Comparison of Created Vernal Pools to Natural Vernal Pools on Community Composition and Physiochemistry

William H. Kish

Department of Biological and Environmental Sciences

BIOL 455 – Ecology and Conservation of Wetlands

April 30^{th}, 2018

Introduction

When Europeans settled in America in the 1600s, the conterminous United States approximately had 221 million acres of wetlands. By the mid-1980s, the amount of wetlands that remain was about 103 million acres (Dahl & Allord, 1996). Wetlands are defined as transitional areas between terrestrial and aquatic ecosystems that are either flooded or saturated for extended periods to produce hydric soil and support hydrophilic vegetation (Hongjun et al. 2010).The Clean Water Act managed by the U.S. Army Corps of Engineers has helped in mitigating the wetland loss in the United States (Gibbs, 2000) due to the construction and restoration of wetlands being used to mitigate the loss of wetlands elsewhere (Russell and Beauchamp, 2017).

Vernal pools have very distinct characteristics, they prominently fill up with rainwater and snow melt in the fall and winter months and dry out in the summer months. They tend to be hydrologically isolated from other permanent bodies of water but can be connected through groundwater (Gamble & Mitsch, 2009). For these reasons, they are often one of the hardest wetland systems to recreate (Kolozsvary and Holgerson 2016). In this literature review, the effectiveness of created vernal pools in mimicking natural vernal pools is examined. The vegetation and fauna community composition and physiochemical features of created pools are compared to natural pools. This paper demonstrates that created pools are significantly different than natural pools in vegetation and fauna composition as well as physiochemistry.

Fauna

Many species of amphibians rely on vernal pools for their daily lives. Some amphibian species, especially the wood frog and spotted salamander, predominantly use vernal pools to lay their eggs (DiMauro & Hunter, 2002). Macroinvertebrates use these pools for breeding and are food sources for other organisms (Kolozsvary & Holgerson, 2016). For these reasons, macroinvertebrates and amphibians will be focused upon in this literature review.

A few studies have directly researched how effective created vernal pools are in housing amphibian communities. Korfel et al. (2010) surveyed amphibian biomass in vernal pools at 2 different wetland mitigation sites in central Ohio. Two different sampling methods were used, dip netting and funnel traps, and it was found that overall amphibian biomass was higher in created pools across both sampling methods. Using similar methods, Kolozsvary and Holgerson (2016) found that amphibian species richness did not differ between pool types. The occupancy by amphibians did not cluster to any of the pool types. Spotted salamanders and wood frogs were found in all the natural pools, but not in the created pools. Likewise, Petranka et al. (2003) found that created pools had significantly more species than natural pools. The occupancy between created and natural pools by amphibians differed significantly and that amphibians used the constructed pools more often than the natural pools.

Korfel et al. (2010) and Kolozsvary and Holgerson (2016) and Petranka et al. (2003) found comparable and conflicting results. There could be many reasons for there to be similar and conflicting results. Amphibians respond to several factors in the environment, one factor is canopy cover over the pools. Canopy cover was found to determine the species diversity and abundance due to the amount and quality of plant detritus at the bottom of the pool (Kolozsvary & Holgerson, 2016). Another factor would be local weather conditions. Different environmental conditions affect the composition of families and the conditions vary from year to year (Korfel et al. 2010).

Egg mass counts were also considered in the amphibian biomass. Kolozsvary and Holgerson (2016) counted spotted salamander and wood frog egg masses across the 7 created and 6 natural pools. They found that there were significantly more spotted salamander egg masses in natural pools than there were in created pools. But with wood frog egg masses, there were significantly more egg masses in created pools than natural pools. Similarly, DiMauro and Hunter (2002) also studied spotted salamander and wood frog egg masses. They found that of 34 constructed pools, 30 pools contained both wood frog and spotted salamander egg masses, two contained only wood frog egg masses, and two contained only spotted salamander egg masses. In 20 natural pools, 16 contained both wood frog and spotted salamander egg masses, two contained only wood frog egg masses, and two only contained spotted salamander egg masses.

The differences in egg mass counts could be due to many various reasons. First, the quality of plant detritus in the pool affects the amphibian performance. Detritus with increased carbon levels can affect the larval survival, growth, and development. Lastly, the predation on egg masses in vernal pools. Predatory amphibians, like the green frog, have been found to prey on other amphibian egg masses (Kolozsvary & Holgerson, 2016). But the reason that the egg mass counts are similar is because amphibians have great ability to colonize new breeding sites (DiMauro & Hunter, 2002).

While macroinvertebrates make up most of the vernal pools biomass, there are relatively few studies on them. Kolozsvary and Holgerson (2016) found 39 macroinvertebrate families throughout all the pools. Three families were exclusive to created pools and 3 were exclusive to natural pools. Overall family richness did not differ between reference pools and created pools. Different environmental conditions tend to affect the macroinvertebrate community composition, but macroinvertebrates tend to be habitat generalists.

It was found through these studies that amphibian composition is hard to predict. Through conflicting results, it is still not clear if amphibians do or do not cluster to one pool type. There are also conflicting results with the spotted salamander and wood frog egg masses, one study found similar egg mass counts across both pools while one study found only one type of egg masses in only one type of pool. But there were some similarities, most studies found there to be more amphibians in created pools than natural pools. With macroinvertebrates, the results were mixed, some families were only found in created pools while some in natural pools concluding that macroinvertebrates are habitat generalists.

Vegetation

Plant life in wetlands is a key characteristic that the U.S. Army Corps of Engineers have defined in what is a wetland (Gibbs, 2000). Vegetation in and around the pool have strong influences on the pools chemistry and how the pools ecosystems are shaped (Kolozsvary & Holgerson, 2016). An understanding of the plant community composition in created

Kolozsvary and Holgerson (2016) studied the plant biomass in and around the pools. Submerged shrubs and aquatic plant life was relatively low in both pool types and did not differ significantly. But the composition of emergent and floating-leaved plants differed between pools due to created pools having more of *Lemna*, *Typha*, and *Phragmites* (duckweed family, monocotyledonous seeds, specie of large perennial grasses respectively) plants. It was also discovered that there was no difference in algal biomass between natural and created pools. A similar study by Collinge et al. (2003) found 73 plant species in both pools during the study. There were no significant differences between the created and natural pools in absolute or relative cover by vernal pool endemics (VPEs). Cover of native plants was positively and non-linearly associated with water depth. Created pools that mimicked the hydrologic conditions like those of natural pools were more likely to support native plant populations.

These findings can be explained through many key factors. Created pools plant composition consisted of more *Typha* and *Phragmites australis* which are not normally in vernal pools. These species of plants could lead to future issues with the hydrology and biogeochemical processes as well as more competition with native vernal pool plants. With the algal biomass, temperature and sunlight affect the amount of algae. Although created pools were warmer and received more sunlight, the algal biomass did not differ. This could lead to future implications that the amount of sunlight and temperature may not be the best predicator of algal biomass (Kolozsvary & Holgerson, 2016). With VPEs, the hydrology dictated the coverage of VPE. Positive correlations between the pool depth and duration of inundation and the VPE coverage (Collinge et al. 2003).

Overall, the algal biomass and vegetation community composition seemed to all be dictated by pool hydrology. Differences were found between created and natural pool plant composition because created pools held species not normally found in natural pools. VPEs coverage was all dependent on the hydrology of the pools. Algal biomass did not differ between pool types even though temperature and amount of light received were different.

Physiochemistry

Physiochemistry refers to the physical and chemical traits of the vernal pool. Some major physiochemical parameters that are focused on are hydrology, size, dissolved oxygen, conductivity, and total dissolved solids. Hydrology can most arguably be the most important because of its major effects on amphibian and vegetation community composition (Korfel et al. 2010).

Because of hydrology's importance to a vernal pool, it is heavily discussed in this section. Korfel et al. (2010) studied groundwater and surface water and concluded that hydrologic connectivity differed between the pool types. Created pools tended to stay inundated longer even though pool depths were relatively the same. Likewise, Collinge et al. (2003) found that maximum water depth and duration of inundation were similar between both types of pools at start of experiment. After 9 years, created pools were shallower and had shorter inundation duration. Similarly, Gamble and Mitsch (2009) found that created pools did not always dry up like natural pools. The average inundation period for created pools was 309 ± 32 days while natural pools was 250 ± 16 days. Created pools had an inundation duration of 163-365 days with three pools being permanently inundated throughout the study.

Many distinct reasons could be behind the differences in pool hydrology. Clay liners in the created pools, differences in vegetation and canopy cover, and the initial size of the pools (Korfel et al. 2010). Soil differences could also affect the hydrology. Created pools tend to have soils with clay in them while natural pools have more hydric soil and organic muck layers all affecting how much ground water seepage (Gamble & Mitsch, 2009).

Onto the chemical aspects of vernal pools, Korfel et al. (2010) discovered that dissolved oxygen, conductivity, and hourly temperature were all significantly different between pool types. While redox potential, pH, and weekly temperature did not differ significantly. Similarly, Kolozsvary and Holgerson (2016) concluded that total dissolved nitrogen (TDN) did not significantly differ while total dissolved phosphorus and carbon (TDP, TDC) increased seasonally in both pool types. Created pools had higher conductivity and pH.

Possibly reasonings for the dissolved oxygen, conductivity, and temperature to differ could be due to differences in canopy cover, water source, and nutrient concentrations (Korfel et al. 2010). Differences and increases in the TDN, TDP, and TDC are due to the pools drying that leave a higher nutrient concentration in the remaining water. The higher pH and conductivity in created pools could be caused by geology, hydrology, soil, and land use around the pools to differ (Kolozsvary & Holgerson, 2016).

Hydrology between pools differed when it came to pool depth and inundation period. Created pools tended to be filled longer and shallower following development. The chemical levels of the pools differed in some respects but not in others. In some cases, the pH did differ but in others it did not. Other chemistry of the pools increased in both pools as the season went on.

Conclusion

Conflicting results made it hard to truly determine if created pools were good for the amphibian community composition. In some cases, species composition did differ between pool types while in some cases the species community composition did not differ. Amphibian occupancy tended to not cluster to any pool type while in other cases created pools were used more than often. Again, amphibian egg mass counts have conflicting results. Some egg masses were found in only one pool type while in other cases, the egg masses were found across all pool types. With macroinvertebrates, the results were mixed, with some families being in only one or both pool types.

Vegetation throughout the pools did not significantly differ, but the created pools had plant species not native to vernal pools. Hydrology played a huge role in the plant community composition across both pool types. Although temperature and light exposure usually played a role in the amount of algal biomass in a vernal pool, there was no different in biomass across both pool types.

Lastly, created pools were not able to mimic natural pools hydrology. Typically, the created pool was smaller in depth and either had a longer inundation period or stayed filled all year round. But, the inundation sometimes changed due to it being established longer and becoming more like the reference pools. Temperature of the pools were mixed with hourly and weekly temperature being different from one another. The pH and conductivity were higher in created pools and the TDN, TDP, and TDC all increased in both pool types.

Conservation plans should become more of an effort instead of trying to recreate vernal pools elsewhere (Calhoun et al. 2003). One conservation strategy includes using citizen science so that local communities can incorporate conservation strategies into regulatory processes and local planning (Morey, 1998). Future directions for this topic include more research into how plant communities and the physiochemistry respond to created pools. Thus, when vernal pools need to be created elsewhere, there will be a more complete understanding of how the community composition and physiochemistry respond to created pools.

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