landscapes. I want to form private partnerships so that I can help private industry become leaders in improving urban landscapes to mitigate their environmental impacts on water quality. And together I think we can solve lots of problems. Given the opportunity, I would like to explore more to strengthen my knowledge and give back something applicable to the world.

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