Conference Proceedings. Spring-fed Wetlands: Important Scientific and Cultural Resources of the Intermountain Region, 2002.
http://www.wetlands.dri.edu

Algae and Invertebrates of a Great Basin Desert Hot Lake: A description of the Borax Lake ecosystem of southeastern Oregon

Joseph Furnish
Pacific Southwest Region 5, U.S. Department of Agriculture,
Forest Service, Vallejo, CA
jfurnish01@fs.fed.us

James McIver
Pacific Northwest Research Station, U.S. Department of Agriculture,
Forest Service, LaGrande, OR

Mark Teiser
Department of Oceanography, Oregon State University, Corvallis, OR

Abstract

As part of the recovery plan for the endangered chub *Gila boraxobius* (Cyprinidae), a description of algal and invertebrate populations was undertaken at Borax Lake in 1991 and 1992. Borax Lake, the only known habitat for *G. boraxobius*, is a warm, alkaline water body approximately 10 hectares in size with an average surface water temperature of 30°C. Periphyton algae were surveyed by scraping substrates and incubating microscope slides in the water column. Invertebrates were collected using dip nets, pitfall traps and Ekman dredges. The aufwuchs community was composed of 23 species and was dominated by cyanobacteria and diatoms. More than 7,000 invertebrate specimens were collected during the study period comprising at least 296 species. The Diptera (true flies) was the most diverse order with 84 species, followed by the Coleoptera (beetles) with 64 species, Araneae (spiders) with 38 species, and Hymenoptera (ants, bees, wasps) with 37 species. Springtails, midges, shore flies, and ants were the most commonly collected insects. Borax Lake also appears to have the last remaining population of the lamb rams-horn aquatic snail *Planorbella* (*Pierosoma*) *oregonensis* (Planorbidae). Compared to surveys of other Great Basin hot springs, aquatic species richness at Borax Lake was low, and is probably the result of the stressful combination of high temperatures and high dissolved solids.

Introduction

Borax Lake is a geothermally heated alkaline lake in southeastern Oregon. It represents one of the only permanent water sources in the Alvord Desert, which receives less than 20 cm of rain annually (Green 1978; Cobb et al. 1981). Borax Lake is the only known habitat for *Gila boraxobius*, the Borax Lake chub, a cyprinid fish recognized as a new species in 1980. The chub was listed as endangered under the Endangered Species Act in 1982 because it was believed that geothermal-energy test-well drilling activities near Borax Lake might jeopardize its habitat by altering the flow or temperature of water in the lake. In 1987, the recovery plan for the Borax Lake chub was approved (USFWS 1987). It recommended that a monitoring program be implemented to detect changes in water temperature, water quality, water flow, and the biotic community. This report provides the first detailed survey of periphyton algae and invertebrates associated with Borax Lake. The periphyton and invertebrate communities provide the major food source for the chub (Williams and Williams 1980; Scoppettone et al. 1995), as well as the many migratory birds that visit this alkaline oasis in the desert. Therefore, a better understanding of the structure and function of these communities will support protection and management of the endangered Borax Lake chub.

Description of Study Area

Borax Lake is a natural, geothermally-heated lake located at the southern end of the Alvord Desert about 6 miles NE of the town of Fields, Oregon. The lake is about 4 hectares (10 acres) in size and occupies a depression in the center of a broad, shield-like mound approximately 900 m (meters) in diameter that rises almost 10 m above the surrounding valley floor. Most of the lake is 1 to 2 m in depth. In the southwestern section of the lake there is a cone-shaped vent approximately 30 m deep and 35 m in diameter. The vent is the principal area of geothermal discharge into the lake, which is manifested by the roiling of convection currents at the lake surface above it. Seymour (1992) recorded a maximum temperature of 118^{o}C at a depth of 30 m during February 1991. The mound is primarily composed of an amorphous, non-crystalline siliceous sinter cap impregnated with fossilized marsh vegetation. Underlying the sinter formation are diatomaceous lake sediments. The arrangement of these deposits suggests that the sinter was formed by geothermal discharges into marsh vegetation that developed as glacial Lake Alvord receded during the drying period that ensued at the end of the Pleistocene Epoch. Williams and Bond (1983) provided a description of the events within the Alvord Basin that eventually resulted in isolation of an ancestral stock of "Alvord-type chub." The surrounding desert is a deflation plain resulting from the erosion of fine, poorly consolidated lacustrine sediments leaving the more resistant sinter formation surrounding and defining the lake (Cummings, 1992, Portland State University, personal communication). Since Borax Lake is perched above salt deposits that are underlain by poorly consolidated lake deposits, the entire habitat is quite fragile and unusual.

The waters of Borax Lake have a total dissolved solid concentration of about 1,600 mg/l and a pH of about 7.5. Sodium is the major cation and bicarbonate, sulfate and chloride are the major anions (Brown and Peterson 1980). There are also high concentrations of heavy, toxic metals like arsenic, cadmium, cesium, copper, lead and mercury at levels 2.6x, 90x, 238x, 60x, 1460x, and 12.5x higher than sea water, respectively. Other significant chemical features are the high concentrations of iron (i.e., 0.02 mg/l) and silicon dioxide (190 mg/l), a substance that is essential for diatom growth.

Borax Lake lies within the northern boundary of the Great Basin Province (Franklin and Dyrness 1973) and plant communities in the vicinity of the lake reflect the vegetation described by Cronquist et al. (1972), Daubenmire (1974), Kierstead and Pogson (1976), and Price and Seibert (1981) for this Province. According to Kierstead and Pogson (1976), the lake lies within the Shadscale Zone, which is characterized by the presence of alkali saltgrass (*Distichlis stricta*), greasewood (*Sarcobatus vermiculatus*), and shadscale (*Atriplex confertifolia*), listed in order of decreasing salinity tolerance. Wetland marsh vegetation, mainly composed of Olney’s rush (*Scirpus olneyi*) and beaked spikerush (*Eleocharis rostellata*), occurs wherever water overflows from the lake (see Figure 1). No vascular plants have been reported to occur within Borax Lake. However, Roberts et al. (1976) observed three aquatic macrophytes in "small cold ponds" (presumably at the southern end of the lake), which were identified as stonewort (*Chara hornemannii*), fennel-leaved pondweed (*Potomogeton pectinatus*), and ditchgrass (*Ruppia maritima*).

Figure 1. Borax Lake, view to the southeast from the west lakeshore at pitfall station (Fw) showing the wet marsh vegetation mainly composed of Olney’s rush (*Scirpus olneyi*) and beaked spikerush (*Eleocharis rostellata*). Vegetation in the immediate foreground is mainly alkali saltgrass (*Distichlis stricta*) and Baltic rush (*Juncus balticus*).

The invertebrate fauna of Borax Lake and vicinity had not been investigated prior to this study. However, Cobb et al. (1981) completed an ecological study of invertebrates associated with sand dunes in the Alvord Basin and compiled a list of over 1,000 species of arthropods from the area. Williams and Williams (1980) investigated the feeding ecology of the Borax Lake chub and concluded that the chub is an opportunistic omnivore. The chub's diet was mainly composed of aquatic and terrestrial insects (i.e., 40 percent), microcrustacea (13 percent), snails (9 percent), and diatoms (10 percent). During the winter, the chub fed most extensively on aquatic organisms and ingested fewer food items from the terrestrial environment than in the summer. Scoppettone et al. (1995) found that chubs appear to concentrate on the benthos in their feeding activities and presented evidence that they select the largest zooplankters and benthic organisms available.

Materials and Methods

The species richness and abundance of periphyton, bacteria, fungi, plankton, and aquatic and terrestrial invertebrates living in and around Borax Lake were studied by making collections from the water column, benthos of the lake, littoral (near-shore) zone, and terrestrial environments. The periphyton, protozoans, bacteria and fungi (or aufwuchs, sensu Lamberti and Moore 1984) were studied by exposing glass microscope slides vertically in the water column for two-month periods in spring and summer 1991. Each sampling unit consisted of three slides secured to a wooden block with a neoprene rubber band. Each block was suspended by a float about 15 cm from the bottom with an anchored monofilament line. Twelve of these sampling units were distributed throughout the lake to examine seasonal and within-lake variability in aufwuchs species richness and abundance, and total chlorophyll (an index of productivity). To examine how periphyton abundance varied with depth in the lake's vent, two sampling units were suspended at depths of 3, 6 and 9 m in the water column. Immediately after retrieving each set of three slides, two were placed on ice for later chlorophyll extraction and the third was preserved with 1 percent formalin for determination of taxonomic composition and relative abundance.

Chlorophyll extraction was performed by placing the slides in canning jars with 30 ml of 90 percent nonbuffered acetone for 24 hours at 4.5°C. The resulting extract was centrifuged at 5,000 rpm for 5 minutes and absorbance at photoactive wavelengths was measured with a Cary Model 3 spectrophotometer. Total chlorophyll was determined using the trichromatic method (APHA 1989). Species richness and abundance of periphyton on microscope slides were determined by counting the first 300 cells encountered during a scan. Qualitative aufwuchs samples were also taken from bottom sediments representing three distinct environments: soft organic flocculents, light-colored, semi-hard substrates, and dark-colored, hard substrates that probably represent sinter deposits covered with a superficial organic layer.

The diversity and seasonal abundance of phytoplankton and zooplankton were estimated in April, June, and August 1991, and in January 1992. Phytoplankton were collected by Van Dorn bottle at a 10-m depth in the vent in April 1991, and from the surface at the center of the lake on the other sample dates by filling a one-liter bottle. All samples were preserved in the field with 5-ml Lugol's solution. In the laboratory, samples were subsampled (volume dependent upon plankton density), placed in a settling chamber, and settled as per *Standard Methods* (APHA 1989). The first 300 cells encountered were identified, with counts converted to number/m^3. Zooplankton were collected with an 80-micron-mesh Wisconsin-style plankton net, generally along a north-south transect across the lake, for a distance of 150 to 250 m. During April, a vertical tow was made in the vent from a depth of approximately 10 m to the surface. Samples were preserved in the field using a formalin-sucrose solution. In the laboratory, all samples were brought up to a standard volume of 50 ml, then split in half; one half for identification of plankton and the other for measuring density. Each half was subsampled and all zooplankton encountered were counted. Counts were converted to volumetric units (i.e., number/m^3) by taking into account length of the plankton tow and diameter of the net aperture.

Benthic macroinvertebrates were sampled qualitatively using an Ekman dredge and dip net to collect from soft organic sediments in the lake. Submerged wood was also washed into a dip net to sample wood-associated invertebrates. Littoral habitats at the lake margin, potholes, marshes, springs, and streams flowing from the lake were also sampled by probing submerged vegetation and substrates with a dip net. All aquatic macroinvertebrates were preserved in the field using 75 percent ethanol.

Terrestrial arthropods were collected by hand and with sweep nets, a beating sheet, a light trap, and pitfall traps during April, June, and August 1991, and January 1992. Grass, sedge and rush-inhabiting arthropods were collected by sweep net. Greasewood-inhabiting arthropods were collected with beating sheet (i.e., a canvas sheet held underneath the shrub while striking the main stem). Taxonomic and seasonal patterns of abundance were interpreted qualitatively. Greatest emphasis was placed on pitfall traps because of their effectiveness in sampling terrestrial arthropod activity, which is expected to be correlated with the probability of deposition in the lake and hence becoming a component of the chub's diet. Each pitfall trap was a 16-oz. plastic container buried flush with the ground surface and filled with ethylene glycol to a depth of about 1 cm. Two rings of 22 pitfall traps were installed: an inner ring less than 2 m from the edge of the lake and an outer ring 8 to 30 m from the lake edge (Figure 2). Each pitfall trap of the inner ring was located within 2 m of the U.S. Fish and Wildlife benchmarks utilized to study chub distribution in the lake (Figure 1 in Scoppetone et al. 1995); outer ring traps were situated perpendicular to the lakeshore from their inner ring counterparts. Traps were placed within or close to all the principal habitat types adjacent to the lake and left open from one sampling episode to the next. To contrast diurnal and nocturnal activity patterns, over one 24-hour period during the summer, invertebrates active during day and night periods were captured in pitfall traps. All pitfall traps were cleaned and left open on the night of June 23 from 2100 hours to 0500 hours on the morning of June 24. The captured invertebrates were then removed, the pitfall traps were provisioned with fresh ethylene glycol and again left open during daylight hours from 0500 to 2100 hours when a second collection was made. Data generated by pitfall trap collections were analyzed utilizing Detrended Correspondence Analysis or DECORANA ordination (Hill 1979; Gauch 1982) to detect underlying environmental gradients and elucidate patterns of distribution and abundance of the invertebrate assemblages.

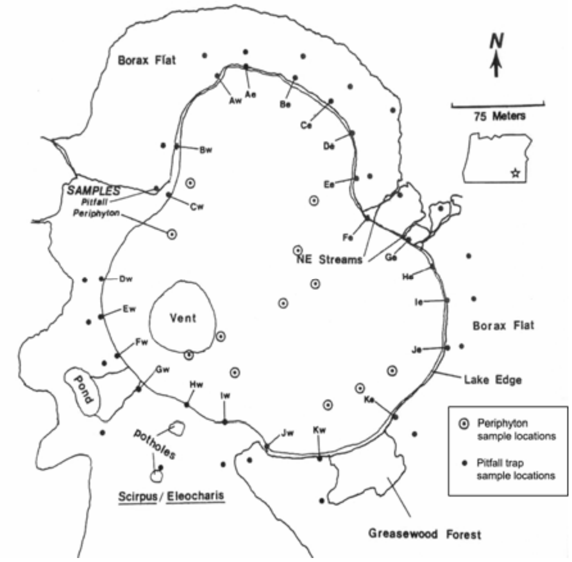

Figure 2. Map of Borax Lake, Harney County, Oregon, showing the type and distribution of sample locations with respect to plant communities, moisture availability, lake shore, and depth. Pitfall trap localities are indicated by largest solid dots. Aufwuchs (periphyton) sample locations are indicated by encircled dots.

Results

During this study, over 7,000 specimens representing 13 species of bacteria (including cyanobacteria), 11 species of Protista, at least one species of fungus, and nearly 300 species of invertebrates were collected and identified. Nearly 240 of these species were insects mainly associated with terrestrial habitats. For a summary of the animal species collected and the estimated number of specimens collected, see Table 3 and Appendix A.

Aufwuchs

A total of 23 species of organisms were identified from the aufwuchs community. Most were cyanobacteria (blue-green algae) and diatoms with eight species each. Most of the algal species were collected from microscope slides where 13 species were observed. Only two taxa, the diatoms, *Denticula elegans* and *Navicula* spp., were observed in every benthic habitat sampled; the remainder showed some degree of substrate specificity (see Table 1). For example, all of the other diatom species and all but one of the cyanobacteria species (i.e., *Aphanocapsa thermalis*) were only collected from artificial substrates; they were not collected on the natural hard, semi-hard or flocculent substrates. The cyanobacteria, *Cyanostylon microcystoides* and *Calothrix thermalis*, fungi and flexi-bacteria were only found on the dark, hard substrates characteristic of the northern and eastern edges of the lake. *Calothrix parietina* var. *thermalis* was only observed on light-colored, semi-hard substrates. The soft flocculent of the lake bottom was the only environment where the purple sulfur bacterium, *Chromatium* sp., the flagellate green algae *Pyramimonas* and *Chlamydomonas*, and the macroscopic green alga, *Chara* sp. were observed in the lake. *Chara* was found growing mainly east of the vent area. Diffuse patches of *Chara* protruded 5 or more cm above the flocculent where they were firmly anchored by rhizoids. Colonies of the protozoan *Vorticella* sp. were only found on microscope slides. Iron-oxidizing bacteria were only recovered from the vent at depths ranging from 4 to 9 m. This range is based on abundant growths of these bacteria on microscope slides recovered from depths of 6 and 9 m and conspicuous black deposits of ferric hydroxide on the monofilament line from 4 to 6 m.

Algal densities were higher in the spring than in the summer. Mean algal cell density on the microscope slides was 14.2 x 10^5 cells/cm^2 on 20 June after 54 days of incubation, and 3.9 x 10^5 cells/cm^2 on 20 August after 61 days of incubation. These values translate to rates of accumulation of 26.3 and 6.4 x 10^3 cells/day for the spring and summer periods, respectively. Thus, algal cells were 3.6x more dense and accumulated 4.1x faster during spring compared to summer. The diatom species *Achnanthes lanceolata* was by far the most abundant periphyton species for both samples regardless of depth and averaged 57 percent (range of 34 to 74 percent) of the total count from the 17 slides recovered. However, it was not observed in benthic samples. The diatoms *Denticula elegans* and *Navicula* spp. were the next most abundant species, averaging 12.9 and 12.3 percent, respectively, followed by the cyanobacteria, *Aphanocapsa thermalis* (8.9 percent) and *Chroococcus minor* (5.4 percent). Algal cell abundance decreased dramatically with depth in the vent. Samples recovered from 3 and 9 m in June and 6 m in August had densities of 11.6, 1.1, and 1.7 x 10^5 cells/cm^2, respectively. In January, the plastic float supporting the sampling unit in the vent was recovered and found to support an algal cell density of 51.1 x 10^5 cells/cm^2 after an incubation period of 269 days. Thus, the rate of algal accumulation on the float was 19 x 10^3 cells/day. Most of the 12 species of cyanobacteria and diatoms found on the float had relative abundances similar to that on other slides. The only exception was *Mastogloia elliptica*, which had a relative abundance of 12 percent on the float versus a mean relative abundance of only 0.7 percent on the microscope slides.

Total chlorophyll concentrations were determined for slides collected in June and August. Mean total chlorophyll concentrations for slides recovered from the shallow portion of the lake were 2.38 and 1.39 micrograms/cm^2 for the June and August samples, respectively. Total chlorophyll concentrations decreased with depth in the vent. At depths of 3, 6, and 9 m total chlorophyll concentrations were 0.57, 0.20, and 0.45 micrograms/cm^2, respectively.

Plankton

A total of 10 phytoplankton taxa and seven zooplankton taxa were collected (Table 2). Among the phytoplankton, all three species of diatoms and four species of cyanobacteria were also present in periphyton collections. *Merismopedia punctata* and *Lyngbya* sp. were strictly planktonic cyanobacteria. Phytoplankton densities were 3,272 and 3,927 cells/ml in June and August, respectively, and 1,227 cells/ml in both April and January. The April sample was taken in the vent at a depth of 10 m, which probably explains the low density at that time. *Aphanocapsa thermalis* was the most common phytoplankton species in April, June, and January when it had a relative abundance of at least 75 percent. In August, *Chroococcus minor* was most common, with a relative abundance of 65 percent, while *Aphanocapsa thermalis* had a relative abundance of only 22 percent.

Table 1. Relative abundance of aufwuchs organisms collected from a variety of substrates and depths in Borax Lake during June and August 1991, and January, 1992. (*** = abundant, ** = common,* = rare)

	Substrate						
Taxon	Hard, Inorganic	Glass	Semi-hard	Floc	Glass, vent, depth of 3 m	Glass, vent, depth of 6 m	Glass, vent, depth of 9 m
Bacillariophyta (diatoms)							
Achnanthes lanceolata		***			***	***	***
Cymbella affinis		*					
Denticula elegans	***	***	***	***	***	***	***
Diploneis oblongata		*					
Mastogloia elliptica		*					
Rhopalodia operculata		*					
Navicula monmouthiana-stodderi		*	***		*	**	
Navicula spp.	***	***	***	***	***	***	***
Bacteria							
Chromatium (purple sulfur bacterium)				*			
Flexi-bacteria	***						
Galionella (iron-oxidizing bacteria)						***	***
Chlorophyta (green algae)							
Chlamydomonas sp.				*			
Pyramimonas sp.				*			
Cyanophyta (blue-green algae)							
Aphanocapsa thermalis		*		***	*		
Calothrix parietina var. *thermalis*			***				
Calothrix thermalis	***						
Chroococcus minor						**	
Cyanostylon microcystoides	***						
Microcystis holsatica		***			*		
Synechocystis miniscula		*					
Fungi							
Unidentified fungal spp.	***						
Protozoa							
Vorticella sp.		*					

Table 2. Phytoplankton and zooplankton collected at Borax Lake during 1991 to 1992. Values in table are number of cells per milliliter for phytoplankton and number of organisms per cubic meter for zooplankton.

Month **Year**	Apr 1991	Jun 1991	Aug 1991	Jan 1992
Phytoplankton	Depth, type of phytoplankton tow			
	Vertical tow in vent (0 to 10 m)	Near surface	Near surface	Near surface
Bacillariophyta (diatoms)				
Achnanthes lanceolata	12	16	20	0
Cymbella sp.	0	16	0	0
Navicula monmouthiana- stodderi	0	0	0	6
Chlorophyta (green algae)	0	0	0	6
Cyanophyta (blue-green algae)				
Aphanocapsa thermalis	1,123	2,667	864	1,098
Chroococcus minor	0	0	2,553	49
Chroococcus sp.	0	65	0	0
Lyngbya sp.	18	115	0	0
Merismopedia punctata	0	82	255	0
Synechocystis miniscula	74	311	236	68
Total cells/ml	1,227	3,273	3,927	1,227
Number of taxa	4	7	5	5
Zooplankton				
Ostracoda	7	15	4	0
Copepoda *Macrocyclops fuscus*	7	11	53	6
Cletocamptus albuquerquesnsis	0	19	0	0
Cladocera *Alona rectangulata*	7	4	0	0
Bosmina longirostris	7	0	0	0
Rotifera *Lepadella* sp.	0	4	0	0
Notholca sp.	0	7	0	0
Number of taxa	4	6	2	1
Number/m^3	30	59	58	6

Of the seven species of zooplankton collected, only the cyclopoid copepod, *Macrocyclops fuscus*, was present in samples from all four seasons (Table 2). Ostracods were found in every season except winter. The cladoceran, *Alona rectangulata* was collected in April and June. Four taxa appeared at only one time during the year: the cladoceran, *Bosmina longirostris* in April, and the harpacticoid copepod, *Cletocamptus albuquerquensis* and two rotifers, *Lepadella* sp. and *Notholca* sp. in June. Zooplankton abundance was highest in June and August, with densities of 59 and 57/m^3, respectively, and lowest in January with a density of only 6/m^3. All of the individuals collected in January were *Macrocyclops fuscus*. Highest zooplankton species richness was observed in June when six taxa were collected. The high zooplankton density observed in August was primarily due to *Macrocyclops fuscus*, which made up 92 percent of the sample.

Aquatic Macroinvertebrates

At least 80 of the macroinvertebrate species collected were totally dependent upon aquatic habitats created by the occurrence of the lake-spring system. Aquatic flies were the most diverse group with 39 taxa (including 15 species of chironomid midges and 10 spp. of shoreflies). Odonates and beetles were represented by 13 aquatic species, and true bugs by eight. Relatively few specimens were found in samples taken from the organic flocculent substrates characteristic of the lake benthos. Aquatic snails and chironomid midge larvae (e.g., *Apedilum elachistum*, *Paratendipes* sp., *Tanypus* sp.) were the only commonly encountered taxa. These midges were widely distributed in the flocculent sediments and were all found in the vent at a depth of 4 m. While *Tanypus* sp. was only collected from open water habitats in the lake, *A. elachistum* and *Paratendipes* sp. were also common along the lakeshore and in marshes and potholes where they were associated with submerged vegetation. Aquatic insect species were most often collected along the lakeshore or in ponds and potholes, and not in the open water of the lake. Compared to the lake, these habitats had cooler water temperatures, with ice forming at the margins during the winter, and more protection from the wind. Aquatic insects like the mayfly *Callibaetis* sp., dragonfly and damselfly naiads, water boatmen, and chironomid midges were all abundant along the southern lake shore in sheltered emergent vegetation and backwaters. Larvae of the riffle beetle *Microcylloepus similis* and the oligochaete *Limnodrilus hoffmeisteri* were most commonly found in the mixture of the sand and pebbles that collected in depressions on the dark, hard substrates characteristic of the east edge of the lake. Oligochaetes, and riffle beetle and midge larvae were also abundant on submerged wood. Shoreflies, soldier flies, horseflies, and some chironomid midges (e.g. *Pseudosmittia* spp., *Limnophyes* sp.) were most abundant in the marshy, semi-aquatic habitats associated with springs and seeps surrounding the lake. Dytiscid, gyrinid and hydrophilid beetles, backswimmers, and water striders were most commonly found in the ponds and potholes at the south end of the lake. Two aquatic pulmonate snails, *Planorbella* (*Pierosoma*) *oregonensis* and *Physella* (*Physella*) *gyrina* were abundant and ubiquitous in the lake. *P. oregonensis* was commonly observed along the lake shore on hard substrates or on submerged vegetation. *P. gyrina* was observed on hard substrates and submerged vegetation in the lake, as well as in the potholes and marshes at the south end of the lake. Both snail species were also collected from the vent. During June, single individuals of *P. oregonensis* were found attached to the aufwuchs samplers recovered from depths of 3 and 9 m in the vent. In January, a single *P. gyrina* was found attached to the aufwuchs sampler recovered from 6 m.

Terrestrial Macroinvertebrates

During this study three classes of terrestrial arthropods were collected, comprising 16 orders, 110 families and about 289 taxa. The Insecta and Arachnida dominated the assemblage, and within these two large classes five orders contained over 90 percent of both the total taxa and total catch (see Table 3). The most species-rich order was the Diptera (true flies: 84 taxa), followed by the Coleoptera (beetles: 64 taxa), Araneae (spiders: 38 taxa) and Hymenoptera (bees, ants, wasps: 37 taxa). The most abundant order was Collembola (springtails), of which a species of *Isotoma* was numerically dominant. Although 110 families of macroinvertebrates were collected from Borax Lake in the present study, the five most common families made up 72 percent of the total arthropod abundance (Table 3). Ants (family Formicidae) made up 21.8 percent of the collection; other important families included the chironomid midges (Chironomidae, 16.4 percent), the springtails (mostly Isotomidae, 11.8 percent), the wolf spiders (Lycosidae, 12 percent), and the shore flies (Ephydridae, 7.6 percent). Although biomass was not measured in the present study, it should be noted that individual ants, spiders, and shore flies generally have live weights ranging from 1 to 25 mg, while individual midges and springtails are much smaller, generally weighing no more than 0.01 mg each. Measured as biomass, the ants, wolf spiders, and shore flies are the major terrestrial invertebrates at Borax Lake.

Table 3. Summary of macroinvertebrate higher taxa caught at Borax Lake, Harney County, Oregon, April 1991 to January 1992, with special emphasis on the five most frequently collected families (*), showing percent of total catch.

Year			1991		1992	
Taxon	Number of Species	April	June	August	January	Totals
Annelida	5	0	88	3	1	92
Mollusca	2	0	17	9	0	26
Arthropoda	289	1,995	2,568	2,388	19	6,970
Chilopoda	1	2	3	9	0	14
Arachnida	51	186	488	638	7	1,319
Opiliones	1	0	0	30	0	30
Pseudoscorpionida	1	0	0	1	0	1
Solpugida	1	0	0	2	0	2
Scorpionida	1	0	0	1	0	1
Acari	9	12	15	48	3	78
Araneae	38	174	473	556	4	1,207
Lycosidae* (12.2 percent)	3	94	270	518	4	886
Insecta	237	1,807	2,077	1,741	12	5,637
Collembola	3	490	338	23	8	859
Isotomidae* (11.8 percent)	1	488	338	23	8	857
Ephemeroptera	1	0	0	17	0	17
Odonata	14	1	8	27	0	36
Orthoptera	4	0	5	13	0	18
Hemiptera	19	1	56	31	0	88
Homoptera	5	12	11	18	0	41
Coleoptera	64	85	312	242	3	642
Trichoptera	1	0	0	0	0	0
Lepidoptera	5	2	13	12	0	27
Diptera	84	878	981	353	1	2,213
Chironomidae* (16.4 percent)	6	757	389	41	0	1,187
Ephydridae* (7.6 percent)	10	37	326	190	0	553
Hymenoptera	37	338	353	1,005	0	1,696
Formicidae* (21.8 percent)	11	327	329	919	0	1,575

Although most terrestrial species collected are common in similar habitats in the Great Basin, five taxa were previously unknown to science: the gall midge *Acoenonia* sp., chloropid fly *Malloewia* ca. *diabolus*, dance fly *Micrempis* sp., burrower bug *Melanaethus* sp., and hackled-band weaving spider *Dictyna* sp. In addition, the micro-web spider *Spirembolus* ca. *spirotubus* appears to be a new species, with determination pending examination of additional specimens. Based on distinctive larval characters, the chironomid midges *Dicrotendipes* nr. *crypticus*, *Larsia* sp., *Limnophyes* sp., and *Tanypus* sp. appear to be new species. The most significant range extension is for the spider *Dictyna longispinosa*, which had previously been collected only from the Rocky Mountains. In general, the spider fauna at Borax Lake has a distinctly Rocky Mountain composition. Four species are known only from alkaline lake edges: the ground beetles *Tachys funebris* and *Bembidion diligens*, the ant-like beetle *Thicanus mimus*, and the hackled-band weaving spider *Dictyna littoricolens*. Finally, three taxa are known to be primarily associated with dung and were probably present due to the presence of livestock. They are the hister beetles *Saprinus* *desertoides* and *S. insertus*, and the water-scavenging beetle *Cercyon* sp.

There were strong seasonal trends in the abundance of the five most frequently collected macroinvertebrate families (Table 3). Chironomid midges (15 taxa) were the most common arthropod in April when they comprised about 37 percent of the specimens collected, but their relative abundance decreased to 14 percent in June and 2 percent in August. The springtail *Isotoma* sp. was very common in both April and June, but its abundance had decreased dramatically by August. As a group, shore flies reached peak abundance in June, but the individual taxa differed in their seasonal patterns: *Notiphila decoris*, *Paracoenia bisetosa* and *Scatella marinensis* reflected the group pattern of a June peak, while *Scatophila* sp. and *Scatella* sp. were equally or more abundant in August. All three species of wolf spiders increased in abundance from April to August; however, a substantial portion of the catch in August was represented by spiderlings, so the total biomass was probably fairly even throughout the summer. Abundance of the common species of ants either expressed a sharp peak in August (i.e., *Brachymyrmex depilis*, *Tapinoma sessile*, *Myrmica brevispinosa*), or were commonly collected throughout from April through August (i.e., *Formica manni*, *Manica mutica*). It should be noted that although only 19 individuals were collected in January, the ground-inhabiting arthropods (e.g., ants, spiders, springtails) were still present, but at a much reduced level of activity.

Pitfall trap data indicate that the probability of collecting some of the more common arthropod taxa depended in part on plant species composition and in part on proximity to the lake. When the 36 most commonly collected taxa were ordinated with detrended correspondence analysis (DCA), four distinct habitat and taxa patterns emerge (Figures 3 and 4, respectively). The ordination of sites in species space using DCA shows that sites Cw' and Fw' have high axis 1 values (Figure 3), reflecting a great abundance of the formicine ant *Formica manni* (FORM in Figure 4). Both of these sites were located on dry ground near the edge of *Scirpus* patches: Cw' in the *Sarcobatus* understory and Fw' on an elevated mound dominated by *Distichlis* (see Figure 2). In each case, traps near the lake occasionally caught individual ants, probably foragers working out of nests near Cw' and Fw'.

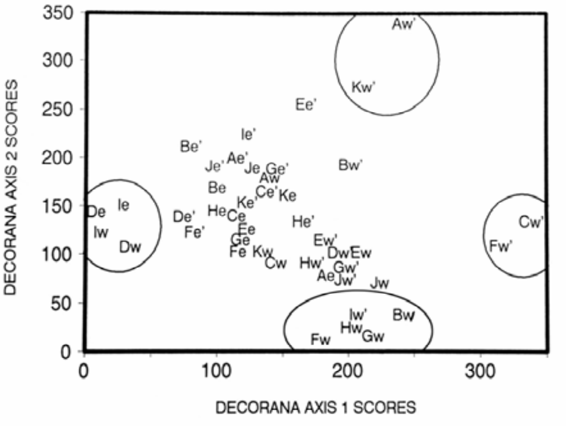

Figure 3. Detrended Correspondence Analysis (DECORANA) ordination of sites along axes 1 and 2 based on total catch in 44 pitfall traps over three sample periods (April, June, and August 1991) at Borax Lake. For site locations see Figure 2. The pitfall sites having highest Axis 1 ordination scores (i.e., polygon around sites Cw’ and Fw’) captured species most often found in habitats on dry ground near *Scirpus* patches. The pitfall sites having lowest Axis 1 ordination scores (i.e., polygon around sites De, Ie, Dw, and Iw) captured species most often found in moist habitats on the lakeshore. The pitfall sites having highest Axis 2 ordination scores (i.e., polygon around sites Aw’ and Kw’) captured species most often found 7 to 30 m from the lakeshore near stands of greasewood. The pitfall sites having lowest Axis 2 ordination scores (i.e., polygon around sites Iw’, Bw, Gw, and Fw) captured species most often found along the lakeshore near marsh vegetation.

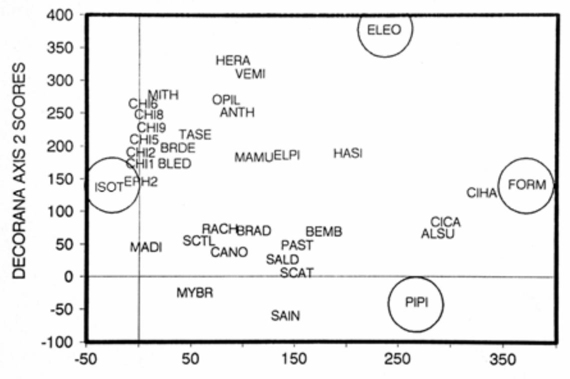

Figure 4. Detrended Correspondence Analysis (DECORANA) ordination of species along axes 1 and 2 based on total catch in 44 pitfall traps over three sample periods (April, June, and August 1991) at Borax Lake. For species identities of the most commonly collected taxa see Figure 5. Ants of the genus *Formica* (i.e., polygon around FORM) characterize species having highest Axis 1 ordination and were most abundant on dry ground. *Isotoma* springtails and chironomid midges (ISOT and CHIs, repectively) have lowest ordination scores on Axis I and represent species that occur along the wet lakeshore. Darkling beetles of the genus *Eleodes* (i.e., polygon around ELEO) characterize species having highest Axis 2 scores. Wolf spiders (PIPI) characterize species having lowest Axis 2 scores.

Traps at the four sites with the lowest Axis 1 values (De, Iw, Ie, Dw) caught large numbers of the springtail *Isotoma* sp.; each of these traps was situated one meter or less from the lake edge, and featured plant species associations ranging from *Scirpus*/*Eleocharis* (Iw) to *Eleocharis*/*Distichlis* (Dw, De) to *Eleocharis*/*Agrostis* (Ie). Nearly all of the large catches of springtails occurred in lakeside traps; the exception is trap Fe', a trap situated in the vicinity of the northeast streams. The three traps having the highest axis 2 values (Figure 3; Aw', Kw', Ee') were situated 7 to 30 m from the lakeshore in *Sarcobatus*-dominated habitat; each of these traps caught relatively high numbers of the darkling beetles *Eleodes pilosus* and *Eleodes* sp. (ELEO in Figure 4). *Eleodes* spp. were rarely caught in traps close to the lake edge. The polygon described by a line delineating the sites Fw--Gw--Bw--Iw'--Hw (Figure 3) is best characterized by an abundance of the wolf spider *Pirata piraticus* (PIPI in Figure 4). Most of these traps were situated either very close to the lake edge (Fw, Bw) or if further away, in riparian habitat (trap Iw'). This wolf spider typically occurs along lake or stream edges. The distributions of most other commonly collected taxa were not clearly associated with plant species compositions. For example, the wolf spiders *Pardosa sternalis* and *Allocosa subparva*, as well as the ants *Tapinoma sessile* and *Manica mutica*, were relatively widespread, with little or no recognizable habitat associations.

Daily activity data for the 18 most frequently collected taxa over a 24-hour period during the summer indicate that most were distinctively diurnal (Figure 5). Thirteen of the 18 taxa were more common in traps opened during the day. Most notably, springtails, midges, ephydrids, ants, and wolf spiders were all more abundantly collected during the day compared to the night catch. Three of these (i.e., the springtail *Isotoma* sp., ant *Manica mutica* and shore bug *Saldula* sp.) were never captured in the traps left open at night. Notable nocturnal taxa included the running spider *Haplodrassus signifer*, darkling beetle *Eleodes pilosus*, rove beetle *Bledius strenuus*, chloropid fly *Malloewia diabolus*, and click beetle *Dalopius* sp. commonly collected during the day.

Discussion

The algal assemblage at Borax Lake had a lower diversity than has been reported from other hot spring habitats with similar temperatures. Ekins and Rushforth (1986) found 56 diatom species at Cowboy Hot Springs in Mono County, California, where the temperature was 41°C and total dissolved solids were 150 mg/l. Kaczmarska and Rushforth (1983) found 136 diatom species at Blue Lake Warm Spring in the Great Basin, where water temperatures were 29°C. Neither of these studies surveyed other algal species so it is not possible to compare assemblages of cyanobacteria. The relatively depauperate algal assemblage at Borax Lake is most probably the result of a combination of high temperature and high dissolved solids.

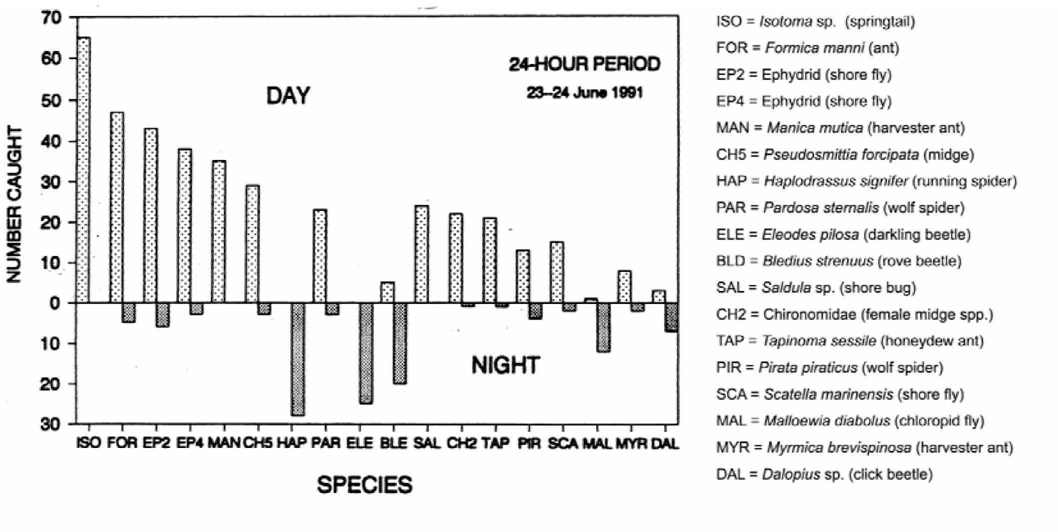

Figure 5. Daily activity periods of 18 species commonly collected in pitfall traps opened during the night (2100-0500) or day (0500-2100), June 23-24, 1991 at Borax Lake. Number of specimens of each species captured is represented by two adjacent histograms, day first, night second.

Considering the composition of chemical constituents of Borax Lake (Brown and Peterson 1980), it is reasonable to assume that only a few elements may be of importance for the productivity of the lake. Most macronutrients (C, O, P and S) and many micronutrients (Ca, Cu, Fe, I, K, Mn and Na) appear to be present in excess amounts for growth of periphyton. However, some factors may limit the primary production in the lake. Since iron readily forms complexes, particularly with hydroxide ions, and insoluble salts with many other anions, iron has a tendency to become a growth-limiting factor even though relatively high concentrations (0.02 mg/l) appear to be present. The presence of iron-oxidizing bacteria in the vent (Table 1) indicates that iron is available in fairly high concentrations in the form of Fe^{+2} below a depth of about 3 m. Notable nutrient limitations that may have an effect on lake biota are nitrogen, which is present in the water column as nitrate (NO_3), and micronutrients such as magnesium, which is essential for oxygenic phototropic primary producers (i.e., algae). If the lake water concentration of 2.5 mg/l truly represents the nitrogen available in the lake, lack of nitrogen may limit the growth of many algal species. The ratio of carbon to nitrogen to phosphorous in the lake is 183 C: 1.7 N: 1 P. The typical ratio in algal biomass is 106 C: 16 N: 1 P (Brock et al. 1984). Based on the disparity in these ratios, nitrogen appears to be a major limiting macronutrient in Borax Lake. Chlorine concentrations (i.e., 250 mg/l) are low in Borax Lake compared to many other alkaline lake ecosystems, which has been shown to have an inhibiting effect on the photosynthetic activities of green algae (Stewart 1974).

The invertebrate community of Borax Lake is quite diverse and was represented by over 300 taxa. Most of these invertebrates occurred primarily in the terrestrial, marsh, and spring environments adjacent to Borax Lake, making these habitats of critical importance in maintaining the biodiversity and integrity of this desert oasis. Invertebrates originating in these habitats also appear to provide a vitally important food source for the Borax Lake chub. Numerically, collembolans, chironomid midges, wolf spiders, and ephydrid flies were the most commonly collected invertebrates. Although most of these species are widespread, the population of the aquatic snail *Planorbella oregonensis* appears to be the last remaining one. Recent attempts to locate the other historic populations of this species in Nevada and Utah have been unsuccessful (T. J. Frest, personal communication). Given these circumstances, this species deserves special attention and protection. Virtually nothing is known about its natural history. A schematic diagram depicting many of the organisms, habitats, and nutrient dynamics discussed in this section of the report is presented in Figure 6. This level of invertebrate diversity is not unusual because other surveys in the Great Basin have also demonstrated a high richness of terrestrial species. Cobb et al. (1981) listed over 1,000 species of insects associated with the Alvord Basin sand dunes. Hornig and Barr (1970) found over 2,000 species of insects in a survey of Craters of the Moon National Monument, which is also located in the Snake River Basin/High Desert ecoregion (Omernik and Gallant 1986). The relatively low number of aquatic species living in the lake is also consistent with patterns observed for other alkaline lakes in the Great Basin (Herbst 1986).

The most striking theme of the great majority of invertebrate species at Borax Lake is their ubiquity. The zooplankter *Bosmina longirostris* has a cosmopolitan distribution and occurs in North America, Eurasia, and Africa. *Pseudosmittia forcipata*, the most commonly collected flying insect at Borax Lake, is found in North America, South America, and southeast Asia. All species of ostracods and oligochaetes are also widespread. For these species, Borax Lake serves as an oasis that has been colonized. The only clear exception to this theme is the occurrence of *Planorbella oregonensis,* which, like the Borax Lake chub, is restricted to Borax Lake. These species have limited powers of dispersal and appear to be relict populations.

Chironomid midge larvae and pupae were one of the most important food sources for the Borax Lake chub during every season of the year (Williams and Williams 1980). The pupae emerging from the lake that were ingested by chubs most likely were *Apedilum elachistum* or *Thienemannimyia barberi*, which were the most abundant and widespread midge larvae collected from the lake. *A. elachistum* is known to be associated with submerged vegetation (Darby1962; Epler 1988). Considering the abundance of adult chironomids and ephydrids in pitfall traps, these groups may have comprised a major portion of the "adult diptera"

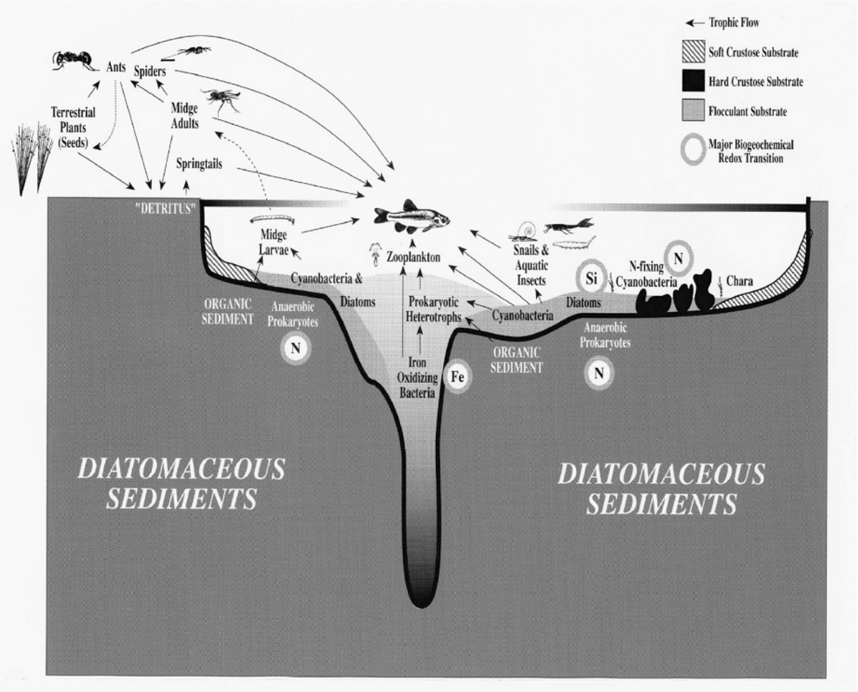

Figure 6. Schematic diagram of trophic and nutrient dynamics of Borax Lake. See the text for an explanation of the processes described in this diagram.

in the chub's diet reported by Williams and Williams (1980). The most abundant adult midge species (e.g., *Pseudosmittia* spp. and *Micropsectra nigriphila* gr.) were not observed as immatures in the lake. *Pseudosmittia* spp. are semi-terrestrial and known to occur in moist soil (Wiederholm 1989). Apparently, adult *Pseudosmittia* spp. emerged from moist soils associated with the lake margin and marsh habitats. *Micropsectra* larvae were only collected from the ponds and potholes at the south end of the lake. Ephydrid flies occupy a diverse variety of unusual aquatic and semi-aquatic habitats and may be extremely abundant in association with thermal springs and alkaline lakes where they are usually associated with algal mats (Merritt and Cummins 1984; Herbst 1986). No larvae were collected from the lake. Adult ephydrids most likely emerged from habitats associated with thermal springs and marshes adjacent to Borax Lake.

Williams and Williams (1980) also found that damselfly and dragonfly niaids were the only aquatic insect group that was ingested during every season. Damselfly niaids of the genus *Ischnura* were the most commonly collected immature odonates and this genus is probably most often preyed upon by chubs. *Ischnura* nymphs were abundant in submerged macrophytes at the lake margin. Considering the abundance of the mayfly *Callibaetis* in the lake, it is surprising that Williams and Williams (1980) did not find them in chub stomach contents. *Callibaetis* niaids are darting swimmers and perhaps they are able to avoid predation by chubs.

Based on the observed seasonal and spatial distribution and behavioral patterns of terrestrial arthropods, it is possible to make predictions on the probability that they would be preyed upon by chubs. Workers of the four species of ants that are abundant along the lake edge do not fly and it is unlikely that they would be deposited on the water surface. Hence, the tendency for them to be preyed upon by chubs is probably reduced by virtue of these behavioral features. Winged ant reproductives of these same species, however, may often be deposited on the water surface during their nuptial flights because they are relatively weak fliers. When considered together as a group, ant reproductives of various species would be present from April through October, and hence would likely represent a significant percentage of the considerable number of Hymenoptera individuals reported to occur in the stomachs of chubs (Williams and Williams 1980). The jumping behavior of springtails, coupled with their distribution close to the lake, would make them another candidate for an important food item for the chub, especially in the early part of the year. Similarly, wolf spiders, especially individuals of *Pardosa sternalis,* often skate on the water surface and may be taken frequently by chubs. Both springtails and wolf spiders (especially younger ones) are soft-bodied and palatable, making it likely that they may contribute significantly to the chub's diet. Williams and Williams (1980) observed a high frequency of spiders in the chub’s diet during spring and summer, which is consistent with seasonal patterns of abundance of the three species of wolf spiders. The great abundance of adult midges and shore flies present in spring and summer corresponds closely to gut content composition reported by Williams and Williams (1980). In fact, dipteran adults represented the greatest volume of gut contents in both spring and summer, the periods of time in which adults of the 25 species in these two families are most common. In summary, while terrestrial arthropods should contribute little to chub diet in the winter, winged ants, shore flies and midges would be expected to be a primary source of food by spring to early summer. By late summer, winged ants, springtails, and spiders should be most common in chub guts, with terrestrial arthropods as a group declining significantly in diet contribution by autumn.

A change in flow into or out of the lake would influence the availability of water near the lake and result in changes to the surrounding vegetative community. Wetter conditions would favor more extensive stands of *Scirpus* and *Eleocharis*; drier conditions would favor the expansion of *Distichlis* and eventually more xeric vegetation. The species composition of invertebrates associated with Borax Lake and the food resources available to the chub are likely to be influenced by any significant change in the vegetation that surrounds it. The most abundant adult flies in our collections were *Pseudosmittia*, ephydrids, and other semi-aquatic species. If this is an accurate reflection of the adult flies known to be consumed by the chub in great numbers (Williams and Williams 1980), then a lowering of the water table would have a disproportionately adverse effect on semi-aquatic habitats and the significant food source which emerges from them. A change in the flow of water into or out of the lake would likely influence the availability of nutrients to algae, bacteria, and invertebrates living in or near the lake and hence ultimately change their productivity. These changes could ultimately affect the abundance and type of food available to chubs. A change in flow could also affect the temperatures of the lake and the springs, seeps, and potholes surrounding it. A significant increase in water temperature could have dire consequences for the Borax Lake chub as well as many aquatic invertebrates living in or near the lake. The critical thermal maximum for the Borax Lake chub is approximately 34.5^{o}C (Williams and Bond 1983).

Physical damage to the fragile salt crust (sinter) surrounding the lake due to trampling by livestock and/or human activities could result in a rapid and significant drop in lake level if this activity were to cause a breech in the fragile sinter along the lakeshore. Changes in water chemistry might also accelerate the chronic dissolution of the salt crust with similar results over a longer period of time. The immediate result of such events might include drying and loss of near-shore habitat, causing reductions and alterations in the algal and invertebrate populations associated with it.

Acknowledgements

We are grateful to the Nature Conservancy for its financial support (Contract Number ORFO-040391) and helpful guidance from Dan Salzer, TNC Project Coordinator. Berta Youtie and Bob Ottersburg provided descriptions of habitat with respect to plants and soils. Mary Lacey-Theisen of the Systematic Entomology Laboratory, U.S. Department of Agriculture (SEL-USDA), Beltsville, MD, distributed many specimens to experts for identification. The following experts verified species identifications: R.C. Anderson, Idaho State University, Pocatello, ID (Scorpionida); B. Bilyj, Freshwater Institute, Winnipeg, Manitoba, Canada (Chironomidae); G.W. Byers, University of Kansas, Lawrence, KS (Tipulidae); R. Crawford, Burke Museum, University of Washington, Seattle, WA (Araneae, Solifugae); C.H. Dietrich, SEL-USDA (Homoptera:Auchenorrhycha); J. DiGiulio, OSU, Corvallis, OR (Hymenoptera); L.D. Delorme, National Water Research Institute, Burlington, Ontario, Canada (Ostracoda); D.G. Farara, Beak Consultants, Brampton, Ontario, Canada (Oligochaeta); T.J. Frest, Deixis Consultants, Seattle, WA (Mollusca); R.C. Froeschner, Smithsonian Institution, Washington, D.C. (Hemiptera); R.J. Gagne, SEL-USDA (Cecidomyiidae); T. Griswold SEL-USDA (Halictidae); W.L. Grogan, Salisbury State University, Salisbury, MD (Ceratopogonidae); T. Henry, SEL-USDA (Hemiptera); D.B. Herbst, Sierra Nevada Aquatic Research Laboratory, Mammoth Lakes, CA (Ephydridae); G.W. Krantz, OSU (Acari); J.R. LaBonte, OSU (Carabidae: *Bembidion, Microlestes,* and *Stenolophus*); W.N. Mathis, Smithsonian Institution, Washington, D.C. (Ephydridae); A.S. Menke, SEL-USDA (Hymenoptera); G.L. Miller, SEL-USDA (Coccidae); A.R. Moldenke, OSU (Collembola, Acari, Pseudoscorpionida); D.A. Nickle, SEL-USDA (Orthoptera); A.L. Norrbom, SEL-USDA, (Cyclorrhapha: Acalyptratae); G.L. Parsons, OSU (Coleoptera); R.V. Peterson, SEL-USDA (Psychodidae); W.D. Shepard, Pinole, CA (*Microcylloepus*); D.R. Smith, SEL-USDA, (Formicidae); C.W. Sobrosky, SEL-USDA (Chloropidae); R. Truitt, OSU, (plankton); and N.E. Woodley, SEL-USDA (Cyclorrhapha). Cheryl Barr, Curator of the Essig Museum of Entomology, University of California, Berkeley, CA, reviewed and provided a taxonomic update for the list of Coleoptera collected. Courtney Loomis, Donna Rainboth, and Tom McIver assisted in the field, and Michael Cummings, David Herbst, and Darlia Wright provided editorial comments on the manuscript.

References

American Public Health Association (APHA). 1989. *Standard Methods for the Examination of Water and Wastewater*. 17th Ed. Washington, D.C.

Brock, T.D., D.W. Smith and M.T. Madigan. 1984. Biology of Microorganisms. 4th Ed. Prentice-Hall, Inc., New Jersey. 847 pp.

Brown, D.E. and N.V. Peterson. 1980. Preliminary geology and geothermal resource potential of the Alvord Desert Area, Oregon. Oregon Department of Geology and Mineral Industries. Open File Report 0-80-10. 57 pp.

Cobb, N., E. Gruber, E. Heske, A. Flecker, D. Lightfoot, A. Masters, N. McClintock, J. Price, T. Seibert and M. Smith. 1981. An ecological study of the Alvord Basin dunes, southeastern Oregon. Final Technical Report for National Science Foundation Grant No. SP-7905328. Oregon State University, Corvallis, OR. 142 pp.

Cronquist, A., A.H. Holmgren, N.H. Holmgren and J.L. Reveal. 1972. Intermountain Flora- Vascular Plants of the Intermountain West, U.S.A. Vol. 1. Hafner Publishing Company, New York, NY. 270 pp.

Darby, R.O. 1962. Midges associated with California rice fields, with special reference to their ecology (Diptera:Chironomidae). *Hilgardia* 32:1-206.

Daubenmire, R.F. 1974. Plants and the Environment. John Wiley & Sons. New York, NY.

Ekins, L. and S.R. Rushforth. 1986. Diatom flora of Cowboy Hotspring, Mono County, CA. *Great Basin Naturalist* 46:612-624.

Epler, J.H. 1988. A reconsideration of the genus *Apedilum* Townes, 1945 (Diptera: Chironomidae). *Spixiana Supplement* 14:105-116.

Franklin, J.F. and C.T. Dyrness. 1973. *Natural Vegetation of Oregon and Washington*. Pacific Northwest Forest and Range Experiment Station. Portland, OR. USDA Forest Service General Technical Report PNW-8. 417 pp.

Gauch, H.G., Jr. 1982. Multivariate Analysis in Community Ecology. Cambridge University Press, New York, NY. 298 pp.

Green, G.A. 1978. Summer birds of the Alvord Basin, Oregon. *The Murrelet* 59:59-69.

Herbst, D.B. 1986. Comparative studies of the population ecology and life history patterns of an alkaline salt lake insect: *Ephydra* (*Hydropyrus*) *hians*. Ph.D. dissertation, Oregon State University, Corvallis, OR. 206 pp.

Hill, M.O. 1979. DECORANA: a FORTRAN program for detrended correspondence analysis and reciprocal averaging. Cornell University, Ithaca, NY. 52 pp.

Hornig, D.S., Jr. and W.F. Barr. 1970. Insects of Craters of the Moon National Monument, Idaho. University of Idaho, College of Agriculture Miscellaneous Series Number 8. 118 pp.

Kaczmarska, I. and S.R. Rushforth. 1983. The diatom flora of Blue Lake Warm Spring, Utah. USA. *Biblio. Diatomologica* 2(1):1-123.

Kierstead, J. and T. Pogson. 1976. A summer flora of the Alvord basin. In, K. Roberts, L. Bischoff, K. Brodersen, G. Green, D. Gritten, S. Hamilton, J. Kierstead, B. Malcom, E. Perkins, T. Pogson, R. Stewart and D.E. Kerley (eds.), A preliminary ecological survey of the Alvord basin. Final Technical Report for National Science Foundation- SOS Grant No. 76-08175. Eastern Oregon State College, LaGrande, OR. 54 pp.

Lamberti ,G.A. and J.W. Moore. 1984. Aquatic insects as primary consumers. Pages 164-195 In, V.H. Resh and D.M. Rosenberg (*eds*.) The Ecology of Aquatic Insects. Praeger Publishers, New York, NY. 625 pp.

Merritt, R.W. and K.W. Cummins. 1984. An Introduction to the Aquatic Insects of North America. 2nd Ed. Kendall/Hunt Publishing Co., Dubuque, IA. 722 pp.

Omernik, J.M. and A.L. Gallant. 1986. Ecoregions of the Pacific Northwest. United States Environmental Protection Agency, EPA/600/3-86/033. 39 pp.

Price, J. and T. Seibert. 1981. A vegetational analysis of the Alvord Basin sand dunes. Pages 14-27 In, N. Cobb and others (eds.), An ecological study of the Alvord Basin sand dunes, southeastern Oregon. Final Technical Report for National Science Foundation Grant No. SP-7905328. Oregon State University, Corvallis, OR. 142 pp.

Roberts, K., L. Bischoff, K. Brodersen, G. Green, D. Gritten, S. Hamilton, J. Kierstead, B. Malcom, E. Perkins, T. Pogson, R. Stewart and D. Kerley. 1976. A preliminary ecological survey of the Alvord Basin. Final Technical Report, NSF-SOS Grant No. 76-08175. Eastern Oregon State College, LaGrande, OR. 54 pp.

Scoppettone, G.G., P.H. Rissler, B. Nielsen, and M. Grader. 1995. Life history and habitat use of Borax Lake chub (*Gila boraxobius* Williams and Bond) with some information on the Borax Lake ecosystem. Report to The Nature Conservancy, Portland, OR. 47 pp.

Seymour, D. 1992. Monitoring of Borax Lake, Unpublished Report, USDI, Bureau of Land Management, Portland, OR. 64 pp.

Stewart, W.D.P. 1974. Algal Physiology and Biochemistry. Botanical Monographs, Volume 10. University of California Press. 989 pp.

U.S. Fish and Wildlife Service (USFWS). 1987. Recovery plan for the Borax Lake chub, *Gila boraxobius*. U.S. Fish and Wildlife Service, Portland, OR. 57 pp.

Wiederholm, T. 1989. The adult males of the Chironomidae (Diptera) of the Holarctic region: Keys and diagnoses. *Entomolgica Scandinavica Supplement* 34:1-532.

Williams, J.E. and C.E. Bond. 1983. Status and life history notes on the native fishes of the Alvord Basin, Oregon and Nevada. *Great Basin Naturalis*t 43:409-420.

Williams, J.E. and C.D. Williams. 1980. Feeding ecology of *Gila boraxobius* (Osteichthyes: Cyprinidae) endemic to a thermal lake in southeastern Oregon. *Great Basin Naturalist* 40:101-114.

Appendix A. Occurrence and seasonal abundance of invertebrate species collected at Borax Lake, Harney County, Oregon. When the total number of specimens collected was not recorded for a given field trip, only the individual taxon identified was entered.
Designated collection dates: April 25-29, June 20-25, August 22-25, 1991, and January 10-13, 1992.
Sampling methods included pitfall traps, a light trap, sweep nets, beating sheet, and aquatic dip net.

Phylum/Class/Order/Family	Taxon		Apr	Jun	Aug	Jan	Total
ANNELIDA							
Enchytraeidae		Oligochaete worms			1		1
Tubificidae	*Ilyodrilus templetoni* (Southern)	“ “			1		1
	Limnodrilus hoffmeisteri Claparede	“ “				1	1
	Limnodrilus sp.	“ “		84			84
	Potamothrix moldaviensis Vejdovsky & Mrazek	“ “		4	1		5
MOLLUSCA							
Physidae	*Physella* (*Physella*) *gyrina*	tadpole physa snail					
Planorbidae	*Planorbella* (*Pierosoma*) *oregonensis*	lamb rams-horn snail					
ARTHROPODA							
OPILIONES							
Phalangiidae	*Opiliones* sp. (OPIL)	Harvestmen			30		30
PSEUDOSCORPIONIDA							
Cheirididae	*Apocheiridium fergusoni* Benedict	Pseudoscorpions			1		1
SOLFUGAE							
Eremobatidae	*Eremobates mormonus* Roewer	Sun-scorpions or Wind Spiders			2		2
SCORPIONIDA							
Vaejovidae	*Paruroctonus boreus* (Girard)	Scorpions			1		1
ACARI							
Anystidae	Hololena sp. juv.	Mites		3	1		4
Caeculidae	*? Caeculus* sp.	"					1
Crotoniodea	*Malaconothrus* sp.	"					
Damaeoidea		"			9		9
Erythraeidae		"			13		13
Ixodidae	*Ixodes* sp.	"		1			1
Oripodoidea	*Oribatula* sp.	"			2		2
Pionidae	*Nautarachna* sp.	"					1
Trombidiidae	(VEMI)	"	12	11	18		41
ARANEAE							
Agelenidae	*Hololena* sp. juv.	Funnel-web weaver spiders			2		2
Amaurobiidae	*Argenna obesa* Emerton	Hackled-band weaver spiders	4	7			11
Araneidae	*Neoscona* sp. juv.	Orb weaver spiders		54	1		55
Clubionidae	*Phrurotimpus parallelus* (Chamb.)	Diurnal running spiders	1	1	4		6
Dictynidae	*Dictyna littoricolens* Chamb. & Ivie	Hackled-band weaver spiders			2		2
	Dictyna reticulata Gertsch & Ivie	" " " "		6			6
	Dictyna sp. nov. ("*longispina*" group)	" " " "			1		1
	Tricholathys spirals Chamb. & Ivie	" " " "		8	1		9

Appendix A. Occurrence and seasonal abundance of invertebrate species collected at Borax Lake, Harney County, Oregon. When the total number of specimens collected was not recorded for a given field trip, only the individual taxon identified was entered.

Designated collection dates: April 25-29, June 20-25, August 22-25, 1991, and January 10-13, 1992. Sampling methods included pitfall traps, a light trap, sweep nets, beating sheet, and aquatic dip net.

Phylum/Class/Order/Family	**Taxon**		Apr	Jun	Aug	Jan	Total
Gnaphosidae	*Drassyllus depressus* (Emerton)	Nocturnal running spiders	3	19	2		24
	Drassodes neglectus (Keyserling)	" " "		5	2		7
	Haplodrassus signifer (C.Koch) (HASI)	" " "	10	39	6		55
	Micaria longispina Emerton	" " "	1	2			3
	Micaria rossica Thorell	" " "	1				1
	Zelotes puritanus Chamberlin	" " "		1			1
Lycosidae	*Allocosa subparva* Dondale & Redner (ALSU)	Wolf spiders	20	78	104		202
	Pardosa sternalis (Thorell) (PAST)	" "	49	93	183		325
	Pirata piraticus (Clerck) (PIPI)	" "	25	99	231		355
Microphantidae	*Erigone dentosa* O. Pickard-Cambridge	Sheet-web weaver spiders	5	9	3		17
	Halorates plumosus (Emerton)	" " " "	1				1
	Satilatlas insolens Millidge	" " " "	30	1			31
	Spirembolus sp. nr. *spirotubus* (Banks)	" " " "	18				18
	Walckenaeria subspiralis Millidge	" " " "	30				30
Oxyopidae	*Oxyopes* sp. juv.	Lynx spiders		6			6
Philodromidae	*Philodromus insperatus* Schick	Crab spiders		3	1		4
	Thanatus coloradensis Keyserling	" "	1	1	1		3
Salticidae	*Habronattus americanus* (Keyserling)	Jumping spiders		2			2
	Habronattus hirsutus (Peck. & Peck.)	" "	1	3	2		6
	Habronattus sp. juv.	" "			1		1
	Metaphidippus clematus Levi & Levi	" "		11	2		13
	Metaphidippus (*Phanias*) sp. juv.	" "		6			6
	Sassacus sp. juv.	" "	1				1
	Synageles occidentalis Cutler	" "		3	1		4
Tetragnathidae	*Tetragnatha pallescens F. Pickard-Cambridge*	Long-jawed orb weaver spiders		1	2		3
Theridiidae	*Theridion goodnightorus* Levi	Comb-footed spiders		2	1		3
	Theridion petraeum L. Koch	" " "		1			1
Theridiidae	*Enoplognatha* sp.	" " "		1			1
Thomisidae	*Ozyptila beaufortensis* Strand	Crab spiders	2	10	2		14
	Xysticus montanensis Keyserling	" "		2	1		3
CHILOPODA							
Lithobiomorpha		Centipedes	2	3	9		14
COLLEMBOLA							
Hypogastruridae	*Hypogastrura* (*Ceratophysella*) sp.	Springtails					1
Isotomidae	*Isotomurus* new sp. (ISOT)	"	488	598	23	8	1,109
Poduridae		"	2				2
Sminthuridae		"			7		7
THYSANOPTERA							
Thripidae	(Scoppettone et al. 1995)						

Appendix A. Occurrence and seasonal abundance of invertebrate species collected at Borax Lake, Harney County, Oregon. When the total number of specimens collected was not recorded for a given field trip, only the individual taxon identified was entered.
Designated collection dates: April 25-29, June 20-25, August 22-25, 1991, and January 10-13, 1992.
Sampling methods included pitfall traps, a light trap, sweep nets, beating sheet, and aquatic dip net.

Phylum/Class/Order/Family	Taxon		Apr	Jun	Aug	Jan	Total
EPHEMEROPTERA							
Baetidae	*Callibaetis* sp.	Mayflies			17		17
ODONATA							
Aeschnidae	*Anax* sp.	Darners (Dragonflies)		1			1
	Erythemis sp.	" "			3		3
Coenagrionidae	*Amphiagrion* sp. (from Scoppettone et al. 1995)	Damselflies					
	Argia sp.	"		1			1
	Enallagma carunculatum Morse	"			1		1
	Enallagma clausem Morse	"			1		1
	Erythemis sp	"					
	Ischnura cervula Selys	"			2		2
	Ischnura denticollis (Burmeister)	"		1	9		10
	Ischnura perparva Selys	"			1		1
	Ischnura sp 1	"		1	2		3
Libellulidae	*Libellula lydia* Drury	Common skimmers (Dragonflies)		1	10		11
	Sympetrum corruptum (Hagen)	" " "					
	Sympetrum costiferum Hagen	" " "		1			1
	Sympetrum internum Montgomery	" " "	1	1			2
ORTHOPTERA							
Acrididae	*Circotettix carlinianus* (Thomas)	Snapper grasshoppers					1
Acrididae	*Melanoplus sanguinipes* (Fabricius)	Lesser migratory grasshoppers					1
Gryllacrididae	*Ceuthophilus* sp.	Camel crickets			1		1
Gryllidae	*Gryllus* sp.	Crickets		3	11		14
Tettigonidae	*Conocephalus* sp.	Lesser meadow katydids		1			1
HEMIPTERA							
Anthocoridae		Minute pirate bugs			2		2
Belostomatidae	*Belostoma bakeri* (Montandon)	Giant water bugs			3		3
Corixidae	*Corisella decolor* (Uhler)	Water boatmen		7			7
	Graptocorixa sp	" "			2		2
	Hesperocorixa laevigata (Uhler)	" "		1			1
Gerridae	*Gerris* sp.	Water striders		2			2
Lygaeidae sp 1	3 spp.	Seed bugs	1	2	3		6
	Lyslus sp (from Scoppettone et al. 1995)						
	Phylinae	Plant or leaf bugs		7			7
	Clivinema sp.	" " "		1			1
Nabidae	*Nabis* sp. prob. *alternatus* Parshley	Damsel bugs		1	1		2
Notonectidae	*Notonecta spinosa* Hungerford	Backswimmers		2	3		5
	Notonecta unifasciata Guerin-Menevill	"					
Reduviidae	*Zelus* sp.	Assassin bugs			1		1
Saldidae	*Saldula* sp. (SALD)	Shore bugs		31	16		47
Scutelleridae	*Eurygaster alternata* (Say)	Shield-back bugs					

Appendix A. Occurrence and seasonal abundance of invertebrate species collected at Borax Lake, Harney County, Oregon. When the total number of specimens collected was not recorded for a given field trip, only the individual taxon identified was entered. Designated collection dates: April 25-29, June 20-25, August 22-25, 1991, and January 10-13, 1992.
Sampling methods included pitfall traps, a light trap, sweep nets, beating sheet, and aquatic dip net.

Phylum/Class/Order/Family	**Taxon**		Apr	Jun	Aug	Jan	Total
HOMOPTERA							
Aphidae		Aphids		1	5		6
Cicadellidae	Athysanella utahana Osborn (CICA)	Leafhoppers	12	9	9		30
Cicadellidae	2 spp.	"			4		4
COLEOPTERA							
Anthicidae	*Anthicus* sp. (ANTH)	Antlike flower beetles	1	5	16		22
	Cyclodinus mimus (Casey)	" " "					
Cantharidae	*Cantharis alticola* LeConte	Soldier beetles	1				1
Carabidae	*Agonum* sp.	Ground beetles					
	Amara scitula Zimmerman	" "		2			2
	Bembidion diligens (BEMB)	" "	1				1
	Bembidion insulatum LeConte (BEMB)	" "	1				1
	Bembidion mormon Hayward (BEMB)	" "	2				2
	Bembidion nebraskensis LeConte (BEMB)	" "	1				1
	Bembidion obtusangulum LeConte (BEMB)	" "	1				1
	Bembidion praecinctum LeConte (BEMB)	" "	1				1
	Bembidion roosvelti Pic (BEMB)	" "	9				9
	Bembidion timidium LeConte (BEMB)	" "	1				1
	Bembidion spp.	" "		11	11		22
	Chlaenius pennsylvanicus Say	" "		1	8		9
	Dyschirius 2 spp.	" "	3	9	1		13
	Cicindela haemorrhagica LeConte	Tiger beetles			29		29
	Cicindela willistoni LeConte	" "			2		2
	Elaphrus lecontei Crotch	Ground beetles		3	2		5
	Harpalus somnulentus Dejean	" "					
	Harpalus sp.	" "					
	Microlestes linearis LeConte	" "	15	11	12		38
	Stenolophus anceps LeConte	" "	2	3	10		15
	Tachys corax LeConte	" "	11				11
	Tachys sp.	" "		1	7		8
Chrysomelidae	*Metachroma immaculatum* Blake	Leaf beetles			1		1
Cleridae	*Phyllobaenus subfasciatus* LeConte	Checkered beetles	1				1
Coccinellidae	*Coccinella transversoguttata richardsoni* Brown	Ladybird beetles	1				1
	Hippodamia convergens Guerin	" "		1			1
	Hyperaspis lateralis Mulsant	" "		1			1
	Hyperaspis simulatrix Dobzhansky	" "		1			1
	Hippodamia convergens Guerin	" "		1			1
	Paranaemia vittigera (Mannerheim)	" "			2		2
	Scymnus marginicollis Mannerheim	" "	1	1			2

Appendix A. Occurrence and seasonal abundance of invertebrate species collected at Borax Lake, Harney County, Oregon. When the total number of specimens collected was not recorded for a given field trip, only the individual taxon identified was entered.
Designated collection dates: April 25-29, June 20-25, August 22-25, 1991, and January 10-13, 1992.
Sampling methods included pitfall traps, a light trap, sweep nets, beating sheet, and aquatic dip net.

Phylum/Class/Order/Family	Taxon		Apr	Jun	Aug	Jan	Total
Curculionidae	*Notiodes setosus* (LeConte) *****	Weevils			2		2
	Sphenophorus aequalis Gyllenhal	"					
	Sphenophorus simplex LeConte	"		4	5		9
Dytiscidae	*Dytiscus marginicollis* LeConte	Predaceous diving beetles					
	Hygrotus infuscatus (Sharp)	" " "					
	Laccophilus mexicanus atristernalis Crotch	" " "					
	Laccophilus maculosus decipiens LeConte	" " "			1		1
Elateridae	*Aeolus mellillus* Say	Click beetles		3	5		8
	Dalopius sp.	" "		23	3		26
Elmidae	*Microcylloepus similis* (Horn)	Riffle beetles		25	15		40
Gyrinidae	*Gyrinus* sp.	Whirligig beetles		1			1
Haliplidae	*Peltodytes callosus* LeConte	Crawling water beetles					
Histeridae	*Euspilotus insertus* (LeConte)	Hister beetles					
	Saprinus desertoides McGrath & Hatch	" "		1	1		2
Hydraenidae	*Ochthebius lineatus* LeConte	Hydraenid beetles	1			1	2
Hydrophilidae	*Berosus* sp.	Water scavenger beetles					
	Cercyon sp.	" " "					
	Cymbiodota dorsalis Motschulsky	" " "	5	4	2		11
	Helophorus sp.	" " "					
	Tropisternus lateralis Fabricius	" " "			2		2
Leiodidae	*Cyrtusa picipennis* (LeC.)	Round fungus beetles		1	7		8
Melyridae	*Malachius horni* Fall	Blister beetles		10			10
Oedemeridae	*Asclera* sp.	False blister beetles		1			1
Silphidae	*Heterosilpha ramosa* (Say)	Carrion beetles		38	41		79
Staphylinidae	Aleocharinae	Rove beetles	10	5	4		19
	Astenus sp.	" "	2				2
	Bledius eximius Casey	" "					
	Bledius strenuus Casey	" "	22	45	24		91
	Orus parallelus Casey	" "					
	Philonthus sp. 1	" "	5	7	6		18
	Philonthus sp. 2	" "					
	Reichenbachia sp.	" "					
	Stenus prob. *costalis* Casey	" "	1				1
	Tachinus sp. (Possibly undescribed)	" "		1			1
Tenebrionidae	*Coniontus* sp.	Darkling beetles	3		7		10
	Eleodes pilosa Horn	" "	1	48	22		71
	Eleodes sp.		1	46	5		52
TRICHOPTERA							
Limnephilidae	*Limnephilus assimilis*	Caddis flies					
LEPIDOPTERA							
Geometridae		Inchworms		2			2
Noctuidae		Noctuid moths		4			4

Appendix A. Occurrence and seasonal abundance of invertebrate species collected at Borax Lake, Harney County, Oregon. When the total number of specimens collected was not recorded for a given field trip, only the individual taxon identified was entered.

Designated collection dates: April 25-29, June 20-25, August 22-25, 1991, and January 10-13, 1992. Sampling methods included pitfall traps, a light trap, sweep nets, beating sheet, and aquatic dip net.

Phylum/Class/Order/Family	**Taxon**		Apr	Jun	Aug	Jan	Total
DIPTERA							
Anthomyiidae		Anthomyiid flies			5		5
Asilidae		Robber flies		1			1
Cecidomyiidae		Gall midges			6		6
Ceratopogonidae		Biting midges	5	20			25
Chironomidae	*Apedilum elachistum* Townes	Non-biting midges	58	24	1		83
	Chironomus maturus Johannsen	" " "			1		1
	Conchapelopia pupa	" " "					
	Cricotopus (*Isocladius*) *sylvestris* (Fabricius)	" " "	1	5			6
	Dicrotendipes nr. *Crypticus* Epler	" " "					
	Larsia n. sp. Bilyj	" " "					
	Limnophyes sp.	" " "					
	Micropsectra nigripila group	" " "	138	20	2		160
	Microtendipes pedellus (from Scoppettone et al. 1995)	" " "					
	Mixed spp	" " "	243	57	5		305
	Paratendipes sp.	" " "					
	Procladius sp.	" " "					
	Pseudosmittia forcipata (Goetghebuer.)	" " "	232	141	25		398
	Tanypus sp.	" " "					
	Thienemannimyia barberi (Coquillett)	" " "	47	14			61
Chloropidae	*Homaluroides distichliae* (Malloch)	Chloropid flies		1			1
	Malloewia n. sp. 1, near diabolus *(Becker)*	" " "	3	47	5		55
	Malloewia n. sp. 2, near diabolus *(Becker)*	" " "	1	6	4		11
	Thaumatomyia pulla (Adams)	" " "		6	1		7
Culicidae	*Culex p. pipiens* (Linnaeus)	Mosquitoes		2			2
	Culiseta inornata (Williston)	"		2			2
Dolichopodidae		Long-legged flies		6			6
	Drapetis sp.	" " "			11		11
Drosophilidae		Pomace flies			2		2
Empididae		Dance flies		1			1
Ephydridae	*Calocoenia platypelta* (Cresson)	Shore flies	2	102	12		116
	Ephydra hians (Say)	" "		4	1		5
	Notiphila sp.	" "					
	Ochthera sp.	" "	1				1
	Paracoenia bisetosa (Coquillett)	" "	1	74			75
	Scatella marinensis (Cresson)	" "	14	29			43
	Scatella stagnalis (Fallen)	" "					
	Scatophila sp.	" "		18	79		97
Muscidae	2 spp.	House flies					

Appendix A. Occurrence and seasonal abundance of invertebrate species collected at Borax Lake, Harney County, Oregon. When the total number of specimens collected was not recorded for a given field trip, only the individual taxon identified was entered.
Designated collection dates: April 25-29, June 20-25, August 22-25, 1991, and January 10-13, 1992.
Sampling methods included pitfall traps, a light trap, sweep nets, beating sheet, and aquatic dip net.

Phylum/Class/Order/Family	**Taxon**		Apr	Jun	Aug	Jan	Total
Otididae	*Haigia nevadena* Steyskal	Picture-winged flies		21			21
	Tritoxa pollinosa Cole	" " "		6			6
Psychodidae	*Psychoda* sp. female	Moth flies			1		1
Sarcophagidae	*Ravinia* sp. near *pectinata* (Aldrich)	Flesh flies			4		4
Scatopsidae		Minute black scavenger flies		6			6
Sciaridae	*Bradysia* 2 spp.	Dark-winged fungus gnats	52	14			66
Sepsidae	*Sepsis* sp.	Black scavenger flies	1	1			2
Shaeroceridae	*Rachispoda* sp.	Small dung flies		11	28		39
	Shaeroceridae 4 spp.	" " "	1	19	26		46
Stratiomyidae	*Micrempis* sp.	Soldier flies					
	Nemotelus sp.	" "			1		1
	Odontomyia sp.	" "					
	Stratiomys sp.	" "	2	2	3		7
Syrphidae		Bee flies			1		1
Tabanidae	*Chrysops* sp.	Deer flies					
	Tabanus sp.	Horse flies	4	1			5
Tachinidae	Zaira sp.	Tachinid flies			1		1
Therevidae		Stiletto flies			3		3
Tipulidae	*Limonia brevivena* (Osten Sacken)	Crane flies		13			13
HYMENOPTERA							
Alloxystidae		Gall wasps	4	3	9		16
Bethylidae	Epyris sp.	Bethylid wasps		1			1
Braconidae (4 spp.)		Braconid wasps		2	2		4
Ceraphronidae	*Ceraphron* sp.	Ceraphronid wasp					
Chalcididae	*Hockeria* sp.	Chalcid wasps		1			1
Chrysididae	*Hedychridium amabile* Cockerell	Cuckoo wasps			1		1
Cynipidae	*Kleidotoma* sp.	Gall wasps		4			4
Diapriidae	*Trichopria* 3 spp.	Diapriid wasps	2	1	9		12
Dryinidae	Gonatopodinae	Dryinid wasps		1	1		2
Eulophidae	*Tetrastichus* sp.	Eulophid wasps		2	2		4
Formicidae	*Acryomyops murphyi (Forel)*	Ants			7		7
	Brachymyrmex depilis Emery	"	2	3	120		125
	Formica manni Wheeler	"	110	104	431		645
	Formica neoclara Emery	"			5		5
	Lasius crypticus Wilson	"	8	6	4		18
	Lasius sp.	"		1			1
	Leptothorax sp.	"			3		3
	Manica mutica (Emery)	"	104	123	96		323
	Myrmica brevispinosa Wheeler	"	27	10	53		90
	Pheidole sp.	"			3		3
	Tapinoma sessile (Say)	"	76	83	197		356

Appendix A. Occurrence and seasonal abundance of invertebrate species collected at Borax Lake, Harney County, Oregon. When the total number of specimens collected was not recorded for a given field trip, only the individual taxon identified was entered.
Designated collection dates: April 25-29, June 20-25, August 22-25, 1991, and January 10-13, 1992.
Sampling methods included pitfall traps, a light trap, sweep nets, beating sheet, and aquatic dip net.

Phylum/Class/Order/Family	**Taxon**		Apr	Jun	Aug	Jan	Total
Halictidae	*Dialictus* sp.	Halictid wasps					
	Oxybelus emarginatum Say (Sphecidae)	" "			1		1
	Sphecodes sp.	" "					
Hylaenidae		Yellow-faced bees			7		7
Mutillidae	*Dasymutilla* sp.	Velvet ants			1		1
	Pseudomethoca sp.	" "	1		3		4
Pompilidae	*Anoplius* sp.	Spider wasps		3	16		19
Pteromalidae	*Mesopolobus* sp.	Pteromalid wasps			1		1
	Pachyneuron sp.	" "		1	1		2
Scelionidae	*Trimorus* sp.	Scelionid wasps		1	14		15
Sphecidae	*Lyroda subita* Say	Thread-waist wasp			2		2
	Oxybelus emarginatum Say	" " "					
CRUSTACEA-Cladocera	*Alona rectangula*	Water fleas					
	Bosmina longirostris (O.F.M.)	" "					
-Copepoda	*Cleptocampus albuquerquensis*	Harpacticoid copepods					
	Macrocyclops fuscus (Jurine)						
-Ostracoda	*Candona* sp.	Seed shrimps					
	Cyprinotus glaucus Furtos	" "					
	Darwinula sp.	" "					
	Limnocythere sappaensis Staplin	" "					
-Amphipoda	*Hyallela azteca* (from Scoppettone et al. 1995)						
ROTIFERA	*Asplancha* sp. (from Scoppettone et al. 1995	Rotifers					
	Keratella (from Scoppettone et al. 1995)	"					
	Lepadella sp.	"					
	Notholca sp.	"					