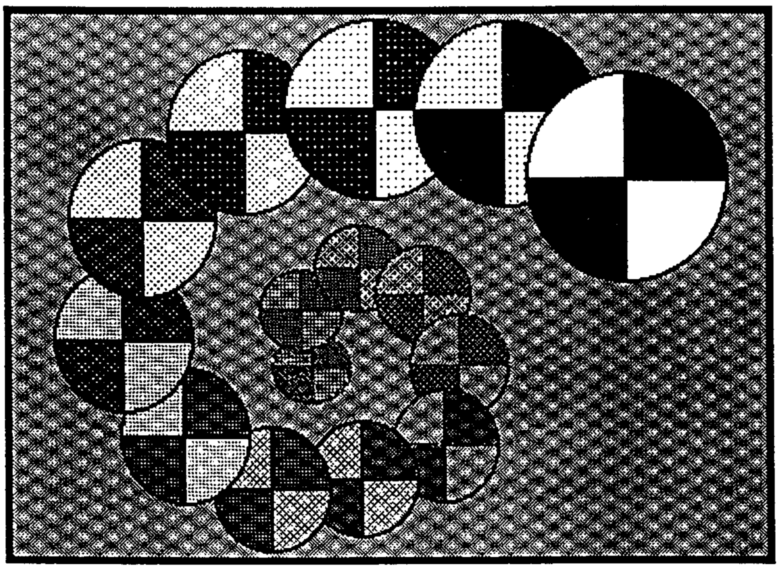
Rogue Community College

Whitehorse Ponds

Crater Lake National Park

Limnological & Vascular Plant Survey, 1993

Final Report, RCC-9404



July, 1994

Photographs by Richard Miller

August 9, 1993

Crater Lake National Park
Whitehorse Pond
Limnological and Vascular Plant Study
Summer, 1993

Report RCC-9404

Produced for

Crater Lake National Park
Natural History Association
July, 1994

by

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EXECUTIVE SUMMARY

Crater Lake National Park contains many unique environs. The collection of ponds on the top of Whitehorse Bluff is one such special area. In 1993 the Crater Lake Natural History Association sponsered this environmental research project designed to continue work begun by Roger Brandt in 1992. This study focused on the physical, chemical, and biological characteristics of the ponds themselves and includes a survey of the flora found on the Bluff.

The ponds were visited between July 14 and September 10, 1993. In the first of several field trips the ponds were found to be close to full of water and teeming with life. The ponds were found to support healthy populations of dragon flies, water striders, invertebrates, many types of aquatic insects, frogs, toads, salamander and their tadpoles, moss and other aquatic plants, and many types of plankton. Later in the summer all but two ponds were completely dry. One challenge in surveying the ponds was simply to identify the individual ponds.

The Whitehorse Ponds are located within a mosaic of forest communities of which red fir and lodgepole pine forest were the most important. The dominant overstory tree was Shasta red fir (*Abies magnifica* var. *shastensis*) which, in combination with mountain hemlock (*Tsuga mertensiana*), provided a nearly closed canopy over large areas of the bluff top. The single day's floral survey documented twenty-nine taxa in and around the ponds.

Study of plants in the Whitehorse Bluff area over a summer would surely add to the listing begun by David Hartesvelt. He suggested that the bryophytes alone are deserving of a more complete survey. The bryophytes were observed but not documented here.

The ponds themselves supported a limited flora of vascular plants. Two aquatic plants, western quillwort (*Isoetes occidentalis*) and small bur-weed (*Sparganium natans*), were observed in the largest and deepest of all the ponds. These species were not observed in any other ponds. Two additional species, water sedge (*Carex aquatilis*) and narrow-spiked reedgrass (*Calamagrostis inexpansa*), were observed growing as emergent vegetation along the shallow margins of most ponds occurring on the White Horse Bluffs.

In this brief period the water temperatures varied from 13 to 24° C, the acid concentration or pH varied from 5.55 to 6.20, dissolved oxygen levels were low and varied from 4.5 to 6.7 mg/L and the conductivity of the pond water varied from 7.6 to 16.6 µMHO/cm.

Chemical concentrations paralleled the concentrations of a bulk deposition (precipitation) study completed in September 1988 (Larson, 1993). All chemical species determined were of similar concentration except nitrate and sulfate ions. Nitrate ion was found to be 18 times less concentrated in the ponds than in precipitation. Nitrate ion, an important nutrient, was probably being taken up by plants in and around the ponds. Sulfate ion was also found in very small concentrations in the ponds about 100 times less than in Park precipitation. Total phosphate, sodium, potassium, calcium, magnesium, and chloride were all similar in concentration when compared to precipitation.

When Crater Lake water chemical specie concentrations were compared to pond water concentrations, they ranged from similar, as in total phosphate, to 50 times greater for alkalinity. All the other chemical species were in the 8 to 20 times range greater in the Lake. The ponds are probably fed by precipitation alone. Changes in the quality of the precipitation would certainly affect the ponds.

Phytoplankton were sampled three times. The two samples taken on August 9 from two separate ponds were very similar in population with nine taxa identified in each and biovolumes of 225,000 and 350,000 $\mu m^3/L$. The single sample from September 10 contained only four taxa but had a biovolume of 14,300,00 $\mu m^3/L$. There was a great diversity and biovolume of phytoplankton for such small water bodies. Further study will probably reveal that this study underestimates the true diversity in the phytoplankton community.

A review of all the plankton data suggests that the Whitehorse ponds were eutrophic in quality with a high amount of organic material present. The pond color supports this as well as the presence of the euglenoids that require certain organic materials to live. Phytoplankton cell densities increased 30 times in September due to a reduction in nutrients, higher temperatures, and greater light intensities as Bob Truitt has suggested. Chemical analyses do not support the nutrient suggestion. However, it has been documented that later in the summer the number of phytoplankton species decrease and the cell densities increase. More study into this trend would reveal interesting relationships.

Zooplankton were more diverse than the phytoplankton. Similarity indices indicated that different ponds also had unique zooplankton communities. Zooplankton feed on the smaller phytoplankton. There was a documented difference in the zooplankton assemblages on a pond's surface and on the pond's bottom. This was seen to be true even in very shallow ponds about 1 m deep. The large diversity in zooplankton depended little on the date of collection. A greater number of samples through time and for each pond would also document very interesting trends in zooplankton community structure.

Future study of the Whitehorse Ponds would document changes in the ponds due to changes in this small watershed.

ACKNOWLEDGMENTS

This study was supported by the Crater Lake Natural History Association. Observing and trying to understand the special features of the Whitehorse ponds can be an exciting challenge. The CRNHA helped continue a study begun by Roger Brandt in 1992. His work on many ponds in the Park initiated many park researchers to look into the intricate systems present in these delicate environs.

The authors of this report enjoyed their small part in putting this study together. The principle investigator, John Salinas, would like to thank Bob Truitt for his painstaking work with the phytoplankton and zooplankton. Bob did not have many samples to work with, however he did observe some very interesting trends and has asked for more samples from more ponds at more frequent intervals. The seeds for another very interesting study have been planted. Bob Truitt would like to thank the major investigator, John Salinas, for his interest, financial help, and his patience.

Thanks also to David Hartesveldt who walked the bluff as if he lived there. He inventoried the many plants and suggested that the flora should be more completely studied in the near future. A single day on the bluff in August began a study which should continue through spring, summer, and autumn.

The physical characteristics of the ponds themselves were also very interesting. Further *in situ* measurements along with grab samples would surely clarify some of the trends identified in this study. This study will continue in one of many forms. Hopefully these authors will be involved in these future studies.

Finally, thank you to the CLNHA for their support and encouragement. Also thanks to Cam Jones of the Cooperative Chemical Analytical Laboratory who completed the chemical determinations. Cam has supported many of us with his fine laboratory work. This report would have been years in the writing without this great support.

1.0 INTRODUCTION

The study of the Whitehorse Pond Complex began in 1992 with the work of Roger Brandt (Brandt, 1992). Whitehorse ponds are located in Crater Lake National Park on Whitehorse Bluff just south of Highway 62 and west of the Pacific Crest Trail. From the top of the bluff one can see the highway. From the highway the bluff is seen above a one-hundred foot gray wall of rock to the south. The current study was initiated because of the author's keen interest in both the Crater Lake environs as well as the quality of water in the High Cascades. His research proposal is included in Appendix I.

The White Horse Ponds are located on White Horse Bluff in Crater Lake National Park approximately 0.25 to 0.5 miles south and west of Highway 62. White Horse Bluff is a conspicuous outcrop of what appears to be andesitic lava achieving elevations of 6,300 to 6,350 feet national geodetic vertical datum (NGVD). Previous studies have identified 12 ponds (Brandt 1992). Some of the numbered ponds should be referred to as pond complexes, because more than one pond are associated with them. For example, Pond 7 includes four interconnected ponds. These ponds occupy topographic depressions in the lava with spill elevations two to four feet above the invert elevations of the pond bottoms. Ponds of only one to two feet of depth often become dry late in the summer, although the deepest ponds (e.g. Pond 3) remain inundated through most summers.

The Whitehorse pond area was visited five times during the summer of 1993. The author was accompanied on most trips by field researchers working in or around the Park on similar research. Studies included field and taxonomic observations of the flora surrounding the pond area, *in situ* aquatic monitoring of temperature, and pH. Grab samples included the collection water for the determination of dissolved oxygen, nutrient chemical concentrations, phytoplankton, and zooplankton. The chemical analyses were completed by the Cooperative Chemical Analytical Laboratory (CCAL) in Corvallis headed by Mr. Cameron Jones. This lab was established by memorandum of understanding no. PNW-82-187 between the USDA Forest Service and the Department of Forest Science, Oregon State University.

A survey of the flora in the Whitehorse ponds area was completed by Mr. David Hartesveldt. The observations documented in this report were limited by the single survey undertaken in August of 1993. The flora of Whitehorse Bluffs and, possibly, the ponds themselves, is almost certainly more diverse than is indicated in this report. Due to the varied phenology of the montane flora of Crater Lake, one field survey conducted late in the summer necessarily misses plants blooming earlier or later in the summer. No effort was made to collect or identify any of the various bryophytes (e.g. mosses and liverworts) associated with the White Horse Ponds. Yet, mosses were an important component of several ponds, particularly those which were dry at the time of the field survey. For a more complete understanding of the floristic relationships and successional processes of the White Horse Ponds, a more comprehensive floristic study of the ponds that includes the bryophytes would be warranted.

Eight ponds on White Horse Bluff, were sampled for zooplankton and phytoplankton. John Salinas collected 14 total samples, 11 zooplankton and 3 phytoplankton, during a period from July 14 through September 10, 1993. Mr. Robert Truitt analyzed pond water samples for phytoplankton and zooplankton.

This project also exposed students of Rogue Community College to field research. This was accomplished on the August 9th field day. About a dozen students recorded observations and collected pond samples for later analyses. Several of their reports are included in Appendix II.

Roger Brandt's pond numbering system was used to identify individual ponds (Figure 1). A shallow pond far to the east on the plateau was unnamed in Roger's work and has been numbered Pond #0 in this report. A pond to the east of the Pond #9 complex has been called Pond #9 east or Pond #13. There also seem to be two ponds to the extreme southwest of the main pond group, these were called Ponds #14 and #15 and were not visited in this study. East of Ponds 10, 11, and 12 was another unnamed pond which was called Bear Tree pond because a bear had stripped a tree of its bark to about ten feet high.

Ground truthing of Roger's map began as soon as this pond study began. Every effort was made to accurately document each sample with respect to pond location and name. However Roger's map needs to be updated and each pond identified with a simple marker.

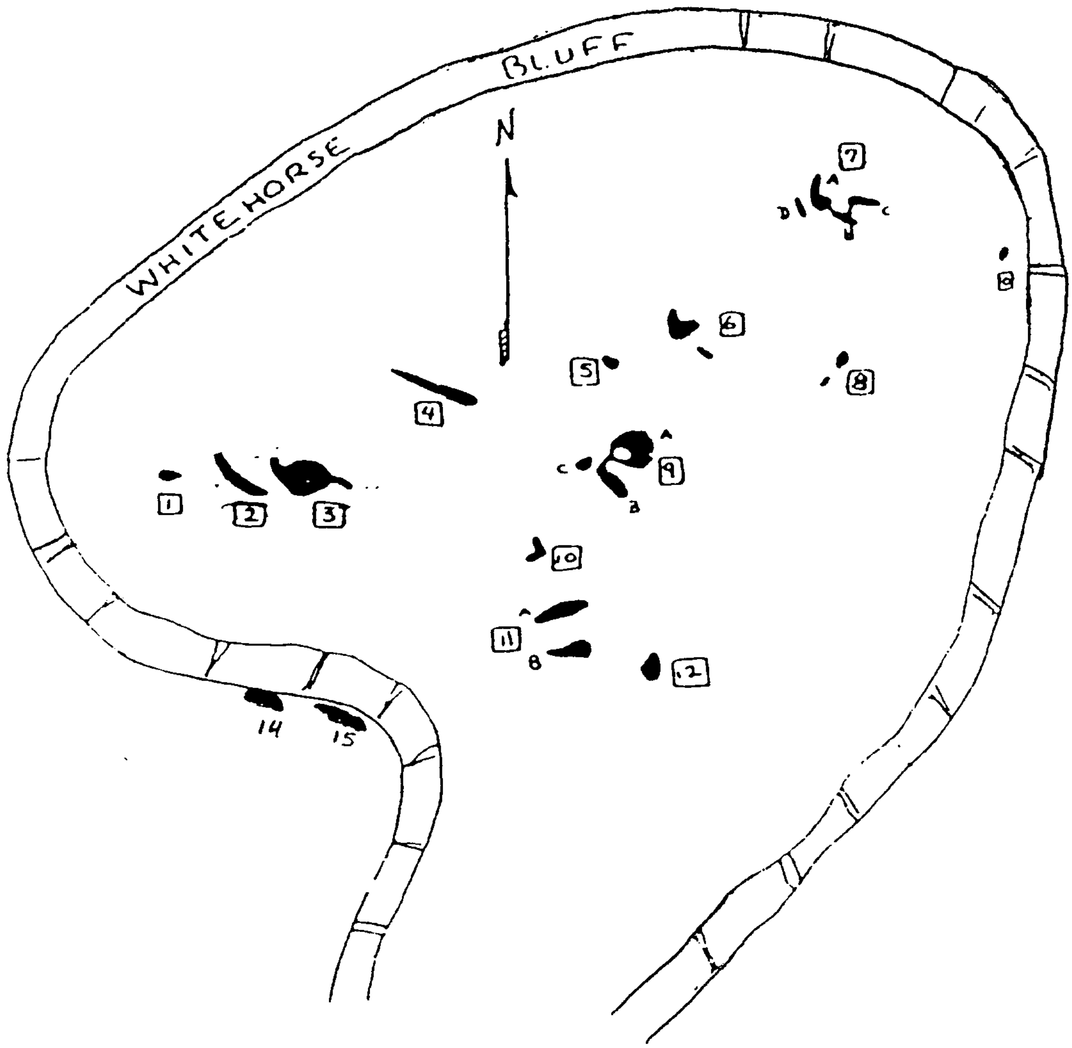

Figure I. A map of the Whitehorse Ponds at Crater Lake National Park.

2.0 METHODS

2.1 Physical Collection Methods

A Hach One pH meter probe was used to quantify *in situ* temperature and acid concentration, pH. This probe is used to measure pH in low conductivity waters. It was calibrated with low ionic strength pH buffers following a similar protocol used in the Crater Lake field lab (Salinas, 1992). An Perstorp *in situ* multiparameter probe was used to measure temperature, pH, and conductivity in addition to the Hach meter.

Pond water samples were collected in a Scott-modified Van Dorn collecting bottle for nutrient chemical concentrations, dissolved oxygen concentration, and phytoplankton. Water was collected in acid rinsed plastic bottles for analyses in the Cooperative Chemical Analytical Laboratory in Corvallis (Jones, 1992). This is the same laboratory used by the Crater Lake monitoring team. Analyses included pH, alkalinity, conductivity, total phosphorus, nitrate/nitrite, sodium, potassium, calcium, magnesium, chloride, and sulfate ions. These ions were only those dissolved in the water since the water was passed through a pre-rinsed glass fiber filter before it was cooled and shipped to Corvallis.

Water samples were preserved in dark plastic bottles for phytoplankton speciation and enumeration. Lugol's iodine solutions was used for this purpose making the sample one percent iodine before storage.

2.2 Plankton Methods

Each phytoplankton sample was preserved with 1% Lugol's solution in the field. In the laboratory, each phytoplankton sample was homogenized by shaking and poured into a 1 L graduated cylinder and settled for 72 hours. The sample was concentrated to 100 ml by aspirating off the top and split into 2-50 ml aliquots. One aliquot was put aside for archiving and the other was rinsed into a Hydro-bios Kiel 50 mL settling chamber and allowed to settle for 24 hours. The settled sample was then placed on a Nikon DIAPHOT-TMD inverted microscope fitted with a Javelin color camera and Sony color printer and monitor. The first 200 cells encountered were counted and identified at 1500 X oil on phase contrast. A digital photomicrograph was taken of the major algal taxa encountered and are included with this report. The cell density was calculated in cells per liter (cells/L) using the following:

$$N = [n(A/WL)] / [V/1000] \ cf,$$

where N = the number of cells per liter;

n = the number of cells counted;

A = the area of the chamber (cm^2);

W = the field width (cm);

L = the total length of the transect counted (cm);

V = the volume of the chamber (mL);

cf= the volume of the concentrated sample divided by the volume of the original field sample.

Zooplankton were collected with a12-centimeter diameter 64 μM mesh sized zooplankton net. It was towed 9.5 meters through the water for each sample. It was kept between the surface and the pond's bottom for each tow. No attempt was made to keep the net at the pond's surface or bottom. All ponds sampled for zooplankton were wide enough and deep enough to accomplish this type of tow. Samples rinsed from the net were preserved with formalin and placed in plastic sample bottles.

Zooplankton samples (ca. 50 mL) were preserved in the field with a 10%/vol. formalin solution to a 4% final concentration in the sample. In the laboratory, all samples were stained with Eosin Y prior to processing to facilitate counting. The samples were diluted to acceptable concentrations using a Folsom Plankton Splitter. One collecting tray, from the splitter, was designated as the counting (C) tray, the other as the picked (P) tray. The sample was placed in the splitter and rocked 5x to randomize sample, then poured into the trays. The splitter was rinsed with 0.22 µm filtered Crater Lake water, rocked 5 more times and poured into the trays. The C tray was poured back into the splitter and the procedure repeated until an approximate density of zooplankton were obtained to facilitate counting (ca. 250-350 organisms/sample), by observing the tray under a stereo microscope. All other remaining organisms were retained in the P tray. Both tray samples were then filtered through 0.10 µm nitex cloth to reduce volume and remove sugar formalin, then rinsed into 25 mL liquid scintillation vials. The P vial was preserved with 1 mL of 10% sugar formalin, used for identification of zooplankton and archived. The C vial was rinsed into a Hydro-bios Kiel 50 mL settling chamber, allowed to settle undisturbed for 24 hours and the sample counted at 4x (for crustacean zooplankton) and 20x (for rotifers) with phase contrast on a Nikon Diaphot-TMD inverted microscope fitted with a Javelin color camera and Sony color printer and monitor. A digital photomicrograph was also taken of the major zooplankton taxon encountered and are included with this report. The counts were used to estimate the number of organisms per cubic meter (organisms/m^3) of lake water filtered:

$$N = (ndf) / V_L,$$

where N = number of organisms per cubic meter;

n = number of organisms counted;

df= dilution factor of sample (splits);

V_L= volume of (m^3) of lake water filtered.

Here, V_L= net opening area (m^2) X length of tow (m) X filter factor (a 100% factor was used).

Sample Analysis

The data were recorded on computer coding sheets according to a standard format required by the programs selected for data analysis (AID1 and AIDN). Each data file was organized into a series of blocks, each of which represented the counts of species occurring in a particular sample (i.e. ponds), the phytoplankton were not analyzed because there were only 3 samples taken. The general approach to the quantitative analysis of distributional patterns in the zooplankton involved: 1) estimation of community composition parameters (AID1 program); 2) calculations of similarity measure for comparing the species compositions of sample pairs (AIDN program); and 3) calculations of a similarity measure for comparing the species compositions of pooled sample pairs (AIDN program).

Two indices of species diversity, the information measure and Simpson's index were used to express community structure, H" and SDI respectively. A measure of dominance (R) for selected taxa was included. A similarity measure (SIMI [a,b]) was used to compare taxonomic similarity between samples a and b. For completeness all statistical outputs are contained in this report (Appendix 3-8).

2.3 Floral Survey

A single survey of the White Horse Bluffs and associated ponds was conducted by David J. Hartesveldt on August 21, 1993. The focus of the survey was the ponds themselves. Most of the twelve ponds were visited and all vascular plants observed in them were noted to species or were collected for later identification. A meander survey was conducted throughout the area of White Horse Bluffs and all vascular plants observed were noted to species.

Unknown taxa were keyed to species within two weeks of collection. Standard floras used to key these species included *A California Flora and Supplement* (Munz 1968), *Flora of the Pacific Northwest* (Hitchcock and Cronquist 1973), and *The Jepson Manual* (Hickman 1993). The names used to refer to a given taxon vary considerably from flora to flora. The names used in the Jepson Manual have been used for the purposes of this study.

3.0 RESULTS

3.1 Physical Characteristics

The ponds were found to be full of water and teeming with life early in the summer season. However, later in this wet year all except two ponds were dry. The following describes the several field days

July 5, 1993, First Trip

The first attempt to visit the ponds was not successful. Beginning on the Pacific Crest Trail, the author and his son, Garrett, walked west and were lead over a series of hilltops and valleys. The ponds were actually farther south and west than the map suggested. This first trip on July 5th did not produce any samples or observations of the ponds directly.

July 14, 1993, Second Trip

The second trip to the ponds was on July 14. Scott Swarts of the Crater Lake stream survey team accompanied the author to Whitehorse Bluff. On this field trip we climbed the bluff on the north side and arrived at **Pond #7** first. Few observations were taken there in hopes of finding larger ponds. Pond #6 was encountered next and its temperature at 1700 hours was 13° C (Table 1). **Pond #8** was encountered next and was determined to be about 7 meters in diameter, grass covered the bottom, and it was 14° C. In addition there were mosquito larvae and water bugs in the water. It was a foot lower than full on this date.

Walking west we arrived at one of the largest ponds on this date, **Pond #9**. We called it **Frog Pond** as it is referred to in Bob Truitt's report. We collected two zooplankton samples. The first at 1800 hours on the north side of **Pond 9A** and the second tow at 1825 hours was collected on the south side of **Pond 9A**. The tows were made by holding the 12 cm diameter net at surface level as the other walked a semicircle with the cord to a spot on the other side of the pond. The net was pulled through undisturbed water about 50 cm deep and 10 cm off the bottom. Any shrimp collected were trapped in the vertical portion of the tow which occurred at the end of the horizontal tow.

Table 1. Physical Data From Selected Whitehorse Ponds.

Pond Reports

Pond	7/14/93	8/21/93 pH	Temp	Notes	9/10/93 pH	Temp	Notes
		5.55	17.4	Salamander polywogs			
3		5.56	18.3	Chem sample, salamanders, frogs, 60 cm deep			
4				Toads			
5				Dry			
6	13 Celsius			12 in deep, drying			
7A		6.2	13.2	frog and salamander polywog	5.92	23.5	7.29 mg DO/L, Chem sample
7C		5.98	15.1	polywogs, zooplankton tow			
8	14 Celsius, 7 m dia						
9	Largest Pond, Zooplc	5.59	22.3	Chem sample, polywogs			
10							
11	16 Celsius			Dry with moss covering			
12							
13		5.55	22	Dark colored			

Frog tadpoles were noticed and were about one inch in length. Also noticed was a campfire ring on the southeast side of **Pond #9A**.

Turning south we encountered **Ponds #10 and #11**. **Pond #11** was 16° C and was down from full by about 30 cm. **Pond #12** was found by walking further south and was covered with a grass bottom.

The final pond group observed on July 14th was east of **Ponds #10, 11,** and **12**. There is no number for this group but we identified it by a tree striped of its bark by a bear. We called it Bear Tree Pond. A single small pond was found north of a larger pond complex. Moss covered the southern side of the smaller pond. Salamander egg masses covered the north side of the larger pond. An adult frog was photographed in the larger pond. Two zooplankton tows were made at 1900 and 1920 hours in the larger pond.

August 9, 1993, Third Trip

This was a very special research trip. Several students from Rogue Community College accompanied the author. The day was spent observing the ponds and collecting samples for later study. Some of these student reports are included in Appendix II.

The plan was to allow a student to study a single pond. In this way several ponds would be studied in detail. An *in situ* probe was used to measure pH, temperature, and conductivity. Water samples were taken and analyzed for dissolved oxygen and phytoplankton (Table 1). The temperatures of the ponds ranged from 23.7 to 16.6° C, the conductivity from 7.6 to 16.6 μMho/cm, the pH from 5.23 to 5.69 units, and the dissolved oxygen concentrations from 4.50 to 6.69 mg/L (Table 2). Ponds observed on this field day included **#0, 3, 4, 6, 9, 10,** and **11**. Notes on special conditions follow.

Table 2. August 9, 1993 observations of Whitehorse Ponds with Rogue Community College students.

Student Pond Reports								
9-Aug-94								
Pond Number	0 SE	3	4	6 north	6 south	9	10	11a
Temp		16.6	18.5			16.7	23.7	22.8
pH		5.23	5.33			5.69	5.39	5.49
Cond		<10	7.6			<10	16.6	
D. Oxy		4.5 to 6.5	5.41			5.25	6.69	4.5 to 6.5
Color		Brown		red brown	clear	Root Beer /clear	Clearer than most ponds	
Animals		Polywogs Deer/Elk tracks Water bugs 2.5 inch shrimp	Polywogs Elk tracks	no shrimp daphnia no water skippers polywogs no animal tracks	Elk/deer tracks quail, grouse track shrimp daphnia no polywogs	Elk tracks Deer tracks frogs/polywogs Squirrel scratchings water bugs	tadpoles shrimp deer/elk prints	Shrimp Ants Elk Track
Shade	95%	50% at 12:30				50%		
Plants						50 foot trees surround Logs in pond		
Size	20 ft X 40 ft	8 to 10 in deep				60 ft X 50 feet X 1.5 fee	100 ft X 20 ft X 1 ft	
Notes	depth 1 inch	three small logs in pond Temp in sun = shade				Water low despite a wet winter	1/3 original volume full size 240 ft X 90 ft	

Pond #0 SE is not shown on any map. However two students selected it for study. Surrounded by tall trees, it was well shaded. The bottom was covered with grass and had only about an inch of water in it. Several zooplankton were collected and drawn in the lab at Rogue Community College (RCC). No chemical sampling was completed here since it was so far away from the main group of ponds. It lies far to the south east on the bluff.

Ponds #1 and 2 were not observed. Pond #3 was a tea brown color. This pond had the coolest water and the temperature changed little in the sun or in the shade. The conductivity of this water was less than 10 μMho/cm.

Pond #4 was observed and had several parameters recorded for it (Table 1). Pond #5 was not observed. **Pond #6** had dried into two basins by this date. The north and south basin were not similar in many respects. Pond #6 north was a reddish color and had many pollywogs with shrimp and animal tracks around it. Pond #6 south was clear and had numerous elk and deer tracks along the shore as well as the tracks of grouse and quail. There were shrimp in this south pond but no pollywogs. These two basins were very different from each other on this date.

Ponds #7 and 8 were not observed on this date. **Pond #9** was sampled and another pond to the east of the main pond was discovered. We called the unmapped pond, **#13** or **Pond #9 east**. **Pond #9** was a root beer color. It had elk tracks as well as pollywogs and frogs in evidence. There were logs in the pond and it was half shaded by 50 foot tall hemlock trees.

Pond #10 was the warmest pond observed and had a temperature of 23.7° C. It also had the highest conductivity of 16.6 μMho/cm. This pond was clearer than most ponds and was observed to contain shrimp. It was about one third of its filled size.

Pond #11a also had shrimp. It was quite warm with a temperature of 22.8° C. **Pond #12** was not observed on this date.

August 21, 1993, Fourth Trip

The author was accompanied by Mr. David Hartesveldt and Mr. Larry Beard and family on this field trip. The Beards and the author worked together to sample the ponds for chemical and biological specimen as well as physical and chemical parameters. Mr. Hartesveldt crisscrossed the Bluff several times observing the flora in and around the ponds.

The tour began at **Pond #7C**. Pollywogs were noted in great numbers. They had bodies about one centimeter in diameter and tails of about 2.5 cm. They also had external gills. A zooplankton tow was completed on the pond's surface. The pH was measured at 5.98 at 15.1° C at 1150 hours. The depth of the pond was 35 cm. Several egg clusters were seen on the shore with 50 or more 0.5 mm eggs per cluster.

Pond #7A had about 80 cm of water in it with a pH of 6.20 at a temperature of 13.2° C. There were two types of pollywogs in this pond, the first type had external gills and the other had no external gills. This second pollywog was round with a white belly and iridescent. A pond sample was taken from this pond for chemical nutrient analyses at CCAL (Table 3).

Pond #6 was observed. It was turbid and about 12 cm deep. There were few pollywogs in this pond. It appeared to be drying fast.

Pond #4 was grass covered and had one centimeter long dark toads all around it. These toads numbered about 30/m^2. What water there was looked turbid. The bank was covered with elk tracks in the wet mud.

Table 3 Chemical Concentrations for Several Whitehorse Ponds.

Whitehorse Pond Study

Date	Location	ALKAL HCO3-C (mg/L)	COND uMHO/cm	TOT-P (mg/L)	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Cl (mg/L)	SO4 (mg/L)	N03/NO2 (mg/L)	pH (units)
23-Aug-93	WH-3	0.51	4.2	0.019	0.38	0.23	0.16	0.058	0.250	T	BD	5.7
23-Aug-93	WH 7-A	0.81	7.2	0.045	0.52	0.32	0.46	0.098	0.190	T	0.003	6.0
23-Aug-93	WH-9	0.54	4.6	0.008	0.14	0.11	0.24	0.068	0.070	T	0.003	5.7
13-Sep-93	WH-7A	0.66	10	0.041	0.77	0.53	0.46	0.106	0.550	T	0.002	5.6
Jan 87/Sept 88	*CRLA Precip			0.005	0.072	0.067	0.093	0.024	0.375	0.362	0.036	
84-89	*CRLA Springs	5.5-18.1	23-99	0.023-0.075	1.4-4.6	1.56-.46	.94-10.5	0.51-2.9	0.38-1.33	0.09-8.80	0.002-0.0898	7.13-7.71
82-90	*CRLA Lake	24.3-31.0	80-121	0.029	10-11	1.5-1.9	6.3-7.8	2.6-2.9		3.4-3.5	0 - 0.016	7.1-7.9

* In Crater Lake Limnological Studies Report, July 1993

Pond #3 was 18.3° C and had a pH of 5.56. There were water striders and dragon flies at this pond. A chemistry nutrient sample was taken for CCAL. The pond was 95% exposed to direct sunlight. Grass was found high out of the water, under the water, and rooted at the bottom of the pond but floating on the surface. There were young salamanders with all four legs and about 8 cm long. An 8 to 10 cm frog was found. It had blue ear areas. This pond measured 60 cm deep and the bottom was covered with rocks and branches.

Pond #2 was 70% shaded and had a temperature of 17.4° C and a pH of 5.55. The pond was tea colored. Salamander pollywogs with external gills were observed.

Pond #5 was passed and was discovered to be dry on this date.

Ponds #11A and **B** were discovered to be dry and covered with moss. This made a very soft bed on which to lie.

Pond #9 was sampled for chemistry nutrient analyses for CCAL. It had salamander pollywogs which were 5 cm long. There were other salamander pollywogs evident with external gills. The temperature was 22.3° C and the pH was 5.59.

Pond #9 East or **Pond #13** had shrimp and was very dark in color. The temperature was 22.0° C and the pH was 5.55.

September 10, 1993, Fifth Trip

We expected that at some time the ponds would be dry. On this field day all ponds were quickly visited and found to be dry except **Pond #7A** and **D**, and **Pond #1**. The ponds were visited between 1540 and 1810 hours. The temperature of **Pond #7a** was 23.5° C, pH was 5.92, and the dissolved oxygen concentration was 7.29 mg/L. A chemistry nutrient sample was taken for

CCAL. A zooplankton tow was completed at **Pond #7D**. Although there was no water, there was an elk wallo in **Pond #12**.

3.2 Plankton

3.2.1 Phytoplankton

Three phytoplankton samples were obtained from three different ponds (Table 4). Pond WH9 was sampled on August 9, 1993, as was pond WH11A. Nine alga taxa were identified in both ponds. Pond WH7A was sampled on September 10, 1993, and only 4 taxa were identified. The species number and their corresponding division, individual species biovolume and species name are arranged in Table 5.

Ponds WH9 and WH11A, both collected on the same date, show many similarities quite different from pond WH7A (Table 4). Nine taxa were identified in WH9 and WH11A, both had similar total cell densities (5289.54 and 4768.45 cells/L, respectively) and biovolumes (224928.79 and 348983.87 $\mu m^3/L$). Pond WH7A, with 4 taxa, had a total cell density of 155900.31 cells/L and total biovolume of 14288870.0 $\mu m^3/L$.

The dominant taxa varied for each pond (Table 4). Pond WH9 was dominated by *Diogenes sp.* and *Synechocystis sp.*, both cyanobacteria with combined cell density of 79.1% and the cryptophyta were 10.9%. In cell biovolume the cryptophta were dominate (65.4%) and the cyanobacteria were greatly reduced (15.4%). Pond WH11A was dominated by a statospore (or cysts) and *Chromulina sp.*, both chrysophytes and had a combined cell density of 82.0% and euglenaophyta had 0.5%. The cell biovolume was 12.7% and 56.0% for chrysophta and euglenaphyta, respectively. Pond WH7A had only one taxa dominate (both in cell density and biovolume), *Chlorella sp.*, in the division chlorophyta (Table 4).

Table 4 Ponds sampled for phytoplankton, date sampled, species codes, cell density and biovolumes, and their proportional abundances.

POND	SAMPLE DATE	SPECIES CODE	CELL DENSITY (cells/L)	PROP. ABUND. (%)	CELL BIOVOLUME (um^3/L)	PROP. ABUND. (%)	
WH9	8/09/93	251	2289.50	43.3	31366.0	13.9	
		174	578.95	10.9	147050.0	65.4	
		156	263.16	5.0	26711.0	11.9	
		272	52.63	1.0	431.6	0.2	
		246	1894.76	35.8	3410.6	1.5	
		100	78.95	1.5	1357.9	0.6	
		135	78.95	1.5	1357.9	0.6	
		109	26.32	0.5	13028.0	5.8	
		273	26.32	0.5	215.8	0.1	
			5289.54	100.0	224928.8	100.0	TOTAL
WH11A	8/09/93	273	2527.28	53.0	20724.0	5.9	
		135	1382.85	29.0	23785.0	6.8	
		251	286.11	6.0	3919.7	1.1	
		156	309.95	6.5	31460.0	9.0	
		173	47.68	1.0	49683.0	14.2	
		174	71.53	1.5	18169.0	5.2	
		275	23.84	0.5	195040.0	56.0	
		252	23.84	0.5	6031.5	1.7	
		246	95.37	2.0	171.7	0.1	
			4768.45	100.0	348983.9	100.0	TOTAL
WH7A	9/10/93	156	128617.76	82.5	13055000.0	91.4	
		251	21046.54	13.5	288340.0	2.0	
		140	5456.51	3.5	747540.0	5.2	
		174	779.50	0.5	197990.0	1.4	
			155900.31	100.0	14288870.0	100.0	TOTAL

Table 5 Phytoplankton species identified and their corresponding codes, divisions, and individual cell biovolumes.

SPECIES CODE	DIVISION	CELL BIOVOLUME	SPECIES NAME
100	CHR	17.2	Chrysophyta, unidentified
109	BAC	495.0	Synedra mazamaensis Sov.
135	CHR	17.2	Chromulina-like sp.
140	CHR	137.0	Ochromonas CL4
156	CHL	101.5	Chlorella sp. (combined 156 & 157)
173	CRY	1042.0	Rhodomonas lacustris Pascher et Ruttner
174	CRY	254.0	Rhodomonas minuta var. nannoplantica Skuja
246	CYN	1.8	Synechocystis sp.
251	CYN	13.7	Diogenes sp.
252	CHL	42.7	Chlamydomonas Cienkowskii Schmidle
272	CHL	8.2	Franceia sp.
273	CHR	8.2	statospore or cysts
275	EUG	8181.2	Euglena elastica Prescott

Division Key: BAC=Bacillariophyta, CHL=Chlorophyta, CHR=Chrysophyta, CRY=Cryptophyta, CYN=Cyanobacteria, EUG=Euglenophyta

On a divisional level, all ponds had a fairly even distribution (Table 6). Pond WH11A had two taxa each of Chlorophyta, Chrysophyta, Cryptophyta, and Cyanobacteria; and one taxon of Euglenophyta. Pond WH7A had one taxon in Chlorophyta, Chrysophyta, Cryptophyta, and Cyanobacteria. Pond WH9 was slightly different with three Chrysophyta, two Chlorophyta and cyanobacteria, one Bacillariophyta and one Cryptophyta.

Table 6 Phytoplankton samples compiled into taxonomic divisions, number of taxa present, and their proportional abundance

POND	SAMPLE DATE	DIVISION	NUMBER OF TAXA	PROP. ABUND. (%)	PROP. ABUND. (%)
WH9	8/09/93	CYN	2	79.1	15.4
		CHL	2	6.0	12.1
		CHR	3	3.5	1.3
		CRY	1	10.9	65.4
		BAC	1	0.5	5.8
WH11A	8/09/93	CYN	2	8.0	1.2
		CHL	2	7.0	10.7
		CHR	2	82.0	12.7
		CRY	2	2.5	19.4
		EUG	1	0.5	56.0
WH7A	9/10/93	CYN	1	13.5	2.0
		CHL	1	82.5	91.4
		CHR	1	3.5	5.2
		CRY	1	0.5	1.4

3.2.2 Zooplankton

The zooplankton exhibited more diversity than did the phytoplankton, probably as a result of the greater number of samples and the larger period of time over which the zooplankton samples were obtained.

There were eleven zooplankton samples taken over a period from July 14 - Sept. 10, 1993 (Table 8). From those samples, 18 different organisms were identified; 8 rotifers, 3 cladorcerans, 2 calanoid copepods, 2 cyclopoid copepods, 1 nauplii (combined both calanoid and cyclopoid), 1 fairy shrimp, and 1 seed shrimp (Table 7). The number of species identified within each sample, ranged from a low of two in FROG1 (7/14/93) to a high of 8 species in 4 ponds; BEAR1 (7/14/93, a surface tow), WH3 (8/21/93), WH7C (8/21/93), and WH7D (9/10/93) (Table 8). In comparing the proportional abundance, the dominate species was *Diaphanosoma brachyurum* Lieven (25.6%), a cladoceran, and the lowest was the seed shrimp and *Hexarthra mira* at 0.3% (Table 9). On a divisional basis, the cladocerans had the highest proportional abundance (39.8%) and the seed shrimp the lowest (0.3%).

The percent similarity, in which all species identified within a sample are used in comparing between all samples, showed that ponds FROG1 and WH11A had the greatest similarity at 92.4%, and the two BEAR samples at 80.2% (Table 10). Sample BEAR2 had no percent similarity (0.0%) with three other samples , FROG1, WH11A, and WH13. Nine other sample combinations had similarities over 50%. Of the total different possible similarity combinations (55), 31 were less than 25% similar.

Table 11 shows the compilation of zooplankton taxa into divisions. The sample BEAR1, with eight taxa, had the greatest number of divisions, six. Two samples, FROG1 and WH11A had only 2 divisions and 2 and 3 taxa, respectively.

TABLE 7. Zooplankton species list with their corresponding codes and taxonomic division.

SPECIES CODE	DIVISION	SPECIES NAME
1	CLA	Scapholeberis kingi Sars
2	CLA	Diaphanosoma brachyurum Lieven
3	CAL	copepodid (calanoid)
4	COP	nauplii (calanoid/cyclopoid)
5	CLA	Daphnia catawba
6	ROT	Conochilus unicornus
7	CAL	Diaptomus (aglaodiaptomus) leptopus S.A. Forbes
8	ROT	Synchetia stylata
9	CYC	Mesocyclpos Dybowskii Lande
10	ROT	Polyarthra remata
11	ROT	Lecane sp.
12	ROT	Keratella heimialis
13	CYC	copepodid (cyclopoid)
14	ANO	Fairy shrimp
15	OST	Seed shrimp
16	ROT	Keratella learis
17	ROT	Monostyla copeis
18	ROT	Hexarthra mira

Division Key: ANO=Anostraca, CAL=Calanoida, CLA=Cladocera, COP= Copepoda, CYC=Cyclopoida, OST=Ostracoda, ROT=Rotifera

TABLE 8. Zooplankton sample ponds, dates sampled, species identified and cell densities (organisms/m^3).

POND	SAMPLE DATE	SPECIES ID	DENSITY (ORG/M^3)
FROG1	7/14/93	2	26694.57
		3	21527.81
FROG2	7/14/93	1	3555.51
		3	16888.85
		2	4000.04
		4	444.54
BEAR1	7/14/93	6	9111.03
		9	444.54
		13	2000.02
		14	444.54
		4	1110.95
		15	444.54
		16	1110.95
		2	222.27
BEAR2	7/14/93	6	30222.19
		13	5333.26
		17	5333.26
		4	3555.51
		8	1777.75
21-9	8/09/93	2	8000.08
		6	23111.18
		3	6666.87
		5	9333.30
		8	2222.29
		9	444.54
		4	444.54
WH11A	8/09/93	2	68444.47
		3	42666.86
		1	2666.83
WH3	8/21/93	10	1444.35
		4	8111.22
		1	333.40
		3	1110.95
		6	10555.78
		2	999.81
		9	333.40
		7	333.40

POND	SAMPLE DATE	SPECIES ID	DENSITY (ORG/M^3)
WH7C	8/21/93	11	444.54
		7	2666.83
		8	3110.97
		2	11111.05
		10	2666.83
		4	444.54
		1	444.54
		12	444.54
WH9	8/21/93	1	3333.24
		2	889.07
		7	555.67
		4	444.54
		9	111.13
WH13	8/21/93	2	111.13
		1	222.27
		10	111.13
		11	222.27
		14	222.27
WH7D	9/10/93	2	16444.31
		13	2222.29
		12	1777.75
		5	10214.13
		8	889.07
		7	2222.29
		9	444.54
		18	1333.22

TABLE 9. Zooplankton species, number of ponds where identified and proportional abundance, total ponds sampled and corresponding proportional abundance based on if species was found in all ponds.

SPECIES ID	PONDS W/SP.	PROP.ABUND. (%)	TOTAL PONDS	PROP.ABUND. (%)
1	6	17.9	11	9.8
2	10	28.1	11	25.6
3	5	33.6	11	15.3
4	7	15.8	11	5.7
5	2	23.7	11	4.3
6	4	54.5	11	19.9
7	4	7.7	11	2.8
8	4	6.3	11	2.3
9	5	1.7	11	0.8
10	3	10.4	11	2.8
11	2	13.5	11	2.5
12	2	3.5	11	0.6
13	3	10.4	11	2.8
14	2	14.0	11	2.5
15	1	3.0	11	0.3
16	1	4.5	11	0.7
17	1	11.5	11	1.0
18	1	3.8	11	0.3

TABLE 10. Percent similarity between ponds using zooplankton species comparisons.

Percentage Similarity

	FROG1	FROG2	BEAR1	BEAR2	21-9	WH11A	WH3	WH7C	WH9	WH13	WH7D
FROG1	100.0										
FROG2	60.7	100.0									
BEAR1	1.5	3.3	100.0								
BEAR2	0.0	1.8	80.2	100.0							
21-9	29.2	30.1	49.3	50.7	100.0						
WH11A	92.9	55.9	1.5	0.0	29.2	100.0					
WH3	9.1	12.3	55.8	53.1	56.3	10.5	100.0				
WH7C	52.1	19.9	3.6	5.9	21.2	54.2	15.5	100.0			
WH9	16.7	32.1	11.0	7.7	17.7	19.0	16.9	31.3	100.0		
WH13	12.5	26.8	4.5	0.0	12.5	14.8	12.0	29.2	37.5	100.0	
WH7D	46.2	16.1	9.0	8.8	37.9	46.2	7.0	57.1	24.2	12.5	100.0

TABLE 11. Zooplankton ponds sampled, date sampled, compilation of taxonomic divisions represented and number of taxa identified in sample.

SAMPLE	SAMPLE DATE	DIVISION	NUMBER OF TAXA
FROG1	7/14/93	CAL	1
		CLA	1
FROG2	7/14/93	CAL	1
		CLA	2
		COP	1
BEAR1	7/14/93	ANO	1
		CLA	1
		COP	1
		CYC	2
		OST	1
		ROT	2
BEAR2	7/14/93	COP	1
		CYC	1
		ROT	3
21-9	8/09/93	CAL	1
		CLA	2
		COP	1
		CYC	1
		ROT	2
WH11A	8/09/93	CAL	1
		CLA	2

SAMPLE	SAMPLE DATE	DIVISION	NUMBER OF TAXA
WH3	8/21/93	CAL	2
		CLA	2
		COP	1
		CYC	1
		ROT	2
WH7C	8/21/93	CAL	1
		CLA	2
		COP	1
		ROT	4
WH9	8/21/93	CAL	1
		CLA	2
		COP	1
		CYC	1
WH13	8/21/93	ANO	1
		CLA	2
		ROT	2
WH7D	9/10/93	CAL	1
		CLA	2
		CYC	2
		ROT	3

3.3 Flora Survey Results

The White Horse Ponds were located within a mosaic of forest communities of which red fir and lodgepole pine forest were the most important. The dominant overstory tree was Shasta red fir (*Abies magnifica* var. *shastensis*) which, in combination with mountain hemlock (*Tsuga mertensiana*), provided a nearly closed canopy over large areas of the bluff top. Other trees observed included lodgepole pine (*Pinus contorta* ssp. *murrayana*), western white pine (*Pinus monticola*) and subalpine fir (*Abies lasiocarpa*).

The ponds themselves supported a limited flora of vascular plants. Two aquatic plants, western quillwort (*Isoetes occidentalis*) and small bur-weed (*Sparganium natans*), were observed in Pond Three, the largest and deepest of all the ponds. These species were not observed in any other ponds. Two additional species, water sedge (*Carex aquatilis*) and narrow-spiked reedgrass (*Calamagrostis inexpansa*), were observed growing as emergent vegetation along the shallow margins of most ponds occurring on the White Horse Bluffs. Drummond's rush (*Juncus drummondii*) was observed occasionally along the waterline of Pond 7, as was a single specimen each of broad-leaved twayblade (*Listera convallarioides*) and corn lily (*Veratrum viride*). These latter two species were not observed within, or adjacent to, any of the other ponds.

Transitional between the aquatic habitat of some ponds (e.g. Ponds Four and Seven) and the more xeric upland habitat of the greater portion of the bluff top were the mesic embankments. These embankments supported dense stands of grouse whortleberry (*Vaccinium scoparium*) and sparse stands of big whortleberry (*Vaccinium membranaceum*). Other species occasionally observed included western wintergreen (*Gaultheria humifusa*) and dwarf bramble (*Rubus lasiococcus*). Much of Pond Four has been filled from sedimentation such that little aquatic habitat remains. Narrow-spiked reedgrass, western wintergreen, alpine everlasting (*Antennaria media*) and mountain spiraea (*Spiraea densiflora*) all contributed to the turf of the developing meadow.

The understory of the remainder of the White Horse Bluffs comprised sparse to dense stands of low shrubs, grasses and forbs. The dominant shrub was grouse whortleberry which was primarily associated with low poorly drained areas of the bluff top which were densely shaded by overstory trees. Open rocky areas supported low stands of pinemat manzanita (*Arctostaphylos nevadensis*) and small clumps of sulfur flower (*Eriogonum umbellatum*). Other understory species observed included Parry's rush (*Juncus parryi*), Ross' sedge (*Carex rossii*), big squirrel tail (*Elymus multisetus*), white-flowered hawkweed (*Hieracium albiflorum*), Scouler's hawkweed (*Hieracium scouleri*), and sandwort (*Arenaria arculeata*).

4.0 DISCUSSION

4.1 Physical Characteristics

The Whitehorse Ponds were visited several times in 1993. Compared to Crater Lake itself, these ponds experience great physical extremes. In winter they are covered with several feet of snow and in spring the fast melting snow flushes each pond and fills it with seasonal water. The quality of the ponds depends completely on the quality of the precipitation.

This study included physical, chemical, phytoplankton, zooplankton, and floral studies. Observations were included on each pond visited. The ponds were visited between July 14 and September 10, 1993. In this brief period the water temperatures varied from 13 to 24° C, the acid concentration or pH varied from 5.55 to 6.20, dissolved oxygen levels were low and varied from 4.5 to 6.7 mg/L and the conductivity of the pond water varied from 7.6 to 16.6 μMHO/L.

Comparing pond chemical concentrations with a bulk deposition study (precipitation and dryfall) completed in 1988, a caldera spring study 1984/89 and chemical species in the Lake itself 1982/90, interesting relationships are revealed (Table 3). Chemical concentrations paralleled the concentrations of a bulk deposition study completed in September 1988 (Larson, 1993). All chemical species determined were of similar concentration except nitrate and sulfate ions. Nitrate ion was found to be 18 times less concentrated in the ponds than in Crater Lake precipitation. Nitrate ion, an important nutrient, was probably being taken up by plants in and around the ponds. Sulfate ion was also found in very small concentrations in the ponds about 100 times less than in Park precipitation. Total phosphate, sodium, potassium, calcium, magnesium, and chloride were all similar in concentration when compared to precipitation.

When Crater Lake water chemical specie concentrations were compared to pond water concentrations, they ranged from similar, as in total phosphate, to 50 times greater for alkalinity. All the other chemical species were in the 8 to 20 times range greater in the Lake. The ponds are probably fed by precipitation alone. Changes in the quality of the precipitation would certainly affect the ponds.

4.2 Plankton Discussion

With only three phytoplankton samples, it is difficult to interpret much. However, with six of the eight freshwater algal divisions represented, the population data suggest the possibility of more eutrophic, than oligotrophic, systems. It is also known that euglenoids require particular organic inputs (i.e. B-12) and therefore, further leads towards more organically rich systems. The greater diversity of taxa, during the August samples, as opposed to the much reduced taxonomic number, but thirty fold increase in cell densities of the September sample, suggests a reduction in nutrients (i.e. available nutrients bound up), higher water temperatures (the dominance of cyanobacteria and the *Cholorella sp.*), and light intensity. The herbivory by the zooplankton is surely of some effect upon the phytoplankton also.

The two Frog Pond (Pond #9) samples are both "surface tows", with FROG1 from the shore and FROG2 from the central part of the pond. Both FROG samples are dominated by a large filter feeding cladoceran, *Diaphanosoma brachyurum* Lieven and a selective feeding copepodid, both herbivores. FROG2 sample contained *Scapholeberis kingi* Sars, a small cladoceran filter feeder and nauplii, also a small filter feeder. All these taxa represent a propensity toward feeding on small phytoplankton, as represented by the majority of phytoplankton identified. The *D. brachyurum* can also select larger and more motile phytoplankton (as the smaller *Rhodomonas* and the *Chromonas* sps. identified). The copepodid, an intermediate stage between nauplii and adult calanoid or cyclopoid copepoda, have the ability to individually select and manipulate food and as more active swimmers are adapted to exploiting the niche held by those areas of higher phytoplankton concentrations and largest of the species (the larger *Rhodomonas* sp. and *Synedra* sp.).

The BEAR samples (BEAR1 and BEAR2) are shown to be >80% similar, even though BEAR1 is a surface tow, and BEAR2 is a bottom tow. The most unique difference in zooplankton between them is the presence of the fairy and seed shrimp, identified from BEAR1, the surface tow. Both of the shrimp species typically swim upside-down and filter feed just below the surface. The seed shrimp will also feed on the periphyton of submerged aquatic macrophytes.

There are three pond comparisons, based on the zooplankton identified, in which there was no similarity. All three comparisons involved BEAR2 sample. The first, is between BEAR2, a bottom sample, with FROG1, a surface sample. Suggesting a strong difference between zooplankton assemblages throughout the water column, even in depths as shallow as 1.5-2 meters. This was further suggested by pond sample WH13, in which the fairy shrimp was again identified, an indication that WH13 is also a surface sample. Pond sample WH11A was the third comparison with no similarity and again, with BEAR2. Indicating that WH11A was either a surface tow or a similar, but more shallow pond.

There was a large diversity in the zooplankton identified, however little seasonal variability was shown. Thirteen taxa were present in less than five samples and of the remaining five taxa, three were present throughout the sampling period. Only the cladocerans, *S. kingi* and *Daphnia catawba* exhibited possible change. *S. kingi* was present in July and August but not the September sample. *D. catawba* was not identified in July but was in the August and September samples.

This short study, even with a scarce number of samples, does suggest possible trends within the water column and seasonally, over time. Greater sampling within several ponds over time would be more helpful and highly suggested.

4.3 Flora Discussion

Twenty-nine taxa of vascular plants were identified during the floristic survey of the White Horse Ponds conducted on August 21, 1993. This survey effort was sufficient to generally characterize the flora of the ponds and their immediate vicinity. It is likely, however, that the vascular flora of this region is considerably more diverse than these survey results indicate. Additional surveys in July, September, and, even, October would be useful in fully assessing the diversity of vascular plants of the White Horse Bluffs.

5.0 GENERAL CONCLUSIONS

This study of the ponds on Whitehorse Bluff was proposed to be an introduction to the many features exhibited by the ponds. The water quality was documented as well as the phytoplankton and zooplankton communities. An initial floral survey was made. It is evident now that there are many aspects of these ponds which would make very interesting studies in the future.

Phytoplankton were sampled three times. The two samples taken on August 9 from two separate ponds were very similar in population with nine taxa identified in each and biovolumes of 225,000 and 350,000 μm^3/L. The single sample from September 10 contained only four taxa but had a biovolume of 14,300,00 μm^3/L. There was a great diversity and biovolume of phytoplankton for such small water bodies. Further study will probable reveal that this study underestimates the true diversity in the phytoplankton community.

Reviewing all the plankton data suggest that the Whitehorse ponds were eutrophic in quality with a high amount of organic material present. The pond color supports this as well as the presence of the euglenoids that require certain organic materials to live. Phytoplankton cell densities increased 30 times in September due to a reduction in nutrients, higher temperatures, and greater light intensities as Bob Truitt has suggested. However chemical analyses do not support the nutrient suggestion. However, it has been documented that later in the summer the number of phytoplankton specie decrease and the cell densities increase. More study into this trend would reveal interesting relationships.

Zooplankton were more diverse than the phytoplankton. Similarity indices indicated that different ponds also had unique zooplankton communities. Zooplankton seem to feed on the smaller phytoplankton. There was a documented difference in the zooplankton assemblages on a pond's surface and on the pond's bottom. This was seen to be true even in very shallow ponds about 1 m deep. The large diversity in zooplankton depended little on the date of collection. A greater number of samples through time and for each pond would also document very interesting trends in zooplankton community structure.

The single day's floral survey documented twenty-nine taxa in and around the ponds. Study of plants in the Whitehorse Bluff area over a summer would surely add to the listing begun by David Hartesvelt. He suggested that the bryophytes alone are deserving of a more complete survey. The bryophytes were observed but not documented here.

The Bluff contained several environments including ponds, wet shores, moist forest, and xeric or dry forest floor. The plants observed were as varied as these environments. The forest contained the Shasta red fir, mountain hemlock, and lodgepole pine, western white pine, and subalpine fir. In the pond area aquatic plants included western quillwort, small burweed, water sedge, and narrow-spiked reedgrass. Further from the ponds the more xeric plants were documented and included whortleberry, pinemat manzainta, and sulfur flower.

Finally, the authors of this report have each suggested that these ponds are each very unique and exhibit great changes in water quality and plant and animal diversity through the seasons. It would be difficult to establish trends and relationships given this limited data set. However, it would be very interesting to begin a study of the ponds at snow melt and continue through the entire summer season to the snows of winter the following winter in any of these areas. Actually the pond study could continue through winter with sampling continuing using snow boring equipment. The results of this type of study would lead to a wealth of information documenting the health and quality of these shallow water bodies.

The significance of this single study has been to document the chemical, physical, and biological conditions of the Whitehorse Ponds area through a single short summer season. By continuing this study, the National Park Service at Crater Lake can make a significant contribution to our understanding of three major environmental concerns:

1. How is the airshed affecting the water shed on Whitehorse Bluff? Is the Cascades themselves changing in water quality?

2. Before chemical analyses can identify without doubt a change in water quality, the plants and animals living in a around a water body have changed noticeably. By continuing to monitor the biota associated with these ponds the NPS may detect early warnings of a change in Southern Oregon waters.

3. Finally, this initial survey could have been directed in several directions. Here the physical, chemical, and biological areas of study were used to document pond conditions. Future work should include a survey of the bryophytes and the amphibians associated with each pond. It has been suggested an increase in UV radiation may be causing a drastic decrease in amphibians (, 1994). A herpetological survey in the future would document the present condition of these indicator species.

If the NPS and the CRLA-NHA can continue this and similar water quality studies in and around the Park, there will be a great resource of information documenting water quality, population characteristics of phytoplankton and zooplankton, plants, and animals of wetland and pond areas. Returning to the ponds in the future would further document changes in the ponds due to changes in precipitation and its effect on this small watershed. These studies will eventually become a very significant resource documenting major trends in aquatic ecosystems in the Southern Oregon region.

6.0 REFERENCES

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7.0 APPENDICES

I. Scope of Work

II. RCC Student Observations

III. Plankton Data

IV. Flora Listing

Appendix I. Scope of Work

A Limnological Survey of the Whitehorse Ponds

in

Crater Lake National Park

A Research Proposal Submitted to the

Crater Lake Natural History Association

by

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Rogue Community College
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Grants Pass, OR 97527

503-471-3519

January 28, 1993

Abstract

Crater Lake National Park has several delicate wetlands within its boundaries. These include streams, bogs, and ponds. The author has been involved with water quality in the Park's Lake Research Program since its inception in 1982. Several of the Park's ponds, Whitehorse, Quilwort and Sphagnum ponds, will be studied specifically for chemical, physical, biological, and geologic characters. Several Park ponds will be visited each month. Ponds which tend to dry in summer may be visited more often in the spring.

Samples of water will be analyzed for the basic nutrients as well as microscopic organisms. Photographs will help document the physical setting and water levels through the summer. Aquatic organisms present will be photographed and samples collected if requested.

A final report will include a summary of changing conditions of each of the dozen or so Whitehorse ponds studied through the summer. This research may continue for several years depending on the availability of funding. This data base will help park managers to understand and protect these little known resources.

Historic Research

Work on the ponds of Crater Lake National park has been sporadic. Several researchers interested in the water and ecology of the park have visited ponds. Employees of the National Park Service have spent some time studying a few of the park's ponds.

One of the most recent surveys was completed in 1992 by a ranger interpreter, Roger Brandt. His report, "Survey of Ponds in Crater Lake National Park and Their Response to the Lowest Record of Precipitation in the History of the Park" documents pond conditions after a series of low precipitation years.

His report also documented the presence of aquatic plants, invertebrates, amphibians, and other animals at each pond. The ponds which will be surveyed and sampled for limnological parameters are all in the area of Whitehorse Bluff.

Other biologists who have visited the Park's ponds will be identified and questioned as a part of this project. The Park's museum will also be searched for historic collections and field data.

Research Objectives

This research proposal will:

1. Document the physical and biological conditions of the dozen Whitehorse ponds throughout the summer,

2. Sample several of the ponds biweekly for nutrients, physical conditions, phytoplankton, and zooplankton,

3. Record the presence and quantity of amphibians, mammal tracks, and other large animals,

4. Review Park records for information on the Park's ponds and include it in this study.

Project Design and Methodology

This preliminary survey of the Whitehorse ponds will begin a data base. The project will attempt to document the physical, biological, chemical, and geological aspects of these ponds. Observations will be collected as often as every two weeks for ponds that typically become dry during the summer season. Other more stable ponds will be sampled each month for a minimum of four visits each.

Field tests of pond water involving the pH, conductivity, dissolved oxygen, alkalinity and temperature will be completed in the park using the park water lab. Further chemical testing will involve filtering and icing water samples and sending them to the Forestry Science Lab for nutrient testing. There nitrate, nitrite, ammonia, phosphate, silicate, ammonia, pH, alkalinity, conductivity, total solids, and trace metals will be determined.

Water samples will be taken and studied for phytoplankton and zooplankton. These samples will be preserved in the field and sent off for organism identification and enumeration. Park staff may recommend labs to accomplish this work.

AMPHIBIANS

Field data will be recorded which will document the physical features of the pond. Photodocumentation will be used to chart the changing conditions of these ponds throughout the summer. As with Roger Brant's inventory, mammal tracks, invertebrates, unique plants, and outward water quality will be recorded. Physical parameters to be recorded will include temperature, aspect, exposure or percent canopy, depth, area, and volume.

Facilities

Park facilities to be used in this research will include the museum, library, and the water lab. Water samples will be packaged for shipping to scientists and labs across the State for specific chemical and biological testing.

Budget

Travel (per trip)	7 trips	1400 miles	$ 364.00
Expendables			$ 300.00
Chemical Analyses	12	$55.00	$ 660.00
Trace Metals	10	$30.00	$ 300.00
Phytoplankton	10	$40.00	$ 400.00
Zooplankton	10	$40.00	$ 400.00
Report Preparation			$ 500.00
		Total	$2924.00

Travel The distance from Rogue Community College to Crater Lake National Park is 100 miles. The Whitehorse Bluff will be visited a minimum of seven times.

Expendables Materials used to complete this project will include bottles for collecting phytoplankton and zooplankton samples, film and video tape, minimum/maximum thermometers, and various field and lab supplies.

Chemical Analyses The Forestry Sciences Laboratory will determine the nutrients and metals in the pond samples.

Biological Analyses A laboratory will be found to help identify the phytoplankton and zooplankton in several ponds. Bob Truitt (Corvallis), Jim Sweet (Portland), or Judy Li (O.S.U.) are possible scientists who could accomplish this work.

Report Preparation The publishing of a concise report including all data, observations, identifications, and pond information will be a large effort. This cost is for supplies and materials to present to the park a professional final report.

James Davis
573-21-3340

GS 199 Special Studies: Crater Lake
August 15, 1993

#9

Whitehorse Bluff Pond Survey

Samples taken Monday, August 9th at approx. 12:30 p.m..

Pond	#9 East
Oxygen Test	Sample #22 5.25 Using a 10 meter horizontal tow.
Zooplankton	Sample #C-8
Water Temp.	16.7 Celsius
pH	5.69
Conductivity	< 10

Appendix II. RCC Student Observations

Field Data

Mammal Tracks:

Elk tracks were found both around and inside the pond. Elk droppings were also found both around the perimeter and within the water. No visual sightings of the elk.

Deer tracks were found around the pond perimeter. No visual sightings.

Squirrel scratchings in the forest floor were numerous around the pond. Small six inch square areas were scratched out in the dirt and could almost be mistaken as a bear track.

A bird feather was found near the pond. It is approx. 9 inches long, light brown with a dark brown stripe across the tip and fading to gray/white at the base. No visual sightings.

Invertebrates:

Vertebrates!

There were several polliwogs in the pond. They were generally about an inch in length.

ok

Various water bugs were visible from the waters edge. Samples were taken. Mosquitos were plentiful.

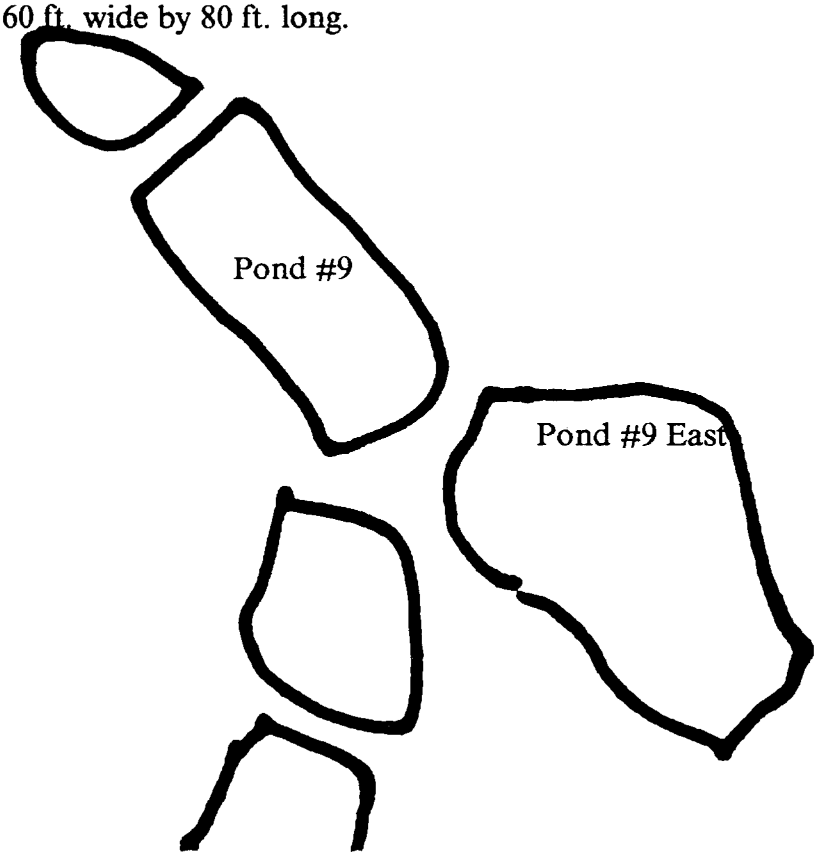
Field Data Continued

Outward Water Quality:

Water level seemed to be low despite the heavy snowfall last winter and the wet spring. The bottom of the pond was a "rootbeer" color. The water seemed to be very clear because the bottom of the entire pond was visible.

Physical Parameters:

Temperature was recorded at 16.7 celsius. 95% of the pond was exposed to the sun. 30--50 ft. hemlock trees surround the pond. The pond doesn't seem to be any deeper than 12 inches. Pond #9 East is approx. 60 ft. wide by 80 ft. long.

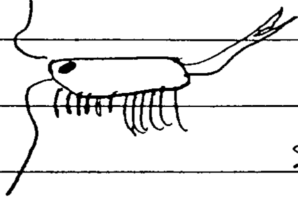


LAB DATA

Pond 9 East 8/11/93

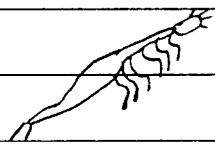
Sample C-8 8/9/93

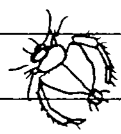
Zooplankton & Phytoplankton

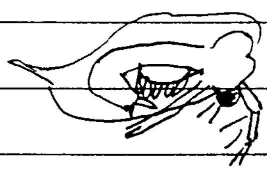
.5X 1)  clear body, visible internal organs
Some of these are in process of emerging from a [illegible]

15X 2)  clear with visible internal organs

15X 3)  brown with lighter eye

4)  6 legs altogether 3/4 in without magnificat[illegible]
light brown on top - clear unders[illegible]

5)  Water beetle (diving) 3/8 in without magnificati[illegible]
black body

[illegible] a cod 6)  clear eggshell, light brown body, trans[illegible]

.5x 7)  Pine pollen

Summary

The following is a summation of my collected data:

The samples were taken carefully.

All sample attempts were clean and successful on the first try.

Mammals frequent the area often.

Several different invertebrates live in and around the pond.

Water seepage and/or evaporation seems to be causing a low water level.

Most of the pond is exposed to direct sunlight.

The water contains a number of zooplankton and phytoplankton.

Monday, August 9th was a perfect day to take samples and observations at Whitehorse Bluff Ponds. The wind was minimal and the outside temperature was pleasant. I really enjoyed the hands-on science experience. Science was meant to be done and not just heard.

If you ever need volunteers to help take more samples or observations at Whitehorse Bluff Ponds, I'd be willing and eager to go.

Thanks for the experience.

CRATER LAKE FIELD STUDIES: LAB REPORT:

Miller, Richard
9 August, 1993

WHITEHORSE PONDS

After a hike in from highway 62 my partner Sharon and I studied what we thought to be Pond #4. Later we learned we were actually on the site of Pond ~~#11~~. 10

The pond which is about 100 ft. long and about 20 ft. wide had a depth of about 1 ft.. From the damp areas around to pond it has shrunk to about 1/3rd it's original size. The pond was quite open to the sun so was quite warm.

Preliminary readings were:

Temp	23.7° C
PH	5.39
uMHO	16.6

The pond and the surrounding area was teeming with life. Visible forms and shapes within the pond or surrounding area were:

- Tadpoles
- Large and small shrimp (all most like brine shrimp)
- Egg masses (small shrimp were eating these)
- Bees
- Mosquitos (if you think the Jurassic Raptors were bad, you should see these mosquitos)
- Assortment of pine needles and cones
- Green mosses and pond grass
- Flies
- Deer Prints
- Elk Prints
- A lot of Dead butterfly wings

There were signs of bear on the walk to and from the pond

It is interesting to note that at one end of the pond there was a space the water didn't cover then came a small pool about 6 ft. in diameter. It had a much higher concentration of small shrimp then the large pond; but there were no tadpoles.

A 10 meter drag was made with a plankton net and samples were viewed under a photo-microscope. (slides attached)

Even though this was a first visit to the Whitehorse Ponds it would be very interesting to return and locate and identify all of the ponds. A current aerial photo of the area overlayed over a BLM map would be very helpful. Another item of importance would be a good compass to use for orientation. As there are no marked trails, without the sun for guidence it would be very easy to get turned around on a cloudy day. Once more visits were made to the area this would no longer be a problem, but to the neo-phyte there could be a situation of dis-orientation.

Having said all that a really nice thing to add to the wish list would be a portable, battery operated LORAN unit. This would really help to pin point the location of the ponds with an accuracy of a few feet.

It was a great experience to see a part of the Park that most visiters don't get to see or even know about. Maybe thats good?

DIANE NABOZNY

Monday Lab #9 August 9, 1993

White horse Ponds

We all met at Mazama Village and drove to where we were to walk in to the ponds. We found the ponds but most were dry. In pond #4 there were lots of polly wogs. I took a picture of #4. Another pond I took a picture of had lots of shrimp and other bugs swimming in it. I don't know which pond it was but I do have a pictur of it. It seemed to have two kinds of shrimp, one was clear with the orange and the other was kind of pale blue. I got all my samples from this pond. I have one shrimp and two other swimming bugs.

In pond #4 all I could find was the pollywogs.

There were lots of Elk tracks and droppings all ~~other~~ over the place.

I never could find most people so I walked out after a while.

Day 3 Sunday August 8, 19

After the Boat Ride

We got back from the boat ride at about 4:30 pm. Five of us went to the restaurant and had dinner. The others that stayed Sunday night spent the night on Hao Rock. Elevation is about 8090 feet. The rest of us stayed in the campground another night. We had a fire and did marshmellows again. Good thing I brought wood with me, at $4, a bundle.

Day 4 Monday Lab August 9, 1993

We got up about 7 a.m. and proceeded to break camp. Then we all met at the store and had a meeting about what we were going to do at Whitehorse Ponds. John is doing some research studies at the ponds for some official people.

Day 4 Monday Lab August 9, 199[illegible]

We were going to take sample from each of the ponds, they were Numbered 1-12. Some zooplankton samples as well as oxygen samples. We were to take note of animal tracks and plant life. We used a net to take zooplankton samples. Another piece of equipment took the oxygen samples. All Kinds of tests and samples are taken at the ponds to study them to see what lives in them and what happens if they dry up; Do the amphibians die or what happens to them?

We were each given a plastic bottle for a sample to look at when we got back to school. We are supposed to record what we find and look them up in books to see if they are in there and what they are.

Sharan Swanson

Crater Lake-Lab

Pond ~~11~~ ~~4~~ 10

cel.-23.7--24.5

PH-5.39

u-Mho-16.6

Inventory;

Deer prints

Elk prints

water beetles

Mosquito's

Bee's

Flies

butterfly wings

Large shrimp

Small shrimp

circle worms

pine needles

cones

green moss between ponds

Pollywogs

Dead butterfly's

Small pond-cut off from other pond-had no pollywogs-loaded with small shrimp

Elk dung

water in sun-not as brown as the other ponds

Pond water was low in comparison to the size of the pond

Sharan Swanson

Cater Lake-Lab

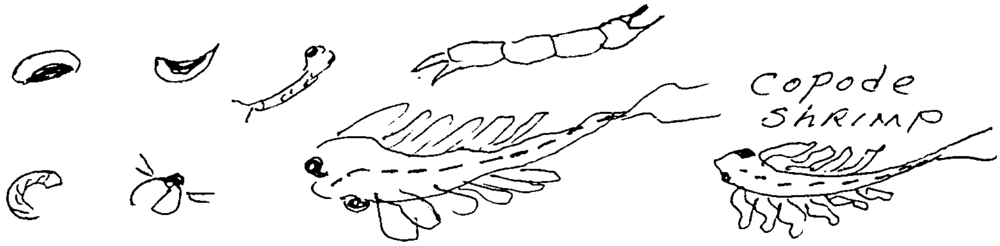
Lab. Research

Slide #1.
Dish

Slide #2.
Dish

Slide #3.
Dish

Slide #4.
Dish



Slide #5.
Dish

Slide #6.
Dish

Slide #7.
Dish

Netted-10 ft. drag

In Iodine bottle and high power micro-scope, I couldn't find anything in my slides.

Rick Shroy
John Salinas
Whitehorse Pond Study
August 11, 1993

Pond 10

Surrounding Area: All of the smaller ponds to the south were dry, and there was considerable amount of loose rock suggesting very good drainage. Two larger ponds to the southwest still held water. The forest in the area was more open than in the area to the north of Pond 10.

Noticeable Animal Signs: Elk and dear droppings were noted with elk being the most abundant. However, there were no sings of animals drinking the pond's water.

Pond Description: Pond 10 is located a very clear opening in the forrest. At full capacity this pond measures 240 feet long by 90 feet wide, at its widest point (see fig. 1). It is estimated the maximum water level is two and a half feet deep. The water in the pond on August 9, 1993 is covering and area 90 feet long x 35 feet wide and carrying an average depth of 5-7 inches.

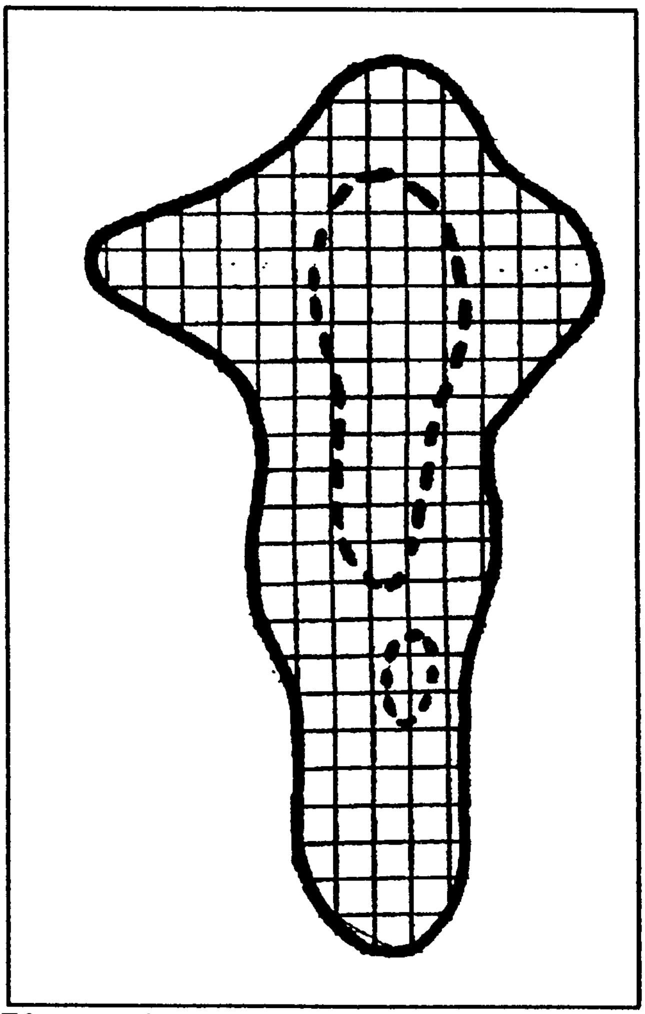


Figure 1 Dashed lines indicate

The water appears clearer than any other pond in the area. Water that was sampled for the oxygen test held less orange sediment in it (less than 3/8 an inch) than the other ponds. The soil on the bottom of the pond was made up of a thin layer of silt with several patches of cinder rock showing on the bottom. There was several areas of water grass growing in the pond.

Technical Data: Temperature = 25 c
Conductivity = 16.16
pH level = 5.39

Pond Life: A few polliwogs were noted in the water. Their present development indicated the starting of leg growth. Also some water beetles that had a yellowish back were also noted (see fig. 2).

The zooplankton test was taken using a ten meter drag. Three different samples were prepared and viewed. Three species of Copepoda were identified (see figs. 3 - 5) Two of which are from the genera of Harpacticoida (figs. 4 & 5). Of the three samples that were viewed, only one Bryocamptus was identified (see fig. 5). Several Cladocera were noted that showed a structure that is very similar to the Daphnidae, Scapholeberis mucronata (see fig.6).

The phytolpanktron test that was conducted reveled little. Three slides were prepared and viewed. Only small amounts of algae were noted using a 100x microscope.

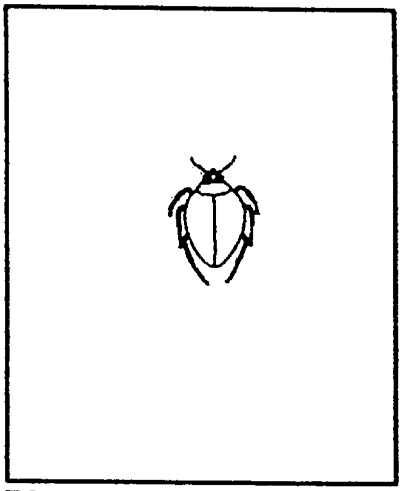


Figure 2

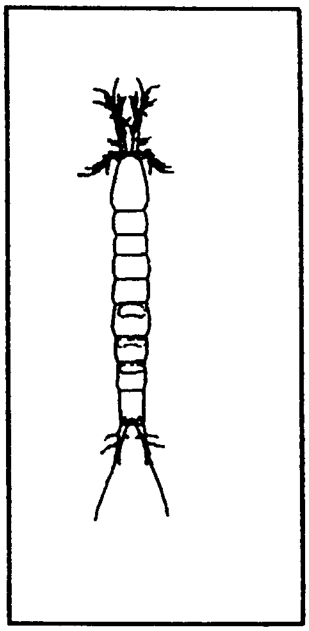


Figure 3

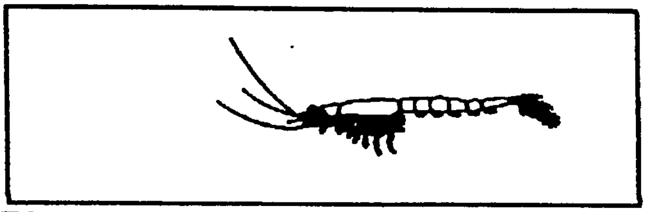


Figure 4

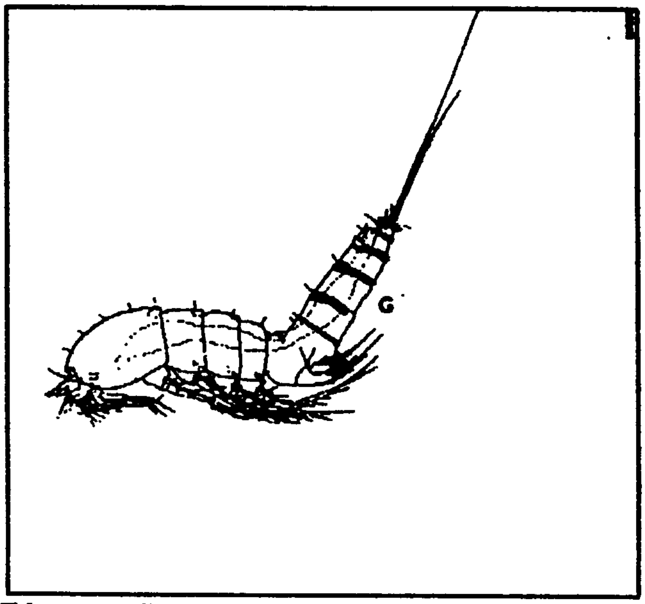


Figure 5

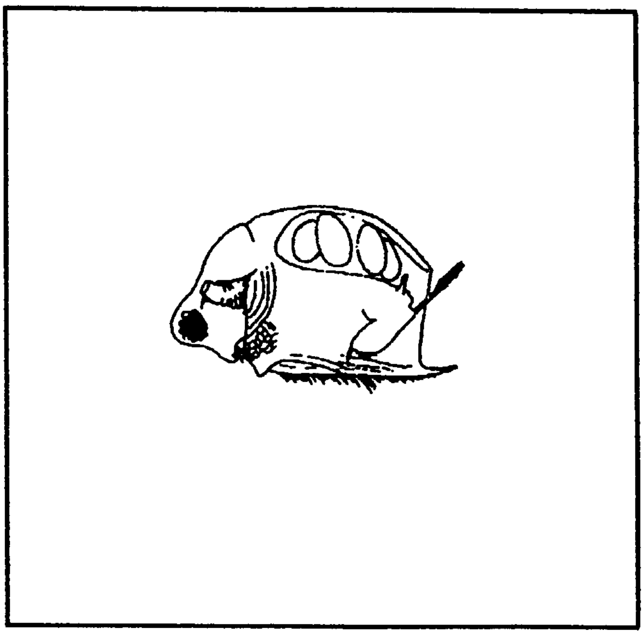


Figure 6

Photo of Whitehorse Bluff Pond # 10.

Appendix III. Plankton Data

APPENDIX

Run Header: AID1 ANALYSIS OF CRLA PONDS ZOOPLANKTON - DENSITY
Data Title: CRLA PONDS ZOOPLANKTON 1993
Sample unit: FROG1
Species observed: 2 Species specified: 2 Sum N = 48222.

INFORMATION			
HE	=	0.68740	COMMON INFORMATION MEASURE
HMAX	=	10.784	UNCONDITIONAL MAXIMUM VALUE OF HE
H(MAX¦S)	=	0.69315	COND. MAX. OF HE, GIVEN S
H(MIN¦S)	=	0.20288E-03	COND. MIN. OF HE, GIVEN S
H2	=	0.99170	BASE 2 INFORMATION MEASURE
H10	=	0.29853	BASE 10 INFORMATION MEASURE
R(H)	=	0.82994E-02	REDUNDANCY INDEX
J(H)	=	0.99170	PIELOU EVENNESS MEASURE
U(H)	=	0.63745E-01	UNIFORMITY MEASURE
E(H)	=	1.9885	EQUIVALENT NO. OF EQUALLY COMMON TAXA
EQ(H)	=	0.99427	INDEX OF EQUITABILITY
EQ2	=	0.98853	HEIP INDEX OF EQUITABILITY
SIMPSON			
LAMBDA	=	0.50574	SIMPSON LAMBDA (PROBABILITY)
SDI	=	0.49426	SIMPSON DIVERSITY MEASURE
SDI(MAX)	=	0.99998	UNCOND. MAX. VALUE OF SDI
SDI(MAX¦S)	=	0.50000	COND. MAX. OF SDI, GIVEN S
SDI(MIN¦S)	=	0.41474E-04	COND. MIN. OF SDI, GIVEN S
R(SDI)	=	0.11481E-01	REDUNDANCY INDEX
J(SDI)	=	0.98852	EVENNESS MEASURE
U(SDI)	=	0.49427	HURLBERT P.I.E.
E(SDI)	=	1.9773	EQUIVALENT NO. OF EQUALLY COMMON TAXA
EQ(SDI)	=	0.98865	INDEX OF EQUITABILITY
MCINTOSH			
MDSQ	=	0.11760E+10	MCINTOSH D-SQUARE
MDI	=	13929.	MCINTOSH DIVERSITY MEASURE
MDI(MAX)	=	48003.	UNCOND. MAX. VALUE OF MDI
MDI(MAX¦S)	=	14124.	COND. MDI MAX., GIVEN S & N
MDI(MIN¦S)	=	1.0003	COND. MDI MIN., GIVEN S & N
R(MDI)	=	0.13819E-01	REDUNDANCY INDEX
J(MDI)	=	0.98618	EVENNESS MEASURE
U(MDI)	=	0.29017	MCINTOSH DENSITY FREE DIVERSITY
E(MDI)	=	1.9773	EQUIVALENT NO. OF EQUALLY COMMON TAXA, GIVEN N
EQ(MDI)	=	0.98865	INDEX OF EQUITABILITY
HILL'S NUMBERS AND RATIOS			
N0	=	2.0000	N0 DIVERSITY INDEX
N1	=	1.9885	N1 DIVERSITY INDEX
N2	=	1.9773	N2 DIVERSITY INDEX
N1/N0	=	0.99427	N1/N0 EVENNESS RATIO
N2/N1	=	0.99435	N2/N1 EVENNESS RATIO
Alatalo	=	0.98864	ALATALO'S EVENNESS RATIO
MARGALEF			
DLOG	=	0.92734E-01	MARGALEF DIVERSITY INDEX
MENHINICK			
DSQR	=	0.91076E-02	MENHINICK DIVERSITY INDEX

Sample unit: FROG2

Species observed: 4 · Species specified: 4 · Sum N = 24889.

INFORMATION					
HE	0.90681	HMAX	10.122	H(MAX¦S)	1.3863
H(MIN¦S)	0.12603E-02	H2	1.3082	H10	0.39382
R(H)	0.34619	J(H)	0.65412	U(H)	0.89586E-01
E(H)	2.4764	EQ(H)	0.61910	EQ2	0.49214
SIMPSON					
LAMBDA	0.50701	SDI	0.49299	SDI(MAX)	0.99996
SDI(MAX¦S)	0.75000	SDI(MIN¦S)	0.24105E-03	R(SDI)	0.34279
J(SDI)	0.65732	U(SDI)	0.49301	E(SDI)	1.9723
EQ(SDI)	0.49308				
MCINTOSH					
MDSQ	0.31407E+09	MDI	7166.8	MDI(MAX)	24731.
MDI(MAX¦S)	12444.	MDI(MIN¦S)	2.9995	R(MDI)	0.42420
J(MDI)	0.57590	U(MDI)	0.28979	E(MDI)	1.9723
EQ(MDI)	0.49308				
HILL'S NUMBERS AND RATIOS					
N0	4.0000	N1	2.4764	N2	1.9723
N1/N0	0.61910	N2/N1	0.79645	Alatalo	0.65858
MARGALEF					
DLOG	0.29638				
MENHINICK					
DSQR	0.25355E-01				

Sample unit: BEAR1

Species observed: 8 · Species specified: 8 · Sum N = 14888.

INFORMATION					
HE	1.3348	HMAX	9.6083	H(MAX¦S)	2.0794
H(MIN¦S)	0.47190E-02	H2	1.9257	H10	0.57968
R(H)	0.35893	J(H)	0.64188	U(H)	0.13892
E(H)	3.7991	EQ(H)	0.47489	EQ2	0.39987
SIMPSON					
LAMBDA	0.40656	SDI	0.59344	SDI(MAX)	0.99993
SDI(MAX¦S)	0.87500	SDI(MIN¦S)	0.94007E-03	R(SDI)	0.32213
J(SDI)	0.67822	U(SDI)	0.59348	E(SDI)	2.4597
EQ(SDI)	0.30746				
MCINTOSH					
MDSQ	0.90121E+08	MDI	5395.3	MDI(MAX)	14766.
MDI(MAX¦S)	9624.6	MDI(MIN¦S)	6.9995	R(MDI)	0.43975
J(MDI)	0.56057	U(MDI)	0.36538	E(MDI)	2.4597
EQ(MDI)	0.30746				
HILL'S NUMBERS AND RATIOS					
N0	8.0000	N1	3.7991	N2	2.4597
N1/N0	0.47489	N2/N1	0.64744	Alatalo	0.52148
MARGALEF					
DLOG	0.72853				
MENHINICK					
DSQR	0.65564E-01				

Sample unit: BEAR2

Species observed: 5 Species specified: 5 Sum N = 46222.

INFORMATION					
HE	1.0988	HMAX	10.741	H(MAX¦S)	1.6094
H(MIN¦S)	0.10810E-02	H2	1.5852	H10	0.47718
R(H)	0.31752	J(H)	0.68270	U(H)	0.10229
E(H)	3.0004	EQ(H)	0.60009	EQ2	0.50011
SIMPSON					
LAMBDA	0.46154	SDI	0.53846	SDI(MAX)	0.99998
SDI(MAX¦S)	0.80000	SDI(MIN¦S)	0.17307E-03	R(SDI)	0.32700
J(SDI)	0.67307	U(SDI)	0.53847	E(SDI)	2.1666
EQ(SDI)	0.43333				
MCINTOSH					
MDSQ	0.98606E+09	MDI	14820.	MDI(MAX)	46007.
MDI(MAX¦S)	25551.	MDI(MIN¦S)	3.9994	R(MDI)	0.42004
J(MDI)	0.58002	U(MDI)	0.32213	E(MDI)	2.1666
EQ(MDI)	0.43333				
HILL'S NUMBERS AND RATIOS					
NO	5.0000	N1	3.0004	N2	2.1666
N1/NO	0.60009	N2/N1	0.72211	Alatalo	0.58320
MARGALEF					
DLOG	0.37240				
MENHINICK					
DSQR	0.23257E-01				

Sample unit: 21-9

Species observed: 7 Species specified: 7 Sum N = 50222.

INFORMATION					
HE	1.4522	HMAX	10.824	H(MAX¦S)	1.9459
H(MIN¦S)	0.13728E-02	H2	2.0951	H10	0.63069
R(H)	0.25388	J(H)	0.74630	U(H)	0.13416
E(H)	4.2726	EQ(H)	0.61037	EQ2	0.54543
SIMPSON					
LAMBDA	0.29141	SDI	0.70859	SDI(MAX)	0.99998
SDI(MAX¦S)	0.85714	SDI(MIN¦S)	0.23892E-03	R(SDI)	0.17336
J(SDI)	0.82669	U(SDI)	0.70861	E(SDI)	3.4316
EQ(SDI)	0.49023				
MCINTOSH					
MDSQ	0.73501E+09	MDI	23111.	MDI(MAX)	49998.
MDI(MAX¦S)	31240.	MDI(MIN¦S)	5.9989	R(MDI)	0.26026
J(MDI)	0.73979	U(MDI)	0.46224	E(MDI)	3.4316
EQ(MDI)	0.49023				
HILL'S NUMBERS AND RATIOS					
NO	7.0000	N1	4.2726	N2	3.4316
N1/NO	0.61037	N2/N1	0.80317	Alatalo	0.74302
MARGALEF					
DLOG	0.55431				
MENHINICK					
DSQR	0.31236E-01				

Sample unit: WH11A

Species observed: 3		Species specified: 3		Sum N = 0.11378E+06	
INFORMATION					
HE	0.76151	HMAX	11.642	H(MAX¦S)	1.0986
H(MIN¦S)	0.25739E-03	H2	1.0986	H10	0.33072
R(H)	0.30691	J(H)	0.69316	U(H)	0.65411E-01
E(H)	2.1415	EQ(H)	0.71384	EQ2	0.57076
SIMPSON					
LAMBDA	0.50305	SDI	0.49695	SDI(MAX)	0.99999
SDI(MAX¦S)	0.66667	SDI(MIN¦S)	0.35156E-04	R(SDI)	0.25459
J(SDI)	0.74542	U(SDI)	0.49695	E(SDI)	1.9879
EQ(SDI)	0.66262				
MCINTOSH					
MDSQ	0.65122E+10	MDI	33080.	MDI(MAX)	0.11344E+06
MDI(MAX¦S)	48088.	MDI(MIN¦S)	2.0011	R(MDI)	0.31212
J(MDI)	0.68790	U(MDI)	0.29160	E(MDI)	1.9879
EQ(MDI)	0.66262				
HILL'S NUMBERS AND RATIOS					
N0	3.0000	N1	2.1415	N2	1.9879
N1/N0	0.71384	N2/N1	0.92825	Alatalo	0.86540
MARGALEF					
DLOG	0.17179				
MENHINICK					
DSQR	0.88939E-02				

Sample unit: WH3

Species observed: 8		Species specified: 8		Sum N = 23222.	
INFORMATION					
HE	1.3622	HMAX	10.053	H(MAX¦S)	2.0794
H(MIN¦S)	0.31164E-02	H2	1.9652	H10	0.59157
R(H)	0.34546	J(H)	0.65506	U(H)	0.13550
E(H)	3.9046	EQ(H)	0.48807	EQ2	0.41494
SIMPSON					
LAMBDA	0.33725	SDI	0.66275	SDI(MAX)	0.99996
SDI(MAX¦S)	0.87500	SDI(MIN¦S)	0.60277E-03	R(SDI)	0.24274
J(SDI)	0.75743	U(SDI)	0.66278	E(SDI)	2.9652
EQ(SDI)	0.37064				
MCINTOSH					
MDSQ	0.18187E+09	MDI	9736.3	MDI(MAX)	23070.
MDI(MAX¦S)	15012.	MDI(MIN¦S)	7.0003	R(MDI)	0.35159
J(MDI)	0.64857	U(MDI)	0.42204	E(MDI)	2.9652
EQ(MDI)	0.37064				
HILL'S NUMBERS AND RATIOS					
N0	8.0000	N1	3.9046	N2	2.9652
N1/N0	0.48807	N2/N1	0.75940	Alatalo	0.67657
MARGALEF					
DLOG	0.69632				
MENHINICK					
DSQR	0.52498E-01				

Sample unit: WH7C

Species observed: 8 | Species specified: 8 | Sum N = 21333.

INFORMATION

HE	1.4630	HMAX	9.9680	H(MAX¦S)	2.0794
H(MIN¦S)	0.35988E-02	H2	2.1107	H10	0.63538
R(H)	0.29695	J(H)	0.70356	U(H)	0.14677
E(H)	4.3190	EQ(H)	0.53987	EQ2	0.47414

SIMPSON

LAMBDA	0.32551	SDI	0.67449	SDI(MAX)	0.99995
SDI(MAX¦S)	0.87500	SDI(MIN¦S)	0.65612E-03	R(SDI)	0.22933
J(SDI)	0.77084	U(SDI)	0.67452	E(SDI)	3.0721
EQ(SDI)	0.38401				

MCINTOSH

MDSQ	0.14815E+09	MDI	9162.0	MDI(MAX)	21187.
MDI(MAX¦S)	13791.	MDI(MIN¦S)	6.9997	R(MDI)	0.33582
J(MDI)	0.66435	U(MDI)	0.43242	E(MDI)	3.0721
EQ(MDI)	0.38401				

HILL'S NUMBERS AND RATIOS

NO	8.0000	N1	4.3190	N2	3.0721
N1/NO	0.53987	N2/N1	0.71130	Alatalo	0.62432

MARGALEF

DLOG 0.70224

MENHINICK

DSQR 0.54772E-01

Sample unit: WH9

Species observed: 5 | Species specified: 5 | Sum N = 5333.4

INFORMATION

HE	1.1158	HMAX	8.5817	H(MAX¦S)	1.6094
H(MIN¦S)	0.77479E-02	H2	1.6097	H10	0.48457
R(H)	0.30823	J(H)	0.69326	U(H)	0.13001
E(H)	3.0519	EQ(H)	0.61037	EQ2	0.51297

SIMPSON

LAMBDA	0.43660	SDI	0.56340	SDI(MAX)	0.99981
SDI(MAX¦S)	0.80000	SDI(MIN¦S)	0.14993E-02	R(SDI)	0.29631
J(SDI)	0.70425	U(SDI)	0.56351	E(SDI)	2.2904
EQ(SDI)	0.45809				

MCINTOSH

MDSQ	0.12419E+08	MDI	1809.3	MDI(MAX)	5260.4
MDI(MAX¦S)	2948.2	MDI(MIN¦S)	3.9997	R(MDI)	0.38683
J(MDI)	0.61370	U(MDI)	0.34395	E(MDI)	2.2904
EQ(MDI)	0.45809				

HILL'S NUMBERS AND RATIOS

NO	5.0000	N1	3.0519	N2	2.2904
N1/NO	0.61037	N2/N1	0.75050	Alatalo	0.62890

MARGALEF

DLOG 0.46611

MENHINICK

DSQR 0.68465E-01

Sample unit: WH13

Species observed: 5 Species specified: 5 Sum N = 888.80

INFORMATION					
HE	1.5596	HMAX	6.7899	H(MAX¦S)	1.6094
H(MIN¦S)	0.35048E-01	H2	2.2500	H10	0.67732
R(H)	0.31667E-01	J(H)	0.96902	U(H)	0.22969
E(H)	4.7568	EQ(H)	0.95137	EQ2	0.93921
SIMPSON					
LAMBDA	0.21875	SDI	0.78125	SDI(MAX)	0.99887
SDI(MAX¦S)	0.80000	SDI(MIN¦S)	0.89756E-02	R(SDI)	0.23703E-01
J(SDI)	0.97656	U(SDI)	0.78213	E(SDI)	4.5714
EQ(SDI)	0.91429				
MCINTOSH					
MDSQ	0.17280E+06	MDI	473.10	MDI(MAX)	858.99
MDI(MAX¦S)	491.32	MDI(MIN¦S)	3.9978	R(MDI)	0.37377E-01
J(MDI)	0.96293	U(MDI)	0.55077	E(MDI)	4.5714
EQ(MDI)	0.91429				
HILL'S NUMBERS AND RATIOS					
NO	5.0000	N1	4.7568	N2	4.5714
N1/NO	0.95137	N2/N1	0.96102	Alatalo	0.95065
MARGALEF					
DLOG	0.58911				
MENHINICK					
DSQR	0.16771				

Sample unit: WH7D

Species observed: 8 Species specified: 8 Sum N = 35547.

INFORMATION					
HE	1.4816	HMAX	10.479	H(MAX¦S)	2.0794
H(MIN¦S)	0.21760E-02	H2	2.1374	H10	0.64343
R(H)	0.28782	J(H)	0.71248	U(H)	0.14139
E(H)	4.3998	EQ(H)	0.54997	EQ2	0.48568
SIMPSON					
LAMBDA	0.30907	SDI	0.69093	SDI(MAX)	0.99997
SDI(MAX¦S)	0.87500	SDI(MIN¦S)	0.39380E-03	R(SDI)	0.21046
J(SDI)	0.78963	U(SDI)	0.69095	E(SDI)	3.2355
EQ(SDI)	0.40444				
MCINTOSH					
MDSQ	0.39054E+09	MDI	15785.	MDI(MAX)	35359.
MDI(MAX¦S)	22979.	MDI(MIN¦S)	6.9996	R(MDI)	0.31318
J(MDI)	0.68692	U(MDI)	0.44643	E(MDI)	3.2355
EQ(MDI)	0.40444				
HILL'S NUMBERS AND RATIOS					
NO	8.0000	N1	4.3998	N2	3.2355
N1/NO	0.54997	N2/N1	0.73537	Alatalo	0.65754
MARGALEF					
DLOG	0.66803				
MENHINICK					
DSQR	0.42431E-01				

Run: AIDN ANALYSIS OF CRLA POND ZOOPLANKTON 1993
Data: CRLA PONDS ZOOPLANKTON 1993
Table I. Data and Summary Statistics

Label	FROG1	FROG2	BEAR1	BEAR2	21-9	WH11A
Totals	48222.30	24888.80	14888.50	46221.70	50222.40	113778.00
Species ID						
1	0.0000	0.1429	0.0000	0.0000	0.0000	0.0234
2	0.5536	0.1607	0.0149	0.0000	0.1593	0.6016
3	0.4464	0.6786	0.0000	0.0000	0.1327	0.3750
4	0.0000	0.0179	0.0746	0.0769	0.0089	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.1858	0.0000
6	0.0000	0.0000	0.6119	0.6539	0.4602	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0385	0.0442	0.0000
9	0.0000	0.0000	0.0299	0.0000	0.0089	0.0000
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
12	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
13	0.0000	0.0000	0.1343	0.1154	0.0000	0.0000
14	0.0000	0.0000	0.0299	0.0000	0.0000	0.0000
15	0.0000	0.0000	0.0299	0.0000	0.0000	0.0000
16	0.0000	0.0000	0.0746	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000	0.1154	0.0000	0.0000
18	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAMBDA	0.5057	0.5070	0.4066	0.4615	0.2914	0.5031
HE	0.6874	0.9068	1.3348	1.0988	1.4522	0.7615
Hill's Numbers						
N(0)	2.0000	4.0000	8.0000	5.0000	7.0000	3.0000
N(1)	1.9885	2.4764	3.7991	3.0004	4.2726	2.1415
N(2)	1.9773	1.9723	2.4597	2.1666	3.4316	1.9879
Hill's Ratios						
N(1)/N(0)	0.9943	0.6191	0.4749	0.6001	0.6104	0.7138
N(2)/N(1)	0.9944	0.7965	0.6474	0.7221	0.8032	0.9283
N(2)-1/N(1)-1	0.9886	0.6586	0.5215	0.5832	0.7430	0.8654

Table I. Data and Summary Statistics

Label	WH3	WH7C	WH9	WH13	WH7D
Totals	23222.10	21333.50	5333.40	888.80	35547.20
Species ID					
1	0.0144	0.0208	0.6250	0.2500	0.0000
2	0.0431	0.5208	0.1667	0.1250	0.4626
3	0.0478	0.0000	0.0000	0.0000	0.0000
4	0.3493	0.0208	0.0833	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.2873
6	0.4546	0.0000	0.0000	0.0000	0.0000
7	0.0144	0.1250	0.1042	0.0000	0.0625
8	0.0000	0.1458	0.0000	0.0000	0.0250
9	0.0144	0.0000	0.0208	0.0000	0.0125
10	0.0622	0.1250	0.0000	0.1250	0.0000
11	0.0000	0.0208	0.0000	0.2500	0.0000
12	0.0000	0.0208	0.0000	0.0000	0.0500
13	0.0000	0.0000	0.0000	0.0000	0.0625
14	0.0000	0.0000	0.0000	0.2500	0.0000
15	0.0000	0.0000	0.0000	0.0000	0.0000
16	0.0000	0.0000	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000	0.0000	0.0375
LAMBDA	0.3373	0.3255	0.4366	0.2187	0.3091
HE	1.3621	1.4630	1.1158	1.5596	1.4816
Hill's Numbers					
N(0)	8.0000	8.0000	5.0000	5.0000	8.0000
N(1)	3.9046	4.3190	3.0519	4.7568	4.3998
N(2)	2.9652	3.0721	2.2904	4.5714	3.2355
Hill's Ratios					
N(1)/N(0)	0.4881	0.5399	0.6104	0.9514	0.5500
N(2)/N(1)	0.7594	0.7113	0.7505	0.9610	0.7354
N(2)-1/N(1)-1	0.6766	0.6243	0.6289	0.9506	0.6575

Table III. Ubiquity Indicies

Sample size: 11

SPECIES	Prop	B(0)	B(1)	B(2)	B(3)	B(4)
1	0.0274	6.00000	4.06290	3.12686	3.56869	2.44112
2	0.3560	10.0000	4.38287	7.27372	3.19193	6.30759
3	0.2311	5.00000	3.52682	3.87612	3.01983	3.44312
4	0.0379	7.00000	3.64246	3.96178	2.63326	2.82494
5	0.0508	2.00000	1.99797	1.95416	1.99595	1.91202
6	0.1898	4.00000	3.55578	3.94698	3.24556	3.89608
7	0.0150	4.00000	3.04692	3.32181	2.67728	3.06174
8	0.0208	4.00000	3.67481	3.11848	3.44691	2.53812
9	0.0046	5.00000	4.60371	4.57933	4.41372	4.22668
10	0.0110	3.00000	2.12311	2.87018	1.93558	2.77535
11	0.0017	2.00000	1.88982	1.31155	1.79989	1.16554
12	0.0058	2.00000	1.64945	1.83269	1.47066	1.71002
13	0.0248	3.00000	2.69673	2.86557	2.44256	2.76431
14	0.0017	2.00000	1.88982	1.40427	1.79989	1.23548
15	0.0012	1.00000	1.00000	1.00000	1.00000	1.00000
16	0.0029	1.00000	1.00000	1.00000	1.00000	1.00000
17	0.0139	1.00000	1.00000	1.00000	1.00000	1.00000
18	0.0035	1.00000	1.00000	1.00000	1.00000	1.00000

Table IV. Weighted Mean Ubiquity Indicies

	B(0) (var)	B(1) (var)	B(2) (var)	B(3) (var)	B(4) (var)
FROG1	7.7679(12.36)	4.0007(0.36)	5.7569(5.71)	3.1151(0.01)	5.0288(4.06)
FROG2	5.9821(4.36)	3.7430(0.15)	4.3167(2.32)	3.1190(0.05)	3.7493(1.83)
BEAR1	3.8358(2.75)	3.1737(0.87)	3.4876(1.40)	2.8483(0.67)	3.3280(1.27)
BEAR2	3.7692(2.24)	3.1730(0.87)	3.4514(1.15)	2.8545(0.67)	3.2967(1.14)
21-9	4.7522(7.16)	3.4095(0.64)	4.0662(2.94)	2.9887(0.29)	3.7847(2.06)
WH11A	8.0312(8.81)	4.0543(0.25)	5.9024(4.28)	3.1362(0.02)	5.1428(3.11)
WH3	5.3349(3.54)	3.5462(0.21)	4.0133(0.65)	2.9504(0.20)	3.5063(0.72)
WH7C	7.0208(11.64)	3.6991(0.88)	5.2303(5.33)	2.9391(0.33)	4.5546(3.92)
WH9	6.5209(3.65)	3.9866(0.17)	3.9382(2.89)	3.3527(0.18)	3.2194(2.51)
WH13	4.1250(9.51)	2.7739(1.48)	2.7287(4.46)	2.4331(0.78)	2.3459(3.30)
WH7D	5.9384(16.75)	3.2302(1.61)	4.5776(7.47)	2.6226(0.56)	4.0709(5.16)

Table V. Unweighted Mean Ubiquity Indicies

	B(0) (var)	B(1) (var)	B(2) (var)	B(3) (var)	B(4) (var)
FROG1	7.5000(12.50)	3.9548(0.37)	5.5749(5.77)	3.1059(0.01)	4.8754(4.10)
FROG2	7.0000(4.67)	3.9038(0.16)	4.5596(3.41)	3.1034(0.15)	3.7542(3.07)
BEAR1	4.1250(9.84)	2.8464(2.05)	3.2540(4.66)	2.4659(1.39)	2.9069(3.48)
BEAR2	3.8000(4.70)	2.9140(1.31)	2.9786(1.46)	2.5537(0.93)	2.6047(1.08)
21-9	5.2857(6.57)	3.6263(0.70)	4.1015(2.66)	3.1353(0.55)	3.5926(2.07)
WH11A	7.0000(7.00)	3.9909(0.19)	4.7589(4.88)	3.2602(0.08)	4.0639(4.03)
WH3	5.5000(4.86)	3.6181(0.62)	4.1196(1.92)	3.0857(0.53)	3.6221(1.54)
WH7C	4.7500(7.64)	3.0590(1.10)	3.3521(3.22)	2.5905(0.62)	2.8531(2.34)
WH9	6.4000(5.30)	3.9478(0.38)	4.4527(2.81)	3.2970(0.54)	3.7724(2.45)
WH13	4.6000(11.80)	2.8697(1.55)	3.1973(5.88)	2.4592(0.73)	2.7850(4.39)
WH7D	3.8750(7.84)	2.8816(1.68)	3.2432(3.84)	2.5799(1.23)	2.9401(2.79)

Table VI. Percentage Similarity Matrix

Panel 1 of 1.

	FROG1	FROG2	BEAR1	BEAR2	21-9	WH11A	WH3	WH7C	WH9	WH13	WH7D
FROG1	100.0										
FROG2	60.7	100.0									
BEAR1	1.5	3.3	100.0								
BEAR2	0.0	1.8	80.2	100.0							
21-9	29.2	30.1	49.3	50.7	100.0						
WH11A	92.9	55.9	1.5	0.0	29.2	100.0					
WH3	9.1	12.3	55.8	53.1	56.3	10.5	100.0				
WH7C	52.1	19.9	3.6	5.9	21.2	54.2	15.5	100.0			
WH9	16.7	32.1	11.0	7.7	17.7	19.0	16.9	31.3	100.0		
WH13	12.5	26.8	4.5	0.0	12.5	14.8	12.0	29.2	37.5	100.0	
WH7D	46.3	16.1	9.0	8.8	37.9	46.3	7.0	57.1	24.2	12.5	100.0

Table IX. SIMI Matrix

Panel 1 of 1.

	FROG1	FROG2	BEAR1	BEAR2	21-9	WH11A	WH3	WH7C	WH9	WH13	WH7D
FROG1	1.00000										
FROG2	0.77393	1.00000									
BEAR1	0.01822	0.00822	1.00000								
BEAR2	0.00000	0.00284	0.97272	1.00000							
21-9	0.38406	0.30136	0.82773	0.82693	1.00000						
WH11A	0.99212	0.70193	0.01985	0.00000	0.38029	1.00000					
WH3	0.10942	0.11528	0.82449	0.82143	0.71964	0.10725	1.00000				
WH7C	0.71059	0.21428	0.02564	0.01860	0.29092	0.77546	0.11943	1.00000			
WH9	0.19637	0.24986	0.02214	0.01428	0.07702	0.24522	0.12263	0.30398	1.00000		
WH13	0.20804	0.16756	0.03128	0.00000	0.07886	0.24434	0.06165	0.34157	0.57299	1.00000	
WH7D	0.64772	0.18781	0.04422	0.02164	0.42753	0.70575	0.06503	0.79903	0.22835	0.22239	1.00000

Table XII. ESIMI Matrix

Panel 1 of 2.

	1	2	3	4	5	6	7	8	9	10
1	1.00000									
2	0.23878	1.00000								
3	0.17053	0.59738	1.00000							
4	0.23204	0.10749	0.08814	1.00000						
5	0.00000	0.42476	0.07960	0.01279	1.00000					
6	0.00857	0.08258	0.08279	0.62330	0.22622	1.00000				
7	0.56359	0.57271	0.00434	0.24797	0.30011	0.03377	1.00000			
8	0.02771	0.53142	0.04075	0.10680	0.28295	0.25886	0.71104	1.00000		
9	0.45675	0.24963	0.04891	0.57339	0.36422	0.62183	0.42962	0.10531	1.00000	
10	0.26912	0.39805	0.01753	0.34540	0.00000	0.13656	0.50397	0.61121	0.11338	1.00000
11	0.36412	0.15009	0.00000	0.00460	0.00000	0.00000	0.05936	0.07610	0.00000	0.72011
12	0.01163	0.56104	0.00000	0.02132	0.77510	0.00000	0.60479	0.49746	0.27466	0.25654
13	0.00000	0.14727	0.00000	0.26775	0.27952	0.75990	0.11898	0.20080	0.60723	0.00000
14	0.36030	0.11259	0.00000	0.02354	0.00000	0.06569	0.00000	0.00000	0.08424	0.66231
15	0.00000	0.01335	0.00000	0.19852	0.00000	0.55395	0.00000	0.00000	0.71042	0.00000
16	0.00000	0.01335	0.00000	0.19852	0.00000	0.55395	0.00000	0.00000	0.71042	0.00000
17	0.00000	0.00000	0.00000	0.20466	0.00000	0.59188	0.00000	0.24167	0.00000	0.00000
18	0.00000	0.41372	0.00000	0.00000	0.83968	0.00000	0.35741	0.15715	0.29755	0.00000

Table XII. ESIMI Matrix

Original Sample Units

Panel 2 of 2.

	11	12	13	14	15	16	17	18
11	1.00000							
12	0.03194	1.00000						
13	0.00000	0.30728	1.00000					
14	0.98951	0.00000	0.08482	1.00000				
15	0.00000	0.00000	0.71532	0.11858	1.00000			
16	0.00000	0.00000	0.71532	0.11858	1.00000	1.00000		
17	0.00000	0.00000	0.61442	0.00000	0.00000	0.00000	1.00000	
18	0.00000	0.92309	0.33289	0.00000	0.00000	0.00000	0.00000	1.00000

Appendix IV. Vascular Plant Listing

LIST OF VASCULAR PLANTS SPECIES
OBSERVED IN THE VICINITY OF WHITEHORSE PONDS
CRATER LAKE NATIONAL PARK
AUGUST 21, 1993

The following list, arranged alphabetically by family, contains vascular plant species observed in the vicinity of White Horse Ponds, Crater Lake, Oregon, during a field survey conducted on August 21, 1993.

SCIENTIFIC NAME	COMMON NAME
ASTERACEAE - Sunflower Family	
Antennaria media	Alpine Everlasting
Hieracium albiflorum	White-flowered Hawkweed
Hieracium scouleri	Scouler's Hawkweed
BORAGINACEAE - Borage Family	
Hackelia micrantha	Jessica's Stickseed
CARYOPHLLACEAE - Pink Family	
Arenaria arculeata	Sandwort
CYPERACEAE - Sedge Family	
Carex aquatilis	Water Sedge
Carex rossii	Ross' Sedge

ERICACEAE - Heath Family

Arctostaphylos nevadensis	Pinemat Manzanita
Chimaphila umbellata	Prince's Pine
Gaultheria humifusa	Western Wintergreen
Vaccinium membranaceum	Big Whortleberry
Vaccinium scoparium	Grouse Whortleberry

ISOETACEAE - Quillwort Family

Isoetes occidentalis	Western Quillwort

JUNCACEAE - Rush Family

Juncus drummondii	Drummond's Rush
Juncus parryi	Parry's Rush
Luzula parviflora	Smooth Wood Rush

LILIACEAE - Lily Family

Veratrum viride	Corn Lily

ORCHIDACEAE - Orchid Family

Listera convallarioides	Broad-leaved Twayblade

PINANCEAE - Pine Family

Abies lasiocarpa	Subalpine Fir
Abies magnifica	Red Fir
Pinus contorta ssp. *murrayana*	Lodgepole Pine
Pinus monticola	Western White Pine
Tsuga mertensiana	Mountain Hemlock

POACEAE - Grass Family

Calamagrostis inexpansa	Narrow-spiked Reedgrass
Elymus multisetus	Bottlebrush Squirreltail

POLYGONACEAE- Buckwheat Family

Eriogonum umbellatum	Sulfer Flower

ROSACEAE - Rose Family

Rubus lasiococcus	Dwarf Bramble
Spiraea densiflora	Mountain Spiraea

SPARGANIACEAE - Bur-reed Family

Sparganium natans	Small Bur-reed