

# **Population Survey of Amphibians in Vernal Ponds of the Upper Peninsula of Michigan Prior to Logging of the Surrounding Forest**

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## **Abstract**

Although the importance of forest management practices for the conservation of biological diversity is recognized, the scientific response has previously focused primarily upon large mammal assemblages. Populations of amphibians in many habitats appear to be experiencing severe declines, range restrictions, and some extinction. Since amphibians are more sensitive to terrestrial environmental changes due to their highly permeable skin and aquatic and terrestrial modes of development, they may serve as important indicators of the overall health of different ecosystems. Also, amphibians respond differentially to environmental changes according to their specific region and species. Therefore, the impact of significant alterations in an ecosystem will be manifest among amphibian populations before other vertebrate species are affected. Through proper monitoring of those amphibians, harmful environmental changes may be noticed and corrected prior to large-scale detrimental effects. In this study, we employ larval amphibians as the indicator of amphibian diversity in the Ottawa National Forest and at the University of Notre Dame Environmental Research Center (UNDERC) in the Upper Peninsula of Michigan. A total of seven vernal ponds were selected for the study: four vernal ponds in the Ottawa National Forest and three on UNDERC. Of the ponds in the Ottawa National Forest, two were located in a region selected for clear-cutting and the other two in an area to be selectively thinned. No logging had yet occurred at either site for the duration of this survey. Amphibians were collected in the field and identified three separate periods throughout the course of the study: first in May 2002, second in June 2002, and third in late July 2002. Great species diversity was found, although low numbers of amphibians were collected. Quantitative characteristics of each vernal pond were collected during the first and third sampling periods. Over the duration of the study, water depth and overall wetted reach of the vernal ponds significantly decreased, with two ponds in the Ottawa becoming desiccated. There was no relative correlation of the variability of species diversity and total number of amphibians with the physical and chemical properties of each particular vernal pond. However, neither the physical nor chemical environments considerably changed throughout the study. The absence of correlation between amphibian diversity and habitat characteristics does not necessarily indicate that those species are unresponsive to environmental fluctuations. It is highly likely that the introduction of habitat fragmentation, changes in the rate of vernal pond desiccation, and alterations in UV-B intensity as a result of the logging of surrounding forest will demonstrate extreme effects on the populations of amphibians in the Upper Peninsula of Michigan. However, further study and experimental manipulation of the forest is required before relative conclusions may be determined.

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## **Introduction**

Over the last few years amphibians have caused increasing concern about the environment because of recognizable population declines (Semlitsch). Also, since the passage of the National Forest Management Act of 1976, forests in the United States have been required to maintain viable levels of vertebrate species populations (Mitchell et al. 1997). However, most of the studies that have been conducted focused upon birds, large mammals, and fish (Mitchell et al. 1997). Hair or feathers do not protect amphibian skin and the eggs lack hard shells; thus both the adult and juvenile stages are perpetually exposed to the environment (Blaustein et al. 1994). It is important to study amphibious species due to their sensitivity to environmental fluctuations resulting from their highly permeable skin and biphasic mode of development. Through observation of changes in amphibian populations to

various habitat changes, forest managers may be able to correct environmental disturbances, thereby reducing the negative impacts upon numerous species.

Although most amphibian species populations decline as a result of environmental disturbance, a few previous studies indicate that a certain amount of natural habitat fluctuations produce greater species diversity. For instance, pond hydroperiods vary each season, and different species perform well in different years depending upon the duration of the hydroperiod (Semlitsch 2000). Pond drying is a natural process that eliminates or reduces predation on larval amphibians; however, negative effects, such as reproductive failure, ensue if there is an excessive duration of the drought. Another study found that tadpole densities were significantly lower in logged streams than in buffered and old-growth zones, suggesting that forested buffer regions near amphibian

breeding sites maintain natural conditions for reproduction (Dupuis and Steventon 1999). However, tadpole densities vary greatly under natural conditions, implying that different amphibian species can be differentially impacted by environmental changes in habitat.

Recent evidence suggests that some amphibians may be experiencing population declines and extinctions as a result of local habitat destruction (Semlitsch). Previous studies at the University of Notre Dame Environmental Research Center (UNDERC) and within the Ottawa National Forest have been conducted to determine amphibian species diversity and abundance in those regions. Selected areas of forest in the Ottawa National Forest have been delineated for clear-cutting and selective thinning. Therefore, in response to growing concern about the integrity of the environment, coupled with current evidence supporting amphibians as indicators of the health of a

habitat, forest managers have requested a long-term study of amphibian populations that incorporates data from both before and after the logging event. The gathered data will help forest resource managers develop plans to protect and maintain viable populations of amphibians, resulting in more complete ecosystems.

### **Materials and Methods**

This study was conducted from late May 2002 until late July 2002, at various sites in the Ottawa National Forest and throughout the property of the University of Notre Dame Environmental Research Center (UNDERC). Scott Chormanski and David Wainman, students of the University of Notre Dame, previously focused upon the collection of amphibian larvae for species richness and abundance characterizations throughout the summer of 2001 breeding period. Our study is a continuation of last year's experimentation in order to collect the

greatest amount of data for a more accurate representation of amphibian populations.

Four sites in the Ottawa National Forest in the Upper Peninsula of Michigan and three sites located on UNDERC property that were carefully selected for larval amphibian sampling during the 2001 survey period were again sampled during the summer of 2002. Two vernal ponds in the Ottawa Forest, OTT-2 and OTT-3, were located in aspen dominated forestry delineated for clear-cutting, while the other two vernal ponds, OTT-5 and OTT-6, were located in a maple forest set for selective thinning by the US Forest Service. Three ponds on the UNDERC property were surveyed as control habitats since those areas in UNDERC will not experience any unnatural environmental degradation caused by logging or selective thinning. All three vernal ponds in UNDERC, ND-N1, ND-N2, and ND-N3, were located in maple and aspen combination forests.

Before larvae sampling began, the physical properties of each vernal pond and general characteristics of the surrounding vegetation were determined in order to compare changes in the habitat throughout the experimentation (Appendix A). The physical habitat characteristic data was collected once at the beginning of the experiment, May 30, 2002 through June 2, 2002 and once at the end of the survey, July 15-16, 2002, for each vernal pond, except OTT-3 and OTT-6 which were completely desiccated at the final sampling session. A Garmin 12 global positioning system (GPS) device was used to determine the UTM coordinates, as well as the latitude and longitude of each pond using the "NAD27 Central" datum. Analysis of the vernal pond water consisted in quantitative measurements of water temperature, ambient temperature, maximum depth of the water, water pH, the dissolved oxygen (D.O.) concentration, and conductivity.

Water temperature and ambient temperature were recorded using a standard alcohol thermometer; depth of the water was measured by a stadia rod; pH was determined using a pHep 3 with ATC meter (Hanna Instruments); D.O. was measured with a YSI 55 D.O. meter (YSI Incorporated); and conductivity was measured by a HI 9033 multi-range conductivity meter (Hanna Instruments). Furthermore, qualitative data was compiled concerning the color of the water, water turbidity, primary substrate, and percent of margin with emergent vegetation. Vegetative undergrowth and tree species were visually identified at each vernal pond location.

For the collection of amphibian larvae, the vernal ponds were divided into plots around the circumference, of dimensions one meter wide and two meters out into the pond. Then, these plots were separated into two one-meter square plots,

denoting one as near shore and the other offshore. Wooden stakes, approximately 40 cm in length were located around the circumference of the pond in ten-meter increments to serve as a frame of reference for data collection sites. A measuring tape was anchored to one end of a stake while stretched to the next stake in order to determine distances around the pond. The boundaries between sampling plots corresponded to each meter interval on the measuring tape. One-fourth of the total number of 1m by 2m plots at each vernal pond was randomly selected for sampling using a random number table. A coin was flipped to determine whether the near shore (a-heads) or offshore (b-tails) plot would be surveyed.

The first sampling period occurred during May 30, 2002 in the Ottawa National Forest until June 2, 2002 on UNDERC property. Midsummer surveying was conducted on June 24, 2002 within

UNDERC and June 25, 2002 in the Ottawa National Forest. The third and final sampling occurred on July 15, 2002 in UNDERC until July 16, 2002 within the Ottawa National Forest. A 31-gallon Rubbermaid© bin with the bottom removed, measuring .876m length by .508m width by .425m depth, was used as the apparatus to collect larvae. The bin was placed in the pond water within a specified 1m by 1m plot and held firmly against the substrate such that no larval amphibians could escape. Then, a 12.5cm by 15.0cm fish net was swept around the interior of the bin to collect the larvae, the contents of which were placed into a bucket for inspection. The net was swept an average of 15 times through the bin to ensure complete collection of larvae. Debris was taken out of the collection bucket in order to allow proper scanning for amphibian larvae in the residual water at the bottom of the bucket. The captured larvae were placed in labeled

1-gallon Zip-Lock™ plastic bags for identification and measuring back at the laboratory. Larval salamanders were identified to species by the differentiation of body coloration and lateral stripes between *Ambystoma laterale* and *Ambystoma maculatum*. The tadpoles were analyzed under a stereomicroscope and identified to species by certain distinctive bodily characteristics, but primarily according to examination of mouthpart structures, size, and tail length to body length ratio. After identification, the length of each larval amphibian was measured using a standard caliper (Appendix B). One example of each species was placed in 95% EtOH for preservation in use as future reference. The remaining amphibian species were returned to their respective vernal ponds.

The collection of adult amphibian species for population density and abundance identification was conducted in a preliminary drift fence and pit-fall trap

experiment (Heyer et al. 1994). Vernal pond number five on UNDERC property, close to Roach Lake and the turnout for the President's Lodge, was the chosen location for this preliminary experiment (Appendix C). One hundred and seventy-five meters of drift fence were stretched around the vernal pond one-meter away from the wetted perimeter. The stakes were driven into the soil with fencing placed into small grooves about three inches into the ground which were covered with excess dirt, such that the fence was a permanent boundary. Two-quart buckets with drainage holes poked into the bottoms and a four-inch diameter hole cut out of the tops were placed at the beginning, end, and at twenty-meter increments along the fence. Buckets were placed into holes in the earth so that the tops were level with the ground. The experiment lasted a forty-eight hour duration, with the traps being checked every eight hours.

## **Results**

Amphibian sampling was conducted in four vernal ponds within the Ottawa National Forest. Two of the vernal ponds, OTT-2 and OTT-3, reside in an area slated for clear-cutting in the near future, while the other two, OTT-5 and OTT-6, are present in an area pre-determined for selective thinning (Appendix C). Three vernal ponds on UNDERC property, ND-N1, ND-N2, and ND-N3, serve as controls, where no logging will occur throughout the duration of this study (Appendix C). Each pond was sampled three times: once at the beginning of the summer in late May, early June; once again in the middle of the summer in late June; and finally during the end of July for late summer sampling. Two of the vernal ponds in the Ottawa National Forest, OTT-3 and OTT-6, were completely desiccated by the third sampling period in late summer. The other two ponds, OTT-2 and OTT-5, still retained sufficient water levels for

sampling, although there had been a significant reduction in the size of each pond. All three UNDERC control vernal ponds remained wet through the duration of the study, although water levels were significantly lower during the final sampling period than at the beginning of the summer.

The primary purpose of this study is to determine the diversity of amphibian species present at each vernal pond and the total number of those amphibians. Figure 1 compares the diversity of species present at each site location during the three sampling periods. At the first sampling period on UNDERC property, ND-N1 did not contain any amphibians, ND-N2 contained two species, and ND-N3 contained one species. In the Ottawa National Forest, there was one species in OTT-2, none in OTT-3, one species in OTT-5, and two species in OTT-6 during the first sampling period. The second sampling in UNDERC resulted in the collection of one species in ND-N1, six

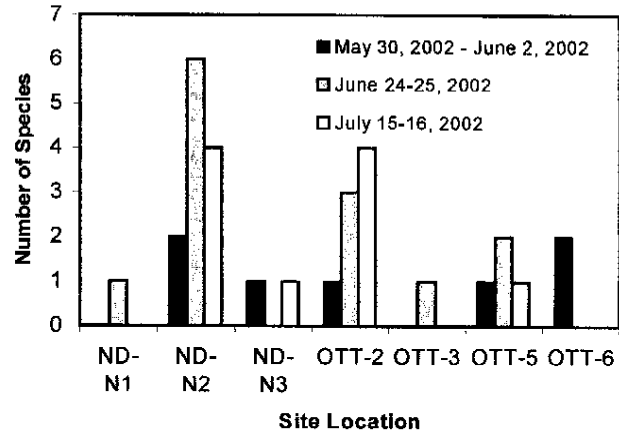


Figure 1. Amphibian diversity by of each site location and date of sampling period.

species in ND-N2, and no amphibians from ND-N3. In the Ottawa National Forest, there were three species present in OTT-2, two amphibian species in OTT-3, as well as OTT-5, and OTT-6 contained no species during the second collection. Results continue to vary during the third and final sampling period. No amphibian species were found in ND-N1, four species in ND-N2, and one species was present in ND-N3. During the third sampling period in the Ottawa National Forest, four species were collected in OTT-2 and one species in OTT-5. Two of the vernal ponds were completely desiccated, OTT-3 and OTT-6; therefore

neither contained any amphibian larvae. The general trend for species diversity appears to be an increase and then decrease in number of species throughout the course of the summer.

Comparing the contribution of the number of each species to the total number of amphibian species across the varying site locations also represents the diversity of amphibian species found at each site (Figure 2). During the first sampling period at the end of May and beginning of June, there is very little species diversity in the UNDERC and Ottawa National Forest vernal ponds (Figure 2a). Both ND-N2 and OTT-6 contained species of *Ambystoma maculatum* and *Rana sylvatica*; ND-N3 and OTT-2 contained *R. sylvatica*; *A. maculatum* was present in OTT-5; and there were no amphibian species present in ND-N1 or OTT-3. At the second sampling period, the diversity increases in all vernal ponds, except ND-N3 and OTT-6 in which the

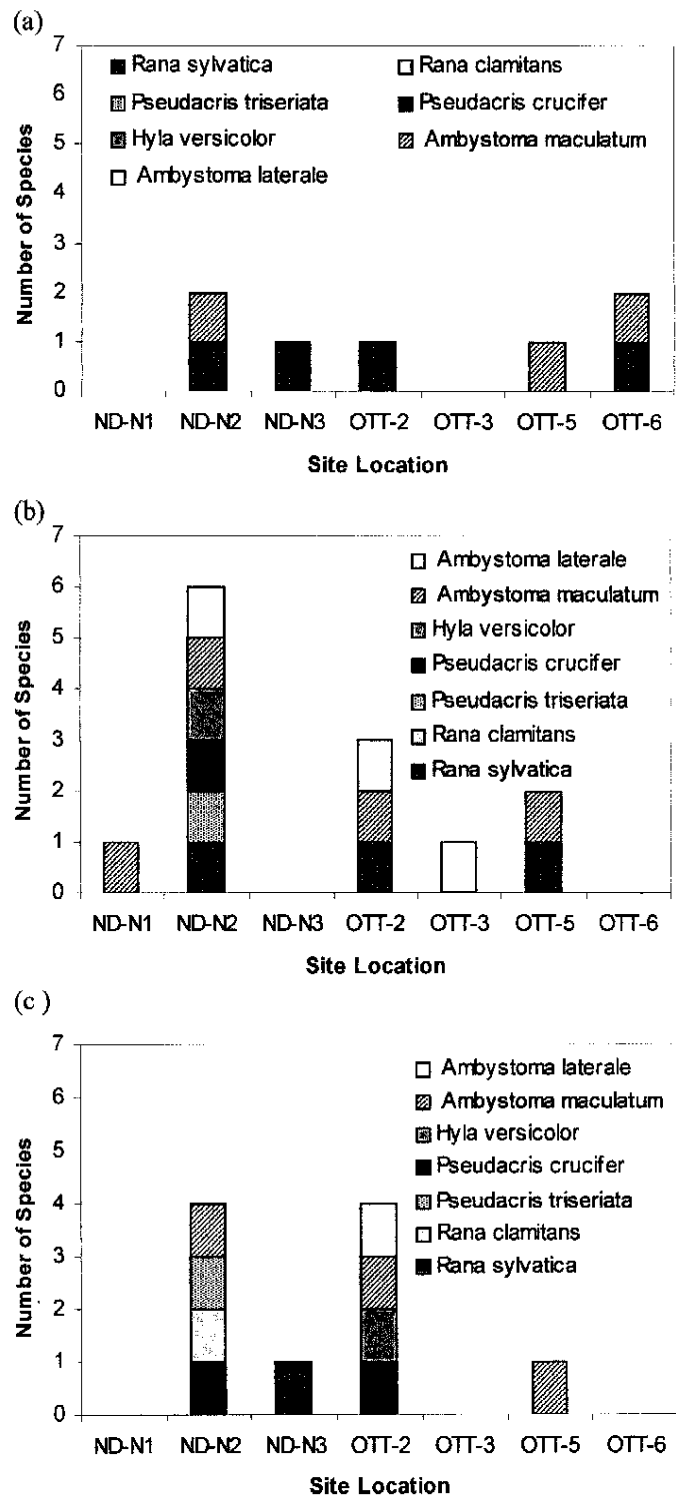


Figure 2. Larval amphibian diversity by species at each site as measured on: (a) May 30 – June 2, 2002, (b) June 24 – 25, 2002, and (c) July 15 – 16, 2002.

diversity decreases (Figure 2b). ND-N1 contained one species identified as *A. maculatum*. Six species were found in ND-N2, namely, *Ambystoma laterale*, *A. maculatum*, *Hyla versicolor*, *Pseudacris crucifer*, *Pseudacris triseriata*, and *R. sylvatica*. The four amphibian species in OTT-2 were *A. laterale*, *A. maculatum*, and *R. sylvatica*. One species found in OTT-3 was determined to be *A. laterale*. There were no species found in ND-N3 or OTT-6. In general, species diversity decreased during the third sampling period except for ND-N3 and OTT-2 in which the diversity increased (Figure 2c). ND-N2 contained species of *A. maculatum*, *P. triseriata*, *Rana clamitans*, and *R. sylvatica*. *R. sylvatica* was collected from vernal pond ND-N3. OTT-2 contained *A. laterale*, *A. maculatum*, *H. versicolor*, and *R. sylvatica*. The one species present in OTT-5 was identified as *A. maculatum*. There were no amphibian

species in ND-N1, OTT-3, and OTT-6, the latter two of which were completely dry.

Further analysis of the data compares the contribution of the number of individuals per species within the total number of species present across site locations at each sampling period (Figure 3). The first sampling period shows collection of the least total number of amphibians (Figure 3a). Only two species were collected at this time, namely *A. maculatum* and *R. sylvatica*. The greatest total numbers of individual amphibians were collected during the second sampling period, in which all species except *R. clamitans* were identified (Figure 3b). Fewer amphibians were found during the third sampling than the second sampling, although there were still more than the first collection (Figure 3c). At least one representative species from each species, except *P. crucifer*, was found during this final collection time.

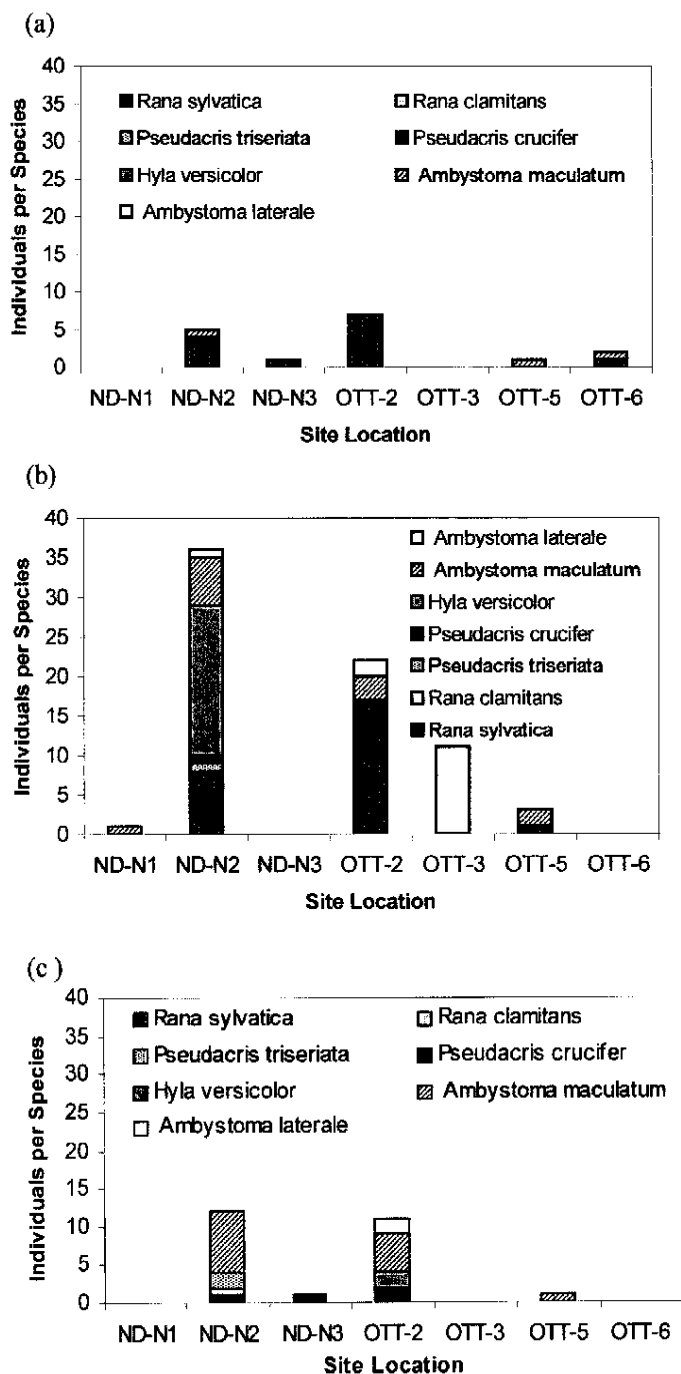


Figure 3. Total amphibian count by species at each site location as measured on: (a) May 30 – June 2, 2002, (b) June 24 – 25, 2002, and (c) July 15 – 16, 2002.

A comparison of each treatment type to the contribution of the number of species or individuals per species collected during the three sampling periods begins to indicate some general trends in the data. In the areas slated to be clear-cut, the number of species increased from May to July. The regions selected for selective thinning remain the same from May to June, but decrease from June to July in the number of species. In the control vernal ponds, species number increases from May to June, but decreases from June to July (Figure 4).

The vernal ponds pre-determined for clear-cutting demonstrate an increase in amphibian numbers from May to June, but a decrease from June to July, although the final numbers in July are higher than those in May. In the selective thinning ponds, the individuals per species remain the same from May to June, and decreases from June to July. Finally, the control ponds demonstrate a rise in amphibian numbers

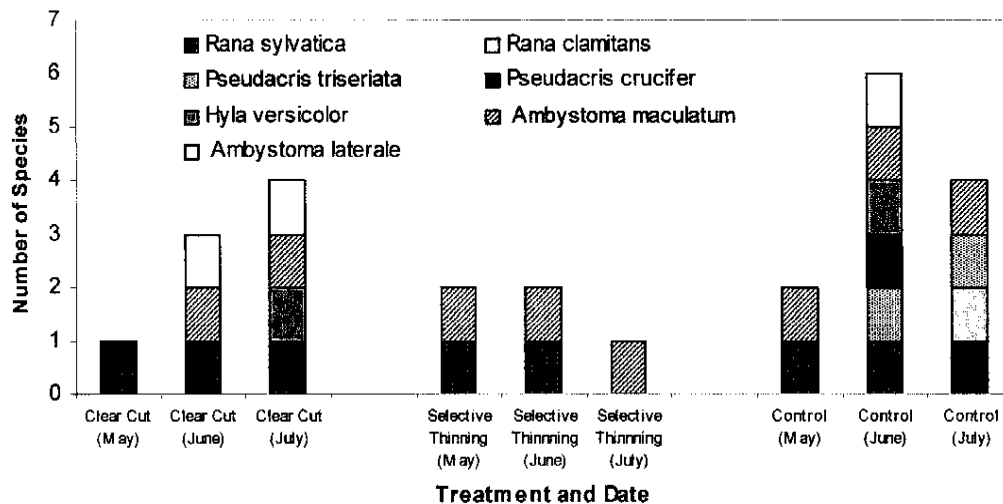


Figure 4. Number of larval amphibian species by species, treatment type, and date. Vernal ponds OTT-2 and OTT-3 made up the clear-cut sites, OTT-5 and OTT-6 made up the selectively thinning sites, and ND-N1, ND-N2, and ND-N3 represent the control sites. Both OTT-3 and OTT-6 were completely desiccated in July, thus they were not sampled.

from May through June, and a decrease from June to July, although the last count in July is greater than that at the outset (Figure 5).

*R. sylvatica* is present in each treatment type of vernal pond at every time period, except the July sampling of those ponds slated for selective thinning. *A. maculatum* was found at every time period in each treatment type, except the vernal ponds in the clear-cut regions during the first sampling period in May. The other

amphibian larvae species are not equally represented at each vernal pond treatment type. *P. crucifer*, *P. triseriata*, and *R. clamitans* were only found in the control ponds on UNDERC property during the last two sampling periods from the middle to the end of summer. *H. versicolor* was found in the control ponds during the June sampling and the ponds in the Ottawa National Forest slated for clear-cutting during the July collection (Figure 4). *A. laterale* was first

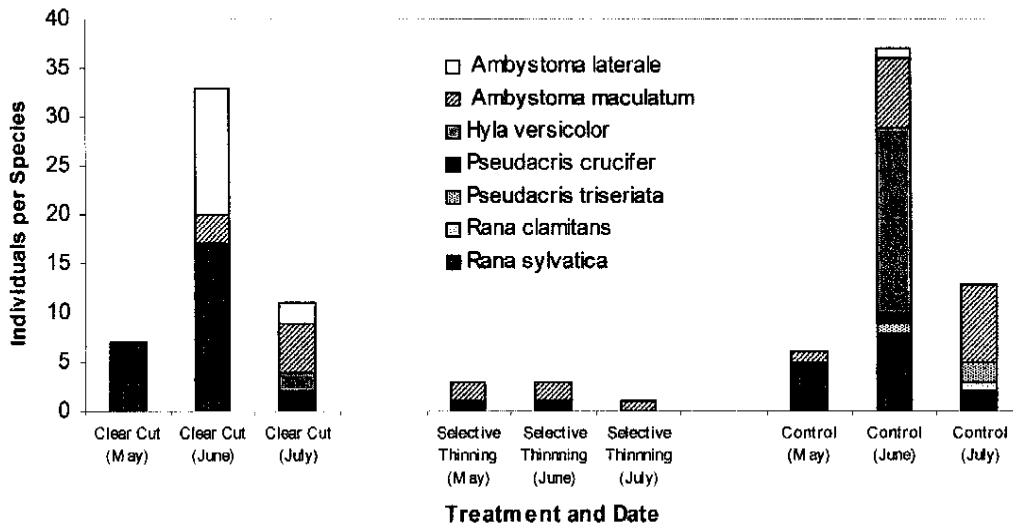


Figure 5. Total individual larval amphibian count by species, treatment type, and date. Vernal ponds OTT-2 and OTT-3 made up the clear-cut sites, OTT-5 and OTT-6 made up the selective thinning sites, and ND-N1, ND-N2, and ND-N3 represent the control sites. Both OTT-3 and OTT-6 were completely desiccated in July, thus they were not sampled.

collected during the June sampling period in the ponds determined for clear-cutting and the control ponds, and the number of individuals decreased from that time until the final sampling occurred in late July (Figure 5).

Scott Chormanski and David Wainman performed a similar study during the summer of 2001. A comparison of the results from 2001 with those collected in 2002 show some interesting correlations of the amphibian data. In general, greater

species diversity was found in the 2002 study, considering four different species found in 2001 compared with seven different species during the second survey (Figure 6). However, much greater numbers of individuals of each species were collected in 2001 versus 2002 (Figure 7). In those ponds slated for clear-cutting, species of *R. sylvatica* and *A. maculatum* were collected during both sampling periods of June and July in each year (Figure 6). Also, the numbers of individuals of *R. sylvatica* decreased from June to July in both the

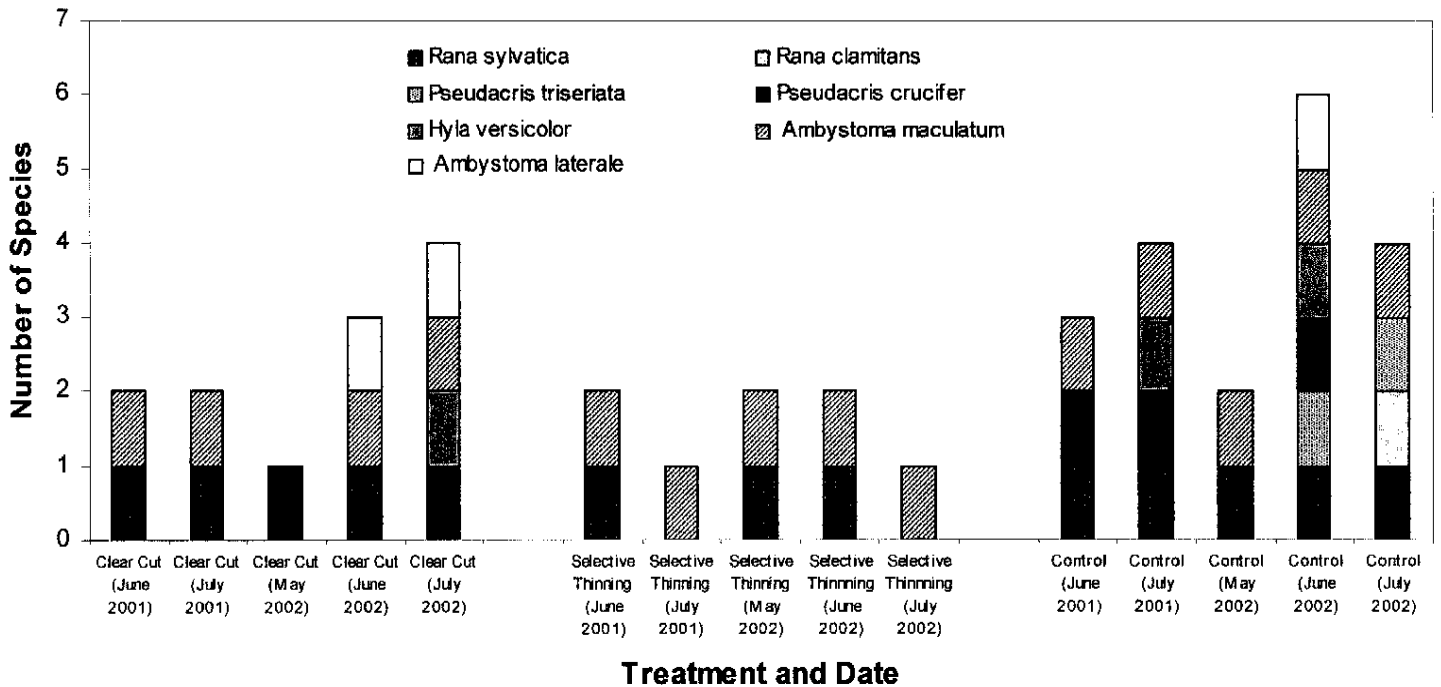


Figure 6. Number of larval amphibian species by species, treatment type, and date for two consecutive years of data. Vernal ponds OTT-2 and OTT-3 made up the clear-cut sites, OTT-5 and OTT-6 made up the selectively thinning sites, and ND-N1, ND-N2, and ND-N3 represent the control sites. Both OTT-3 and OTT-6 were completely desiccated in July, thus they were not sampled at that time.

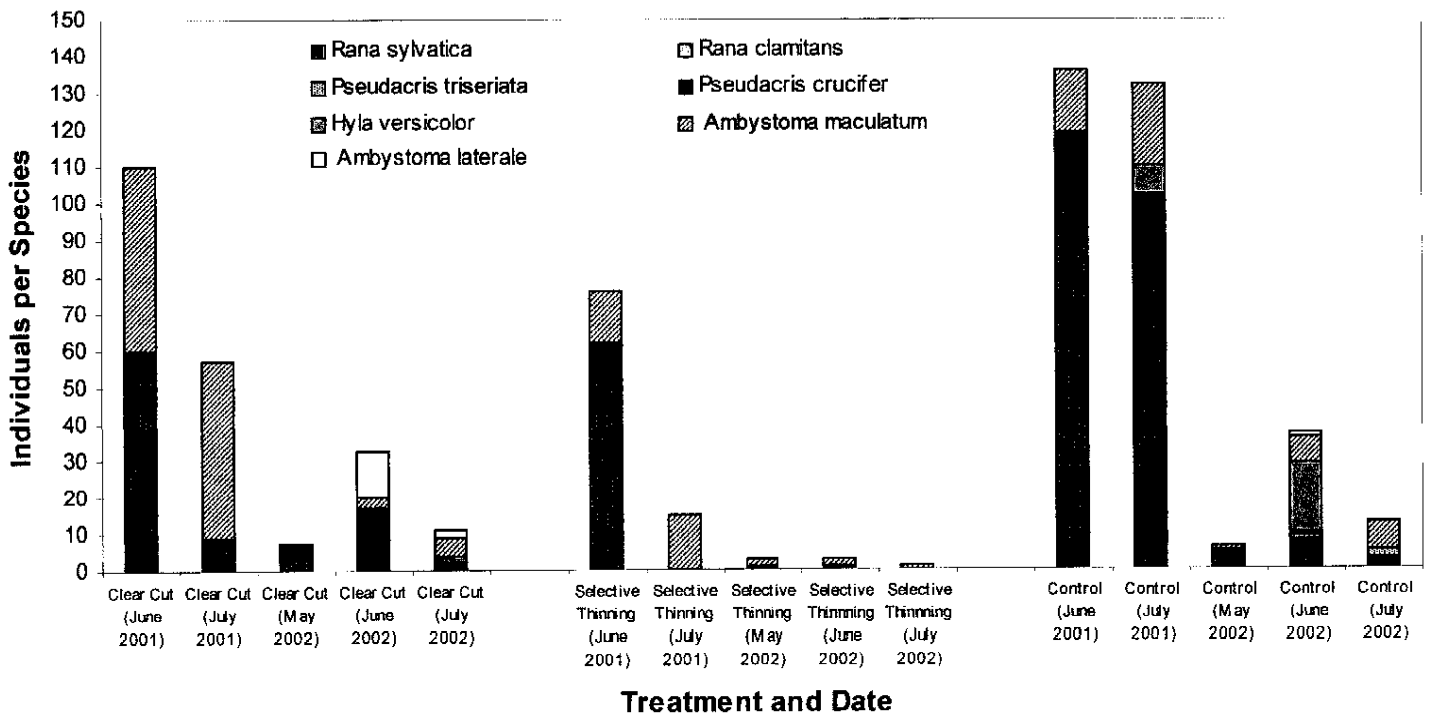


Figure 7. Total individual larval amphibian count by species, treatment type, and date for two consecutive years of data. Vernal ponds OTT-2 and OTT-3 made up the clear-cut sites, OTT-5 and OTT-6 made up the selective thinning sites, and ND-N1, ND-N2, and ND-N3 represent the control sites. Both OTT-3 and OTT-6 were completely desiccated in July, thus they were not sampled.

years 2001 and 2002 (Figure 7). Interestingly, in the ponds pre-determined for selective thinning the only species collected were *R. sylvatica* and *A. maculatum* during the June sampling in 2001 and 2002 (Figure 6). Then, during July of both years, *A. maculatum* is the only species represented, with a disappearance of *R. sylvatica* (Figure 6). The most discrepancies of data occur in the control ponds of which much greater diversity was collected in the year 2002, yet greater numbers of individuals per species were found in 2001 (Figures 6 and 7). Numbers of the species of *R. sylvatica* decreased from June to July, while numbers of *A. maculatum* increased from June to July in both years. The appearance and disappearance of other species, *A. laterale*, *H. versicolor*, *P. crucifer*, *P. triseriata*, and *R. clamitans*, varies from the year 2001 to 2002 in the control vernal ponds (Figure 7).

Quantitative measurements recorded during sampling were compared to the amphibian density and total number of amphibians at each vernal pond (Figures 8 and 9). Water temperature was measured at each vernal pond during all three sampling periods. However, water pH, dissolved O<sub>2</sub> concentration, conductivity, length and width, and maximum depth were measured for each vernal pond during the first and last sampling times only. There is no significant correlation of the data with either total amphibian count or amphibian density. Conductivity appears to show a general inverse trend with total amphibian number and amphibian densities decreasing with increasing conductivity (Figure 8d and 9d). Another interesting result is the negative relationship of total amphibian count to water temperature, such that amphibian numbers decrease with increasing temperature (Figure 8a). This may be a consequence of amphibian species adapting

to colder early summer temperatures, or a demonstration of the detrimental effects of higher temperatures upon amphibian populations.

Further analysis of the amphibian data involves a comparison of the size range of each species measured across all treatment types (Table 1 in Appendix D). In general, each species increases in size from May through June to July. The absence of some species during the first sampling period is most likely the result of later hatching season. Also, for those species present initially, but absent during the later sampling times, this is due to their metamorphosis into adult amphibians, or death due to a competing factor such as limiting resources. A generalized summary of the total number of amphibians of each species found at the different vernal pond sites is located in Table 2 (Appendix D).

In the vernal pond drift fence experiment, one small shrew was captured

in trap number five along the second fence. No adult amphibians were trapped during the forty-eight hour course of the trial. An adult frog was placed into one of the traps in the field as a test, and it promptly jumped directly out of the trap. Therefore, it is possible that some adults were trapped, but escaped before data collection. Drift fence and pitfall traps could provide important information regarding the adult amphibian species inhabiting each vernal pond. However, deeper pitfall traps must be constructed to effectively capture amphibians, particularly adult frogs.

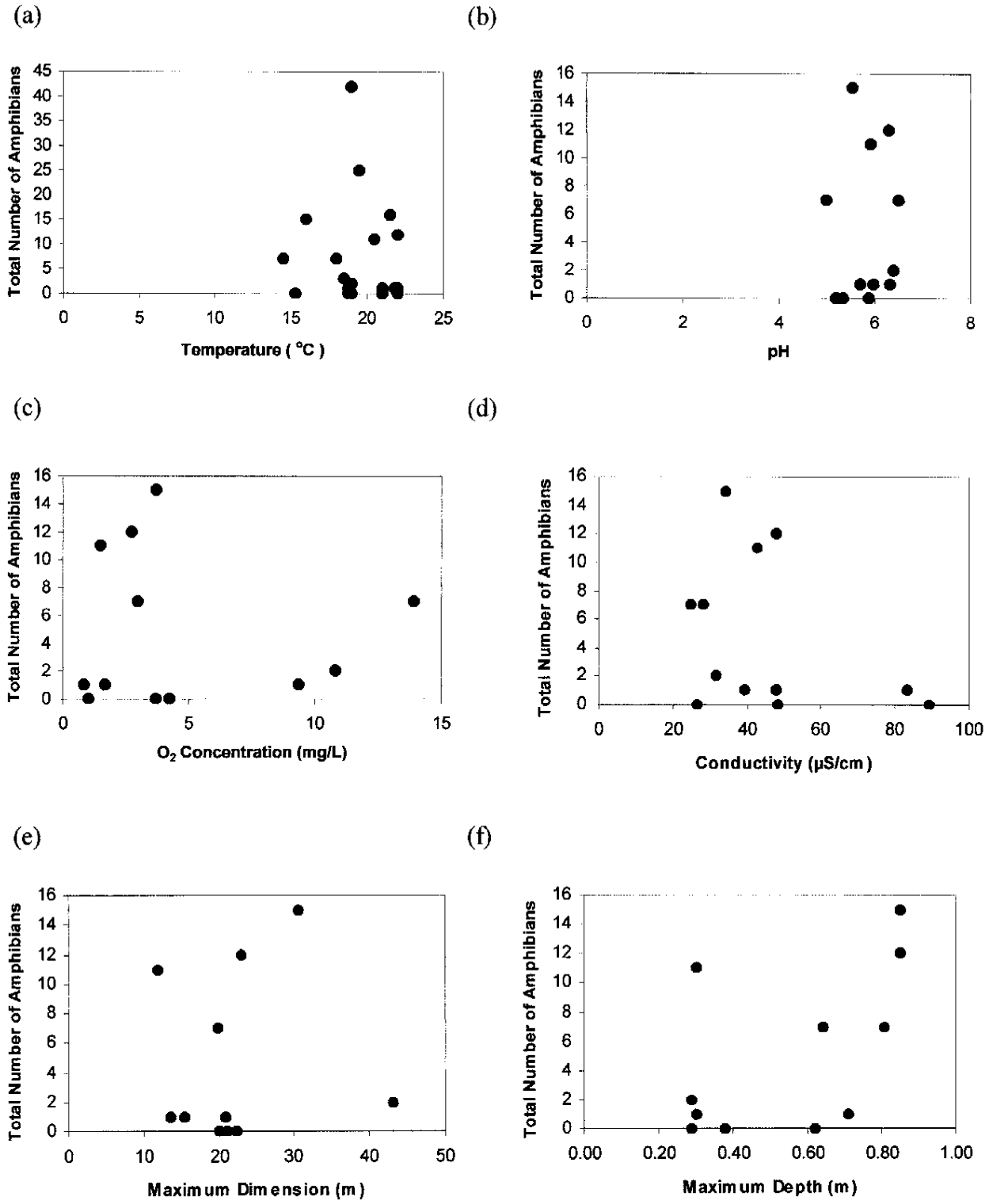


Figure 8 Total Larval Amphibian Count By: (a) water temperature ( $R^2 = 0.0036$ ), (b) water pH ( $R^2 = 0.0057$ ), (c) dissolved O<sub>2</sub> concentration ( $R^2 = 0.0020$ ), (d) conductivity ( $R^2 = 0.1134$ ), (e) maximum dimension ( $R^2 = 0.0071$ ), and (f) maximum depth ( $R^2 = 0.2950$ ).

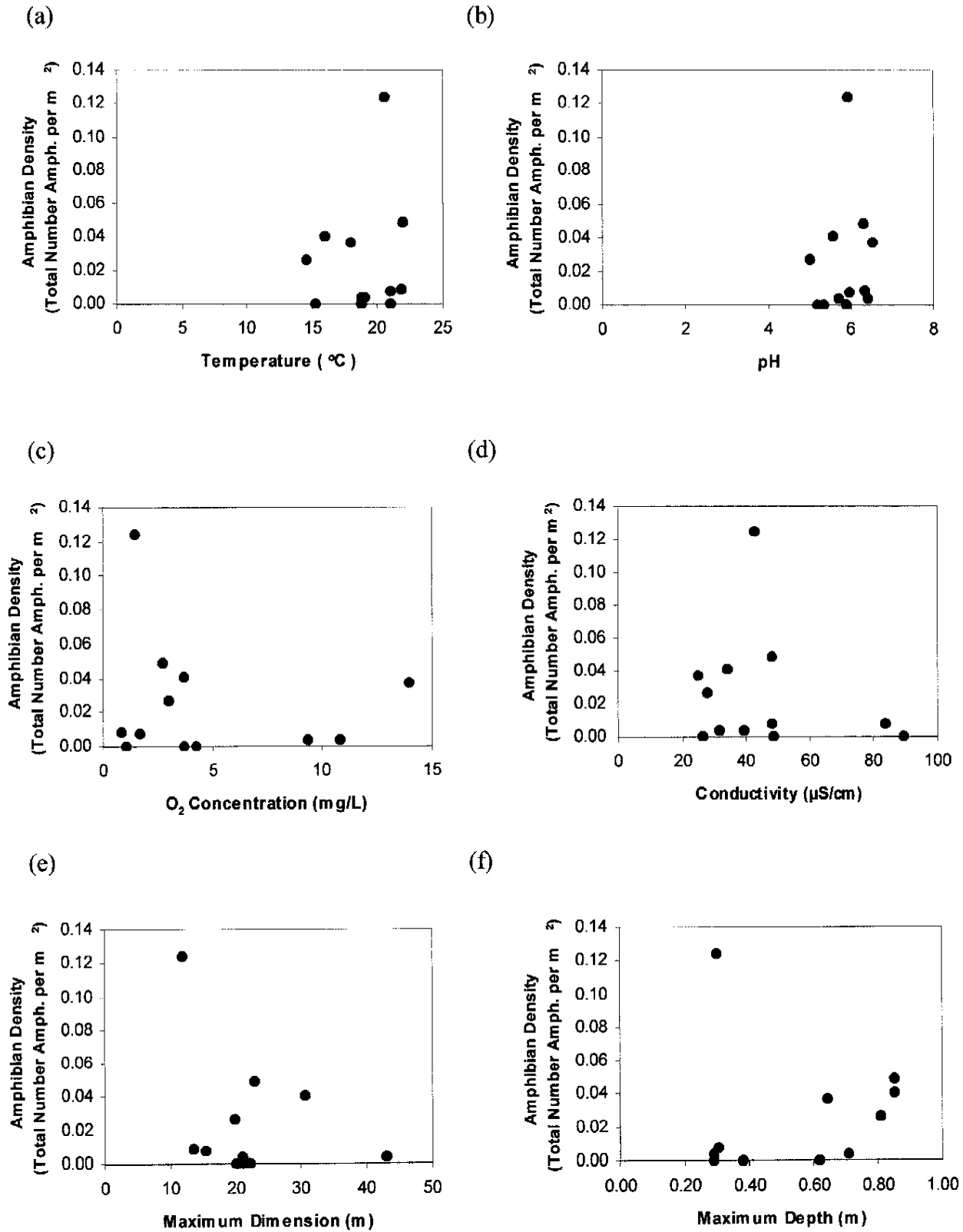


Figure 9 Larval Amphibian Density By: (a) water temperature ( $R^2 = 0.0152$ ), (b) water pH ( $R^2 = 0.0214$ ), (c) dissolved O<sub>2</sub> concentration ( $R^2 = 0.0230$ ), (d) conductivity ( $R^2 = 0.0385$ ), (e) maximum dimension ( $R^2 = 0.0887$ ), and (f) maximum depth ( $R^2 = 0.0020$ ).

## Discussion

Over the past decade, increasing numbers of studies have been conducted involving amphibians due to their importance as indicators of the environmental health of a particular region. One study focused especially upon deforestation, demonstrating that this practice, “eliminates shade, increases surface temperature, disrupts soil structure, and reduces soil moisture, making these areas inhospitable or less suitable for many species” (Semlitsch 2000). Such consequences are likely to occur within the areas that are to be clear-cut and selectively thinned in the Ottawa National Forest. Our manipulative experiment should provide the necessary data to develop proper management practices for forests in the northern mid-west region, regarding protection of amphibian populations.

We found a significant diversity of amphibian species in the vernal ponds of the

Upper Peninsula of Michigan. However, it appears that there is greater overall diversity in vernal ponds located on UNDERC property than those ponds in the Ottawa National Forest (Figure 1). There is no significant correlation between the physical and chemical characteristics of the vernal ponds with amphibian density; thus a variety of factors may be influencing the diversity distinction of the two different locations. Also, the 2002 breeding season may have been different than previous years because of a slow start to the summer. The summer season was about two weeks late in 2002, so amphibians may have started breeding later than usual. However, since there was not a continuous increase in amphibian numbers throughout the experiment, adults may have bred at the usual time, but many of the progeny could have been destroyed by the delayed season, resulting in the collection of fewer numbers of amphibians than previous years (Figure 7).

An important characteristic of all the vernal ponds in the Ottawa is their shallow water depth (< 0.71 m). Evaporation will occur more quickly with the removal of the forest canopy, resulting in faster desiccation of those vernal ponds. Amphibians have adjusted their development to compensate for eventual desiccation of ponds; however, if the pond dries too soon, those amphibians will not be able to metamorphose quickly enough to successfully leave their aquatic environment. Drought occurred sooner in vernal ponds OTT-3 and OTT-6 than any other pond. OTT-3 is important since one species was identified, *A. maculatum*, during the second sampling period that could have been affected by the desiccation of the pond by the third sampling effort. OTT-6 also dried up completely by the third sampling, however the two species identified, *A. maculatum* and *R. sylvatica*, during the first sampling were not present at

the second sampling and were likely unaffected by the desiccation.

Amphibians breed at different times, so different species will be affected by the timing of vernal pond desiccation in the Ottawa. If vernal ponds become dry at the beginning of breeding season, then little to no population growth will occur across all sites. However, if desiccation occurs in the middle of the breeding season, such as June, the species that will be affected are *A. laterale*, *A. maculatum*, and *R. sylvatica*. A drought in June will significantly affect the numbers of amphibians because the most were collected at this time period (Figure 3). Desiccation in late July may possibly affect species of *A. laterale*, *A. maculatum*, *R. sylvatica*, and *H. versicolor*. However, since all of the species except *H. versicolor* appeared in previous sampling periods, the most adversely affected species will be *H. versicolor* due to its late breeding season.

Another important consideration of the viability of amphibian species in the face of impending logging, is the result of habitat fragmentation. Semlitsch argues that the “loss of wetlands reduces the number and density of breeding sites, thereby diminishing the capacity to maintain local and regional species populations” (2000). Several other studies show that juvenile emigration from temporary breeding pools to densely foliated surrounding terrestrial habitats is an important step in the maturation of amphibians (de Maynadier 1999). The wetland type and proximity to forestry is an important determinant of amphibian species richness (Mitchell 1997). Also, Mitchell found that “eliminating terrestrial vegetation around aquatic breeding sites causes amphibian populations to decline” (1997). Therefore, not only is the wetted area of the actual vernal pond important to amphibian populations, but so

is the surrounding forest and foliage integral to the propagation of species.

Population declines of amphibians have been linked to increased UV-B radiation. Since amphibians usually lay their eggs in shallow water with direct exposure to sunlight, the incidence of UV-B radiation is higher for those ponds not protected by a forest canopy (Blaustein 1993). These increases in UV-B radiation have been correlated with reduced survival and hatching success with negative impacts on development and growth of certain amphibians (Semlitsch 2000). More importantly, increased levels of UV-B intensify factors such as chemical contaminants, low pH, and disease susceptibility (Semlitsch 2000). In our study, amphibians propagated in pH environments ranging from 5.2-6.5 (Figure 8b). At lesser pH values there are no representatives of any species. The previous study conducted in 2001, found amphibian

growth at a pH range of 5.9-6.2, with no total amphibian count at pH of 5.5 (Chormanski 2001). Since we found growth at lower pH values, acidic pH values do not inhibit reproduction. However, the significantly lower total numbers of amphibians collected in 2002 may be the result of acidic pH environments of the vernal ponds.

The importance of maintaining viable populations of amphibians hinges upon the necessity to balance biological diversity in the ecosystem. Also, amphibians are proving to be important indicators of environmental stress upon habitats, influencing regulation to prevent further degradation. This study provides important biological data concerning amphibian populations of a specific region in the Upper Peninsula of Michigan that will influence the development of forestry management strategies. It is imperative to continue monitoring the vernal ponds of the

Ottawa National Forest prior to and subsequent to logging of the surrounding forest. The results of such a large-scale manipulation of a northern mid-west ecosystem may serve to influence future projects in the same region that involve similar species.

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## References Cited

- Alford, R.A. and S.J. Richards. 1999. Global Amphibian Declines: A Problem in Applied Ecology. *Annual Review of Ecology and Systematics*. 30: 133-165.
- Blaustein, A.R., P.D. Hoffman, D.G. Hokit, J.M. Kiesecker, S.C. Walls, and J.B. Hays. 1994b. UV repair and resistance to solar UV-B in amphibian eggs: a link to population declines. *Proceedings of the National Academy of Science*. 91: 1791-1795.
- Chormanski, Scott and David Wainman. 2001. Characterization of Larval Amphibian Populations Present in Vernal Ponds of the Ottawa National Forest Prior to Large-Scale Logging of the Surrounding Forest. UNDERC report: University of Notre Dame.
- Delis, P.R., Mushinsky, H.R., and E.D. McCoy. 1996. Decline of some west-central Florida Anuran Populations in Response to Habitat Degradation. *Biodiversity and Conservation*. 5(12): 1579-1595.
- de Maynadier, P.G. and M.L. Hunter. 1999. Forest Canopy Closure and Juvenile Emigration by Pool-Breeding Amphibians in Maine. *Journal of Wildlife Management*. 63(2): 441-450.
- Dodd, C.K. and B.S. Cade. 1998. Movement Patterns and the Conservation of Amphibians Breeding in Small, Temporary Wetlands. *Conservation Biology*. 12(2): 331-339.
- Dupuis, Linda and Doug Steventon. 1999. Riparian management and the tailed frog in northern coastal forests. *Forest Ecology and Management*. 124: 35-43.
- Heyer, W.R., et al. 1994. Transect Sampling. *Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians*. Washington D.C. Smithsonian Institution Press: 75- 141.
- Knutson, M.G., Sauer, J.R., Olsen, D.A., Mossman, M.J., Hemesath, L.M., and M.J. Lannoo. 1999. *Conservation Biology*. 13(6): 1437-1446.
- Kolozsvary, M.B. and R.K. Swihart. 1999. Habitat fragmentation and the distribution of amphibians: patch and landscape correlates in farmland. *Canadian Journal of Zoology*. 77(8): 1288-1299.
- Mitchell, J.C., S.C. Rinehart, J.F. Pagels, K.A. Buhlmann, and C.A. Pague. 1997. Factors influencing amphibian and small mammal assemblages in central Appalachian forests. *Forest Ecology and Management*. 96: 65-76.
- Semlitsch, R.D. 2000. Principles for Management of Aquatic-Breeding Amphibians. *Journal of Wildlife Management*. 64(3): 615-631.
- Welsh Jr., H.H. and S. Droege. 2001. A Case for Using Plethodontid Salamanders for Monitoring Biodiversity and Ecosystem Integrity of North American Forests. *Conservation Biology*. 15(3): 558-569.

Quantitative Data for ND-N1

| 6/2/2002 14:00           | Average       |
|--------------------------|---------------|
| Air Temp (°C)            | 12.100        |
| Water Temp (°C)          | 15.300        |
| pH                       | 5.800         |
| Conductivity (µS/cm)     | 47.200        |
| Dissolved Oxygen (mg/L)  | 4.400         |
| Water Color              | Stained       |
| Water Turbidity          | Cloudy        |
| Fish                     | None Present  |
| Primary Substrate        | Silt and Mud  |
| Emergent Vegetation (%)  | > 50 %        |
| Shore to Forest Edge (m) | 0             |
|                          | <b>5.340</b>  |
|                          | <b>48.460</b> |
|                          | <b>4.232</b>  |

| 7/15/2002 12:07          | Average       |
|--------------------------|---------------|
| Air Temp (°C)            | 27.000        |
| Water Temp (°C)          | 21.000        |
| pH                       | 6.300         |
| Conductivity (µS/cm)     | 109.700       |
| Dissolved Oxygen (mg/L)  | 1.370         |
| Water Color              | Stained       |
| Water Turbidity          | Cloudy        |
| Fish                     | None Present  |
| Primary Substrate        | Silt and Mud  |
| Emergent Vegetation (%)  | > 50 %        |
| Shore to Forest Edge (m) | 0             |
|                          | <b>5.880</b>  |
|                          | <b>89.340</b> |
|                          | <b>1.014</b>  |

| UTM Coordinates | Grid | North   | East   |
|-----------------|------|---------|--------|
| Elevation (ft)  | 16T  | 5123750 | 306377 |

| Max Depth (m) | 6/2/2002 | 7/15/2002 |
|---------------|----------|-----------|
|               | 0.62     | 0.29      |

Sampling Data

| Date      | Start Time | End Time | Air Temp (°C) | Water Temp (°C) | Anura Tadpoles | Caudata Tadpoles | Adult Anura    | Adult Caudata | Egg Masses |
|-----------|------------|----------|---------------|-----------------|----------------|------------------|----------------|---------------|------------|
| 6/2/2002  | 14:00      | 15:30    | 12.1          | 15.3            | 0              | 0                | 0              | 0             | 0          |
| 6/24/2002 | 10:15      | 11:15    | 27.5          | 22              | 0              | 0                | 1 R. Sylvatica | 0             | 0          |
| 7/14/2002 | 12:07      | 12:53    | 27            | 21              | 0              | 0                | 1 R. Sylvatica | 0             | 0          |

Quantitative Data for ND-N2

| 6/2/2002 15:30           |              | Average |
|--------------------------|--------------|---------|
| Air Temp (°C)            | 10.000       | 5.540   |
| Water Temp (°C)          | 16.000       | 34.340  |
| pH                       | 5.500        | 3.718   |
| Conductivity (µS/cm)     | 35.600       | 5.500   |
| Dissolved Oxygen (mg/L)  | 3.920        | 36.000  |
| Water Color              | Stained      | 2.050   |
| Water Turbidity          | Cloudy       |         |
| Fish                     | None Present |         |
| Primary Substrate        | Silt and Mud |         |
| Emergent Vegetation (%)  | 25 - 50 %    |         |
| Shore to Forest Edge (m) | 0            |         |

| 7/15/2002 14:00          |              | Average |
|--------------------------|--------------|---------|
| Air Temp (°C)            | 26.500       | 6.300   |
| Water Temp (°C)          | 22.000       | 47.900  |
| pH                       | 6.300        | 2.748   |
| Conductivity (µS/cm)     | 48.600       | 6.100   |
| Dissolved Oxygen (mg/L)  | 1.700        | 51.000  |
| Water Color              | Stained      | 1.360   |
| Water Turbidity          | Clear        |         |
| Fish                     | None Present |         |
| Primary Substrate        | Silt and Mud |         |
| Emergent Vegetation (%)  | > 50 %       |         |
| Shore to Forest Edge (m) | 0            |         |

| UTM Coordinates | Grid | North   | East   |
|-----------------|------|---------|--------|
| Elevation (ft)  | 16T  | 5123774 | 306387 |

|               |          |           |
|---------------|----------|-----------|
| Max Depth (m) | 6/2/2002 | 7/15/2002 |
|               | > 0.85   | > 0.85    |

Sampling Data

| Date      | Start Time | End Time | Air Temp (°C) | Water Temp (°C) | Anura Tadpoles | Caudata Tadpoles | Adult Anura                    | Adult Caudata | Egg Masses           |
|-----------|------------|----------|---------------|-----------------|----------------|------------------|--------------------------------|---------------|----------------------|
| 6/2/2002  | 15:30      | 16:47    | 10            | 16              | 14             | 1                | 1 R. sylvatica                 | 0             | 1 Caudata, 1 Unknown |
| 6/24/2002 | 11:16      | 12:34    | 27.5          | 19              | 31             | 11               | 0                              | 0             | 0                    |
| 7/15/2002 | 14:00      | 16:15    | 26.5          | 22              | 4              | 8                | 1 R. sylvatica, 1 R. clamitans | 0             | 0                    |

Quantitative Data for ND-N3

| 6/2/2002 10:00           | Average      |
|--------------------------|--------------|
| Air Temp (°C)            | 12.200       |
| Water Temp (°C)          | 14.500       |
| pH                       | 5.200        |
| Conductivity (µS/cm)     | 5.200        |
| Dissolved Oxygen (mg/L)  | 25.900       |
| Water Color              | 3.420        |
| Water Turbidity          | Stained      |
| Fish                     | Cloudy       |
| Primary Substrate        | None Present |
| Emergent Vegetation (%)  | Silt and Mud |
| Shore to Forest Edge (m) | 1 - 25 %     |
|                          | 0 - 00       |
|                          | 5.000        |
|                          | 28.100       |
|                          | 2.980        |

| 7/15/2002 10:00          | Average      |
|--------------------------|--------------|
| Air Temp (°C)            | 27.900       |
| Water Temp (°C)          | 21.000       |
| pH                       | 6.000        |
| Conductivity (µS/cm)     | 43.100       |
| Dissolved Oxygen (mg/L)  | 2.300        |
| Water Color              | Stained      |
| Water Turbidity          | Clear        |
| Fish                     | None Present |
| Primary Substrate        | Silt and Mud |
| Emergent Vegetation (%)  | 1 - 25 %     |
| Shore to Forest Edge (m) | 0            |
|                          | 6.000        |
|                          | 47.920       |
|                          | 1.674        |

| UTM Coordinates | Grid | North   | East   |
|-----------------|------|---------|--------|
| Elevation (ft)  | 16T  | 5119974 | 308757 |

| Max Depth (m) | 6/2/2002 | 7/15/2002 |
|---------------|----------|-----------|
|               | 0.81     | 0.303     |

Sampling Data

| Date      | Start Time | End Time | Air Temp (°C) | Water Temp (°C) | Anura Tadpoles | Caudata Tadpoles | Adult Anura    | Adult Caudata | Egg Masses |
|-----------|------------|----------|---------------|-----------------|----------------|------------------|----------------|---------------|------------|
| 6/2/2002  | 10:00      | 12:10    | 12.2          | 14.5            | 7              | 0                | 0              | 0             | 0          |
| 6/24/2002 | 15:01      | 15:45    | 26            | 19              | 0              | 0                | 1 R. clamitans | 0             | 0          |
| 7/15/2002 | 10:00      | 11:05    | 27.9          | 21              | 1              | 0                | 1 R. clamitans | 0             | 0          |

Quantitative Data for V.P. 2

| 5/30/2002 11:20          |              | Average |
|--------------------------|--------------|---------|
| Air Temp (°C)            | 27.000       | 6.500   |
| Water Temp (°C)          | 18.000       | 24.800  |
| pH                       | 6.500        | 13.925  |
| Conductivity (µS/cm)     | 24.800       |         |
| Dissolved Oxygen (mg/L)  | 16.000       | 13.200  |
| Water Color              | 13.000       | 13.500  |
| Water Turbidity          | Stained      |         |
| Fish                     | Clear        |         |
| Primary Substrate        | None Present |         |
| Emergent Vegetation (%)  | Silt and Mud |         |
| Shore to Forest Edge (m) | 1 - 25 %     |         |
|                          | 0            |         |

| 7/16/2002 10:45          |              | Average |
|--------------------------|--------------|---------|
| Air Temp (°C)            | 26.000       | 5.920   |
| Water Temp (°C)          | 20.500       | 42.620  |
| pH                       | 6.000        | 1.498   |
| Conductivity (µS/cm)     | 42.300       | 6.000   |
| Dissolved Oxygen (mg/L)  | 4.200        | 40.000  |
| Water Color              | 0.590        | 52.700  |
| Water Turbidity          | Stained      | 1.150   |
| Fish                     | Cloudy       |         |
| Primary Substrate        | None Present |         |
| Emergent Vegetation (%)  | Silt and Mud |         |
| Shore to Forest Edge (m) | 1 - 25 %     |         |
|                          | 4            |         |

|                 | Grid | North   | East   |
|-----------------|------|---------|--------|
| UTM Coordinates | 16T  | 5125141 | 303021 |
| Elevation (ft)  | 1803 |         |        |

|               | 5/30/2002 | 7/16/2002 |
|---------------|-----------|-----------|
| Max Depth (m) | 0.643     | 0.300     |

Sampling Data

| Date      | Start Time | End Time | Air Temp (°C) | Water Temp (°C) | Anura Tadpoles | Caudata Tadpoles | Adult Anura | Adult Caudata | Egg Masses  |
|-----------|------------|----------|---------------|-----------------|----------------|------------------|-------------|---------------|-------------|
| 5/30/2002 | 11:50      | 13:00    | 27            | 18              | 7              | 0                | 0           | 0             | 2 Solo Eggs |
| 6/25/2002 | 13:54      | 14:46    | 22            | 19.5            | 18             | 7                | 0           | 0             | 0           |
| 7/16/2002 | 11:53      | 12:45    | 26            | 20.5            | 4              | 7                | 0           | 0             | 0           |

Quantitative Data for V.P. 3

|                          |              |                |
|--------------------------|--------------|----------------|
| <b>5/30/2002 11:16</b>   |              | <b>Average</b> |
| Air Temp (°C)            | 20.500       |                |
| Water Temp (°C)          | 18.800       |                |
| pH                       | 5.200        | 5.200          |
| Conductivity (µS/cm)     | 26.300       | 26.300         |
| Dissolved Oxygen (mg/L)  | 3.700        | 3.700          |
| Water Color              | Stained      |                |
| Water Turbidity          | Clear        |                |
| Fish                     | None Present |                |
| Primary Substrate        | Silt and Mud |                |
| Emergent Vegetation (%)  | 25 - 50%     |                |
| Shore to Forest Edge (m) | 0            |                |

|                          |           |  |
|--------------------------|-----------|--|
| <b>7/16/2002 13:00</b>   |           |  |
| Air Temp (°C)            | DESSICANT |  |
| Water Temp (°C)          | DESSICANT |  |
| pH                       | DESSICANT |  |
| Conductivity (µS/cm)     | DESSICANT |  |
| Dissolved Oxygen (mg/L)  | DESSICANT |  |
| Water Color              | DESSICANT |  |
| Water Turbidity          | DESSICANT |  |
| Fish                     | DESSICANT |  |
| Primary Substrate        | DESSICANT |  |
| Emergent Vegetation (%)  | DESSICANT |  |
| Shore to Forest Edge (m) | DESSICANT |  |

|                 |             |              |             |
|-----------------|-------------|--------------|-------------|
|                 | <b>Grid</b> | <b>North</b> | <b>East</b> |
| UTM Coordinates | 16T         | 5125063      | 302986      |
| Elevation (ft)  | 1842        |              |             |

|               |                  |                  |
|---------------|------------------|------------------|
|               | <b>5/30/2002</b> | <b>7/16/2002</b> |
| Max Depth (m) | 0.38             | DESSICANT        |

**Sampling Data**

| Date      | Start Time | End Time  | Air Temp (°C) | Water Temp (°C) | Anura Tadpoles | Caudata Tadpoles | Adult Anura | Adult Caudata | Egg Masses  |
|-----------|------------|-----------|---------------|-----------------|----------------|------------------|-------------|---------------|-------------|
| 5/30/2002 | 11:16      | 13:00     | 20.5          | 18.8            | 0              | 0                | 0           | 0             | 1 Ambystoma |
| 6/25/2002 | 12:39      | 13:36     | 22            | 21.5            | 4              | 12               | 0           | 0             | 0           |
| 7/16/2002 | DESSICANT  | DESSICANT | DESSICANT     | DESSICANT       | DESSICANT      | DESSICANT        | DESSICANT   | DESSICANT     | DESSICANT   |

Quantitative Data for V.P. 5

| 5/30/2002 12:20          |              | Average |
|--------------------------|--------------|---------|
| Air Temp (°C)            | 21.500       | 5.700   |
| Water Temp (°C)          | 18.800       | 39.300  |
| pH                       | 5.700        | 9.354   |
| Conductivity (µS/cm)     | 39.300       |         |
| Dissolved Oxygen (mg/L)  | 7.330        | 9.450   |
| Water Color              | 9.450        | 11.050  |
| Water Turbidity          | 9.740        | 9.200   |
| Fish                     | Stained      |         |
| Primary Substrate        | Clear        |         |
| Emergent Vegetation (%)  | None Present |         |
| Shore to Forest Edge (m) | Silt and Mud |         |
|                          | 1 - 25 %     |         |
|                          | 0            |         |

| 7/16/2002 13:00          |              | Average |
|--------------------------|--------------|---------|
| Air Temp (°C)            | 26.900       | 6.320   |
| Water Temp (°C)          | 21.800       | 83.420  |
| pH                       | 6.300        | 0.832   |
| Conductivity (µS/cm)     | 77.300       | 6.300   |
| Dissolved Oxygen (mg/L)  | 1.270        | 6.300   |
| Water Color              | 0.870        | 82.000  |
| Water Turbidity          | 0.650        | 97.600  |
| Fish                     | Stained      | 0.790   |
| Primary Substrate        | Clear        |         |
| Emergent Vegetation (%)  | None Present |         |
| Shore to Forest Edge (m) | Silt and Mud |         |
|                          | 1 - 25 %     |         |
|                          | 0            |         |

|                 | Grid | North   | East   |
|-----------------|------|---------|--------|
| UTM Coordinates | 16T  | 5125048 | 302778 |
| Elevation (ft)  | 1814 |         |        |

|               |           |           |
|---------------|-----------|-----------|
|               | 5/30/2002 | 7/16/2002 |
| Max Depth (m) | 0.71      |           |

Sampling Data

| Date      | Start Time | End Time | Air Temp (°C) | Water Temp (°C) | Anura Tadpoles | Caudata Tadpoles | Adult Anura    | Adult Caudata | Egg Masses              |
|-----------|------------|----------|---------------|-----------------|----------------|------------------|----------------|---------------|-------------------------|
| 5/30/2002 | 13:15      | 14:30    | 21.5          | 18.8            | 1              | 0                | 0              | 0             | 3 Unknown               |
| 6/25/2002 | 10:45      | 11:26    | 22.5          | 18.5            | 1              | 2                | 1 R. sylvatica | 0             | 1 Green, Clear, Various |
| 7/16/2002 | 13:14      | 13:48    | 26.9          | 21.8            | 0              | 1                | 0              | 0             | 0                       |

**Quantitative Data for V.P. 6**

| 5/30/2002 12:55          | Average      |        |
|--------------------------|--------------|--------|
| Air Temp (°C)            | 23.400       | 6.400  |
| Water Temp (°C)          | 19.000       | 31.700 |
| pH                       | 6.400        | 10.820 |
| Conductivity (µS/cm)     | 38.100       |        |
| Dissolved Oxygen (mg/L)  | 25.100       |        |
| Water Color              | 33.900       |        |
| Water Turbidity          | 12.900       |        |
| Fish                     | 9.800        |        |
| Primary Substrate        | Stained      |        |
| Emergent Vegetation (%)  | Clear        |        |
| Shore to Forest Edge (m) | None Present |        |
|                          | Silt and Mud |        |
|                          | > 50 %       |        |
|                          | 0            |        |

| 7/16/2002 13:00          |           |  |
|--------------------------|-----------|--|
| Air Temp (°C)            | DESSICANT |  |
| Water Temp (°C)          | DESSICANT |  |
| pH                       | DESSICANT |  |
| Conductivity (µS/cm)     | DESSICANT |  |
| Dissolved Oxygen (mg/L)  | DESSICANT |  |
| Water Color              | DESSICANT |  |
| Water Turbidity          | DESSICANT |  |
| Fish                     | DESSICANT |  |
| Primary Substrate        | DESSICANT |  |
| Emergent Vegetation (%)  | DESSICANT |  |
| Shore to Forest Edge (m) | DESSICANT |  |

|                 | Grid | North   | East   |
|-----------------|------|---------|--------|
| UTM Coordinates | 16T  | 5125120 | 302682 |
| Elevation (ft)  | 1816 |         |        |

|               | 5/30/2002 | 7/16/2002 |
|---------------|-----------|-----------|
| Max Depth (m) | 0.29      | DESSICANT |

**Sampling Data**

| Date      | Start Time | End Time  | Air Temp (°C) | Water Temp (°C) | Anura Tadpoles | Caudata Tadpoles | Adult Anura    | Adult Caudata | Egg Masses |
|-----------|------------|-----------|---------------|-----------------|----------------|------------------|----------------|---------------|------------|
| 5/30/2002 | 13:07      | 14:40     | 23            | 19              | 1              | 1                | 2 R. sylvatica | 0             | 0          |
| 6/25/2002 | 11:38      | 12:19     | 24            | 22              | 0              | 0                | 0              | 0             | 0          |
| 7/16/2002 | DESSICANT  | DESSICANT | DESSICANT     | DESSICANT       | DESSICANT      | DESSICANT        | DESSICANT      | DESSICANT     | DESSICANT  |

Appendix B

ND-N1 Identification Data

| Date      | Family         | Genus     | Species   | Body Length (mm) | Tail Length (mm) | Total Length (mm) | Miscellaneous |
|-----------|----------------|-----------|-----------|------------------|------------------|-------------------|---------------|
| 6/24/2002 | Ambystomatidae | Ambystoma | maculatum |                  |                  | 22.4              |               |

ND-N2 Identification Data

| Date      | Family         | Genus      | Species    | Body Length (mm) | Tail Length (mm) | Total Length (mm) | Miscellaneous          |
|-----------|----------------|------------|------------|------------------|------------------|-------------------|------------------------|
| 6/2/2002  | Ranidae        | Rana       | sylvatica  | 6.8              | 10.1             | 16.9              |                        |
| 6/2/2002  | Ranidae        | Rana       | sylvatica  | 9.1              | 17.1             | 26.2              |                        |
| 6/2/2002  | Ranidae        | Rana       | sylvatica  | 8.4              | 15.7             | 24.1              | (part of tail missing) |
| 6/2/2002  | Ranidae        | Rana       | sylvatica  | 9.5              | 10               | 19.5              |                        |
| 6/24/2002 | Ambystomatidae | Ambystoma  | laterale   |                  |                  | 26.5              |                        |
| 6/24/2002 | Ambystomatidae | Ambystoma  | maculatum  |                  |                  | 13.3              |                        |
| 6/24/2002 | Ambystomatidae | Ambystoma  | maculatum  |                  |                  | 15.2              |                        |
| 6/24/2002 | Ambystomatidae | Ambystoma  | maculatum  |                  |                  | 13.3              | (part of tail missing) |
| 6/24/2002 | Ambystomatidae | Ambystoma  | maculatum  |                  |                  | 19.2              |                        |
| 6/24/2002 | Ambystomatidae | Ambystoma  | maculatum  |                  |                  | 12.7              | (part of tail missing) |
| 6/24/2002 | Ambystomatidae | Ambystoma  | maculatum  |                  |                  | 18.3              |                        |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 8.7              | 16.3             | 25                |                        |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 6                | 7.9              | 13.9              |                        |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 7.2              | 8.1              | 15.3              | (part of tail missing) |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 8.4              | 11.4             | 19.8              | (part of tail missing) |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 5.9              | 7.4              | 13.3              |                        |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 7.3              | 8.1              | 15.4              |                        |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 5.6              | 16.4             | 22                | (part of tail missing) |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 6.2              | 5.2              | 11.4              | (part of tail missing) |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 5.8              | 10.9             | 16.7              |                        |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 5.9              | 12               | 17.9              |                        |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 6.3              | 7.5              | 13.8              | (part of tail missing) |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 5.5              | 8                | 13.5              |                        |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 6.8              | 11.4             | 18.2              |                        |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 5.4              | 10.5             | 15.9              |                        |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 7                | 13.4             | 20.4              |                        |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 6.1              | 6.1              | 12.2              | (part of tail missing) |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 6.4              | 9.1              | 15.5              |                        |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 5.6              | 6.8              | 12.4              | (dead)                 |
| 6/24/2002 | Hylidae        | Hyla       | versicolor | 5.2              | 8.5              | 13.7              | (dead)                 |
| 6/24/2002 | Hylidae        | Hyla       | triseriata | 6.3              | 11.5             | 17.8              |                        |
| 6/24/2002 | Hylidae        | Pseudacris | crucifer   | 5.7              | 12.1             | 17.8              |                        |
| 6/24/2002 | Ranidae        | Rana       | sylvatica  | 14.4             | 23.2             | 37.6              |                        |
| 6/24/2002 | Ranidae        | Rana       | sylvatica  | 14.4             | 20.2             | 34.6              |                        |
| 6/24/2002 | Ranidae        | Rana       | sylvatica  | 14.6             | 27.1             | 41.7              |                        |
| 6/24/2002 | Ranidae        | Rana       | sylvatica  | 16.7             | 34.2             | 50.9              |                        |

**ND-N2 Identification Data (continued)**

| Date      | Family         | Genus      | Species    | Body Length (mm) | Tail Length (mm) | Total Length (mm) | Miscellaneous     |
|-----------|----------------|------------|------------|------------------|------------------|-------------------|-------------------|
| 6/24/2002 | Ranidae        | Rana       | sylvatica  | 15               | 24.2             | 39.2              |                   |
| 6/24/2002 | Ranidae        | Rana       | sylvatica  | 15.6             | 28.8             | 44.4              | Legs Present      |
| 6/24/2002 | Ranidae        | Rana       | sylvatica  | 14.3             | 24.5             | 38.8              | Legs Present      |
| 6/24/2002 | Ranidae        | Rana       | sylvatica  | 17.4             | 28.2             | 45.6              | Legs Present      |
| 7/15/2002 | Ambystomatidae | Ambystoma  | maculatum  |                  |                  | 30.5              | Legs Present      |
| 7/15/2002 | Ambystomatidae | Ambystoma  | maculatum  |                  |                  | 26.2              | Legs Present      |
| 7/15/2002 | Ambystomatidae | Ambystoma  | maculatum  |                  |                  | 30.8              | Legs Present      |
| 7/15/2002 | Ambystomatidae | Ambystoma  | maculatum  |                  |                  | 28.5              | Legs Present      |
| 7/15/2002 | Ambystomatidae | Ambystoma  | maculatum  |                  |                  | 30.4              | Legs Present      |
| 7/15/2002 | Ambystomatidae | Ambystoma  | maculatum  |                  |                  | 31.2              | Legs Present      |
| 7/15/2002 | Ambystomatidae | Ambystoma  | maculatum  |                  |                  | 20.7              | Legs Present      |
| 7/15/2002 | Ambystomatidae | Ambystoma  | maculatum  |                  |                  | 30.3              | Legs Present      |
| 7/15/2002 | Hylidae        | Pseudacris | triseriata | 9.6              | 17.8             | 27.4              | Hind Legs Present |
| 7/15/2002 | Hylidae        | Pseudacris | triseriata | 9.8              | 17.5             | 27.3              | Hind Legs Present |
| 7/15/2002 | Ranidae        | Rana       | clamitans  | 20.5             | 46.5             | 67                | Hind Legs Present |
| 7/15/2002 | Ranidae        | Rana       | sylvatica  | 17.3             | 35.7             | 53                | Hind Legs Present |

**ND-N3 Identification Data**

| Date      | Family  | Genus | Species   | Body Length (mm) | Tail Length (mm) | Total Length (mm) | Miscellaneous |
|-----------|---------|-------|-----------|------------------|------------------|-------------------|---------------|
| 6/2/2002  | Ranidae | Rana  | sylvatica | 7.5              | 12.6             | 20.1              |               |
| 7/15/2002 | Ranidae | Rana  | sylvatica | 21.3             | 40.4             | 61.7              |               |

**V.P.2 Identification Data**

| Date      | Family         | Genus     | Species   | Body Length (mm) | Tail Length (mm) | Total Length (mm) | Miscellaneous          |
|-----------|----------------|-----------|-----------|------------------|------------------|-------------------|------------------------|
| 6/25/2002 | Ambystomatidae | Ambystoma | laterale  |                  |                  | 31.8              |                        |
| 6/25/2002 | Ambystomatidae | Ambystoma | laterale  |                  |                  | 19.3              |                        |
| 6/25/2002 | Ambystomatidae | Ambystoma | maculatum |                  |                  | 19.6              |                        |
| 6/25/2002 | Ambystomatidae | Ambystoma | maculatum |                  |                  | 18.2              |                        |
| 6/25/2002 | Ambystomatidae | Ambystoma | maculatum |                  |                  | 14.1              |                        |
| 6/25/2002 | Ranidae        | Rana      | sylvatica | 16.7             | 28.9             | 45.6              | (part of tail missing) |
| 6/25/2002 | Ranidae        | Rana      | sylvatica | 15               | 18.8             | 33.8              |                        |
| 6/25/2002 | Ranidae        | Rana      | sylvatica | 15               | 23.9             | 38.9              |                        |
| 6/25/2002 | Ranidae        | Rana      | sylvatica | 13.1             | 16.8             | 29.9              |                        |
| 6/25/2002 | Ranidae        | Rana      | sylvatica | 13.1             | 28.1             | 41.2              |                        |
| 6/25/2002 | Ranidae        | Rana      | sylvatica | 12.5             | 20.7             | 33.2              | (part of tail missing) |
| 6/25/2002 | Ranidae        | Rana      | sylvatica | 13               | 21.8             | 34.8              |                        |
| 6/25/2002 | Ranidae        | Rana      | sylvatica | 11.8             | 20.5             | 32.3              |                        |
| 6/25/2002 | Ranidae        | Rana      | sylvatica | 12.5             | 17.9             | 30.4              |                        |
| 6/25/2002 | Ranidae        | Rana      | sylvatica | 12.6             | 26.6             | 39.2              |                        |
| 6/25/2002 | Ranidae        | Rana      | sylvatica | 16.9             | 29.8             | 46.7              |                        |
| 6/25/2002 | Ranidae        | Rana      | sylvatica | 14.6             | 25.6             | 40.2              |                        |

V.P. 2 Identification Data (continued)

| Date      | Family         | Genus     | Species    | Body Length (mm) | Tail Length (mm) | Total Length (mm) | Miscellaneous     |
|-----------|----------------|-----------|------------|------------------|------------------|-------------------|-------------------|
| 6/25/2002 | Ranidae        | Rana      | sylvatica  | 15               | 23.1             | 38.1              |                   |
| 6/25/2002 | Ranidae        | Rana      | sylvatica  | 13.6             | 20.7             | 34.3              |                   |
| 6/25/2002 | Ranidae        | Rana      | sylvatica  | 15.6             | 25.6             | 41.2              |                   |
| 6/25/2002 | Ranidae        | Rana      | sylvatica  | 12.4             | 21.5             | 33.9              |                   |
| 6/25/2002 | Ranidae        | Rana      | sylvatica  | 14.4             | 27.3             | 41.7              | Legs Present      |
| 7/16/2002 | Ambystomatidae | Ambystoma | laterale   |                  |                  | 37.3              |                   |
| 7/16/2002 | Ambystomatidae | Ambystoma | laterale   |                  |                  | 20.4              |                   |
| 7/16/2002 | Ambystomatidae | Ambystoma | maculatum  |                  |                  | 33                | Legs Present      |
| 7/16/2002 | Ambystomatidae | Ambystoma | maculatum  |                  |                  | 27.7              | Legs Present      |
| 7/16/2002 | Ambystomatidae | Ambystoma | maculatum  |                  |                  | 32.2              | Legs Present      |
| 7/16/2002 | Ambystomatidae | Ambystoma | maculatum  |                  |                  | 34.6              | Legs Present      |
| 7/16/2002 | Ambystomatidae | Ambystoma | maculatum  |                  |                  | 33.8              | Legs Present      |
| 7/16/2002 | Hylidae        | Hyla      | versicolor | 12.4             | 16.5             | 28.9              | Hind Legs Present |
| 7/16/2002 | Hylidae        | Hyla      | versicolor | 10.7             | 18.6             | 29.3              | Hind Legs Present |
| 7/16/2002 | Ranidae        | Rana      | sylvatica  | 18.8             | 34.9             | 53.7              | Hind Legs Present |
| 7/16/2002 | Ranidae        | Rana      | sylvatica  | 20.8             | 40.5             | 61.3              | Hind Legs Present |

V.P. 3 Identification Data

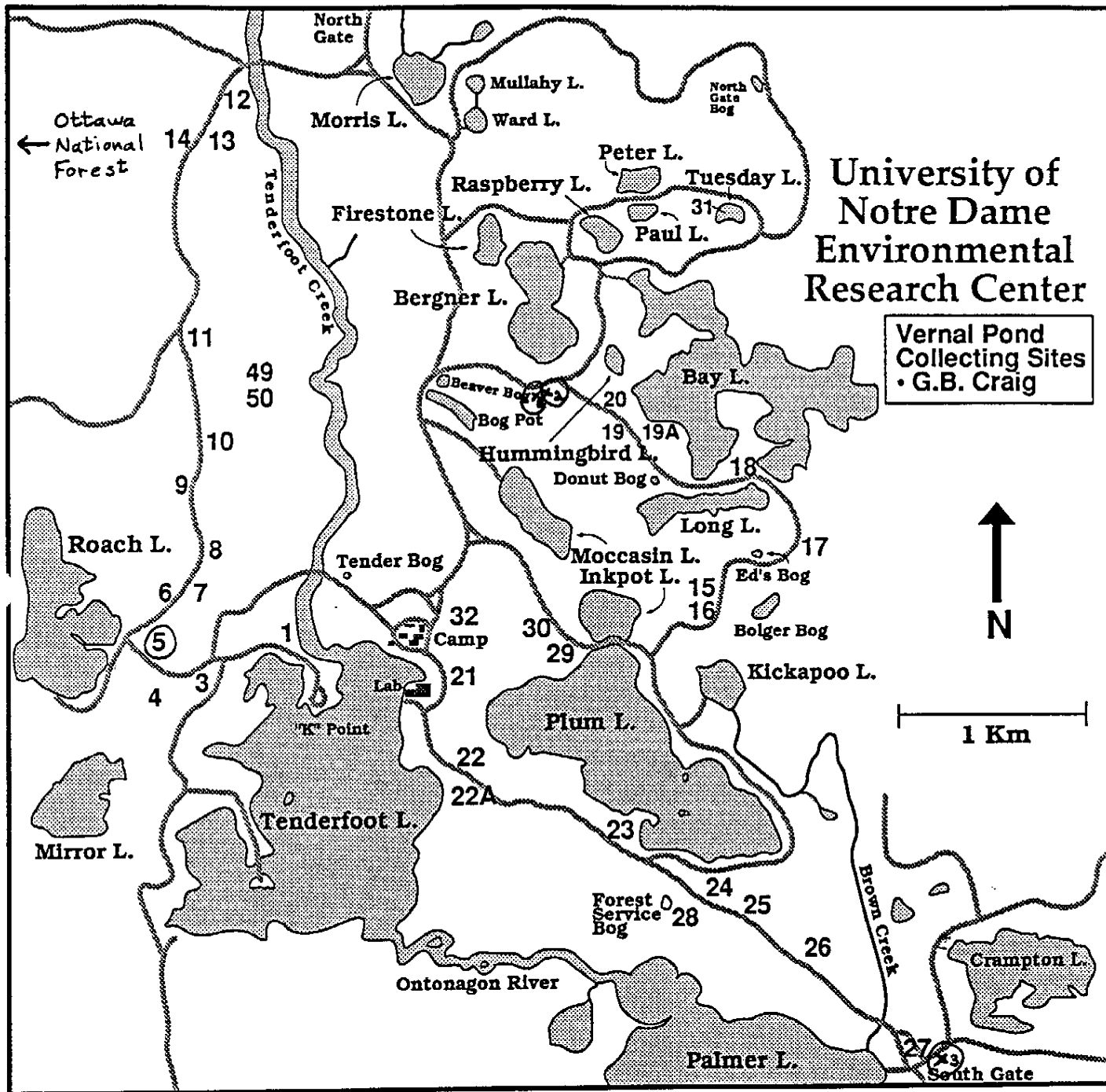
| Date      | Family         | Genus     | Species  | Body Length (mm) | Tail Length (mm) | Total Length (mm) | Miscellaneous |
|-----------|----------------|-----------|----------|------------------|------------------|-------------------|---------------|
| 6/25/2002 | Ambystomatidae | Ambystoma | laterale |                  |                  | 19.5              |               |
| 6/25/2002 | Ambystomatidae | Ambystoma | laterale |                  |                  | 27.7              |               |
| 6/25/2002 | Ambystomatidae | Ambystoma | laterale |                  |                  | 27.8              |               |
| 6/25/2002 | Ambystomatidae | Ambystoma | laterale |                  |                  | 20.3              |               |
| 6/25/2002 | Ambystomatidae | Ambystoma | laterale |                  |                  | 27.1              |               |
| 6/25/2002 | Ambystomatidae | Ambystoma | laterale |                  |                  | 23.1              |               |
| 6/25/2002 | Ambystomatidae | Ambystoma | laterale |                  |                  | 21.9              |               |
| 6/25/2002 | Ambystomatidae | Ambystoma | laterale |                  |                  | 24.0              |               |
| 6/25/2002 | Ambystomatidae | Ambystoma | laterale |                  |                  | 17.6              |               |
| 6/25/2002 | Ambystomatidae | Ambystoma | laterale |                  |                  | 20.5              |               |
| 6/25/2002 | Ambystomatidae | Ambystoma | unknown  |                  |                  | N/A               |               |

V.P. 5 Identification Data

| Date      | Family         | Genus     | Species            | Body Length (mm) | Tail Length (mm) | Total Length (mm) | Miscellaneous |
|-----------|----------------|-----------|--------------------|------------------|------------------|-------------------|---------------|
| 5/30/2002 | Ambystomatidae | Ambystoma | maculatum egg mass |                  |                  |                   | (~25 hatched) |
| 5/30/2002 | Ambystomatidae | Ambystoma | maculatum egg mass |                  |                  |                   | (~30 hatched) |
| 6/25/2002 | Ambystomatidae | Ambystoma | maculatum          |                  |                  | 15.2              |               |
| 6/25/2002 | Ambystomatidae | Ambystoma | maculatum          |                  |                  | 21.6              |               |
| 7/16/2002 | Ambystomatidae | Ambystoma | maculatum          |                  |                  | 36                |               |

V.P. 6 Identification Data

| Date      | Family         | Genus     | Species   | Body Length (mm) | Tail Length (mm) | Total Length (mm) | Miscellaneous |
|-----------|----------------|-----------|-----------|------------------|------------------|-------------------|---------------|
| 5/30/2002 | Ambystomatidae | Ambystoma | unknown   |                  |                  |                   |               |
| 5/30/2002 | Ranidae        | Rana      | sylvatica |                  |                  |                   |               |



|  |                                   |         |
|--|-----------------------------------|---------|
| (X <sub>1</sub> ) - ND-N1                          | Ottawa National Forest            | - OTT-2 |
| (X <sub>2</sub> ) - ND-N2                          | (To the west of UNDERC property.) | OTT-3   |
| (X <sub>3</sub> ) - ND-N3                          |                                   | OTT-5   |
| (5) - Preliminary adult amphibian collection site. |                                   | OTT-6   |

34 (1 Km.)

↑  
N

Appendix D

**Table 1** Amphibian size range for each species by site .

***Ambystomatidae Ambystoma maculatum***

| Location | Date                        |                  |                  |
|----------|-----------------------------|------------------|------------------|
|          | May 30, 2002 - June 2, 2002 | June 24-25, 2002 | July 15-16, 2002 |
| ND-N1    | --                          | 22.4 (mm)        | --               |
| ND-N2    | --                          | 12.7-19.2        | 20.7-31.2 (mm)   |
| ND-N3    | --                          | --               | --               |
| OTT-2    | --                          | 14.1-19.6        | 27.7-34.6        |
| OTT-3    | --                          | --               | --               |
| OTT-5    | *                           | 15.2-21.6        | 36.0             |
| OTT-6    | --                          | --               | --               |

\* Two egg masses of ~25 and ~30 hatchlings

***Ambystomatidae Ambystoma laterale***

| Location | Date                        |                  |                  |
|----------|-----------------------------|------------------|------------------|
|          | May 30, 2002 - June 2, 2002 | June 24-25, 2002 | July 15-16, 2002 |
| ND-N1    | --                          | --               | --               |
| ND-N2    | --                          | 26.5 (mm)        | --               |
| ND-N3    | --                          | --               | --               |
| OTT-2    | --                          | 19.3-31.8        | 20.4-37.3 (mm)   |
| OTT-3    | --                          | 17.6-27.8        | --               |
| OTT-5    | --                          | --               | --               |
| OTT-6    | --                          | --               | --               |

***Ranidae Rana sylvatica***

| Location | Date                        |                  |                  |
|----------|-----------------------------|------------------|------------------|
|          | May 30, 2002 - June 2, 2002 | June 24-25, 2002 | July 15-16, 2002 |
| ND-N1    | --                          | --               | --               |
| ND-N2    | 16.9-26.2 (mm)              | 34.6-50.9 (mm)   | 53 (mm)          |
| ND-N3    | 20.1                        | --               | 61.7             |
| OTT-2    | --                          | 29.9-46.7        | 53.7-61.3        |
| OTT-3    | --                          | --               | --               |
| OTT-5    | --                          | --               | --               |
| OTT-6    | --                          | --               | --               |

***Ranidae Rana clamitans***

| Location | Date                        |                  |                  |
|----------|-----------------------------|------------------|------------------|
|          | May 30, 2002 - June 2, 2002 | June 24-25, 2002 | July 15-16, 2002 |
| ND-N1    | --                          | --               | --               |
| ND-N2    | --                          | --               | 67.0 (mm)        |
| ND-N3    | --                          | --               | --               |
| OTT-2    | --                          | --               | --               |
| OTT-3    | --                          | --               | --               |
| OTT-5    | --                          | --               | --               |
| OTT-6    | --                          | --               | --               |

***Hylidae Hyla versicolor***

| Location | Date                        |                  |                  |
|----------|-----------------------------|------------------|------------------|
|          | May 30, 2002 - June 2, 2002 | June 24-25, 2002 | July 15-16, 2002 |
| ND-N1    | --                          | --               | --               |
| ND-N2    | --                          | 11.4-25.0 (mm)   | --               |
| ND-N3    | --                          | --               | --               |
| OTT-2    | --                          | --               | 28.9-29.3 (mm)   |
| OTT-3    | --                          | --               | --               |
| OTT-5    | --                          | --               | --               |
| OTT-6    | --                          | --               | --               |

***Hylidae Pseudacris triseriata***

| Location | Date                        |                  |                  |
|----------|-----------------------------|------------------|------------------|
|          | May 30, 2002 - June 2, 2002 | June 24-25, 2002 | July 15-16, 2002 |
| ND-N1    | --                          | --               | --               |
| ND-N2    | --                          | 17.8 (mm)        | 27.3-27.4 (mm)   |
| ND-N3    | --                          | --               | --               |
| OTT-2    | --                          | --               | --               |
| OTT-3    | --                          | --               | --               |
| OTT-5    | --                          | --               | --               |
| OTT-6    | --                          | --               | --               |

***Hylidae Pseudacris crucifer***

| Location | Date                        |                  |                  |
|----------|-----------------------------|------------------|------------------|
|          | May 30, 2002 - June 2, 2002 | June 24-25, 2002 | July 15-16, 2002 |
| ND-N1    | --                          | --               | --               |
| ND-N2    | --                          | 17.8 (mm)        | --               |
| ND-N3    | --                          | --               | --               |
| OTT-2    | --                          | --               | --               |
| OTT-3    | --                          | --               | --               |
| OTT-5    | --                          | --               | --               |
| OTT-6    | --                          | --               | --               |

**Table 2** Amphibian species total at each site

| Species                                   | Site  |       |       |      |      |      |      |
|---|-------|-------|-------|------|------|------|------|
|   | ND-N1 | ND-N2 | ND-N3 | OTT2 | OTT3 | OTT5 | OTT6 |
| <i>Ambystomatidae Ambystoma laterale</i>  | 0     | 1     | 0     | 4    | 11*  | 0    | 1*   |
| <i>Ambystomatidae Ambystoma maculatum</i> | 1     | 14    | 0     | 8    | 0*   | 5**  | 0*   |
| <i>Hylidae Hyla versicolor</i>            | 0     | 19    | 0     | 2    | 0    | 0    | 0    |
| <i>Hylidae Pseudacris crucifer</i>        | 0     | 1     | 0     | 0    | 0    | 0    | 0    |
| <i>Hylidae Pseudacris triseriata</i>      | 0     | 3     | 0     | 0    | 0    | 0    | 0    |
| <i>Ranidae Rana clamitans</i>             | 0     | 1     | 0     | 0    | 0    | 0    | 0    |
| <i>Ranidae Rana sylvatica</i>             | 0     | 13    | 2     | 19   | 0    | 0    | 1    |

\* One *Ambystoma* species is unknown and could be either *laterale* or *maculatum*

\*\* Two *Ambystoma maculatum* egg masses included as individual counts