Altering Hydrology in Breeding Ponds to Benefit Imperiled Amphibians During Drought

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By

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ABSTRACT

Ephemeral wetlands are essential breeding habitat for Species of Greatest Conservation Need, including the gopher frog (*Lithobates capito*; state-threatened at the time this grant was approved but now no longer state-listed), the striped newt (*Notophthalmus perstriatus*; a candidate species for Federal listing), and the ornate chorus frog (*Pseudacris ornata*). This project builds on a pre-existing project to repatriate the striped newt into Apalachicola National Forest ephemeral wetlands. Pond liners were installed in three striped newt repatriation recipient wetlands to increase the hydroperiod and increase likelihood of success of repatriation efforts. By comparing wetland hydroperiod and amphibian community composition in paired unlined and lined wetlands, this project will determine the effectiveness of this management tool for the relocation, repatriation, and translocation of imperiled amphibian species expected to be negatively impacted by climate change-induced drought. We hereby report results from the second year of our study. Although still preliminary, results from this year mirror results from last year. Data generated from this year continued to show that liners significantly extend wetland hydroperiod, provide increased opportunities for amphibian breeding, and allow resident larval amphibians to complete metamorphosis. Lined ponds also may go dry, albeit with less frequency. Results also show that liners, if installed properly, do not detrimentally alter ephemeral pond ecosystems but rather enhance habitat to benefit targeted species.

INTRODUCTION

The purpose of this project is to build on a pre-existing effort to repatriate the striped newt back into Apalachicola National Forest (ANF) ephemeral wetlands. This particular aspect of the project focuses on using synthetic pond liners in wetlands to increase the hydroperiod to benefit repatriated striped newt larval development. Pond liners were installed in three striped newt recipient wetlands to increase the hydroperiod and improve success of repatriation efforts. By comparing wetland hydroperiod and amphibian community composition in paired unlined and lined wetlands, this project will determine the effectiveness of this management tool for the relocation, repatriation, and translocation of imperiled amphibian species expected to be negatively impacted by climate change-induced drought. Ephemeral wetlands are essential breeding habitat for the gopher frog (*Lithobates capito*; state-threatened at the time this grant was approved but now no longer state-listed), and Species of Greatest Conservation Need species including the striped newt (*Notophthalmus perstriatus*), a candidate species for Federal listing, and the ornate chorus frog (*Pseudacris ornata*).

The ANF is the former western stronghold of the striped newt (Means et al. 2013). Coastal Plains Institute (CPI) sampling data show that up until 1999, individuals of the western striped newt in the ANF were relatively abundant. However, since that time, the striped newt in the ANF has undergone a mysterious decline. CPI's sampling data from the ANF through 2007, coupled with data from other researchers, was the impetus for the petitioning to federally list the striped newt as "threatened" under guidelines of the Endangered Species Act (Means et al. 2008). In March 2010, the U.S. Fish and Wildlife Service issued a 90-day notice of listing for the striped newt in the Federal Register in response to the petition (USFWS 2011).

One possible cause of the striped newt decline in the ANF is drought. Drought has been linked to some amphibian declines and extirpations of populations (Lips et al. 2005). Since 1998, North Florida experienced two prolonged, excessive droughts during the 10-year period from 1998-2008 (M. Griffin, Florida Climate Center, pers. comm.). Severe droughts lasted from 1998-2001 and 2006-2008. Hydroperiods were much shorter in ephemeral wetlands across the Munson Sandhills during the droughts (R. C. Means and D.B. Means, unpublished data). Rarely were there prime opportunities for striped newts to breed, and when there were opportunities, CPI biologists did not detect larval newts despite considerable sampling effort (Means 2007, Means et al., 2008, Means et al. 2015). With the onset of climate change, hydroperiods are expected to shorten in ephemeral wetlands (Bates et al. 2008). In the sandhills habitat, climate-induced drought likely will have negative impacts on ephemeral pond-breeding amphibians. These habitat specialists cannot breed unless the breeding pond fills during the appropriate season and stays hydrated long enough for aquatic larvae to reach metamorphosis into their terrestrial phase.

There is conservation benefit to be gained for the future management of the striped newt and other imperiled species through this study. Since the striped newt is not state-listed in Florida, a Species Action Plan (SAP) does not exist. However, this salamander is identified as a Species of Greatest Conservation Need (SGCN) in the Florida's State Wildlife Action Plan (SWAP). The striped newt is a Federal Candidate, and a SGCN species in Florida because of biological vulnerability (FNAI = S2, Millsap = 29). The gopher frog (SGCN) and ornate chorus frog (SGCN) use the same wetlands, and require sufficient hydroperiod. There is a clear need to evaluate the use of pond-liners as a hydroperiod enhancement technique to benefit Florida's imperiled ephemeral-pond breeding amphibians. Hydroperiod enhancement techniques, such as the use of pond liners, are expected to become more and more necessary in conservation projects as we move forward into the climate change era.

To meet the intent of the State Wildlife Grants Program and to foster the SWAP, FWC's Florida's Wildlife Legacy Initiative was created to assist in development and implementation of the SWAP (FWC 2012). This project is relevant to Florida's SWAP and Legacy Initiative Goals because it is an on-the-ground project to limit the effects of drought through hydroperiod alteration in ephemeral wetlands. This project will evaluate how applied techniques (i.e. pond liners) can increase hydroperiod for amphibians in the face of increased drought expected from climate change. While installing liners in ephemeral wetlands on a landscape level is not a practical management tool, this project will provide a template for targeted, specific active management practices in instances where drought may have severe and lasting negative impacts. Those activities could include relocation, repatriation, or translocation, and efforts to increase population sizes of imperiled amphibian species expected to be negatively impacted by climate change-induced drought.

The following three objectives will be met by this project:

1. Utilize, maintain, and repair already-installed liners in three ponds to enhance repatriation sites for sufficient pond hydroperiod throughout critical larval metamorphosis lifestage.
2. Monitor amphibian populations in three lined and three unlined ponds with frog-call surveys, incidental observations, and monthly dipnet surveys to assess influence of increased hydroperiod in lined ponds versus ponds without liners.

3. Evaluate expected hydroperiod changes in lined ponds relative to paired, unlined reference ponds.

METHODS

Study Area

The project is located within the Apalachicola National Forest (ANF) just south of Tallahassee, FL in Leon County (Figure 1). The targeted habitat is longleaf pine sandhill with embedded ephemeral wetlands, located within the Munson Sandhills. While the Munson Sandhills region is approximately 45,000 acres in size, this project is concentrated in an area of less than 600 acres. The six study wetlands range in size from 0.5 acres to 0.6 acres.

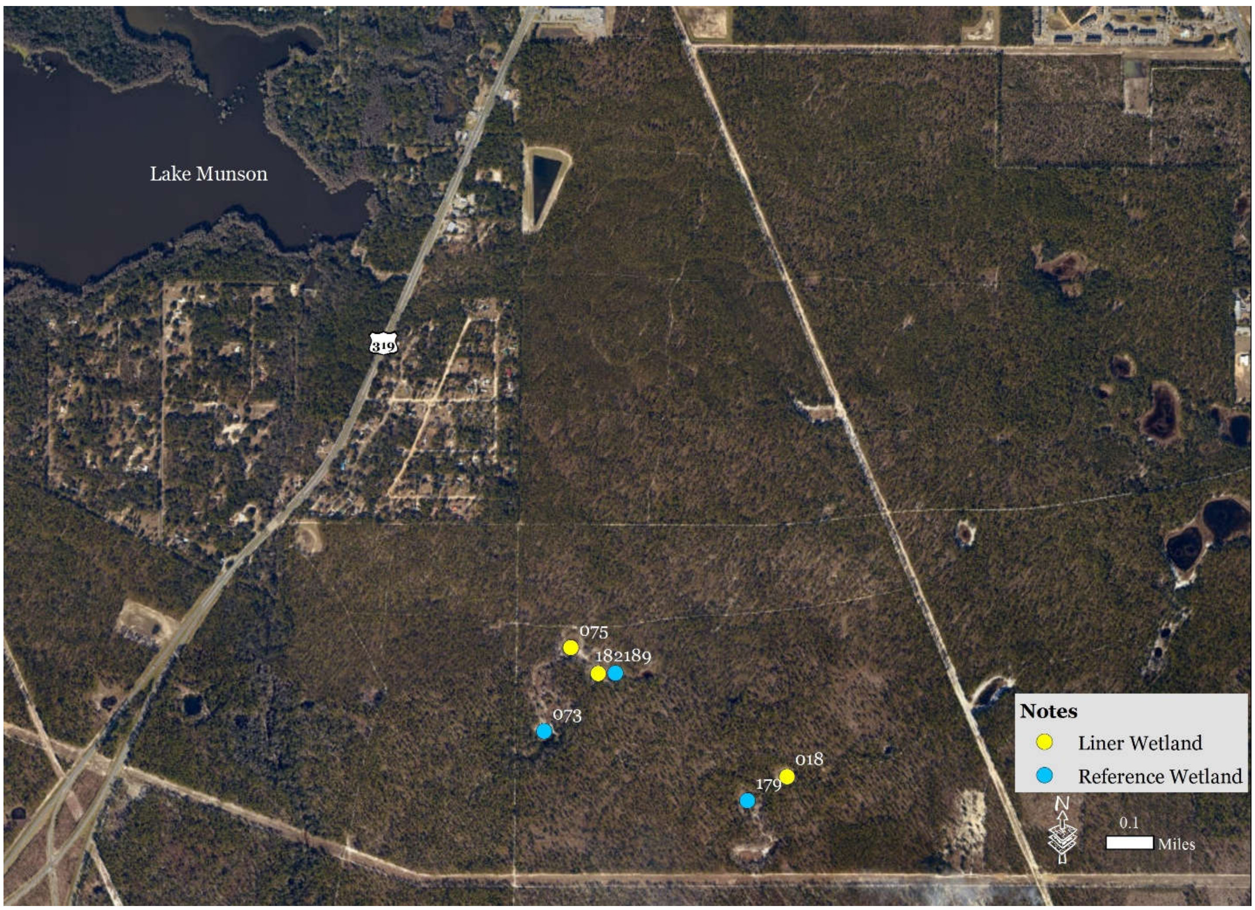

Figure 1: Map of the northeastern ANF showing the location of lined wetlands that serve as striped newt repatriation sites and unlined wetlands that serve as a hydrological control. Pond 18 is paired with Pond 179, Pond 75 is paired with Pond 73, and Pond 182 is paired with Pond 189.

Hydrological Monitoring

Hydrological work conducted by Katherine Milla (Florida A&M University) and Steve Kish (Florida State University) revealed that Munson Sandhills ponds are aquifer-driven, meaning they predominately respond to fluctuations in the groundwater table over time, not to individual rainfall events (pers. comm). With that knowledge, CPI hypothesized that installation of liners would create an artificial geological confining layer, currently non-existent in the sandy soiled Munson Sandhills, that would effectively change the way in which lined ponds would hydrate. Lined wetlands would begin responding to individual rain events whereas unlined ponds would still require groundwater to rise in order to become hydrated.

During 2012 and as part of a larger striped newt repatriation study (see Means et al. 2012), CPI selected four wetlands as repatriation (recipient) wetlands based on historic striped newt breeding habitat and suitability for synthetic liner installation. We installed synthetic (EPDM), 40-mil, "fish grade" rubber liners underneath the central portions of three of four selected repatriation wetlands (Ponds 18, 75, and 182) that had been gripped by severe drought at the time of installation. Liners were square-shaped and measured 40 feet long by 40 feet wide. We hypothesized that liners would boost recipient pond hydroperiods, thereby making them more drought resistant for the purpose of providing any repatriated newt larvae with enough time to reach metamorphosis. The fourth wetland, Pond 16, also was scheduled to receive a liner, but conditions there have been too wet to complete installation.

In an effort to quantify the hydrological impact of liners, we selected nearby wetlands that were hydrologically similar pre-liner installation to serve as reference/control wetlands. Pond 18 is paired with Pond 179 (Figure 2), Pond 75 is paired with Pond 73 (Figure 3), and Pond 182 is paired with Pond 189 (Figure 4). On 20 December 2016, we installed one, 0-3.32 foot, WaterMark ® Style "C" Stream Gauges in each of the six wetlands to begin quantitatively monitoring water levels. We attached each gauge to the top three feet of a four-foot section of PVC pipe using pre-drilled holes in the gauges and 2" galvanized screws. Using a mallet, we hammered the PVC pipe/stream gauges into the center of all six wetland basins until the gauge bottom (reading of 0.00") was flush with the wetland floor. All three reference wetlands were dry during time of installation. The three liner wetlands held small pools of water so we could not gain a visual reference of the wetland floor. Instead, we hammered the PVC pipe down until, using our hands, we could feel the bottom of the staff gauge was flush with the wetland floor. We were able to get an accurate read because the floor of these wetlands was firm. We did not hammer the PVC pipe deep enough to puncture the liners. Liners are covered by approximately 16-18" of organic soil beneath present wetland bottoms.

We also placed 5" Rain Gauges adjacent to wetlands. We checked pond water levels and rain gauges once a week beginning 10 January and at least every other day from January through June. The monitoring effort corresponded to the opening of drift fences associated with the striped newt repatriation project. During site visits, we checked that the liners were intact and seemingly functional based on the appearance of pooled water above the liner locations. We also checked for physical damage from off-road vehicle use, which has been an issue in the past.

Figure 2. Pond 18 (top picture), a lined wetland, and it's paired, unlined wetland Pond 179 (bottom picture). Before installation of the pond liner, these wetlands, which are within 1/10 of a mile from each other, were hydrologically similar.

Figure 3. Pond 75 (top picture), a lined wetland, and it's paired, unlined wetland Pond 73 (bottom picture). Before installation of the pond liner, these wetlands, which are less than 2/10 of a mile from each other, were hydrologically similar.

Figure 4. Pond 182 (top picture), a lined wetland, and it's paired, unlined wetland Pond 189 (bottom picture). Before installation of the pond liner, these wetlands, which are less than 200 feet from each other, were hydrologically similar.

Amphibian Community Assessment

We used dipnet surveys to detect larval and breeding adult amphibians in lined and unlined, reference wetlands. We sampled using a heavy duty dipnet (Memphis Net and Twine Co. HDD-2 model) with 3/16" mesh. The number of dip net sweeps or time of sampling per paired lined/unlined wetland was held constant but varied between wetland pairs based on wetland size and hydration. We concentrated sweep efforts along pond periphery and herbaceous vegetation patches. To prevent harm, dipnetting did not take place during periods when striped newt breeding activity was occurring or when tiny larvae were present.

CPI conducted seasonal, nocturnal call surveys at all six ponds during prime breeding weather conditions to ascertain the presence of all adult anuran species. Frog call surveys were conducted between the hours of 10 pm and 12:30 am and involved recording the species and relative number per species heard calling during a 15-minute period (none, sporadic, and chorus). In order to reduce hour-of-night influence on survey results, time between call surveys at a lined wetland and its unlined pair did not exceed 15 minutes.

We conducted opportunistic searches around the pond perimeters during dipnetting and frog call surveys. We documented all amphibians observed by species and quantity, including egg masses, larvae, and adults. Because only the lined wetlands have drift fencing around them, we did not include data associated with fences (in bucket traps or observed along the fences themselves).

PROGRESS

CPI began hydrological and rainfall monitoring on 10 January and we recorded water levels and rainfall amounts simultaneously, every other day minimum, throughout the study period until 30 June 2018. We conducted four dipnet surveys at hydrated wetlands from January – June and completed three frog call surveys at all wetlands (twice in February and once in June). We conducted opportunistic searches at all six wetlands during dipnet and frog call surveys. All liners continue to be in good condition. No off-road vehicle damage has occurred in the current study to date, and no repairs have been needed.

RESULTS AND DISCUSSION

Hydrological Monitoring

In 2018, during our 6-month sampling period, all lined ponds exhibited significantly longer hydroperiods than their unlined, paired wetland counterparts. Also, lined ponds responded instantly to single rainfall events, while unlined control ponds rapidly absorbed almost every single rain (Appendix A-C).

Our study region experienced overall relative dryness during winter 2017-2018. Sporadic rains, some heavy, did occur during the winter and early spring. Extreme arid conditions occurred in late April and lasted until mid-May. Abruptly on 15 May, the early onset of our local summer rainy season initiated with a 2.5" rainfall. From 15 May to 10 June, the region received approximately 12.5 inches of rain. And several more showers occurred until the end of our sampling season on June 30. Shallow water pools resided, with some fluctuation, on top of the lined portions of ponds throughout nearly the entire sampling period.

Pond 18 held water for the entire study period, while its paired, unlined counterpart, Pond 179, remained completely dry. Pond 18 nearly went dry by mid-May (0.65'), but a heavy, 2.5" thunderstorm instantly raised water levels to 1.62' on 15 May. This bump in water level allowed hundreds of gopher frog tadpoles to survive. The same rainfall event was instantly absorbed by the parched sandy wetland bottom of Pond 179 (Appendix A).

Pond 75 held water for four straight months before drying on 7 May. It remained dry for one week. A big rain on 15 May re-hydrated Pond 75, while its unlined counterpart, Pond 73, remained dry. Pond 75 remained hydrated for the rest of the sampling period. Several heavy rains ensued during the rest of May and consistently into June. Pond 75 continued to rise while Pond 73 remained dry. On 10 June, after another 1.5" rain event, Pond 73 hydrated to a measurable level. Pond 73 continued to hold very shallow water for the 20 remaining days of the 6-month sampling period, from 10 June 10 through 30 June (Appendix B).

Pond 182 followed a similar hydroperiod as Pond 75 but its reference wetland, Pond 189, remained dry throughout the entire study period (Appendix C). Pond 182 did go dry for a week in mid-May, but quickly rehydrated on 15 May. A given rain would provide a boost to water level at Pond 182 while the same rain would be soaked up rapidly at nearby Pond 189.

Events at all our study ponds provide a glimpse into area hydrogeoloy, but Ponds 75 and 73 provide more subtle details. On 19 March, a 4" rain raised water levels in Pond 73 from zero to 0.57 feet rapidly. The very next day, all pooled rain had percolated into the sandy soils and Pond 73 had gone dry. The same rain boosted water levels at Pond 75 by nearly a foot, and water resided for months. The same water level boost occurred at the other lined ponds, but other unlined ponds soaked up the water instantly.

Although Pond 73 absorbed rainwater like the other unlined ponds, it is noteworthy that perculation occurred more slowly at Pond 73 and this pond, in fact, became hydrated by season's end while the other unlined ponds remained dry. We hypothesize that Ponds 75 and 73 are both measurably lower in elevation, and therefore located closer to the underground water table, than the other two pond pairs. The water table simply did not rise high enough to hydrate the other two unlined ponds which are perched higher above the water table.

When all lined ponds hydrated instantly during the heavy May15 rainfall, it took 25 more days, and multiple rains totaling 12.5 inches, to raise the local groundwater table such that just one of our unlined ponds (Pond 73) could hydrate. Such events are strong indicators that liners provide effective barriers to pool rain water while unlined ponds, lacking in underlying confining layers, absorb given rains like sponges during periods when the ground water table is well below wetland bottoms.

In summary, lined ponds held water for dramatically longer than unlined ponds in 2018. Our data also show that it takes many rains and a significant period of time to raise our local groundwater table. If our study region's local groudwater aquifer (presumed to be the Floridan Aquifer System) is recessed deeply underground due to climatic dryness, groundwater withdrawl, and/or other factors, then local unlined ephemeral wetlands require much rainfall and long periods of time in order to become hydrated. Unlined area ponds do not respond to single rainfall events but depend on a rise in the underground aquifer level in order to hydrate. However, because of the presence of the impermeable liners, lined ponds respond instantly to single large rainfalls.

We note that when installing the liners, it was our intent to provide water refugia for developing striped newts that would eventually be released into the ponds. We needed to ensure that released newts would have enough water, and therefore time, to reach metamorphosis in what had been a drought-stricken, aquifer-recessed landscape. This year's hydrological data, coupled with last year's, show that liners have increased hydroperiods of ponds and are performing their intended role. It was of equal importance that we not create "permanent" wetlands. After two years of collecting daily hydrological data with a sound scientific design, the evidence shows we have thus far accomplished both objectives.

Amphibian Community Assessment

Data for striped newts are not reported as they are affected by our repatriation efforts, and likely only in the wetlands in which they have been repatriated. Repatriation activities can be variable from pond to pond, and often are dependent on several other uncontrolled variables. We detected only one other salamander species, the central newt, at one wetland (Pond 182) in 2018, but several anuran species expected as part of the ephemeral wetland community were present at lined wetlands and were absent or not as abundant at unlined wetlands (Figure 5) (Table 1).

Figure 5. Gopher frog and egg mass observed at Pond 18. Gopher frog egg masses were detected during observational surveys at Pond 18 (8 egg masses) and Pond 182 (2 egg masses).

Table 1. Species detected at lined versus unlined wetlands, January through June 2018. Detection methods included dipnet, frog call surveys, and opportunistic searches. Two of the three unlined wetlands (Pond 179 and 189) were dry throughout the study period.

Amphibian Species	Lined Wetlands	Unlined Wetlands
Notophthalmus viridescens	X	
Lithobates sphenocephalus	X	
Lithobates catesbiana	X	
Lithobates capito	X	
Acris gryllus	X	X
Anaxyrus quercicus	X	
Hyla femoralis	X	X
Hyla gratiosa	X	
Pseudacris ornata	X	
Species Richness	8	1

We conducted four dipnet surveys in all hydrated wetlands from January through June. Pond 73 was essentially dry until 10 June and therefore we only dipnetted this wetland once. Ponds 179 and 189 remained dry throughout the study period, we therefore did not dipnet these wetlands. Because the unlined wetlands either never hydrated (Ponds 179, 189) or did not have substantial water (Pond 73), we found a significant difference in the larval amphibian community between these two lined and unlined wetland pairs (Table 2).

Table 2. Larval amphibian species detected at six study wetlands during dipnet sampling events January through June, 2017.

Larval Amphibian Species	Lined Pond 18	Unlined Pond 179	Lined Pond 75	Unlined Pond 73	Lined Pond 182	Unlined Pond 189
Notophthalmus viridescens	0	0	0	0	2	0
Acris gryllus	50-100	0	2	0	23	0
Anaxyrus quercicus	4	0	0	0	0	0
Hyla femoralis	10	0	>100	11	>100	0
Hyla gratiosa	>100	0	25	0	>100	0
Lithobates capito	>100	0	5	0	14	0
Lithobates catesbiana	0	0	0	0	0	0
Lithobates sphenocephalus	>100	0	16	0	12	0
Pseudacris ornata	0	0	0	0	0	0
Psuedacris ocularis	0	0	0	0	0	0
Species Richness	6	0	5	1	6	0

We conducted three frog call surveys during the 2018 study year. Most wetlands throughout the region remained completely dry, including all reference (unlined) wetlands.

A winter survey was conducted on 12 February during a 1.5" rain event. Lined wetlands were hydrated, but at very low levels and all reference wetlands were dry. We detected no amphibian activity. We returned the following night during a smaller rain event, hoping that repeated rains would stimulate breeding activity. Southern leopard frogs were calling sporadically at Pond 18 and no frogs were heard at the reference pond, Pond 179. Ornate chorus frogs were calling sporadically at Pond 182 but no frogs were calling at Pond 189. No amphibian activity was detected at Pond 75 or its reference wetland, Pond 73.

We conducted a summer frog call survey on 16 June during a nighttime thunderstorm. Oak toads were calling lightly from the uplands surrounding all the pond basins; these were likely rain calls not breeding calls. The only chorus we documented was of southern cricket frogs at Pond 182.

Because lined wetlands held water for most of the study period, two of the three unlined wetlands remained dry throughout the study period, and the third unlined wetland held water for only 20 days during the study period, we attribute the greater amphibian activity (and especially breeding events) to the liners. Had unlined wetlands become hydrated long enough to entice local amphibians to breed, we believe that similar species that utilized lined ponds would also utilize unlined ponds. To test this, we must await a suitable wet climatic period to occur during our study. At no time did we detect any unexpected or invasive amphibian species within lined or unlined wetlands.

In conclusion, our results thus far suggest that liners have increased pond hydroperiods, provided increased opportunities for resident amphibians to breed, including our targeted imperiled species, and have thus far not had any observed deleterious effects to pond fauna. Additionally, liners are providing habitat for species previously undocumented at those wetlands, such as gopher frogs and central newts at Pond 182. We conclude that liners, thus far, are operating favorably and in line with our current conservation and management needs. We expect that next year's data also will mirror our findings from the previous two years.

FUTURE PLANS

We expect to begin field operations for Year 3 in January 2019, in conjunction with the beginning of the striped newt repatriation project. Because we are in the beginning phases of this project, statistical data interpretation is not appropriate yet. As we gather sufficient empirical water level and biological data from lined and unlined ponds, we expect to identify potential differences between amphibian communities (species richness and abundance) and hydrology at lined versus unlined wetlands using paired t-Tests.

If we decide to de-activate liners in the future, we can simply auger holes into the liners from above to restore original hydroperiods and allow for aquifer interaction with ponds.

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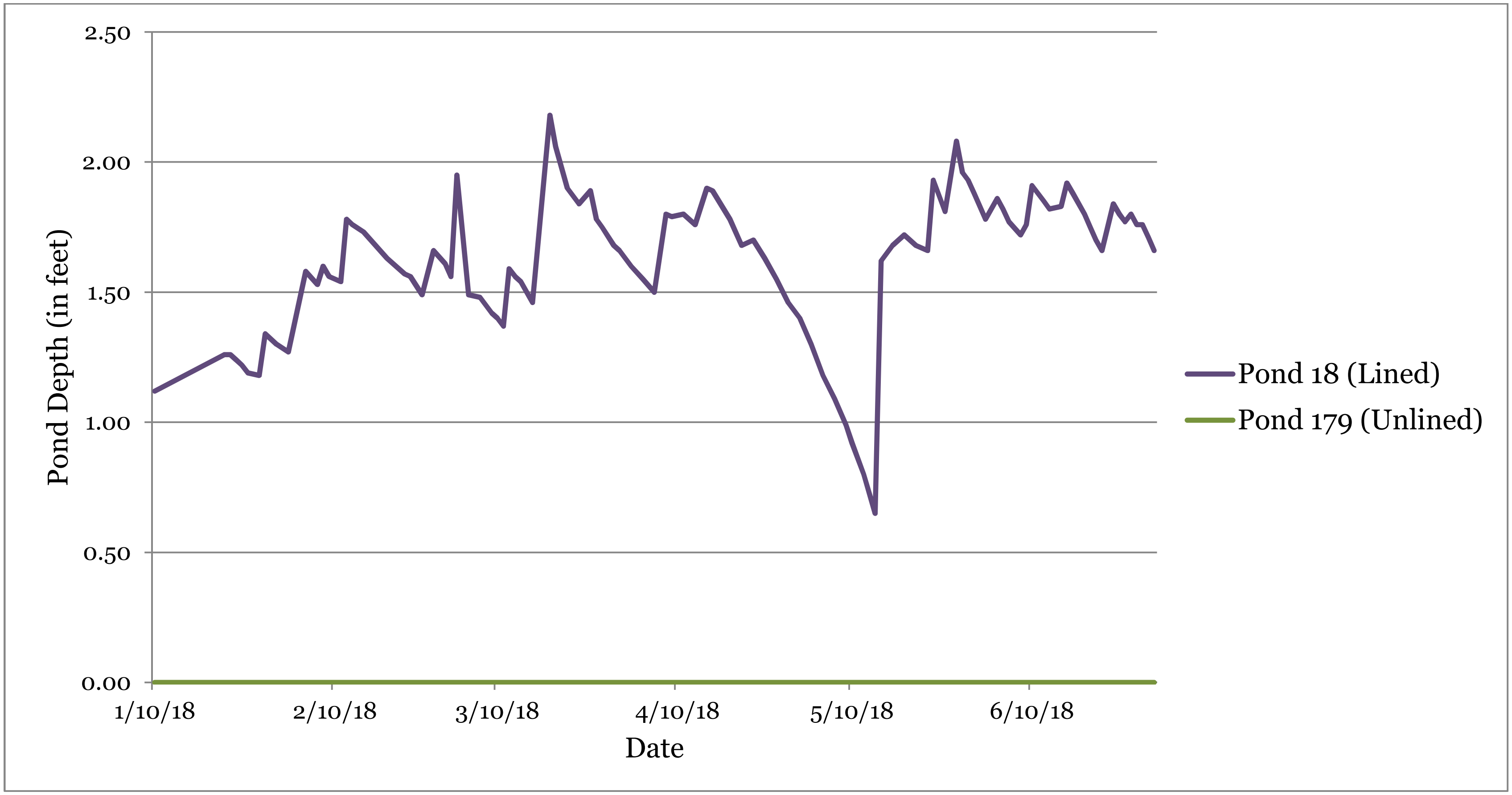
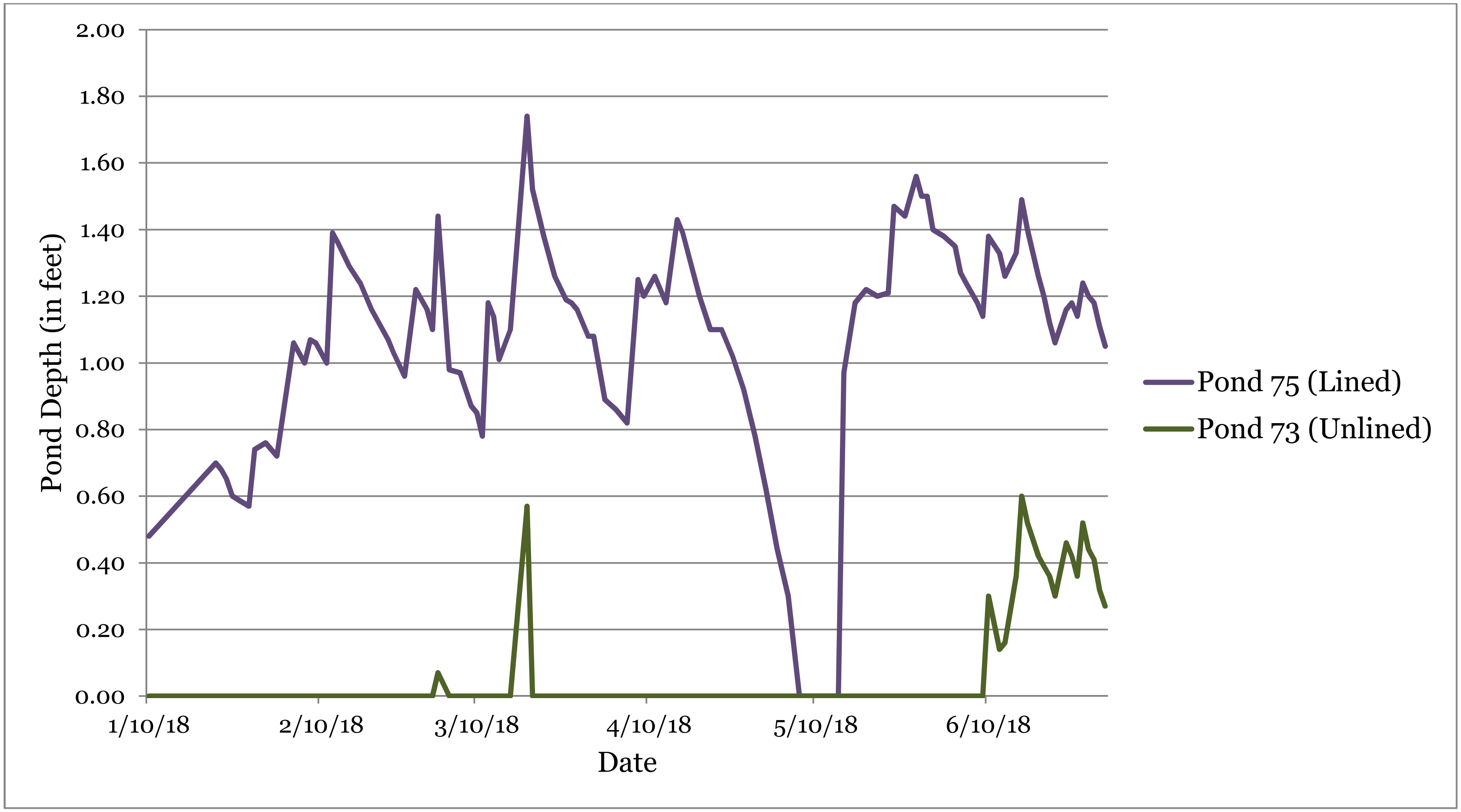
APPENDIX A. Hydrological Graphs of paired lined and unlined wetlands Ponds 18 and 179. Pond 18 remained hydrated throughout the study period while Pond 179 was completely dry



APPENDIX B. Hydrological Graphs of paired lined and unlined wetlands Ponds 75 and 73. Pond 75 held water for most of the year, except for 9 days in May. Pond 73 hydrated for very short periods of time during heavy rainfall episodes or periods. On 19 March, a 4" rain raised water levels in Pond 73 to 0.57 feet. The very next day, all pooled rain had percolated into the sandy soils and Pond 73 was dry. The same rain boosted water levels at Pond 75 by nearly a foot. Such events are strong indicators that liners provide effective barriers to pool rain water while unlined ponds, lacking in underlying confining layers, absorb given rains like sponges during periods when the ground water table resides well below the wetland bottom.



APPENDIX C. Hydrological Graphs of paired lined and unlined wetlands Ponds 182 and 189. Pond 182 held water for nearly the entire sampling period, except for drying during one week in mid-May. Pond 189 was dry during the entire sampling period.