Environmental Variables in Open Canopy Vernal Ponds and in Closed Canopy Vernal Ponds

BIOS 569: Practicum in Field Biology

Katherine Davila Olmo

Advisor: Matt Michel

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Abstract:

Vernal ponds are temporary pools that are formed from spring rains and snow melt. Many different factors regulate and have important effects on the ecosystem processes of vernal ponds. In this study, I explore how environmental variables change in a vernal pond as a function of the canopy cover of the pond. Five open canopy vernal ponds and five closed canopy vernal ponds were studied and sampled for seven environmental variables. The environmental variables to be studied were: overhead canopy cover, water depth, number of vegetative stems, amount of tadpoles, amount of predators, chlorophyll α concentration and the amount of leaf litter. The two sample t- test showed that canopy cover (p-value = 0.007), stems (p-value = 0.045) and leaf litter (p-value = 0.000) differed between open and closed canopy ponds. By Pearson's correlation test, the only relationships that demonstrated to be significant were in open canopy ponds and they were ,canopy cover vs. leaf litter (p = 0.010), canopy cover vs. stems (p = 0.062), and water depth vs. stems (p = 0.020). Environmental variables were found to be different in open and closed canopy ponds. Certain environmental variables within the open canopy ponds were correlated to each other,

Introduction:

Vernal ponds are temporary pools that are formed from spring rains and snow melt. In the last decades, they have shown to be a critical breeding habitat

for species of invertebrates and vertebrates (Kenney and Burne, 2001). These ponds support heterogeneous communities of aquatic organisms and of rare and unique species making this habitat significant for regional biodiversity (Oertli et.al, 2002; Williams et al., 2004). Considering how important a vernal pond is for many species, the conservation and management of these habitats has become more pronounced.

Many different factors regulate and have important effects on the ecosystem processes of vernal ponds. Communities that inhabit freshwater systems show restrictions in their distribution along the water body hydroperiod. Hydroperiod is the period of time during which a wetland is covered with water making this a critical gradient for species that inhabit it. How the variation in the hydroperiod and the effect this has over the species distribution and their attributes in a vernal pond has been of major concern for amphibian ecologists (e.g., Heyer et al., 1975; Wilbur, 1984; Werner and Mcpeek, 1994). Ecologists have realized that the permanence of a body of water determines what kind of animal communities form within it (Skelly, 1997). This is why it is crucial for certain environmental variables (such as vegetation, canopy cover, leaf litter, chlorophyll) to be present in some habitats in order for some species of tadpoles to complete their metamorphosis before the pond dries out.

The distribution of amphibian larvae in ponds has been demonstrated to be related with water depth, predator presence or absence, presence of aquatic

vegetation, substrate type, dissolved oxygen content and temperature (e.g., Noland and Ultsch 1981). In prior studies, gradients formed by overhead canopy cover have been proven to act as a selective sieve for the distribution of amphibian larvae among ponds (Skelly, 2001). Anuran species exhibit preferences for breeding habitats according to the degree of shading or canopy cover (e.g., Minton, 1972; Collins, 1993). Wood frog tadpoles will be the species used in this study to determine how certain environmental factors affect their abundance and distribution in vernal ponds including the microhabitats present in those ponds. Wood frog tadpoles grow at varying rates depending on water temperature, tadpole density and available food resources, such as periphyton (Wilbur 1977; Riha and Berven, 1991). In order to determine the density of wood frog tadpoles in different microhabitats present in a vernal pond we must first examine and evaluate the environmental variables that separate and create these microhabitats.

Most anuran species are able to live on just a small section of the vernal pond gradient (Skelly, 1997). This is why it is important to study how tadpole distributions in vernal ponds are regulated by different environmental variables. This may lead to improved conservation and management of vernal ponds to be able to maintain the amphibian populations and biodiversity in these types of habitats. In this study, I explore how environmental variables change in a vernal pond as a function of the canopy cover of the pond. Five open canopy vernal

ponds and five closed canopy vernal ponds were studied and sampled for seven environmental variables. The environmental variables to be studied were: overhead canopy cover, water depth, number of vegetative stems, amount of tadpoles, amount of predators, chlorophyll α concentration and the amount of leaf litter. Three hypotheses were tested: 1) Different canopy covers will have an effect on environmental variables that regulate life on vernal ponds. I predict that canopy cover, depth of the vernal pond and the leaf litter encountered will be greater in the closed canopy vernal ponds than in the open canopy cover ponds. I also predict that the amount of stems, tadpoles, predators and chlorophyll will be greater in the open canopy ponds. 2) Environmental variables within the open canopy vernal ponds will be correlated with each other. I predict that there will be a direct and significant relationship between overhead canopy cover and leaf litter, amount of vegetative stems and water depth, amount of tadpoles and the amount of predators, chlorophyll α concentrations and the amount of vegetative stems, the overhead canopy cover and the water depth, and the overhead canopy cover and the chlorophyll α concentration. 3) Environmental variables within the closed canopy vernal ponds will be related with each other. I predict that there will be a direct and significant relationship between canopy cover and leaf litter, amount of tadpoles and amount of predators, amount of stems and canopy cover, canopy cover and the depth, amount of chlorophyll and the amount of stems, and the amount of chlorophyll and the canopy cover.

Methods and Materials:

Study Sites:

The study was conducted in 10 vernal ponds known to contain wood frog tadpoles. These 10 vernal ponds were located in the UNDERC property which consists of 7,500 acres on both sides of the state line between Wisconsin and Michigan's Upper Peninsula. It includes a land area of deciduous forest of 6150 acres and 30 lakes and bogs with a combined surface area of 1350 acres (UNDERC SITE). Five of the vernal ponds studied are closed canopy ponds and the remaining five ponds are open canopy ponds.(Table 1).

Environmental variables measurements: (Table 2)

All 10 ponds were separately divided into 2m X 2m grids. At each intersecting point, we placed a pin flag with its proper identification.

Overhead Canopy Cover:

Every pin flag placed in every vernal pond was sampled for canopy cover measurements. A densitometer was placed on top of every pin flag and four measurements of 90 degrees were taken at every pin flag.

Water Depth, Vegetative Stems, Amount of Tadpoles, Leaf Litter:

A 30.5 cm diameter PVC pipe was placed and pushed downward over each pin flag in order to measure these environmental variables. The highest water reading inside the pipe was taken to the water depth in that point. Then the

number of vegetative stems that were inside the pipe where quantified. A dip net was used to collect the tadpoles that were inside the PVC pipes. Leaf Litter inside the pipe was also quantified by counting the number of leaves that were big enough to cover a tadpole or a predator.

Amount of predators:

G40 Minnow Traps were placed in pin flags that had the water level deep enough so that they could be accommodated. This was done for all ten vernal ponds sampled. The traps were checked every day for two consecutive weeks in May.

Chlorophyll α concentration:

We put 1 inch by 4 inch piece of yellow flagging tape at each pin flag in all ten vernal ponds. All the flagging tapes that were in water were retrieved, algae was scraped off the tape, then filtered what collected through a Whatman glass microfiber filter. Then, each filter was soaked in 10 ml of methanol overnight. The next day, each sample was analyzed with a fluorometer which showed the chlorophyll concentrations.

Statistical Analysis:

For our first hypothesis, a two sample t-test was made to compare differences in environmental variables between open canopy and closed canopy ponds. The ponds were first grouped according to overhead canopy. The tests were made on each environmental variable comparing the open vs. closed canopy

ponds using the average value of that environmental variable for each pond. Pearson correlations tests were made in order to test the second and third hypotheses. The environmental variables were tested for correlations for the separate types of canopy covers.

Results:

The two sample t- test showed that canopy cover (p-value = 0.007), stems (p-value = 0.045) and leaf litter (p-value = 0.000) differed between open and closed canopy ponds. Closed canopy ponds showed to have more overhead canopy cover (mean = 97.3), (Figure 1), and more leaf litter (mean = 62.9), (Figure 3), than the open canopy ponds (OCC mean = 55, LL mean = 11.7). The open canopy ponds showed to have a greater amount of vegetative stems (mean = 14.9), (Figure 2), than the closed canopy ponds (mean = 2.2). The Pearson correlation for open canopy ponds showed that there was a positive direct relationship between canopy cover vs. leaf litter (0.442). It also showed that there was an inverse relationship between canopy cover vs. stems (-0.380), water depth vs. vegetative stems (-0.419), water depth vs. chlorophyll (-0321). The only relationships that demonstrated to be significant were canopy cover vs. leaf litter (p = 0.010), (Figure 4), canopy cover vs. stems (p = 0.062), (Figure 5), and water depth vs. stems (p = 0.020), (Figure 6). The Pearson correlation for closed canopy ponds showed that there was a positive direct relationship between canopy cover vs. water depth (0.430), canopy cover vs. tadpoles (0.341), canopy cover vs.

predators (0.313), and depth vs. tadpoles (0.609). It also showed that there was an inverse relationship between canopy cover vs. chlorophyll (-0.568), water depth vs. chlorophyll (-0.431), tadpoles vs. chlorophyll (-0.456), predators vs. chlorophyll (-0.512). None of the relationships were significant.

Discussion:

Environmental variables were found to be different in open and closed canopy ponds meaning that my first hypothesis was failed to be rejected. This means that life in closed canopy ponds and open canopy ponds is going to be different because the variables that regulate the processes occurring in it act differently in every vernal pond. Several studies have been made that identify forest canopy cover as an important gradient that influences the distribution of amphibian species (Werner and Glennemeirer, 1999). Canopy cover is related with most of the differences between these ponds, especially with different resource bases for the anuran larvae and different predator types (Werner, 1992).

Overhead canopy cover, leaf litter and the amount of vegetative stems were the only variables that showed being significantly different between the two types of ponds. Overhead canopy cover and leaf litter proved to be greater in the closed canopy ponds, while the amount of vegetative stems proved to be greater in open canopy ponds. Overhead canopy cover was greater in closed canopy ponds because there are more trees that cover the area in which sunlight penetrates over the vernal pond. Leaf litter also was greater in closed canopy

ponds because the overhead canopy cover is full of vegetation which will lead to increased detritus cover and more organic material once the leaves senesce from the tree and fall to the pond bottom . The amount of vegetative stems was greater in the open canopy pond because there is more light penetration that reaches the surface and surroundings of the vernal pond leading for vegetation grow.

Certain environmental variables within the open canopy ponds were correlated to each other, which mean that my second hypothesis was failed to be rejected. Canopy cover had a positive relationship with leaf litter. This is because as the more tree cover there is, the more leaf litter or organic matter decomposition there will be. Vegetative stems showed to have an inverse relationship with both overhead canopy cover and water depth meaning that as the greater the overhead canopy cover and the water depth are, the fewer amounts of vegetative stems there will be. The dense overhead canopy cover will not allow much sunlight to reach the pond, restricting the amount of sunlight for the aquatic vegetation to grow. Vegetative stems will not be able to grow either if the water depth is greater because less sunlight will reach them.

My third hypothesis is rejected because environmental variables within the closed canopy vernal ponds were not significantly related to each other in any way. Some trends and relationships were found like canopy cover, leaf litter, tadpoles, stems, predators, water depth and chlorophyll relationship but none of them were significantly different from each other. One reason why there was no

significant difference was that the closed canopy ponds were smaller which means that there were fewer points to sample. All the sites in the closed canopy ponds had very similar values meaning that these ponds were more homogenous than the open canopy ponds and they didn't provide that many microhabitats as the open canopy ponds did.

For future studies I would recommend that more vernal ponds should be sampled, including the same amount of closed vs. open canopy ponds. The closed canopy ponds chosen for study should be bigger in size that the ones that were sampled in order to have more sampling sites within these ponds so that there can be more variation in the environmental variables studied. What could have gone wrong in this experiment was that every measurement was attached to a possible error in quantification. Canopy cover has proved to be one of the most important regulators of life and distribution of amphibian larvae in vernal ponds. Environmental variables have shown to have different effect on every vernal pond meaning that each pond is different in its own particulate way because relationships withheld in that ecosystem are unique for that location. Vernal ponds should be managed and conserved in different ways. Closed canopy ponds don't have the same characteristics as the open canopy ponds meaning that biological and chemical processes occurring within these ponds are going to differ in many ways.

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Tables and Figures:

Table 1: Ponds Sampled

This table contains the ten ponds sampled for this study localized in the UNDERC property. Five of the ponds sampled were open canopy vernal ponds and the remaining five were closed canopy vernal ponds.

POND NAME	CANOPY COVER
VP27	OPEN
VP9B	OPEN
VPNBB	OPEN
VPNFL	OPEN
VPSML	OPEN
VPEFGH	CLOSED
VPJ	CLOSED
VPN	CLOSED
VP12	CLOSED
VPGD	CLOSED

Table 2: Tools for measurement of environmental variables

Seven environmental variables were measured for this study. For each one a different measurement tool was used.

Environmental Variables	Tools
Overhead Canopy Cover	Densiometer
Vegetative Stems	PVC Pipe
Leaf Litter	PVC Pipe
Tadpoles	PVC Pipe and dip net
Chlorophyll	Flagging Tape
Predators	G40 Minnow Traps
Water Depth	PVC Pipe

Figure 1:

Overhead Canopy Cover vs. Canopy Cover Vernal Pond

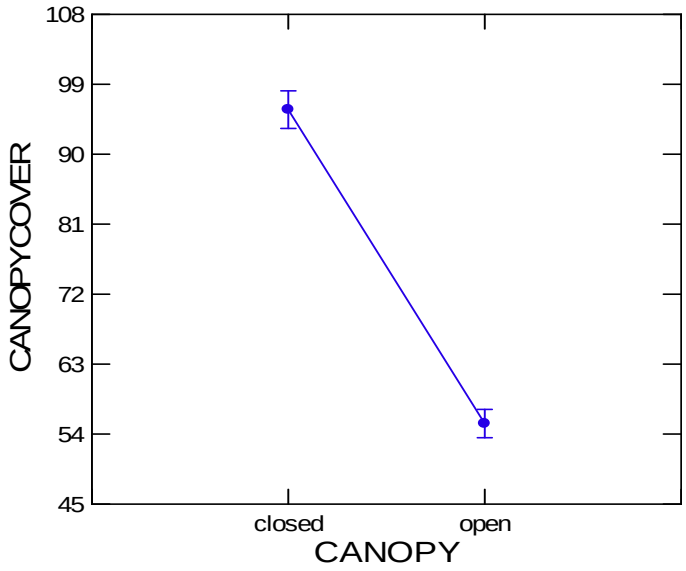

Figure 1:

Overhead canopy cover showed to be greater in the closed canopy cover vernal pond than in the open canopy cover vernal pond. This environmental variable was sampled for al ten ponds containing different canopy cover. There was a significant difference between the overhead canopy cover and the canopy cover vernal ponds.

Figure 2:

Vegetative Stems vs. Canopy Cover in Vernal Ponds

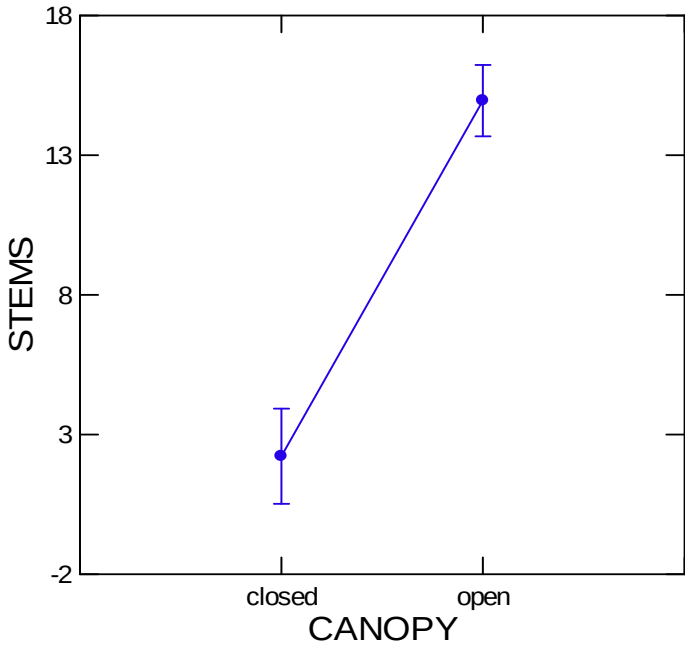

Figure 2:

The amount of vegetative stems showed to be greater in the open canopy cover vernal pond than in the closed canopy cover vernal pond. This environmental variable was sampled for al ten ponds containing different canopy cover. There was a significant difference between the amount of vegetative stems and the canopy cover vernal ponds.

Figure 3:

Leaf Litter vs. Canopy Cover in Vernal Ponds

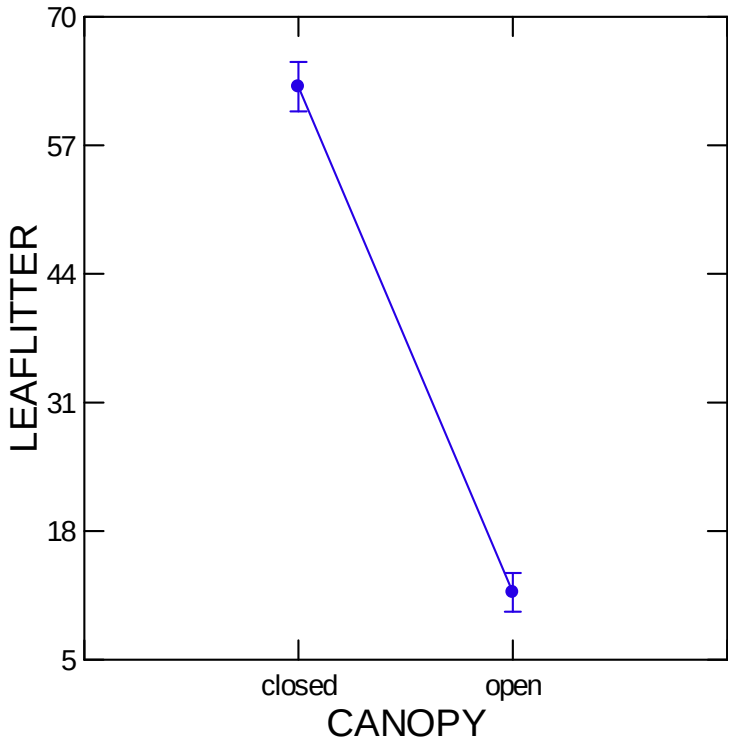

Figure 3:

The amount of leaf litter showed to be greater in the closed canopy cover vernal pond than in the open canopy cover vernal pond. This environmental variable was sampled for al ten ponds containing different canopy cover. There was a significant difference between the amount of leaf litter and the canopy cover vernal ponds.

Figure 4:

Overhead Canopy Cover vs. Leaf Litter in Open Canopy Vernal Ponds

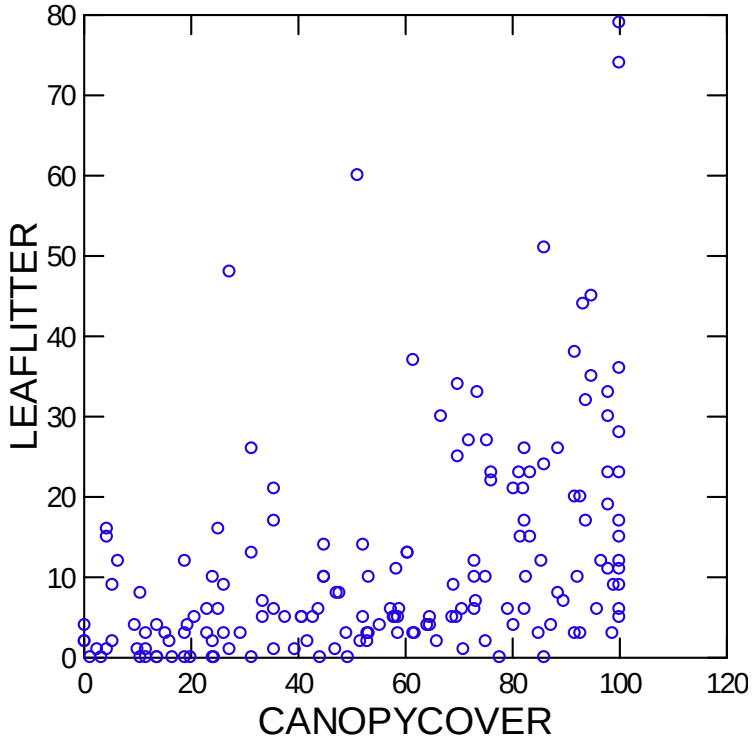

Figure 4:

Leaf Litter is less were the overhead canopy cover of the open ponds is smaller. A trendline can be observed as the overhead canopy cover becomes greater, the amount of leaf litter starts to increase.

Figure 5:

Overhead Canopy Cover vs. Vegetative Stems in Open Vernal Ponds

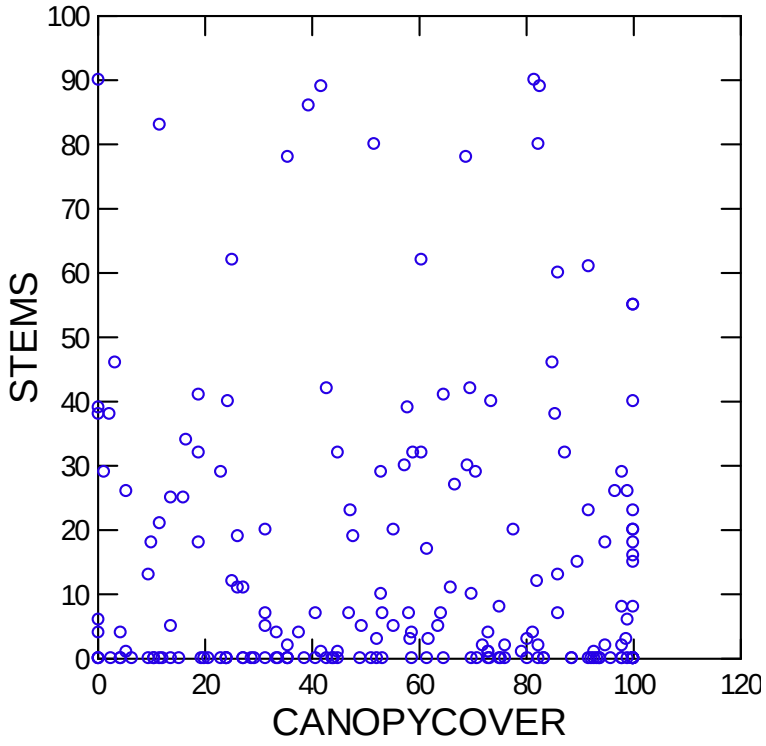

Figure 5:

The amount of vegetative stems is more or less the same throughout the overhead canopy cover gradient. As the overhead canopy cover amount starts to increase the amount of vegetative stems starts to decrease. Vegetative stems are more likely to increase in concentration where there is more sunlight available

Figure 6:

Water Depth vs. Vegetative Stems in Open Canopy Vernal Ponds

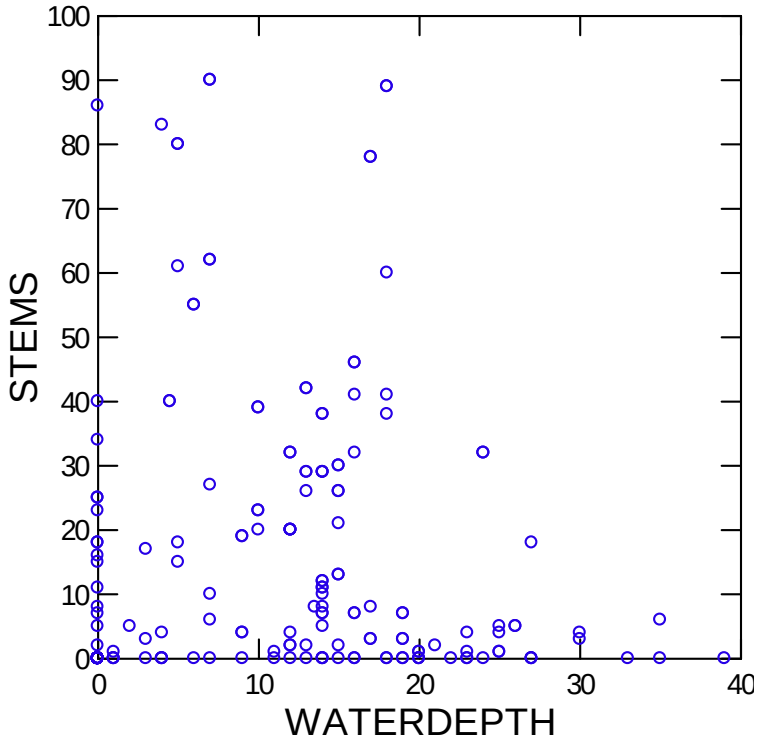

Figure 6:

The amount of vegetative stems is directly related to the water depth of the vernal pond. As the water depth is shallower, the more vegetative stems are going to be found. This is because the amount of sunlight that penetrates is going to be greater in the shallower water giving the opportunity for the vegetative stems to grow.