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A WATER-QUALITY ASSESSMENT USING AQUATIC MACROINVERTEBRATES FROM STREAMS OF THE LONG PINE CREEK WATERSHED IN BROWN COUNTY, NEBRASKA

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The macroinvertebrate communities of Long Pine and Bone creeks were assessed between July, 1979, and October, 1982, as part of a water-quality monitoring program of the Long Pine watershed. At least 125 and 90 taxa were collected from Long Pine and Bone creeks, respectively. Data were summarized for the six collection sites by density, taxonomic composition, and species diversity. A biotic index, modified for Nebraska waters, was used to describe the biological integrity of streams sampled. The findings are discussed in relation to observed water-quality degradation and land-use practices. Analysis showed a slight trend of impaired water quality from headwaters to downstream monitoring stations. The results represent the first documented collections of macroinvertebrates from these waters, and serve as baseline information to document trends in water quality.

† † †

INTRODUCTION

The Long Pine Creek watershed in north-central Nebraska has undergone considerable changes in land use since 1965 as a result of irrigation development. This area, which had been almost exclusively rangeland and hay meadows, is now more than 30% cropland. Historically, the streams of this area have been of high quality, but recent monitoring has shown these surface waters to have impairments in water quality as a result of these land use changes (Maret, 1985).

Long Pine and Bone creeks, the two major streams in this watershed, are unique aquatic resources in the state. Long Pine Creek is the longest self-sustaining trout stream in Nebraska (52 km). Bone Creek, the major tributary to Long Pine Creek, is home to several state-threatened species of fish, including the northern redbelly dace, *Phoxinus eos*, and pearl dace, *Semotilus margarita*. Three state-owned areas on these streams provide important recreational resources to the public.

Due to the statewide importance of these resources and the identified decline in surface-water quality of this area, a multiagency effort was undertaken to thwart non-point pollution. In 1981, a Rural Clean Water Program (RCWP), a 15-year cost-sharing program, was awarded to local agencies to implement "best management practices" (BMPs) to treat agricultural runoff.

The Nebraska Department of Environmental Control (NDEC) agreed to collect chemical, physical, and biological stream data prior to BMP implementation. This information will be used to document success of land treatment on improving quality of streams in the program area.

The Clean Water Act of 1977 mandates the protection of chemical, physical and biological integrity of water resources. Karr and Dudley (1981) define biological integrity as "the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region." Biological monitoring has often been overlooked under the assumption that chemical sampling for water quality is sufficient to safeguard biological populations. Assessments of water quality based exclusively on physicochemical parameters are often inadequate, especially when habitat degradation from channelization or sedimentation from non-point pollution occurs (Karr and Dudley, 1981). The inherent variability of biological populations due to habitat preferences and seasonality, in addition to taxonomic difficulties in identification, has hampered the development of tools to assess water quality.

Macroinvertebrates are an important component of an aquatic ecosystem, and have been used extensively to evaluate water quality of streams affected by both point and non-point pollutants. Reasons for their utility are that they are common in almost all streams, easy to collect, relatively sessile and have specific environmental requirements to complete their life cycles. Macroinvertebrates are excellent indicators of both long-term environmental changes such as siltation (Lenat et al., 1979) and slug loading of short duration (Prophet and Edwards, 1973).

Aquatic faunal collections from streams in this basin are lacking, particularly for macroinvertebrate communities. The results in this paper represent the first published accounts of the aquatic fauna of macroinvertebrates occurring in Long Pine Creek watershed. These findings will (1) provide baseline data of macroinvertebrate data to evaluate the effectiveness of the RCWP; (2) describe the diversity, relative abundance and occurrences of macroinvertebrates in streams of this watershed; and (3) apply a biotic index to streams in Nebraska to assess water quality.

DESCRIPTION OF STUDY AREA

The Long Pine Creek watershed on the northern border of the Nebraska sandhills, in Brown and Rock counties (Fig. 1), is a diverse area containing mid-grass prairie, cropland and rugged,

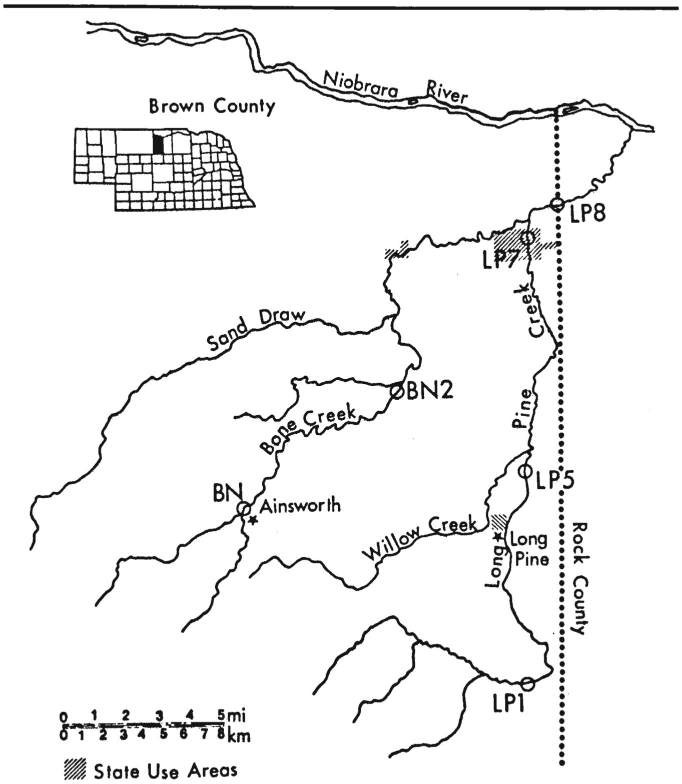

FIGURE 1. Long Pine Creek watershed, showing sampling stations on Long Pine and Bone creeks. This location is characterized by an open, wide and shallow channel with a shifting sand bottom.

FIGURE 2. Long Pine Creek headwaters (***LP1***) north of the town of Long Pine, October, 1982.

FIGURE 3. Long Pine Creek at Pine Glen (***LP7***) State Wildlife Management Area, June, 1980. Here the stream is in a wooded canyon with an abundance of gravel riffles and deep pool habitat.

timber-filled canyons (Figs. 2, 3). According to Omernik's (1987) classification of ecoregions of the United States, this watershed would be in the Nebraska sandhills, based on soils, topography, native vegetation, and land use. The watershed encompasses 1,186 km^2 (458 mi^2). Approximately 2,226 ha (5,500 a) are irrigated with center pivots, using water from either the Ainsworth Irrigation District or local groundwater wells. In addition, 3,140 ha (7,756 a) are gravity-irrigated, using water from the Ainsworth Irrigation District. Corn and alfalfa are the major irrigated crops, but some soybeans are grown.

The vegetative cover in this watershed consists principally of grasses such as switch grass, *Panicum virgatum*; sand bluestem, *Andropogon hallii*; little bluestem, *Andropogon scoparius*; blue grama, *Bouteloua gracilis*; sand lovegrass, *Eragrostis trichodes*; and needle-and-thread, *Stipa comata* (scientific names from Hitchcock, 1971).

Trees and shrubs of the canyons include bur oak, *Quercus macrocarpa*; ponderosa pine, *Pinus ponderosa*; American elm, *Ulmus americana*; eastern red cedar, *Juniperus virginiana*; black walnut, *Juglans nigra*; cottonwood, *Populus deltoides*; smooth sumac, *Rhus glabra*; American plum, *Prunus americana*; and gooseberry, *Ribes missouriense*. Shrubs commonly found near streams in the riparian zone include false indigo, *Amorpha fruticosa* and willows, *Salix* sp. (scientific names from Pool, 1978). Aquatic macrophytes commonly found in Long Pine Creek include water cress, *Nasturtium officinale*; water buttercup, *Ranunculus* sp.; waterweed, *Elodea canadensis;* and monkey flower, *Mimulus glabratus* (scientific names from Fassett, 1975).

Flowing streams in the project area are limited to Long Pine Creek and its major tributaries, including Bone Creek, Sand Draw, and Short Pine Creek. A total of 126.4 km (79 mi) is in the project area (Fig. 1). Surface elevations for Long Pine Creek range from 742 m (2,434 ft) at the headwaters to 587 m (1,925 ft) at the lower end; the gradient averages 3.4 m per km for the lower two-thirds of the watershed.

Average annual precipitation in the project area is 53.8 cm (21 in) with a maximum of 114.5 cm (40 in) recorded in 1915 and a minimum of 28.5 cm (11 in) in 1940. Most precipitation occurs as rainfall of high-intensity, brief thunderstorms. Large volumes of overland runoff from these intense rains increase the delivery of sediment to receiving streams. Sixty-five percent of the annual precipitation occurs during spring and summer. The frost-free period is from May to mid-October, with an average growing season of approximately 146 days.

The soils in the project area are easily-eroded and highly-permeable sands, sandy loams, and silt loams. Dundy, Simeon, Valentine, Hord, Basille, Labu, Sansarc and Tassel are the major soil series (Anonymous, 1985).

The Ainsworth Irrigation District, which provides abundant water to this area for irrigation, disposes of excess water into streams. These discharges, in addition to irrigation-return flow, cause seasonal increases in stream flows of the watershed. Water brought in by the Irrigation District by transbasin diversion has also increased both the levels of groundwater and subsequent groundwater recharge into streams.

There are point sources from municipal treatment plants from the towns of Long Pine and Ainsworth. Long Pine wastes are treated by lagoons only, with sporadic discharges into Grease Creek and on rare occasions into Long Pine Creek. The Ainsworth treatment plant has secondary treatment with continuous, non-chlorinated effluent discharge into Bone Creek. Both facilities are permitted discharges under the National Pollution Discharge Elimination System (NPDES) program administered by NDEC.

Eleven feedlot confinements permitted under the NPDES program are located in this watershed. These operations maintain more than 20,000 head of cattle, most of which are close to Bone Creek. Runoff from feedlots due to heavy rainfall has been documented in Bone Creek as a result of inadequate controls (Maret, 1985). Grazing of the rangeland and cropland adjacent to streams is a common practice in this area.

Intensive recreational use occurs in certain reaches of Long Pine and Bone creeks. The Nebraska Game and Parks Commission maintains three public-use areas on these streams. Five hundred thirty-eight ha (1,311 a) are open for public access and are managed for fish and wildlife. Trout fishing and swimming are major recreational uses of Long Pine Creek. There are many private homes located along the creek, especially in the Hidden Paradise area south of the town of Long Pine.

SITES AND METHODS

Description of Stations

Six surface-monitoring stations were selected, based on their year-round accessibility (Fig. 1). Sites were also chosen to represent and describe various natural or man-made changes in the quality of Long Pine Creek and its major perennial tributary, Bone Creek. Table I summarizes the physical characteristics of each station. Station locations were:

Station ***LP1:*** NW¼, Sec. 20, T29N, R20W; upper reaches of Long Pine Creek (5.2 km south of Long Pine); Lat. 42° 28′29″, Long. 99° 41′45″

Station LP5: NW¼, Sec. 17, T30N, R20W; Long Pine Creek at Camp Witness immediately above Willow Creek (3.2 km north of Long Pine); Lat. 42° 34′34″, Long. 99° 41′33″

Station LP7: SW¼, Sec. 8, T31N, R20W; Long Pine Creek in Pine Glen State Recreation Area (12.8 km north of Long Pine); Lat. 42° 40′23″. Long. 99° 41′37″

Station LP8: NE¼, Sec. 5, T31N, R20W; Long Pine Creek at U.S. Geological Survey gaging station approximately 1.6 km below confluence with Bone Creek (14.4 km north of the town of Long Pine); Lat. 42° 41′21″, Long. 99° 40′45″

Station BN: SW¼, Sec. 23, T30N, R22W; Bone Creek upper reaches, northwest edge of Ainsworth above Ainsworth Sewage Treatment Plant; Lat. 42° 35′33″, Long. 99° 52′00″

Station BN2: SW¼, Sec. 34, T31N, R21W; Bone Creek mid-reaches above Sand Draw confluence; Lat. 42° 36′35″, Long. 99° 46′25″

Sampling Methods

Most studies on macroinvertebrates and water quality assess the community structure or species diversity. The data collected for the communities existing at sample stations were assessed quantitatively by reporting densities of individuals. Also, qualitative estimates of the organisms present and their relative numbers were assessed to determine the existing health of the streams in the watershed. Species diversity and biotic indices using tolerance values were used in the interpretation of data. These indicators provide numerical results understandable to the public as well as to the resource manager.

Qualitative samples of macroinvertebrates were collected between September 1979 and October 1982, using multiplate artificial substrates at Long Pine and Bone Creek stations. Hester and Dendy (1962) used a similar plate sampler to evaluate water quality. The samplers consisted of seven 7.62 cm × 7.62 cm × 0.64 cm plates of tempered masonite separated by two 1.27 cm × 1.27 cm spacers. Plates were held together by a large I-bolt. The samplers offered a surface area of approximately 948 cm^2 for colonization. Two samplers were set in the main channel at each station. Samplers, anchored to fence posts and cement blocks, were allowed at least four weeks to colonize. Samplers were retrieved with the aid of a dip net with 1.0 mm meshing to ensure organisms were not lost. Samplers were scraped clean of all organisms and then returned to the stream. The composite of scraped material was then sieved and concentrated with a No. 30 standard sieve (0.595 mm), placed in a jar, and preserved with a 10% formalin solution.

A Surber sampler consisting of a 0.0929 m^2 (1 ft^2) sampling area was also used to collect quantitative benthos samples from Long Pine Creek stations. Three Surber samples were taken from the cross-section of a gravel-rock riffle when present. The substrate was disturbed inside the square for equal lengths of time to achieve equal efforts. The contents of the net representing the three samples were deposited in a bucket, concentrated with a No. 30 sieve, and preserved in 10% formalin.

Macroinvertebrates were processed in the laboratory by examination under a dissecting microscope with 7–30 × magnification. In some cases when samples were prohibitively large, random subsamples were taken using a sample splitter similar to that used by Waters (1969). Chironomids were also sub-sampled on occasion. Normally, at least one quarter of the sample was analyzed when sub-sampling was necessary.

Invertebrates were identified to the lowest practicable taxonomic level, usually the genus. Chironomid identification was aided by mounting the larvae on glass slides in a CMC-10 mounting medium and using a compound microscope with 40 × objective as outlined by Parrish (1975).

Taxonomic identifications were made with the aid of works by Burks (1953), Edmunds et al. (1976), Merritt and Cummins (1984), Oliver et al. (1978), Pennak (1978), Simpson and Bode (1980), and Wiggins (1977). Selected specimens were sent to the Kansas Biological Survey for verification.

TABLE I. Summary of physical characteristics for stations sampled (from Maret, 1985)

Stations	Water temperature[a]	Substrate composition[b] Gravel	Sand	Ave width (m)	Ave depth (m)	Stream order[c]	Ave flow (m^3/s)	River Mile	(km)
Long Pine Creek									
LP1	coldwater	2	97	3.8	0.14	2	0.31	32.5	(52.0)
LP5	coldwater	66	33	5.8	0.34	2	1.73	14.8	(23.7)
LP7	coldwater	71	29	10.6	0.33	3	2.76	6.4	(10.2)
LP8	warmwater	31	68	12.5	0.29	3	4.87	5.0	(8.0)
Bone Creek									
BN	coldwater	12	87	4.1	0.19	2	0.18	21.2	(33.9)
BN2	warmwater	45	55	5.1	0.21	2	1.03	12.2	(19.5)

[a] coldwater seldom exceeds 25° C.

[b] predominant substrate listed as average percent by weight.

[c] Horton's (1945) classification scheme using perennial streams.

Two biological indices were utilized to evaluate macroinvertebrate samples: the Shannon index of species diversity ($\overline{H}$) based on information theory (Wilhm and Dorris, 1968; Weber, 1973), and the biotic index (Chutter, 1972; Hilsenhoff, 1977), to evaluate the effects of organic pollution on invertebrates. These indices were calculated as follows:

$$\text{Shannon index of species diversity } (\overline{H}) = -\Sigma\left(\frac{n}{N}\right)\log_2\left(\frac{n}{N}\right)$$

Wilhm and Dorris (1968), who evaluated numerous $\overline{H}$-values from many sources, suggested that values between 1 and 3 were indicative of moderate pollution. Values approaching 4 were typically of unpolluted streams, while values below 1 were indications of a stressed community affected by heavy organic pollution.

$$\text{Biotic (BI) Index} = \Sigma\frac{(n)\,(a)}{N}$$

where: N = number of individuals in the sample
n = number of individuals of each taxon
a = pollution-tolerance value assigned to that taxon

Most tolerance values were assigned to each taxon based on works by Hilsenhoff (1977) and Jones et al. (1981). However, it was necessary to assign or change approximately 34% of the tolerance values for the taxa collected using professional judgment to more accurately reflect Nebraska waters. Opinions from Kansas Biological Survey staff members were also used on occasion. Table II lists the tolerance values assigned for all taxa collected during this study. Values assigned were based on tolerances to sediment and organic waste. A value of 0 indicates that a taxon occurs in very high quality streams (essentially unaltered, or pristine), and a value of 5 indicates a taxon known to occur in severely-polluted streams. Intermediate values are assigned to those species occurring in moderately-polluted areas. Since most organisms were not identified to species, the tolerance values correspond to the most pollution-tolerant species of that genus or category (Hilsenhoff, 1977).

Biotic index values range from 0 to 4. Clean, unpolluted waters have a BI <1.75 (EXCELLENT), and polluted waters will have a BI >3.25 (POOR). Two intermediate categories, slightly enriched ($1.75 < \text{BI} < 2.50$) and enriched ($2.50 < \text{BI} < 3.25$), represent conditions of transition (GOOD, FAIR, respectively) (Chutter, 1972; Hilsenhoff, 1977).

RESULTS AND DISCUSSION

The macroinvertebrate fauna collected from Long Pine Creek contained at least 125 taxa (Fig. 4, Table II). Artificial substrates collected a greater diversity of organisms than did Surber samples during the sampling period July 1979 through August 1982. This difference can be attributed to habitats sampled. Surber samples were selective for riffle-dwelling, rheophilic organisms, whereas artificial substrates offered opportunity for colonization in a wide variety of habitats. The faunal assemblage of Long Pine was dominated by Ephemeroptera (mayflies), Trichoptera (caddisflies) and Chironomidae (midges). This type of community structure is common for Midwestern streams (Maret and Christiansen, 1981; Prophet and Edwards, 1973). Many of the taxa collected from these stations indicate cold-water conditions. Table III summarizes the common taxa and the average number of individuals collected at Long Pine stations, using artificial substrates. Specific taxa that were abundant and often found at all Long Pine locations included *Cura foremanii* (flatworms); *Baetis, Ephemerella, Heptagenia, Tricorythodes,* (mayflies); *Isoperla* and *Perlesta* (stoneflies); *Brachycentrus* and *Hydropsyche* (caddisflies); Elmidae (beetles); Simuliidae (black flies); *Brillia, Cardiocladius, Cricotopus, Eukiefferiella, Orthocladius, Parametriocnemus, Rheotanytarsus, Thienemanniella* and *Thienemannimyia* group (midges); and Empididae (Diptera).

At least 90 taxa were collected from the two Bone Creek stations, using artificial substrate samples between May, 1980, and October, 1982 (Table III). Chironomidae (midges), Oligochaeta (tubificids) and Ephemeroptera (mayflies) were the predominant organisms collected. Specific taxa often found in abundance included *Baetis, Heptagenia, Tricorythodes, Hydropsyche,* Elmidae, *Cricotopus, Orthocladius, Rheotanytarsus, Tanytarsus,* and the *Thienemannimyia* group. Table IV summarizes the common taxa collected at the two stations. Bone Creek fauna typically was made up of many tubificid worms, indicating an organically-enriched aquatic environment. The large number of worms found on these types of samplers is unusual. Field observations confirm that the plates were often covered with fine sediment and organic matter, making them conducive to colonization by tubificids. *Tricorythodes,* a silt-tolerant group of mayfly species, was also abundant at both stations.

Chironomids such as *Cricotopus* and *Dicrotendipes,* considered to be facultative genera, were frequently collected and often found in high densities at both stations. Both indicate waters with much silt and organic enrichment.

Plecopterans (stoneflies), which have often been used as indicators of good water quality and are frequently collected at Long Pine stations, were not found at the headwaters of Bone Creek (*BN*). They were rarely collected, and only in winter or spring samples at the lower station on Bone Creek (*BN2*). This appears to indicate unfavorable conditions existing for this order. The heavy load of silt and warmer summer water temperatures, especially at the lower station on Bone Creek, are probable causes for their scarcity.

TABLE II. Macroinvertebrates collected using Surber and artificial substrate samplers from Long Pine Creek, and artificial substrate samplers from Bone Creek, July 1979 to October 1982. Also listed are pollution tolerance values used to calculate the biotic index (BI). Values range from 0 (pollution-intolerant) to 5 (very pollution-tolerant).

	STATIONS						POLLUTION
TAXON	*LP1*	*LP5*	*LP7*	*LP8*	*BN*	*BN2*	TOLERANCE VALUE
Coelenterata							
HYDROZOA							
Hydroidae							
Hydra					A		3
Platyhelminthes							
TURBELLARIA							
Cura foremanii	A/S*	A/S	A	A	A	A	2
Nematoda	A/S	A/S	A/S			A	4
Nematomorpha	A	S	A/S	S			4
Annelida							
Oligochaeta	A/S	A/S	A/S	A/S	A	A	4
Hirudinea	A/S	S		S	A	A	3
Arthropoda							
ARACHNIDA							
Hydracarina	A	A/S	A/S	A/S	A	A	3
CRUSTACEA							
Amphipoda							
Gammarus lacustris		A	A		A		2
Hyalella azteca	A/S	A/S	A	A/S	A	A	4
Decapoda			A	A	A		4
INSECTA							
Collembola		A/S		S			4
Ephemeroptera							
Baetis	A/S	A/S	A/S	A/S	A	A	3
Caenis	A/S			A/S	A	A	4
Dactylobatis						A	2
Epeorus			S				0
Ephemerella	A/S	A/S	A/S	A/S	A	A	2
Heptagenia	A	A/S	A	A	A	A	2
Isonychia	A	A		A		A	3
Leptophlebia	A	A		A/S	A	A	2
Paraleptophlebia	A				A		1
Pseudocloeon	A	A/S	A/S	A/S	A	A	2
Stenonema	A			A	A		3
Tricorythodes	A/S	A/S	A/S	A/S	A	A	3
Odonata							
Zygoptera							
Argia	A	A/S			A		3
Coenagrion		A		A/S	A	A	3
Hetaerina		A	A	A/S	A	A	4
Anisoptera							
Aeshna					A		3
Gomphus	A	A	A/S	A	A	A	3
Libellula	A						3
Ophiogomphus	A	S	S	A		A	2
Plecoptera							
Amphinemura						A	0
Acroneuria		A		A			1
Isoperla	A/S	A/S	A/S	A			2
Malenka		S	S				0
Nemoura			A				0
Perlesta	A	A/S	A/S	A/S		A	2
Pteronarcys		A/S	A	A		A	2
Taeniopteryx		S	A	A		A	2

TABLE II—*(Continued on page 75)*

TABLE II—*(Continued from page 74)*

TAXON	LP1	LP5	LP7	LP8	BN	BN2	POLLUTION TOLERANCE VALUE
Hemiptera							
Belostomatidae							
Belostoma	A		A			A	4
Lethocerus	A						2
Corixidae	A/S	S	A/S	A/S			4
Naucoridae							
Ambrysus				A	A		3
Cryphocricos				A		A	3
Pelocoris				A	A		2
Nepidae							
Nepa apiculata	A						1
Notonectidae			S				4
Pleidae							
Neoplea			S				3
Vellidae			S				4
Megaloptera							
Chauliodes	A						1
Trichoptera							
Brachycentrus	A/S	A/S	A/S	A/S			1
Cheumatopsyche	A/S	A/S			A	A	3
Glossosoma		S	S				1
Hesperophylax	A						4
Hydatophylax		A	A				2
Hydropsyche	A/S	A/S	A/S	A/S	A	A	3
Hydroptila	A/S	A/S	S	A/S	A	A	2
Lepidostoma	A						2
Leucotrichia	A	A/S	A/S	A/S			1
Moselyana			A				2
Nectopsyche	A	A	A/S			A	3
Oecetis						A	2
Oxyethira	S						2
Pseudostenophylax	S						4
Ptilostomis	A						2
Triaenodes	S	S					2
Lepidoptera							
Paragyractis			A/S				3
Coleoptera							
Dytiscidae	A		A	A			3
Agabus			S		A	A	3
Colymbetes	S						2
Hygrotus			S				3
Laccophilus	S	S		S			3
Dryopidae			S				3
Elmidae	A	A/S	A/S	A	A	A	3
Haliplidae							
Haliplus			S				2
Peltodytes					A	A	4
Hygrotus			S				3
Laccophilus	S	S		S			3
Hydrophilidae							
Anacoena	S						4
Berosus						A	3
Diptera							
Athericidae							
Atherix	A	A/S	A/S	A/S		A	4
Ceratopogonidae							
Atrichopogon	A/S				A	A	3
Palpomyia	A/S	A/S	S	A/S		A	3

TABLE II—*(Continued on page 76)*

TABLE II—(Continued from page 75)

TAXON	STATIONS						POLLUTION TOLERANCE VALUE
	LP1	*LP5*	*LP7*	*LP8*	*BN*	*BN2*	
Chironomidae							
Ablabesmyia	A						3
Brillia	A/S	A/S	A/S	A	A		2
Cardiocladius	A/S	A/S	A/S	A/S			3
Chironomus				S	A	A	5
Cladotanytarsus	S		S	S	A	A	3
Corynoneura	S	A	A/S				3
Cricotopus	A	A/S	A/S	A/S			3
Cryptochironomus		A		A	A	A	3
Cyphomella						A	3
Demicryptochironomus				A			3
Diamesa	S		A	A	A		2
Dicrotentipes	A/S	A	A	A/S	A	A	4
Endochironomus						A	3
Eukiefferiella	A/S	A/S	A/S	A/S	A	A	2
Glyptotendipes	S					A	5
Hydrobaenus	A		A				2
Larsia	A		A	A	A	A	3
Micropsectra	A/S		A		A	A	3
Nanocladius	A	A	A	A	A	A	2
Odontomesa	A/S	A				A	1
Orthocladius	A/S	A/S	A/S	A/S	A	A	2
Parachironomus					A		3
Parakiefferiella	A				A		1
Paralauterborniella	A						2
Parametriocnemus	A	A	A/S	A/S		A	2
Paraphaenocladius	A		A		A	A	2
Paratanytarsus			A	A		A	3
Pentaneura	A						2
Phaenopsectra	A/S	S				A	3
Potthastia	A		A	A			1
Polypedilum	A/S	S	A/S	A/S	A	A	3
Procladius	S	A/S			A	A	4
Pseudochironomus		A/S	A/S	A/S	A	A	3
Pseudosmittia				S			1
Rheocricotopus	A	A/S	A/S	A/S	A	A	3
Rheotanytarsus	A/S	A/S	A/S	A/S	A	A	3
Saetheria	S						3
Stenochironomus		A/S	A	A	A	A	2
Stictochironomus	S		A/S	A/S	A	A	3
Tanytarsus	A/S	A	A/S	A/S	A	A	3
Thienemanniella	A/S	A/S	A/S	A	A	A	3
Thienemannimyia group	A	A	A	A	A	A	2
Tribelos		S					3
Dixidae							
Dixa	A					A	3
Dolichopodidae	A				A		4
Empididae	A/S	A/S	A/S	A	A	A	3
Ephydridae	A/S				A		3
Muscidae	S	S	S	S		A	4
Psychodidae							
Pericoma					A		3
Psychoda						A	3
Simuliidae	A/S	A/S	A/S	A/S	A	A	4
Tabanidae				A	A		3
Tipulidae							
Tipula	A	A	A			A	3
Mollusca							
Gastropoda							
Physidae							
Physa	A/S	A/S	S	A/S	A	A	4
Planorbidae							
Gyralus	A	S					4
Pelecypoda							
Sphaeriidae	A/S	A/S	A/S	S		A	4

* A = artificial substrate sampler; S = Surber sampler.

TABLE III. Frequency of occurrence for common taxa (>10%) and average number collected from artificial substrates from four stations on Long Pine (September 1979 through October 1982). Numbers in parentheses are average number collected for all samples.

TAXON	--- *LP1* --- Frequency Occurrence		--- *LP5* --- Frequency Occurrence		--- *LP7* --- Frequency Occurrence		--- *LP8* --- Frequency Occurrence	
Platyhelminthes								
Turbellaria	40.0	(13)	13.3	(<1)				
Cura foremanii	55.0	(18)	53.3	(3)	22.2	(1)	43.7	(6)
Nematoda	15.0	(<1)	26.6	(<1)	33.3	(1)	18.7	(<1)
Annelida								
Oligochaeta	70.0	(23)	40.0	(2)	66.6	(42)	87.5	(68)
Hirudinea	50.0	(2)						
Arthropoda								
ARACHNIDA								
Hydracarina	75.0	(12)	73.3	(7)	66.6	(17)	50.0	(7)
Amphipoda	15.0	(3)	13.3	(<1)	11.1	(<1)		
Gammarus			13.3	(<1)				
Hyalella azteca	40.0	(6)	26.6	(<1)	16.6	(<1)	31.2	(<1)
INSECTA								
Ephemeroptera								
Baetis	90.0	(159)	100.0	(73)	88.8	(89)	93.7	(32)
Caenis							31.2	(<1)
Ephemerella	75.0	(142)	80.0	(19)	66.6	(105)	50.0	(44)
Heptagenia	55.0	(3)	66.6	(2)	83.8	(19)	75.0	(21)
Isonychia			26.6	(<1)			31.2	(6)
Leptophlebia							12.5	(<1)
Paraleptophlebia	15.0	(<1)						
Pseudocloeon	25.0	(6)	26.6	(2)	50.0	(4)	50.0	(6)
Tricorythodes	100.0	(81)	93.3	(17)	94.4	(205)	100.0	(159)
Odonata								
Zygoptera								
Argia			33.3	(<1)				
Coenagrion			13.3	(<1)				
Hetaerina					22.2	(<1)	18.7	(<1)
Anisoptera								
Gomphus	20.0	(<1)					12.5	(<1)
Ophiogomphus	35.0	(2)					18.7	(1)
Plecoptera								
Acroneuria							12.5	(1)
Isoperla	55.0	(24)	46.6	(2)	72.2	(27)	56.2	(9)
Perlesta	25.0	(8)	46.6	(<1)	38.8	(2)	18.7	(2)
Pteronarcys							31.2	(1)
Taeniopteryx							12.5	(<1)
Hemiptera								
Belostomatidae								
Belistoma	10.0	(<1)						
Corixidae	10.0	(<1)						
Naucoridae							31.2	(2)
Megaloptera								
Chauliodes	15.0	(1)						
Trichoptera								
Brachycentrus	80.0	(33)	100.0	(27)	88.8	(21)	56.2	(3)
Cheumatopsyche	70.0	(100)						
Hesperophylax	15.0	(1)						
Hydatophylax			13.3	(<1)				
Hydroptila	90.0	(70)	20.0	(<1)			31.2	(2)
Hydropsyche	100.0	(453)	93.3	(127)	100.0	(194)	100.0	(67)
Lepidostoma	25.0	(3)						
Leucotrichia					72.2	(14)		
Coleoptera								
Elmidae	69.2	(5)	100.0	(55)				
Dytiscidae	15.0	(<1)			11.1	(4)	12.5	(1)
Diptera								
Tipulidae	45.0	(2)	20.0	(<1)	16.6	(<1)		

TABLE III—*(Continued on page 78)*

TABLE III—*(Continued from page 77)*

TAXON	STATIONS --- *LP1* --- Frequency Occurrence		--- *LP5* --- Frequency Occurrence		--- *LP7* --- Frequency Occurrence		--- *LP8* --- Frequency Occurrence	
Psychodidae	15.0	(<1)						
Ceratopogonidae								
Palpomyia	20.0	(1)	13.3	(<1)				
Simuliidae	70.0	(12)	86.6	(77)	88.8	(93)	75.0	(17)
Chironomidae								
Brillia	50.0	(7)	33.3	(1)	27.7	(1)	18.7	(1)
Cardiocladius	45.0	(15)	13.3	(1)	38.8	(3)	31.2	(23)
Cladotanytarsus	15.0	(1)			38.8	(1)	18.7	(1)
Corynoneura	25.0	(10)						
Cricotopus	35.0	(18)	13.3	(<1)	38.8	(1)	25.0	(4)
Cryptochironomus			6.6	(1)			12.5	(1)
Dicrotendipes	10.0	(1)	6.6	(<1)				
Eukiefferiella	100.0	(542)	86.6	(51)	83.8	(69)	68.7	(207)
Hydrobaenus	10.0	(<1)						
Larsia	25.0	(34)			11.1	(1)	31.2	(6)
Micropsectra	10.0	(32)						
Nanocladius			13.3	(1)	11.1	(<1)		
Odontomesa			6.6	(1)				
Orthocladius	60.0	(21)	40.0	(1)	61.1	(41)	43.7	(360)
Parakiefferiella	10.0	(<1)						
Parametriocnemus	30.0	(21)	53.3	(9)	11.1	(8)	31.2	(4)
Paratanytarsus					16.6	(1)	12.5	(<1)
Pentaneura	10.0	(1)						
Polypedilum					16.6	(1)	12.5	(<1)
Potthastia							12.5	(1)
Procladius			13.3	(1)				
Pseudochironomus			33.3	(4)	27.7	(1)	25.0	(4)
Rheocricotopus	10.0	(8)	73.3	(26)	50.0	(16)		
Rheotanytarsus	90.0	(117)	100.0	(78)	100.0	(351)	93.7	(597)
Stenochironomus			66.6	(18)	38.8	(2)	25.0	(10)
Tanytarsus	30.0	(22)	20.0	(<1)	11.1	(1)	12.5	(1)
Thienemanniella	25.0	(3)	26.6	(1)	50.0	(4)	25.0	(3)
Thienemannimyia group	30.0	(5)	40.6	(3)	33.3	(8)	31.2	(2)
Athericidae								
Atherix			13.3	(<1)	55.5	(1)	25.0	(1)
Empididae	25.0	(2)	53.3	(4)	83.8	(10)	68.7	(3)
Mollusca								
GASTROPODA								
Physa	15.0	(3)	13.3	(1)			12.5	(<1)
PELECYPODA								
Sphaeriidae	45.0	(2)	6.6	(1)	11.1	(<1)		

Macroinvertebrate fauna of Long Pine Creek

LP1 — The community at this headwaters location indicates an unpolluted coldwater stream. Taxa such as *Cura foremanii, Ephemerella, Pseudocloeon, Isoperla, Perlesta, Brachycentrus* and *Hydroptila* were frequently collected and often abundant (Table III). All these taxa are associated with cold water and are relatively intolerant of organic pollution. Other intolerant genera occasionally collected at this station included *Paraleptophlebia, Chauliodes, Leucotrichia, Odontomesa, Parakiefferiella,* and *Potthastia*. Artificial substrate samples typically had high densities of individuals, with a mean of 10,802/m^2, the highest of all stations (Table V). This station also had the most taxa, with at least 76 collected using artificial substrate samplers. Taxa collected (Fig. 4) using artificial substrates ranged from 8 to 34, with a mean of 23. This is somewhat contradictory to other studies, where headwaters of streams often exhibit a lower diversity of taxa (Canton and Chadwick, 1983; Hynes, 1970). The numerous taxa and high densities at this station suggest that a diverse community including many "clean water" types can be supported here.

Biotic index (BI) values for this station were 2.24-3.03, with a mean of 2.63. Figure 5 shows that BI values were primarily in the GOOD range of water quality, with a few values in the FAIR category.

TABLE IV. Frequency of occurrence for common taxa (>10%) and average number collected from artificial substrates from two stations on Bone Creek (May 1980 through November 1982). Numbers in parenthesis are average number collected for all samples.

	STATIONS			
	--- BN --- Frequency Occurrence		*--- BN2 ---* Frequency Occurrence	
TAXON				
Platyhelminthes				
TURBELLARIA				
Cura foremanii	38.4	(9)	46.1	(21)
Annelida				
OLIGOCHAETA	100.0	(118)	100.0	(500)
HIRUDINEA	23.0	(1)	30.7	(2)
Arthropoda				
ARACHNIDA				
Hydracarina	30.7	(1)	53.8	(6)
Amphipoda				
Hyalella azteca	30.7	(2)	15.3	(<1)
INSECTA				
Ephemeroptera				
Baetis	46.1	(6)	69.2	(26)
Caenis	53.8	(9)	30.7	(3)
Dactylobaetis			23.0	(1)
Ephemerella	23.0	(1)	34.4	(36)
Heptagenia	69.2	(10)	76.9	(25)
Isonychia			15.3	(<1)
Leptophlebia	30.7	(4)	23.0	(5)
Pseudocloeon			30.7	(5)
Tricorythodes	100.0	(96)	84.6	(147)
Odonata				
Zygoptera				
Argia	23.0	(<1)		
Hetaerina	15.3	(<1)		
Anisoptera				
Gomphus	15.3	(1)	30.7	(1)
Ophiogomphus			38.4	(1)
Hemiptera				
Naucoridiae				
Ambrysus	15.3	(1)		
Trichoptera				
Cheumatopsyche	38.4	(2)	30.7	(1)
Hydropsyche	46.1	(2)	92.3	(80)
Coleoptera				
Haliplidae				
Peltodytes	23.0	(1)		
Dytiscidae	15.3	(<1)		
Elmidae	69.2	(5)	100.0	(55)
Diptera				
Tipulidae			38.7	(1)
Psychodidae				
Pericoma	15.3	(<1)		
Ceratopogonidae			15.3	(1)
Palpomyia			15.3	(1)
Simuliidae	30.7	(1)	84.6	(136)
Chironomidae				
Brillia	53.8	(6)		
Cladotanytarsus	30.7	(3)	23.0	(1)
Chironomus	15.3	(1)		
Cricotopus	69.2	(17)	69.2	(28)
Cryptochironomus	15.3	(<1)	30.7	(2)
Dicrotendipes	76.9	(41)	38.4	(2)
Endochironomus			15.3	(<1)
Eukiefferiella	38.4	(3)	69.2	(39)
Larsia	15.3	(1)	15.3	(<1)
Micropsectra	15.3	(<1)		
Nanocladius	61.5	(3)	38.4	(4)
Orthocladius	53.8	(92)	53.8	(59)
Parakiefferiella	30.7	(2)	23.0	(1)
Parametricnemus			23.0	(59)
Paraphaenocladius			15.3	(8)
Polypedilum	38.4	(2)	23.0	(1)
Rheocricotopus			35.3	(69)
Rheotanytarsus	53.8	(11)	76.9	(92)
Stenochironomus	38.4	(2)	38.4	(10)
Stictochironomus	30.7	(2)		
Tanytarsus	84.6	(25)	46.1	(35)
Thienemanniella	15.3	(<1)		
Thienemannimyia group	84.6	(17)	61.5	(16)
Empididae	46.1	(1)	61.5	(7)
Mollusca				
GASTROPODA	15.3	(1)		
Physa sp.	30.7	(1)	23.0	(2)
PELECYPODA				
Sphaeriidae			23.0	(1)

Diversity values ($\overline{H}$) were 0.93–3.62, with a mean of 2.92, indicating a relatively balanced, unstressed community, with most values above or approaching 3.0 (Fig. 6). The low value of 0.93 in June, 1982, was due to an abundance of midge larvae of the genus *Eukiefferiella*, with 1,984 collected.

Surber-sample results in Table VI reveal a lower density of benthos when compared to downstream stations *LP5* and *LP7*. This is likely due to the lack of stable gravel-riffle habitat in this stretch of Long Pine. The bottom was composed in excess of 90% sand for the entire collection period (Table I). Sand is generally considered to be low in benthic densities due to its instability (Lenat et al., 1979). Densities ranged from 7 to 251 individuals/m^2, with a mean of 60. An average of only 7 was collected from bottom samples. The bottom fauna in this stretch of Long Pine Creek can be characterized as depauperate. A lack of stable gravel-riffle areas limits the production of macroinvertebrates. A general lack of riparian habitat, likely due to grazing damage, also limits production. Increased diversity of habitat would enhance macroinvertebrate production and likely increase the source of food for trout in this stretch of Long Pine Creek.

LP5 — The macroinvertebrates collected at this location (Table III), which is representative of the mid-reaches of Long Pine Creek characteristically were cold-water types typically found associated with GOOD water quality. Some of these "clean water" forms included *Cura foremanii, Ephemerella, Isoperla, Perlesta, Brachycentrus, Hydroptila, Eukiefferiella, Parametriocnemus*, and *Odontomesa*.

TABLE V. Number of individuals/m² using artificial substrate samplers from Long Pine and Bone creeks. Each value represents a composite of two samplers.

	STATION					
DATE	*LP1*	*LP5*	*LP7*	*LP8*	*BN*	*BN2*
1979 Sept. 6	912	7,747	2,704	26		
Oct 31	8,279		6,819	3,062		
1980 Jan. 15	33,754		6,651	92,847		
April 23	4,975			2,061		
May 28	4,812	2,835	701	1,919	2,140	5,022
June 24	10,941		1,054			
July 29	2,039	2,103		1,834	1,449	5,107
Sept. 23	1,170	5,064	5,560	274	1,823	9,602
1981 Jan. 13	16,189	1,597	1,839	8,722	2,319	18,856
May 12	538	427	2,614	2,140	7,610	8,242
July 27	9,043	1,149	4,664	2,656	3,373	4,311
Sept. 23	7,358	938	6,124	4,801	812	10,108
Nov. 3	1,913	1,286	2,403	5,449	1,165	26,123
1982 Jan. 20	11,299		60,120			
April 6	5,971	8,790	4,195	2,487		
May 26	5,939	1,697	1,096		358	1,080
June 23	13,839	1,075	3,436	2,229	2,814	7,325
July 27	74,086	4,090		13,259	6,134	1,086
Aug. 23	2,140	4,580		1,997	2,498	959
Oct. 5	838	1,829			2,598	3,483
MEAN	10,802	3,014	7,332	9,110	2,699	7,793

TABLE VI. Number of individuals/m² obtained using a Surber sampler at four locations on Long Pine Creek. Each value represents a composite of three samples. Below are average and total numbers of individuals collected, 1979–1982.

	STATION			
DATE	*LP1*	*LP5*	*LP7*	*LP8*
1979 July 24	47	513	1,657	32
Aug. 14	111	290	606	22
Sept. 6	25	319	986	29
Oct. 31	14	344	330	90
1980 Jan. 15	115	348	767	179
April 23	79	366	237	4
May 28	143	678	366	14
June 24	111	459	86	25
July 29	100	237	1,083	133
Aug. 26	39	126	559	118
Sept. 23	251	574	2,557	65
Nov. 4	82	204	739	43
1981 Jan. 13	14	1,503	1,789	54
April 7	11	283	563	115
May 12	57	423	839	65
June 9	32	377	997	29
July 27	126	298	1,481	43
Aug. 25	39	194	617	29
Sept. 23	22	165	247	36
Nov. 3	68	186	344	79
1982 April 6	133	391	290	47
May 26	22	391	93	47
June 23	29	201	143	72
July 27	50	194	423	39
Aug. 23	7	538	420	43
MEAN	69	384	729	58

Artificial substrates acquired at least 56 taxa (Table II). The number collected (Fig. 4) using artificial substrates ranged from 16 to 25, with a mean of 21. A mean of 3,014 individuals/m² was recorded for these samples, the lowest for Long Pine stations during the collection period (Table V).

Even though the densities and number of taxa were lowest for Long Pine stations at this location, the BI values (Fig. 5) were indicative of GOOD water quality, with a mean value of 2.68. One BI value of 3.50, recorded for April, 1982, was due to an abundance of Simuliidae (blackflies), which made up 62% of the individuals and have a tolerance level of 4. It is not uncommon to have seasonal abundances of blackflies on artificial substrates. Even though this value indicated polluted conditions, intolerant forms were also found in the sample, indicating the contrary condition.

Diversity values ($\overline{H}$) were 2.14–3.38, with a mean of 2.79 (Fig. 6). They indicate a relatively balanced community; most values approached or exceeded 3.0. One exception occurred in April, 1982, when a value of 2.14 was recorded. This coincides with the BI of 3.5 on this same date for reasons aforementioned.

Surber-sample results (Table VI) were 126–1,503 individuals/m², with a mean of 384. This is comparable to densities reported by Jensen and Christiansen (1983), using Surber samples in riffle habitats on Elm Creek in south-central Nebraska. They found values of 251–1,546 individuals/m² for this marginal coldwater stream. According to Binns and Eiserman (1979), who used macroinvertebrate densities as a component of a predictive

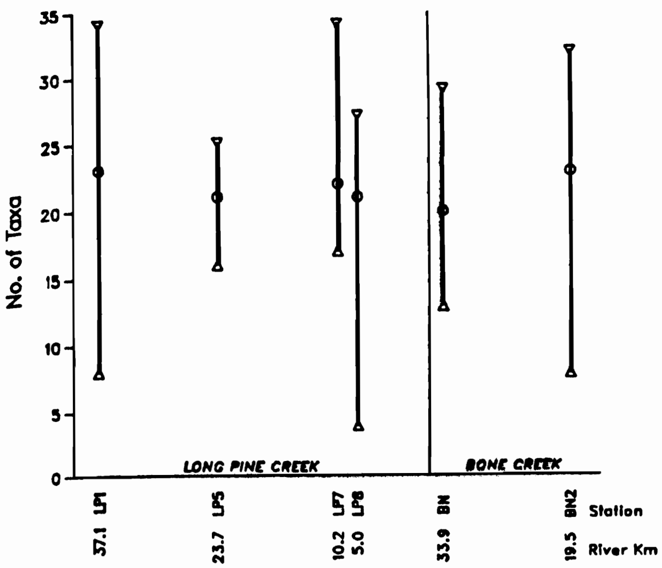

FIGURE 4. Summary of the mean number of taxa and ranges for macroinvertebrates collected from Long Pine and Bone creek stations using artificial substrates, 1979–1982.

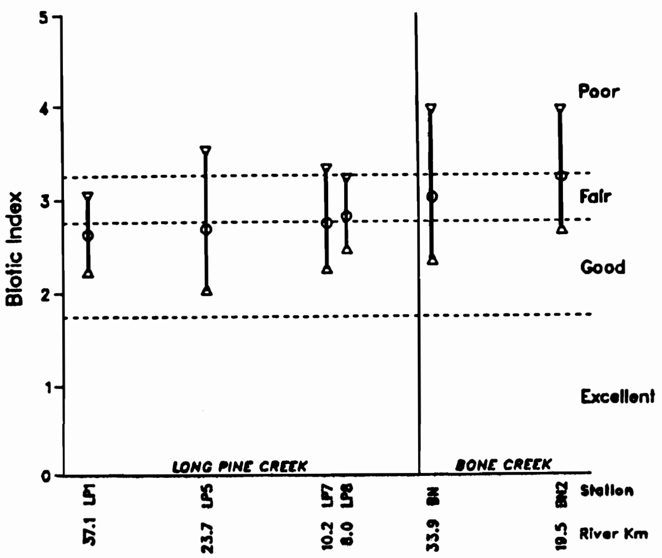

FIGURE 5. Summary of biotic indices (BI) for macroinvertebrates collected using artificial substrates from Long Pine and Bone creek stations. Values depicted are means and ranges for data collected between 1979 and 1982.

model for trout standing-crops in Wyoming streams, the densities for Long Pine Creek would not be exceptionally good. Values of 280–2,679 individuals/m^2, which were characteristic at *LP5*, would be given a rating of 1 or 2, with 0 being worst (<259/m^2) and 4 having the best rating (>5,380/m^2). Fish food abundance appears to be less than optimum compared to Wyoming standards.

LP7 — Macroinvertebrate collections at this location were characteristic of unpolluted cold water. Genera such as *Ephemerella, Heptagenia, Pseudocloeon, Isoperla, Brachycentrus,*

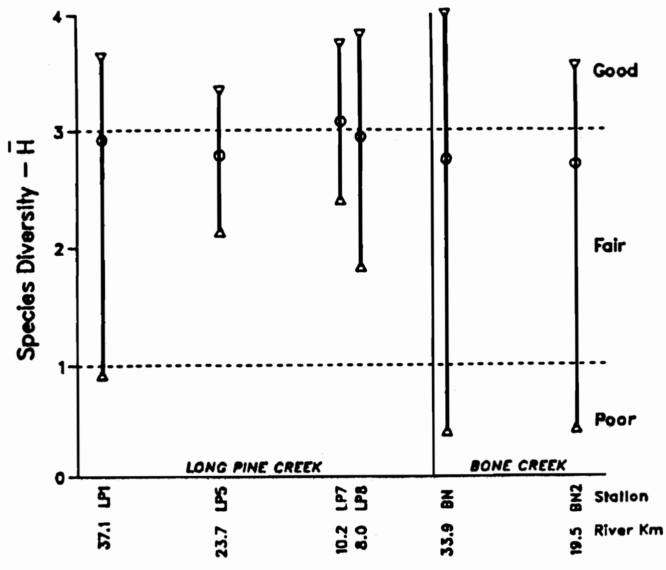

FIGURE 6. Summary of species diversity ($\overline{H}$) for macroinvertebrates collected using artificial substrates from Long Pine and Bone creek stations. Values depicted are means and ranges for data collected between 1979–1982.

Leucotrichia, and *Eukiefferiella* frequently were collected, often in abundance (Table II). Other, less common taxa collected that indicate GOOD water quality included *Cura foremanii, Perlesta, Brillia, Glossosoma* and *Stenochironomus.*

Artificial substrates gathered at least 61 taxa. The number using artificial substrates ranged from 17 to 34, with a mean of 22 (Fig. 4). A mean of 7,332 individuals/m^2 was recorded for these samples (Table V).

The BI values were for the most part indicative of GOOD water quality, with values of 2.26–3.31, and a mean of 2.74 (Fig. 5). The 3.31 value in the poor range reflects an abundance of Simuliidae in the August, 1982, collection.

Diversity values ($\overline{H}$) were 2.41–3.73, with a mean of 3.07. Figure 6 shows the values to be in the FAIR to GOOD categories for all collections. This station had the highest mean $\overline{H}$ value for all locations on Long Pine Creek, indicating that a diverse assemblage of macroinvertebrates was present.

Surber-sample densities were the highest for all stations sampled, with mean of 729 individuals/m^2 (Table VI). These high densities are an indicator of the good gravel substrate in this stretch, providing bottom habitats suitable for attachment.

LP8 — The community collected at this location indicated "clean water" for the most part. Taxa such as *Cura foremanii, Baetis, Ephemerella, Heptagenia, Pseudocloeon, Tricorythodes, Isoperla, Brachycentrus, Hydropsyche,* Simuliidae, *Eukiefferiella, Rheotanyarsus,* and Empididae were frequently collected, often in abundance (Table II). The taxa were in general similar to *LP7,* the upstream station.

One notable difference between stations *LP7* and *LP8*, representing sites above and below the confluence with Bone Creek, is the reduction of individuals found on artificial substrates. In 8 of the 12 collections made together from these two stations, there were fewer individuals/m^2 collected at *LP8* (Table V). This was most evident during summer and early fall collections (July and September). This is the time of year when Bone Creek's impacts are greatest on Long Pine Creek. Suspended and bedload sediment are typically much higher during this time at this station than at *LP7* (Maret, 1985). In addition, some of the lowest densities were below the confluence with Bone Creek (*LP8*), on artificial substrates. Gammon (1970) found that impacts due to sediment typically reduce the number of macroinvertebrates, but have little effect on community diversity. Hydropsychid caddis flies, which use silken nets to collect food, did not appear to be affected by the increased suspended sediment. Large numbers were common on artificial substrates, contrary to what might be expected.

Artificial substrates acquired at least 62 taxa. A mean of 9,110 individuals/m^2 was collected with these samples (Table V). A September, 1979, collection had 4 taxa with 26 individuals, the lowest for all collections. A review of chemical parameters and field observations does not offer an explanation for these low values.

The BI values were 2.47–3.21, all in the FAIR to GOOD range (Fig. 5). The mean of 2.81 was the highest for Long Pine stations, indicating the lowest quality water. However, this is only a slight difference compared to other upstream stations.

Diversity values ($\overline{\text{H}}$) were 1.84–3.81, with a mean of 2.94 (Fig. 6). These values indicated a relatively balanced, healthy fauna in the FAIR to GOOD range.

Surber samples were strikingly different than collections taken 2.2 km upstream at *LP7*. Station *LP8* had the lowest mean densities, with 58 individuals/m^2 for all Long Pine stations (Table VI). The extremely unstable, shifting, sandy bottom at this station, similar to the *LP1* headwaters station, is unproductive for macroinvertebrates. Gravel-riffle areas are absent in this area, except for the occasional patches occurring in winter and early spring, when there are few sources contributing sediment, and the bottom is scoured clean of sand in riffle areas.

Macroinvertebrate fauna of Bone Creek

BN — The community collected at this station was different in a number of ways from Long Pine Creek stations. There were no stoneflies. This is surprising considering the primary water source at this location is spring-flow, which would be favorable to stoneflies. The types and numbers of certain taxa collected indicate enriched waters. Taxa such as Oligochaeta, *Caenis, Tricorythodes, Cricotopus* and *Dicrotendipes* were frequently collected in abundance (Table IV). These are often associated with organically-enriched waters.

Artificial substrates acquired at least 62 taxa. The number collected (Fig. 4) using artificial substrates was 13–29, with a mean of 20. A mean of 2,699 individuals/m^2 was collected using artificial substrates (Table V), the lowest density recorded for all six stations. Artificial substrate plate-samplers were often covered with a layer of fine sediment, making colonization difficult for many taxa.

The BI values were 2.43–3.94, with a mean of 3.01. Most values were in the FAIR range (Fig. 5). The highest value of 3.94 was recorded in October, 1982, due to an unbalanced population of tolerant oligochaetes, which made up over 95% of the collection. This obviously is an indication of an unhealthy aquatic community during this period.

Diversity ($\overline{\text{H}}$) was 0.42–3.99, with a mean of 2.75. The ($\overline{\text{H}}$) values were highly variable, with indications of stress occurring at certain times (Fig. 6). Lower ($\overline{\text{H}}$) values (<2.50) were typically dominated by oligochaetes and *Tricorythodes,* both primarily pollution-tolerant groups.

BN2 — This station was strikingly different from all others, except that it resembled *BN* in having much of the same fauna. Taxa such as Oligochaeta, *Tricorythodes, Hydropsyche,* Elmidae, Simuliidae, Cricotopus, and *Eukiefferiella* were frequently collected in abundance (Table V). Similarly to station *BN*, a few taxa often dominated the collections. Oligochaetes and *Tricorythodes* were usually found in large numbers. The animals collected at this site are generally considered warm-water organisms.

Artificial substrates acquired at least 72 taxa. The number of taxa gathered (Fig. 4) using artificial substrates was 8–33, with a mean of 23. A mean of 7,793 individuals/m^2 was collected with these samplers (Table V). In all but two cases the number of individuals exceeded that collected at *BN*. Chironomids were much more common and diverse at this station than at *BN*. Lenat et al. (1979) found that moderate organic pollution and sedimentation may actually increase the abundance and diversity of chironomids in lotic environments. This appears to be the case at *BN2*, where some organic enrichment is obvious from chemical data (Maret, 1985). This can be attributed to point-source discharges such as the Ainsworth sewage treatment discharge and sporadic feedlot discharges. Surprisingly, hydropsychids were abundant at this station. Apparently runoff events and the elevated concentrations of sediment are brief enough that they are not as detrimental to these caddisflies as previously perceived. The enriched waters at this station apparently provide a good source of food for these sessile collectors.

The BI values were 2.55–3.93, with a mean of 3.22. Most of these values were in the FAIR to POOR range. Figure 5 shows this station to have the highest mean BI of all stations, indicating the most degraded water quality of all stations. Biotic Index values were often above 3.0, indicating that the communities were primarily composed of tolerant organisms.

Diversity values ($\overline{H}$) were 0.44–3.54, with a mean of 2.71. The results were highly variable, with some values falling into the POOR range (Fig. 6). Lower diversity was usually the result of collecting oligochaetes and *Tricorythodes* in large numbers, which caused unbalances in the community structure.

CONCLUSIONS

1. The biological community shows a slight degradation in water quality at the downstream stations on both Long Pine and Bone creeks.
2. Both Bone Creek stations showed large fluctuations in diversity and species composition, and at times exhibited stressed aquatic faunas.
3. Surber samples taken from the headwaters (*LP1*) and farthest downstream station (*LP8*) on Long Pine Creek showed very low densities of benthic faunas, due to the lack of stable gravel bottom.
4. Biotic indices showed no values in the EXCELLENT range for Long Pine stations, as expected. Refinement of tolerance values resulting from better taxonomic resolution is needed to develop a more sensitive tool to identify high quality as well as impaired waters. Until this refinement is achieved, collections containing large numbers of facultative organisms (e.g., Simuliidae) must be assessed with caution.
5. Community indices used in this study showed variability due to seasonal changes and habitat preferences. This indicates the importance of using other assessment methods (i.e., species composition, indicator species, and densities) in conjunction with these indices to effectively evaluate water quality.

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