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Aquatic biosurvey of the Lovell River on UNH land

Kathleen B. Utter, Rachel D. Skokan, David Rivers, Patrick K. Quinn, Jody D. Potter, Chris R. Peter, Emily A. Lund, Jessica L. Knox, Jorel I. Knobelman, James F. Haney, Sonya C. Carlson, Shane R. Bradt, Lisa M. Barry

Center for Freshwater Biology, Dept. of Zoology, University of New Hampshire, Durham, 03824

Abstract

We assessed the physical, chemical and biological conditions at two sites along the Lovell River on University of New Hampshire (UNH) -owned conservation land. The discharge was 4.4 m^3 s^{-1} at Site 1 and 5.7 m^3 s^{-1} downstream at Site 2. Canopy coverage ranged from 8-25%. Canopy was dominated by Eastern Hemlock (79-84%). Much of the stream was strewn with large boulders and the substrate consisted of rocks of highly variable sizes (3-549 cm dia.). Specific conductivity (22.1-23.3 µS), pH (6.4) and temperature (7.9-8.3 °C) varied little between sites. Macro-invertebrate bio-indices indicated either excellent water quality with no apparent organic pollution (3.0/10) or good water quality with possible slight organic pollution (4.4/10).

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Introduction

The Lovell River is located in Ossipee, New Hampshire. The University of New Hampshire owns a 193.2 hectare (477.4 acres) property that includes the portion of the Lovell River examined in this study (Figs. 1 & 2). The Lord family donated this property to the University of New Hampshire in 1951. Prior to our aquatic study, forestry and wildlife surveys of the property were conducted, but there are no reports on the ecology and hydrology of the Lovell River system. The purpose of this study was to assess the physical, chemical and biological condition of the Lovell River and provide the University and the public with this information.

History

Mr. Frank S. Lord became owner of the Bear Camp River tract at an unspecified date. Upon his death in 1933, Mr. Lord's will directed that the bulk of his estate, including many parcels of land, go to his two sisters and that, upon the death of the last of them, the estate go to the University of New Hampshire. The second of Mr. Lord's sisters died in 1951 and the estate was transferred to UNH in December of that year. Mr. Lord's will stipulated that all proceeds from land sales and from investments of assets be deposited in a scholarship fund for UNH-bound students from Carroll County, NH. Since 1951, the Lovell River tract has been managed by the UNH Office of Woodlands and Natural Areas (Communication from the UNH OWNA).

Acknowledgements

We thank Bob Craycraft for use of stream gauging equipment and Tom Lee for information pertaining to the property. This study was conducted as a project of the UNH Stream Ecology class of 2003. The authors are the members of the class and are listed in descending alphabetical order. We would also like to give special mention to Shane Bradt and Sonya Carlson for their hard work in editing and manuscript preparation.

Methods

GPS coordinates and site elevations for each site (see Site Description) were taken based on an average of 10 minutes of readings using a hand-held GPS unit (Magellan NAV 6000). Specific conductivity (corrected for 25°C), temperature, and pH of stream water were measured using an YSI 30 Sonde. Benthic macroinvertebrates were sampled by both kick and pick sampling. The kick sampling was done using 0.5 mm mesh aquatic insect nets. The kicking was done for 10 minutes at two locations at each site. Pick sampling consisted of removing rocks from the streambed within the area kick sampled and collecting organisms present on

Table 1. Physical and chemical characteristics of all sites.

Site name	Location	Elev. (m)	pH	Temp. (°C)	Sp. Cond. (µS)	Canopy cover Mean ± SE (%)	Substrate size Mean ± SE (cm)
Cascade 1	43° 46.463' N, 71° 10.578' W	152.7	6.4	7.9	22.4	25 ± 8	29.5 ± 19.6
Reach 1	43° 46.463' N, 71° 10.578' W	152.7	6.4	8.3	23.3	25 ± 8	20.2 ± 12.8
Cascade 2	43° 46.399' N, 71° 10.528' W	145.1	-	-	-	-	-
Cascade 3	43° 46.404' N, 71° 10.414' W	145.7	6.4	8.0	22.2	5 ± 2	195.1 ± 91.9
Reach 3	43° 46.404' N, 71° 10.414' W	145.7	6.4	8.0	22.1	5 ± 2	108.7 ± 37.0
Reach 4	43° 46.456' N, 71° 10.334' W	142.6	-	-	-	-	-

each rock. This provided organisms that colonize larger substrates. Macro-invertebrates were identified in the lab to the lowest taxonomic level possible using Merritt and Cummins (1996) Peckarsky *et al*. (1990) and Needham *et al*. (2000).

Both the Modified Family Biotic Index (MFBI) (Hilsenhoff 1988) and the Family/Genus Biotic Index (FGBI) (Barbour *et al.* 1999) were used to measure the health of the river as indicated by the macro-invertebrates present. In order to calculate the biotic index of a river, an index value ranging from zero to ten is assigned to each taxonomic group. Zero indicates the organism is generally found only in areas of good water quality and ten indicates the organism tolerates water heavily contaminated with organic pollutants. In the MFBI, index values are only assigned to families. The FGBI assigns values to family and genus allowing for a more accurate indication of pollution tolerance. The index values for the MFBI are the same across the entire United States. The FGBI values are given from five different regions in the United States: Ohio, Idaho, Wisconsin, South Carolina, and the Mid-Atlantic states. When the index values varied between regions, the values were averaged for that organism. The following equation is used to calculate both indexes:

$$BI = (\Sigma(n_i * v_i))/N$$

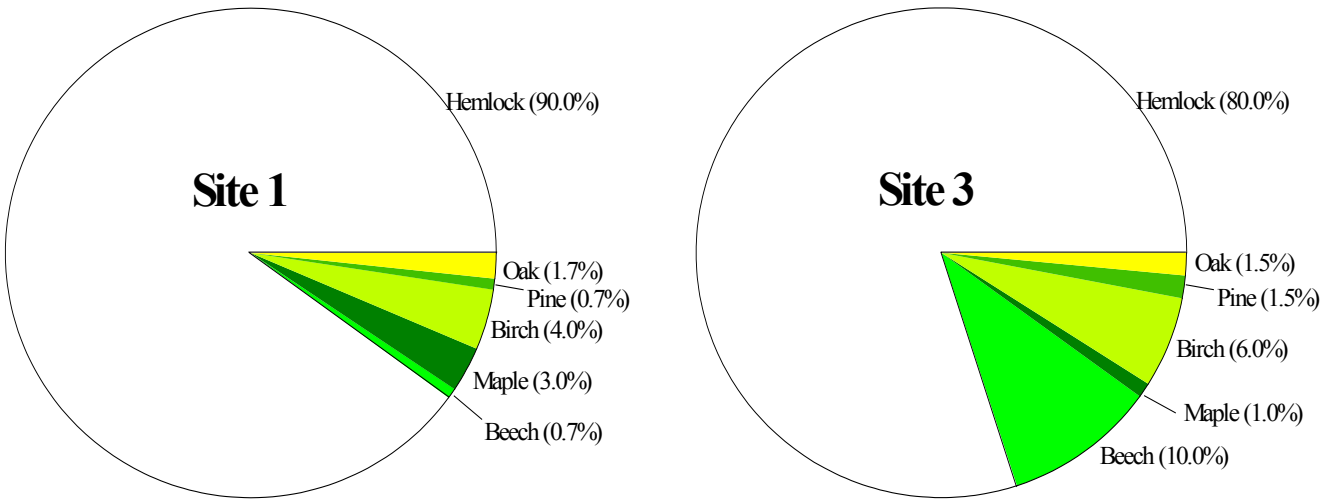


Figure 1. Average canopy cover composition of site 1 (reach 1, cascade 1) and site 3 (reach 3, cascade 3).

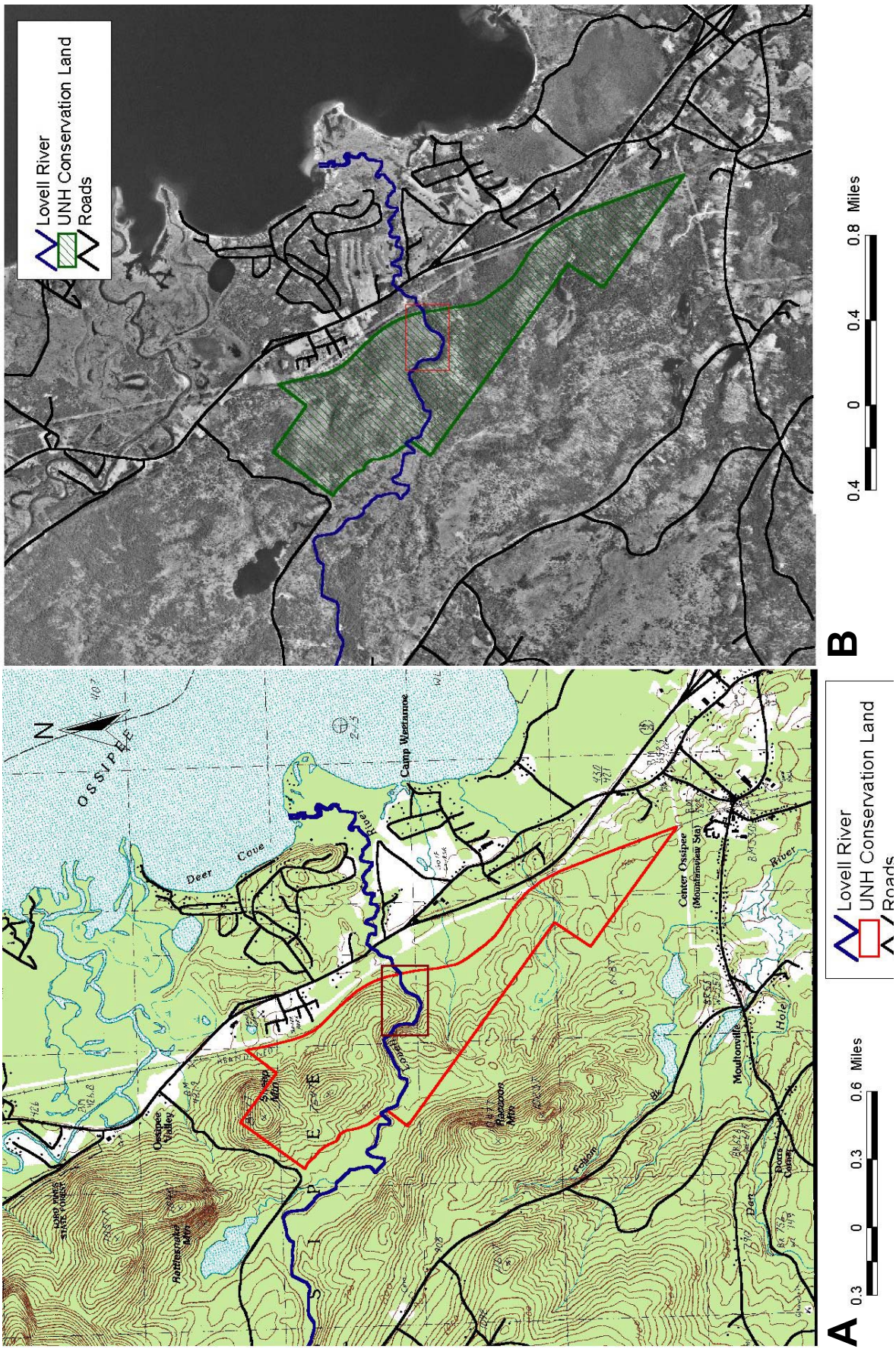


Fig. 2.. Topographical (A) and aerial maps (B) showing the location of the UNH-Conservation land that surrounds the Lovell River.

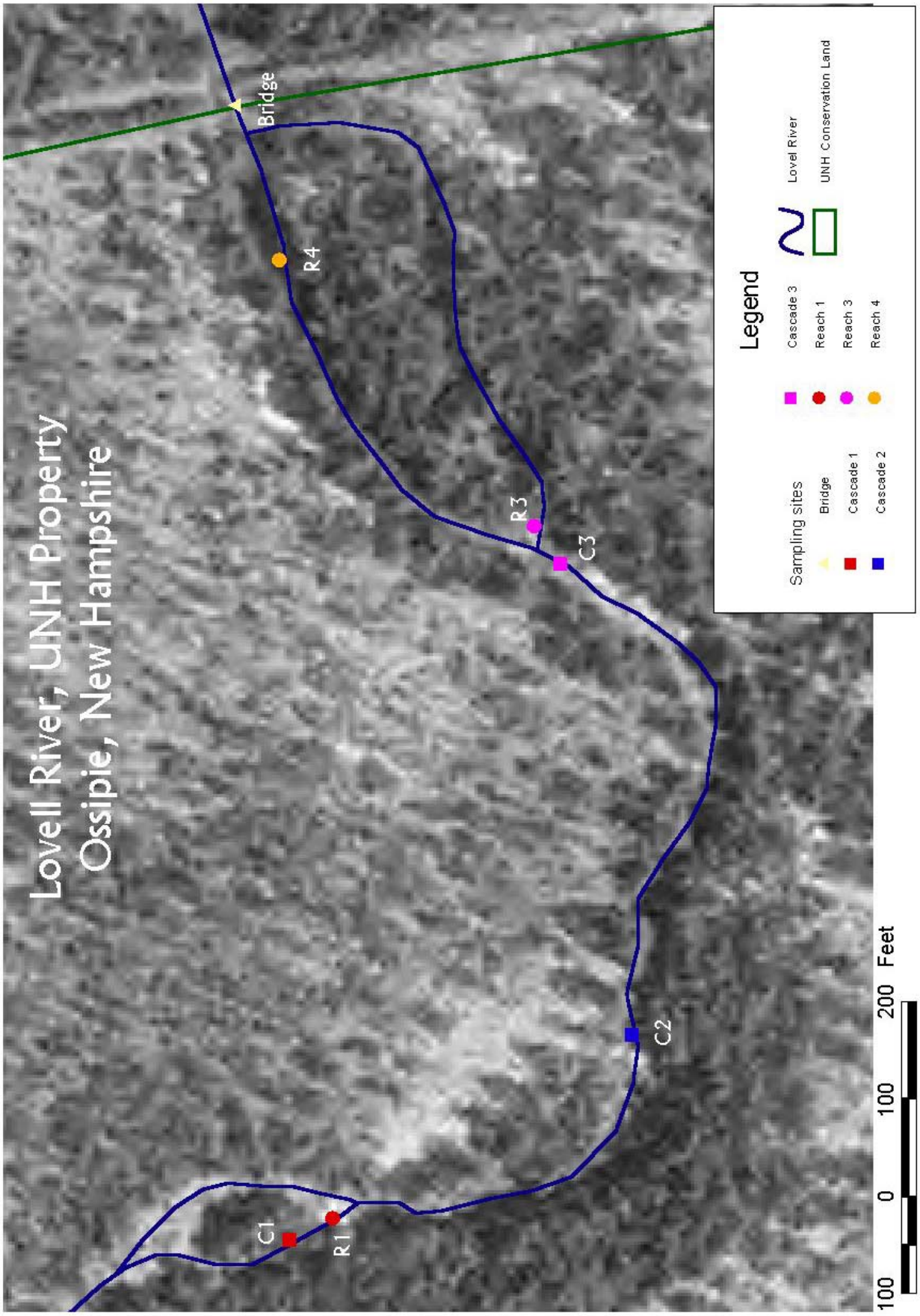
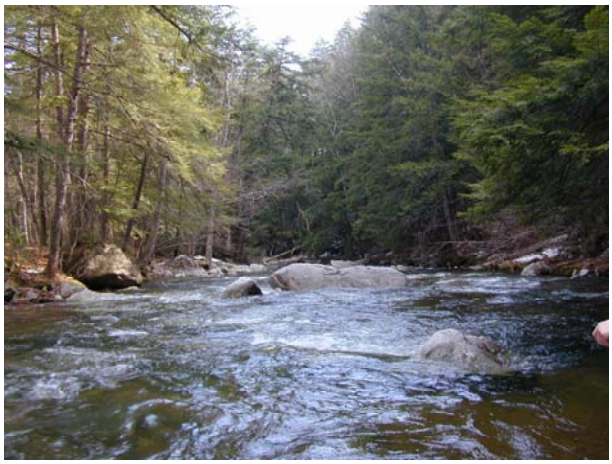


Fig 3. Sampling sites on Bearcamp River. Reaches are shown as R1 (Reach 1), R3 (reach 3), R4 (reach 4) and cascades are shown as C1 (cascade 1), C2 (cascade 2) and C3 (Cascade 3).

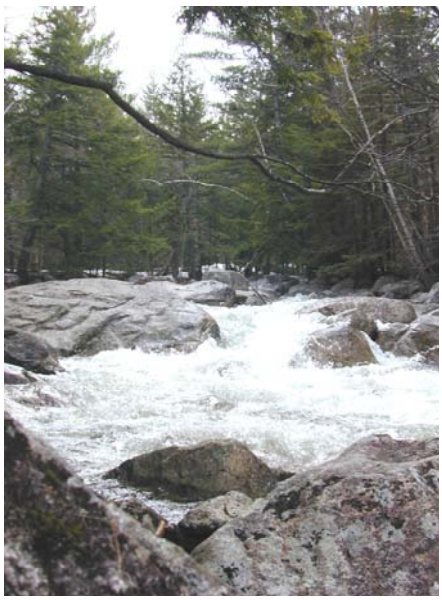


Reach 1 (R1)

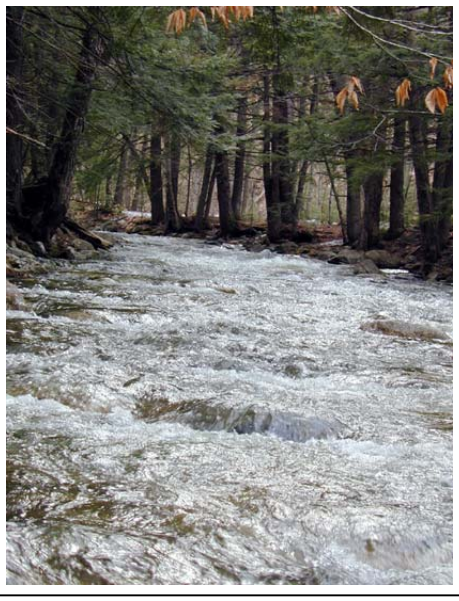
Cascade 1 (C1)

Cascade 2 (C2)

Reach 3 (R3)

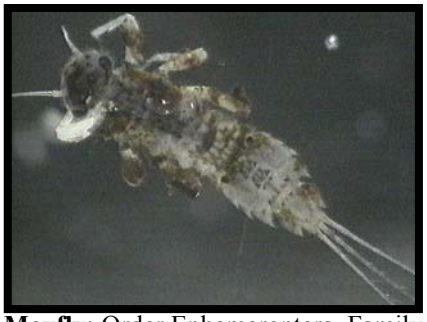


Cascade 3 (C3)

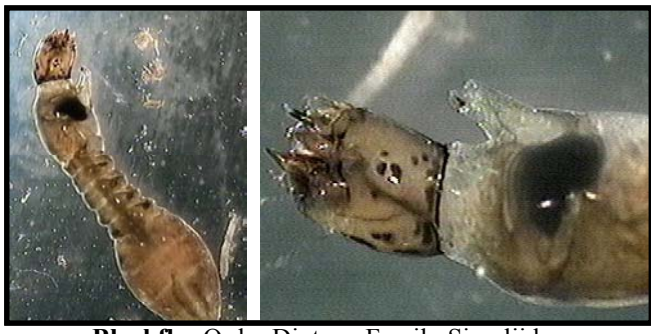


Reach 4 (R4)

Fig. 4. Photographs of each site. See Fig. 3 for locations.

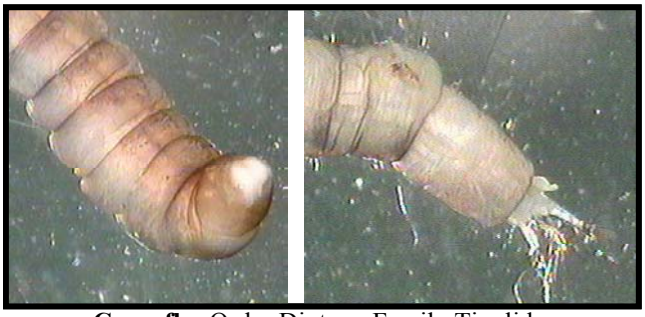


Mayfly: Order Ephemeroptera, Family Ephemerellidae, Genus *Eurylophella*



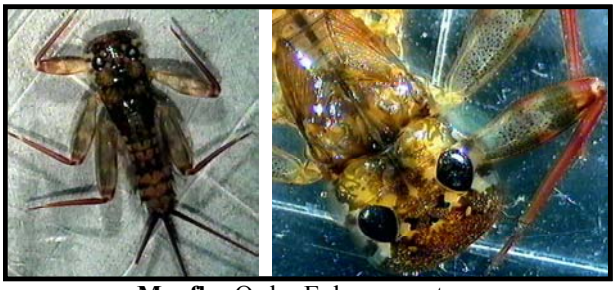
Blackfly: Order Diptera, Family Simuliidae Genus *Cnephia*

Mayfly: Order Ephermeroptera, Family Heptageniidae, Genus *Epeorus*



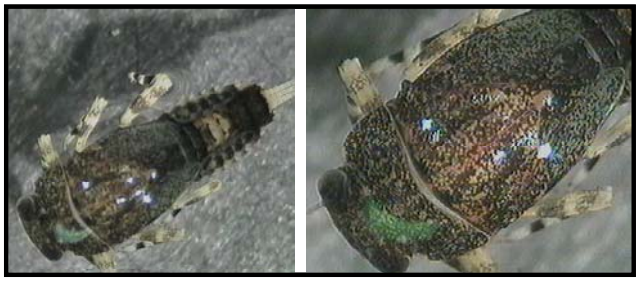
Cranefly: Order Diptera, Family Tipulidae

Mayfly: Order Ephermeroptera, Family Leptophlebiidae, Genus *Paraleptophlebia*



Mayfly: Order Ephermeroptera, Family Heptageniidae, Genus *Stenonema*

Dragonfly: Order Odonata, Family Cordulegastridae, Genus *Cordulegaster*



Mayfly: Order Ephermeroptera, Family Ephemerellidae, Genus *Ephemerella*

Fig. 5. Representative images of stream macroinvertebrates collected in the Lovell River.

Table 2. Lovell River Composition and Richness Metrics. EPT is the combined values of the insect orders Ephmeroptera (Mayflies), Plecoptera (Stoneflies), and Trichoptera (Caddisflies). Metric formulas from EPA website.

Category	Metric	Formula	Value
Composition with *Cnephia*	% EPT	(Total # EPT) / Total # organisms X 100	38.0%
	% Diptera	(Total # Diptera) / Total # organisms X 100	60.6%
	% Hydropsychids	(Total # Hydropsychids) / Total # Trichoptera X 100	11.5%
Composition without *Cnephia*	% EPT	(Total # EPT) / Total # organisms	94.1%
	% Diptera	(Total # Diptera) / Total # organisms	2.0%
Richness	Taxon Richness	Total number of taxa found	17
	EPT Diversity	# E taxa + # P taxa + # T taxa	11
	E Diversity	# Ephemeroptera taxa	5
	P Diversity	# Plecoptera taxa	3
	T Diversity	# Trichoptera taxa	4

where: n_i is the number of organisms of a single taxon found in the river. v_i is the index value for that taxon. N is the total number of all organisms found in the river.

Velocity measurements were obtained at each site using a Global Water FP101 flow probe. Measurements of depth and velocity were taken at five relatively equally-spaced locations across the river. Velocity measurements were taken at a depth that was 0.6 times the maximum depth of the river at the sampling location. Mean depth and width were used to calculate discharge assuming the stream channel was rectangular.

Site Description

On 15 April 2003, four sites were sampled on the Lovell River (Figs. 2 & 3). Two of the sites (site 1 and site 3) were sampled extensively and two sites (site 2 and site 4) were only observed and described photographically (Fig. 4). Sites 1 and 3 were divided into both a reach and cascade section designated as reach 1 (R1), cascade 1 (C1), reach 3 (R3) and cascade 3 (C3). Site 2 and site 4, were observed photographically, and are referred to a cascade 2 (C2) and reach 4 (R4). The total length of the river covered by our sampling points (Fig. 1 & Fig. 2) was about 550 m and represented an elevation change of 10 m (Table 1). The pH (6.4), specific conductivity (22.1-23.3 μS) and temperature (7.9-8.3 °C) of the river varied little over the stretch of river sampled (Table 1). The river channel was at capacity due to a large snowmelt that occurred a few day prior to sampling. The section of the Lovell River sampled in our study flows through a naturally forested area of mixed hardwoods and hemlock.

Site 1 had a riparian coverage of 25% over the river consisting mostly of hemlock and mixed hardwoods (Fig 1). The average river substrate size was 24.9 cm in diameter; however, substrate was highly variable with a gradient from sand to large boulders. The river at Site 1 had a width of 10 m, an average depth of 0.49 m, with a discharge of 4.4 m^3 s^{-1}.

Site 3 had a riparian coverage of 8% over the river. As in site 1 the vegetation consisted of hemlock and mixed deciduous, as seen in Figure 1. Substrate size at Site 2 was considerably larger than Site 1, with an mean size of 152 cm. There was little to no sand; most of the substrate was cobble and boulders. The river diverged at this site. One fork of the river was 7.1 m wide with an average depth of 0.44 m and a discharge of 1.2 m^3 s^{-1}. The other fork

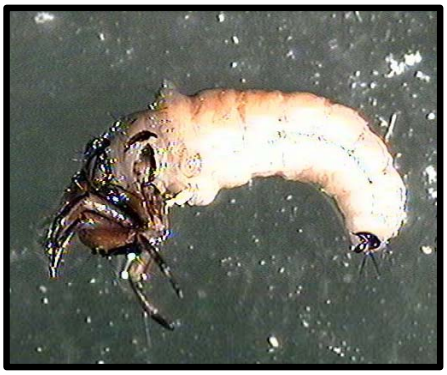
Table 3. Biotic Index criteria used for Modified Family and Family/Genus (Hilsenhoff 1988).

Biotic Index	Water Quality	Degree of Organic Pollution
0.00-3.50	Excellent	Not apparent
3. 51-4.50	Very good	Slight possible
4. 51-5.50	Good	Some
5. 51-6.50	Fair	Fairly significant
6.51-7.50	Fairly poor	Significant
7.51-8.50	Poor	Very Significant
8.51-10.0	Very poor	Severe

was 11.6 m wide with an average depth of 0.48 m and a discharge of 4.5 m^3 s^{-1}.

Results

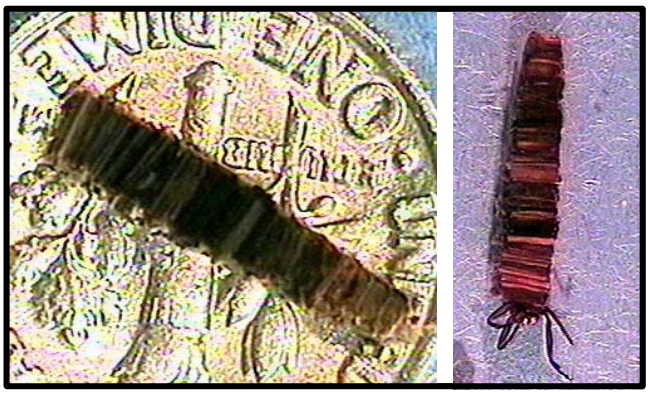
The composition of the invertebrate populations in the Lovell River were described with images (Figs. 5 & 6) and with a variety of richness metrics (Table 2). Another biological indicator indicating good water quality is the EPT index, the percentage of all of the benthic macroinvertebrates that were from the orders Ephemeroptera



Tube-dwelling Caddisfly:
Order Tricoptera, Family Leptoceridae

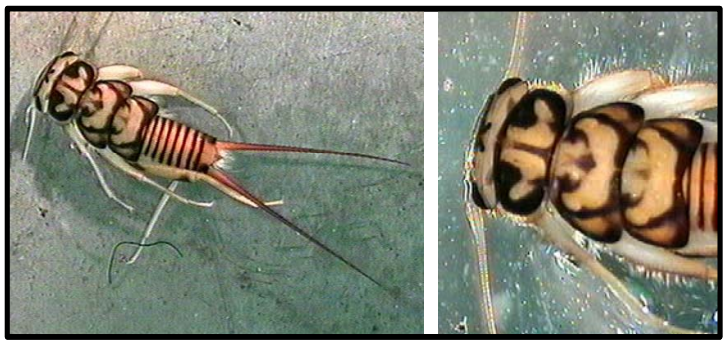
Tube-dwelling Caddisfly:
Order Tricoptera, Family Limnephilidae

Web-spinning Caddisfly:
Order Tricoptera, Family Hydropsychidae



Tube-dwelling Caddisfly:
Order Tricoptera, Family Brachycentridae

Hellgramite: Order Megaloptera,
Family Corydalidae



Stonefly: Order Plecoptera, Family Perlidae

Fig. 6. Representative images of stream macroinvertebrates collected in the Lovell River

(mayflies), Plecoptera (stoneflies), and Trichoptera (caddis flies). In the Lovell River, this index was 38.0%. The percentage of all benthic macro-invertebrates that were Diptera (true fly larvae) was 60.6%. This high value was due to the large abundance of blackfly larvae, dominated by *Cnephia*. When the percentages were calculated without *Cnephia*, the EPT index increased dramatically to 94.1% and the percent Diptera dropped to 2.0%. Insects found represented the seven orders: Coleoptera, Diptera, Ephemeroptera, Megaloptera, Odonata, Plechoptera and Trichoptera. In all, there were 17 families of aquatic insects found in the Lovell River.

A total of 16 benthic invertebrate taxa were identified from both sites, with 12 EPT taxa, 5 Ephemeroptera and 3 Plecoptera (Table 2). Diptera (true flies), generally an indicator of poorer water quality, were highest at the Reach 2 site.

Discussion and conclusions

The chemical and biological parameters measured all indicate that this section of the Lovell River is a system with excellent water quality. The low acidity and specific conductance measurements indicate excellent water quality. The pH of 6.4 is relatively high for New Hampshire streams and is probably near the low value for the year considering the study was conducted during the time of snowpack melt. The Modified Family Biological index indicates the Lovell river had low levels of organic pollution whether or not blackflies were included. The Family/Genus index indicated excellent water quality when blackflies were excluded and a very good rating when they were included. In this study, we were able to identify 9 distinct taxon to the family level and 7 to the genus level. One family had two genera represented. This should be looked at as a conservative estimate of species richness since it is likely that species richness would increase if we had identified organsims to species. The parameters measured all indicate very good water quality for this section of the Lovell River.

The Lovell River and the UNH property bordering the river have several valuable and unique features. The Lovell River is one of the largest streams in the Ossippee Mountains, well-defined ancient mountains of volcanic origin. The portion of the Lovell River within the UNH property is within the foothills of the Ossippee Mountains. The river basin and substrate reflect this volcanic origin. It would be useful to compare the fauna and flora of the UNH Lovell River section to reference streams outside of the Ossippee Mountains. Surveys of the bird, mammal, fish, and amphibian populations are needed. Anecdotally, we noted moose and otter tracks along the stream during our observations.

It is also of interest that the Lovell River enters Lake Ossippee downstream on a second UNH property. Near the Lovell River inlet, the stream deepens and has a sandy bottom, contrasting sharply with the section of river described in this report. Biological surveys of this region are also needed.

The Lovell River has a highly diverse community of aquatic macroinvertebrates. The survey presented in this report is a first step in characterizing the general physical/chemical and biological characteristics of the Lovell River. It would be valuable to repeat this survey at different seasons

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APPENDIX A

Table 4. Stream discharge calculation for site reach 1 (R1).

	From shore (m)	Depth (m)	Velocity (m s^{-1})	Ave. dis. (m^3 s^{-1})
	1	0.43	0.91	
	3	0.76	1.13	
	5	0.53	1.09	
	7	0.43	0.88	
	9	0.28	0.52	
Total	10	0.49	0.90	4.41

Table 5. Stream discharge calculation for site reach 3 (R3).

Branch	From shore (m)	Depth (m)	Velocity (m s^{-1})	Ave. dis. (m^3 s^{-1})
A.	1.4	0.49	0.07	
	2.8	0.53	0.25	
	3.2	0.52	0.44	
	4.6	0.49	0.66	
	6.4	0.44	0.50	
Branch total	7.1	0.49	0.39	1.20
B.	2.3	0.54	0.73	
	4.6	0.55	0.70	
	6.9	0.56	0.85	
	9.2	0.51	0.98	
	11.5	0.48	0.79	
Branch total	11.6	0.53	0.81	4.50
Stream total				5.70

Table 6. Family/Genus macroinvertebrate index (Barbour et. al 1999)

			Number of organisms					
			Site 1		Site 2		Total	Index
Order	Family	Genus	Reach	Cascade	Reach	Cascade		Value
Coleoptera	Haliplidae		0	0	0	1	1	5.0
Diptera	Simuliidae	*Cnephia*	8	18	82	42	150	4.5
	Pelecorhynchidae		1	1	0	0	2	3.0
Ephemeroptera	Heptageniidae	*Epeorus*	9	10	30	7	56	0.4
	Leptophlebiidae	*Paraleptophlebia*	1	0	1	2	4	1.4
	Heptageniidae	*Stenonema*	0	2	0	0	2	3.0
	Ephemerellidae	*Eurylophella*	0	0	0	1	1	3.1
	Ephemerellidae	*Ephemerella*	2	0	0	0	2	2.0
Megaloptera	Corydalidae		0	1	0	0	1	0.0
Odonata	Cordulegastridae	*Cordulegaster*	0	1	0	0	1	3.0
Plecoptera	Taeniopterygidae		1	0	0	1	2	2.0
	Perlidae		0	0	0	1	1	1.0
	Pteronarcyidae		1	0	1	0	2	0.0
Trichoptera	Limnephilidae		3	2	0	2	7	4.0
	Brachycentridae		2	7	4	2	15	1.0
	Leptoceridae		1	0	0	0	1	4.0
	Hydropsychidae		2	0	1	0	3	4.0
Total macroinvertebrates counted			31	43	119	58	250	
Total index value with *Cnephia*								3.0 ± 0.6
Total index value without *Cnephia*								1.3 ± 0.5

Table 7. Modified family macroinvertebrate index (Hilsenhof 1988).

Order	Family	Genus	Number of Organisms				Total	Index Value
			Cascade 1	Reach 1	Cascade 2	Reach 2		
Coleoptera	Haliplidae		0	0	1	0	1	5
Diptera	Simuliidae	*Cnephia*	18	8	42	82	150	6
	Pelecorhynchidae		1	1	0	0	2	5
Ephemeroptera	Heptageniidae	*Eporus*	10	9	7	30	56	3
	Leptophlebiidae	*Paraleptophlebia*	0	1	2	1	4	3
	Heptageniidae	*Stenonema*	2	0	0	0	2	3
	Ephemerellidae	*Eurylophella*	0	0	1	0	1	1
	Ephemerellidae	*Ephemerella*	0	2	0	0	2	1
Megaloptera	Corydalidae		1	0	0	0	1	4
Odonata	Cordulegastridae	*Cordulegaster*	1	0	0	0	1	3
Plecoptera	Taeniopterygidae		0	1	1	0	2	2
	Perlidae		0	0	0	1	1	2
	Pteronarcyidae		0	1	0	0	1	0
Trichoptera	Limnephiladae		2	3	2	0	7	3
	Brachycentridae		7	2	2	4	15	1
	Leptoceridae		0	1	0	0	1	4
	Hydropsychidae		0	2	0	1	3	4
	Total macroinvertebrates counted		42	31	58	119	250	
	Total index value with *Cnephia*						4.4 ± 0.7	
	Total index value without *Cnephia*						2.7 ± 0.1	