Influence of Hydroperiod and Depth of Woodland Vernal Pools on Small Mammal Abundance and Diversity in the Upper Great Lakes Region

Matthew T. Farr

Purdue University
West Lafayette, IN, USA

University of Notre Dame
Environmental Research Center
Land 'O Lakes, WI, USA

July 2013

Research Advisor: Robert Mckee

Abstract

The preservation of biodiversity is vital in maintaining function and structure of forest ecosystems. Woodland vernal pools are correlated with biodiversity in forest ecosystems, and the depth and hydroperiod of woodland vernal pools are known to be a predictor of species richness. Presently, there is a lack of research and scientific literature on how the presence of woodland vernal pools affects the activity and presence of small mammal populations. The purpose of this study was to determine the activity and habitat preferences of small mammals at woodland vernal pools. The diversity and abundance of small mammal populations at "long-cycle pools" and "short-cycle pools" were compared. H. B. Sherman traps were used along transects to capture small mammals in order to calculate the Jolly-Seber abundance index, Shannon's diversity index, and Simpson's diversity index. More individuals were caught near "long-cycle pools" than at "short-cycle pools." The majority of individuals caught were *Peromyscus maniculatus*, but other species included *Glaucomys sabrinus, Glaucomys volans, Zapus hudsonius,* and *Tamiascurius hudsonicus*. Depth was determined to be an indicator of small mammal abundance. There was no statistical relationship between vernal pool hydroperiods and the abundance and diversity of small mammal populations. The distance from vernal pools was found to be positively correlated with the activity of small mammal populations.

Keywords: Hydroperiod, Jolly-Seber Abundance, Shannon's Diversity, Small Mammals, Simpson's Diversity, Woodland Vernal Pools.

Introduction

The preservation of biodiversity is important for maintaining critical ecological services and functions in forest ecosystems, and multiple features of forest ecosystems simultaneously aid in preserving or increasing biodiversity (Bennet and Balvanera 2007). The future projections of biodiversity levels are largely uncertain for forest ecosystems (Sala et al. 2000). Thus, it is critical to understand how certain features currently promote biodiversity in forest areas.

Within the United States, vernal pools have been found to contribute to forest biodiversity, and vernal pools influence the composition of both flora and fauna (Brooks and Hayashi 2002, Colburn 2004). Colburn (2004) found that the spatial biodiversity in forest ecosystems is largely increased by the presence of vernal pools. Vernal pools also contain a high variability in alpha diversity between each other, thus they have high beta diversity. Therefore, Colburn (2004) found that the regional biodiversity or gamma diversity of a forest ecosystem is directly influenced by the presence of vernal pools. Therefore, it is necessary to understand how vernal pools alter the function and fitness of species.

Vernal pools are temporary bodies of water that have fluctuating water levels through seasonal flooding and drying out periods (Colburn 2004, McGreavy et al. 2012). The periods of fluctuating water levels are referred to as vernal pools' hydroperiods (Brooks and Hayashi 2002). Vernal pools are classified based on the surrounding matrix and ecosystem, and the majority of vernal pools in the northern Midwest are classified as woodland vernal pools, which are surrounded by forested areas (Colburn 2004).

Woodland vernal pools have been shown to benefit amphibians by providing them with breeding sites and preferred habitat (Preisser et al. 2000, Brooks and Hayashi 2002). However, the use of woodland vernal pools by small mammals has not been well documented or studied compared to that of amphibians (Mitchell et al. 2007). Brooks and Doyle (2001) did provide some insight on the activity levels of small mammals at vernal pools and showed that the microhabitat provided by woodland vernal pools largely benefit small mammals. Woodland vernal pools provide complex vegetation structures that coincide with the complex microhabitat requirements of small mammal species, which require coarse woody debris and a high percent of ground cover (Yahner 1986, Zollner and Crane 2003, Colburn 2004). In addition woodland vernal pools contain a high abundance and diversity of invertebrates, which provide a source of food for small mammals that prey upon them (Brooks and Doyle 2001, Colburn 2004, Francl 2005). Mitchell (2007) found that food sources indirectly produced by the presence of vernal pools are frequently consumed by small to mid-sized mammals, and vernal pools can serve as foraging sites for small mammals. Prey abundance and foraging efficiency is an important microhabitat requirement that can affect the fitness of small mammals (Yahner 1986).

Depending on their hydroperiod and size, woodland vernal pools can be an unpredictable resource for small mammals (Brooks and Doyle 2001). The hydroperiod of a vernal pool is a determinate of faunal composition and function, which influences reproduction and fitness (Brooks and Hayashi 2002). Therefore, geographic, seasonal, and annual variation in vernal pool hydroperiods can change or alter how they aid or benefit small mammals.

However, vernal pool depth is correlated with the number of species at a vernal pool and thus is an effective predictor of species richness (Ripley and Simovich 2009). The depth of vernal pools is also correlated with the hydroperiods of vernal pools (Brooks and Hayashi 2002). Hence, hydroperiods of a vernal pool are also correlated with the number of species and can be used to predict species richness at a site (Ripley and Simovich 2009). Thus, understanding the variability in hydroperiods is important in determining species activity at vernal pool sites. Colburn (2004) classified woodland vernal pools into groups according to their hydroperiod. "Short-cycle pools" are considered to be vernal pools that shrink in water depth and volume directly after they reach their maximum depth in the spring. "Long-cycle pools" are vernal pools that shrink in water depth and volume after they reach their maximum depth in the spring, but remain flooded up to twice as long as "short-cycle pools."

The aim of this study was to measure small mammal activity at woodland vernal pools in the Upper Great Lakes area. The study specifically looked at the preference of small mammals between "long-cycle pools" and "short-cycle pools." It was hypothesized that small mammals will have a greater presence at "long-cycle pools" than "short-cycle pools" due to the complex microhabitat that is provided by longer hydroperiods. Therefore, it was predicted that small mammal abundance and diversity would be greater at vernal pools with longer hydroperiods, and that small mammal abundance and diversity would be positively correlated with the water depth of vernal pools. The distance from the edges of vernal pools was predicted to be negatively correlated with the abundance and diversity of small mammal populations.

Methods

Study Area

Research was carried out at the University of Notre Dame Environmental Research Center (UNDERC) in Gogebic County, Michigan and Vilas County, Wisconsin. The UNDERC property encompasses 6150 acres of secondary growth forest and mostly consists of northern mesic hardwood forest containing *Populus*, *Betula*, *Pinus*, *Acer*, *Tsuga*, and other hardwood and conifer genera. A total of 30 lakes and bogs and a vast amount of woodland vernal pools are present on the property (University of Notre Dame Environmental Research Center [UNDERC] 2006).

Treatments and Field Techniques

In order to analyze how vernal pools affect the presence and activity of small mammals, two treatments were used in the study. Treatment 1 consisted of 4 sites with "long-cycle pools" with high water depths while Treatment 2 consisted of 4 sites with "short-cycle pools" that were dried up or possessed very low water depths (Table 1, Figure 1). Each replicate or pool was paired with a pool from the other treatment whose small mammal populations were measured at the same time.

Small mammal trapping was used to estimate the abundance and diversity of small mammal populations at each site. H.B. Sherman traps (3 x 3.5 x 9") were used to trap small mammals as they have been shown to be one of the most efficient live trapping methods of small mammals (Morris 1968, Whittaker et al. 1998). Twenty Sherman traps were used at each site, with a total of 40 Sherman traps being used at a time. The edges of dried up vernal pools were determined to be the potential maximum level of water during the pools' hydroperiod, and this was considered to be where soil moisture conditions changed from moist to dry.

Due to the irregular shapes of vernal pools, a normal trapping grid was not practical. Thus, 10 transects leading away from the vernal pool edges were used at both treatments with 5 transects on each side of the pool spaced 10 meters apart (Figure 2). Two Sherman traps were placed along each transect, one at 5 meters from the vernal pool edge, and the second at 15 meters from the vernal pool edge.

Small mammals were caught during four, four-night trapping periods between June 24 and July 15. Sherman traps were set and baited around 8 PM and then were checked and closed at 6 AM the following morning. Early morning trap checks were preformed in order to reduce trap mortality. A mix of sunflower seeds, oats, and dried mealworms were used as bait.

Small mammals captured in Sherman traps were identified to species (Kurta 1995). Body weight, sex, and species indicator measurements were taken for each individual. Individuals were then ear tagged using an ear tag applicator and released on site. If an individual was a recapture from a previous day, only the weight was recorded.

Site Measurements

To measure the depth of each pool, the maximum length and the corresponding width was identified. Depth was measured across the maximum length and corresponding width of the pool at intervals of 1 meter. The length and width depths were averaged together to calculate an average depth for each vernal pool.

Abundance and Diversity

The abundances of each small mammal population were calculated using a capture, mark, and recapture (CMR) method. CMR has been shown to be an accurate abundance estimator of small mammal populations and is more precise than other abundance models

(Seber 1986, Pacheco et al. 2013). Specific species' abundances were not calculated due to a low sample size; therefore, the total abundance of all small mammal species was calculated. The Jolly-Seber method was selected to calculate small mammal abundance at each site because it allows for multiple days of trapping. The Jolly-Seber method presumes that the measured population is open, capture probability of all individuals is equal, and that marking individuals does not decrease their fitness (Jolly 1965, Kaminski et al. 2007). In addition the Jolly-Seber method assumes that all individuals of a single population may not be homogeneous and allows for individuals to be of different species (Jolly 1965).

Shannon's diversity (H') and Simpson's diversity (1-D) indices were used to calculate species diversity at each site. Shannon's diversity is based on information theory and uses the degree of uncertainty to calculate diversity. Simpson's diversity is a dominance index, which gives weight to the most common species in its calculation of diversity (Williams et al. 2005).

Data Analysis

Data analyses were run (SYSTAT 13.1) to determine if the presence of vernal pools influenced the activity of small mammals. A paired t-test was used to evaluate the difference between paired replicates of each treatment for small mammal Jolly-Seber abundances and both diversity indices. In addition a linear regression was utilized to determine if there was a relationship between Jolly-Seber abundance and the depth of vernal pools. Additional linear regressions were performed to determine if there was a relationship between vernal pool depth and the diversity indices. The distance, 5 or 15 meters, each trap was from the edge of each pool was also evaluated using two separate

one-way ANOVA analyses. Percent capture, the number of captures out of the total number of traps, was used a response variable. The aggregate percent of capture, the percent of captures out of the total number of captures, was used as the other response variable.

Results

Fifty-two individuals were captured during the trapping period. Thirty-seven *Peromyscus maniculatus* individuals were caught. The other 15 individuals were *Glaucomys sabrinus, Glaucomys volans, Myodes gapperi, Zapus hudsonius, or Tamiascurius hudsiconus*. Thirty-one individuals were found at "long-cycle pool" sites (Treatment 1). Twenty-one individuals were found at "short-cycle pool" sites (Treatment 2). The overall species diversity for both Shannon's diversity and Simpson's diversity for Treatment 1 (H' = 1.145, [1 – D] = 0.566) was higher than Treatment 2 (H' = 0.501, [1 - D] = 0.254).

A mean abundance of 4.8 small mammals were found at "long-cycle pool" sites, and a mean abundance of 3.1 small mammals were found at "short-cycle pool" sites. The paired t-test for Jolly-Seber abundance for "long-cycle pool" sites and "short-cycle pool" sites was not significant ($p > 0.05$, Table 2, Figure 3).

The mean diversity for Shannon's diversity index at "long-cycle pools" was 0.326, while the mean diversity for Simpson's diversity index was 0.572. The mean diversity for Shannon's diversity index at "short-cycle pools" was 0.180, and the mean diversity for Simpson's diversity index was 0.311. The paired t-test for Shannon's diversity index and Simpson's diversity index for "long-cycle pool" sites and "short-cycle pool" sites were both non-significant ($p > 0.05$, Table 2, Figure 4, Figure 5).

However, there was an apparent trend in the data showing that "long-cycle pool" sites, Treatment 1, had higher values than "short-cycle pool" sites (Treatment 2) for both Shannon's diversity and Simpson's diversity.

The linear regression for the Jolly-Seber abundance with changes in depth was non-significant ($p > 0.05$, Table 2, Figure 6); however the value for Control 1 pool was identified as an outlier. Therefore, an additional linear regression without the outlier was preformed. The adjusted linear regression for the Jolly-Seber abundance with changes in depth came out as significant ($p = 0.015$, $F_{1,5} = 13.307$, $R^2 = 0.727$, Figure 7). The linear regressions for Shannon's diversity and Simpson's diversity with changes in depth were non-significant ($p > 0.05$, Table 2).

The ANOVA for percent capture between 5 meters and 15 meters came out as significant ($p = 0.039$, $F_{1,14} = 5.166$, $R^2 = 0.519$, Figure 8). The ANOVA for aggregate percent of capture between 5 meters and 15 meters came out as significant ($p = 0.004$, $F_{1,14} = 11.800$, $R^2 = 0.457$, Figure 9).

Discussion

Site Preference: Abundance and Diversity

The results showed a greater amount of small mammals were found at "long-cycle pools" ($N = 31$) than at "short-cycle pools" ($N = 21$). In addition both Shannon's and Simpson's diversity indices were higher in "long-cycle pools" ($H' = 1.145$, $[1 – D] = 0.566$) than at "short-cycle pools" ($H' = 0.501$, $[1 - D] = 0.254$). However, there was no statistical evidence that small mammals preferred "long-cycle pools" or "short-cycle pools". Despite trends in the data there was no statistical evidence that small mammal abundance or diversity differed between "long-cycle pools" and "short-cycle pools". The statistical

results do not support the study's original hypothesis, which predicted that there would be higher small mammal diversity at "long-cycle pools".

The Jolly-Seber abundance trended towards "long-cycle pools" having a higher abundance than "short-cycle pools." As for both diversity indices, the data trended towards "long-cycle pools" having a higher diversity than "short-cycle pools." Even though there was no statistical evidence, the mean of the data for all of the analyses trended towards "long-cycle pools" as being more abundant and diverse, which suggests that small mammals may prefer "long-cycle pools" over "short-cycle pools." However, the variability within each treatment between the replicate pools could be the reason that there is no statistical difference in preference between "long-cycle pools" and "short-cycle pools." Therefore, a larger sample size and more replicates, would likely have reduced variability between replicates and better allowed an assessment of whether small mammals' preferred "long-cycle pools" over "short-cycle pools".

The results of this study agree with the findings of Brooks and Doyle (2001). Brooks and Doyle (2001) found that there were no significant differences for small mammal abundances between vernal pool sites and sites without a water source. Their reasoning for the lack of significant difference between their two treatments was due to the small hydroperiod in their vernal pool sites, which is different from this study.

The results could have also been influenced by the trapping methods used. Lethal trapping and pitfall traps have been shown to be significantly more effective ways to capture small mammals than live trapping (Umetsu et al. 2006, Eulinger and Burt 2011). Francl (2004) used snap traps and pitfall traps within the UNDERC property and trapped a variety of shrew species near vernal pools; therefore, small mammal abundance and

diversity could have been much higher for "long-cycle pools" in this study if lethal trapping would have been utilized. Lethal trapping was not used due to the capture, mark, and recapture method that was being used to estimate abundance.

Vernal Pool Depth: Abundance Indicator

Though neither the linear regression for Shannon's diversity index upon water depth nor the linear regression for Simpson's diversity index upon water depth was statistically significant, both regressions showed a slight positive trend as depth increased. The linear regression for the Jolly-Seber abundance upon water depth also was non-significant but showed a positive trend. However, the "short-cycle pool," Control 1, was statistically determined to be an outlier for the Jolly-Seber abundance linear regression. The Control 1 site encompassed the largest amount of area for any of the replicates in the "short-cycle pool" treatment, and it also had the largest distance between the first set of 5 transects and the last set of 5 transects. Hence, Control 1 likely had a higher probability of capturing more small mammals because it encompassed a larger area and had a smaller trap density at the site. Therefore, it was determined that there was enough justification to remove this replicate from the data analysis and to re-run the linear regression for Jolly-Seber abundance with changes in depth. After this adjustment the regression of Jolly-Seber abundance upon water depth was significant. Thus, as the depth of vernal pools increased the abundance of small mammals increased as well. The results of the adjusted linear regression support this study's hypothesis that small mammal abundance increases with depth. The results are consistent with the claim by Brooks and Hayashi (2002) and Ripley and Simovich (2009) that depth and hydroperiod are indicators of small animal populations. Increases in vernal pool depths most likely indirectly influence

small mammal abundance by drawing in more prey species for small mammals to consume (Mitchell et al. 2007).

Distance from Vernal Pool

The study found that small mammals were significantly more likely to be caught in traps further away from the edge for both "long-cycle pools" and "short-cycle pools." This may indicate that small mammals were avoiding the edges of vernal pools. For the "long-cycle pools" these results are partially due to the inability of small mammals to occupy the area within the actual pond, and thus they can only enter the trapping area from the side nearer to the 15 meter traps. Consequently the15 meter traps likely had a higher probability of catching small mammals in "long-cycle pools". However, this does not explain the significant differences between traps at different distances in "short-cycle pools" since no water barrier was located adjacent to the 5 m traps. Thus, small mammals showed a preference for the 15 meter traps even when a physical barrier was not present. The results possibly also could be explained by the presence of edge effects at the border between the forest interior and vernal pools. Vernal pools often have a lower percent of canopy cover than the surrounding forest (Colburn 2004). Small mammal activity is influenced by the presence of forest edges and increases as distance from an edge increases (Klein and Cameron 2012). In addition both "short-cycle pools" and "long-cycle pools" might lack preferred microhabitat features that are more common in the surrounding forest. Small mammals prefer areas with coarse woody debris and canopy cover (Zollner and Crane 2003). Klein and Cameron (2012) found that small mammal activity increases on a gradient as vegetation structure increases from the edges of forest. Vernal pools could be having edge effects on small mammals by creating a

gradient of vegetation structure from the edge of the pool outwards and thus providing reason to why 15 meter traps were capturing more small mammals than 5 meter traps.

Implications and Further Research

The results of this study do not clearly define "long-cycle pools" as a preferred habitat for small mammal species, but the data does reveal trends that indicate vernal pools are a viable habitat for a diverse amount of small mammals. In addition the results reinforce the hypothesis that vernal pool depth and hydroperiod are indicators of species richness and abundance. The area around vernal pools is therefore vital in providing habitat to small mammals. In order to maintain the biodiversity at vernal pools and their ecological roles in the ecosystem, additional research will need to be conducted to better understand mammals' relationship with vernal pools. According to Colburn (2004), many steps have been taken to conserve habitat with vernal pools, but further understanding and research is required in order to better conserve these areas of high biodiversity.

Acknowledgments

Thank you to Robert Mckee for help with data collection, research guidance, and his unwavering commitment to this research. Thank you also to Riley Parrot and Ivy Yen for their countless hours of aid. Thank you to Amy Johnson and Linsey McMullen for their help in the field. In addition, thank you to Dr. Michael Cramer, David Flagel, and Claire Mattison for their research guidance, and finally thank you to the Hank family for their generosity through the Bernard J. Hank Family Endowment that made this research possible.

Literature Cited

Bennett, E. M. and Balvanera, P. 2007. The future of production systems in a globalized world. *Frontiers in Ecology and the Environment,* **5**: 191-198.

Brooks, R. T. and Doyle, K. L. 2001. Shrew Species Richness and Abundance in Relation to Vernal Pond Habitat in Southern New England. *Northeastern Naturalist,* **8**: 137-148.

Brooks, R. T. and Hayashi, M. 2002. Depth-area-volume and hydroperiod relationships of ephemeral (vernal) forest pools in southern New England. *Wetlands*, **22**: 247-255.

Colburn, E. A. 2004. Vernal pools: natural history and conservation. The McDonald & Woodward Publishing Company, Granville, Ohio.

Eulinger, K. G. and Burt, M. S. 2011. Comparison of captures between Sherman live traps and museum special kill traps. *Southwestern Association of Naturalists*, **56**: 241-246.

Francl, K. E. 2004. Aquatic survey of shrews in the Great Lakes region. *UNDERC Research,* 1-21.

Francl, K. E. 2005. Bat activity in woodland vernal pools. *UNDERC Research*, 1-26.

Jolly, G. M. 1965. Explicit estimates from capture-recapture data with both death and immigration-stochastic model. *Biometrika*, **52**: 225-247.

Kaminski, J. A., Davis, M. L., Kelly, M., and Keyser, P. D. 2007. Disturbance effects on small mammal species in a managed Appalachian forest. *The American Midland Naturalist*, **157**: 385-397.

Klein, G. P. and Cameron, G. N. 2012. Effect of habitat gradients on space use by white-footed mice (*Peromyscus leucopus*). *American Society of Mammalogists*, **93**: 706-715.

Kurta, A. 1995. *Mammals of the Great Lakes Region*. M. M. Douglas (Ed.). Ann Arbor, MI: The University of Michigan Press.

McGreavy, B., Webler, T., and Calhoun, A. J. K. 2012. Science communication and vernal pool conservation: a study of local decision maker attitudes in a knowledge-action system. *Journal of Environmental Management*, **95**: 1-8.

Mitchell, J. C., Paton, P. W. C., and Raithel, C. J. 2007. The importance of vernal pools to reptiles, birds, and mammals. In: Calhoun, A. J. K. deMaynadier, P. G. (eds.), *Science and Conservation of Vernal Pools in Northeastern North America*. CRC Press, Boca Raton, Florida, pp. 169-190.

Morris, R. D. 1968. A comparison of capture success between Sherman and Longworth live traps. *The Canadian field-naturalist*, **82**: 84-87.

Pacheco, M., Kajin, M., Gentile, R., Zangrandi, P. L., Vieira, M. V., and Cerqueira, R. 2013. A comparison of abundance estimators for small mammal populations. *Zoologia*, **30**.

Preisser, E. L., Kefer, J. Y., and Lawrence, J. D. 2000. Vernal pool conservation in Connecticut: an assessment and recommendations. *Environmental Management*, **26**: 503-513.

Ripley, B. J. and Simovich, M. A. 2009. Species richness on islands in time: variation in ephemeral pond crustacean communities in relation to habitat duration and size. *Hydrobiologia*, **617**: 181-196.

Sala, O. E., Chapin, S., Armesto, J. J., Berlow, E., Bloomfield, J., Dirzo, R., Huber-Sanwald, E., Huenneke, L. F., Jackson, R. B., Kinzig, A., Leemans, R., Lodge, D. M., Mooney, H. A., Oesterheld, M., Poff, N. L., Sykes, M. T., Walker, B. H.,

Walker, M., and Wall, D. H. 2000. Global biodiversity scenarios for the year 2100. *Science*, **287**: 1770-1774.

Seber, G. A. F. 1986. A review of estimating animal abundance. *Biometrics*, **42**: 267-292.

SYSTAT Software Inc. 2013. SYSTAT 13.1. *SYSTAT Inc*., Chicago.

Umetsu, F., Naxara, L., and Pardini, R. Evaluating the efficiency of pitfall traps for sampling small mammals in the neotropics. *Journal of Mammalogy*, **87**: 757-765.

University of Notre Dame Environmental Research Center. 2006. *UNDERC plant list* [Data file]. Retrieved from http://www3.nd.edu/~underc/east/about/.

Williams, V. L., Witkowski, E. T. F., and Balkwill, K. 2005. Application of diversity indices to appraise plant availability in the traditional medicinal markets of Johannesburg, South Africa. *Biodiversity and Conservation*, **14**: 2971-3001.

Whittaker, J. C., Fledhamer, G. A., and Charles, E. M. 1998. Capture of mice, *Peromyscus*, in two sizes of Sherman live traps. *The Canadian field-naturalist*, **112**: 527-529.

Yahner, R. H. 1986. microhabitat use by small mammals in even-aged forest stands. *American Midland Naturalist*, **115**: 174-180.

Zollner, P. A. and Crane, K. J. 2003. Influence of canopy closure and shrub coverage on travel along coarse woody debris by eastern chipmunks (*Tamias striatus*). *The American Midland Naturalist*, **150**: 151-157.

Appendix

Table 1. Pool and corresponding depths

Pool	Depth (m)
P	0.336451906
Control 1	0.003031915
9	0.36307971
Control 2	0.010199557
L	0.638816327
Control 3	0.034494598
7	0.860943089
Control 4	0.004114583

Table 2. Results of statistical analyses

Analysis	N	Mean	df	R^2	F	p-value
Jolly-Seber Paired t-Test	8	Treatment 1: 4.8±0.801 Treatment 2: 3.1±0.916	3	-	-	0.333
Shannon's Diversity Paired t-Test	8	Treatment 1: 0.326±0.060 Treatment 2: 0.180±0.119	3	-	-	0.279
Simpson's Diversity Paired t-Test	8	Treatment 1: 0.572±0.108 Treatment 2: 0.311±0.206	3	-	-	0.237
Jolly-Seber vs Depth Linear Regression	8	-	6	0.388	3.801	0.099
Jolly-Seber vs Depth Linear Regression Adjusted	7	-	5	0.727	13.307	0.015
Shannon's Diversity vs Depth Linear Regression	8	-	6	0.27	2.218	0.187
Simpson's Diversity vs Depth Linear Regression	8	-	6	0.279	2.308	0.179
Percent Capture ANOVA	16	5 Meters: 0.110±0.020 15 Meters: 0.186±0.027	14	0.519	5.166	0.039
Aggregate Percent of Capture ANOVA	16	5 Meters: 0.348±0.051	14	0.457	11.8	0.004

15 Meters: 0.704±0.090

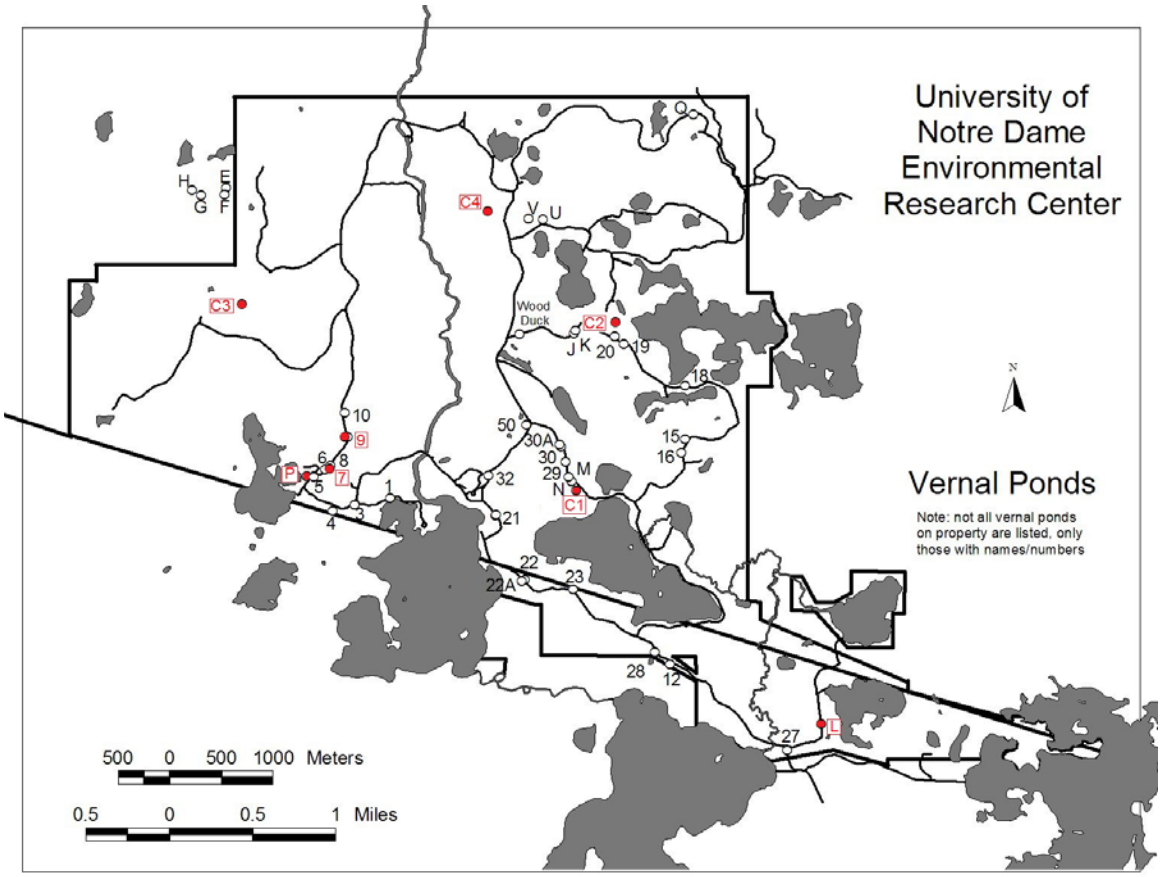

Figure 1. Site locations of vernal pools (UNDERC 2006).

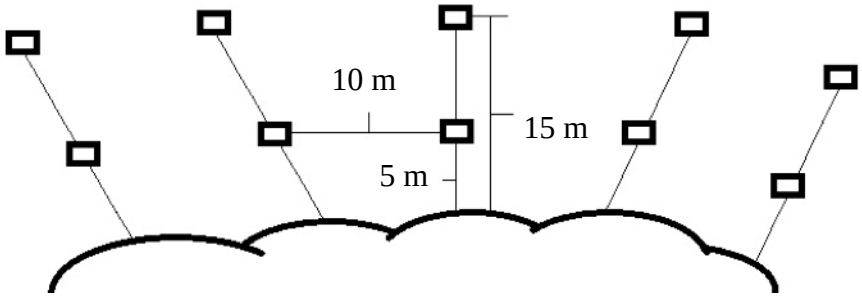

Figure 2. Trapping transects and dimensions

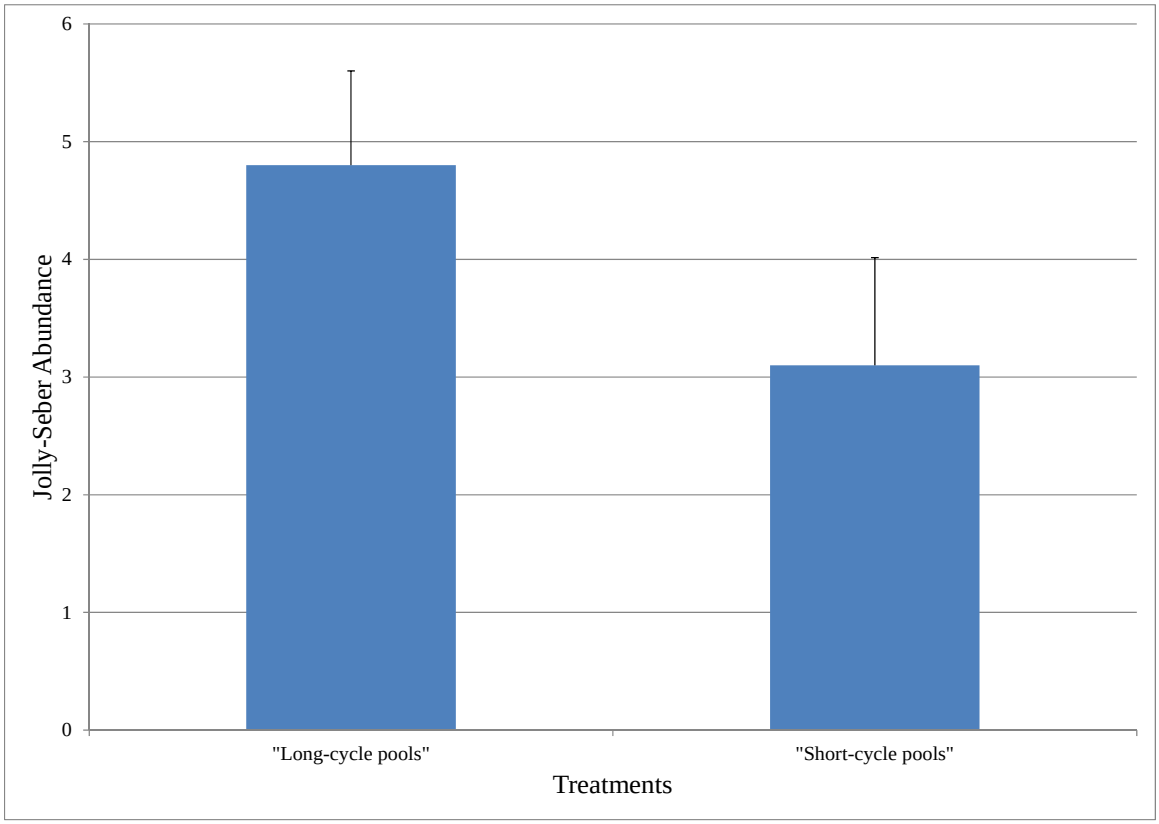

Figure 3. Mean values of Jolly-Seber abundance between “long-cycle pools” and “short-cycle pools” (Paired t-Test, p = 0.333).

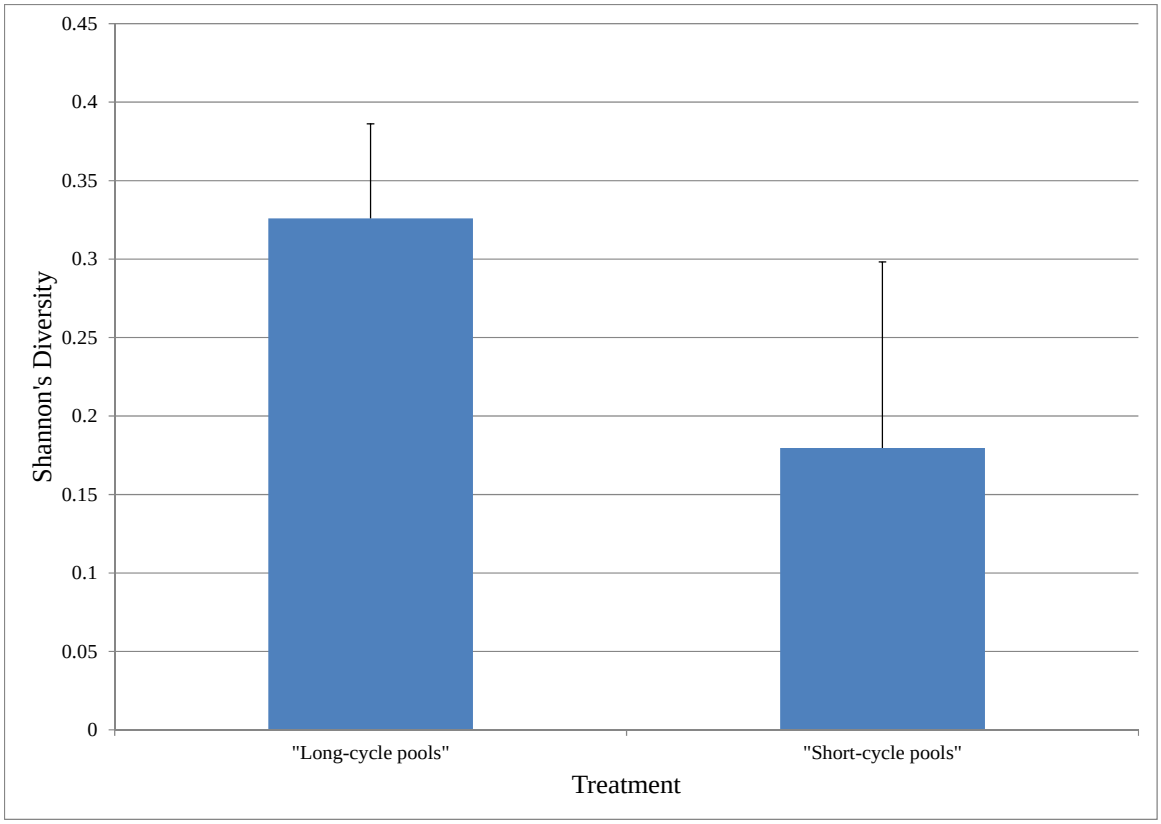

Figure 4. Mean values of Shannon’s Diversity between “long-cycle pools” and “short-cycle pools” (Paired t-Test, p = 0.279).

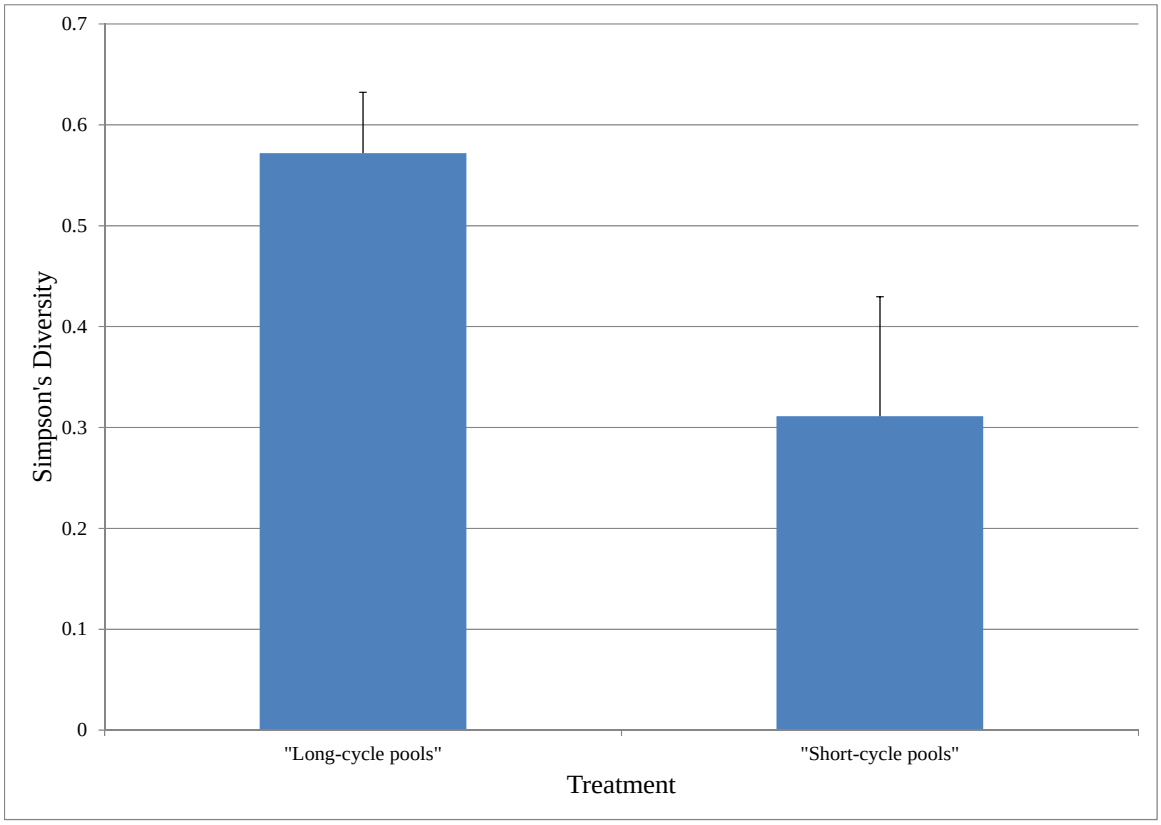

Figure 5. Mean values of Simpson's Diversity between "long-cycle pools" and "short-cycle pools" (Paired t-Test, p = 0.237).

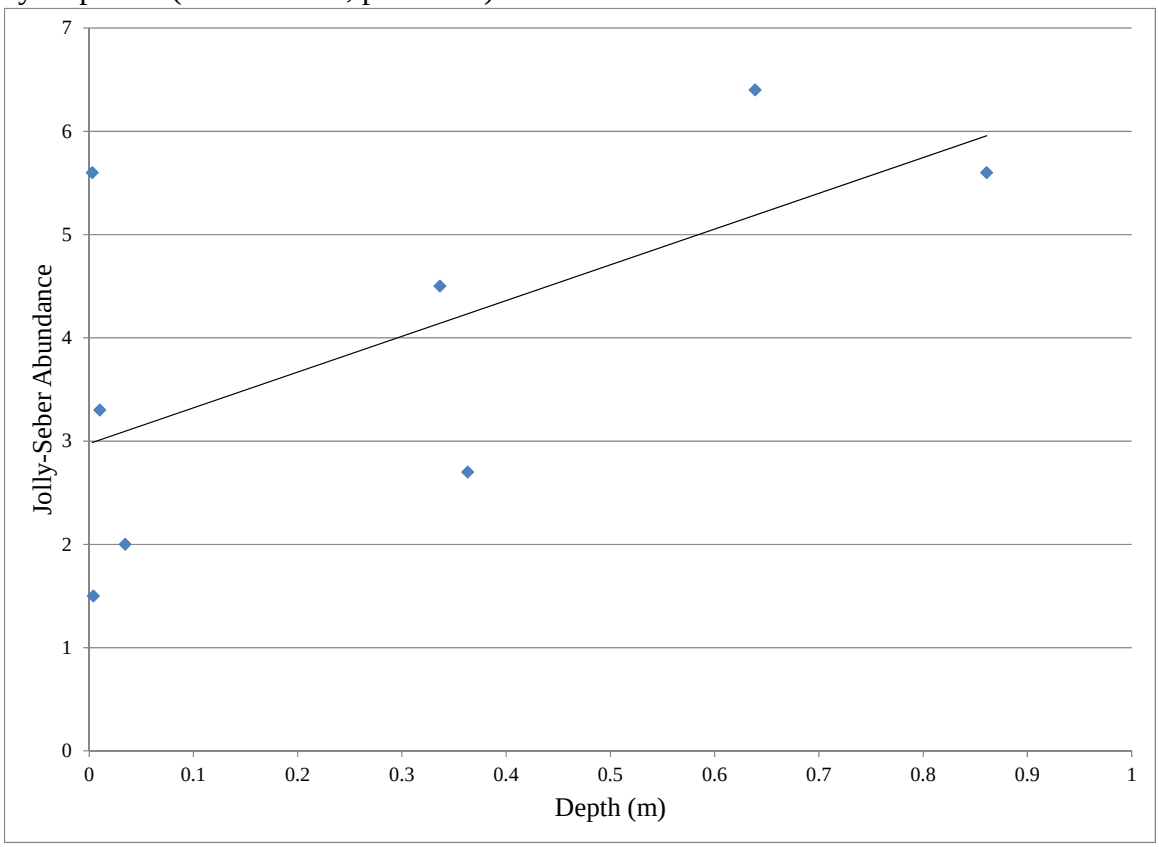

Figure 6. Jolly-Seber abundance for each replicate site with changes in depth (Linear Regression, p = 0.099, $F_{1,6}$ = 3.801, R2 = 0.388).

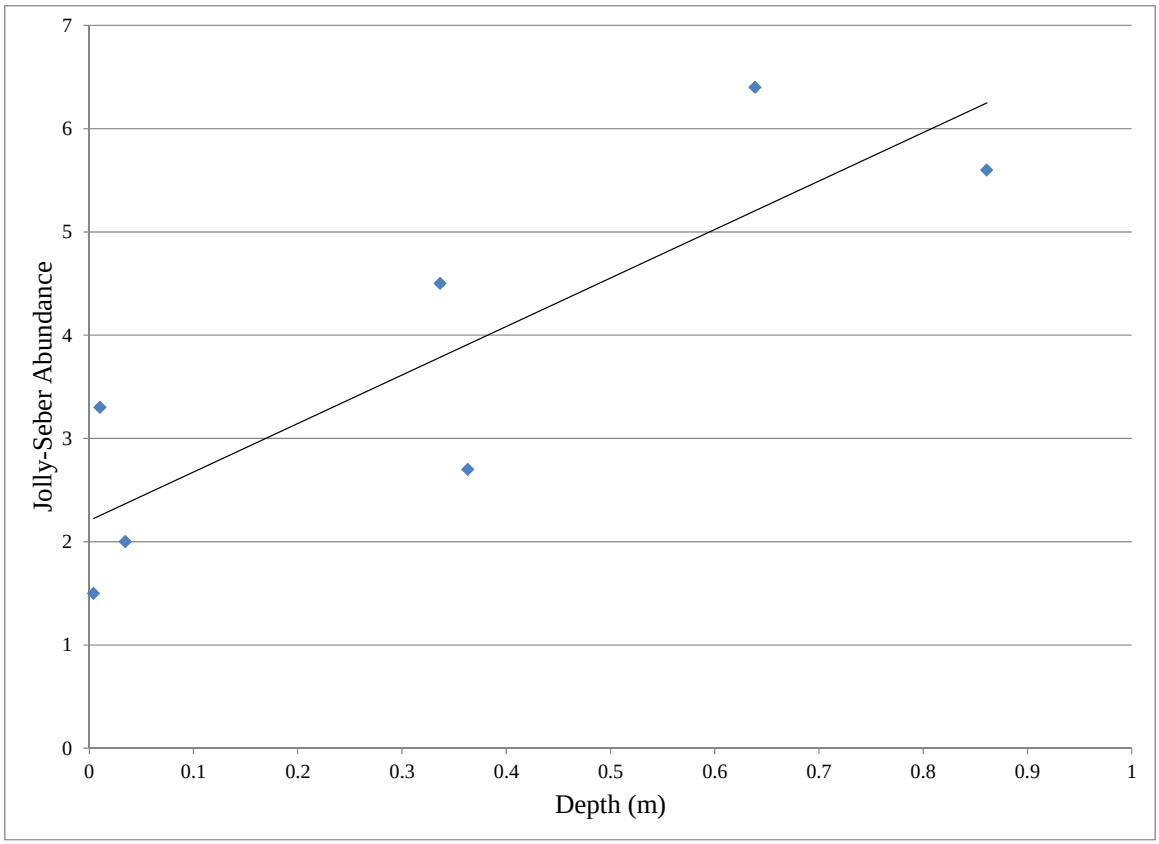

Figure 7. Adjusted Jolly-Seber abundance for each replicate site with changes in depth (Linear Regression, $p = 0.015$, $F_{1,5} = 13.307$, $R2 = 0.727$).

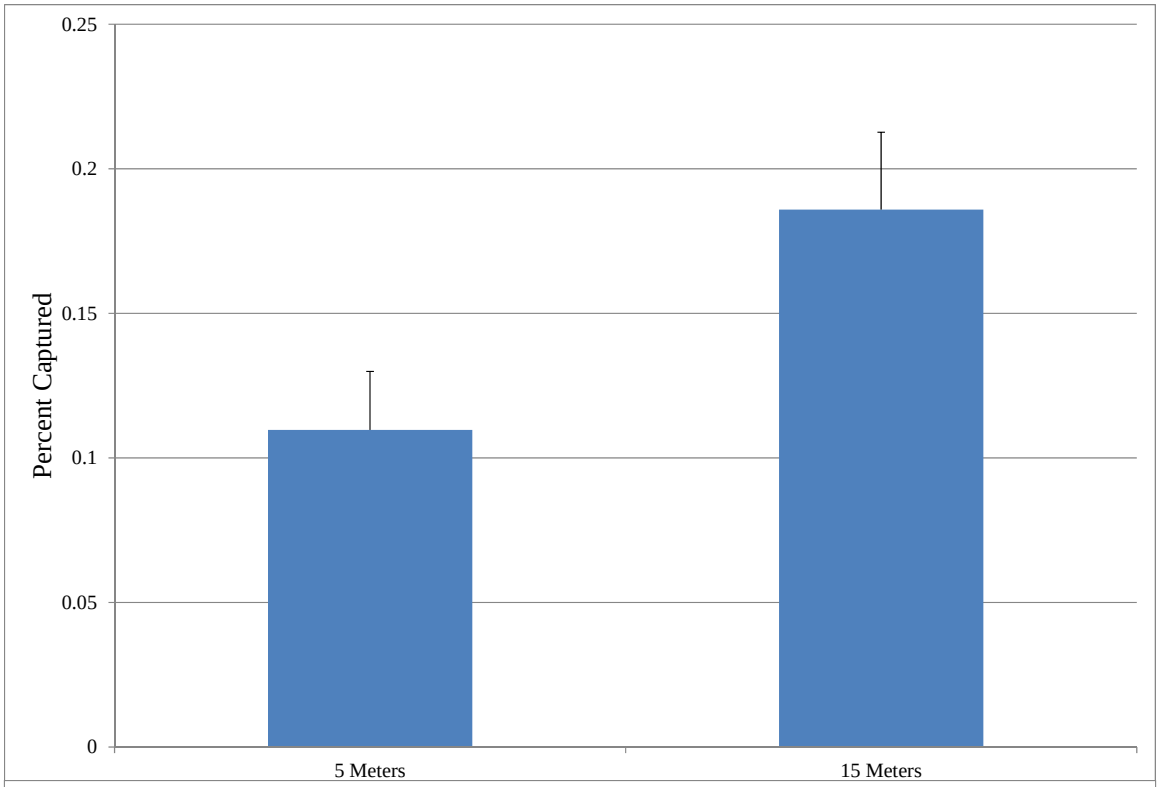

Figure 9. Mean values of aggregate percent of capture between 5 and 15 meters (ANOVA, $p = 0.004$, $F_{1,14} = 11.800$, $R2 = 0.457$).