# RESPONSES OF INVERTEBRATE DRIFT TO STREAMSIDE BRUSH REMOVAL

by

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## ABSTRACT

Invertebrate drift, a principle food of trout, was sampled in the Little Plover River once a month from June 1976 through August 1977 to determine if removal of woody streamside vegetation increased drift number and biomass, and altered taxonomic composition. Simultaneous drift net samples of invertebrates and detritus were collected in a Meadow Zone, two Brushy Zones, and a Treatment Zone where the streamside brush was removed from both stream banks in spring 1973. Results were compared between zones and to pretreatment drift and benthos studies conducted in 1972-73. Brush removal was initiated to improve trout habitat and the sport fishery.

Numbers and biomass of drifting aquatic invertebrates in the Treatment Zone were not significantly different from drift in the Upper and Lower Brushy Zones in 1976-77, four years after brush removal, or from drift in the Treatment Zone in 1972, before removal. Benefits of brush removal to invertebrate growth and reproduction from increased area of productive substrate (aquatic vegetation) in the Treatment Zone may have been nullified by unusually high water temperatures, low stream flow, and thick ice. Numbers and biomass of aquatic drift in the Meadow Zone were significantly higher than in the other zones in 1976-77 as well as in 1972. Greater abundance of aquatic drift in the Meadow Zone was probably related to greater amounts of productive substrates (aquatic vegetation and gravel) and a richer detritus food base than in the other zones. There was no significant difference in total drift between zones. Drifting detritus in the Treatment Zone was significantly greater than in the Lower Brushy Zone

and similar to detritus in the Meadow and Upper Brushy Zones. Mean monthly drift per $100m^3$ of discharge in the Meadow Zone, Treatment Zone, Upper Brushy Zone, and Lower Brushy Zone were: total numbers, 814, 677, 327, and 798 organisms; aquatic numbers, 660, 192, 153, 146 organisms; aquatic biomass, including molluscs, 9.45, 2.12, 1.30, and 3.91 grams, and without molluscs, 2.13, 0.43, 0.31, and 0.30 grams; detritus weight, 15.6, 8.3, 11.0, and 5.5 g dry wt/$100m^3$. Aquatic drift comprised 44.3% of the number and 96.0% of the biomass of the total invertebrate drift in all zones combined. Terrestrial drift was much more abundant in the Treatment and Lower Brushy Zones than in the Meadow and Upper Brushy Zones.

Only in the Lower Brushy Zone were aquatic numbers significantly higher in 1976-77 than in the pretreatment drift study in 1972, however, terrestrial and total drift were significantly greater in all zones in 1976-77. There was no significant difference in drifting detritus between studies.

The monthly mean number of drifting taxa in the Treatment Zone (29) was significantly greater than in the Upper Brushy Zone (19), similar to that in the Lower Brushy Zone (30), and less than that in the Meadow Zone (37). All zones except the Upper Brushy Zone had significantly higher numbers of taxa in 1976-77 than in 1972. Gammarus spp. decreased in importance from 1972 to 1976-77, whereas Lymnaea spp. and Chironomidae increased, probably due to higher water temperatures.

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# INTRODUCTION

Invertebrate drift in the Little Plover River, Wisconsin, was sampled monthly from June 1976 through August 1977 in a Meadow Zone, two Brushy Zones, and a Treatment Zone where the streamside brush was removed in the spring of 1973. The objective was to determine if removing woody streamside vegetation increases the number and biomass of drift and alters the composition of drifting invertebrates, an important food for trout. Results from my study were compared between zones and to pretreatment drift (Braatz 1974) and benthos (Scullin 1977) studies conducted in 1972-73.

Investigations of brush removal were initiated in 1970 by the Coldwater Research Group of the Wisconsin Department of Natural Resources to assess its potential as a management technique to increase trout carrying capacity and improve sport fisheries in small brushy streams where water temperatures will not become excessively high (Hunt 1971). This evaluation on the Little Plover River, conducted by the Wisconsin Department of Natural Resources and graduate students of the University of Wisconsin-Stevens Point, included studies on brook trout (*Salvelinus fontinalis*) angler exploitation and use, stream morphology, flow, temperature, and chemistry, and solar radiation.

Trout carrying capacity is often depressed in small Wisconsin streams that are heavily shaded by streamside vegetation (White and Brynildson 1967). Such streams often lack stable banks, channel constricting aquatic vegetation is sparse or absent, and hiding cover for trout at the streams edge is limited. Branches that hang or fall into the stream catch debris, reduce water velocity causing increased silt deposition, and result in a stream channel that is relatively wide and shallow in relation to the volume of flow.

Removal of woody streamside vegetation allows grasses to stabilize the banks and instream vegetation to increase, both of which confine the stream flow. Confinement in turn causes the current to dig deeper, exposing gravel substrates and creating a more suitable stream channel for trout. A sturdy turf often forms overhangs, and with increased aquatic vegetation, provides hiding cover for trout. Aquatic vegetation and gravel were the most productive substrates for aquatic invertebrates in the Little Plover River in 1972-73 (Scullin 1977), as well as in other streams (Tarzwell 1936, Minckley 1963, Witcomb 1968, Hynes 1970, Sanders 1976, Schmal 1978).

Invertebrate drift refers to the downstream transport of organisms in stream currents (Waters 1972). Drift is not a distinct "fauna", seperate from benthic fauna, but rather a temporary event in the life of substrate-oriented invertebrate populations. Also, terrestrial insects often fall into streams and contribute to the drift. Both aquatic and terrestrial drift can be important food for fish, especially trout (Hunt 1965, Waters 1969). Three types of aquatic drift according to cause have been recognized, (1) Catastrophic drift, a result of physical disturbance of the bottom fauna, (2) Behavioral drift, a result of behavior patterns of certain species, and (3) Constant drift, the continuous drift of representatives of all species (Minckley 1964, Waters 1965 and 1972). Regardless if drift is density-dependent (Dimond 1967, Waters 1961 and 1966) or density-independent (Pearsom and Franklin 1968, Hildebrand 1974, Reisen and Prins 1972) on benthic density, an increase in benthic density usually results in an increase in invertebrate drift.

In a study of benthos (Scullin 1977) and drift (Braatz 1974) on the Little Plover River before brush removal, mean numbers were highest in a Meadow Zone ($322/m^2$ and $614/100m^3$) and lower in two brushy zones

(137/$m^2$ and 273/100$m^3$, 154/$m^2$ and 130/100$m^3$) respectively. Mean benthic biomass was also higher in the Meadow Zone (3.47 g/$m^2$) than in the Brushy Zones (1.36 g/$m^2$ and 1.45 g/$m^2$).

Woodall and Wallace (1972) found the highest numbers of benthic invertebrates in a stream traversing an old field succession, similar to the Little Plover River meadow, and highest biomass in a stream flowing through a forest that had been cut and allowed to sprout. Streams flowing through white pine and hardwood forests supported lower numbers and biomass of aquatic invertebrates. Hobbs (1948) observed that trout "avoid" heavily shaded water and recommended tree removal for penetration of light. Westlake, et al. (1970) found that production of a sculpin (*Cottus gobio*) was higher in unshaded rather than shaded areas of a chalk stream in southern England.

## STUDY AREA

The Little Plover River is located in the sand plains of central Wisconsin, about 8 kilometers southeast of Stevens Point (Figure 1). The dominate fish species are wild brook trout and mottled sculpin (*Cottus bairdi*). The river originates near the Arnott moraine, has a gradient of 1.9 m or less per kilometer and an average discharge of 0.3 $m^3/s$ near its lower end. Approximately 6.6 kilometers from its origin it empties into the Wisconsin River near the Village of Plover. The watershed covers about 19,800 hectares and is underlain by 12-30 m of permeable glacial outwash sand and gravel (Weeks, et al. 1965). Impermeable crystalline rock underlies the glacial deposits with a sandstone ridge impeding movement of groundwater from the basin via underflow.

Direct surface runoff is minor, and flooding is uncommon due to relatively rapid infiltration in the sandy soils, however, high discharge rates have occurred when heavy precipitation fell on frozen subsoil or near saturated soil (Braatz 1974; Scullin 1977). Stream temperature is moderated by groundwater input, which normally contributes 90 to 95% of the total streamflow (Weeks, et al. 1965). Groundwater is used extensively for agricultural irrigation within the Little Plover River watershed. In 1965, Weeks (et al.) estimated that extensive irrigation might reduce streamflow by 7%.

My study area was a 1.6 kilometer section of the stream near its headwaters, between Kennedy and Eisenhower roads in Sections 13 and 24 of T23N, R8E (Figure 1). Four study zones were established; a 1210 m Meadow Zone; a downstream adjacent 372 m Upper Brushy Zone; a further downstream adjacent 724 m Treatment Zone which had its dense woody streamside vegetation removed in spring 1973, which created a meadow

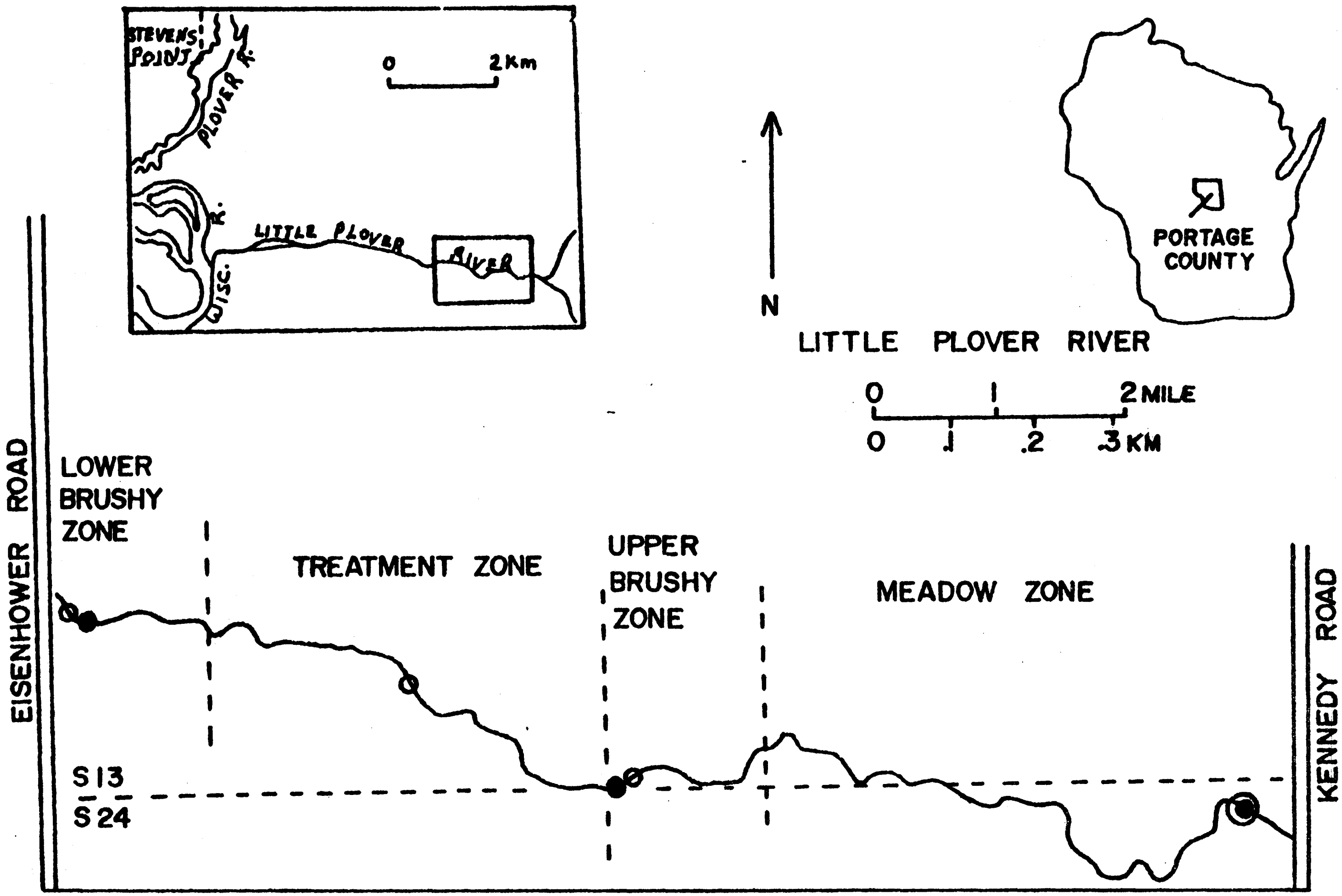


FIGURE 1. The Little Plover River, Portage County, Wisconsin, with study zones, 1976-77 drift stations (○), 1972 drift stations (●), and location relative to Stevens Point, Wisconsin.

habitat; and a still further downstream adjacent 367 m Lower Brushy Zone. Only 3 study zones were established in the pretreatment drift and benthos studies; a Meadow and an Upper Brushy Zone which were the same in my study, and a Lower Brushy Zone (Braatz 1974; or Brushy Treatment Zone, Scullin 1977), which included both the Treatment and Lower Brushy Zones in my study.

The drift sampling station in the Meadow Zone was in the same location as in the pretreatment study, 90 m downstream from Kennedy Road (Figure 1). The stream channel averaged 4.3 m wide, 16.0 cm deep, and in 1973 the bottom consisted of 59.5% sand, 20.3% detritus, and 7.2% gravel (Table 1). Aquatic vegetation, primarily Veronica spp. and Ranunculus spp., was most abundant in this zone covering up to 20% of the bottom during July. The Meadow was a horse pasture until about 6 years before the beginning of the brush removal project in 1970. As a result grasses, mostly reed canary (Phalaris arundinaceae), are now the predominate streambank vegetation. The grasses stabilized the banks, hang over the water, and result in ideal undercut bank habitat. Trees and shrubs were only a minor part of the streamside vegetation in 1971, but since then have grown and begun to form a canopy in some places. Upstream from the Meadow Zone, the stream is bordered by a cow pasture. Two drainage ditches flow into the stream at the upper boundary of the Meadow Zone. The stream in the cow pasture is wide and shallow, the banks are trampled and unstable, and detritus is the major bottom type. Fertility and detritus input to the Meadow Zone from the cow pasture and drainage ditches wasn't determined but may be a factor in the increased productivity of invertebrates found in that zone compared to the other study zones.

The Upper and Lower Brushy Zones typically had unstable banks, few undercut banks, and alder (Alnus spp.) as the major streamside vegetation, whose canopy limited light penetration. The drift station in the Upper

Table 1. Physical characteristics of the study zones of the Little Plover River, based on field mapping in 1971-1973 before brush removal and in 1976-1977 after removal. Pretreatment data are from Scullin (1977). The Lower Brushy Zone before brush removal was divided into the Treatment and Lower Brushy Zones after removal.

| | Before Removal | | | After Removal | | | |
|---|---|---|---|---|---|---|---|
| ITEM | MEADOW ZONE | UPPER BRUSHY ZONE | LOWER BRUSHY ZONE | MEADOW ZONE | UPPER BRUSHY ZONE | TREATMENT ZONE | LOWER BRUSHY ZONE |
| Mid-channel length (meters) | 1210 | 372 | 1092 | 1210 | 372 | 724 | 367 |
| Average width (meters) | 4.3 | 4.1 | 4.3 | 4.3 | 4.1 | 4.3 | 4.2 |
| Average depth (centimeters) | 16.0 | 14.2 | 17.8 | 16.0 | 14.2 | 17.3 | 19.3 |
| Surface area (square meters) | 5445 | 1517 | 4691 | 5445 | 1502 | 3550 | 1569 |
| Instream vegetation (square meters) (a) (b) | 148 | 27 | 0 | 250 | 85 | 448 | 1 |
| % of zone bottom covered by vegetation | 12 | 2 | 0 | 20 | 6 | 14 | 0 |
| Substrate composition (a) (c) | | | | | | | |
| % gravel | 7.2 | 1.3 | 5.1 | - | - | - | - |
| % sand | 59.5 | 80.0 | 69.0 | - | - | - | - |
| % detritus | 20.3 | 18.7 | 25.1 | - | - | - | - |

(a) Values change seasonally.
(b) Maximal values.
(c) Estimated in June 1973.

Brushy Zone was located 16 m upstream from its lower boundary, 56 m upstream from the pretreatment station (Figure 1). The stream channel averaged 4.1 m wide, 14.2 cm deep, and in 1973 the bottom consisted of 80.0% sand, 18.7% detritus, and 1.3% gravel (Table 1). Scattered openings in the canopy occurred in this zone and aquatic vegetation covered up to 6% of the bottom. The drift station in the Lower Brushy Zone was 43 m upstream from Eisenhower Road, 7 m downstream from the pretreatment station 3. The stream channel averaged 4.2 m wide, 19.3 cm deep, there was no openings in the canopy, and aquatic vegetation never covered more than 0.1% of the bottom. In 1973 the bottom consisted of 69.0% sand, 25.1% detritus, and 5.1% gravel (Table 1).

The Treatment Zone was similar to the Brushy Zone before brush removal (Table 1). Grasses became the predominate streambank vegetation after alder, and some elm (Ulnus spp.), ash (Fraxinus spp.), and birch (Betula spp.), were removed from a 9.2 m wide area along both sides of the stream in 1973. Aquatic vegetation increased from less than 0.1% before the brush removal to a maximum of 14% of the bottom covered in July 1977. The drift station in the Treatment Zone was 445 m below its upper boundary, 405 m downstream from station 2 in the pretreatment study (Figure 1). The stream channel averaged 4.3 m wide and 17.3 cm deep (Table 1).

Annual precipitation for Stevens Point, Wisconsin, in 1976 was 54.9 cm, well below the 80.3 cm annual average, and it was 86.8 cm in 1977 (Figure 2). Mean monthly discharge in the Meadow Zone was 0.09$m^3$/s in 1976 and 0.06$m^3$/s in 1977 (Figure 2). The percent of time the average discharge in the Meadow Zone is expected to be equal to or lower than the average discharge that occurred in 1976 and 1977 is 46.0 and 15.5% respectively, based on a flow duration curve from monthly data during July 1959 through December 1977 (Figure 3). In comparison, the flow that occurred in 1972 and 1973 is expected to be equalled or lower 78.7% and 97.0% of the time respectively.

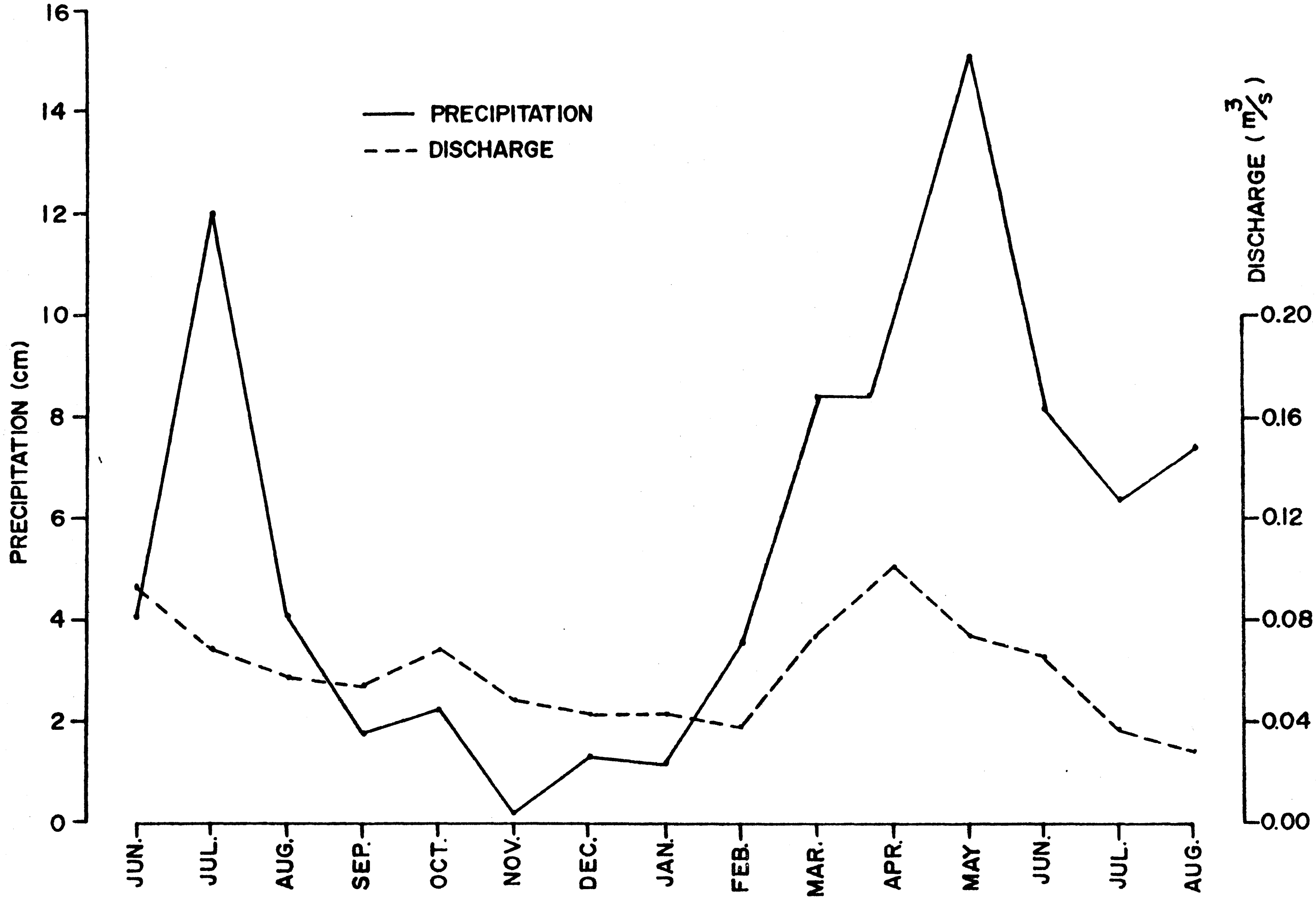


FIGURE 2. Mean monthly discharge ($m^3/s$) in the Meadow Zone and monthly mean precipitation (cm) at Stevens Point, Wisconsin, June 1976-August 1977 (U.S. Geological Survey 1976 and 1977, U. S. Dep. of Commerce 1976 and 1977).

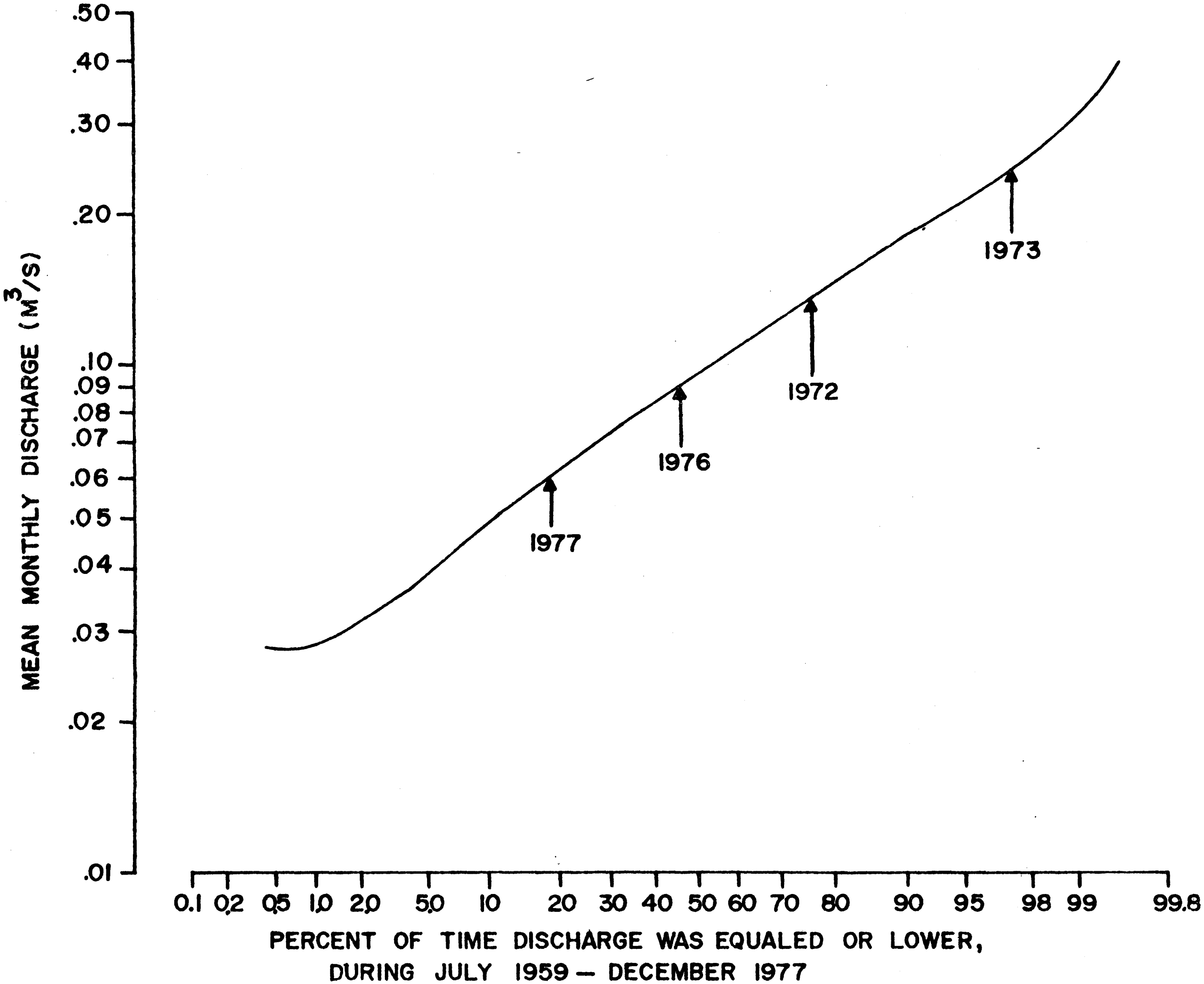


FIGURE 3. Flow duration curve for the Meadow Zone of the Little Plover River, based on monthly flow records from July 1959-December 1977 (U. S. Geological Survey).

Mean monthly air temperature was 6.1$^{o}$C in 1976 and 7.1$^{o}$C in 1977 (U. S. Dep. of Commerce 1976, 1977). Mean monthly water temperatures, recorded by Taylor thermographs calibrated 4 times a year, at the upper and lower boundary of the Treatment Zone and the lower boundary of the Lower Brushy Zone were 8.2, 8.7, and 8.6$^{o}$C in 1976 and 9.8, 9.9, and 9.5$^{o}$C in 1977 respectively (Appendix A). Increases in water temperature from increased solar radiation reaching the stream after brush removal in the Treatment Zone were insignificant (Appendix B). During my study the Treatment and Brushy Zones had complete ice cover from about the middle of December 1976 to March 1977. The ice became 61 cm thick and had a snow cover 5-15 cm thick. The Meadow Zone had a thin ice cover for about 2 weeks in January 1977.

Precipitation, discharge, and winter air temperatures were lower and summer air temperatures higher during my study than in the pretreatment studies (Appendix C). During 1971-1977, mean monthly water temperatures were highest in 1976-77 (Appendix A). In 1972, complete ice cover lasted less than 2 weeks in the Treatment and Brushy Zones, and did not occur in the Meadow Zone (Braatz 1974).

# MATERIALS AND METHODS

## Invertebrates

Drifting invertebrates were collected simultaneously in all zones during a 24-hour period once each month from June 1976 to August 1977, except in December 1976 in the Lower Brushy Zone and in January 1977 in all zones when no samples were taken because of thick ice. One drift net in each zone was set in the area of maximum discharge for a series of 6 to 12, 10-minute samples (Appendix D), 3 to 4 hours apart except for 2 samples before and 2 after sunrise and sunset when samples were taken 30 to 50 minutes apart, as in the pretreatment study (Braatz 1974). In November 1976 and in March 1977 all samples were taken 3 to 5 hours apart.

Drift nets had an opening 30.5 by 30.5 cm and were made of Nitex nylon bolting cloth with a mesh size of 760 microns. Net frames were positioned in holes drilled in wooden boards that were anchored flush to the stream bottom and perpendicular to stream flow (Braatz 1974, Waters 1962). The tops of all nets were above the water surface hence both aquatic and terrestrial drift were collected. I considered terrestrial drift to include emergent aquatic insects. The average percent of the total stream discharge sampled by a drift net in each zone was: 20.9±1.2% in the Meadow Zone, 8.6±1.4% in the Upper Brushy Zone, 19.5±1.9% in the Treatment Zone, and 21.8±7.5% in the Lower Brushy Zone.

Total stream discharge was estimated with a Parshall flume in the Lower Brushy Zone and by a Marsh McBirney electronic current meter in the other zones. If discharge in a zone was not measured, flow through the drift net was estimated using the average percent of total stream discharge sampled in each zone and the relationship between total discharge in the study zones and discharge at the Parshall flume in the Lower Brushy Zone.

Drift samples were placed in plastic bags containing 70% ethyl alcohol and 0.25 g/1 of Rose Bengal stain. The stain facilitated separation of invertebrates from detritus and did not interfere with identification (Braatz 1974, Mason and Yevich 1967). Aquatic invertebrates were identified to genus when possible and terrestrial drift was identified to order. All invertebrates were counted and biomass was determined from their calculated volume multiplied by 1.05 g/cm$^3$ (Hynes and Coleman 1968). A volumetric syringe device was used to determine volume (Myers and Peterka 1974), except for large organisms (generally 2.00 ml or more) when a 25 or 50 ml graduated cylinder was used. Organisms were soaked in distilled water at least 20 minutes, bottled dry on filter paper and placed in the measuring device which contained distilled water. No effort was made to determine volume change due to preservation in alcohol. An average volume, calculated from a large representative sample, was used to determine the volume of commonly occurring invertebrates that individually had volumes less than the 0.01 ml accuracy of the syringe. Volume of individuals smaller than 0.01 ml, that varied greatly from the representative sample or that did not occur commonly was determined by visual comparison with a 0.001 ml standard sample.

Drift density expressed as number or grams of organisms per m$^3$ of water sampled, was calculated for each 10 minute sample and multiplied by 100 to give number or grams of organisms per 100 m$^3$. Drift density is representative of the drift in the entire stream, when the percent of the total stream drift sampled is equal to the percent of the total stream discharge sampled. Results were expressed as monthly drift density which was the mean of all the 10 minute drift densities for a given month and zone.

Detritus

Detritus caught in the drift net was dried at 65°C for 3 days and weighed to the nearest 0.001 g. Results were expressed as monthly detritus density in g dry wt/100$m^3$.

Data Analysis

Number densities of total, aquatic, and terrestrial drift, number of total and aquatic taxa, and densities of drifting detritus were used in a two-within design (Lindquist 1953: 237-238) to test the hypotheses, (1) that there was no difference in drift between zones, (2) that there was no difference in drift between 1972 and 1976-77, and (3) that there was no interaction. The Upper Brushy Zone of the pretreatment study was matched to both the Upper Brushy and Treatment Zones of my study. Basis for matching are because drift samples for both studies were taken on approximately the same date and at comparable locations.

If there was significant interaction or if I wanted to determine which values were significantly greatest, the two-within design was reduced to the component randomized block designs. One randomized block design tested for a difference in drift between zones for each drift study, another tested for differences between any pair of zones in either the 1972 or 1976-77 study, and another tested differences between years for each zone. The randomized block design was also used to compare aquatic biomass, with and without molluscs, between zones in my study.

Only data from months sampled in both studies were used in comparisons between drift studies. These months included March, April, May, June, July, August, September, and October. Monthly densities during June, July, and August of 1972 were compared to values during the same months in both 1976 and 1977. Due to a flood during August 1972 (Braatz 1974), preflood number densities for August were used in the analysis between studies. Braatz (1974) did not calculate preflood values for drifting taxa and detritus, hence August was not used in the analysis between studies for taxa and detritus. For comparisons between zones in only one drift study, data from all months sampled in that study were used, except for December 1976 when the Lower Brushy Zone was not sampled.

## RESULTS AND DISCUSSION

### Differences in Drift Among Zones

Four years after brush removal, aquatic invertebrate drift in the Treatment Zone was not greater than drift in the Brushy Zones. Mean numbers and biomass of aquatic drift in the Treatment Zone (191.8/100m$^3$ and 1.30 g/100m$^3$) were not significantly different (Appendix E) from drift in the Upper Brushy (153.4/100m$^3$ and 2.12 g/100m$^3$) and Lower Brushy (145.9/100m$^3$ and 3.19 g/100m$^3$) Zones in 1976-77, (Figure 4). Mean aquatic drift numbers and biomass were significantly higher (Appendix E) in the Meadow Zone (660.3/100 and 9.45 g/100m$^3$) than in the other study zones. Total (aquatic and terrestrial numbers were highest, and terrestrial numbers of drift lowest in the Meadow Zone, but the differences were not significant (Appendix E) among zones.

Brush removal did not increase aquatic drift in the Treatment Zone from 1972 to 1976-77, however, terrestrial and total drift were greater in 1976-77. Mean numbers of aquatic invertebrate drift in the Treatment, Meadow and Upper Brushy Zones in 1976-77 were not significantly different (Appendix E) from the drift in the same zones in 1972 (Figure 5). Only in the Lower Brushy Zone were aquatic numbers significantly greater (Appendix E) in 1976-77 than in 1972. Terrestrial and total drift were significantly (Appendix E) greater in all zones in 1976-77.

Apparently more favorable environmental conditions caused an increase in abundance of terrestrial insects during my study as compared to the pretreatment study. Also the created meadow habitat in the Treatment Zone may have been more productive for terrestrial invertebrates than the pretreatment brushy habitat. Increased wind disturbance in the Treatment

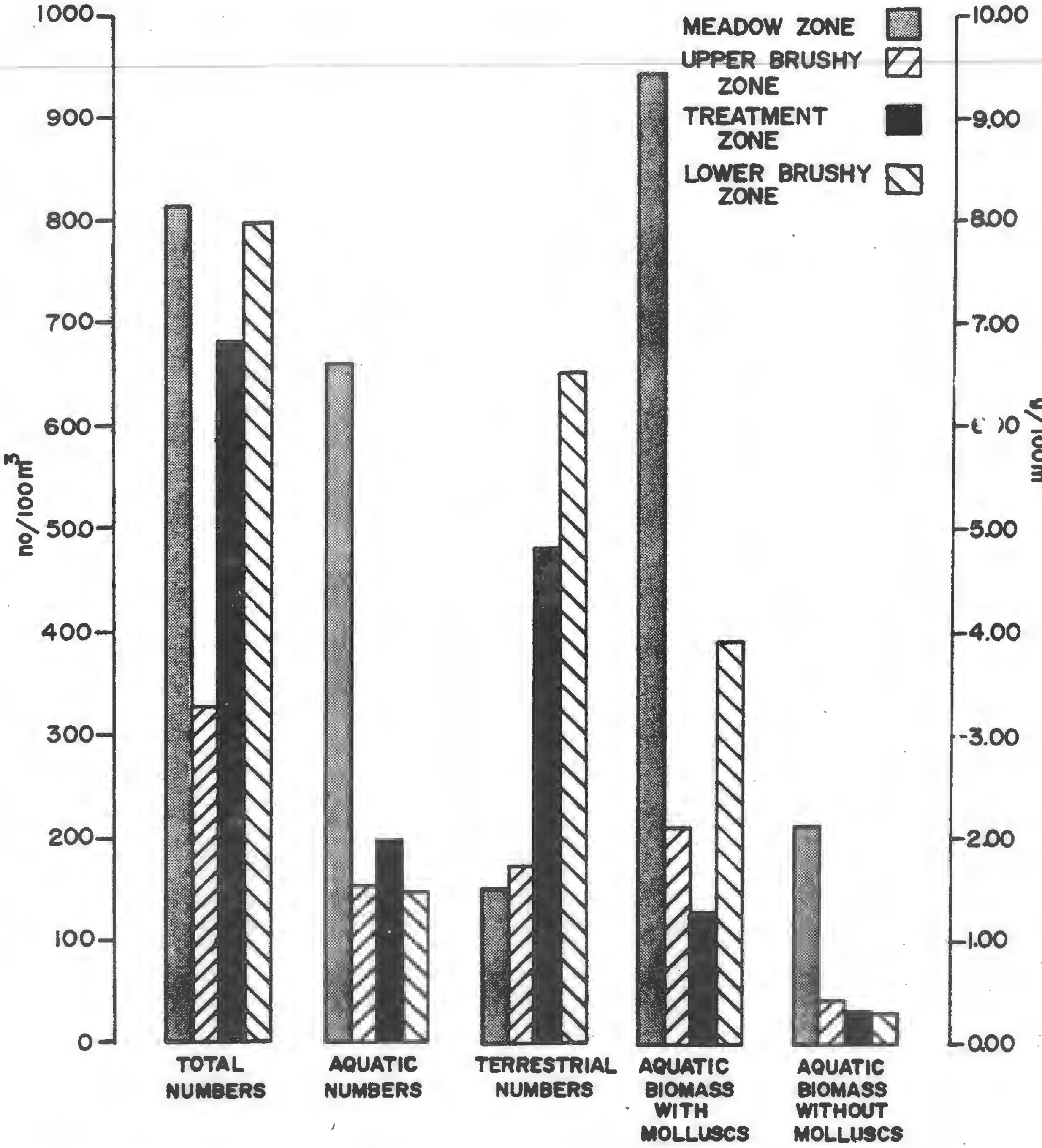


FIGURE 4. Mean monthly drift density of Total, Aquatic, and Terrestrial numbers, and Aquatic Biomass with and without molluscs, in the Little Plover River, June 1976-August 1977 (excluding December 1976 and January 1977).

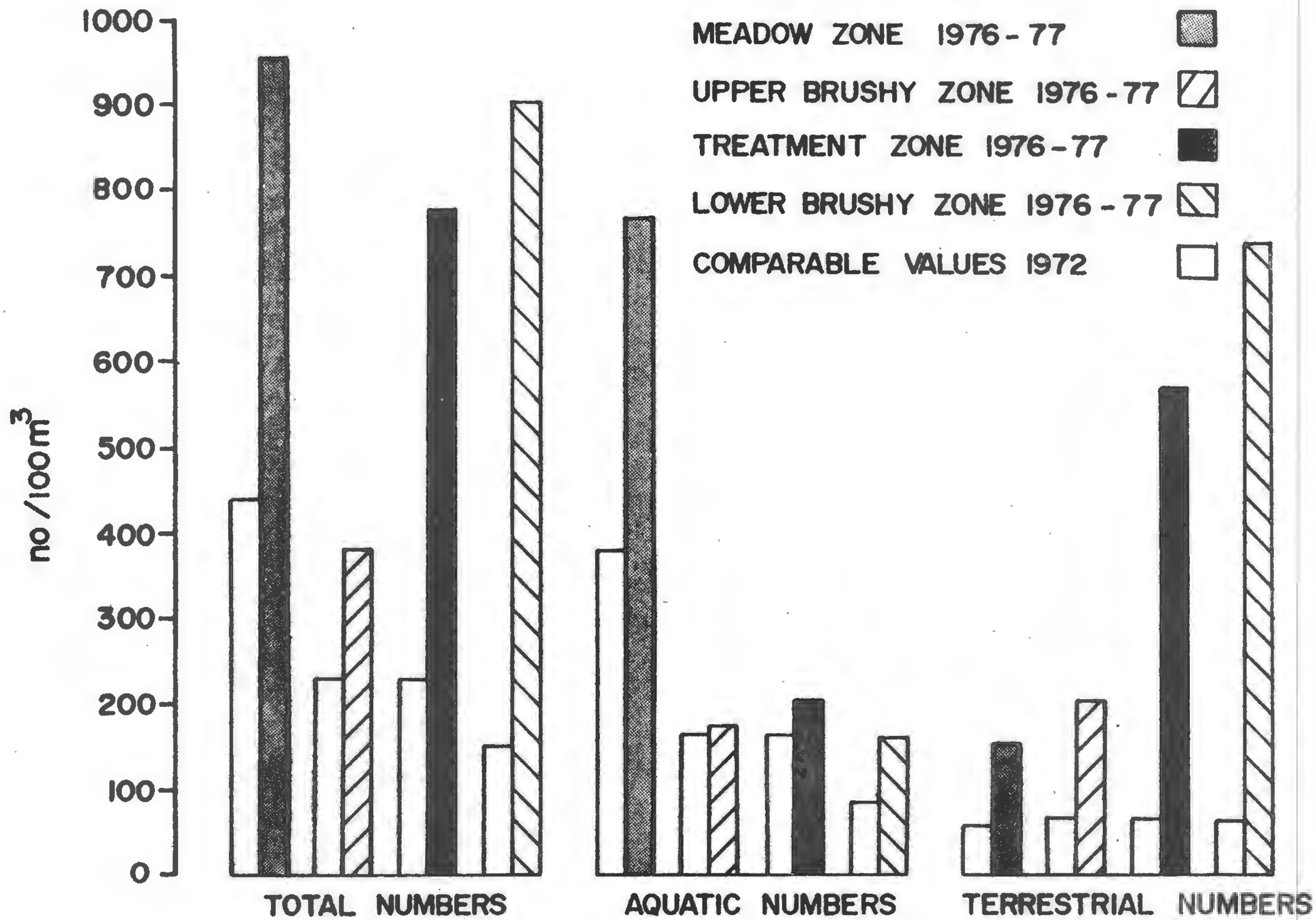


FIGURE 5. Mean monthly drift density of Total, Aquatic, and Terrestrial numbers in the Little Plover for comparable values in 1972 and 1976-77 (March-October 1972 and 1976, and June-August 1977).

Zone following brush removal may also have contributed to increased terrestrial drift.

In the Treatment Zone, benthic invertebrates should have increased and caused an increase in drift, since productive substrate (aquatic vegetation) increased following brush removal (Table 1). Braatz (1974) found the highest drift density, and Scullin (1977) the highest benthic number and biomass in the Meadow Zone in 1972-73. Schmal (1978) found benthic density to be positively correlated (r=0.400 to 0.480) with percent composition of productive substrate (i.e. aquatic vegetation, silt and detritus, and gravel), in drainage ditches and natural streams in the Buena Vista Marsh of central Wisconsin.

In the Little Plover River, record high water temperatures (for 1971-1977; Appendix A and B), low flow (Appendix C), and unusually thick ice may have limited benthic invertebrate growth, reproduction, or behavior in the Treatment Zone, in spite of an increase of productive substrate (Table 1). _Gammarus_ spp. was the most abundant organism in the drift during the pretreatment study comprising 51.4% of the total number for all zones combined (Braatz 1974), but comprised only 1.6% of the total drift for all zones combined during my study. Smith (1973) stated that while both _Gammarus lacustris_ and _G. pseudolimnaeus_ acclimated at 18°C can tolerate temperatures 21-26°C for brief periods, probably neither could maintain an "ecologically significant population at temperatures materially above 18°C." In 1976-77, mean monthly water temperatures during July exceeded 18°C (Appendix A), and maximum water temperatures in the Treatment Zone during June through July ranged from 24.2 to 30.3°C (Appendix B). In 1972, mean monthly water temperatures were always below 15.5°C (Appendix A). Maciolek and Needham (1952) found that as frazil and surface ice break up they scour the stream bottom washing loose bottom fauna and sediments. Hunt (unpublished data) found that variations in flow in the study zones caused larger fluctuations in standing stocks of brook trout than did the influence of brush removal.

In the Buena Vista Marsh, however, aquatic vegetation (productive substrate) indirectly had a negative effect on invertebrate drift (Schmal 1978). Invertebrate drift was positively correlated with drifting seston (detritus) and drifting seston was negatively correlated with percent composition of productive substrate, but drift was not significantly correlated (positive or negative) with productive substrate. During the summer, aquatic vegetation in the ditches covered up to 90% of the stream bottom and apparently "strained" drifting seston and invertebrates out of the stream column (Schmal 1978). Aquatic vegetation in the Treatment Zone may also have "strained out" the drift after brush removal, although aquatic vegetation covered only 14% of the bottom during the summer, and Schmal (1978) did not determine if benthic production exceeded the carrying capacity of the vegetation substrate.

Higher numbers and biomass of drifting and benthic invertebrates in the Meadow Zone probably are related to the higher levels of detritus and larger areas of productive substrate (aquatic vegetation and gravel) in that zone compared to the other study zones (Scullin 1977). Allochthonous detritus is now accepted as the most significant energy source for most stream ecosystems (Hynes 1963, Cummins et al. 1966, Minshall 1967, Kaushik and Hynes 1968, Hynes 1970, Fisher and Likens 1973, Sedell et al. 1973, Cummins 1974, McDowell and Fisher 1976, Melchiorri-Santolini and Hopton 1972). Greater abundance of benthos, drifting invertebrates, and drifting detritus in the Meadow Zone, and greater area of productive substrate in the Treatment Zone after brush removal indicates that as the Treatment Zone continues to develop as a meadow habitat, invertebrate drift should increase.

Brush removal may have increased drifting detritus in the Treatment Zone. In 1976-77, drifting detritus in the Treatment Zone was significantly higher (Appendix E) than in the Lower Brushy Zone (Figure 6), however, there was no difference (Appendix E) in detritus between the Meadow, Upper Brushy, and Treatment Zones. There was no significant difference (Appendix E) in drifting detritus between 1972 and 1976-77 (Figure 6). The Meadow Zone in the pretreatment had significantly higher (Appendix E) levels of drifting detritus than the Upper and Lower Brushy Zones. Variation in seasonal input of detritus between the 4 study zones (Figure 9) is probably the reason why there is no significant difference in drifting detritus in the Meadow, Upper Brushy, and Treatment Zones in 1976-77 even though the mean monthly density in the Meadow and Upper Brushy Zone was 1.9 and 1.4 times greater than detritus in the Treatment Zone (Figure 6). In 1973, the organic matter of detritus substrate was highest in the Meadow Zone (37%), and similar in the Upper (28%) and Lower (27%) Brushy Zones (Scullin 1977). The amount of detritus in the Meadow Zone that originated from cattle activity upstream is unknown but may be significant.

## Seasonal Patterns

### Aquatic Drift

Seasonal patterns of aquatic drift were not affected by brush removal since maximum and minimum drift in the Treatment Zone usually occurred at the same time as drift in the Upper or Lower Brushy Zones (Figure 7 and 8). Maximum numbers in 1970 and 1977, and minimum numbers during the study were:

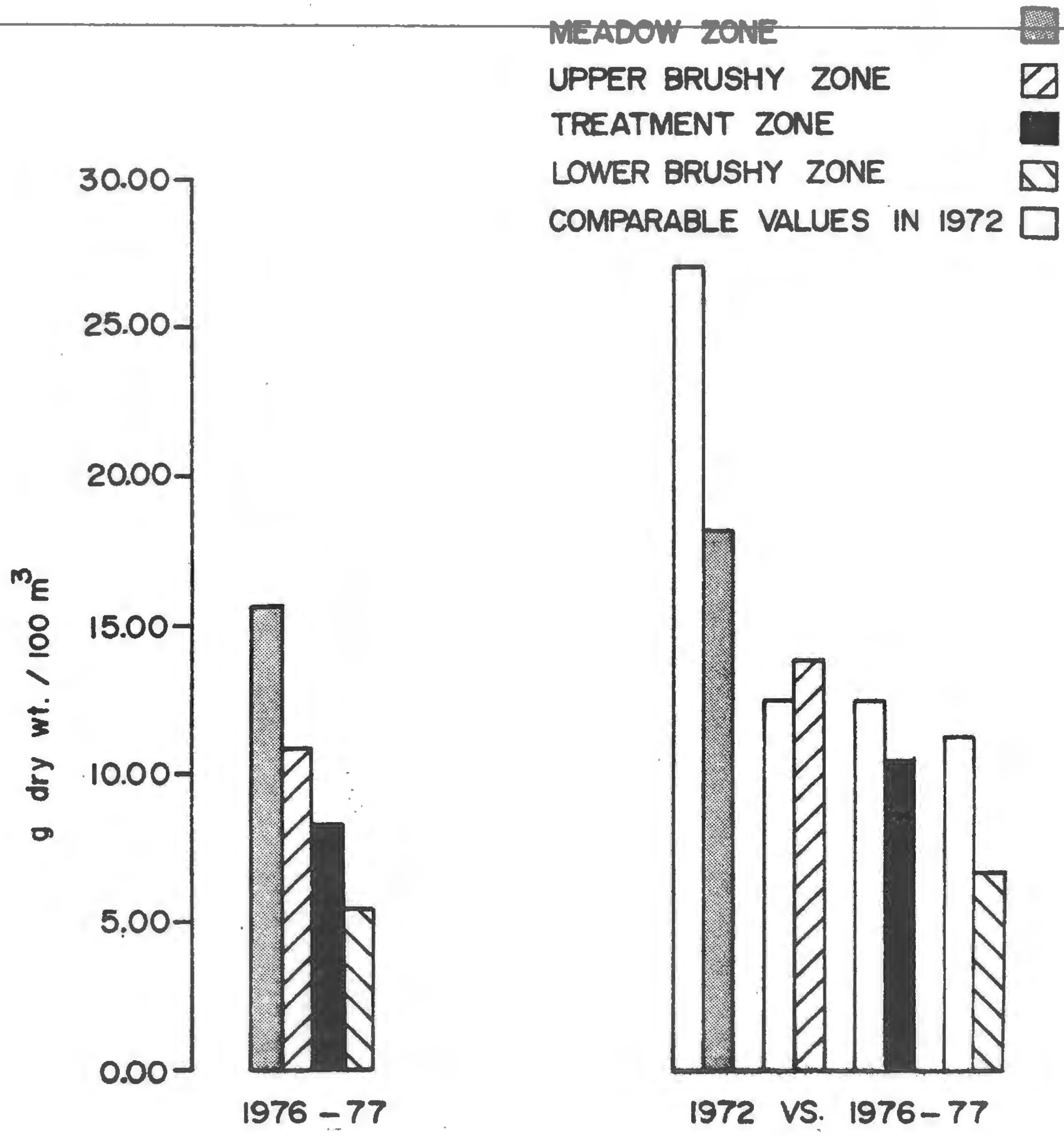


FIGURE 6. Mean monthly density of drifting detritus in the Little Plover River, June 1976-August 1977 (excluding December 1976 and January 1977), and for comparable values in 1972 and 1976-77 (March-October 1972 and 1976, and June-August 1977).

| Meadow Zone | Upper Brushy Zone |
|---|---|
| 2112.2/100m$^3$, July 1976 | 143.8/100m$^3$, June 1976 |
| 697.7/100m$^3$, June 1977 | 545.9/100m$^3$, June 1977 |
| 14.4/100m$^3$, February 1977 | 16.6/100m$^3$, February 1977 |
| **Treatment Zone** | **Lower Brushy Zone** |
| 247.5/100m$^3$, June 1976 | 243.4/100m$^3$, August 1976 |
| 925.6/100m$^3$, May 1977 | 309.7/100m$^3$, May 1977 |
| 21.6/100m$^3$, February 1977 | 40.8/100m$^3$, February 1977 |

Snails, primarily Lymnaea but also Physa and Planorbidae, accounted for 80.4% of the aquatic biomass for all zones combined, consequently, maximum aquatic biomass occurred when snails were present and minimum biomass occurred when they were absent (Figure 8). Maximum biomass in 1976 and 1977 and minimum biomass during this study were:

| Meadow Zone | Upper Brushy Zone |
|---|---|
| 21.34 g/100m$^3$, June 1976 | 3.78 g/100m$^3$, June 1976 |
| 48.93 g/100m$^3$, June 1977 | 11.59 g/100m$^3$, June 1977 |
| 0.11 g/100m$^3$, February 1977 | 0.05 g/100m$^3$, February 1977 |
| **Treatment Zone** | **Lower Brushy Zone** |
| 3.74 g/100m$^3$, June 1976 | 6.71 g/100m$^3$, June 1976 |
| 4.14 g/100m$^3$, June 1977 | 19.08 g/100m$^3$, July 1977 |
| 0.10 g/100m$^3$, August 1977 | 0.02 g/100m$^3$, September 1976 |

Excluding snails, aquatic biomass in all zones was generally highest from May through June.

## Terrestrial Drift

Seasonal patterns of terrestrial drift among zones were also not affected by brush removal (Figure 7 and Table 5). Maximum numbers of terrestrial drift during 1976 and 1977 were:

| Meadow Zone | Upper Brushy Zone |
|---|---|
| 957.3/100m$^3$, July 1976 | 398.6/100m$^3$, July 1976 |
| 248.1/100m$^3$, May 1977 | 1197.9/100m$^3$, May 1977 |
| **Treatment Zone** | **Lower Brushy Zone** |
| 2230.8/100m$^3$, August 1976 | 3893.8/100m$^3$, August 1976 |
| 2014.0/100m$^3$, May 1977 | 1895.5/100m$^3$, May 1977 |

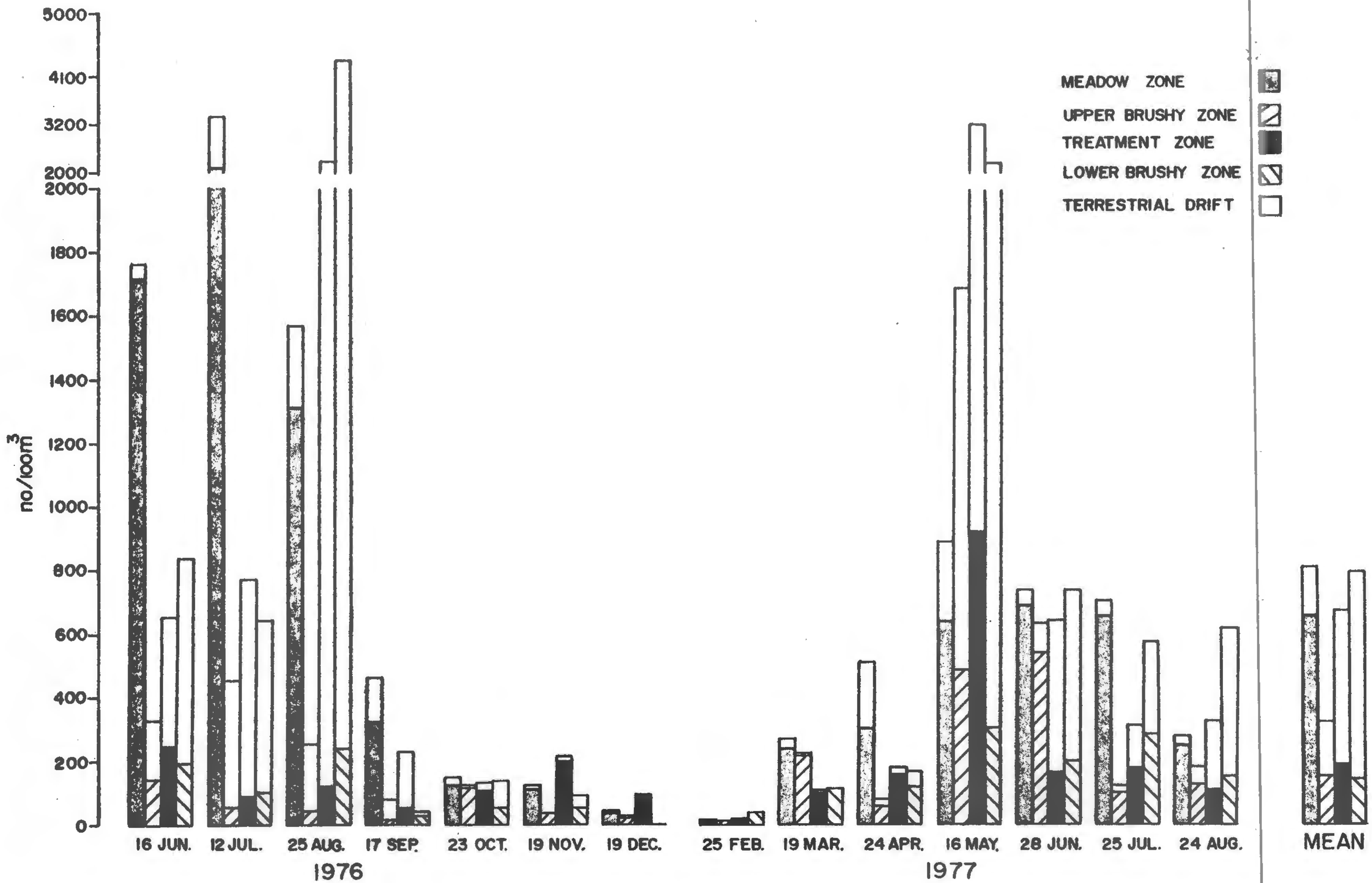


FIGURE 7. Monthly number density and mean monthly number density for invertebrate drift in the Little Plover River, June 1976-August 1977 (excluding December 1976 and January 1977). Lower portion of the bar is Aquatic drift.

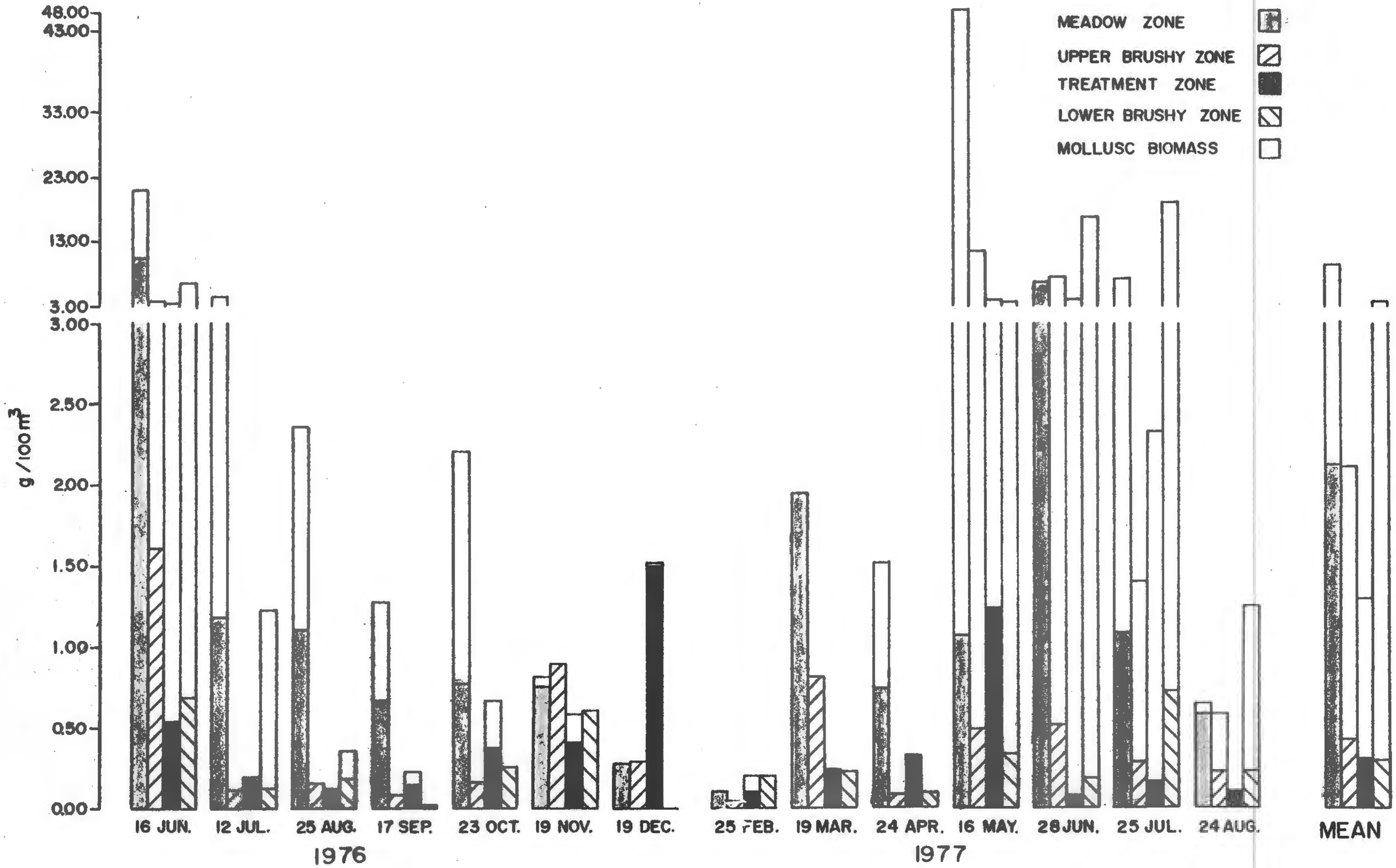


FIGURE 8. Monthly biomass density and mean monthly biomass density for invertebrate drift in the Little Plover River, June 1976-August 1977 (excluding December 1976 and January 1977). Lower portion of the bar is Aquatic biomass excluding molluscs.

Maximum terrestrial biomass drift in all zones except the Meadow Zone occurred at the same time as the maximum number drift:

| Meadow Zone | Upper Brushy Zone |
|---|---|
| 0.94 $g/100m^3$, September 1976 | 0.18 $g/100m^3$, June 1976 |
| 0.19 $g/100m^3$, June 1977 | 0.59 $g/100m^3$, May 1977 |
| **Treatment Zone** | **Lower Brushy Zone** |
| 0.39 $g/100m^3$, August 1976 | 0.84 $g/100m^3$, August 1976 |
| 0.61 $g/100m^3$, May 1977 | 0.41 $g/100m^3$, May 1977 |

Terrestrial drift always occurred in the Meadow Zone, but did not occur during November 1976 and February 1977 in the Upper Brushy Zone, during December 1976 and February 1977 in the Treatment Zone, and during February 1977 in the Lower Brushy Zone.

## Detritus Drift

Seasonal input of detritus is usually influenced most by leaf fall, but may also be influenced by wind and rainfall (Vannote 1969). A large autumn surge in detritus input was not apparent in the drift of the Little Plover River in 1976-77 (Figure 9) or in the 1972 study (Braatz 1974). Braatz (1974) found that maximum drifting detritus in all zones occurred during unusually high discharge rates in August caused by heavy rainfall. In the Meadow Zone, grasses may be a greater and more constant source of detritus than leaves, since grass roots and old stalks hang into the water year round. Maximum densities of drifting detritus in 1976 and 1977 and minimum densities in the study were:

Meadow Zone

30.6 g dry wt/$100m^3$, June 1976
34.1 g dry wt/$100m^3$, June 1977
4.1 g dry wt/$100m^3$, December 1976

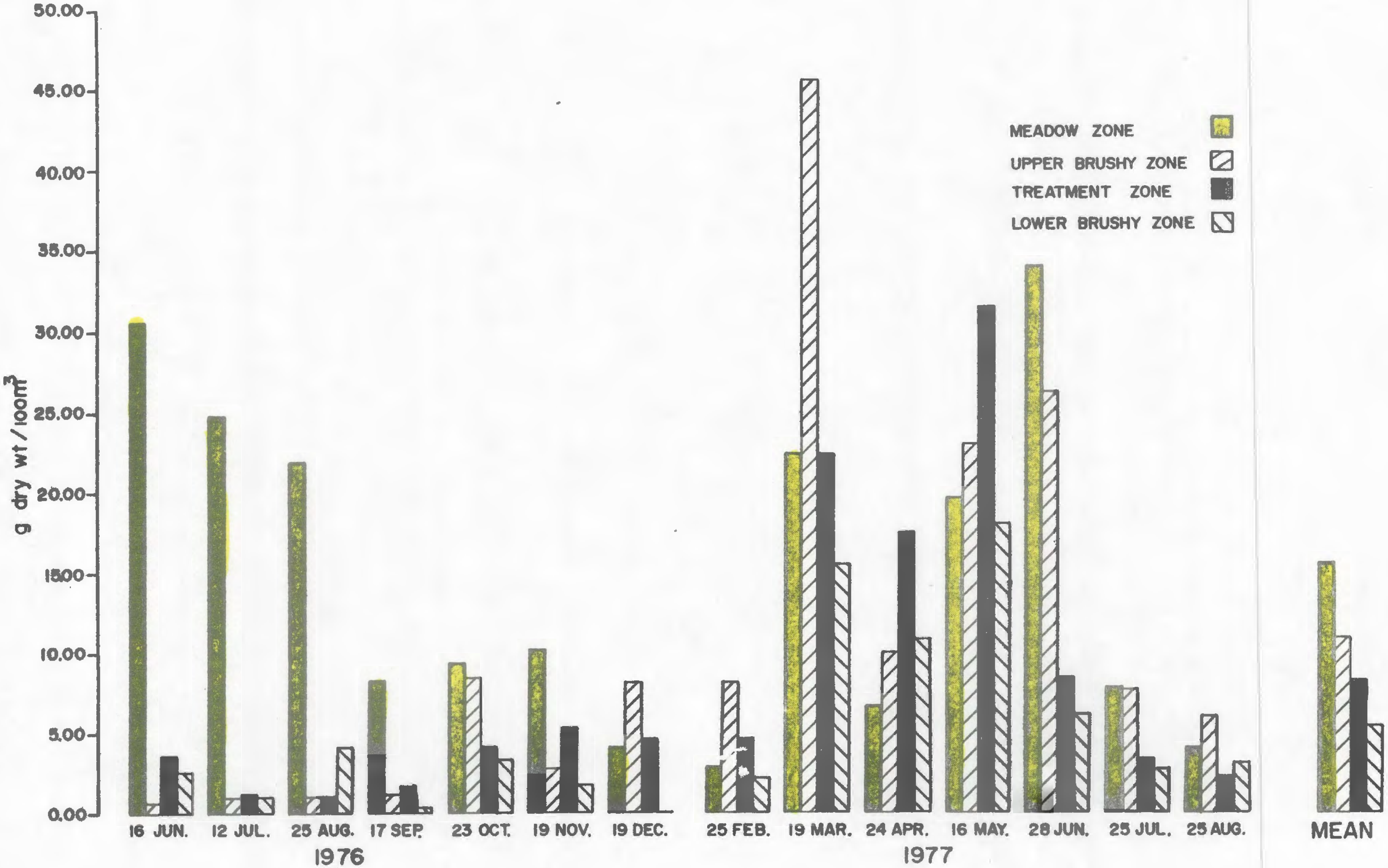


FIGURE 9. Monthly density and mean monthly density of drifting detr[illegible]us in the Little Plover River, June 1976-August 1977 (excluding December 1976 and January 1977).

Upper Brushy Zone

8.5 g dry wt/100m$^3$, October 1976
45.8 g dry wt/100m$^3$, March 1977
0.8 g dry wt/100m$^3$, June 1976

Treatment Zone

5.4 g dry wt/100m$^3$, November 1976
31.6 g dry wt/100m$^3$, May 1977
1.1 g dry wt/100m$^3$, August 1976

Lower Brushy Zone

4.1 g dry wt/100m$^3$, August 1976
18.1 g dry wt/100m$^3$, May 1977
0.4 g dry wt/100m$^3$, September 1976

## Composition and Relative Abundance

Brush removal may have increased drifting taxa in the Treatment Zone. In 1976-77 the mean number of total and aquatic drift taxa in the Treatment Zone (29 and 22) were significantly (Appendix E) greater than in the Upper Brushy Zone (19 and 13), similar to the Lower Brushy Zone (30 and 20), and less than in the Meadow Zone (37 and 29)(Figure 10). Increased taxa in the Lower Brushy Zone may be a result of the drift from the Treatment Zone. The highest number of aquatic taxa during the study occurred in July 1976 in the Meadow (45), May 1977 in the Upper Brushy Zone (22), and in May 1977 in both the Treatment Zone (42) and Lower Brushy Zone (30). The lowest number of taxa occurred in February 1977 in the Meadow (12), Upper Brushy (5), and Treatment (14) Zones, and in September 1976 in the Lower Brushy Zone (11). All zones except the Upper Brushy Zone had significantly greater numbers of total and aquatic drift taxa in 1976-77 than in 1972 (Figure 10, Appendix E).

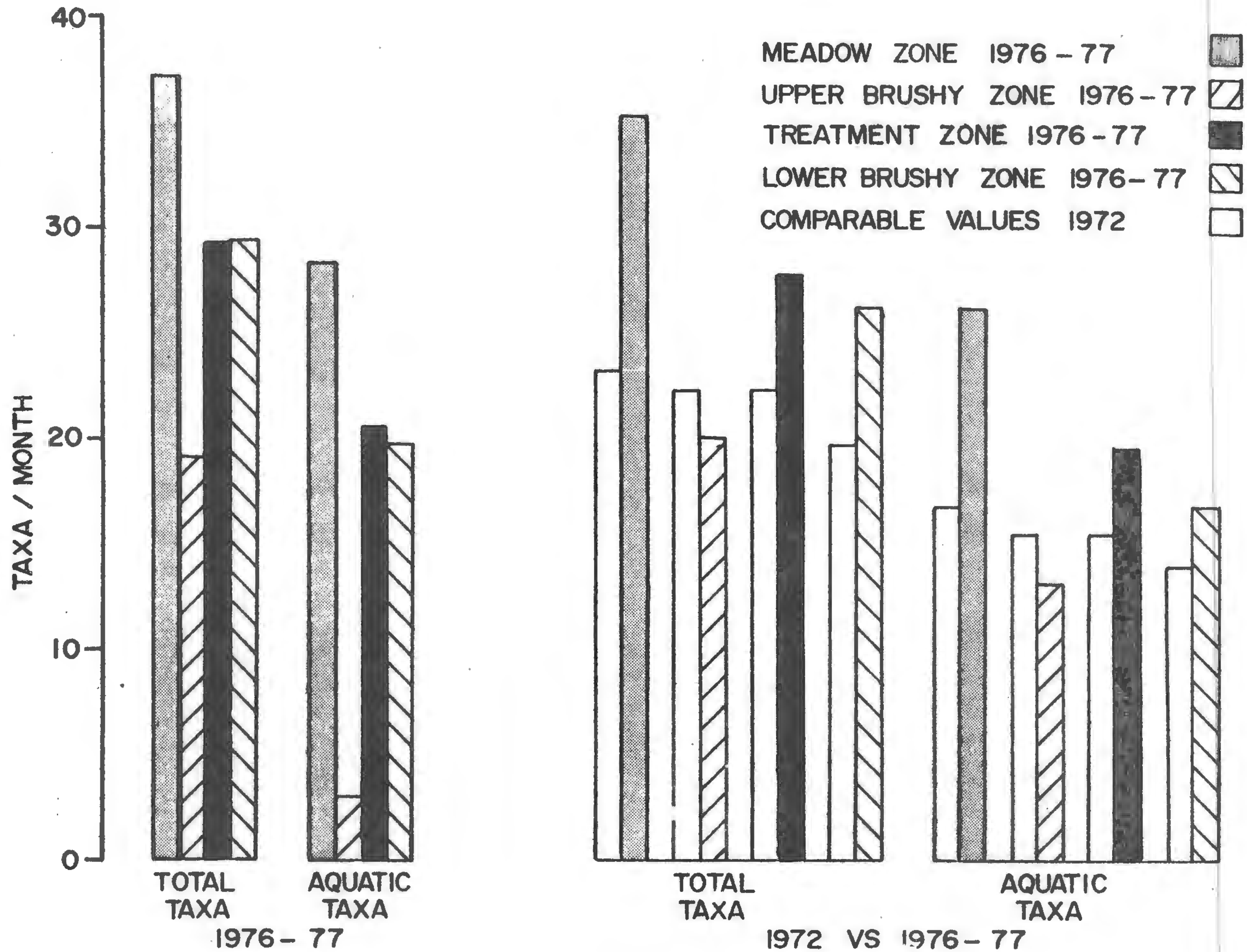


FIGURE 10. Mean monthly number of Total and Aquatic taxa in the Little Plover River, June 1976-August 1977 (excluding December 1976 and January 1977), and for comparable values in 1972 and 1976-77 (March-October 1972 and 1976, and June-August 1977).

Aquatic Drift

Drifting aquatic invertebrates were more abundant in the Meadow Zone than in the other zones during my study. Aquatic invertebrates made up 81.2% of total number drift in the Meadow Zone, 47.3% in the Upper Brushy Zone, 29.1% in the Treatment Zone, and 18.3% in the Lower Brushy Zone (Table 2). Aquatic biomass comprised 98.1, 94.4 90.3, and 94.0% of the total biomass drift in the Meadow, Upper Brushy, Treatment, and Lower Brushy Zones respectively (Table 3). In 1972, aquatic numbers comprised 90% of the total drift in the Meadow Zone, 78% in the Upper Brushy Zone, and 65% in the Lower Brushy Zone (Braatz 1974). During 1976-77, taxa comprising 1.0% or more of the aquatic numbers for all zones combined were Chironomidae, 25.6%; Oligochaeta, 11.1%; Corixidae, 10.9%; Lymnaea spp., 8.7%; Hydra spp., 8.4%; Diptera pupae, 6.8%; Brachycentrus spp., 4.6%; Baetis spp., 4.2%; Gammarus, 3.7%; unidentified Trichoptera, 2.5%; Simuliidae, 2.2%; Dytiscidae, 1.6%; and Hydropsychidae, 1.3% (Table 2). Taxa making up 1.0% or more of the aquatic biomass for all zones combined were Lymnaea, 80.0%; Corixidae, 6.4%; Lethocerus spp., 2.8%; Limnephilidae, 1.6%; Gammarus, 1.3%; Brachycentrus, 1.2%; and Dytiscidae, 1.0% (Table 3). The remaining aquatic drift was made up of 84 additional taxa (Appendix F).

Brush removal had no effect on aquatic drift composition since composition of aquatic drift during 1976-77 was similar in the Treatment and Brushy Zones. Aquatic drift composition in the Meadow Zone was different than in the other zones. Oligochaeta, Corixidae, Hydra, and Gammarus were more important in the Meadow Zone whereas Chironomidae, Diptera pupae, Brachycentrus, and Baetis were more important in the other zones. Aquatic drift composition also changed substantially from 1972 to 1976-77 in all zones. Generally Brachycentrus, Chironomidae, Oligochaeta,

Table 2. Percentages of taxa equal or exceeding 1.0% of the Aquatic number density for all zones combined, and percentages of the Total number density comprised by total Aquatic drift in the Little Plover River, June 1976-August 1977 (excluding December 1976 and January 1977).

| | Chironomidae | Oligochaeta | Corixidae | *Lymnaea* | *Hydra* | Diptera Pupae | *Brachycentrus* | *Baetis* | *Gammarus* | Unidentified Trichoptera | Simuliidae | Dytiscidae | Hydropsychidae | Aquatic Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MEADOW ZONE | 17.3 | 18.8 | 16.8 | 8.7 | 18.8 | 2.1 | 2.1 | 2.1 | 6.1 | 1.2 | 2.6 | 1.1 | 1.6 | 81.2 |
| UPPER BRUSHY ZONE | 41.6 | 0.6 | 3.7 | 5.3 | 0.6 | 7.5 | 13.8 | 5.4 | 1.2 | 5.6 | 1.3 | 1.6 | 0.4 | 47.3 |
| TREATMENT ZONE | 42.1 | 1.5 | 1.8 | 6.0 | 1.5 | 16.0 | 6.5 | 6.9 | 0.3 | 2.9 | 1.4 | 1.7 | 0.6 | 29.1 |
| LOWER BRUSHY ZONE | 24.3 | 0.8 | 4.2 | 15.5 | 0.8 | 14.6 | 3.5 | 8.5 | 0.2 | 4.7 | 2.1 | 4.7 | 2.1 | 18.3 |
| ALL ZONES COMBINED | 25.6 | 11.1 | 10.9 | 8.7 | 8.4 | 6.8 | 4.6 | 4.2 | 3.7 | 2.5 | 2.2 | 1.6 | 1.3 | 44.3 |

Table 3. Percentages of taxa equal or exceeding 1.0% of the Aquatic biomass density for all zones combined, and percentages of the Total biomass density comprised by total Aquatic drift in the Little Plover River, June 1976-August 1977 (excluding December 1976 and January 1977).

| | *Lymnaea* | Corixidae | *Lethocerus* | Limnephilidae | *Gammarus* | *Brachycentrus* | Dytiscidae | Aquatic Total |
|---|---|---|---|---|---|---|---|---|
| MEADOW ZONE | 77.0 | 9.2 | 5.0 | 1.2 | 2.2 | 0.6 | 0.2 | 98.1 |
| UPPER BRUSHY ZONE | 78.6 | 5.8 | 0.0 | 4.6 | 0.3 | 3.9 | 1.0 | 94.4 |
| TREATMENT ZONE | 69.4 | 2.3 | 0.0 | 2.5 | 0.2 | 4.3 | 6.3 | 90.3 |
| LOWER BRUSHY ZONE | 92.0 | 1.4 | 0.0 | 0.3 | 0.0 | 0.4 | 1.0 | 94.0 |
| ALL ZONES COMBINED | 80.0 | 6.4 | 2.8 | 1.6 | 1.3 | 1.2 | 1.0 | 96.0 |

Corixidae, and *Lymnaea* increased in importance and *Gammarus*, *Lepidostoma* spp., and Copepods decreased from 1972 to 1976-77.

The high water temperatures (Appendix A and B) probably had the greatest affect on composition of the aquatic invertebrate communities by directly or indirectly affecting normal growth, reproduction, and behavior of the invertebrates and altering algae and periphyton communities which constitute potential food for the invertebrates. Other factors that may have influenced aquatic drift composition were, (1) low stream flow caused by low rainfall (Appendix C), (2) low fish predation caused by a record low (for 1970-1977) brook trout population (Hunt, unpublished data), and (3) extremely thick ice for such a small stream. Although changes in substrate composition were not measured, many studies have shown the importance of substrate composition on invertebrate numbers and composition (Tarzwell 1937, Smith and Moyle 1944, Pennak and Van Gerpen 1947, Sprules 1947, Eriksen 1966, Thorup 1966, Sanders 1976, Schmal 1978). Deposition of sediments from low stream flow and scouring of the bottom from ice could affect substrate composition.

Chironomidae during 1976-77 were more abundant in the Meadow and Treatment Zone than the Brushy Zones (Table 4), and more abundant in my study than in the pretreatment study. Mean monthly numbers for comparable data in 1972 and 1976-77 were: in 1976-77, 121.7, 84.5, 89.4, and 42.4/100m$^3$ in the Meadow, Upper Brushy, Treatment, and Lower Brushy Zones respectively; in 1972, 54.0, 23.3, and 19.0/100m$^3$ in the Meadow, Upper Brushy, and Lower Brushy Zones respectively. In 1976-77, Chironomidae comprised 17.3% of the aquatic numbers in the Meadow Zone, 41.6% in the Upper Brushy Zone, 42.1% in the Treatment Zone, and 24.3% in the Lower Brushy Zone (Table 2). Biomass of Chironomidae was insignificant, never exceeding 0.4% (0.03 g/100m$^3$) of the aquatic total in any zone (Table 3). During the pretreatment studies

Chironomidae made up 11, 10, and 26% of the drift numbers (Braatz 1974) and 15, 18, and 26% of the benthic numbers (Scullin 1977), in the Meadow, Upper Brushy, and Lower Brushy Zones respectively. If low stream flow in 1976-77 resulted in greater deposition of sand and silt in the study zones, organisms associated with sand and silt might have increased. The most abundant organism in sand substrates in drainage ditches and natural streams in a central Wisconsin marsh were Chironomidae (Sanders 1976, Schmal 1978). Since I did not measure changes in substrate composition, I do not know if sand and silt increased sufficiently to account for the increase in Chironomidae.

During 1976-77, Oligochaeta were abundant only in the Meadow Zone (Table 4), and comprised 18.8, 0.6, 1.5, and 0.8% of the aquatic numbers in the Meadow, Upper Brushy, Treatment and Lower Brushy Zones respectively (Table 2). Oligochaeta did not exceed 1% of the aquatic biomass in any zone (Table 3). Oligochaeta were less abundant in 1972, when they comprised less than 1.0% of the aquatic numbers for all zones combined (Braatz 1974).

Corixidae were most abundant in the Meadow Zone than in the other zones during my study (Table 4 and 5). After July 1976, Corixidae were never an important component of the drift (Table 4 and 5). Corixidae comprised 16.8, 0.6, 1.5, and 0.8% of the aquatic numbers and 9.2, 5.8, 2.3, and 1.4% of the aquatic biomass in the Meadow, Upper Brushy, Treatment, and Lower Brushy Zones respectively (Table 2 and 3). Corixidae were less than 1% of the drift in the pretreatment study (Braatz 1974).

*Lymnaea* was more abundant in the Meadow and Lower Brushy Zones than in the other zones (Table 4 and 5). *Lymnaea* comprised 8.8% of the aquatic

TABLE 4. Monthly number densities (no/100m$^3$) of taxa equal or exceeding 1.0% of the Aquatic or Terrestrial drift for all zones combined; and monthly densities for Aquatic drift, Terrestrial drift, and Total drift in the Meadow (M), Upper Brushy (UB), Treatment (T), and Lower Brushy (LB) Zones of the Little Plover River, June 1976-August 1977 (excluding January 1977).

| | Zone | 16 Jun. 1976 | 12 Jul. 1976 | 25 Aug. 1976 | 17 Sep. 1976 | 23 Oct. 1976 | 19 Nov. 1976 | 19 Dec. 1976 | 25 Feb. 1977 | 19 Mar. 1977 | 24 Apr. 1977 | 16 May 1977 | 28 Jun. 1977 | 25 Jul. 1977 | 24 Aug. 1977 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AQUATIC DRIFT | | | | | | | | | | | | | | | |
| Amphipoda | M | 19.9 | 24.8 | 23.2 | 13.2 | 8.7 | 46.0 | 8.3 | 4.6 | 16.1 | 19.5 | 42.1 | 59.6 | 157.7 | 78.9 |
| Gammarus | UB | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 11.2 | 3.1 | 9.9 | 0.0 |
| | T | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.7 | 6.1 | 0.0 | 1.2 | 0.0 |
| | LB | 1.8 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | (1) | 0.0 | 0.0 | 0.0 | 0.9 | 0.0 | 0.0 | 0.0 |
| Coelenterata | M | 17.9 | 12.5 | 563.0 | 190.5 | 9.8 | 0.0 | 0.9 | 0.0 | 0.0 | 4.5 | 49.7 | 169.6 | 119.5 | 69.7 |
| Hydra | UB | 0.0 | 0.0 | 0.0 | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7.1 | 4.3 | 1.6 | 1.5 |
| | T | 0.0 | 0.7 | 2.2 | 3.7 | 3.3 | 7.7 | 2.3 | 2.6 | 0.0 | 0.0 | 7.6 | 0.0 | 3.6 | 6.1 |
| | LB | 0.0 | 0.0 | 0.0 | 0.0 | 5.7 | 3.2 | (1) | 0.0 | 0.0 | 1.1 | 2.8 | 0.0 | 0.0 | 1.9 |
| Coleoptera | M | 8.0 | 18.3 | 1.8 | 4.7 | 7.6 | 6.1 | 3.7 | 2.3 | 11.7 | 0.0 | 10.5 | 8.8 | 1.5 | 0.0 |
| Dytiscidae | UB | 3.9 | 2.2 | 0.0 | 0.0 | 1.2 | 0.0 | 5.9 | 3.0 | 10.2 | 0.0 | 1.4 | 1.6 | 1.6 | 0.0 |
| | T | 1.9 | 2.7 | 0.0 | 0.0 | 1.2 | 2.6 | 12.1 | 1.8 | 21.8 | 0.7 | 2.2 | 1.0 | 0.0 | 0.0 |
| | LB | 3.6 | 3.3 | 11.8 | 0.0 | 2.4 | 15.9 | (1) | 10.2 | 27.1 | 1.1 | 5.6 | 5.6 | 3.3 | 2.0 |
| Diptera | M | 100.9 | 282.1 | 340.8 | 53.1 | 29.5 | 27.6 | 7.4 | 0.8 | 60.5 | 89.5 | 168.7 | 243.5 | 67.8 | 16.4 |
| Chironomidae | UB | 16.3 | 12.3 | 1.4 | 2.6 | 91.6 | 22.8 | 10.6 | 6.0 | 73.5 | 21.5 | 202.2 | 318.5 | 21.8 | 40.0 |
| | T | 67.9 | 11.6 | 25.3 | 16.4 | 73.1 | 156.8 | 60.4 | 3.0 | 34.5 | 102.4 | 378.6 | 42.7 | 77.1 | 39.6 |
| | LB | 26.1 | 24.7 | 11.8 | 11.0 | 16.4 | 17.4 | (1) | 7.9 | 33.0 | 76.0 | 85.3 | 69.5 | 36.9 | 44.7 |
| Diptera | M | 27.9 | 64.6 | 13.0 | 0.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 90.7 | 10.4 | 6.0 | 11.4 | 2.1 |
| Simuliidae | UB | 5.2 | 0.0 | 1.4 | 1.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.7 | 9.1 | 1.7 | 1.3 |
| | T | 13.5 | 0.7 | 3.7 | 0.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.7 | 3.7 | 4.7 | 1.2 | 3.1 |
| | LB | 17.9 | 3.3 | 3.9 | 1.0 | 0.0 | 0.0 | (1) | 0.0 | 0.0 | 4.3 | 2.8 | 1.8 | 3.3 | 1.9 |
| Diptera | M | 7.2 | 46.3 | 25.9 | 11.4 | 0.6 | 0.0 | 0.9 | 0.0 | 2.7 | 45.0 | 28.5 | 8.6 | 2.9 | 1.9 |
| Unidentified Pupae | UB | 1.3 | 2.3 | 1.4 | 0.0 | 6.0 | 0.0 | 0.0 | 0.0 | 1.8 | 0.0 | 121.9 | 16.2 | 0.0 | 0.0 |
| | T | 18.3 | 5.5 | 40.9 | 0.7 | 1.1 | 0.0 | 0.0 | 1.8 | 0.9 | 2.1 | 323.6 | 10.4 | 2.5 | 7.0 |
| | LB | 4.5 | 0.0 | 118.8 | 1.4 | 0.0 | 0.0 | (1) | 0.0 | 0.0 | 6.4 | 112.4 | 10.0 | 17.4 | 6.0 |
| Ephemeroptera | M | 27.8 | 4.1 | 64.8 | 14.6 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 5.2 | 5.9 | 4.9 | 33.3 | 19.1 |
| Baetis | UB | 6.9 | 13.6 | 13.6 | 4.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 | 60.8 | 3.0 | 1.7 | 4.5 |
| | T | 37.6 | 9.5 | 16.4 | 3.8 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 86.9 | 9.5 | 7.1 | 7.2 |
| | LB | 24.4 | 32.5 | 19.6 | 1.9 | 2.5 | 3.2 | (1) | 0.0 | 0.0 | 1.1 | 44.5 | 12.1 | 16.6 | 3.1 |
| Gastropoda | M | 55.4 | 169.6 | 56.5 | 21.0 | 13.3 | 4.6 | 0.0 | 0.0 | 0.0 | 2.9 | 204.5 | 81.2 | 128.6 | 18.3 |
| Lymnaea | UB | 5.1 | 5.7 | 1.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 | 0.0 | 32.6 | 50.6 | 5.1 | 4.3 |
| | T | 11.4 | 20.7 | 0.7 | 3.4 | 2.7 | 3.8 | 0.0 | 0.9 | 0.8 | 0.0 | 9.1 | 49.5 | 45.2 | 7.7 |
| | LB | 11.7 | 4.5 | 2.9 | 0.0 | 0.0 | 0.0 | (1) | 0.0 | 0.0 | 0.0 | 12.0 | 70.7 | 178.2 | 14.3 |

TABLE 4. Continued

| | Zone | 16 Jun. 1976 | 12 Jul. 1976 | 25 Aug. 1976 | 17 Sep. 1976 | 23 Oct. 1976 | 19 Nov. 1976 | 19 Dec. 1976 | 25 Feb. 1977 | 19 Mar. 1977 | 24 Apr. 1977 | 16 May 1977 | 28 Jun. 1977 | 25 Jul. 1977 | 24 Aug. 1977 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hemiptera Corixidae | M | 1139.6 | 232.2 | 13.0 | 5.4 | 8.7 | 1.5 | 2.8 | 0.0 | 1.0 | 1.5 | 3.8 | 8.7 | 14.7 | 14.1 |
| | UB | 10.0 | 0.7 | 0.1 | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.2 | 1.6 | 0.0 | 0.0 |
| | T | 31.7 | 2.7 | 0.7 | 0.7 | 1.6 | 2.6 | 0.8 | 0.0 | 0.9 | 0.7 | 0.8 | 0.0 | 2.3 | 0.0 |
| | LB | 54.8 | 2.2 | 0.0 | 0.0 | 4.9 | 3.2 | (1) | 2.4 | 5.1 | 1.1 | 0.9 | 1.0 | 2.3 | 1.1 |
| Oligochaeta | M | 256.4 | 1137.9 | 105.6 | 6.9 | 4.6 | 0.0 | 0.0 | 0.0 | 0.0 | 2.2 | 47.3 | 41.9 | 9.9 | 5.9 |
| | UB | 1.3 | 1.1 | 0.0 | 0.0 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | 1.5 | 0.0 | 4.5 | 0.0 | 3.0 |
| | T | 10.9 | 5.4 | 1.5 | 0.7 | 0.0 | 2.6 | 0.0 | 1.8 | 0.0 | 1.4 | 8.4 | 2.8 | 0.0 | 2.3 |
| | LB | 1.8 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | (1) | 0.8 | 0.0 | 0.0 | 4.7 | 4.5 | 1.1 | 1.0 |
| Trichoptera Brachycentrus | M | 22.0 | 5.2 | 34.3 | 8.5 | 16.8 | 6.1 | 2.8 | 0.8 | 38.7 | 0.0 | 0.8 | 7.1 | 32.7 | 7.7 |
| | UB | 34.9 | 7.8 | 10.9 | 5.9 | 8.3 | 4.6 | 2.4 | 6.0 | 26.3 | 1.5 | 1.4 | 100.7 | 49.9 | 17.9 |
| | T | 41.2 | 21.6 | 6.7 | 10.4 | 10.9 | 7.7 | 6.0 | 1.8 | 5.1 | 2.8 | 0.7 | 29.4 | 17.6 | 6.1 |
| | LB | 27.9 | 2.3 | 1.0 | 8.5 | 4.1 | 1.6 | (1) | 0.0 | 2.6 | 1.1 | 0.9 | 6.4 | 4.5 | 5.2 |
| Trichoptera Hydropsychidae | M | 0.9 | 14.5 | 25.9 | 7.3 | 5.8 | 4.6 | 2.8 | 1.5 | 63.8 | 1.5 | 0.7 | 1.3 | 1.5 | 3.8 |
| | UB | 0.0 | 0.0 | 0.0 | 1.3 | 1.2 | 0.0 | 0.0 | 0.0 | 1.7 | 0.0 | 1.4 | 0.0 | 0.0 | 3.0 |
| | T | 0.0 | 0.0 | 0.0 | 2.3 | 2.3 | 0.0 | 0.8 | 0.0 | 0.9 | 0.0 | 2.3 | 0.0 | 2.4 | 4.0 |
| | LB | 0.0 | 2.2 | 3.0 | 1.9 | 4.1 | 1.6 | (1) | 5.5 | 2.5 | 2.1 | 0.9 | 0.0 | 5.5 | 11.9 |
| Trichoptera Unidentified | M | 1.6 | 17.4 | 4.6 | 7.6 | 2.9 | 3.1 | 0.0 | 0.0 | 9.0 | 0.0 | 6.7 | 7.2 | 38.2 | 7.8 |
| | UB | 0.0 | 0.0 | 2.7 | 0.0 | 0.0 | 2.3 | 1.2 | 0.0 | 36.9 | 18.4 | 9.9 | 0.0 | 5.1 | 37.0 |
| | T | 1.3 | 0.0 | 7.4 | 0.0 | 0.0 | 2.6 | 0.0 | 0.0 | 23.8 | 15.7 | 9.5 | 0.0 | 4.8 | 9.2 |
| | LB | 0.9 | 0.0 | 25.5 | 1.9 | 6.5 | 0.0 | (1) | 0.8 | 6.3 | 7.5 | 8.4 | 0.0 | 1.1 | 30.6 |
| Aquatic Total | M | 1717.0 | 2112.2 | 1316.8 | 375.4 | 127.3 | 115.0 | 40.5 | 14.4 | 240.0 | 307.1 | 645.8 | 697.7 | 659.6 | 255.6 |
| | UB | 143.8 | 56.2 | 47.7 | 17.7 | 120.2 | 38.8 | 27.1 | 16.6 | 221.5 | 59.8 | 490.8 | 545.9 | 105.1 | 130.4 |
| | T | 247.5 | 91.2 | 122.7 | 53.1 | 107.5 | 201.4 | 96.7 | 21.6 | 102.1 | 160.9 | 925.6 | 168.8 | 180.1 | 111.4 |
| | LB | 193.6 | 103.8 | 243.4 | 33.1 | 54.8 | 55.4 | (1) | 40.9 | 94.6 | 121.0 | 309.7 | 203.9 | 289.6 | 153.2 |
| TERRESTRIAL DRIFT | | | | | | | | | | | | | | | |
| Adult Diptera | M | 14.4 | 107.8 | 79.6 | 34.1 | 12.2 | 1.5 | 0.9 | 0.8 | 10.3 | 53.0 | 209.8 | 20.7 | 17.5 | 15.6 |
| | UB | 140.3 | 295.6 | 145.9 | 38.0 | 2.4 | 0.0 | 1.2 | 0.0 | 1.7 | 7.7 | 1086.8 | 69.3 | 8.4 | 44.5 |
| | T | 347.9 | 621.3 | 1960.9 | 118.5 | 19.1 | 7.7 | 0.0 | 0.0 | 2.6 | 7.1 | 1912.6 | 419.1 | 88.2 | 184.8 |
| | LB | 515.7 | 431.1 | 3374.6 | 5.7 | 49.9 | 15.8 | (1) | 0.0 | 6.4 | 30.0 | 1804.6 | 455.3 | 174.5 | 393.4 |
| Homoptera | M | 11.8 | 797.8 | 157.4 | 41.2 | 4.6 | 1.5 | 0.9 | 0.8 | 17.7 | 133.2 | 15.9 | 6.0 | 20.1 | 3.8 |
| | UB | 29.7 | 72.5 | 39.5 | 19.8 | 0.0 | 0.0 | 1.2 | 0.0 | 1.9 | 1.5 | 43.7 | 1.5 | 5.2 | 1.5 |
| | T | 24.8 | 35.8 | 116.0 | 44.4 | 7.1 | 2.6 | 0.0 | 0.0 | 2.7 | 4.9 | 32.0 | 27.8 | 12.1 | 10.6 |
| | LB | 45.5 | 47.4 | 308.2 | 3.7 | 27.0 | 9.5 | (1) | 0.0 | 8.9 | 3.2 | 38.2 | 29.9 | 28.5 | 31.9 |

TABLE 4 Continued

| | Zone | 16 Jun. 1976 | 12 Jul. 1976 | 25 Aug. 1976 | 17 Sep. 1976 | 23 Oct. 1976 | 19 Nov. 1976 | 19 Dec. 1976 | 25 Feb. 1977 | 19 Mar. 1977 | 24 Apr. 1977 | 16 May 1977 | 28 Jun. 1977 | 25 Jul. 1977 | 24 Aug. 1977 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hymenoptera | M | 6.6 | 17.6 | 3.7 | 15.2 | 1.7 | 0.0 | 0.0 | 0.0 | 1.9 | 2.2 | 9.8 | 4.8 | 4.4 | 2.8 |
| | UB | 1.3 | 13.4 | 8.2 | 5.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.6 | 25.4 | 6.1 | 1.6 | 4.5 |
| | T | 1.9 | 11.5 | 13.4 | 10.1 | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 | 5.6 | 15.7 | 8.3 | 14.5 | 9.1 |
| | LB | 17.0 | 26.0 | 65.8 | 0.0 | 0.0 | 1.6 | (1) | 0.0 | 1.3 | 8.6 | 15.6 | 17.2 | 44.5 | 11.7 |
| Terrestrial Total | M | 46.5 | 957.3 | 255.6 | 93.5 | 23.2 | 6.1 | 3.7 | 3.0 | 32.6 | 208.4 | 248.1 | 44.8 | 52.0 | 28.1 |
| | UB | 185.6 | 398.3 | 205.9 | 67.6 | 6.0 | 0.0 | 2.4 | 0.0 | 3.5 | 23.2 | 1197.9 | 91.5 | 20.1 | 55.0 |
| | T | 407.6 | 685.6 | 2108.1 | 178.1 | 29.5 | 17.8 | 0.0 | 0.0 | 10.4 | 23.3 | 2014.0 | 477.4 | 137.3 | 218.3 |
| | LB | 646.5 | 542.6 | 3893.8 | 10.4 | 83.4 | 38.0 | (1) | 0.0 | 22.9 | 49.2 | 1895.5 | 538.4 | 291.0 | 468.7 |
| TOTAL DRIFT | M | 1763.4 | 3069.5 | 1572.4 | 468.9 | 150.5 | 121.1 | 44.2 | 17.4 | 272.6 | 515.5 | 893.9 | 742.5 | 711.6 | 283.7 |
| | UB | 329.4 | 454.6 | 253.6 | 85.3 | 126.1 | 38.8 | 29.5 | 16.6 | 225.1 | 83.0 | 1688.6 | 637.4 | 125.2 | 185.4 |
| | T | 655.1 | 776.8 | 2230.8 | 231.2 | 136.9 | 219.2 | 96.7 | 21.6 | 112.5 | 184.2 | 2939.6 | 646.2 | 317.4 | 329.7 |
| | LB | 840.1 | 646.4 | 4137.2 | 43.5 | 138.3 | 93.4 | (1) | 40.9 | 117.6 | 170.2 | 2205.2 | 742.3 | 580.5 | 621.9 |

(1) no sample taken.

TABLE 5. Monthly biomass density (g/100m$^3$) of taxa equal or exceeding 1.0% of the Aquatic drift for all zones combined; and monthly densities for Aquatic drift, Terrestrial drift, and Total drift in the Meadow (M), Upper Brushy (UB), Treatment (T), and Lower Brushy (LB) Zones of the Little Plover River, June 1976-August 1977 (excluding January 1977).

| | Zone | 16 Jun. 1976 | 12 Jul. 1976 | 25 Aug. 1976 | 17 Sep. 1976 | 23 Oct. 1976 | 19 Nov. 1976 | 19 Dec. 1976 | 25 Feb. 1977 | 19 Mar. 1977 | 24 Apr. 1977 | 16 May 1977 | 28 Jun. 1977 | 25 Jul. 1977 | 24 Aug. 1977 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AQUATIC DRIFT | | | | | | | | | | | | | | | |
| Amphipoda | M | 0.06 | 0.05 | 0.05 | 0.17 | 0.09 | 0.50 | 0.17 | 0.07 | 0.29 | 0.01 | 0.05 | 0.22 | 0.61 | 0.38 |
| Gammarus | UB | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.05 | 0.00 |
| | T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.01 | 0.00 |
| | LB | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | (1) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Coleoptera | M | 0.07 | 0.09 | 0.00 | 0.01 | 0.07 | 0.03 | 0.00 | 0.00 | 0.01 | 0.00 | 0.04 | 0.03 | 0.01 | 0.00 |
| Dytiscidae | UB | 0.03 | 0.01 | 0.00 | 0.00 | 0.03 | 0.00 | 0.07 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 |
| | T | 0.01 | 0.01 | 0.00 | 0.00 | 0.01 | 0.03 | 1.01 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | LB | 0.02 | 0.00 | 0.01 | 0.00 | 0.03 | 0.27 | (1) | 0.04 | 0.03 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 |
| Gastropoda | M | 10.47 | 3.52 | 1.24 | 0.61 | 1.43 | 0.06 | 0.00 | 0.00 | 0.00 | 0.77 | 57.76 | 22.66 | 6.18 | 0.06 |
| Lymnaea | UB | 2.15 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.11 | 7.19 | 1.11 | 0.36 |
| | T | 3.20 | 0.01 | 0.00 | 0.08 | 0.22 | 0.16 | 0.00 | 0.10 | 0.00 | 0.00 | 2.81 | 4.06 | 2.17 | 0.00 |
| | LB | 6.02 | 1.10 | 0.15 | 0.00 | 0.00 | 0.00 | (1) | 0.00 | 0.00 | 0.00 | 3.43 | 16.77 | 18.21 | 1.02 |
| Hemiptera | M | 10.05 | 0.71 | 0.06 | 0.07 | 0.09 | 0.02 | 0.02 | 0.00 | 0.01 | 0.02 | 0.02 | 0.07 | 0.15 | 0.11 |
| Corixidae | UB | 1.47 | 0.03 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.02 | 0.00 | 0.00 |
| | T | 0.28 | 0.03 | 0.00 | 0.01 | 0.02 | 0.03 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.02 | 0.00 |
| | LB | 0.48 | 0.01 | 0.00 | 0.00 | 0.07 | 0.03 | (1) | 0.03 | 0.05 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 |
| Hemiptera | M | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.21 | 0.00 | 0.00 |
| Lethocerus | UB | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | LB | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | (1) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Trichoptera | M | 0.29 | 0.01 | 0.03 | 0.15 | 0.32 | 0.01 | 0.00 | 0.00 | 0.07 | 0.10 | 0.53 | 0.13 | 0.00 | 0.00 |
| Limnephilidae | UB | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 | 0.35 | 0.17 | 0.00 | 0.18 | 0.02 | 0.08 | 0.33 | 0.00 | 0.07 |
| | T | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.07 | 0.01 | 0.05 | 0.00 | 0.20 | 0.04 | 0.00 | 0.00 | 0.01 |
| | LB | 0.00 | 0.01 | 0.01 | 0.00 | 0.07 | 0.00 | (1) | 0.04 | 0.00 | 0.01 | 0.00 | 0.00 | 0.06 | 0.01 |
| Tricoptera | M | 0.04 | 0.02 | 0.03 | 0.06 | 0.11 | 0.03 | 0.02 | 0.00 | 0.27 | 0.00 | 0.02 | 0.04 | 0.03 | 0.02 |
| Brachycentrus | UB | 0.06 | 0.04 | 0.03 | 0.06 | 0.05 | 0.04 | 0.02 | 0.04 | 0.32 | 0.02 | 0.02 | 0.08 | 0.20 | 0.12 |
| | T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 |
| | LB | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | (1) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| Aquatic Total | M | 21.34 | 4.71 | 2.37 | 1.28 | 2.21 | 0.82 | 0.28 | 0.11 | 1.95 | 1.53 | 48.93 | 29.55 | 7.39 | 0.65 |
| | UB | 3.78 | 0.12 | 0.16 | 0.08 | 0.17 | 0.90 | 0.29 | 0.05 | 0.82 | 0.09 | 11.59 | 7.85 | 1.40 | 0.59 |
| | T | 3.74 | 0.19 | 0.12 | 0.23 | 0.67 | 0.59 | 1.51 | 0.20 | 0.24 | 0.33 | 4.07 | 4.14 | 2.33 | 0.11 |
| | LB | 6.72 | 1.22 | 0.36 | 0.02 | 0.26 | 0.61 | (1) | 0.20 | 0.23 | 0.10 | 3.77 | 16.96 | 19.07 | 1.25 |

TABLE 5. Continued

| | Zone | 16 Jun. 1976 | 12 Jul. 1976 | 25 Aug. 1976 | 17 Sep. 1976 | 23 Oct. 1976 | 19 Nov. 1976 | 19 Dec. 1976 | 25 Feb. 1977 | 19 Mar. 1977 | 24 Apr. 1977 | 16 May 1977 | 28 Jun. 1977 | 25 Jul. 1977 | 24 Aug. 1977 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TERRESTRIAL DRIFT | | | | | | | | | | | | | | | |
| Terrestrial Total | M | 0.09 | 0.55 | 0.20 | 0.94 | 0.02 | (2) | (2) | (2) | 0.03 | 0.03 | 0.16 | 0.19 | 0.16 | 0.01 |
| | UB | 0.13 | 0.18 | 0.08 | 0.08 | 0.01 | 0.00 | (2) | 0.00 | (2) | 0.02 | 0.59 | 0.27 | 0.29 | 0.01 |
| | T | 0.23 | 0.21 | 0.39 | 0.04 | 0.01 | 0.01 | 0.00 | 0.00 | 0.01 | 0.01 | 0.61 | 0.24 | 0.15 | 0.08 |
| | LB | 0.54 | 0.44 | 0.84 | (2) | 0.04 | 0.03 | (1) | 0.00 | 0.03 | 0.02 | 0.41 | 0.32 | 0.33 | 0.24 |
| TOTAL DRIFT | M | 21.43 | 5.26 | 2.56 | 2.21 | 2.23 | 0.82 | 0.28 | 0.12 | 1.99 | 1.55 | 49.09 | 29.74 | 7.56 | 0.66 |
| | UB | 3.91 | 0.30 | 0.25 | 0.17 | 0.19 | 0.90 | 0.29 | 0.05 | 0.82 | 0.11 | 12.18 | 8.12 | 1.69 | 0.61 |
| | T | 3.96 | 0.40 | 0.51 | 0.26 | 0.68 | 0.60 | 1.51 | 0.20 | 0.25 | 0.33 | 4.68 | 4.38 | 2.48 | 0.19 |
| | LB | 7.25 | 1.66 | 1.20 | 0.02 | 0.30 | 0.63 | (1) | 0.20 | 0.26 | 0.12 | 4.18 | 17.28 | 19.40 | 1.49 |

(1) no sample taken.
(2) wt less than 0.01 g.

numbers in the Meadow Zone, 5.3% in the Upper Brushy Zone, 6.0% in the Treatment Zone, and 15.5% in the Lower Brushy Zone (Table 2). It was the dominant organism in terms of biomass comprising 77.0, 78.6, 69.4, and 92.0% of the aquatic drift in the Meadow, Upper Brushy, Treatment, and Lower Brushy Zones respectively (Table 3). In the pretreatment studies Gastropods comprised only 0.8% of the aquatic numbers for all zones combined (Braatz 1974), and 2, 0, and 1% of the benthic numbers (Scullin 1977) in the Meadow, Upper Brushy, and Lower Brushy Zones respectively.

The increased abundance of Lymnaea may have been caused by better growth and food (periphyton) conditions as a result of the increase in water temperature. Vaughn (1944) found the optimum temperature for hatching of eggs and growth of young L. stagnalis to be 20°C, similar to the mean monthly temperatures in July 1977 (Appendix A). Changes in water temperatures can cause changes in periphyton composition, with green algae replacing diatoms as temperatures approach 25°C (Cairns 1970). Lymnaea stagnalis is generally a herbivore and obtains its food by feeding on rooted submerged vegetation, raking small food particles from the surface film while gliding upside down under it, and scraping material from rocks and other such surfaces (McDonald 1969). During my study I commonly observed snails floating upside down at the surface film, apparently feeding. If the increase in water temperature substantially increased the amount of food available at the surface film, the drift of Lymnaea may have been amplified by this feeding behavior which leaves the snail vulnerable to drift in a stream system.

Hydra, like Oligochaeta, were abundant only in the Meadow Zone during my study (Table 4). In 1976-77 Hydra comprised 14.0, 0.8, 1.5, and 0.8% of the aquatic numbers in the Meadow, Upper Brushy, Treatment, and Lower Brushy Zones respectively, and less than 1.0% of the aquatic biomass for all zones (Table 2 and 3). Hydra were more important in the pretreatment study comprising 12, 5 and 5% of the aquatic drift in the Meadow, Upper Brushy, and Lower Brushy Zones respectively (Braatz 1974).

Drifting Diptera pupae were more abundant in the Treatment and Lower Brushy Zones in 1976-77 (Table 4). Diptera pupae comprised 2.1, 7.5, 16.0, and 14.6% of the aquatic numbers in the Meadow, Upper Brushy, Treatment, and Lower Brushy Zones respectively, and less than 2.0% of the aquatic biomass in all zones (Table 2). Maximum Diptera pupae drift coincided with maximum adult Diptera drift in the Treatment and Lower Brushy Zones (Table 4).

Brachycentrus made up a larger percentage of aquatic numbers in the Treatment and Brushy Zones than in the Meadow Zone, as in the pretreatment studies (Braatz 1974, Scullin 1977) (Table 2). Brachycentrus comprised 13.8% of the aquatic numbers in the Upper Brushy Zone and from 2.1 to 6.5% in the other zones. Brachycentrus comprised 3.9% of the aquatic biomass in the Upper Brushy and Treatment Zones, and less than 1.0% in the other two zones. The abundance of Brachycentrus was similar in 1972 and 1976-77 (Table 4 and Braatz 1974). In the pretreatment study, Brachycentrus comprised 0, 13, and 9% of the aquatic numbers in the Meadow, Upper Brushy, and Lower Brushy Zones respectively (Braatz 1974). In the Meadow Zone during my study, Brachycentrus occurred in every month except April 1977. In the pretreatment study it occurred only in September (Braatz 1974).

Baetis also made up a larger percentage of aquatic numbers in the Treatment and Brushy Zones than in the Meadow (Table 2). The percent of aquatic numbers comprised of Baetis in 1976-77 was 8.5, 6.9, 5.4, and 2.1% in the Lower Brushy, Treatment, Upper Brushy, and Meadow Zones respectively, although monthly densities were similar between zones (Table 2 and 4). Baetis comprised 2.2% of the aquatic biomass in the Treatment Zone and less than 1.0% in the other zones (Table 3). In the pretreatment study Baetis comprised 2, 13, and 18% of the aquatic numbers in the Meadow, Upper Brushy, and Lower Brushy Zones respectively (Braatz 1974).

Gammarus was most abundant in the Meadow Zone in both studies probably because of lower water temperatures (from groundwater input) and more aquatic vegetation and detritus in that zone than in the other study zones. Gammarus was much less abundant in my study than in the pretreatment study. Mean monthly numbers of Gammarus for comparable data in 1972 and 1976-77 were: in 1976-77, 39.1, 2.7, 1.0, and 0.1/100m$^3$ in the Meadow, Upper Brushy, Treatment, and Lower Brushy Zones respectively; in 1972, 114.9, 16.1 and 2.5/100m$^3$ in the Meadow, Upper Brushy, and Lower Brushy Zones respectively. In 1976-77 Gammarus comprised 6.1% of the aquatic numbers in the Meadow Zone, 1.2% in the Upper Brushy Zone, 0.3% in the Treatment Zone, and 0.2% in the Lower Brushy Zone (Table 3). Gammarus made up 2.2, 1.2, 0.2, and less than 0.1% of the aquatic biomass in the Meadow, Upper Brushy, Treatment, and Lower Brushy Zones respectively (Table 4). In the pretreatment studies Gammarus comprised 59, 49, and 11% of the aquatic drift numbers (Braatz 1974) and 42, 30, and 20% of the benthic numbers (Scullin 1977) in the Meadow, Upper Brushy and Lower Brushy Zones respectively. The high water temperatures in 1976-77 (Appendix A and B), probably caused the decrease in abundance of Gammarus compared to 1972. Pennak and Rosine (1976) did not find Gammarus lacustris in water above 20$^{o}$C. Pentland (1930) stated that temperature, vegetation, and presence of enemies may be important factors in the distribution of *Gammarus* spp. in North America.

## Terrestrial Drift

Terrestrial insects were a major part of the total number drift but only a minor part of the total biomass drift. Terrestrial drift comprised 18.8% of the total numbers in the Meadow Zone, 52.7% in the Upper Brushy Zone, 70.9% in the Treatment Zone, 81.7% in the Lower Brushy Zone (Table 6). Terrestrial biomass was 1.9, 5.6, 9.7, and 6.0% of the total drift in the Meadow, Upper Brushy, Treatment, and Lower Brushy Zones respectively (Table 6). Terrestrial drift was much less important during the pretreatment study comprising only 10, 22, and 36% of the total number in the Meadow, Upper Brushy, and Lower Brushy Zones respectively (Braatz 1974). Taxa making up 1.0% or more of the total terrestrial drift numbers for all zones combined were adult Diptera, 80.9%; Homoptera, 12.2%; and Hymenoptera, 2.3% (Table 6). Taxa comprising 1.0% or more of the terrestrial drift biomass for all zones combined include adult Diptera, 29.1%; Coleoptera, 22.6%; Trichoptera, 9.4%; Lepidoptera, 8.3%; Homoptera, 7.1%; Hymenoptera, 5.1%; Ephemeroptera, 2.5%; Hemiptera, 2.4%; and Arachnida, 1.4% (Table 6). The remaining terrestrial drift was made up of 12 additional taxa (Appendix G).

Brush removal had no affect on terrestrial drift composition since the composition of the terrestrial drift in 1976-77 was similar in the Treatment and Brushy Zones. The composition of terrestrial drift was different in the Meadow Zone than in the other zones. Homoptera were most abundant in the Meadow Zone and adult Diptera were most abundant in the other zones.

Table 6. Percentages of taxa equal or exceeding 1.0% of the Terrestrial number or biomass density for all zones combined, and percentages of the Total drift comprised by total Terrestrial drift in the Little Plover River, June 1976-August 1977 (excluding December 1976 and January 1977).

| | NUMBERS | | | | BIOMASS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Adult Diptera | Homoptera | Hymenoptera | Terrestrial Total | Adult Diptera | Coleoptera | Trichoptera | Lepidoptera | Homoptera | Hymenoptera | Ephemeroptera | Hemiptera | Aracnida | Terrestrial Total |
| MEADOW ZONE | 28.9 | 60.5 | 3.5 | 18.8 | 6.1 | 47.9 | 11.5 | 1.6 | 12.5 | 7.5 | 1.6 | 1.3 | 1.5 | 1.9 |
| UPPER BRUSHY ZONE | 81.6 | 9.7 | 3.1 | 52.7 | 19.6 | 17.1 | 4.7 | 22.9 | 5.0 | 4.7 | 3.9 | 3.5 | 0.4 | 5.6 |
| TREATMENT ZONE | 90.2 | 5.1 | 1.5 | 70.9 | 46.6 | 12.4 | 9.1 | 10.7 | 5.0 | 2.5 | 3.5 | 2.9 | 0.8 | 9.7 |
| LOWER BRUSHY ZONE | 85.6 | 6.9 | 2.5 | 81.7 | 39.9 | 13.0 | 10.5 | 4.3 | 5.5 | 5.1 | 1.8 | 2.3 | 2.4 | 6.0 |
| ALL ZONES COMBINED | 80.9 | 12.2 | 2.3 | 55.7 | 29.1 | 22.6 | 9.4 | 8.3 | 7.1 | 5.1 | 2.5 | 2.4 | 1.4 | 4.0 |

Drifting adult Diptera in 1976-77 were more abundant in the Treatment and Lower Brushy Zones than in the Meadow and Upper Brushy Zones. Adult Diptera were also more abundant in 1976-77 than in 1972. Mean monthly numbers of drifting adult Diptera for comparable data in 1972 and 1976-77 were: in 1976-77, 53.3, 183.4, 392.9, and 385.9/$100m^3$ in the Meadow, Upper Brushy, Treatment, and Lower Brushy Zones respectively; in 1972, 38.0, 48.3, and 45.8/$100m^3$ in the Meadow, Upper Brushy, and Lower Brushy Zones respectively.

As in the pretreatment study, adult Diptera made up a higher percent of the drift in the lower zones than in the Meadow Zone. Adult Diptera comprised 28.9, 81.6, 90.2, and 85.6% of the terrestrial number and 6.1, 19.6, 46.6, and 35.1% of the terrestrial biomass in the Meadow, Upper Brushy, Treatment, and Lower Brushy Zones combined (Table 6). In 1972, adult Diptera comprised 48, 59, and 61% of the terrestrial numbers in the Meadow, Upper Brushy, and Lower Brushy Zones respectively. I believe that the majority of the drifting adult Diptera in my study, originated from aquatic Diptera in the Little Plover River, since maximum Diptera pupae drift coincided with maximum adult Diptera drift and through partial identification while sorting.

Homoptera were most abundant in the Meadow Zone and Hymenoptera were most abundant in the Lower Brushy Zone during my study (Table 4). Homoptera comprised 60.5, 9.7, 5.1, and 6.9% of the terrestrial numbers, and 12.5, 5.0, and 5.5% of the terrestrial biomass in the Meadow, Upper Brushy, Treatment, and Lower Brushy Zones respectively (Table 6). Hymenoptera made up 3.5, 3.1, 1.5, and 2.5% of the terrestrial numbers and 7.5, 4.7, 2.5, and 5.1% of the terrestrial biomass in the Meadow, Upper Brushy, Treatment, and Lower Brushy Zones respectively. In the pretreatment study, Hymenoptera comprised 12, 5, and 8% of the terrestrial numbers in the Meadow, Upper Brushy, and Lower Brushy Zones respectively (Braatz 1974).

Detritus Drift

For all zones combined, monthly aquatic invertebrate number density (y) was positively correlated with monthly detritus density (x), r=0.600 and y=0.102x + 26.552. Such correlation may be expected since the particle size of detritus caught in a 760 micron drift net is about the same size and density as the invertebrates caught. Monthly aquatic numbers were most highly correlated with detritus density in the Treatment Zone (r=0.724), followed by the Meadow Zone (r=0.696), and the Upper Brushy Zone (r-0.685), but was not correlated in the Lower Brushy Zone (r=0.398). There was no significant correlation between aquatic biomass density and detritus density. For all zones combined, Chironomidae was the only taxa that was significantly correlated with monthly detritus density (r=0.677). Braatz (1974) found a correlation r=0.824, between total number density and monthly detritus density.

## LITERATURE CITED


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APPENDIX A. Mean monthly water temperatures ($C^{o}$) at three sites on the Little Plover River, 1971-1977. Data are from the Coldwater Research Group, Wisconsin Department of Natural Resources.

| | Treatment Zone Upper Boundary | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 |
| Jan. | -- | 0.6 | 2.1 | 1.0 | 0.8 | 0.2 | -0.7 |
| Feb. | 2.5 | 2.6 | 1.7 | 0.6 | 1.9 | 3.3 | 1.4 |
| Mar. | 4.3 | 4.6 | 4.6 | 3.4 | 3.9 | 3.9 | 5.9 |
| Apr. | 8.9 | 5.3 | 6.6 | 8.5 | 7.2 | 9.1 | 10.8 |
| May | 12.7 | 11.6 | 8.4 | 10.3 | 13.1 | 11.9 | 16.4 |
| Jun. | 16.2 | 13.3 | 9.8 | 12.2 | 13.2 | 16.4 | 16.2 |
| Jul. | 15.5 | 15.3 | 11.4 | 14.9 | 16.7 | 17.1 | 19.7 |
| Aug. | 15.7 | 13.9 | 10.7 | 14.0 | 15.3 | 15.7 | 17.0 |
| Sep. | 10.8 | 11.3 | 8.6 | 10.2 | 11.3 | 11.9 | 14.2 |
| Oct. | 10.2 | 7.0 | 6.9 | 7.4 | 9.5 | 7.2 | 9.6 |
| Nov. | 4.5 | 4.4 | 1.9 | 3.4 | 7.3 | 2.2 | 5.1 |
| Dec. | 2.4 | 1.0 | 0.7 | 0.7 | 3.2 | 0.0 | 1.8 |
| Mean | 9.4 | 7.5 | 6.1 | 7.2 | 8.6 | 8.2 | 9.8 |

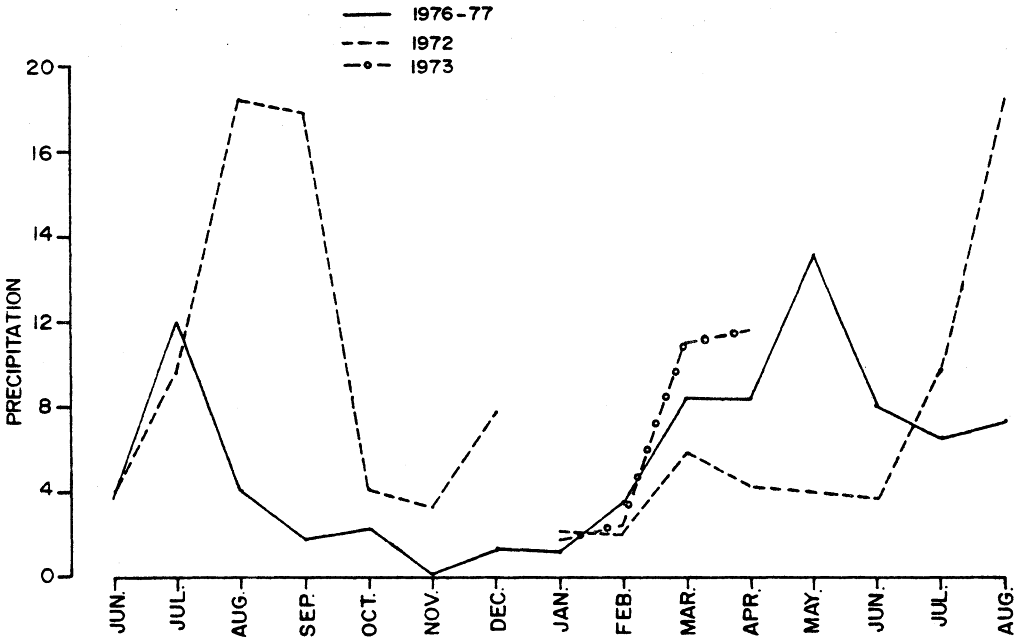
| | Treatment Zone Lower Boundary | | | | |
|---|---|---|---|---|---|
| | 1973 | 1974 | 1975 | 1976 | 1977 |
| Jan. | -- | 1.1 | 0.9 | 0.5 | 0.2 |
| Feb. | -- | 1.1 | 0.9 | 2.8 | 0.8 |
| Mar. | -- | 3.7 | 3.8 | 4.2 | 5.6 |
| Apr. | -- | 7.9 | 7.6 | 9.5 | 10.6 |
| May | -- | 10.6 | 14.1 | 12.6 | 16.4 |
| Jun. | 12.1 | 13.0 | 14.3 | 17.1 | 16.4 |
| Jul. | 13.8 | 16.2 | 17.6 | 18.1 | 20.1 |
| Aug. | 12.9 | 14.9 | 14.7 | 16.5 | 17.1 |
| Sep. | 11.1 | 10.5 | 11.3 | 12.5 | 14.17 |
| Oct. | 9.2 | 7.8 | 10.4 | 7.5 | 9.7 |
| Nov. | 4.1 | 3.7 | 6.1 | 2.6 | 5.4 |
| Dec. | 1.6 | 0.4 | 2.3 | 0.4 | 2.3 |
| Mean | -- | 7.6 | 8.6 | 8.7 | 9.9 |

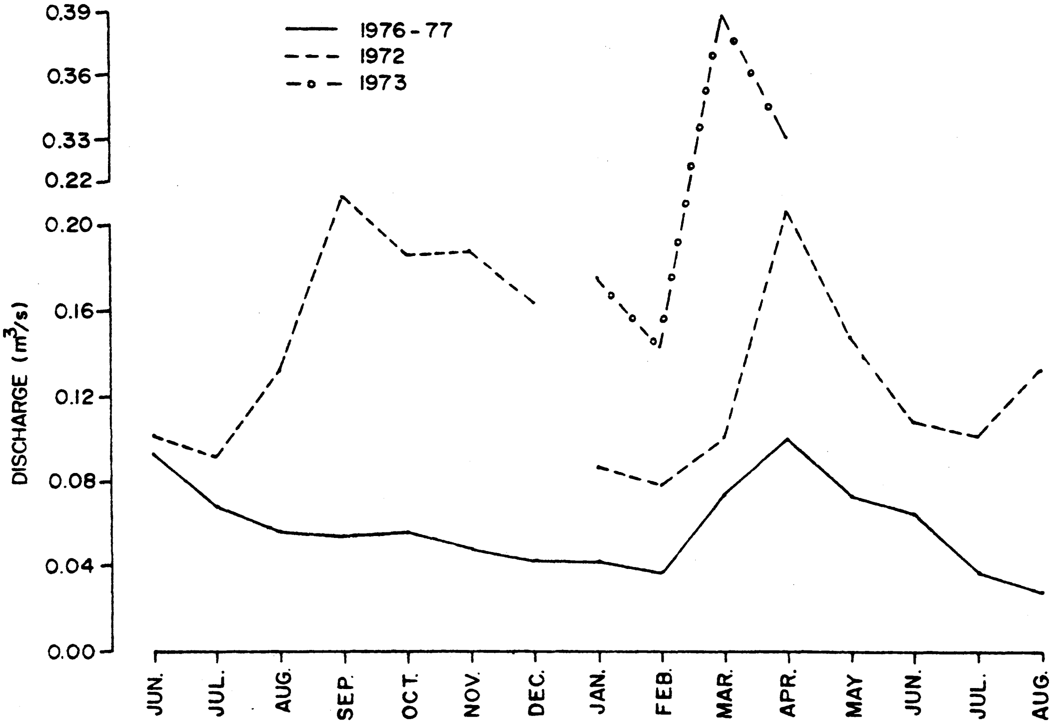
| | Lower Brushy Zone Lower Boundary | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 |
| Jan. | 0.6 | 0.7 | 2.1 | 1.8 | 1.1 | 0.3 | -0.1 |
| Feb. | 1.8 | 0.8 | 1.9 | 1.7 | 0.6 | 2.7 | 0.4 |
| Mar. | 4.5 | 3.6 | 5.3 | 4.6 | 2.5 | 3.2 | 4.7 |
| Apr. | 8.8 | 7.8 | 5.7 | 9.3 | 6.8 | 9.3 | 9.8 |
| May | 13.1 | 13.3 | 7.2 | 12.0 | 14.8 | 12.4 | 16.4 |
| Jun. | 16.0 | 14.0 | 10.3 | 14.3 | 16.7 | 16.8 | 16.8 |
| Jul. | 15.5 | 13.8 | 11.6 | 17.1 | 19.8 | 18.0 | 20.2 |
| Aug. | 14.9 | 13.4 | 10.9 | 15.8 | 17.8 | 16.5 | 17.4 |
| Sep. | 11.2 | 10.8 | 8.6 | 11.7 | 11.6 | 12.9 | 13.9 |
| Oct. | 10.6 | 7.1 | 6.6 | 8.7 | 8.9 | 7.6 | 8.8 |
| Nov. | 4.6 | 3.7 | 1.8 | 5.1 | 7.6 | 2.6 | 4.6 |
| Dec. | 2.7 | 1.8 | -- | 2.3 | 1.8 | 0.3 | 0.9 |
| Mean | 8.7 | 7.6 | 6.6 | 8.7 | 9.1 | 8.6 | 9.5 |

APPENDIX B. Maximum water temperatures (C°) at the Treatment Zone boundaries June-August 1973-1977. Data are from the Coldwater Research Group, Wisconsin Department of Natural Resources.

| | 1973 | | | 1974 | | | 1975 | | | 1976 | | | 1977 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Upper | Lower | Difference | Upper | Lower | Difference | Upper | Lower | Difference | Upper | Lower | Difference | Upper | Lower | Difference |
| Jun. | 15.6 | 17.8 | 2.2 | 19.2 | 20.8 | 1.6 | 22.8 | 24.4 | 1.6 | 24.4 | 25.3 | 0.9 | 26.1 | 26.7 | 0.6 |
| Jul. | 17.2 | 20.0 | 2.8 | 23.1 | 25.0 | 1.9 | 23.9 | 25.0 | 1.1 | 24.4 | 25.6 | 1.2 | 29.4 | 30.3 | 0.9 |
| Aug. | 16.1 | 18.3 | 2.2 | 19.4 | 21.1 | 1.7 | 23.3 | (1) | -- | 23.1 | 24.2 | 1.1 | 24.2 | 24.7 | 0.5 |

(1) insufficient data.




APPENDIX C. Mean monthly discharge ($m^3$/s) in the Meadow Zone and mean monthly precipitation (cm) for Stevens Point, Wisconsin, June 1976-August 1977, January-December 1972, and January-March 1973 (U. S. Geological Survey 1972, 1973, 1976; U. S. Dep. of Commerce 1972, 1973, 1976, 1977). Discharge data for 1977 are from the Coldwater Research Group, Wisconsin Department of Natural Resources.

APPENDIX D. Number of samples taken, volume of water sampled, and percentages of the total number and biomass drift comprised by aquatic and terrestrial drift in the Meadow (M), Upper Brushy (UB), Treatment (T), and Lower Brushy (LB) Zones of the Little Plover River, June 1976-August 1977 (excluding January 1977).

| | Zone | 16 Jun. 1976 | 12 Jul. 1976 | 25 Aug. 1976 | 17 Sep. 1976 | 23 Oct. 1976 | 19 Nov. 1976 | 19 Dec. 1976 | 25 Feb. 1977 | 19 Mar. 1977 | 24 Apr. 1977 | 16 May 1977 | 28 Jun. 1977 | 25 Jul. 1977 | 24 Aug. 1977 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of samples taken (equal for all zones). | | 12 | 12 | 12 | 10 | 9 | 6 | 10 | 9 | 6 | 8 | 9 | 9 | 10 | 11 |
| Volume of water sampled ($m^3/s$). | M | 125 | 97 | 108 | 145 | 173 | 65 | 109 | 134 | 109 | 136 | 133 | 83 | 70 | 103 |
| | UB | 78 | 74 | 73 | 86 | 84 | 44 | 85 | 66 | 58 | 65 | 71 | 67 | 60 | 67 |
| | T | 157 | 148 | 135 | 142 | 183 | 78 | 133 | 114 | 118 | 141 | 134 | 106 | 85 | 130 |
| | LB | 111 | 91 | 102 | 127 | 122 | 63 | (1) | 127 | 81 | 105 | 108 | 110 | 92 | 101 |
| NUMBERS (no./100$m^3$) | | | | | | | | | | | | | | | |
| Percentage of drift that was aquatic. | M | 97.3 | 68.8 | 83.7 | 80.1 | 84.5 | 95.0 | 91.6 | 82.8 | 88.0 | 59.6 | 72.3 | 94.0 | 92.7 | 90.1 |
| | UB | 43.7 | 12.4 | 18.9 | 20.7 | 95.3 | 100.0 | 92.0 | 100.0 | 98.4 | 72.1 | 29.1 | 85.6 | 84.0 | 70.3 |
| | T | 37.8 | 11.7 | 5.5 | 23.0 | 78.5 | 91.8 | 100.0 | 100.0 | 90.7 | 87.3 | 31.5 | 26.1 | 56.7 | 33.8 |
| | LB | 23.1 | 16.1 | 5.8 | 76.2 | 39.6 | 59.3 | (1) | 100.0 | 80.5 | 71.1 | 14.1 | 27.5 | 49.8 | 24.6 |
| Percentage of drift that was terrestrial. | M | 2.7 | 31.2 | 16.3 | 19.9 | 15.5 | 5.0 | 8.4 | 17.2 | 12.0 | 40.4 | 27.7 | 6.0 | 7.3 | 9.9 |
| | UB | 56.3 | 87.6 | 81.1 | 79.3 | 4.7 | 0.0 | 8.0 | 0.0 | 1.6 | 27.9 | 70.9 | 14.4 | 16.0 | 29.7 |
| | T | 62.2 | 88.3 | 94.5 | 77.0 | 21.5 | 8.2 | 0.0 | 0.0 | 9.3 | 12.7 | 68.5 | 73.9 | 43.3 | 45.2 |
| | LB | 76.9 | 83.9 | 94.2 | 23.8 | 60.4 | 40.2 | (1) | 100.0 | 80.5 | 71.1 | 14.1 | 27.5 | 49.8 | 24.6 |
| BIOMASS (g/100$m^3$) | | | | | | | | | | | | | | | |
| Percentage of drift that was aquatic. | M | 99.6 | 89.5 | 92.4 | 57.7 | 99.2 | 99.6 | 99.3 | 97.3 | 98.4 | 98.2 | 99.7 | 99.4 | 97.8 | 98.3 |
| | UB | 96.7 | 41.1 | 66.5 | 50.0 | 92.7 | 100.0 | 99.2 | 100.0 | 99.8 | 80.0 | 95.2 | 96.7 | 83.1 | 98.2 |
| | T | 94.3 | 48.2 | 23.7 | 85.9 | 99.2 | 98.9 | 100.0 | 100.0 | 95.3 | 97.4 | 87.0 | 94.6 | 93.8 | 56.8 |
| | LB | 92.6 | 73.8 | 30.0 | 81.7 | 87.2 | 95.5 | (1) | 100.0 | 87.2 | 81.9 | 90.2 | 98.2 | 98.3 | 84.1 |
| Percentage of drift that was terrestrial. | M | 0.4 | 10.5 | 7.6 | 42.3 | 0.8 | 0.4 | 0.7 | 2.7 | 1.6 | 1.8 | 0.3 | 0.6 | 2.2 | 1.7 |
| | UB | 3.3 | 58.9 | 33.5 | 50.0 | 7.3 | 0.0 | 0.8 | 0.0 | 0.2 | 20.0 | 4.8 | 3.3 | 16.9 | 1.8 |
| | T | 5.7 | 51.8 | 76.3 | 14.1 | 0.8 | 1.1 | 0.0 | 0.0 | 4.7 | 2.6 | 13.0 | 5.4 | 6.2 | 43.3 |
| | LB | 7.4 | 26.2 | 70.0 | 18.3 | 12.8 | 4.5 | (1) | 0.0 | 12.8 | 18.1 | 9.8 | 1.8 | 1.7 | 5.9 |

(1) no sample taken.

APPENDIX E. Values compared, statistical design used, F-ratio, degrees of freedom (d.f.), and P(type I error) for statistical comparisons between the Meadow (M), Upper Brushy (UB), Treatment (T), and Lower Brushy (LB) Zones for 1972, 1976-77, and 1972 vs. 1976-77. The statistical design used was either Two-within (TW) or Randomized Block (RB).

| VALUES COMPARED | DESIGN USED | F-ratio | d.f. | P |
|---|---|---|---|---|
| AQUATIC NUMBERS | | | | |
| T 1976-77 vs. UB 1976-77 | RB | 0.59 | 1,12 | 0.05 |
| T 1976-77 vs. LB 1976-77 | RB | 0.80 | 1,12 | 0.05 |
| M 1976-77 vs. UB 1976-77 | RB | 7.24 | 1,12 | 0.025 |
| M 1976-77 vs. T 1976-77 | RB | 6.14 | 1,12 | 0.05 |
| M 1976-77 vs. LB 1976-77 | RB | 8.68 | 1,12 | 0.025 |
| T 1976-77 vs. UB 1972 | RB | 0.50 | 1,10 | 0.05 |
| M 1976-77 vs. M 1972 | RB | 3.79 | 1,10 | 0.05 |
| UB 1976-77 vs. UB 1972 | RB | 0.10 | 1,10 | 0.05 |
| LB 1976-77 vs. LB 1972 | RB | 11.36 | 1,10 | 0.01 |
| AQUATIC BIOMASS INCLUDING MOLLUSCS | | | | |
| All zones 1976-77 | RB | 3.53 | 3,36 | 0.05 |
| AQUATIC BIOMASS EXCLUDING MOLLUSCS | | | | |
| All zones 1976-77 | RB | 4.63 | 3,36 | 0.01 |
| TOTAL NUMBERS | | | | |
| All zones 1976-77 | RB | 1.68 | 3,36 | 0.05 |
| All zones 1976-77 vs. All zones 1972 | TW | | | |
| Difference between zones | | 2.42 | 3,30 | 0.05 |
| Difference between years | | 6.08 | 1,10 | 0.05 |
| Interaction | | 1.55 | 3,30 | 0.05 |

APPENDIX E. Continued

| VALUES COMPARED | DESIGN USED | F-ratio | d.f. | P |
|---|---|---|---|---|
| TERRESTRIAL NUMBERS | | | | |
| All zones 1976-77 | RB | 2.86 | 3,36 | 0.05 |
| All zones 1976-77 vs. All zones 1972 | TW | | | |
| Difference between zones | | 2.95 | 3,30 | 0.05 |
| Difference between years | | 4.77 | 1,10 | 0.05 |
| Interaction | | 2.87 | 3,30 | 0.05 |
| DETRITUS DRY WEIGHT | | | | |
| T 1976-77 vs. UB 1976-77 | RB | 1.24 | 1,12 | 0.05 |
| T 1976-77 vs. LB 1976-77 | RB | 5.47 | 1,12 | 0.05 |
| M 1976-77 vs. UB 1976-77 | RB | 1.30 | 1,12 | 0.05 |
| M 1976-77 vs. T 1976-77 | RB | 4.10 | 1,12 | 0.05 |
| M 1976-77 vs. LB 1976-77 | RB | 11.33 | 1,12 | 0.01 |
| All zones 1976-77 vs. All zones 1972 | TW | | | |
| Differences between zones | | 5.14 | 3,30 | 0.05 |
| Differences between years | | 1.41 | 1,10 | 0.05 |
| Interaction | | 1.77 | 3,30 | 0.05 |
| TOTAL TAXA | | | | |
| T 1976-77 vs. UB 1976-77 | RB | 46.24 | 1,12 | 0.01 |
| T 1976-77 vs. LB 1976-77 | RB | 0.04 | 1,12 | 0.05 |
| T 1976-77 vs. M1976-77 | RB | 9.97 | 1,12 | 0.01 |
| M 1976-77 vs. M 1972 | RB | 77.15 | 1,8 | 0.01 |
| UB 1976-77 vs. UB 1972 | RB | 1.86 | 1,8 | 0.05 |
| T 1976-77 vs. UB 1972 | RB | 11.71 | 1,8 | 0.01 |
| LB 1976-77 vs. LB 1972 | RB | 40.59 | 1,8 | 0.01 |

APPENDIX E. Continued

| VALUES COMPARED | DESIGN USED | F-ratio | d.f. | P |
|---|---|---|---|---|
| AQUATIC TAXA | | | | |
| T 1976-77 vs. UB 1976-77 | RB | 24.87 | 1,12 | 0.01 |
| T 1976-77 vs. LB 1976-77 | RB | 0.68 | 1,12 | 0.05 |
| T 1976-77 vs. M 1976-77 | RB | 10.70 | 1,12 | 0.01 |
| M 1976-77 vs. M 1972 | RB | 100.00 | 1,8 | 0.01 |
| UB 1976-77 vs. UB 1972 | RB | 3.56 | 1,8 | 0.05 |
| T 1976-77 vs. UB 1972 | RB | 8.17 | 1,8 | 0.025 |
| LB 1976-77 vs. LB 1972 | RB | 10.56 | 1,8 | 0.025 |

APPENDIX F. Monthly occurrence of drifting aquatic invertebrates in the Meadow (1), Upper Brushy (2), Treatment (3), and Lower Brushy (4) Zones of the Little Plover River, June 1976-August 1977 (excluding January 1977).

| | 16 Jun. 1976 | 12 Jul. 1976 | 25 Aug. 1976 | 17 Sep. 1976 | 23 Oct. 1976 | 19 Nov. 1976 | 19 Dec. 1976 | 25 Feb. 1977 | 19 Mar. 1977 | 24 Apr. 1977 | 16 May 1977 | 28 Jun. 1977 | 25 Jul. 1977 | 24 Aug. 1977 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AMPHIPODA | | | | | | | | | | | | | | |
| Gammarus | 1 34 | 1 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 3 | 1234 | 12 | 123 | 1 |
| Hyalella | 1 | 1 | 1 | | | 1 | | | | 12 | | 3 | | 1 |
| EPHEMEROPTERA | | | | | | | | | | | | | | |
| Baetis | 1234 | 1234 | 1234 | 1234 | 1 34 | 4 | | | | 12 4 | 1234 | 1234 | 1234 | 1234 |
| Cleon | | 2 | | | | | | | | | | | | |
| Pseudocleon | | | | | | | | | | | 4 | | | |
| Caenis | | | | | | | | | | | 3 | | | 4 |
| Ehemerella | 4 | | 3 | 1 3 | 1 34 | 3 | 123 | 1 34 | 1234 | 1 34 | 1234 | 4 | 1 3 | 1 34 |
| Stenonema | | | 2 4 | | | | | 4 | 4 | | | | 1 4 | 1 3 |
| Leptophlebia | | | 4 | | | 1 | 1 3 | 4 | 1 3 | | | | | |
| Paraleptophlebia | | 1 | | | | 1 3 | | | | | | | 1 4 | |
| Unidentified | 1 3 | | 1 4 | 34 | | 4 | | | | 4 | | 2 | 3 | 34 |
| TRICHOPTERA | | | | | | | | | | | | | | |
| Brachycentrus | 1234 | 1234 | 1234 | 1234 | 1234 | 1234 | 123 | 123 | 1234 | 234 | 1234 | 1234 | 1234 | 1234 |
| Hydropsychidae spp. | | 1 4 | 1 4 | 1 34 | 3 | | | 4 | | | | | 1 4 | 1 3 |
| Hydropsyche | 1 | | 4 | 12 | 1 34 | 1 4 | | 1 | 1234 | 4 | 3 | | 3 | 234 |
| Cheumatopsyche | | 1 | 1 | 1 | 1234 | 1 | 1 3 | 4 | 1 | 1 | 1234 | 1 | 34 | 1 34 |
| Ceraclea | 4 | | | | | 2 | | 2 | 2 | 34 | 3 | | | |
| Mystacides | | | | | | | | | | 3 | | | | |
| Lepidostoma | | 1 | | | 123 | 3 | 1 3 | 3 | 1234 | 1 3 | 34 | | | 1 |
| Limnephilidae spp. | 1 | 1 | 1234 | 1 34 | 1 3 | | 2 | 4 | 2 | 1234 | 123 | 12 | 1 | 234 |
| Hesperophylax | | | | | | | | | 1 | | | | | |
| Onocosmoecus | | 2 | 1 | | | | | | | | | | | |
| Platycentropus | 1 | | 1 | | 1 | 1 | 23 | 1 34 | 12 | 3 | 1 | 1 | | |
| Psychoglypha | | 4 | 2 | 1 | 1 | | | | | | | | 4 | 2 |
| Pycnopsyche | | | 1 | 1 3 | 1 4 | 23 | 2 | | 3 | 3 | | | | 2 |
| Molanna | | | | | | | | | | 1 | | | | |
| Cyrnellus | | | | | | | | | | | 3 | | | |
| Unidentified | 1 34 | 1 | 1234 | 1 4 | 1 4 | 123 | 2 | 4 | 1234 | 234 | 1234 | 123 | 1234 | 1234 |

APPENDIX F. Continued

| | 16 Jun. 1976 | 12 Jul. 1976 | 25 Aug. 1976 | 17 Sep. 1976 | 23 Oct. 1976 | 19 Nov. 1976 | 19 Dec. 1976 | 25 Feb. 1977 | 19 Mar. 1977 | 24 Apr. 1977 | 16 May 1977 | 28 Jun. 1977 | 25 Jul. 1977 | 24 Aug. 1977 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COLEOPTERA | | | | | | | | | | | | | | |
| *Donacia* | | 4 | | | | | | | | | | | | |
| *Helichus* | | | | | | | | | 4 | | | | | |
| *Helodidae* | | 1 | | | | | | | | | | | | |
| *Agabetes* | | 34 | 1 4 | | | | | | | | | | | 4 |
| *Agabus* | | | | | 1 | | | | | | | | | |
| *Copotomus* | | 1 | | | | | | | | | 4 | | | |
| *Dytiscus* | | | | | | | 3 | | | | | | | |
| *Hydroporus* | 1 24 | 123 | | 1 | 1 | 1 4 | 123 | 1234 | 1 | 34 | 1234 | 1 34 | 4 | |
| *Hydrovatus* | 4 | | | | | | | | | | | | | |
| *Hygrotus* | 123 | 1 | | | | | | | | | 1 | | 1 4 | |
| *Illybius* | 4 | 1 | | | | | | | | | | | | |
| *Laccophilus* | 1 | 1 | | | 1234 | 1 34 | 23 | 4 | | | 1 | 1 | 2 | |
| *Laccornis* | 2 | | | | 1 | | | | | | | | | |
| *Liodessus* | 1 34 | 12 4 | 1 4 | 1 | 1 34 | 1 34 | 1 3 | 1234 | 1234 | | 1 34 | 12 4 | 4 | |
| *Thermonectus* | | | | | | | | | | | 1 | | | |
| *Dubiraphia* | 4 | 4 | | | | 1 | | 1 | 23 | 2 4 | 34 | 3 | 3 | |
| *Optioservus* | 1234 | 3 | 1 4 | 1 4 | 2 | 1 | 12 | 3 | 1234 | 1 34 | 1234 | 1 34 | 1 3 | 2 4 |
| *Gyrinus* | | | | | | | 3 | 4 | | | | | | |
| *Haliplus* | 1 34 | 1 34 | 1 | 1 | | | | | 234 | 1 3 | 1234 | 1 | 1 4 | 34 |
| *Peltodytes* | 1 4 | 1 3 | 1 | 1 | 4 | | | | | 1234 | 1 34 | 4 | 1 | 1 |
| *Hydraena* | 1 | 1234 | | | | | | | | | 34 | | | 3 |
| *Anacaema* | 1 | 1 | 4 | | 1 3 | | | | 3 | 3 | 1 3 | | 1 4 | |
| *Berosus* | | | | | | | | | | | | | 1 | |
| *Crenitis* | | | 4 | | | | | | | | | | | |
| *Heleophorus* | 1 3 | 4 | | | 3 | 4 | | | 34 | 3 | 1 4 | 3 | | |
| *Hydrobius* | 2 | | | | | | | | | | | | | |
| *Hydrochus* | | 1 3 | | | | | | | 2 | | 1 | 4 | | |
| *Spercopsis* | 4 | 1 3 | | | | 4 | | | | | 4 | 4 | | |
| *Tropisternus* | 1 | | 1 | | 1 | 1 34 | | | | 1 | 1 | 4 | 1 | 1 |
| HEMIPTERA | | | | | | | | | | | | | | |
| Belostoma | | | | | 3 | | | | | | | | | |
| *Lethocerus* | | | | | | | | | | | | 1 | | |
| Corixidae | 1234 | 1234 | 1 3 | 1 3 | 1234 | 1 34 | 1 3 | 4 | 1 34 | 1 34 | 1234 | 12 4 | 1 34 | 1 4 |
| Gerridae | 34 | 1234 | | | | | | | | | | | 3 | 4 |
| Notnectidae | | 1 | | | | | | | | | | | | |
| *Ranatra* | | | | 1 | | | | | | | 1 | | | |
| *Plea* | | | | 1 3 | 1 | | | | | | | | 2 4 | 4 |
| Vellidae | | 34 | | | | | | | | | | | | 4 |

APPENDIX F. Continued

| | 16 Jun. 1976 | 12 Jul. 1976 | 25 Aug. 1976 | 17 Sep. 1976 | 23 Oct. 1976 | 19 Nov. 1976 | 19 Dec. 1976 | 25 Feb. 1977 | 19 Mar. 1977 | 24 Apr. 1977 | 16 May 1977 | 28 Jun. 1977 | 25 Jul. 1977 | 24 Aug. 1977 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PLECOPTERA | | | | | | | | | | | | | | |
| Isoperla | | 1 | 1 | 1 | 34 | 23 | 1 | 1 4 | 1 4 | 3 | 234 | | | 2 4 |
| ODANATA | | 1 | 1 | 1 | | | | | | 1 | 1 4 | | 1 | 1 |
| MEGALOPTERA | | | | | | | | | | | | | | |
| Sialis | | | | | | | | 1 | 3 | | 12 | 3 | | |
| DIPTERA | | | | | | | | | | | | | | |
| Unidentified Pupae | 1234 | 123 | 1234 | 1 34 | 123 | | 1 | 3 | 123 | 1 34 | 1234 | 1234 | 1 34 | 1 34 |
| Ceratopogonidae | 3 | 1 | | | | | | | | 1 3 | 23 | 1 | | |
| Chaoboridae | | 1 | | | | | | | | | | | | |
| Chironomidae | 1234 | 1234 | 1234 | 1234 | 1234 | 1234 | 123 | 1234 | 1234 | 1234 | 1234 | 1234 | 1234 | 1234 |
| Culicidae | | 1 | | | | | | | | | | | 3 | |
| Dixidae | 34 | 12 4 | 1 34 | 1 3 | 1 4 | | | | | 3 | 3 | 4 | | 4 |
| Empididae | | | | | | | | | 4 | | 3 | 12 | | 4 |
| Ephydridae | | | | | | | | | | | 34 | | | |
| Muscidae | | | | | | | | | | 1 | | | | |
| Psychodidae | 3 | | | | | | | | | | | 1 34 | 3 | |
| Rhagionidae | | | 1 | | | | | | 1 | 1 | | | | |
| Sciomyzidae | 3 | | | | 4 | | | | | | 3 | | 2 | |
| Simulidae | 1234 | 1 34 | 1234 | 1234 | | | | | | 1 34 | 1234 | 1234 | 1234 | 1234 |
| Stratiomyidae | 1 3 | | 1 | 1 | | | 1 | | 1 | 1 3 | 1 3 | 1 | | |
| Syrphidae | | | | | | | | | | | 1 | | | |
| Tabanidae | 3 | 1 3 | | | | | | | 2 | 1234 | 123 | 23 | | |
| Tipulidae | | 1 | 23 | | | 2 | | | 1 4 | 1 | 3 | 4 | | 4 |
| Unidentified | 1 | 1 | 1 4 | | 1 | | | | | | 1 34 | | | |
| COELENTERATA | | | | | | | | | | | | | | |
| Hydra | 1 | 1 3 | 1 3 | 123 | 1 34 | 34 | 1 3 | 3 | | 1 4 | 1234 | 12 | 123 | 1234 |
| Planaria | | | 1 | 1 | 1 | 1 | 1 | | | | 1 3 | 12 | 1 | |
| COPEPODA | 1 | 1 3 | 1 | | 1 | | | | | 1 4 | 1 | | | |
| CLADOCERA | | 1 | | | | | | | | 3 | | | 1 | 1 |
| GASTROPODA | | | | | | | | | | | | | | |
| Lymnaea | 1234 | 1234 | 1234 | 1 3 | 1 3 | 1 3 | | 3 | 23 | 1 | 1234 | 1234 | 1234 | 1234 |
| Physa | 12 | 1 34 | 1 34 | 1 34 | 123 | 3 | 3 | | | | 1 3 | 1234 | 1234 | 34 |
| Planorbidae | | 4 | 1 4 | | | | | | | | 1 | | 3 | 23 |

APPENDIX F. Continued

| | 16 Jun. 1976 | 12 Jul. 1976 | 25 Aug. 1976 | 17 Sep. 1976 | 23 Oct. 1976 | 19 Nov. 1976 | 19 Dec. 1976 | 25 Feb. 1977 | 19 Mar. 1977 | 24 Apr. 1977 | 16 May 1977 | 28 Jun. 1977 | 25 Jul. 1977 | 24 Aug. 1977 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PELECYPODA | 12 | | 2 | | | 1 | 1 | | 23 | | 1 3 | 12 | | |
| OLIGOCHAETA | 1234 | 1234 | 1 3 | 1 3 | 12 | 3 | | 34 | | 123 | 1 34 | 1234 | 1 4 | 1234 |
| HIRUDINEA | 1 | | | | | | | | | | | | | |
| NEMATOMORPHA | | | | 1 | | | | | | | | | | |
| HYDRACARINA | 1 34 | 12 4 | 1234 | 1 3 | 1 34 | 4 | 1 | 1 3 | 12 | 1234 | 1234 | 1234 | 234 | 1 34 |
| LEPIDOPTERA | | | | | | | | | | | | | 4 | |
| Unknown | 1 | | 1 | | | | 2 | 3 | | | 23 | 1 | | |

No sample was taken in the Lower Brushy Zone in December 1976.

APPENDIX G. Monthly occurancé of drifting terrestrial invertebrates in the Meadow (1), Upper Brushy (2), Treatment (3), and Lower Brushy (4) Zones in the Little Plover River, June 1976-August 1977 (excluding January 1977).

| | 16 Jun. 1976 | 12 Jul. 1976 | 25 Aug. 1976 | 17 Sep. 1976 | 23 Oct. 1976 | 19 Nov. 1976 | 19 Dec. 1976 | 25 Feb. 1977 | 19 Mar. 1977 | 24 Apr. 1977 | 16 May 1977 | 28 Jun. 1977 | 25 Jul. 1977 | 24 Aug. 1977 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ARACHNIDA | 34 | 1234 | 1 34 | 4 | 2 | 4 | | | 1 4 | 4 | 1234 | 34 | 1 34 | 1234 |
| COLEOPTERA | 1234 | 1234 | 1234 | 1 | | | | | | 12 | 1234 | 1234 | 1234 | 1 34 |
| COLLEMBOLA | 1234 | 1234 | 1 34 | 123 | 1 34 | 1 34 | 1 | 1 | 1 34 | 1 34 | 1234 | 34 | 34 | 34 |
| DIPLOPODA | 1 | | | 1 | | | | | | | | | | |
| EPHEMEROPTERA (Adults) | 1234 | 34 | 2 4 | | | 4 | | 1 | | | 123 | 4 | 1 | |
| HEMIPTERA | 1234 | 1234 | 1234 | 23 | 123 | 34 | | | 3 | 2 | 34 | 1 34 | 34 | 1 34 |
| HYDRACARINA | 3 | | | | | | | | | | | | | |
| HYMENOPTERA | 1234 | 1234 | 1234 | 123 | 1 | 4 | | | 1 34 | 1234 | 1234 | 1234 | 1234 | 1234 |
| HOMOPTERA | 1234 | 1234 | 1234 | 1234 | 1 34 | 1 34 | 12 | 1 | 1234 | 1234 | 1234 | 1234 | 1234 | 1234 |
| DIPTERA | 1234 | 1234 | 1234 | 1234 | 1234 | 1 34 | 12 | 1 | 1234 | 1234 | 1234 | 1234 | 1234 | 1234 |
| ISOPODA | | 1 | 4 | | | | | | | | | | | |
| LEPIDOPTERA | 1 34 | 1234 | 1234 | | 4 | | | | 3 | 1234 | 1234 | 34 | 1234 | 4 |
| MECOPTERA | | | | | | | | | | | | 4 | | |
| MEGALOPTERA (Adults) | | | | 4 | | | | | | | | | 4 | |
| NEMATOMORPHA | 1 34 | 2 | | | 3 | | | | | 1 3 | 234 | 12 | | |
| ORTHOPTERA | | | | | | | | | | | | 2 | | 3 |
| PLECOPTERA (Adults) | | | | | | | | | | | | 2 | | |
| PSOCOPTERA | 2 4 | 1 34 | 4 | 1 | 4 | 1 4 | | | | 123 | | 4 | 12 | 4 |

APPENDIX G. Continued

| | 16 Jun. 1976 | 12 Jul. 1976 | 25 Aug. 1976 | 17 Sep. 1976 | 23 Oct. 1976 | 19 Nov. 1976 | 19 Dec. 1976 | 25 Feb. 1977 | 19 Mar. 1977 | 24 Apr. 1977 | 16 May 1977 | 28 Jun. 1977 | 25 Jul. 1977 | 24 Aug. 1977 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| THYSANOPTERA | 1 3 | 1 3 | 4 | 1 3 | | | | | | | 1234 | 34 | 4 | 1 |
| TRICHOPTERA (Adults) | 234 | 1 34 | | 2 | 1 4 | | | | 4 | | 1234 | 1 4 | 4 | 4 |
| ZOROPTERA | 4 | 2 | | | | | | | | | 2 | | | |

No sample was taken in the Lower Brushy Zone in December 1976.