MACROINVERTEBRATE SURVEY
of
25 SOFT WATER-pH SENSITIVE LAKES
in
VERMONT

Presented as part of the
Vermont Acid Precipitation Program
Long-Term Lake Monitoring

by

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INTRODUCTION

Over the last decade increasing concern over the deleterious effects of acid precipitation on the aquatic biota has developed. Scientific research has shown that poorly buffered aquatic systems are susceptible to rapid pH drops during spring snow melts and long term pH declines as calcium ions and other watershed buffers are reduced by incoming H+ ions (Burnham and Clarkson, 1983; Haines and Akielaszek, 1983; Schofield, 1976). It has also been shown that as pH declines below 5.5 and the biologically important calcium ions become less available, the aquatic biota of all trophic levels are directly or indirectly altered (Beamish 1974b; Roff and Kwaitkowski 1976; Raddum and Saether 1981; Okland and Okland 1980; Collins et al 1981). Several reports have indicated a decrease in benthic taxa richness and shifts in taxa composition found in acid lakes when compared to more alkaline lakes (Weiderholm and Eriksson 1977; Roff and Kwaitkowski 1977; Raddum and Saether 1981; Uutala 1981).

J. Okland and K. Okland have reported that depleted calcium levels in acidified lakes have influenced the distribution of Gastropods, mussels, and other fish food organisms in Norway (J. Okland 1980; K. Okland 1980; Okland and Okland 1980). D. F. Malley (1980) showed that crayfish kept in low pH water of 5.75 had difficulty extracting calcium for their exoskeltons during molts, and that uptake ceased altogether at pH 4.00. Several species of dragonflies, stoneflies, caddisflies, and mayflies were laboratory tested for pH tolerances by Bell (1971). A caddisfly was found to be the most tolerant to low pH and a mayfly to be the least tolerant, with 30-day LC50 values of pH 2.45 and 5.38 respectively. In this study, as well as a 1970 study of the life cycle of the midge Tanytarsus dissimilis, Bell found the period of emergence to be the most sensitive of the life cycle (Bell, 1971, 1970).

Starting in the winter of 1979/1980, the Vermont Department of Environmental Conservation began a chemical survey of lakes located in potentially sensitive watersheds. By 1982, 184 lakes had been surveyed. From this preliminary screening, 36 of the lakes thought to be the most sensitive to acidification were chosen to be chemically monitored on a long-term basis. This report will present both qualitative and semi-quantitative findings of the benthic fauna of 25 of those 36 lakes. The benthic macroinvertebrate data presented here was collected during the period 1981-1983; in conjunction with the State's long-term chemical monitoring program. Baseline data on the fish, plankton and macrophyte communities of most of the 36 long-term chemical survey lakes was concurrently gathered. These data bases will be utilized to assess the long-term environmental effects of "acid deposition" on these lakes.

MATERIALS AND METHODS

Qualitative data was collected over a three year period from 1981-1983. All lakes were sampled qualitatively for a period of at least one hour in the spring, summer, and fall. Collecting was done with a large D-frame sweep net, stiff strainers, and forceps. Specimens were immediately preserved in 75% ethanol. In the laboratory, samples were washed of alcohol through a #30 sieve, picked, sorted, and identified to the lowest possible taxon. Efforts were made to seek out and sample all littoral habitat types at each lake. With this as a goal, the following habitat classifications were used: silt-muck, sand, gravel-cobble-rock, organic detritus (leaves), logs, and submergent and emergent vegetation. The specific sampling sites and habitat types were recorded on field sheets for each lake.

The semi-quantitative (Ekman dredge) data was collected through the ice during the winter of 1982-1983. All stations were located in the sub-littoral zone of each lake (2.0-4.5m depth). This zone was sampled because it should yield the greatest number of species, the most valued fish food organisms, is less influenced by other natural limiting factors than the profundal zone (i.e. dissolved oxygen), and was a zone common to all the lakes. Duplicate Ekman dredge samples (232 sq. cm.) were collected from three stations at each lake totaling to six replicate samples per lake. All samples were sieved on site through a #30 sieve and preserved in 8:1 formalin spiked with Phloxine B dye to allow for easier sorting. In the laboratory the samples were washed of formalin through a #30 sieve and emptied into a white enamel tray from which all organisms were picked, sorted, and identified to the lowest possible taxon.

All chemical data in this report is from the Department of Environmental Conservation long-term lake monitoring program. All chemical values cited here are the medians from five sampling dates over a one year period (1982 or 1983) for each lake. The methodology used for all chemical sampling and analyses can be found in the "Vermont Acid Precipitation Program Long-Term Lake Monitoring Program 1983" report. The chemical parameter values for each individual sampling date are also presented in this report.

RESULTS - QUALITATIVE

A complete taxa list for all the lakes, along with each lakes median pH and alkalinity value is presented in Appendix 1. This list includes all the taxa found in these lakes over a three year period as well as those taken with Ekman dredges during the winter of 1982-1983.

Table 1 lists by lake, in order of descending pH, the number of invertebrate taxa found within order/family groups. This table reveals that the two invertebrate groups most sensitive to low pH and assosciated chemistry are the Crustacea + Mollusca and Ephemeroptera. The order Hemiptera and Coleoptera appear to increase slightly in taxa richness with declining pH. The taxa richness of Trichoptera, Odonata, and Chironomidae, as well as the total number of invertebrate taxa, show no apparent relationship to pH.

The taxa richness of both the Crustacea + Mollusca group and the order Ephemeroptera decreases significantly as lake pH declines from 7.00 to below 5.00 and calcium levels decline from 3.0 to below 1.0 mg/l (Figures 1 and 2). Neither group could be found in Haystack Pond, a clearwater lake with a pH of 4.66 and calcium level of 0.90 mg/l.

Only two Gastropod taxa were found in lakes with pH below 6.00. These were the taxa Fossaria sp. (pH 5.61) and Ferrissia sp. (pH 4.75). No other Gastropods were found in lakes with a median pH below 6.00 and calcium levels below 1.5 mg/l. Only one fingernail clam taxon was found to tolerate similar conditions; Pisidium sp. was found in Branch Pond, a colored lake with a pH of 4.66 and a calcium level of 0.86 mg/l.

The Crustacea group contains very few taxa that are able to tolerate conditions of low pH and alkalinity with the Decapoda appearing to be the most intolerant. Decapods were found in only two lakes, Little Rock Pond and Sucker Pond, both with pH's well above 6.00 and calcium levels above 2.0 mg/l. In both lakes their populations, though not quantified, appear to be strong and would be considered a common species. The Amphipoda were represented by two taxa, Hyalella azteca and Crangonyx richmondensis. The larger C. richmondensis appeared to inhabit the colored lakes with pH below 6.00. Neither taxa was found below pH 5.00 with H. azteca not found below pH 5.18. The order Isopoda occurred only in Little Pond (Woodford) with a pH of 5.08 and calcium level of 1.2 mg/l. The order was represented by the taxon Asellus racovitzai and was very abundant in Little Pond, being observed on all sampling visits. No amphipods were found in Little Pond.

TABLE 1: SOME CHEMICAL PARAMETERS, THE NUMBERS OF INVERTEBRATE TAXA BY GROUP, AND THE TOTAL NUMBER OF TAXA IN 25 ACID SENSITIVE LAKES

	pH	Alk. mg/l	Calcium mg/l	Total Dis. Alum. mg/l	Crustacea & Mollusca	Ephemeroptera	Trichoptera	Odonata	Chiroromidae	Hemiptera	Coleoptera	Other	TOTAL TAXA
Little Rock	6.68	6.68	2.8	.120	5	6	16	12	17	4	2	5	67
Ninevah	6.75	3.27	2.3	.030	7	3	7	4	14	1	2	6	44
* Sucker	6.69	3.90	2.2	.060	5	6	10	4	18	3	4	5	55
* Kettle	6.55	4.08	2.8	.030	5	6	3	6	12	1	4	5	42
Cole	6.31	2.16	1.9	.040	2	3	4	11	13	1	2	5	41
South	6.20	1.30	1.8	.065	2	3	6	5	9	1	2	5	33
Sunset	6.14	.77	1.5	.040	3	6	10	15	18	3	6	5	66
Lily	6.14	2.12	1.5	.040	7	3	6	16	16	1	6	4	59
Stratton	6.10	1.37	1.4	.060	4	7	9	8	6	1	2	6	43
Grout	5.99	1.10	1.5	.040	2	4	16	4	19	1	0	5	51
* Unknown	5.94	1.38	1.9	.220	1	3	4	7	10	0	0	4	29
* Little (Win)	5.86	1.71	1.4	.070	3	2	5	7	10	4	4	5	40
Hardwood	5.78	1.39	1.8	.070	2	3	5	10	15	2	1	7	45
* Griffith	5.69	1.44	2.1	.200	2	6	5	7	13	1	0	4	38
* Howe	5.61	1.89	2.0	.200	3	2	11	3	17	4	4	6	50
Stamford	5.51	.52	1.4	.190	2	3	7	5	13	4	1	4	39
* Levi	5.18	.15	1.6	.150	3	2	5	11	14	5	3	5	48
* Moses	5.15	.25	1.0	.200	0	1	4	6	12	3	3	3	32
Little (Wood)	5.08	-.11	1.2	.180	2	2	7	10	20	4	6	6	56
* Big Mud	5.03	-.07	2.1	.370	1	1	7	6	13	5	3	5	41
* Bourn	4.96	-.27	.89	.160	1	2	13	11	21	5	6	4	63
* Beebe	4.86	-.42	1.0	.350	1	2	10	7	8	2	4	3	37
Forester	4.75	-.58	1.0	.200	1	1	8	10	13	3	3	5	44
* Branch	4.66	-.83	.86	.260	1	1	6	9	17	4	4	4	46
Haystack	4.66	-.71	.9	.200	0	0	7	7	11	2	4	4	35

* True color >30 pt-co units

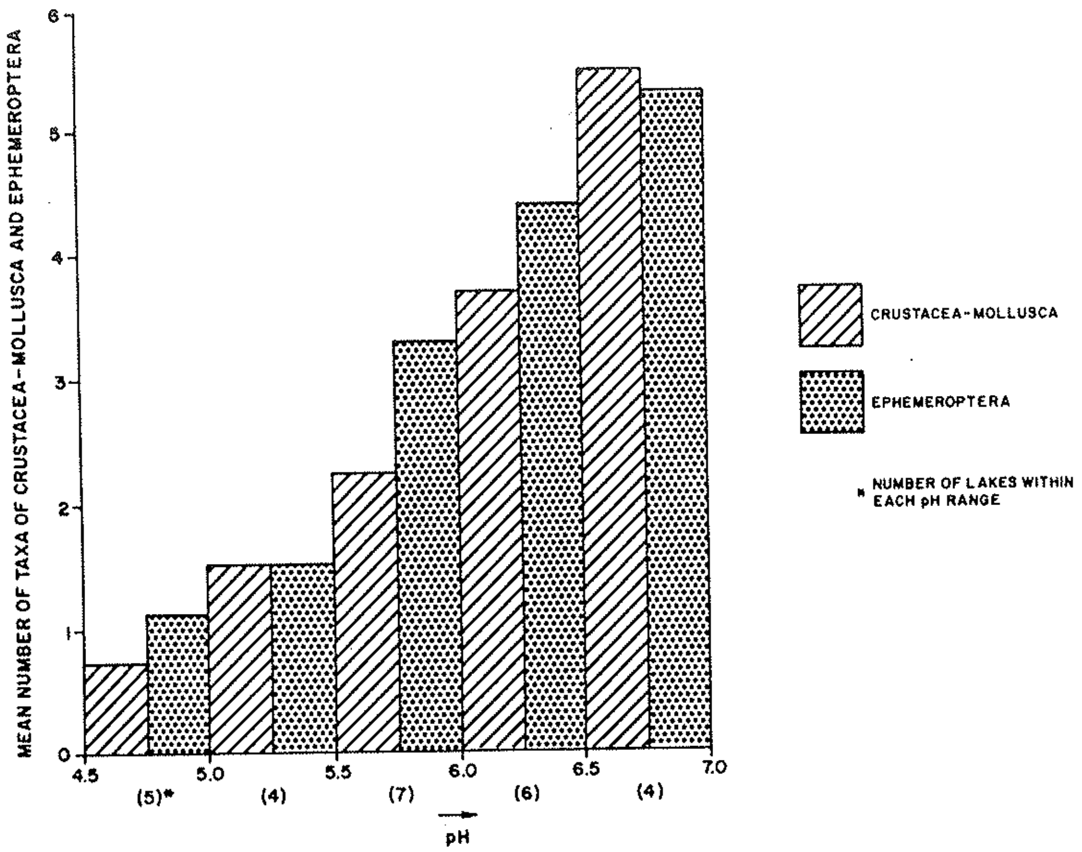

FIGURE I SHOWING THE MEAN NUMBER OF CRUSTACEA-MOLLUSCA AND EPHEMEROPTERA TAXA FOUND IN THE GROUPS OF LAKES WITHIN A pH RANGE

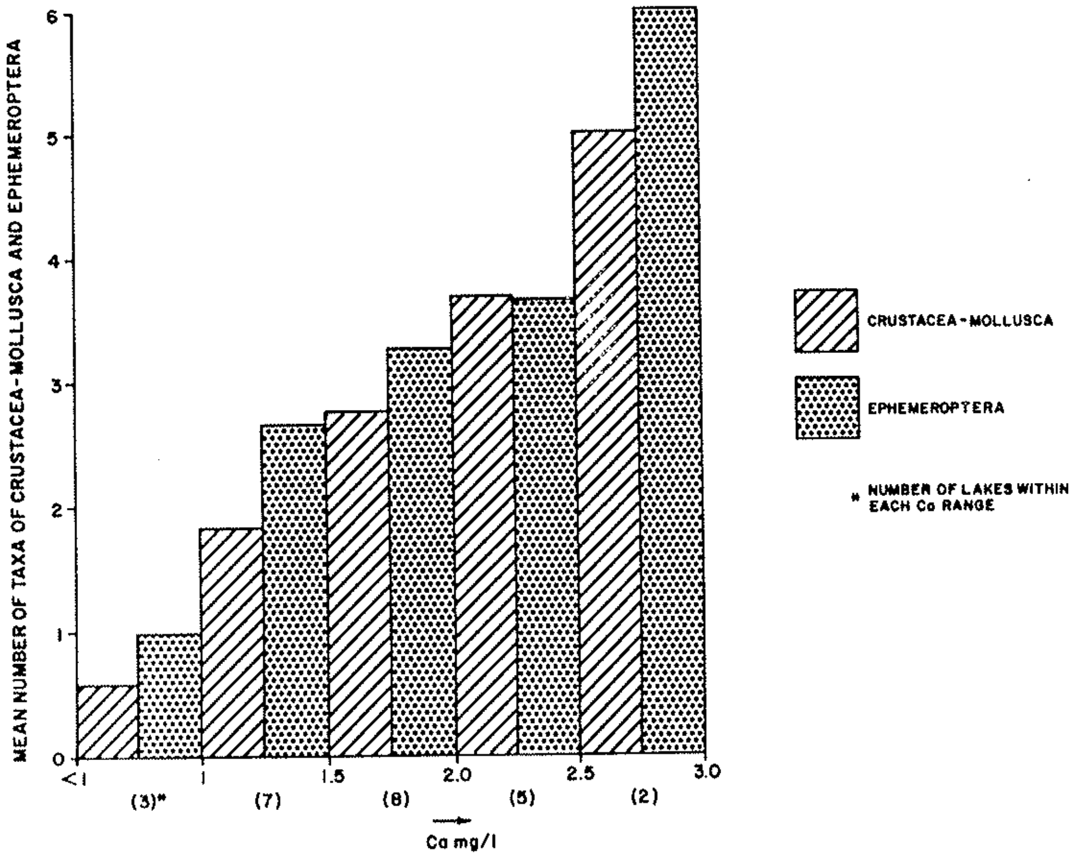

FIGURE 2 SHOWING THE MEAN NUMBER OF CRUSTACEA-MOLLUSCA AND EPHEMEROPTERA TAXA FOUND IN THE GROUPS OF LAKES WITHIN A Ca RANGE

The Ephemeroptera (mayflies) were present in every lake except Haystack Pond. The most common taxon was Paraleptophlebia sp., occurring in 22 of the 26 lakes. Other common taxa were Eurylophella temporalis, Stenacron interpunctatum, Caenis sp., and Hexagenia limbata, occurring in 16, 12, 9, and 8 of the lakes respectively. Of these common taxa, Paraleptophlebia sp., Eurylophella temporalis, and Caenis sp. were the most tolerant, occurring in lakes with pH's of 4.66, 4.66, and 4.75 respectively. Stenacron interpunctatum and Hexagenia limbata appear to be slightly less tolerant, occurring in lakes with pH's of 5.18 and 4.96 respectively.

The apparent direct relationship between the taxa richness of the macroinvertebrate groups (from Table 1 mentioned above) to pH, alkalinity, calcium and dissolved aluminum (DAl) is borne out by strong statistical correlations being found between them (Table 2). The taxa richness data was log-transformed using the formula log (x+1) before running the correlations. This was done to normalize the data base and because based on the literature the resulting log curve would better simulate the expected biological response to pH toxicity. The resulting correlations between pH and the Crustacea-Mollusca (R2 = 0.80) and the Ephemeroptera (R2 = 0.79) at p<.01 for both correlations; indicates that lake pH is a limiting factor for these taxa. Crustacea-Mollusca and Ephemeroptera taxa number also correlated well with alkalinity, calcium, and dissolved aluminum. This indicates that pH may only be one factor of several limiting chemical parameters, which act synergistically in creating a toxic and/or chemically limiting aquatic habitat for these groups.

The lake data set was divided into clear lakes, color < 30, and colored or dystrophic lakes, color > 30. The results indicate that the amount of color (dissolved organic carbon) in a lake tends to modify and lessen the impact that low pH, alkalinity, calcium, and high dissolved aluminum have on the benthic fauna (Table 2). The correlation between the Crustacea-Mollusca taxa and pH increased in the clear lake data set to R2 = 0.86 (p<0.001) and became insignificant (R2 = 0.37) in the colored lake data set. This dramatic dichotomy between the clear and colored lake data sets was also very pronounced with the correlations between dissolved aluminum and Crustacea-Mollusca taxa (clear R2 = -0.72, p<0.01; colored R2 = -0.34, p>0.10) and Ephemeroptera taxa (clear R2 = -0.65, p<.01; colored R2 = -0.40, p>0.10). This trend was also evident, to a lesser extent, with the parameters of alkalinity and calcium.

TABLE II: CORRELATION MATRIX OF MAJOR CHEMICAL PARAMETERS ON SENSITIVE TAXA

	pH			ALKALINITY			CALCIUM			DISSOLVED ALUMINUM		
	Cl[1]	All[2]	Co[3]	Cl	All	Co	Cl	All	Co	Cl	All	Co
LOG (1+ Crustacea, Mollusca)	0.86***	0.80**	0.37	0.75**	0.74**	0.46	0.69**	0.65**	0.55	-0.72**	-0.65**	-0.34
LOG (1+ Ephemeroptera)	0.80***	0.797**	0.70**	0.63*	0.67**	0.65*	0.64**	0.61**	0.49	-0.65**	-0.58**	-0.40
HEMIPTERA	-0.31	-0.475*	-0.64*	-0.02	-0.23	-0.5	-0.15	-0.23	-0.25	0.59*	0.41*	0.08
COLEOPTERA	-0.17	-0.24	-0.77**	-0.14	-0.18	-0.63	-0.17	-0.33	-0.65*	0.02	0.016	0.20

[1] Cl 15 clear lakes (co-pt ≤ 30)

[2] All 25 lakes clear and colored

[3] Co 10 colored lakes (co-pt > 30)

*** significant at the .001 level

** significant at the .01 level

* significant at the .05 level

The orders Hemiptera and Coleoptera reacted in the opposite manner. Hemiptera taxa number and pH showed a negative correlation in the total lake data set (R2 = -0.47, $p<.05$) and the colored lake data set (R2 = -0.64, $p<.05$), but no significant correlation in the clear lake data set. Coleoptera taxa numbers showed a strong negative correlation with pH only in the colored lake data set (R2 = -0.77, $p<.01$).

Multiple regressions were generated for the log-transformed taxa numbers with combinations of the four primary chemical parameters (pH, Alk, Ca, Al). Table 3 contains the results for the Crustacea-Mollusca taxa partitioned into clear, colored, and total lake data sets. The analysis indicates that pH explains 75% and 64% of the variation of the Crustacea-Mollusca taxa present in the clear and total lake data sets respectively. When all four major chemical parameters are regressed on the number of taxa, there is only a slight increase in the explained variation in the clear lake (78%) and total lake (66%) data sets. In the colored lake data set, pH alone accounted for very little of the variation in taxa number. When combined with calcium and dissolved aluminum, however, 52% of the variation is accounted for.

Stepwise multiple regressions of pH on Ephemeroptera taxa indicate that 65% and 64% of the taxa variability in the clear lake and total lake data sets respectively is explained by pH alone (Table 4). In the colored lake data set, only 50% of the variation is explained by pH alone. The addition of the other major chemical parameters to the regression has virtually no effect on the explained variability in taxa numbers, indicating that pH is a critical limiting factor to the distribution of Ephemeroptera taxa.

RESULTS - SEMI-QUANTITATIVE

The raw numbers of individuals found in duplicate Ekman dredge samples taken at three stations on the 25 study lakes appear in Appendix 2. These numbers should not be considered precise density estimates due to the large standard deviations found in the data set. They are useful, however, for inter-lake comparisons of relative abundance, percent composition, and in defining how frequently a taxa group occurs in a lake.

TABLE III: MULTIPLE CORRELATION COEFFICIENTS (R^2) OF SELECTED CHEMICAL PARAMETERS ON LOG (# CRUSTACEA AND MOLLUSCA TAXA +1)

	R^2 VALUE		
	CLEAR (n=15)	ALL (n=25)	COLORED (n=10)
pH	0.751	0.643	0.14
pH, Ca	0.756	0.645	0.309
pH, Ca, DAl	0.759	0.658	0.52
pH, Alk, Ca, DAl	0.784	0.663	0.557
pH, DAl	0.751	0.646	0.171

TABLE IV: MULTIPLE CORRELATION COEFFICIENTS (R^2) OF SELECTED CHEMICAL PARAMETERS ON LOG (# EPHEMEROPTERA TAXA +1)

	R^2 VALUE		
	CLEAR (n=15)	ALL (n=25)	COLORED (n=10)
pH	0.653	0.635	0.50
pH, Alk	0.659	0.637	0.503
pH, Alk, DAl	0.671	0.642	0.507
pH, Alk, DAl, Ca	0.673	0.642	0.507

TABLE VI: THE OCCURRENCE OF "pH SENSITIVE TAXA" FROM A TOTAL OF 6 EKMAN DREDGE SAMPLES TAKEN PER LAKE IN THE WINTER OF 1982-1983

(# of dredge samples in which taxon occurred - total of 6 dredge samples)

LAKE	AMPHIPODA	GASTROPODA	PISIDIUM	EPHEMEROPTERA
Little Rock Pond	2			5
Lake Ninevah		2	3	
Kettle Pond		1	2	3
Sucker Pond		6	6	5
Grout Pond	4	1	1	1
South Pond	1			3
Cole Pond			1	
Sunset Lake			1	4
Stratton Pond				
Lily Pond	6	4		
Little Pond (Win.)				
Hardwood Pond				
Unknown Pond			1	
Griffith Lake				
Howe Pond				
Stamford Pond				6
Bourn Pond				
Little Pond (Wood.)				4
Levi Pond				1
Beebe Pond				1
Moses Pond				
Forester Pond				5
Branch Pond				
Big Mud Pond				
Haystack Pond				

TABLE VII: PERCENT COMPOSITION OF ALL TAXA GROUPS FOUND IN EKMAN DREDGE SAMPLES TAKEN IN THE WINTER OF 1982-1983 FROM 25 ACID SENSITIVE LAKES

(Based on the mean number of individuals from six Ekman dredge samples)

	Chironomidae	Copepoda	Ceratopogonidae	*Pisidium* sp.	*Chaoborus* sp.	Oligocheata	*Hyalella azteca*	*Hexagenia* sp.	Odonata	*Sialis* sp.	MEAN TOTAL #/DREDGE
Little Rock Pond	72				7.1	10.7					84.2
Lake Ninevah	44				36.4	13.2					75.9
Kettle Pond	87			5.4							18.4
Sucker Pond	67		5.0	21.5							634.8
Grout Pond	79		8.6								84.5
South Pond	94										10.2
Cole Pond	98										86.7
Sunset Lake	50		31.0					8.6			26.7
Stratton Pond	85					14.2					7.0
Lily Pond	64					6.6	17.6				69.9
Little (Win.)	60				18.4	20.9					111.6
Hardwood Pond	64				21.9	8.1					82.3
Unknown Pond	12				78.9	7.0					18.5
Griffith Lake	72				14.5	13.0					20.7
Howe Pond	84										51.1
Stamford Pond	81	19.2									138.8
Bourn Pond	54				14.5	30.6					18.6
Little (Wood.)	72					6.5			17.3		61.6
Levi Pond	92					4.6					107.1
Beebe Pond	94										19.8
Moses Pond	95										102.0
Forester Pond	84					8.5					933.1
Branch Pond	86					10.6					19.7
Big Mud Pond	79				9.1						73.3
Haystack Pond	75		10.5							5.1	25.6

The percent composition data for the Chironomidae only is presented in Table 8. Tanytarsus sp. and Procladius sp. appeared most frequently as the dominant taxa (18 and 22 lakes respectively). Both taxa were dominant in the highest and lowest pH lakes. Of the 14 dominant Chironomidae taxa, only three - Microtendipes sp., Cladotanytarsus sp., and Micropsectra sp. - appeared to be pH intolerant, dropping out of the dominant taxa at pH 5.50. Based on the criteria of greater than 20% in at least two lakes with a pH below 5.50, the following taxa appear to be somewhat acidobiontic: Chironomus spp., Heterotanytarsus sp., Psectrocladius spp., Heterotrissocladius sp., Procladius spp., and Zalutschia sp.

DISCUSSION

The qualitative findings from the 26 lakes are in accord with the findings of similar synoptic surveys (Hendry and Wright, 1976; Kelso et al, 1982; Okland, 1980) in that the most sensitive taxa to low pH-alkalinity waters are the Crustacea, Mollusca, and Ephemeroptera. The semi-quantitative data supported these same findings with the relative abundance and commonness of the sensitive taxa decreasing in low pH lakes and certain tolerant taxa becoming more dominant. Neither data set revealed any relationship between pH and the overall taxa richness, diversity, or relative abundance of individuals of a lake.

Both J. Okland and K. Okland (1980,1982) studied the distribution of snails (Gastropoda) and fingernail clams (Sphaeriidae) from 1,000 lakes in Norway and found that a pH of 6.00 was critical to both taxa, which supports the findings from the 26 lakes studied here. In addition, these same researchers indicated that the effects of low pH may be lessened if calcium levels are elevated. Size limitations of the Vermont data set (26 lakes, calcium range 0.86-2.8 mg/l) precluded analysis for a similar effect. Data from colored (color > 30) lakes in the Vermont data set does indicate a weakening of the direct effects of pH on the Crustacea-Mollusca in colored or dystrophic lakes.

TABLE VIII: PERCENT COMPOSITION OF THE CHIRONOMIDAE TAXA IN
EKMAN DREDGE SAMPLES TAKEN IN THE WINTER OF 1982-1983
FROM 25 ACID SENSITIVE LAKES

(Based on the mean number of individuals from six Ekman dredge samples)

	Chironomus spp.	Pagastiella sp.	Tanytarsus spp.	Heterotanytarsus sp.	Procladius spp.	Ablabesmyia spp.	Microtendipes sp.	Cladotanytarsus. sp.	Psectrocladius spp.	Heterotrissocladius sp.	Cladopelma sp.	Zalutschia sp.	Micropsectra spp.	Dicrotendipes sp.
L. Rock	5.4	62.1	14.3	14.8	28									
Ninevah	9.0	21.0			67.0	12.0								
Kettle		12.4	41.6		24.8									
Sucker			5.0		7.5		42.9	20.0	14.1					
Grout		8.5	38.2		10.9				8.5	25.3				
South			20.8		49.0						13.5	7.2		
Cole	23.4		55.0		7.0			4.3	5.0					
Sunset			22.2	17.0	22.2		9.6		14.8	7.4				
Stratton	46.0				46.0									
Lily			13.3		47.3			14.8					10.2	
Little(Win.)		58.6	6.9		31.5				5.0					
Hardwood			19.4		37.7						7.0	27.0		
Unknown					56.5				30.4					
Griffith	58.0		4.6		8.6						4.6		22.0	
Howe			24.6		27.6			6.9				23.7	6.2	
Stamford			36.7	29.7	24.0									
Bourn				9.8	58.8					9.8				
Little(Wood.)					20.1	19.6			52.6					
Levi			42.0		7.3				36.2					8.3
Beebe	77.8											23.9		
Moses	94.0													
Forester		1.4	6.4		5.4				86.0					
Branch			9.4		21.8					27.6	23.5			
Big Mud		34.5			57.0									
Haystack			5.1	18.6	27.5				8.8	41.4				

The Decapoda appear to be the most sensitive of all the Crustacea, disappearing as pH falls below 6.00 and calcium levels fall below 3.5 mg/l. This finding is supported by both laboratory physiological tolerance experiments (Malloy 1979) and field surveys (Bengstrom and Hendry 1976). Collins (1980), however, has reported breeding populations of Decapods in lakes with pH values below 5.00. These lakes, however, had calcium levels of 3.0 mg/l or greater, supporting the theory that high calcium levels can offset the toxic physiological stress of low pH.

The two Amphipoda species encountered in the 26 lakes, Hyalella azteca and Crangonyx richmondensis, are common in low-pH lakes and have been mentioned as being present down to a pH of 5.00 (Kelso in D'itri 1982). The preference of C. richmondensis for dystrophic lakes is confirmed in a survey of the amphipods of glaciated North America (Bousfield 1958). This is a large species that could serve as an alternate high-quality food source for fish in lakes with pH below 6.00; which are unable to support many of the other Crustacea-Mollusca taxa. The Isopoda Asellus racovitzai was present in only one lake (pH 5.08). This pH is near the lower limit (pH 4.80) of the recorded distribution of a similar Europeon specie, Asellus aquaticus, in Norway (Okland and Okland 1980), with only sparse populations reported below pH 5.20. A. racovitzai was "abundant" in Little Pond-Woodford.

A decrease in the number of Ephemeroptera taxa similar to our findings has been reported in the literature (Hendry and Wright 1976, Collins 1981). Paraleptophlebia sp. was by far the most common and abundant mayfly specie found in the littoral zone of the 22 lakes. The specie has a one-year life cycle, hatching in early May with small nymphs reappearing by late summer. Bell (1971) has determined that mayflies are the most susceptible insect species to low pH. This general statement seems to be supported by our data set. Bell also states that emergence is the most critical period of time during the life cycle. It would seem that Paraleptophlebia sp. would be very susceptible to acidification since it is emerging from the littoral zone during the spring low-pH period. The specie's habit, however, of leaving the water just prior to the sensitive sub-imago stage (Edmunds 1976) may partially explain its tolerance toward pH down to 4.66 that we have reported here.

The occurrence of the mayfly Hexagenia limbata from Bourne Pond (pH 4.96) is consistent with Collins' 1980 findings from central Ontario in which he reported finding the specie down to a pH of 4.67 (Collins 1981). This is possibly due to the fact that Hexagenia is a burrowing genus that generally hatches in mid-summer (Edmunds 1976). The sediments of lakes often have a pH higher than the overlying water (Anderson et al. 1978) and may explain why lake pH can be as low as 4.60 and the specie still survive.

The increase in the number of Coleoptera and Hemiptera taxa in the low pH lakes has been well documented in the literature (Hendry 1976, Wiederholm 1977). The reasons given for their increase have been both physiological resistance to sodium loss and being able to maintain an internal acid-base balance in low pH waters (Havas 1981, Vangenechten and Vandenborght 1980). Another possible cause given is the elimination of fish as a top predator, allowing the invertebrate predators to increase (Ericksson 1980). The two fishless lakes from this data set (Little Pond-Woodford and Haystack Pond) were the only two lakes where a large invertebrate predator composed over 5 percent of the relative abundance in the bottom fauna.

Strong correlations were found between the Crustacea + Mollusca and Ephemeroptera taxa numbers vs. pH, alkalinity, calcium, and dissolved aluminum, especially in the clearwater lakes. This supports the conclusion that these interrelated parameters are in part responsible for limiting the number of taxa from these groups found in the lake data set. Okland and Okland (1980) present strong evidence that either calcium and/or pH can ultimately limit the Crustacea-Mollusca taxa numbers. Collins (1981), in comparing qualitative findings of Decapoda and Ephemeroptera taxa from Florida lakes to findings from the Adirondacks and Scandinavia concluded that dissolved aluminum levels might ultimately be the limiting factor for these organisms.

The weakened correlations found between the "pH sensitive" taxa vs. pH, alkalinity, calcium, and dissolved aluminum in the colored lakes may be caused in part by the fact that the data set is very small (ten lakes) to be handled statistically and the pH range is very narrow (4.60-5.90) and clustered below a level that is already critical for many Crustacea-Mollusca taxa. Data from colored lakes with pH above 6.00 would increase the statistical validity of the data set.

The sub-littoral (depth 2-5m) taxa as described by the percent composition of individuals from dredge samples were consistently dominated by the Chironomidae and the Oligochaetae. The dominance of these groups is typical, but the actual numbers per square meter in most of the study lakes appears slightly lower than reported elsewhere for similar lakes (Wiederholm 1977, Raddum 1981).

The percent composition of the Chironomidae taxa has been extensively studied in low pH lakes. The taxa Psectrocladius sp., Chironomus spp., Polypedilum sp., Heterotrissocladius sp., Ablabesmyia sp., Zalutschia sp., and Macropelopia sp. have consistently been reported to dominate in low-pH lakes (Raddum 1981, Herrickson 1982, Kelso 1982). The dominant taxa of the two clear-water lakes with pH less than 5.00 in this study confirm Psectrocladius sp. and Heterotrissocladius sp. as pH tolerant genera. The genera Procladius spp. and Heterotanytarsus sp. also were dominant in Haystack Pond, a clearwater pond with a pH of 4.66. These two taxa have previously been reported as less tolerant to acidic conditions (Raddum 1982). The genera Zalutschia sp., Heterotanytarsus sp., and Chironomus spp. have been reported as dominant in dystrophic lakes with pH less than 5.70 (Kelso 1982). These taxa, as well as Pagastiella sp., Procladius sp., and Tanytarsus spp. were among the dominant taxa found in the dystrophic lakes (color > 30) from this study.

The genus Chironomus spp. is also well known to be extremely tolerant to hypoxia. Its dominance in Moses Pond, Beebe Pond, and Stratton Pond could be due to the occurrence of anaerobic conditions in the sediments of these lakes. These three ponds also had the poorest taxa richness and diversity numbers which are consistently reported in lakes with poor dissolved oxygen levels in their sediments (Wiederholm 1980).

The high abundance of the genera Microtendipes sp., Cladotanytarsus sp., and Tanytarsus spp. in Kettle Pond, Cole Pond, Lily Pond, Forester Pond, Little Pond-Woodford, Levi Pond, Unknown Pond, Sunset Pond, and Sucker Pond is probably related to the extensive macrophyte growth in the littoral and sub-littoral zones of these ponds. The genus Microtendipes sp. seems to become less abundant in the above-mentioned lakes as the pH drops below 6.00, indicating a possible intolerance of acidic conditions.

CONCLUSIONS AND RECOMMENDATIONS

In summary, the overall conclusions from this macroinvertebrate survey are as follows:

1. The invertebrate taxa groups most sensitive to low pH are the Mollusca, Crustacea, and Ephemeroptera. A pH of 6.00 appears to be critical to the richness of the Crustacea + Mollusca fauna (snails, clams, and crayfish) and a pH of 5.50 appears to be critical to the Ephemeroptera (mayfly) fauna.

2. The least sensitive invertebrate taxa groups are the Hemiptera and Coleoptera, which often appear to increase in richness and abundance at low pH.

3. Even within the most sensitive taxa groups, there are species which exhibit extreme tolerance toward low pH. However, the frequency of occurrence of the sensitive taxa groups appears to decrease in low pH waters.

4. pH, followed by alkalinity, calcium, and dissolved aluminum are the most important chemical parameters in relationship to the benthic communities in acid-sensitive lakes.

5. Dystrophic lakes (those high in organic acids as measured by color values greater than 30 cobalt-platinum units) often have a naturally low pH. In addition, the dissolved organic material in the water column chelates dissolved aluminum and renders it non-toxic to the aquatic biota (NRSC 1981). These characteristics tend to weaken the relationship between the four primary chemical parameters and biologic parameters.

6. Lake-specific conclusions based on the above relationships and each lake's qualitative data are:

   A. Haystack Pond contains no Crustacea, Mollusca, or Ephemeroptera fauna. Due to the present adverse water quality conditions of low pH and calcium, it would probably not be able to support populations of these taxa if introduced.

   B. There are five clearwater lakes presently below the critical pH value of 6.00 which support only a limited number of the most tolerant species from the Crustacea, Mollusca, and Ephemeroptera taxa groups.

   C. With the exception of Cole Pond and South Pond, all nine lakes with pH above 6.00 support a rich Mollusca, Crustacea, or Ephemeroptera fauna. Specifically:

      1. Little Rock Pond and Sucker Pond contain an abundant Decapoda (crayfish) fauna.

      2. Sucker Pond, Lake Ninevah, and Lily Pond all contain a strong population of Gastropods (snails) and/or Mollusca (fingernail clams).

      3. Little Rock Pond, Kettle Pond, Sunset Pond, Sucker Pond, and Stratton Pond all contain a rich Ephemeroptera (mayfly) fauna.

Based on the above conclusions, the most dramatic change in the invertebrate fauna occurs in two stages: initially as the pH falls below 6.00 and secondarily as the pH falls below 5.50. This relationship is especially pronounced in clearwater lakes (color < 30), which appear to be the most sensitive to anthropogenic acid loading. These findings have been documented by other researchers in the field and appear to be valid in all geographic regions studied.

Based on these findings and the findings of other researchers in the field, the presence/absence of the Crustacea + Mollusca can be used as early warning indicator organisms to acidification. Their populations should be documented in all lakes with pH below 6.50 and alkalinity less than 12.5 mg/l for the following reasons:

1. The Crustacea and Mollusca are the most pH intolerant invertebrate or fish species of concern in these lakes.

2. The Crustacea and Mollusca represent a valuable, high quality fish food resource.

3. The presence or absence of the Crustacea and Mollusca taxa in a lake can be easily monitored due to their relative immobility and preference for the littoral zones of lakes.

It is from this point of initial loss of the most sensitive taxa that the entire biological communities in lakes will begin to change. If any lake management policy aimed at preserving an optimal fishery resource in a lake were to be implemented, this would seem to be a good point to begin such management. At the very least, it would be the point at which the fishery resource itself should begin to be monitored for impact. Once these sensitive taxa begin to drop out the lake's ecological balance is clearly being altered, and its ability to support pH-sensitive animals impaired.

REFERENCES

Andersson, Gunner, et. al. 1978. Influence of Acidification on Decomposition Processes in Lake Sediment. Verh. Internat. Verein Zonnol. 20:802-807.

Beamish, R.J. 1974b. Loss of Fish Populations from Unexploited Remote Lakes in Ontario, Canada - a Consequence of Atmospheric Fallout of Acid. Water Research 8:85-95.

Bell, Henry L. 1970. Effects of pH on the Life Cycles of the Midge Tanytarsus dissimilis. The Canadian Entomologist 102:636-639.

------ 1971. Effect of Low pH on the Survival and Emergence of Aquatic Insects. Water Research. 5:313-319.

Borgstrom, R. and G. Hendrey. 1976. pH Tolerance of the First Larval Stages of Lepidurus arcticus (Pallas) and Adult Gammarus lacustris. G.O. Sars Acid Precipitation - Effects on Forest and Fish Project. Report IR 11/76, Aas, Norway.

Bousfield, E.Z. 1958. Freshwater Amphipod Crustaceans of Glaciated North America. Canadian Field National 72:55-113.

Burnham, D. and Brenda Clarkson. 1983. Vermont Acid Precipitation Program Long-Term Lake Monitoring 1981-1982. State of Vermont, Agency of Environmental Conservation, Department of Water Resources and Environmental Engineering.

Collins, N.C. et al. Comparisons of Benthic Infauna and Epifauna Biomasses in Acidified and Non-Acidified Ontario Lakes. pp. 35-49. In: R. Singer Ed. 1981. Effects of Acidic Precipitation on Benthos. North American Benthological Society.

Department of Water Resources. 1983. Long Term Lake Monitoring Report. Vermont Agency of Environmental Conservation.

Edwards, G.F. et al. 1976. The Mayflies of North and Central America. University of Minnesota Press, Minneapolis.

Erickson, M.D. et al. 1980. Predator Prey Relations Important for the Biotic changes in Acidified Lakes. Ambio. 9:248-249.

Haines, Terry A. 1981. Acidic Precipitation and Its Consequences for Aquatic Ecosystems: A Review. Transaction of the American Fisheries Society. 110:669-698.

------ and John Akielaszek. 1983. A Regional Survey of the Chemistry of Headwater Lakes and Streams in New England: Vulnerability to Acidification. U.S. Fish and Wildlife Service, Eastern Energy and Land Use Team, FWS/OBS - 80-40:15:151 pp.

Havas, Magda. Physiological Response of Aquatic Animals to Low pH. pp. 49-66. In: R. Singer Ed. 1981. Effects of Acidic Precipitation on Benthos. North American Benthological Society.

Hendrey, G. and R. Wright. 1976. Acid Precipitation in Norway: Effects on Aquatic Fauna. Journal of Great Lakes Research 2 (supplement 1):192-207.

Kelso, John R.M. et al. Chemical and Biological Status of Headwater Lakes in the Sault Ste. Marie District, Ontario. Chapter 8 In: Frank M. D'itri Ed. 1982. Acid Precipitation: Effects on Ecological Systems. Ann Arbor Science Publisher, Ann Arbor, Mich.

Langdon, Richard. 1982. Fisheries Status in Relation to Acidity in Selected Vermont Lakes. Vermont Department of Water Resources and Environmental Engineering. Montpelier, VT.

Malley, D.F. 1980. Decreased Survival and Calcium Uptake by the Crayfish Orconects virilis in Low pH. Can. J. Fish. Aquatic Science 37:364-372.

Okland, J. 1980b. Environmental and Snails (Gastropoda): Studies of 1,000 Lakes in Norway. pp. 322-323 In: Drablos and Tollan Eds. 1980. Ecological Impact of Acid Precipitation.

------ and K. Okland. pH Level and Food Organism for Fish: Studies of 1,000 Lakes in Norway. pp. 326-327. In: Drablos and Tollan Eds. 1980. Ecological Impact of Acid Precipitation.

Okland, K.A. Mussels and Crustaceans: Studies of 1,000 Lakes in Norway. pp. 324-325 In: Drablos and Tollan Eds. *Ecological Impact of Acid Precipitation*.

------- and J. Kuiper. 1982. Distribution of Small Mussels (Sphaeriedae) in Norway, with notes on their ecology. Proc. Seventh International Melacological Congress. Melacologia 22: pp. 469-477.

Raddum, Gunner G. and Ole A. Seather. 1981. Chironomid Communities in Norwegian Lakes with Different Degrees of Acidifcation. Verh. Internat. Verein. Limnol. 21 pp. 399-405.

Roff, J.C. and R.E. Kwaitkowski. 1977. Zooplankton and Zoobenthos Communities of Selected Northern Ontario Lakes of Different Acidities. Can J. Zool. 55:899-911.

Schofield, C. 1976. Acid Precipitation: Effects on Fish. Ambio 5:228-230.

Uutala, Allen J. Composition and Secondary Production of the Chironomid (Diptera) communities in Two Lakes in the Adirondack Mountain Region, New York. pp. 139-154. In: R. Singer Ed. 1981. *Effects of Acidic Precipitation in Benthos*. North American Benthological Society.

Vangerechten, J. and O. Varrderboright. Effect of Acid pH on Sodium and Chloride Balance in an Inhabitant of Acid Freshwaters: The Waterbug *Corixa punctata* (illig) (Insecta, Hemiptera). pp. 342-343 In: Drablos and Tollan Eds. 1981. *Ecological Impact of Acid Precipitation*.

Widerholm, T. 1980. Use of Benthos in Lake Monitoring. Journal of W.P.C.F. 52:537-547.

---- and L. Eriksson. 1977. Benthos of an Acid Lake. Oikos 19:261-267.

APPENDIX I

QUALITATIVE BENTHOS FROM 25 LOW ALKALINITY LAKES 1981-1983

Lake	Little Rock	Ninevah	Sucker	Kettle	Cole	South	Sunset	Lily	Stratton	Grout	Unknown	Little Winhall	Hardwood	Griffith	Howe	Stamford	Levi	Moses	Woodford	Big Mud	Bourn	Beebe	Forester	Branch	Haystack
pH	6.84	6.75	6.69	6.55	6.31	6.20	6.14	6.14	6.10	5.99	5.94	5.86	5.78	5.69	5.61	5.52	5.18	5.15	5.08	5.03	4.96	4.86	4.75	4.66	4.66
Alk	6.68	3.27	3.90	4.08	2.16	1.30	.77	2.12	1.37	1.10	1.38	1.71	1.39	1.44	1.89	.52	.15	.25	-.11	-.07	-.27	-.42	-.58	-.84	-.71
Crustacea																									
Decapoda sp.	x	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hyalella azteca	x	x	x	x	x	x	x	x	x	x	-	x	x	x	x	x	x	-	-	-	-	-	-	-	-
Crangonyx richmondensis	-	-	-	x	-	-	x	x	x	-	-	x	-	-	-	-	x	-	-	x	-	-	-	-	-
Isopoda Asellus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-
Mollusca																									
Amnicola sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Planorbula sp.	-	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ferrissia sp.	x	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-
Campeloma decisum	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gyraulus sp.	-	x	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Helisoma anceps	-	x	-	x	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Physella sp.	x	x	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stagnicola sp.	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lymnaedae	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fossaria sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-
Pisidium spp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	x	-	x	-	-	x	-
Ephemeroptera																									
Eurylophella temporalis	x	x	x	x	x	-	x	x	x	x	x	x	x	x	-	x	x	-	-	-	-	-	-	x	-
Attenella attenuata	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ephemerella sp.	-	-	x	-	-	x	x	-	x	-	-	-	-	x	-	-	-	-	x	-	-	-	-	-	-
Heptagenia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-
Arthroplea bibunctatum	-	-	-	-	-	-	x	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenonema sp.	-	-	-	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenacron interpuctatum	x	-	x	x	-	-	x	x	x	x	x	-	x	x	x	-	x	-	-	-	-	-	-	-	-
Paraleptophlebia sp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	x	x	x	x	-	x	-
Caenis sp.	-	x	x	-	-	-	-	-	x	x	-	-	-	-	-	x	-	x	x	-	-	x	x	-	-
Hexagenia limbata	x	-	x	x	-	x	x	-	-	-	-	-	-	x	-	x	-	-	-	-	x	-	-	-	-
Ephemera sp.	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Siphlonorus sp.	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tricorythodes sp.	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anisoptera																									
Aeshna umbrosa	x	-	-	-	-	-	-	-	-	x	-	x	x	x	-	x	-	x	x	x	-	x	x	-	x
interrupta	-	-	-	-	-	-	-	-	-	x	-	x	-	x	-	-	x	x	-	x	x	x	-	x	-
verticalis	-	-	-	-	-	-	-	-	-	-	-	x	x	-	x	-	-	-	-	-	-	-	-	-	-
eremita	-	-	-	-	-	-	-	-	-	-	-	x	-	x	-	-	x	-	x	-	-	-	x	x	x
tuberculifera	x	-	-	x	-	-	x	x	x	-	x	x	-	-	-	x	x	-	x	x	x	x	x	x	-
canadensis	-	-	-	-	-	-	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Boyeria vinosa	-	-	-	x	-	-	x	x	x	x	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-
Basiaeschna janata	x	-	-	x	x	x	x	x	-	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Didymops transversa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-
Cordulia shurtleffi	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Somatochlora albicincta	-	-	-	-	-	-	-	x	-	-	x	-	x	-	-	-	-	x	x	-	-	x	x	x	x
cingulata	x	-	-	-	-	-	x	x	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	x
Tetragoneuria cynosura	x	x	x	-	x	-	x	x	-	-	x	-	x	x	-	-	x	x	-	-	x	-	x	-	-
sp.	-	-	x	x	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
Epicordulia princeps	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	x
Helocordulia uhleri	x	-	-	-	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ladona julia	-	-	-	-	-	-	x	-	x	-	-	x	x	x	-	x	x	x	x	x	x	x	x	x	-
exusta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-
Sympetrum sp.	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leucorrhinia hudsonica	-	-	-	-	x	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nannothemis bella	-	-	-	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-
Libellula quadrimaculata	x	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	x	-	-	x	x	x	-	x	x
Celithemis martha	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Pachydiplax longipennis	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	x	-	x	-	x	-	-	x	x
Gomphus exilis	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
borealis	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-
spicatus	x	-	-	-	-	-	x	x	x	-	x	-	-	x	-	-	x	-	-	-	-	-	-	-	-
sp.	-	-	-	-	x	x	-	x	x	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-
Lanthus sp.	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordulegaster maculatus	-	-	-	-	-	-	-	-	x	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zygoptera																									
Ischnura sp.	x	x	x	x	x	x	x	x	-	-	-	-	x	-	-	-	x	-	-	-	x	-	x	-	-
Enallagma sp.	-	x	x	-	x	-	x	x	-	-	-	-	x	x	x	-	x	x	x	-	x	-	x	-	-
Chromagrion conditum	-	-	-	-	x	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	x	x	x	-	-
Anomalagrion hastatum	-	x	-	-	-	-	x	-	-	-	-	-	x	-	-	x	-	-	-	-	-	-	-	x	-
Argia sp.	-	-	-	x	-	x	x	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nehalennia sp.	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lestes sp.	-	-	-	-	x	-	x	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	x	-

Lake	Little Rock	Minevah	Sucker	Kettle	Cole	South	Sunset	Lily	Stratton	Grout	Unknown	Little Winhall	Hardwood	Griffith	Howe	Stamford	Levi	Moses	Little Woodford	Big Mud	Bourn	Beebe	Forester	Branch	Haystack
Hemiptera																									
Notonecta sp.	x	-	x	-	-	-	x	-	x	-	-	x	x	-	x	x	x	x	x	x	x	x	x	x	x
Buenoa sp.	-	-	-	-	-	-	-	-	-	-	-	x	-	-	x	-	x	-	x	-	x	-	x	x	-
Gerris sp.	-	x	-	-	-	-	-	-	-	x	-	x	x	-	-	-	x	x	x	x	x	-	-	x	-
Rheumatobates sp.	-	-	x	x	-	-	-	-	-	-	-	-	-	x	x	x	-	-	-	x	-	-	-	-	-
Limnogonus sp.	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-
Metrobates sp.	x	-	-	-	x	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lethocerus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	x	-	-	x	-
Corixidae sp.	x	-	x	-	-	x	-	x	-	-	-	x	-	-	x	x	x	x	x	x	x	x	x	x	x
Nepidae Ranatra sp.	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-
Coleoptera																									
Gyrinus sp.	x	x	x	-	x	x	x	x	-	-	-	x	-	-	x	-	-	x	x	x	-	x	x	x	x
Dineutus sp.	-	x	x	-	x	-	x	x	-	-	-	x	x	-	x	-	-	-	x	x	-	-	x	x	x
Haliplus sp.	-	-	x	x	-	-	x	x	-	-	-	-	-	-	-	-	-	x	x	-	x	-	-	-	-
Graphoderus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	x	-	-
Hydroporus sp.	-	-	x	-	-	-	x	-	x	-	-	x	-	-	-	x	x	x	x	x	x	x	-	x	x
Agabus sp.	x	-	-	-	-	-	x	-	-	-	-	x	-	-	x	-	x	-	-	-	x	-	-	-	x
Dytiscus sp.	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	x	-
Laccophilus sp.	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Uvarus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	x	x	-	-	-
Coptotomus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
Ectopria sp.	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Donacia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-	-
Ancyronyx sp.	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Macronychus glabratus	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenelmis sp.	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dubiraphia sp.	-	-	-	x	-	-	-	x	x	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-
Trichoptera																									
Anabolia sp.	x	x	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Asynarchus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-	-	-	-	-	-
Glyphopsyche irronata	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-
Grammotaulius sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x
Limnephilus sp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Hydatophylax sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-
Platycentropus sp.	x	x	-	x	x	x	-	x	-	-	-	x	x	-	x	x	x	x	x	-	x	x	x	-	x
Nemotaulius hostilis	x	x	-	-	-	-	-	x	x	x	-	-	-	-	x	-	-	-	-	x	x	x	x	x	-
Pycnopsyche sp.	x	-	x	-	x	x	-	-	x	x	-	-	-	-	-	-	-	x	-	x	x	-	-	-	x
Ptilostomis sp.	x	-	-	-	-	-	-	-	-	x	-	-	-	-	x	x	-	-	x	-	x	x	-	x	-
Banksiola smithi	x	-	-	-	-	-	x	-	-	-	x	x	-	-	x	x	-	-	x	x	x	x	x	x	x
B. dossuaria	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B. crotchi	x	-	-	-	-	-	-	-	-	-	-	-	x	-	x	-	x	-	-	-	-	x	-	-	-
Phryganea sp.	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	-	x	x	-	-	-
Agrypnia improba	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	x	x	-	x	-	-
vestita	-	-	-	-	-	x	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Polycentropus sp.	x	x	x	-	x	x	x	x	x	x	-	-	x	x	x	x	-	-	x	x	x	x	x	x	x
Nyctiophylax sp.	-	x	-	-	-	-	-	-	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phylocentropus sp.	x	-	x	-	-	-	x	-	x	x	-	-	-	x	-	-	-	-	-	-	-	-	-	x	x
Oecetis sp.	x	-	x	-	-	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	x	x	-	-	-
Mystacides sp.	x	x	x	-	-	-	x	-	x	x	x	-	-	-	x	x	-	-	-	-	x	-	-	-	-
Triaenodes sp.	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-
Nectopsyche sp.	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ceraclea sp.	x	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Molanna tryphena	x	-	-	x	-	-	x	-	x	x	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-
blenda	x	-	x	-	-	-	x	-	x	x	-	-	-	-	x	-	-	-	-	x	x	-	-	-	-
uniophila	x	-	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-
Agarodes sp.	-	-	-	-	-	-	x	x	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydroptila sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-
Oxyethira sp.	-	-	x	-	-	-	-	-	-	x	-	-	-	-	x	-	-	-	x	-	-	x	x	-	-
Megaloptera																									
Sialis sp.	x	-	x	x	-	x	x	x	x	x	-	-	x	x	x	x	x	-	x	x	x	-	x	x	x
Chauliodes sp.	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydracarina sp.	-	x	-	-	x	-	-	x	-	-	-	x	x	-	x	-	-	-	x	-	-	x	x	x	-
Hirudinea sp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	x	x	-	-	-	-	-
Chironomidae																									
Microtendipes sp.	-	x	x	-	x	-	x	x	-	x	x	x	x	x	x	x	x	x	x	x	x	-	x	-	x
Cryptochironomus sp.	x	x	x	-	x	x	-	x	-	x	-	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Pseudochironomus sp.	-	-	x	x	x	-	x	x	-	x	-	x	-	-	x	-	x	-	x	-	x	-	x	-	-
Tribelos sp.	-	-	-	x	-	-	x	x	x	x	x	x	-	-	-	-	x	-	x	x	x	-	x	x	x
Chironomus sp.	x	x	x	x	x	-	-	-	x	-	x	-	x	x	x	x	x	x	-	x	x	x	-	x	x
Pagastiella ostansa	x	x	x	x	-	-	x	x	-	x	x	x	x	x	x	x	-	-	-	x	x	-	x	x	-
Polypedilum sp.	x	x	x	x	x	x	x	x	-	x	x	x	x	x	x	x	x	x	x	x	x	-	-	x	-
[illegible] sp.	-	-	-	-	-	x	-	-	-	-	x	-	x	x	-	-	-	-	-	-	-	-	x	-	-
Parachironomus sp.	-	-	x	-	x	-	-	x	-	-	-	-	-	-	-	-	x	-	x	-	-	-	-	-	-
Dicrotendipes sp.	-	-	x	-	x	-	x	-	-	x	-	-	-	-	x	x	-	x	x	-	x	-	-	x	-
Endochironomus sp.	-	-	-	-	-	-	-	x	x	x	-	-	x	x	-	x	-	x	x	-	x	-	-	x	-
[illegible] sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-
[illegible] sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
[illegible] sp.	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	x	-	x	-	-	-	-	-	x
[illegible] sp.	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[illegible] sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	x	-	-	x	-	-	-
[illegible] sp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	-	x	x	x

Lake	Little Rock	Minevah	Sucker	Kettle	Cole	South	Sunset	Lily	Stratton	Grout	Unknown	Little Winhall	Hardwood	Griffith	Howe	Stamford	Levi	Moses	Little Woodford	Big Mud	Bourn	Beebe	Forester	Branch	Haystack
Chironomidae (Cont'd)																									
Cladotanytarsus sp.	-	x	x	-	x	-	x	x	-	-	-	-	-	-	x	-	-	-	x	-	-	-	-	-	-
Rheotanytarsus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	-	-	-	-
Micropsectra sp.	x	-	-	x	-	x	x	x	-	x	-	-	-	x	x	-	-	-	-	-	-	-	-	-	-
Paratanytarsus sp.	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psectrocladius sp.	x	x	x	x	x	x	x	x	-	x	x	x	x	x	-	x	x	-	x	x	x	x	x	x	x
Orthocladius sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	x	-
Zalutschia zalutschicola	x	-	-	-	-	x	-	-	-	x	-	-	x	-	x	-	-	-	-	-	x	x	-	x	-
Heterotrissocladius sp.	x	x	x	-	-	-	x	-	-	x	-	-	x	-	-	-	-	-	x	-	x	-	-	x	x
Heterotanytarsus sp.	x	x	x	x	-	-	x	x	-	x	-	-	x	x	x	x	-	-	x	-	x	-	x	x	x
Parametriocnemus sp.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-
Corynoneura sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-
Nanocladius sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-
UN ID orthoclad	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-
Cricotopus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	x	x	-	-
Procladius sp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Ablabesmyia sp.	x	x	x	-	-	-	x	x	x	-	-	-	x	-	x	x	x	-	x	-	x	-	x	x	-
Thienemannimyia gr. sp.	x	-	-	-	x	-	x	-	-	x	-	-	x	x	x	-	-	-	x	-	x	-	-	x	-
Larsia sp.	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Natarsia sp.	x	-	x	-	-	x	x	-	-	x	x	-	-	-	-	-	x	-	x	x	-	-	-	x	-
Clinotanypus sp.	-	x	x	x	x	-	x	-	-	x	-	-	-	-	-	-	x	x	x	x	x	-	x	x	-
Pentaneura sp.	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	x	-	-	-	-	-	-	-
Coelotanypus sp.	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Protanypus sp.	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-
Chaoboridae																									
Chaoborus sp.	x	x	x	x	x	x	x	x	-	x	x	x	x	x	x	-	x	x	x	x	x	x	x	x	-
Ceratopogonidae																									
Bezzia-Probezzia sp.	x	x	x	x	x	-	x	x	-	x	x	x	x	-	x	x	x	-	x	x	x	-	-	-	x
Alluaudomyia sp.	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	x	-	-	-	-	x	-	x
Dasyhelea sp.	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-
Palpomyia tibiales	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oligocheata	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

Appendix 2: The total number of benthos by group found in the Ekman Dredge samples taken in 1983 for each lake and the resulting total relative benthic density per m^2.

Lake	1a	1b	2a	2b	3a	3b	Ave. #/m^2
BEEBE							
Hydracarina	-	-	-	1	1	-	14
Chaoboridae	8	3	4	4	7	9	254
Chironomidae	10	13	31	32	11	18	833
Ephemeroptera	1	-	-	-	-	-	7
Trichoptera	-	-	-	-	1	-	7
						Total	1,115
SUCKER							
Ceratopogonidae	22	28	31	42	38	29	1,377
Chaoboridae	1	-	-	-	-	-	7
Chironomidae	197	415	359	262	793	292	16,797
Ephemeroptera	4	2	2	20	5	-	239
Megaloptera	-	-	1	-	-	3	28
Trichoptera	3	7	17	6	7	-	287
Gastropoda	6	1	9	29	30	11	623
Pisidium	114	150	89	185	140	141	5,935
Anisoptera	-	-	-	-	1	-	7
						Total	25,300
STAMFORD							
Oligochaeta	-	-	12	3	-	-	109
Ceratopogonidae	1	-	-	-	-	-	7
Chironomidae	108	149	175	56	192	205	6,413
Megaloptera	-	1	-	-	-	1	14
Ephemeroptera	1	4	5	2	1	1	101
Trichoptera	2	-	2	-	-	-	29
						Total	6,673
LEVI							
Oligochaeta	1	-	1	8	13	6	210
Ceratopogonidae	-	7	4	3	-	-	101
Chironomidae	23	116	125	320	15	6	4,384
Ephemeroptera	-	-	1	-	-	-	7

Appendix 2 (Cont.)

Lake	1a	1b	2a	2b	3a	3b	Ave. #/m^2
LEVI (Cont.)							
Anisoptera	1	–	–	2	–	–	22
Trichoptera	–	1	1	–	7	8	123
Nematoda	–	1	–	–	–	–	7
Chaoboridae	–	–	–	–	2	1	22
						Total	4,876
KETTLE							
Oligochaeta	–	–	2	–	1	–	22
Ceratopogonidae	–	–	2	–	–	–	14
Chaoboridae	–	–	1	–	–	1	14
Chironomidae	8	18	22	33	5	16	739
Trichoptera	2	1	1	–	–	–	29
Gastropoda	–	–	5	–	–	–	36
Pisidium	–	–	–	3	–	2	36
Ephemeroptera	–	–	–	1	1	3	36
Megaloptera	–	–	–	1	–	–	7
						Total	933
SUNSET							
Oligochaeta	–	–	4	2	–	–	43
Ceratopogonidae	2	9	13	13	6	7	362
Chironomidae	17	17	17	13	10	16	652
Ephemeroptera	–	–	7	5	2	2	116
Trichoptera	1	2	2	–	–	–	35
Pisidium	–	–	2	–	–	–	14
Chaoboridae	–	–	–	–	–	2	14
						Total	1,236
GRIFFITH							
Oligochaeta	–	–	7	2	8	–	123
Chaoboridae	–	3	2	8	2	3	130
Chironomidae	5	8	18	25	27	18	732
Megaloptera	1	–	–	1	–	–	14
Anisoptera	1	–	–	–	–	–	7
Trichoptera	7	–	–	–	–	–	51
						Total	1,057

Appendix 2 (Cont.)

Lake	1a	1b	2a	2b	3a	3b	Ave. #/m^2
BIG MUD							
Oligochaeta	–	–	–	1	–	–	7
Chaoboridae	6	6	7	7	6	8	290
Chironomidae	63	66	59	55	68	87	2,884
Trichoptera	–	7	–	–	–	–	51
						Total	3,232
FORESTER							
Oligochaeta	66	67	210	76	17	30	3,377
Hydracarina	–	–	–	1	–	1	29
Ceratopogonidae	1	3	11	–	–	2	123
Chaoboridae	50	18	9	17	4	9	775
Chironomidae	981	553	1095	704	1002	456	34,572
Ephemeroptera	3	–	1	1	2	1	58
Anisoptera	5	3	3	2	10	1	174
Zygoptera	–	1	4	6	–	1	87
Trichoptera	21	15	97 + cases	31	37	31	979
						Total	40,174
UNKNOWN							
Ceratopogonidae	1	1	–	1	–	1	29
Chaoboridae	3	–	17	18	13	35	623
Chironomidae	5	–	1	1	4	4	109
Trichoptera	–	–	–	–	11	5	116
Pisidium	–	–	–	–	1	–	7
Hirudinea	–	–	–	–	–	1	7
						Total	891
STRATTON							
Oligochaeta	–	2	–	1	1	–	29
Chironomidae	6	2	7	15	2	7	283
						Total	312
LITTLE (WIN.)							
Oligochaeta	41	24	25	18	8	22	1,000
Hydracarina	–	–	1	–	–	–	7
Ceratopogonidae	–	–	1	–	–	–	7
Chaoboridae	40	20	10	9	13	31	891

Appendix 2 (Cont.)

Lake	1a	1b	2a	2b	3a	3b	Ave. #/m^2
LITTLE (WIN.) (Cont.)							
Chironomidae	135	39	71	19	29	121	3,000
Hemiptera	–	1	–	–	–	–	7
Trichoptera	2	8	4	5	6	2	196
						Total	5,108
HAYSTACK							
Oligochaeta	–	LA	1	–	4	–	43
Ceratopogonidae	7	LA	–	1	5	3	139
Chironomidae	16	LA	7	10	56	17	922
Megaloptera	3	LA	–	3	1	–	61
Trichoptera	–	LA	–	–	1	–	9
Nematoda	–	LA	–	2	1	–	26
Anisoptera	–	LA	1	–	–	–	9
						Total	1,209
MOSES							
Oligochaeta	4	–	2	3	6	1	116
Chironomidae	142	79	146	110	103	144	5,246
Nematoda	–	–	1	–	–	–	7
						Total	5,369
NINEVAH							
Oligochaeta	6	1	10	28	2	14	442
Chaoboridae	15	4	32	64	18	32	1,996
Chironomidae	52	16	31	80	18	42	1,732
Pisidium	2	1	–	3	–	–	43
Ceratopogonidae	–	–	–	1	1	–	14
Trichoptera	–	–	–	–	–	6	43
Gastropoda	–	–	–	–	2	1	22
Hydracarina	–	1	–	–	–	–	7
						Total	4,299
COLE							
Oligochaeta	–	–	–	1	–	–	7
Ceratopogonidae	–	1	2	1	–	–	29
Chaoboridae	1	–	–	1	–	–	14
Chironomidae	148	133	79	106	–	–	3,377
Pisidium	–	–	3	–	–	–	22
						Total	3,456

Appendix 2 (Cont.)

Lake	1a	1b	2a	2b	3a	3b	Ave. #/m^2
LITTLE ROCK							
Oligochaeta	7	–	–	32	14	–	384
Amphipoda	5	4	–	–	–	–	65
Ceratopogonidae	1	1	–	5	1	3	78
Chaoboridae	–	–	0	4	–	–	261
Chironomidae	229	55	31?	77	32	79	3,500
Ephemeroptera	1	2	–	1	5	5	101
Megaloptera	4	1	–	2	1	4	87
Trichoptera	–	–	–	–	6	–	43
						Total	4,519
HOWE							
Oligochaeta	–	2	1	2	2	1	58
Chaoboridae	–	1	1	1	5	2	72
Chironomidae	40	167	9	45	30	18	2,239
Megaloptera	1	–	–	–	–	–	7
Trichoptera	–	1	3	38	21	21	609
Hydracarina	–	–	–	–	3	–	22
Ceratopogonidae	–	–	–	–	1	1	14
						Total	3,021
GROUT							
Oligochaeta	–	–	–	1	2	3	43
Amphipoda	3	7	3	4	–	–	123
Ceratopogonidae	6	3	–	4	12	21	335
Chironomidae	44	54	12	97	111	70	2,813
Trichoptera	–	–	1	1	2	11	109
Gastropoda	–	–	–	2	–	–	14
Pisidium	–	–	1	–	–	–	7
Ephemeroptera	–	–	–	–	–	2	14
						Total	3,458
BOURN							
Oligochaeta	3	3	26	–	–	–	232
Ceratopogonidae	–	1	–	–	–	–	7
Chironomidae	8	26	17	8	2	6	486
Trichoptera	4	–	–	3	–	–	51
Chaoboridae	–	–	1	–	8	7	116
						Total	892

Appendix 2 (Cont.)

Lake	1a	1b	2a	2b	3a	3b	Ave. #/m^2
BRANCH							
Oligochaeta	11	–	–	–	–	3	101
Ceratopogonidae	–	–	5	–	–	–	35
Chaoboridae	2	1	–	6	–	–	65
Chironomidae	7	27	33	28	9	5	783
Trichoptera	–	3	1	–	–	–	29
Hydracarina	–	–	–	–	1	–	7
						Total	1,020
HARDWOOD							
Oligochaeta	19	11	–	2	4	3	283
Hydracarina	1	–	–	–	–	–	7
Chaoboridae	–	–	27	22	14	10	529
Chironomidae	50	10	126	62	58	26	2,406
Trichoptera	–	–	–	–	–	1	7
						Total	3,246
LILLY							
Oligochaeta	–	–	16	9	3	2	217
Amphipoda	13	5	16	5	30	4	529
Hydracarina	–	–	2	–	–	–	14
Ceratopogonidae	–	–	–	1	7	1	65
Chaoboridae	92	21	25	31	32	21	1,609
Chironomidae	40	5	89	57	82	20	2,123
Trichoptera	–	–	7	8	–	–	109
Gastropoda	5	2	1	7	–	–	109
						Total	4,775
LITTLE (WOOD.)							
Oligochaeta	1	–	2	13	7	2	181
Ceratopogonidae	–	1	–	2	–	–	22
Chironomidae	32	31	33	22	113	55	2,072
Ephemeroptera	–	1	11	10	2	–	174
Anisoptera	16	–	7	2	14	–	283
Trichoptera	2	–	–	–	1	1	29
Nematoda	–	1	–	1	–	–	14
						Total	2,775

Appendix 2 (Cont.)

Lake	1a	1b	2a	2b	3a	3b	Ave. #/m^2
SOUTH							
Oligochaeta	1	–	–	1	–	–	14
Ceratopogonidae	1	–	–	–	–	–	7
Chaoboridae	–	3	1	1	–	–	36
Chironomidae	34	7	9	7	2	5	464
Ephemeroptera	1	–	–	2	–	1	29
Megaloptera	–	–	–	2	–	–	14
Gastropoda	–	1	–	–	–	–	7
						Total	571