Benthic Macroinvertebrates in Logged and Unlogged Low-Order Southeast Alaskan Streams[1]

WILLIAM F. A. DUNCAN AND MERLYN A. BRUSVEN

Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83843

Abstract. The benthic macroinvertebrate communities of three low-order streams in southeast Alaska exhibiting pre- and post logging conditions were examined. The logged watersheds had the highest densities and biomass of benthic macroinvertebrates, while an unlogged coniferous climax forest watershed had the lowest. Benthic macroinvertebrate community composition was similar for key species among the three streams. Collector-gatherers were generally the most abundant functional group comprising up to 80% of the insect community; predator-engulfers were the second most abundant functional group. Salmonid fishes greatly altered the macroinvertebrate community composition during spawning because of mass disturbance of the streambed. Gravels disturbed during spawning were most rapidly recolonized by mayflies and stoneflies, especially *Alloperla* spp.

The energy base of many small southeast alaskan streams may be changed from primarily allochthonous to autochthonous because of logging. These changes can potentially alter the benthic invertebrate community. If, however, most benthic insects are opportunistic detritivores and feed on a variety of food materials and particle sizes, then, drastic community shifts may not be evident. Rounick et al. (1982) showed that the same invertebrate species differentially utilized allochthonous and autochthonous produced materials among streams of different riparian conditions. Hawkins et al. (1982) reported most macroinvertebrate communities were influenced by qualitative differences in food rather than the quantity of food available in Oregon streams.

Benthic macroinvertebrates provide an important link in converting allochthonous and autochthonous plant material into an energy source for juvenile salmonid fishes. Increased autochthonous production in clearcut coastal streams (Hansmann & Phinney 1973, Shortreed & Stockner 1983, Duncan 1984) likely causes an increase in benthic invertebrate production and ultimately salmonid production (Murphy el al. 1981). Our study examined differences in invertebrate community structure and biomass for three low-order southeast Alaska streams having different altered riparian vegetation conditions because of logging.

DESCRIPTION OF STUDY AREA

Three study streams were selected within the Tongass National Forest on Prince of Wales Island, Alaska (Fig. 1). Annual precipitation ranges from 150 to 500 cm; the majority comes in September and October. Air temperatures range from −20° to 36° C.

The streams selected for study were based on several criteria: 1) similar size, 2) gradient, 3) latitude, 4) riparian regeneration time, and 5) extremes in riparian cover. The streams are important for rearing and spawning of anadromous salmonids, e.g., Coho salmon (*Oncorhynchus kisutch*), Pink salmon (*Oncorhynchus gorbuschus*), Dolly Varden

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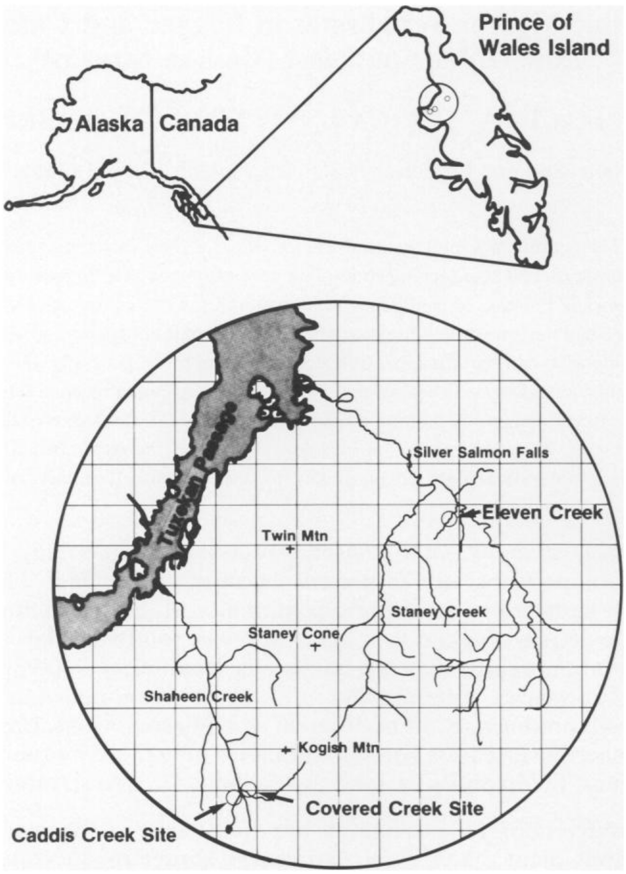

Fig. 1. Location of the three study streams on Prince of Wales Island, Alaska.

(*Salvelinus malma*), steelhead trout (*Salmo gairdneri*), and cutthroat trout (*Salmo clarki*).

Covered and Caddis Creeks (named for study purposes) are tributaries to the Middle Fork of Shaheen Creek, while Eleven Creek (named for study purposes) is a tributary to Staney Creek. The physical and chemical characteristics of the streams are summarized in Table 1. The predominant substrate material for the three streams is large pebbles (25-64 mm) and small cobbles (64-127 mm); Covered Creek had some large cobbles (127-254 mm) and exposed bedrock. The Covered Creek watershed is unlogged and is a climax spruce-hemlock forest, whereas Eleven and Caddis Creek watersheds were logged in 1971 and 1979, respectively. The Caddis Creek watershed has little revegetation, while Eleven Creek drainage is heavily canopied with 6-8 year old red alder. All three streams have mean-summer flows of approximately 0.01 m^3/s and have similar gradients.

METHODS

Benthic invertebrates were sampled using a 0.093 m^2 modified Hess sampler. Two subsections were randomly assigned to each 100-m study site. Four samples were taken in the riffle sections of each 10-m long subsection at randomly chosen locations. The three streams were sampled four times annually in 1982 and 1983 during June through October. Macroinvertebrates were preserved in 70% ethanol, hand sorted from debris under a 2X illuminated magnifier, identified to species or morphospecies using keys by Usinger

TABLE I

Physical and chemical characteristics of the study streams on Prince of Wales Island, Alaska in 1983.

Parameter	Covered Creek	Caddis Creek	Eleven Creek
Mean bank-full width (m)	3.3	5.2	3.8
Gradient (%)	4.3	2.2	2.4
Temperature range (°C)	1-14	1-22	1-14
Mean discharge (m^3/s), (N=4)	0.015	0.010	0.014
Forest canopy development	Closed	Open	Closed
Nutrient range (mg/L)			
NO_3-N	<0.01-0.03	<0.01-0.19	<0.01-0.05
PO_4-P PO_4-P	<0.01	<0.01-0.08	<0.01
Dissolved O_2	10.5-11.9	9.5-11.4	9.2-12.2

(1956), Jensen (1966), Edmunds et al. (1976), Wiggins (1977), Baumann et al. (1977), and Merritt and Cummins (1978), counted and enumerated as numbers per square meter.

Macroinvertebrate biomass of ordinal groups was determined for each sample date. The eight samples collected from a study site on a date were randomly combined into two, four-sample groups. For every combined sample, each ordinal group was individually filtered onto preweighed Gelman Metricel GA-6 0.45 μm filters. The sample was then dried for 24 h at 50° C, cooled in a desiccator, and reweighed to obtain dry weight. The sample was then ashed at 550° C for 4 h, cooled in a desiccator and reweighed. The percentage ash by insect order was then used to correct the dry weights to an ash-free dry weight (AFDW).

Benthic insects were functionally classified according to Merritt and Cummins (1978). Density is reported as mean density/m^2 with associated standard error. Total insect density and percent of total insect density for each ordinal and functional group were calculated for each stream and sample date.

Proportional similarity (Price 1975) and average linkage clustering (Hellawell 1978) were used to elucidate community differences. Seventeen common or 'key' taxa (Table 2) were chosen on the basis of abundance in one or more of the study streams, their dominant functional status, and their importance as a fish food organism. Insect count data of the four sample dates were combined for each year for the 17 'key' taxa. The resultant proportional similarity matrix was then clustered using average linkage clustering.

RESULTS

Ordinal benthic macroinvertebrate density and biomass varied between streams and seasons (Figs. 2 & 3). The logged watersheds of Caddis and Eleven Creeks had the highest biomass and density of insects. Caddis Creek had the highest total counts and biomass in midsummer (July-August). Invertebrate biomass in Eleven Creek was greatest in late spring (June), while the density was relatively unchanged during the sampling period. In contrast, the unlogged watershed (Covered Creek) had the lowest invertebrate density and biomass for all sampling dates.

Low invertebrate densities and biomass occurred on riffles of both Caddis and Eleven Creeks during the salmonid spawning season (Figs. 2 & 3). The spawning activity changed the invertebrate composition to primarily a stonefly-mayfly community (Fig. 2). In 1983,

TABLE II

Checklist and functional classification of invertebrate taxa in Prince of Wales Island study streams.

Taxon	Functional Group	Taxon	Functional Group
Ephemeroptera		Brachycentridae	
Baetidae		*Micrasema* sp.1	Sh - 1
Baetis hageni+	Co - 1	Hydropsychidae	
Baetis bicaudatis	Co - 1	*Arctopsyche* sp.	P - 1
Baetis tricaudatis	Co - 1	Limnephilidae	
Leptophlebiidae		*Dicosmoecus* sp.	Sc - 1
Paraleptophlebia sp.+	Co - 1	*Onocosmoecus* sp.	Sh - 2
Siphlonuridae		*Psychoglypha* sp.	Co - 2
Ameletus sp.+	Co - 1	*Ecclisocosmoecus* sp.	Sc - 2
Ephemerellidae		*Cryptochia* sp.	Sh - 2
Drunella doddsi	Sc - 1		
Drunella spp.+	Co - 1	Coleoptera	
Heptageniidae		Elmidae	
Epeorus spp.+	CoSc - 1*	*Narpus* sp.	Co - 1
Rhithrogena spp.	CoSc - 1	Dytiscidae	P - 1
Cinygmula spp.+	CoSc - 1		
		Diptera	
Plecoptera		Ceratopogonidae+	P - 1
Chloroperlidae+	P - 1	Tipulidae	
Nemouridae		*Hexatoma* sp.	P - 1
Zapada sp.	Sh - 1	*Rhabdomastix* sp.	P - 3
Leuctridae		*Dicranota* sp.+	P - 1
Despaxia augusta+	Sh - 1	*Tipula* sp.	P - 5
		Simuliidae	F - 1
Trichoptera		Empididae	
Lepidostomatidae		*Oreogeton* sp.+	P - 1
Lepidostoma sp.+	Sh - 1	Chironomidae	
Polycentropidae		Chironominae+	Co - 4
Polycentropus sp.	P - 1	Tanypodinae	
Rhyacophilidae		Tanytarsini+	Co - 4
Ryacophila spp.	P - 1	Tanypodini+	P - 4
Glossosomatidae		Orthocladiinae+	CoSh - 3,4
Glossosoma sp.	Sc - 1	*Corynoneura* sp.	Co - 4
		Oligochaeta (spp.)+	

1. Hawkins and Sedell (1981)
2. Wiggins (1977)
3. Personal observation or deduction
4. Merritt and Cummins (1978)
5. Cowan, el al. (1983)

Co - Collector/Gatherer
Sh - Shredder
Sc - Scraper
P - Predator/Engulfer
F - Collector/Filterer

*Collector-scrapers were treated as one-half collector and one-half scraper in all calculations.
+'key' species in community analysis (and Oligochaeta)

the high summer flows allowed earlier spawning than during the previous year so that on the final sampling date (October) invertebrate densities and biomass were comparable to prespawning levels for Caddis and Eleven Creeks.

Collector-gatherers were the most abundant invertebrates representing 17.5 to 79.7% of the total density in the streams studied (Table 2; Fig. 4). Predator-engulfers comprised 10.2 to 59.3% of the insect community. Scrapers and shredders made up the rest of the community except for a small collector-filterer component.

The invertebrate functional group composition in Covered Creek varied little seasonally (Fig. 4), being composed primarily of collector-gatherers and predators (ca. 60-80%). Scrapers (15.9-28.1%) and shredders (3.6-17.4%) comprised the rest of the community. Conversely, the functional group composition in Caddis and Eleven Creeks

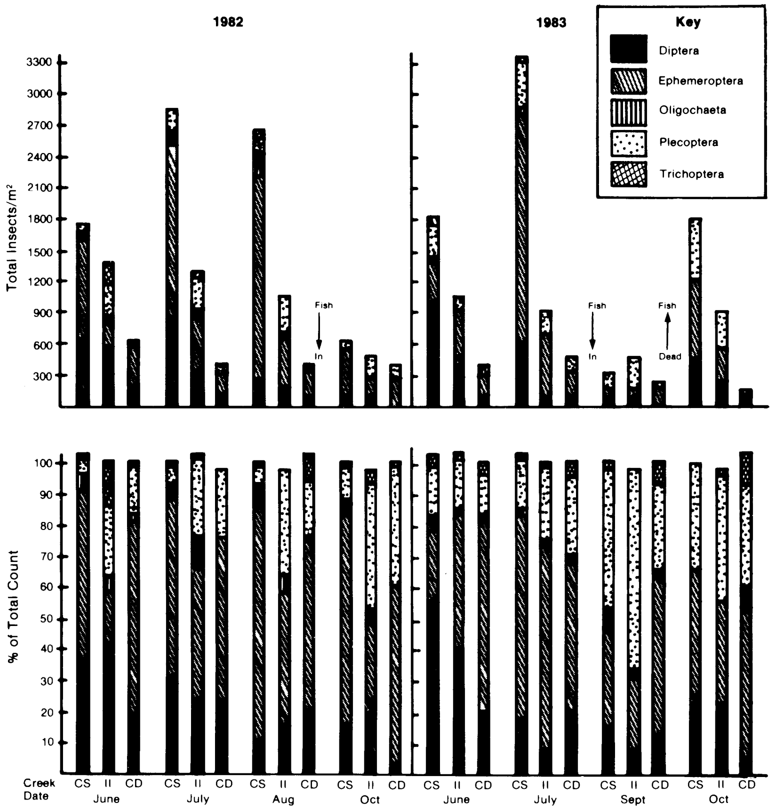

Fig. 2. Ordinal composition of benthic macroinvertebrates for three streams on Prince of Wales Island, Alaska, 1982 and 1983. CS = Caddis Cr.; 11 = Eleven Cr.; CD = Covered Cr.

varied seasonally because of the fish spawning activity in those streams. Thus, October, 1982 and September, 1983 will be ignored in the subsequent discussion of seasonal functional group changes. In Caddis Creek, collector-gatherers and predators dominated (ca. 70-90%) the community and showed little seasonal variation. Scrapers, lowest in the spring (1982, 3.3%; 1983, 6.3%), increased throughout the summer (1982, 10.8-18.9%; 1983, 16.9%). Shredders, a minor group (< 5%), were composed primarily of the dipterans (Orthocladiinae larvae) and *Despaxia augusta*. The Orthocladiinae complex in this stream may have been functioning primarily as a collector-gatherer. Collector filterers (e.g. Simuliidae) were poorly represented. In Eleven Creek, collector-gatherers and predators were the most important functional groups (ca. 60-80%) and showed little seasonal variation. Shredders were most abundant in spring and fall; scrapers were proportionately most abundant during the summer (1982, 12.2%; 1983, 22.2%).

Clustering of proportional similarity values generated from community composition analysis among the three streams showed a high degree of community similarity (Fig. 5). All creeks and years had similarity values of 0.610 to 0.725. Caddis and Eleven Creeks (both logged) had the most similar invertebrate communities.

Discussion

The most obvious benthic macroinvertebrate (BMI) community differences among the study streams were in total density and biomass. The highest mean seasonal BMI biomass was found on Caddis Creek (0.2343 g AFDW/m^2) followed by Eleven Creek (0.1962 g

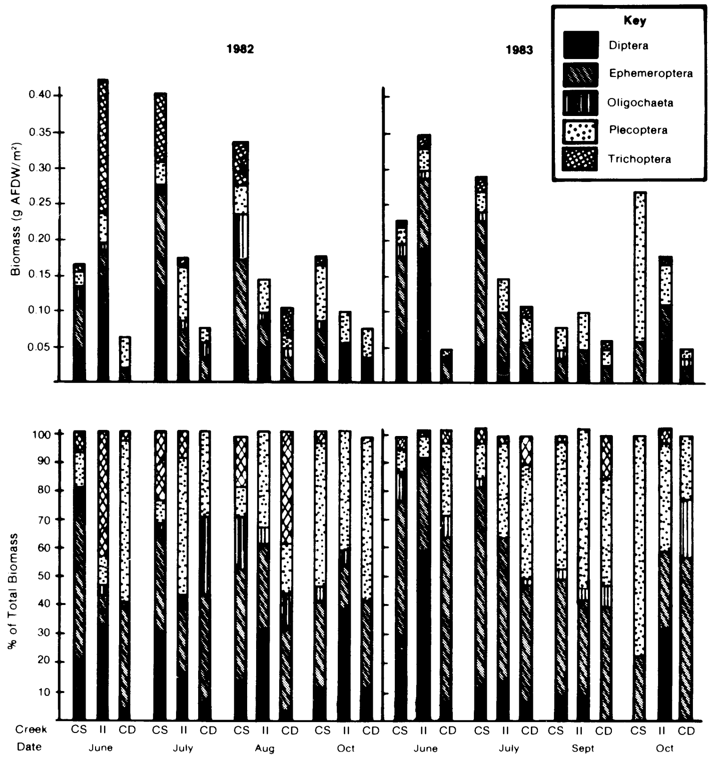

Fig. 3. Ordinal biomass composition of benthic macroinvertebrates for three streams on Prince of Wales Island, Alaska, 1982 and 1983. CS = Caddis Cr.; 11 = Eleven Cr.; CD = Covered Cr.

AFDW/m^2); both watersheds had been previously logged. The high autochthonous production in Caddis Creek (Duncan, 1984) was the likely reason for its high BMI biomass. Our data corroborate similar findings by Murphy et al. (1981) who showed a greater abundance of aquatic species in clearcut or open sections of streams than in shaded sections.

The low autochthonous production and relatively high mean seasonal invertebrate biomass on Eleven Creek (Duncan 1984) suggest that the high allochthonous input is the main energy source for BMI production. Benthic macroinvertebrate biomass was highest in spring and decreased during summer on Eleven Creek. The high spring biomass likely resulted from processing the autumnal allochthonous input. By contrast, the relatively low input of more refractory allochthonous material (coniferous needles and bark) and the low autochthonous production is the probable reason for low production of benthic macroinvertebrates (0.0685 g AFDW/m^2) in Covered Creek.

Benthic invertebrate community composition, as measured by proportional similarity analysis, was similar among the streams in spite of differences in the energy base of each stream. This relationship suggests differential utilization of allochthonous input and autochthonous production by the same invertebrate species in streams having different riparian conditions. Similar findings were reported for New Zealand streams (Rounick et al. 1982).

Total invertebrate numbers and biomass were affected each year by spawning salmonids. After cessation of spawning, BMI biomass and numbers returned to previous levels. Recolonization likely occurred via drift from upstream areas where salmonid

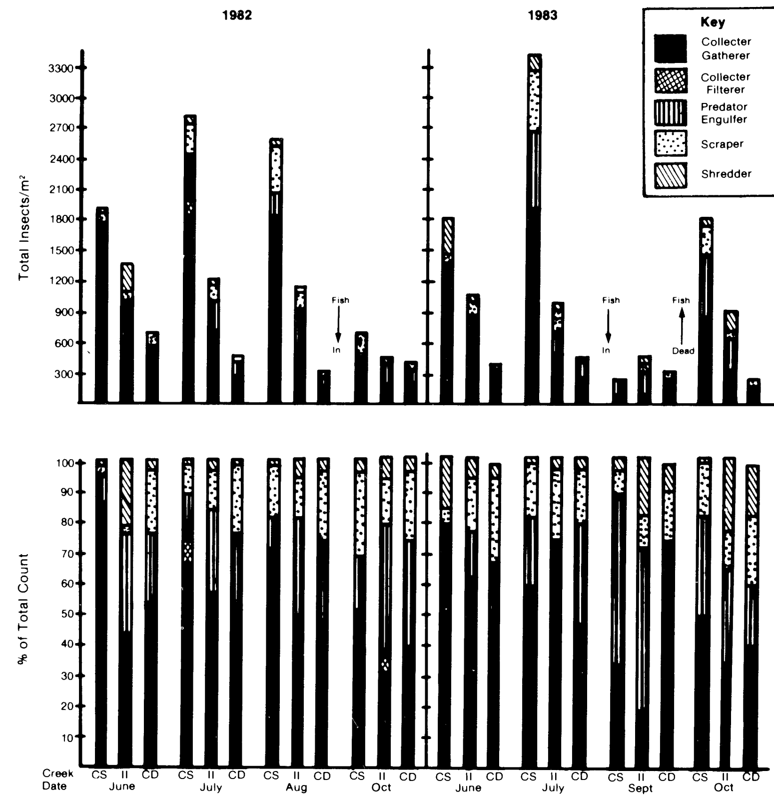

Fig. 4. Functional group composition of benthic macroinvertebrates for three streams on Prince of Wales Island, Alaska, 1982 and 1983. CS = Caddis Cr.; 11 = Eleven Cr.; CD = Covered Cr.

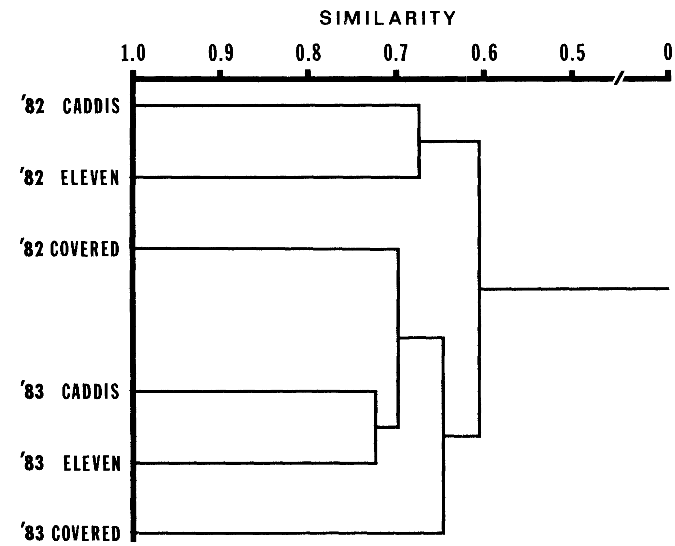

Fig. 5. Average linkage clustering dendrogram of proportional similarity values generated from invertebrate community composition analysis for three streams on Prince of Wales Island, Alaska, 1982 and 1983.

passage was inhibited, from the hyporheic zone, adult insect emergence and oviposition. Spawning activity by fish followed by invertebrates recolonization caused a shift in BMI community composition to mayflies and stoneflies (particularly *Alloperla* spp.). Hyporheic recolonization is probably the main source of the chloroperlid nymphs. Hansen (1980) found *Alloperla* spp. at depths of 30 cm in Porcupine Creek, Etolin Island, S.E. Alaska and discussed their adaptations to movement in stream gravels. High density of chloroperlid nymphs associated with salmonid redds has also been reported by Ellis (1970). He speculated that nymphs of this stonefly functioned as scavengers on dead or unfertilized salmon eggs.

Alteration of a stream's energy base from allochthonous to primarily autochthonous production as a result of logging did not drastically alter the dominant species within the BMI community. The higher density and biomass of invertebrates in the watersheds having high allochthonous or autochthonous production suggests that invertebrate production in many southeast alaskan streams may be food-limited. The possibility of increasing salmonid smolt production by increasing invertebrate production exists if smolt production is also food-limited.

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