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Project Information

Understanding relationships between depressional wetland ecohydrological condition and water management decisions in Tampa Bay, FL, USA

Study Rationale

Geographically-isolated or depressional-basin wetlands perform valuable ecosystem services including carbon storage, nutrient filtration, flood mitigation, and habitat provision (Creed et al. 2017). While described as isolated, recent studies have demonstrated that these wetlands are connected not only to each other but to other surface water bodies through groundwater-surface water interactions with shallow groundwater pools and even deeper unconfined or semi-confined aquifers. These studies demonstrate that wetlands are both a source and sink for groundwater, thereby buffering water table changes and dampening variability in groundwater flow to other landscape elements. Disruptions in groundwater and surface water flows to wetlands can therefore have ramifications across the freshwater landscape by altering their ecosystem functions and reducing water security, which can harm both ecosystems and human populations (Leibowitz and Nadeau 2003; McLaughlin et al. 2014).

Despite this scientific evidence, these wetlands are often regulated at the federal- and state-level as hydrologically isolated, and thus legally unprotected. This puts them at immense risk for degradation and destruction. In many areas across the globe, groundwater extraction for agricultural irrigation and drinking water greatly threaten the hydrological regimes of depressional wetlands (Alley et al. 2000). Specifically, reduced inundation periods can result in the encroachment of facultative as well as obligate upland species depending on how severe changes in hydrologic conditions are (Yepson et al. 2014). Plant community shifts, in addition to these hydrologic changes, can then greatly influence nutrient cycling and increase soil subsidence. Finally, water quality can also be greatly influenced by changes in hydrology with physicochemical properties such as dissolved oxygen, conductivity, and toxicity being directly related to hydrology. In some studies, high rates of groundwater extraction have been shown to mobilize dangerous heavy metals in the aquifer that could be transferred to wetlands during periods of discharge with consequences for human and ecosystem health (Smith et al. 2018).

As groundwater extraction is controlled by social systems like water management agencies, holistically assessing changes in wetland condition requires an integrated framework such as the coupled human and natural systems (CHANS) approach, which posits that there are tightly-formed relationships and feedbacks between human actions and environmental (in this case wetland) condition that can only be understood by using both social and natural science methods (Liu et al. 2007). This framework leads to expectations that water governance and local knowledge and perceptions are human factors that influence and respond to changing environmental conditions such as wetland health (Brown 2017; Casangrande et al. 2007; Katz 2016). **The goal of this research is thus to understand how groundwater extraction influences depressional wetland ecosystem structure and function and how residents and managers perceive and respond to these changes.** Greater understanding of these feedbacks can then result in increased ability to protect these wetlands in all areas where groundwater extraction threatens them.

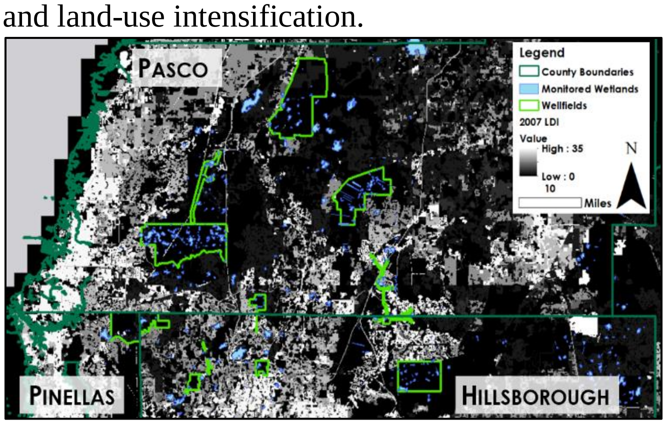
Study System

The Tampa Bay area is an ideal location to study these feedbacks between human decision-making and wetland ecohydrologic condition for several reasons. First, this area hosts numerous wetland complexes with extensive groundwater movement and recharge as they overlay the karst, semi-confined Floridan aquifer. Additionally, in the past two decades, the region's population has increased over 30% and now houses over 3 million residents increasing the need for potable water, which is primarily sourced (60%) by groundwater. Finally, wetlands in the region are managed under a plan that seeks to balance water supply with water resource protection; however, this balance has not always been achieved leading to significant fluctuations in groundwater extraction rates over the past two decades and thus changes in wetland condition (Asefa et al. 2014).

The research funded by this award will integrate the natural and social sciences to improve scientific understanding of ecohydrological outcomes of modifying flow among wetlands and how those outcomes feedback to shape human perceptions of environmental change and management decision-making. This project expands the value of previous work, which more narrowly focused on links between wetland biogeochemistry and groundwater extraction in the Tampa Bay region (Lewis and Feit 2015). It will also increase the data available to management agencies in the area by holistically assessing wetland ecohydrological condition beyond what is typically completed (Haag and Pfeiffer 2012) and consider differences between manager and resident knowledge. All these factors will ultimately improve the data available to protect these vital wetlands and safeguard water security for future generations in the region.

Research Objectives & Brief Methods

Objective 1: Determine how the ecological structure of these wetlands, including plant community composition and biodiversity, have responded to hydrological changes from varying groundwater extraction rates. To achieve this objective, I will be analyzing time-series data collected from over 150 depressional wetlands that have been monitored for the past 15-years by water management agencies in the region (Figure 1). By using long-term ecological and hydrological data, I can assess how variability in groundwater extraction has influenced wetland health. These data will also act as a proxy for how managers have perceived wetland health in the region as they collected this data. **I predict that wetlands with minimal hydrological impacts from groundwater pumping will experience higher biodiversity and contain predominantly obligate and facultative wetland species. I additionally predict that the presence of these wetland species will increase over time as groundwater extraction rates have been gradually reduced over the past 15 years (Figure 2).** This data was recently collated and preliminary results indicate that there is a significant positive correlation between wetland inundation and presence of facultative and obligate wetland species. Additional analysis is needed to discern similar trends in biodiversity as well as address potentially confounding factors such as changes in precipitation and land-use intensification.



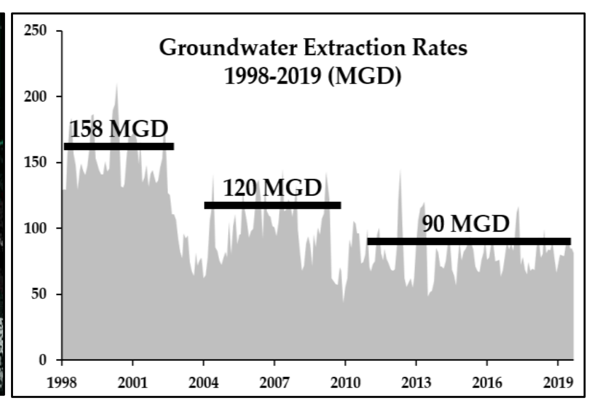


Figure 1 (left): *Active wellfields (lime green) and monitored wetlands (blue) within the Tampa Bay region;* ***Figure 2 (right):*** *Reductions in groundwater extraction volumes (millions of gallons per day, MGD) from the entire regional wellfield network over the past two decades (Adapted from TBW).*

Objective 2: Assess how ecosystem functions have been impacted by legacy groundwater extraction and compare resident perceptions of impaired versus healthy wetlands. While the previous study will analyze how wetland ecosystem structure has changed over time, this project will be an in-depth field-study of only 20 wetlands where multiple wetland properties and functions such as surface water storage, water quality, and soil bulk density (indication of soil subsidence) will be considered. Wetlands selected for this study will be placed into two categories ("healthy" versus "impaired") based on the long-term data from the first study where "impaired" wetlands will have upland species encroachment, lower biodiversity, and shorter inundation periods (Figures 3-4). All wetlands selected for analysis will be in the two wellfields that have the greatest public access so that resident intercept interviews and behavioral observation assessments (counts of visitors) can be completed. **I hypothesize that impaired wetlands will have lower groundwater and surface water quality with a greater presence of heavy metals, higher soil bulk density, and greater surface water storage due to sinkholes increasing basin area. I also hypothesize that resident responses may not always agree with management perceptions as wetlands categorized as impaired may not have obvious visual impairments.** While data has not yet been collected for this study, I anticipate sampling soil and water from these wetlands in May and June 2020 with intercept interviews occurring in November 2020 or February 2021 when these wellfields are most often visited by residents.

Figure 3-4: *Two wetlands being considered for the field-study where managers may categorize the left wetland as healthy and the right as impaired based on inundation periods and wetland species presence, while residents may categorize both as healthy.*

Objective 3: Evaluate predictors of resident perceptions about wetland health and engagement with water management decision-making including demographic factors and proximity to wetland degradation. Through this study, I can better understand what drives resident's understanding of wetland health and potentially what leads them to engage with managers or other residents in wetland protection. This final study will utilize resident interviews collected and archived by the University of South Florida that include both qualitative and quantitative responses. Through collaboration with local water management agencies and non-profits, these data can also be supplemented with information for residents that attend public meetings. Demographic information collected from these surveys and public meetings can then be used to correlate drivers such as socioeconomic status, age, and education level with responses about awareness and engagement. Zip-code information from these surveys can additionally be used to correlate responses with areas of high and low environmental degradation where high-degradation areas will be those closer to intense groundwater extraction, declines in wetland or lake condition, and consistent sinkhole formations or property value losses all of which can be determined using data mined from local water management agencies and realtor sites such as Zillow. **I hypothesize that residents that live closer to visible environmental damage will be more involved in water management decision-making (e.g., water management meeting attendance) and that residents that are wealthier, more educated, and homeowners will likely be more knowledgeable about wetland condition as well as more involved in water management decision-making (e.g., water management meeting attendance).** I am currently in the process of transcribing survey responses as well as coordinating with water managers hosting future public meetings to ensure that I can collect additional information at several meetings over the next two years.

Budget

Materials Requested	**Approximate Cost**
Peristaltic pump and tubing for groundwater sampling	$1,500
Lab supplies – reagent chemicals, pipette tips, collection bottles, resealable bags, gloves, etc.	$660
Travel costs to/from field sites – $0.85/mile * 20 miles (average distance to/from site) * 20 field days (20 sites, 2 sites per day, each site visited 2 times)	$340
Undergraduate field assistance stipend – 20 field days * 8-hour days * $8.56 (Florida minimum wage)	$1,370
Annual Society for Freshwater Science Meeting – membership fee ($40), flight ($300), hotel ($360/3-nights), registration ($330)	$1,130

Benefits to Florida's Wetlands

This project aims to increase scientific understanding of how direct and indirect management policies as well as resident perceptions and decision-making affect wetland function to better protect depressional wetlands in the future. In addition, it will highlight potential thresholds of wetland ecosystem services to different groundwater extraction rates which could benefit numerous regions globally that rely heavily on groundwater. Locally, it will identify key wetland areas in the Tampa Bay region that may not be improving despite management conservation efforts and help illustrate gaps in resident understanding of wetland health and management, which can then be used to generate new or improved education platforms and campaigns.

Dissemination of Results

This research will be collaborative with local water management agencies ensuring that their needs are incorporated into the research design and that they are fully informed of the research outcomes through periodic presentations at stakeholder meetings. In addition, this research will be further disseminated to the broader scientific and water management communities through peer-reviewed publications and presentations at regional and national conferences. This work has already been presented regionally at the Southwest Florida Annual Water Research Conference held in January 2019 and an abstract has been accepted for the annual Water Institute Symposium held at the University of Florida in February 2020.

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