Characterization of Larval Amphibian Populations in Vernal Ponds Prior to Clear-cutting and Selective Logging

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August 2, 2003

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Abstract

One of the most well-documented causes cited for amphibian population declines worldwide has been human-imposed habitat modification. This study will observe the effects of clear-cutting and selective logging on larval amphibian populations in temporary ponds. Three ponds on the University of Notre Dame Environmental Research Center property (ND1, ND2, and ND3) and four in the Ottawa National Forest (OTT2, OTT3, OTT5, and OTT6) in the upper peninsula of Michigan were physically characterized by measuring and recording air and water temperature, pH, conductivity, dissolved oxygen, and percent overhead canopy cover. Larval amphibians were sampled for by dividing the ponds perimeter into 1 x 2 m plots and sampling one fourth of these plots. In each plot sample, a Rubbermaid bin with its bottom cut out was used to determine the number and type of amphibians in each sample plot. After three years of baseline data collection, area around OTT2 and OTT3 will be clear-cut, around OTT5 and OTT6 will be selectively logged, and ND ponds will remain untouched as controls. This paper reports the findings of the data collected during summer 2003, the final year of baseline data collection. All ponds were characterized as closed canopy ponds, with a mean percent canopy cover of 83% (range 74-93%). The most abundant species collected throughtout the summer of 2003 was *Rana sylvatica*. Other species found were *Hyla versicolor, Psuedacris crucifer, Ambystoma maculatum,* and *Ambystoma laterale.* A negative correlation was found between species richness and percent overhead canopy cover ($r = -8.20$, $p = 0.046$) during the second sampling period (6/23-6/26/03). After logging treatments, data will be collected and compared to data from summers 2001-2003 in order to assess the effects on larval amphibian populations in these ponds.

Introduction

The reported decline of amphibian populations worldwide has been a major ecological concern in recent years. It is likely that amphibians are more vulnerable to environmental change than other groups of organisms due to their use of both aquatic and terrestrial environments and their highly permeable skin, and thus are often studied as bioindicators. Many possible reasons have been posed for the decline of amphibian populations, including ultraviolet radiation, predation, invasive species, commercial trade, habitat modification and fragmentation, environmental acidity or toxicants, pathogens and diseases, changes in climate and weather patterns (both human-caused or natural fluctuations), or interactions between any of these factors (Alford and Richards 1999, Semlitsh 2000, Pechmann et. al. 1991). Many of the most well-documented population declines have been associated with habitat modification, fragmentation, or loss.

One of the most common forms of human-implicated habitat modification in North America is logging. Many studies have focused on the effects that the clear-cutting of a forest has on amphibian use of this terrestrial environment. Species such as wood frogs (*Rana sylvatica)* and spotted salamanders (*Ambystoma maculatum)* that breed in temporary waters have been shown to have a preference for closed-canopy habitats when emigrating after metamorphosis (deMaynadier and Hunter 1999). One study measured species diversity in two similar hardwood forest stands, one of which had been clear-cut, and showed that in the uncut stand, only one amphibian species, *Pseudacris triseriata*, was less abundant than in the cut stand (McLeod and Gates 1998). While logging has been shown to have significant effects on populations of terrestrial amphibians, logging near ponds and other bodies of water can also affect the ecology of amphibians living in an aquatic environment, most notably amphibian larvae. One of the most obvious physical properties of an aquatic environment changed by logging is the amount of canopy cover over bodies of water. In recent years, studies on the performance of larval amphibian populations in open and closed canopy ponds have been conducted. It has been shown that wood frog (*Rana sylvatica*), spring peeper (*Pseudacris crucifer*), and American Toad *(Bufo americanus)* larvae perform better in an open canopy environment than a closed environment (Skelly et. al. 2002, Werner and Glennemeier 1999). A more complete picture of the effects of logging on amphibians will require an understanding of the effects on both aquatic and terrestrial environments.

In order to study the effects of logging on larval amphibian populations in the north woods of the Upper Peninsula of Michigan and bordering areas of Wisconsin, populations in seven vernal ponds will be studied. Baseline data of larval amphibian densities will be collected over three summers from three ponds in the University of Notre Dame Environmental Research

Center (UNDERC) and four vernal ponds in the Ottawa National Forest. Subsequently, area around two of the Ottawa ponds will be clear-cut, the other two in Ottawa will be selectively logged, and the three ponds in UNDERC will remain untreated as controls. Data will be gathered for at least three years after logging and compared to baseline data to assess the effect logging has on larval amphibian populations in these ponds. The summer of 2003 will be the final summer of baseline data gathering.

Materials and Methods

Vernal Pond Characterization Three ponds on the University of Notre Dame Environmental Research Center (UNDERC) property (labeled ND1, ND2, and ND3) and four in the Ottawa National Forest (labeled OTT2, OTT3, OTT5, OTT6) were physically characterized and sampled from for larval amphibians in order to add to the growing body of data from identical studies in the summer of 2001 and 2002. All sites were physically characterized by measuring maximum depth, dissolved oxygen, air and water temperature, pH, and conductivity. Other qualitative characteristics were visually observed and recorded, including water color and turbidity, presence of fish, primary substrate, distance from shore to forest edge, percent of canopy cover, and percent of margin with emergent vegetation. Locations of each pond were verified using previously determined Lat/Long as well as UTM coordinates. Water and ambient temperature was measured using a standard alcohol thermometer; water depth was measured with a stadia rod; pH was determined using a pHep 3 with ATC meter (Hanna Instruments); dissolved oxygen was measured using a YSI 55 D.O. meter (YSI Incorporated); conductivity was measured with a HI 9033 multi-range conductivity meter (Hanna Instruments). Percent of forest canopy cover was estimated using a standard densiometer. In each pond, densiometer readings were taken facing north, south, east, and west, at five points, one in the center of the pond, and four at points north, south, east, and west around the perimeter of the pond. These values were averaged to give a mean value of overhead forest canopy cover for each pond.

Larval Amphibian Sampling To sample for larval amphibians, each vernal pond was divided into 1 x 2 meter plots along the shoreline. Stakes were placed every 10 m around the perimeter, and were used as reference points to draw a rough sketch of each pond. In order to sample one fourth of the shoreline of each pond, the total perimeter was divided by four to determine the number of plots sampled. Possible plots were assigned numbers in accordance with measurements around the perimeter, such that plot "1" was located one meter from the "0" stake, and so on. Plots were chosen for sampling using a random number chart. Each plot was subdivided into two areas labeled "A" and "B," with "A" near the shore of the pond, and "B" one meter away from shore. The final digit of the numbers chosen from the random number chart when choosing plots to be sampled was used to assign plots as A or B. An odd final digit assigned the plot as A, while an even one assigned them as B. Plot locations were redetermined during each sampling period due to pond desiccation.

Sampling occurred once in each month of May, June, and July. To sample larval amphibians, a 31-gallon Rubbermaid bin with the bottom removed, measuring 0.876 m long, 0.508 m wide, and 0.425 m deep, was placed in each chosen plot and securely held in place to prevent the escape of larval amphibians. Fish nets were used to collect larvae trapped in the bin, and the number of tadpoles and larval salamanders collected was recorded at each site. Adult amphibians sampled were noted and immediately released, and egg masses collected were noted. Captured larvae were identified and measured in lab (total length, snout-to-vent length, and tail length), and were subsequently be returned to their pond of origin.

Larval amphibian densities were estimated by dividing the number of individuals collected in a specific pond by the number of sites sampled around the perimeter. Biomass by species in each pond was crudely estimated by multiplying the mean snout-vent length of each species included in the calculation by the density of that species. To estimate total biomass within a pond, species biomass estimations were added together. Correlation analysis was run using Systat.

Results

Vernal Pond Characterization The mean area of the seven ponds sampled at the time of the May sampling period (5/28-6/03/03) was approximately 303 m^2 (range 205-597 m^2). Due to desiccation, all ponds at least decreased in size throughout the course of the study. Pond OTT3 completely dried up before the June sampling period (6/23-6/26/03), and therefore was not sampled during this period. Before the July sampling period (7/14-7/16/03), OTT6 dried up as well. The mean depth of the ponds in May was 0.626 m (range 0.2-0.92 m). Percent of overhead forest canopy cover in the seven ponds ranged from about 74 to 96 percent, with a mean of 83%. Mean values of other abiotic factors tested for, including pH, dissolved oxygen, and conductivity are presented in Table 1.

Sampling Period	pH	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Air Temp (ºC)	Water Temp (ºC)
May	6.143	10.048	37.417	14.85714286	13.07142857
June	6.55	19.183	49.55	19.3	18.48333333
July	6.5	9.584	40.7	21.2	18.14

Table 1 *Abiotic Factors* Mean values of several abiotic factors tested for at vernal pond sampling sites during three sampling periods. May (5/28-5/3/03) n = 7 ponds; June (6/23-6/26/03) n = 6 ponds, July (7/14-7/16/03) n = 5 ponds. Not all seven ponds were sampled in June and July due to complete dessication.

Larval Amphibian Populations Five species of larval amphibians were found in the seven ponds over the course of three sampling periods: *Rana sylvatica, Hyla versicolor, Psuedacris* *crucifer, Ambystoma maculatum,* and *Ambystoma laterale.* The most commonly collected species was *R. sylvatica* (Table 2).

Pond	*R. sylvatica*	*H.versicolor*	*P. crucifer*	*A.maculatum*	*A. laterale*
ND1	25	0	0	1	0
ND2	21	1	16	1	1
ND3	14	0	0	0	0
OTT2	62	0	0	8	11
OTT3	0	0	0	0	0
OTT5	24	0	0	1	7
OTT6	22	0	6	0	1

Table 2 *Species Incidence 2003* Sum of the number of individuals of each species collected during all three sampling periods in each pond sampled.

During the May sampling period, only *R. sylvatica* were collected, with the highest density (individuals/plots sampled) occurring in OTT2, and the lowest in OTT3. In following sampling periods, other species were encountered, with *R. sylvatica* remaining the most abundant species. In general, total population densities in each pond increased with each sampling period (Fig 1). This trend is especially pronounced in ponds ND1 and OTT2.

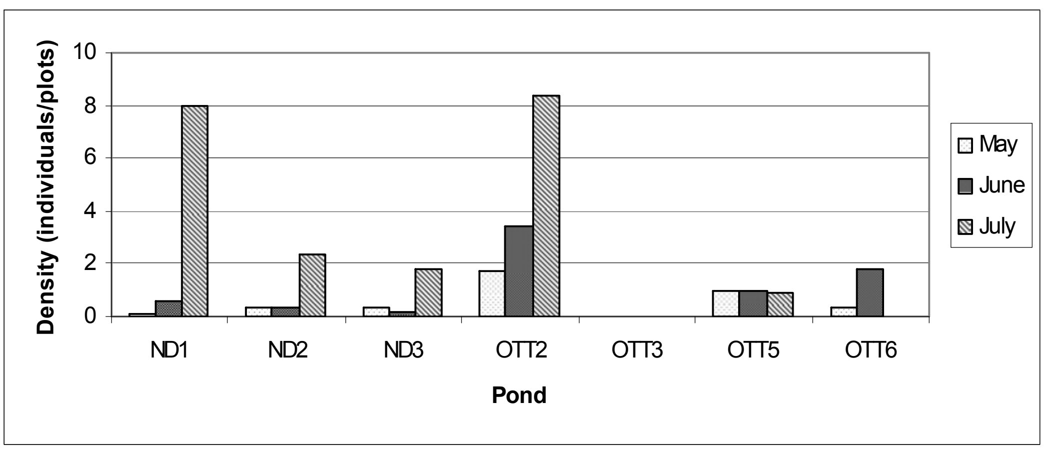
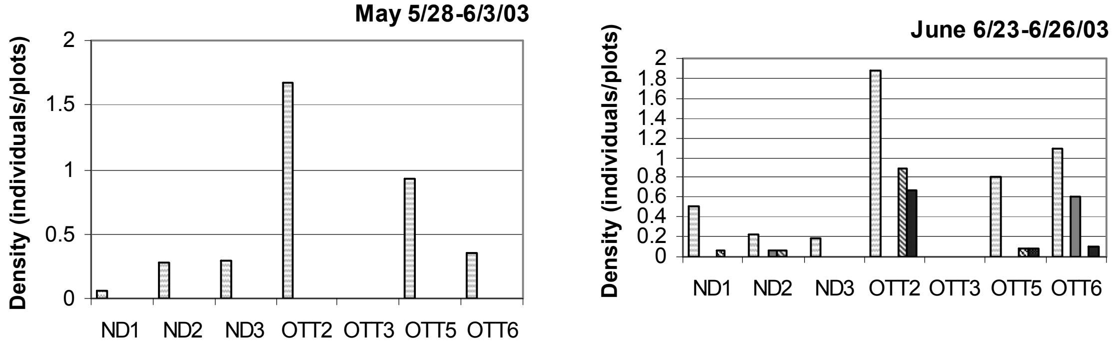


Figure 1 *Population Densities Over Time* Total larval amphibian population densities plotted for each pond, divided by sample periods (May 5/28-6/3/03, June 6/23-6/26/0, July 7/14-7/16/03). OTT 3 was completely desiccated during June sampling period, both OTT3 and OTT6 were completely desiccated during July sampling period.



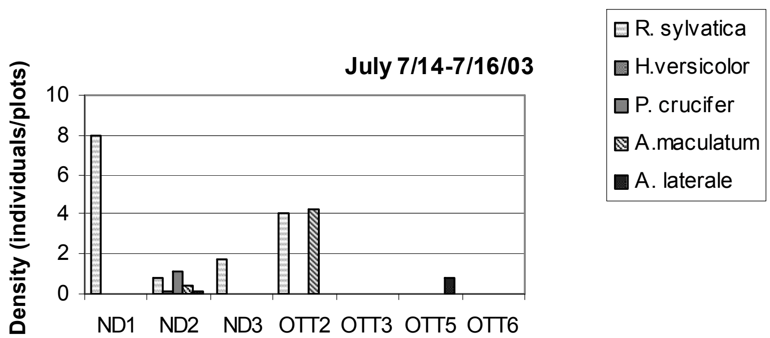


Figure 2. *Density by Species* Larval amphibian population densities by species present in vernal ponds ND1, ND2, ND3, OTT2, OTT3, OTT5, and OTT6. OTT3 was completely desiccated in June, OTT3 and OTT6 completley desiccated in July.

The most notable pattern observed in the species densities within each sampling period is that in most ponds, *R. sylvatica* is present in the highest density, with the exception of ND2, OTT2, and OTT5 during the July sampling period (Figure 2). As the summer progressed, an increased number of different species were encountered in our sampling, peaking at five species in ND2 during the July sampling period (Fig 3).

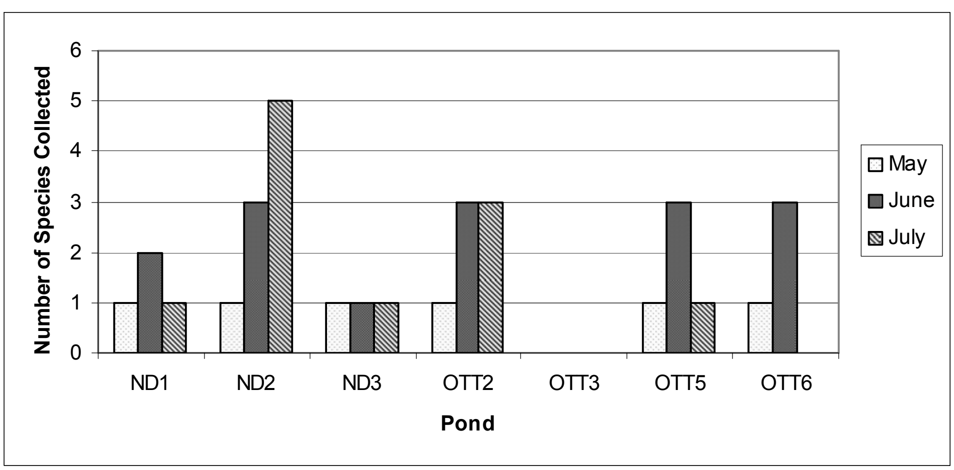


Figure 3. *Species Richness Over Time* Species richness represented as number of species collected within each pond, during each of three sampling periods (May 5/28-6/3/03, June 6/23-6/26/0, July 7/14-7/16/03). OTT3 was completely desiccated in June, OTT3 and OTT6 during July sampling period.

Crude estimates of biomass indicate patterns that reflect those of population density patterns, in that biomass increases with each sampling period in all ponds, with the exception of OTT 5 (Figure 4). In addition, tadpole biomass was greater than larval salamander biomass in all ponds.

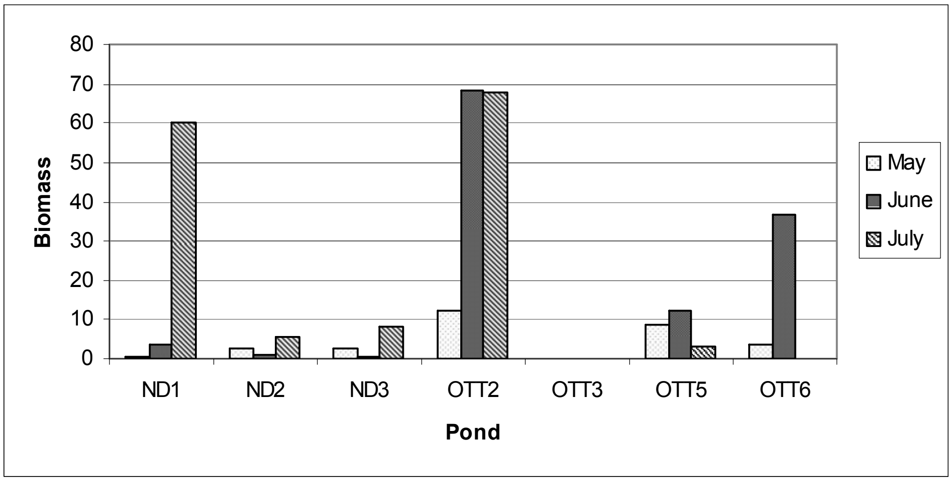


Figure 4. *Biomass* Crude estimates of larval amphibian biomass in each pond using mean SVL of individuals collected and population density estimates. (May 5/28-6/3/03, June 6/23-6/26/0, July 7/14-7/16/03). OTT3 was completely desiccated in June, OTT3 and OTT6 during July sampling period.

Correlation analysis was run to detect possible significant correlations between canopy cover, amphibian density, species richness, pH, dissolved oxygen, and conductivity. During the June sampling period, species richness was found to be negatively correlated to the percent of overhead canopy cover ($r = -8.20$, $p = 0.046$). No other relationships were found to be statistically significant (All p values > 0.05).

Discussion

The ultimate goal of this study is to assess the effect of clear-cutting and selective logging on larval amphibian populations within the seven vernal ponds chosen as sampling sites. The most obvious effect that logging can have on a pond environment is changing the amount of overhead canopy cover, which in turn can affect many aspects of this environment. Based on our estimations using standard densiometer readings, all seven ponds could currently (prior to logging) be characterized as closed canopy ponds, with an average percent of overhead canopy cover of 83% (range 74-93%). During each sampling period, the most abundant larval amphibian species in most ponds was *R. sylvatica*. Past studies have shown *R. sylvatica* to have the capacity to survive and grow well in both closed and open canopy ponds (Skelly et. al. 2002, Werner and Glennemeier 1999). However, other species, such as *R. pipiens*, *Bufo americanus*, and *Pseudacris crucifer*, have been shown to grow and survive poorly in closed canopy ponds but are significantly more successful in open canopy ponds (Skelly et. al. 2002, Werner and Glennemeier 1999). The negative correlation between species richness and percent canopy cover found for the June sampling period in this study supports past studies that suggest that more species of larval amphibians perform better in open canopy pond conditions

It is likely that differences in canopy cover affect larval amphibian populations by influencing the amount of decaying matter within a vernal pond, and thus the amount of dissolved oxygen and the amount and kinds of both resources present for larval amphibian use and predatory and competitive pressures. Percent of overhead canopy cover also can affect the amount of sunlight entering the pond, thus affecting the amount of primary production possible and the amount of UV radiation that reaches organisms living within the pond. Recent increases of UV radiation have been one of the possible causes cited for recent amphibian population declines throughout the world (Alford and Richards 1999, Semlitsch 2000).

The most frequently documented cause of declines in amphibian populations, however, has been habitat modification, usually by humans (Alford and Richards 1999). Logging is a common form of habitat modification in forests surrounding ponds used by amphibian populations that either eliminates large percentages of habitat completely, or fragments areas in ways that prevent amphibians movement between useful areas. Beginning in the summer of 2004, the area surrounding ponds 2 and 3 in the Ottawa National Forest (OTT2 and OTT3) will be clear cut and area around OTT 5 and OTT 6 will be selectively logged. It will be interesting to see what effects this logging has on the species composition and densities in these ponds, in comparison to ponds on University of Notre Dame Environmental Research Center property (ND1, ND2, and ND3), which will remain untouched as controls. Based on previous studies, it is likely that species that are less tolerant of closed canopy conditions, but thrive in open canopy conditions, will become more abundant.

While this study will focus on the effect of logging on amphibians using aquatic habitats, its effects on terrestrial habitats will need to be taken into account, as well, in order to obtain a complete picture of the effects this type of habitat modification has on amphibian populations as a whole. DeMaynadier and Hunter (1999) studied the habitat preferences during juvenile emigration for species that breed in temporary waters, and showed that emigrating *R. sylvatica* juveniles preferred closed canopy environments. Their study also showed a decrease of amphibian abundance along a gradient running from a mature forest habitat to a recently clear-cut stand. A study by McLeod and Gates (1998) compared species abundance in a hardwood stand compared to a clear-cut stand, and found only one species, *P. triseriata*, to be less abundant in the hardwood than the cut stand. These and other studies suggest that logging has a negative effect on amphibians using the terrestrial environment.

The response of amphibian populations to clear-cutting and selective logging will undoubtedly be complex in that amphibians in both aquatic and terrestrial stages may be affected in different ways. While several studies have considered the effects on terrestrial amphibians, few have taken into account larval amphibians utilizing aquatic habitats. We hope that this study will further elucidate the nature of the effects logging can have on these aquatic larval amphibians.

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