DENSITY, DEPTH DISTRIBUTION AND RICHNESS OF EMERGING INSECTS (DIPTERA: CHIRONOMIDAE) BEFORE AND AFTER EXPERIMENTAL WATERSHED DEFORESTATION

BY

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ABSTRACT

The primary objective of this study was to document changes in Chironomidae density, depth distribution, and taxon richness, associated with experimental upland and riparian deforestation of L42, a small boreal forest lake, 250 km northwest of Thunder Bay Ontario. Insects were collected in floating emergence traps (0.28 m^2) in July and August 1995 before logging, and in May to September 1997 and 1998 following 74 % and 61 % clearcut logging of the upland catchment and riparian zone. A total of 738 traps set over twenty-three days collected 4,013 insects from 10 families emerging from lake benthos, with the Chironomidae comprising > 95 % each year.

Chironomid density declined after logging. Mean chironomid density (no. individuals $\cdot$ 0.28 $m^{-2} \cdot d^{-1} \pm$ S.E.) was higher in 1995 at the pre-logging sites (12.1 $\pm$ 1.2) than in 1997 and 1998 (one and two years following clearcut logging, 7.0 $\pm$ 0.7 and 5.4 $\pm$ 0.5 respectively). Density also differed between sites among years. Mean May through September emergence was lowest in 1998 at the clearcut with riparian buffer strip treatment (west site) (3.3 $\pm$ 0.3) and highest during July and August 1995 at the west site (16.2 $\pm$ 2.9). No change in non-chironomid aquatic insect density was detected between timber harvest treatments and years.

Chironomid depth distribution was variable among sites, between years and may have been affected by logging. Chironomid density declined after cutting at littoral depths (0.5 and 1.0 m) and increased at sublittoral depths (3.0 and 4.5 m), possibly due to a documented increase in littoral zone aeolian sediment deposition which peaked in 1997.

Chironomidae taxon richness decreased after watershed deforestation (21 genera (41spp.) vs. 19 (36) and 16 (32)), 1995, 1997 and 1998 respectively. Chironominae was

the most abundant subfamily in each year. After logging, the density of Tanypodinae increased and Orthocladiinae decreased. The ratio of male to female emergence was approximately 1:1 each year. Differences in chironomid community composition could be influenced by voltinism, and potentially to climate.

DEDICATION

This research is dedicated to my "Chicken Soup for the Soul", a.k.a. the Hrabok family and friends. Without your prayers, I would be disillusioned with doubt and dismay. Instead, I have witnessed that God's rainbow is always only a prayer away.

"Optimism is a cheerful frame of mind that enables a tea kettle to sing though it's in hot water up to its nose".

Anonymous

"Go confidently in the direction of your dreams. Live the life you have imagined; the future belongs to those who believe in the beauty of their dreams".

Henry David Thoreau
Eleanor Roosevelt

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INTRODUCTION

Boreal forest timber harvest of white spruce (Picea glauca), black spruce (Picea mariana) and jackpine (Pinus banksiana) is widespread in northwestern Ontario. Beginning in 1988, Ontario logging companies were required to leave a buffer strip (ranging in width from 30 m on level terrain to 90 m on slopes) around lakes and along streams following watershed deforestation to protect the aquatic environment from timber harvest practices (OMNR 1988). The extent to which boreal lake environments are affected by terrestrial disturbance has recently received increased attention (Steedman et al. 1999).

Biomonitoring with chironomids

To effectively detect subtle changes to lake ecosystems following experimental perturbations, impact studies must take into consideration the chemical, physical and biological components of the terrestrial and aquatic environments. It is particularly useful to document the effects of clearcut logging in the boreal forest with the use of indicator species.

Chironomids form an important link between primary producers and secondary consumers. In freshwater ecosystems, chironomids process phytoplankton and algae, and recycle nutrients, particularly phosphorous (Bilyj and Davies 1989). Titmus and Badcock (1980) reported that chironomid production (40-70 kg $ha^{-1}yr^{-1}$) was the limiting factor in mallard duckling early development. As well, Chura (1961) has shown that chironomid pupae and adults constitute 60 % of the diet of 0-6 day old mallard chicks. Invertebrate and vertebrate predators, including watermites (Wiles 1982), the chironomid Procladius (Kajak 1980), dragonfly larvae (Benke 1978), sculpins (Hershey and Dodson 1985) and coho salmon (Mundie et al. 1990) feed

on chironomids at some point in their life cycle. A significant change in chironomid productivity may therefore influence organisms belonging to trophic levels both higher and lower than Chironomidae.

The development of Chironomidae as biological indicators began in Europe early in the 20th century following two different paths: 1) identification of species indicative of anthropogenic degradation of lakes and streams (Kolkwitz and Marsson 1909) and 2) biological classification of lakes (Thienemann 1922; Cairns and Pratt 1993). There are many advantages to using chironomids in biomonitoring of environmental disturbances in freshwater. At the global (8,000 to 20,000 chironomid species) and regional (2,000-3,000 chironomid species) scale, the number of chironomid species present accounts for at least 50% of the total macroinvertebrate species recorded (Armitage et al. 1995). Chironomids are also ubiquitous and exhibit extensive ecological diversity throughout their worldwide distribution (Resh and Rosenberg 1984).

Chironomids emerging from benthos have previously been used as biomonitors to detect changes in water quality following large-scale rotenone treatments (Aagaard and Hanssen 1997), agricultural runoff and industrial waste from chemical and oil enterprises (Zinchenko 1997), altered thermal regimes by hydropeaking dam reservoirs (Brabec 1997), pulp and paper mill effluent (Paasivirta 1997) and experimental acidification (Davies 1980). After experimental additions of carbon, nitrogen, and phosphorous, Bilyj and Davies (1989) detected a Chironomidae species shift and species substitution that replaced pre-treatment common species with opportunistic species.

Experimental acidification increased chironomid emergence density at the Experimental Lakes Area, Kenora, Ontario (Schindler and Fee 1974, Schindler et al. 1985, Schindler et al. 1980). From 1981 to 1983, at lake pH of 5.0 to 5.1, the number of species declined to half of the

original population. The most significant decline occurred in the number of common species. In 1975 there were seven to ten common species. By 1983, there was only one common emerging chironomid, Cladotanytarsus aeiparthenus (Schindler et al. 1985). Species indicative of acidification appeared in 1981 to 1983. Sensitive assemblages included seven new species; Cladotanytarsus muricatus, C. tribelos, C. elaensis, C. daviesi, C. pinnaticornis, C. fusiformis and C. aeiparthenus (Bilyj and Davies 1989). Cladotanytarsus daviesi, C. pinnaticornis, and C. fusiformis were present at the lowest pH recorded in L223 (Bilyj and Davies 1989). Cladotanytarsus aeiparthenus was the most tolerant of all species; it was consistently present at low pHs (Bilyj and Davies 1989).

Effects of logging around boreal forest lakes

The aquatic environment is directly affected by terrestrial disturbance. Logging of riparian and upland forest around boreal forest lakes has been associated with increased wind energy and thermocline deepening (France 1997 a), increased autumn mixing depth, increased phytoplankton biomass and production (Rask et al. 1993), reduced inputs of terrestrial plant material (France 1997 b), and increased littoral insolation and diurnal temperature fluctuations (Steedman et al. 1998). Steedman and France (1999) indexed upland catchment sediment mobility via floating litter traps and showed that sediment was transported by wind following catchment logging into nearby lakes. In addition, a five-fold increase in inorganic aquatic sediment deposition was seen on tiles placed within the littoral zone of L42. However, even this deposition rate in L42 was less than background levels in two nearby undisturbed lakes. Paleoecological studies in and around the Coldwater Lakes Experimental Watersheds area suggest that long-term sedimentation rates in northwestern Ontario lakes appear to be more

strongly associated with regional precipitation and runoff trends than with catchment disturbance by clearcut logging (Blais et al. 1998, and Paterson et al. 1999a).

Sedimentation

Substrate is a limiting factor in chironomid abundance and richness. Erosion of undisturbed watersheds releases small amounts of particulate material (Bormann et al. 1969), whereas forestry practices may result in the introduction of substantial amounts of water-borne sediment. Chironomids can be affected directly when food collection or respiration is obstructed. Suspended or sedimented material can be deleterious because these substances reduce light penetration and consequently plant growth, bury hard surfaces, and fill interstices within the substrate.

Sedimentation has been associated with reduced Chironomidae species richness after large-scale watershed deforestation. Warwick (1975, 1980 a, b) extracted head capsules of chironomid larvae from sediment cores to evaluate the response to historical clearcut logging, including climatic change, at the Bay of Quinte, Lake Ontario. Sediment cores corresponding to the period of most intensive logging in the watershed (about 1850-1860), revealed that chironomids representative of oligotrophic conditions increased relative to the abundance of chironomids that are more typical of eutrophic conditions. The rapid accumulation of mineral sediments during large-scale deforestation and erosion of the watershed resulted in a high input of clay to the lake.

Sediment deposition in freshwater lakes reduces the availability of chironomid food resources. Warwick (1975, 1980 a, b) identified a reduction in benthic food materials by an increase in the organic matter : organic carbon profile obtained from 100 year old sediment cores.

A Chironomidae species shift resulted with a more oligotrophic trophic community (Microspectra and Tanytarsini type 7) replacing species characteristic of eutrophication (Ablabesmyia peleensis, Polypedilum simulans gr. and Chironomus).

Wind velocity

High winds (velocity 9-10 ms^{-1}) on Lake Myvatn, Iceland frequently suspended bottom sediment. Gardarsson et al. (1993) identified Tanytarsus gracilentus as the most abundant benthic chironomid in Lake Myvatn. They speculated that T. gracilentus was able to persist at high densities during periods of high wind and decreasing water depths because it had adapted to live in littoral zones undergoing continued re-suspension of sediment, by virtue of its tube building activity.

Light intensity and temperature

Littoral light intensity and temperature are two important environmental factors that dictate chironomid emergence. Light intensity controls the transformation from larva to pupa whereas temperature is more important in the development of the pupa to adult (Danks 1978). Watershed deforestation has the potential to alter light intensity by eliminating shaded littoral zones. Logging of buffer strips may also result in increased littoral zone water temperatures attributed to increases in light intensity associated with deforestation.

Independent of light intensity, larval development continues under the influence of water temperature (Rempel and Harrison 1987, Danks 1971a), food supply (Jonasson 1965) and stagnation of the habitat (Danks 1971 b). Danks (1978) reared newly hatched chironomid larvae from a shallow eutrophic pond near St. Catherines, Ontario. An 8-hour daily photoperiod inhibited emergence by preventing pupation of final instar larvae, in Endochironomus nigricans

and Chironomus staegeri at 15 °C and 20 °C. Through replicated trials, Danks (1978) determined that interspecific variation in life history response to temperature also exists among chironomids. Normal development to emergence took 26 days at 20 °C and 37 days at 15°C for Chironomus decorus; 35 and 48 days for Endochironomus nigricans; and 68 days at 20°C for Chironomus staegeri.

Objective

The primary objective of this study was to document changes in density, depth distribution and richness of chironomids emerging from benthos following experimental watershed deforestation. The results of two surveys between 1995 and 1998 are presented here. The first survey (Parker 1996) was conducted in 1995 to provide baseline data on the aquatic insect community prior to the proposed experimental timber harvest of 1996. The second survey was collected one (1997) and two (1998) years post watershed deforestation. These data will be used to test three null hypotheses: 1) Chironomidae density will not differ between pre- and post-cut shoreline treatments, 2) Chironomidae depth distribution will not differ between pre- and post-cut shoreline treatments, and 3) Chironomidae taxon richness will not differ between pre- and post-cut shoreline treatments. This aquatic insect research is one component of a comprehensive ecosystem monitoring program, the Coldwater Lakes Experimental Watersheds.

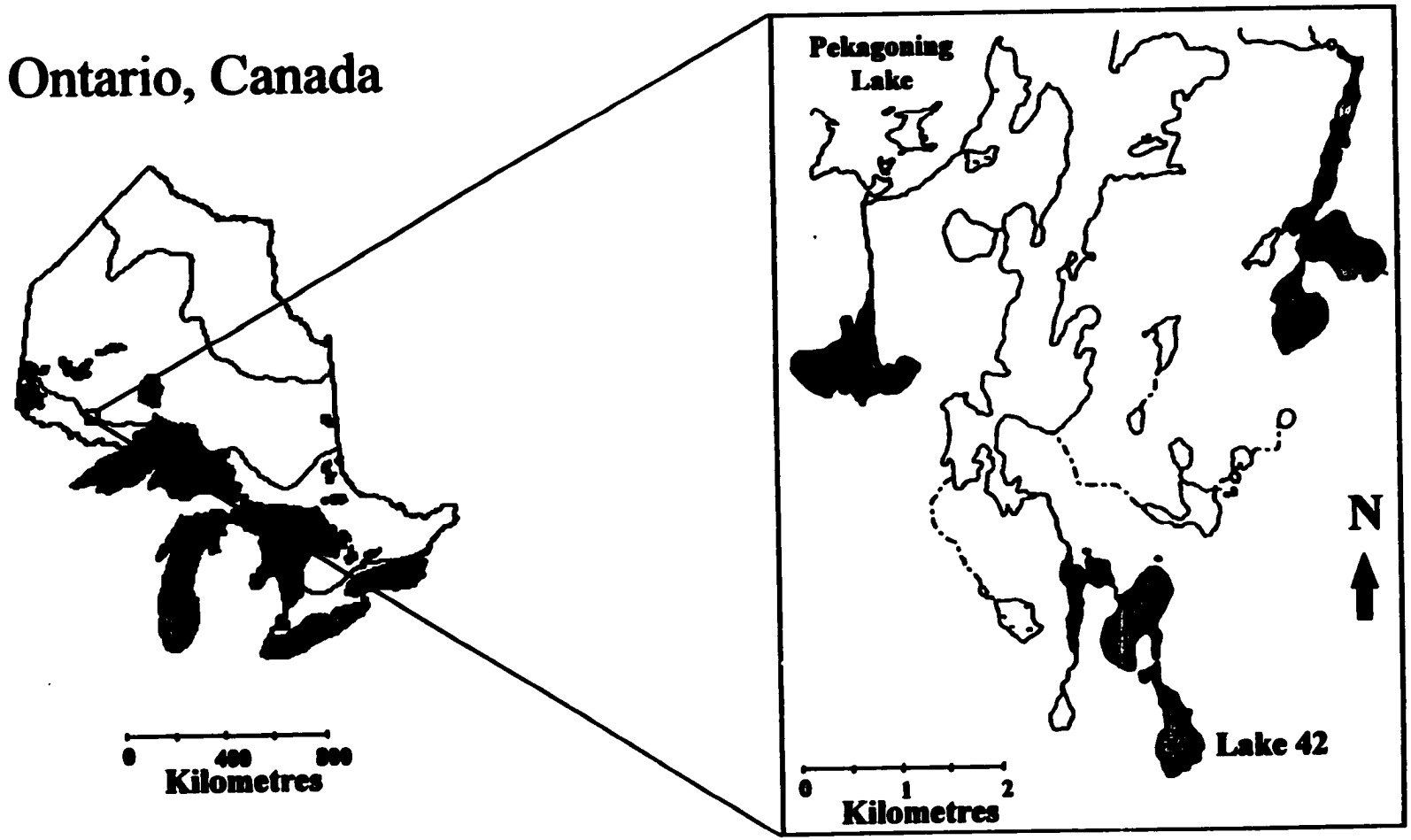
MATERIALS AND METHODS

Coldwater Lakes study area

The Coldwater Lakes study involves five small (30 ha) boreal forest headwater, oligotrophic lakes (49°5' latitude, 92°9' longitude) and their catchments, 250 km northwest of Thunder Bay, Ontario, Canada (Figure 1). From July to September 1996, after five years of pre-disturbance monitoring (1991-1995), the catchments of three lakes (L26, L39 and L42) were harvested by Atikokan Forest Products using a tracked feller buncher, chainsaws and cable skidders; L39 and L42 were clearcut to the shoreline, while L26 retained riparian buffer strips of 30 to 90 m width, proportional to shoreline slope. The catchments of one intermittent tributary stream on each of L26 and L39, and a temporary 30 m wide riparian buffer on the southwest shore of L42 were left undisturbed in 1996. These areas were used for geochemical and hydrodynamic studies from 1996 - July 1998. In the 1996 harvest, 33-71 % of the lake catchments were deforested. A skidder pulling chains and barrels scarified these clearcuts in July and August 1997. Remaining slash piles were burned late October 1997. Two nearby undisturbed lakes (L20, L80) have also been monitored since 1991 for regional reference purposes (Steedman et al.1999).

The Coldwater Lakes Experimental Watersheds program is the first long-term, multi-disciplinary study to evaluate the effectiveness of riparian buffer strips on oligotrophic lakes in Canada (Steedman et al. 1999). Since 1991, biological, chemical and physical monitoring has been phased in; including catchment mapping (soil depth and nutrient capital, vegetation biomass, lake bathymetry, and high-resolution topographic models), upland and lake surface climate monitoring, upland and outflow hydrology, upland geochemistry, regional paleoecology,

FIG. 1. Coldwater Lakes Experimental Watersheds study area, 250 km northwest of Thunder Bay, Ontario.



lake hydrodynamics, water chemistry, profundal and littoral sedimentation, oxygen, light and temperature profiles, periphyton, phytoplankton, zooplankton, and population characteristics of lake trout (Salvelinus namaycush), white sucker (Catostomus commersoni), and small littoral fishes (Cyprinidae, Culaea, Etheostoma, Cottus) (Steedman et al. 1999).

Short-term changes at the Coldwater Lakes Watersheds area were reviewed by Steedman et al. (1999). Studies of sediment cores cover the history of logging (Paterson et al. 1999a), climatic changes (Paterson et al. 1999b), and fire events (Blais et al. 1998). Movement of aeolian inorganic sediment and aquatic sediment deposition was measured in and around riparian and upland clearcuts by Steedman et al. (1999). Wind energy and thermocline deepening (France 1997 b), autumn mixing depth, inputs of terrestrial plant material, and insolation and diurnal temperature fluctuations were also monitored (Steedman et al. 1998).

Meteorological data

Mid-lake surface water temperature and meteorological data (air temperature, precipitation, relative humidity, solar radiation, wind speed and direction) were obtained from the Coldwater Lakes Experimental Watersheds climate monitoring network. These data were collected at five second intervals by a Campbell Scientific data logger and sensors mounted on a raft in the middle of L42 or at an upland site. A 24 hour mean was calculated for each meteorological datum which coincided with the exact length of time in which an emergence trap was deployed (Tables 1 and 2).

In 1997 (first year post-deforestation) April to October rainfall was 409 mm, 70 % of the 1994 to 1996 annual average of 587. 1998 rainfall was 506 mm, or 86 % of the 1994 to 1996 average. The 20 year average (1969 to 1988) April to October rainfall at Atikokan, 70 km SE of

TABLE 1. July to August pre-cut (1995) and post-cut (1997 and 1998) climate data for L42. Data are averages for periods that emergence traps were deployed.

Year	Relative humidity (%)	Wind velocity (m/s)	Wind direction (degrees)	Precipitation (mm)	Water surface temperature (°C)	Ambient air temperature (°C)	Whole sky radiation (KW/m^2)
1995 (pre-cut)	66	2.2	234 (sw)	0.3	21.6	18.5	0.29
1997 (1 yr. Post-cut)	72	2.0	170 (se)	4.8	21.7	17.4	0.25
1998 (2 yrs. Post-cut)	72	2.4	191 (sw)	0.0	22.2	19.7	0.23

TABLE 2. May to September 1997 and 1998 post-deforestation climate data for L42. Data are averages for the period that emergence traps were deployed.

Year	Relative humidity (%)	Wind velocity (m/s)	Wind direction (degrees)	Precipitation (mm)	Water surface temperature (°C)	Ambient air temperature (°C)	Whole sky radiation (KW/m^2)
1997 (1 yr. Post-cut)	69	2.3	199 (sw)	234	17.9	15.0	0.23
1998 (2 yrs. Post-cut)	72	2.3	194 (sw)	69	19.8	16.5	0.22

L42, was 550 mm (Beaty 1998). Maximum daily rainfall in 1997 and 1998 (50 mm, with several days greater than 25 mm) was similar to the 1994 to 1996 pre-logging period. Wind velocity averaged 4 ms^{-1} during the study.

L42 characteristics

Upland characteristics

In general, upland soils are shallow, with abundant Precambrian bedrock outcrops. Catchment relief is about 60 m. In 1995 the forest cover consisted of 75 to 100 year-old mixed wood stands of jack pine (Pinus banksiana), trembling aspen (Populus tremuloides), black spruce (Picea mariana) and white birch (Betula papyrifera), with some eastern white cedar (Thuja occidentalis), red pine (Pinus resinosa) and white pine (Pinus strobus).

Lake level characteristics

Lk 42 basin and catchment morphometry were measured commencing in 1991 by the Coldwater Lakes Ecosystem Monitoring Watersheds field crew (Table 3). The crew was also responsible for collecting lake water samples that were analyzed by either the Ontario Ministry of the Environment and Energy or Lakehead University Center for Analytical Services. Epilimnetic water chemistry medians before and after catchment deforestation are reported in Table 4.

Experimental logging

Experimental logging commenced in 1996 when 71 % of the upland catchment and 42 % of the riparian zone were clearcut leaving a temporary 30 m wide buffer on the southwest shore and some residual riparian forest at various places around the lake. In 1998, the temporary buffer

TABLE 3. L42 basin and catchment morphometry (Steedman et al. 1999)

Number of Tributary Lakes	0
Maximum Depth (m)	18
Mean Depth (m)	6.4
Elevation (m)	440
Surface Area (ha)	26
Lake Volume ($10^4 m^3$)	165.7
Perimeter (km)	3.2
Total Catchment Area (ha)	70
Probability (%) of Complete Mixing in Spring/Fall (1991 to 1995)	100 / 100
Ratio Terrestrial Catchment Area / Lake Surface Area	1.6
Water Renewal Time (years)	13
Percent Catchment Deforested (1996 / 1998 total)	71 / 74
Percent Riparian Zone Deforested (1996 / 1998 total)	42 / 61

TABLE 4. Epilimnetic water chemistry medians, before and after summer 1996 catchment deforestation of L42. Most post-deforestation anaylses were conducted by a different laboratory than was used in the pre-deforestation period (Steedman et al. 1999)

Parameter	Units	Pre-cut[a]	Post-cut[b]
Conductance (25 °C)	umho cm^{-1}	14.0	13.9
Calcium	mgL^{-1}	1.3	1.2
pH		6.7	6.7
Total Alkalinity	mgL^{-1}	5.0	4.8
Sulphate	mgL^{-1}	2.8	2.0
Dissolved Organic Carbon	mgL^{-1}	2.5	2.3
Total Phosphorous	ugL^{-1}	4.0	0
Total Nitrogen	mgL^{-1}	0.23	0.20
Silicate	mgL^{-1}	0.04	0.00
Aluminum	ugL^{-1}	7.30	7.58

[a] Pre-deforestation analyses based on May 1991 to August 1996 sampling.
[b] Post-deforestation analyses based on August 1996 to November 1997 sampling.

was cut, bringing the total to 74 % of the upland catchment and 61 % of the riparian zone. Insect monitoring was conducted on L42 along the north, west and east shores (Figure 2). The west and east sites were chosen because they exhibited similar littoral sediment composition (Table 5). The north site was selected to contrast with the west and east sites because of its high organic sediment composition. In 1995, all sites represented pre-logging conditions.

In 1997 and 1998, two timber harvest treatments were applied to three sites. The north site was clearcut to the shoreline, the west site was clearcut leaving a 30 m wide riparian buffer strip intact, and the east site was clearcut to the shoreline (Table 6).

North site

This site was located in a shallow embayment a few meters west of the lake outflow. Water depths in the embayment were uniform on any given day but they fluctuated between 0.2 and 1.0 m from May through September. Pitcher plant (Sarracenia purpurea) was the dominant marsh species around the fringes of the bay. Other vegetation consisted of yellow pond lily (Nuphar variegatum), white water lily (Nymphaea odorata), water arum (Calla palustris), water shield (Brasenia schreberi), pondweed (Potamogeton), bladderwort (Utricularia vulgaris), leather leaf (Chamaedaphne calyculata), labrador tea (Ledum groenlandicum), sweet gale (Myrica gale), bog rosemary (Andromeda glaucophylla), bog laurel (Kalmia polifolia), and mosses (Sphagnum). Fine dark brown organic material comprised more than 80 % of the substrate. The organic mat was greater than one meter in depth. At least two beavers occupied a lodge along the northwest shore during the 1997 and 1998 insect sampling seasons.

FIG. 2. Coldwater Lakes Experimental Watersheds aquatic insect study sites (north, west, and east) at L42.

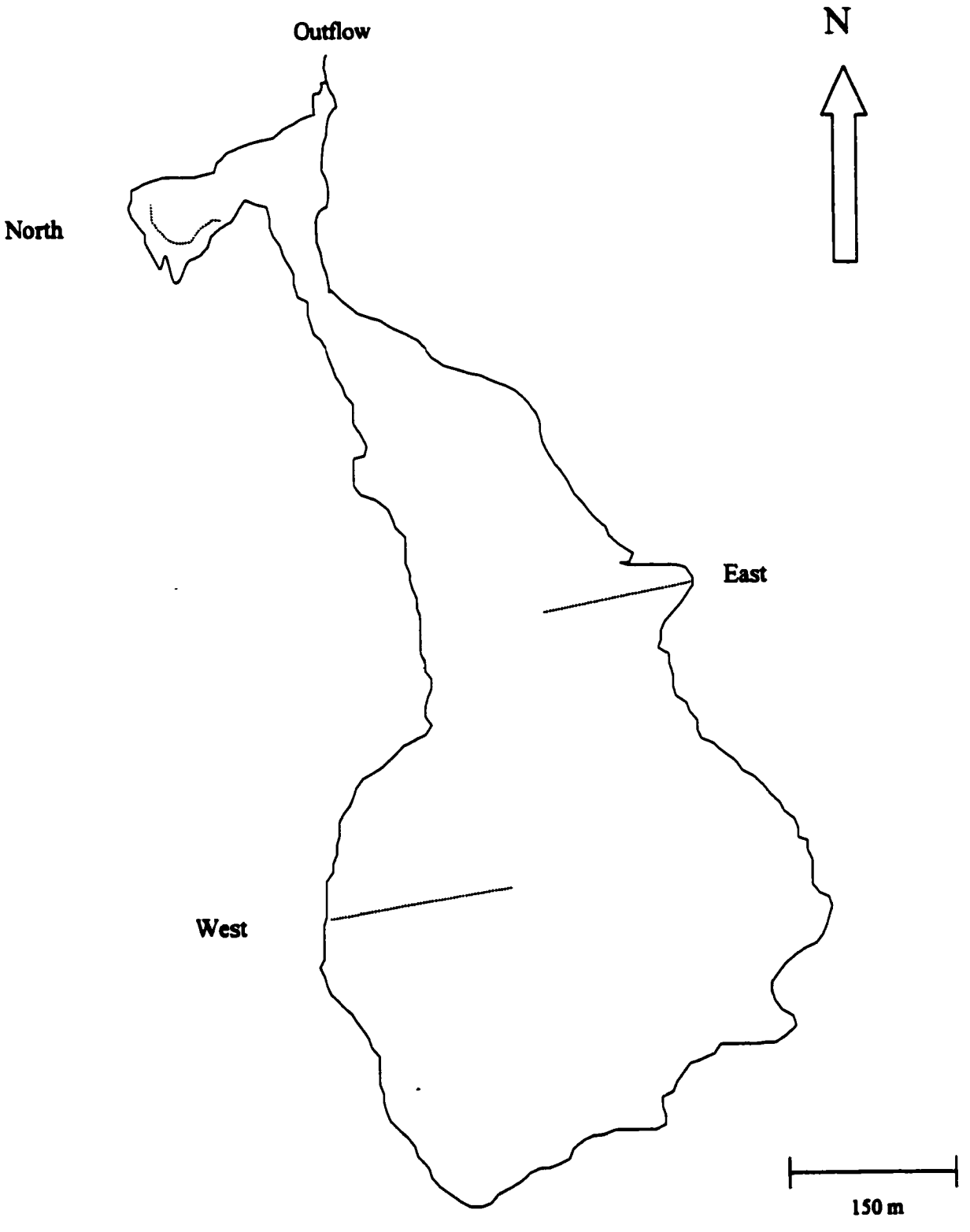


TABLE 5. Composition of littoral substrate types at L42 (%) (OMNR 1988).

Site	Length of shoreline (m)	Depth profile measured at (m)	Composition of substrate (%)[a]							Dominant substrate	Subdominant substrate	Average substrate
			Fine organic	Silt	Sand	Gravel	Cobble	Rubble	Small boulder			
North	61.0	1.1	80	0	0	0	0	20	0	Fine organic	Rubble	Sand
West	153.0	3.0	40	0	0	0	30	30	0	Fine organic	Cobble	Sand
East	97.0	1.1	0	0	0	0	30	70	0	Rubble	Cobble	Fine organic

[a] Substrates were recorded in the order of their abundance with the most abundant type recorded first. Substrate was classified by particle-size measured along the shortest axis diameter: fine organic (fine particulate organic material is discernable), silt (<0.2 mm), sand (0.2-6.3 mm), gravel (6.4-76.0 mm), cobble (76.1-149.9 mm), rubble (150.0-303.9 mm), small boulder (304.0-509.9 mm).

TABLE 6. Summary of disturbance types at the north, west and east site at L42.

Site	1995	1997	1998
North	Undisturbed	Clearcut to shoreline	Clearcut to shoreline
West	Undisturbed	Clearcut with 30 m wide riparian buffer strip	Clearcut with 30 m wide riparian buffer strip until end of June, then clearcut to shoreline
East	Undisturbed	Clearcut to shoreline	Clearcut to shoreline

West site

This site was on the main basin of L42 and had a mean slope of 0.26 to the shoreline (Table 7). Rubble was the dominant substrate. Riparian vegetation consisted of leather leaf (Chamaedaphne calyculata), sweet gale (Myrica gale), moss (Sphagnum), and labrador tea (Ledum groenlandicum).

East site

This site was in a small embayment and had a mean slope of 0.10 to the shoreline (Table 7). An access road to the shoreline was built in 1997. Patches of intact riparian vegetation consisted of leather leaf (Chamaedaphne calyculata), sweet gale (Myrica gale), moss (Sphagnum), labrador tea (Ledum groenlandicum) and honey suckle (Lonicera). Cobble and silt were the most abundant substrata.

Monitoring design

Pre-disturbance emergence was measured in ninety traps over six days from the north, west and east site at L42 during July and August 1995 (Parker 1996). Post-disturbance emergence was monitored from the same sites, one year (1997) and two years (1998) later during May to September, following the experimental timber harvest. Subsamples from 1997 (2, 9, 23, 30 July and 6, 19 August) and 1998 (2, 16, 29 July and 5, 13, 19 August) insect collections, which approximate the temporal span of sampling in 1995 (7, 9, 22 July and 4, 6, 19 August) were identified. Chironomidae taxon richness was only determined using these equal effort July and August samples at 0.5, 1.0, 3.0, 4.5, and 7.0 m depths.

TABLE 7. Distance and slope from shore for the distribution of aquatic insect emergence traps on L42.

Depth of water (m)	West site		East site	
	Distance trap set from shore (m)	Mean slope to shore	Distance trap set from shore (m)	Mean slope to shore
0.5	1.0	0.50	2.2	0.23
1.0	3.4	0.29	7.8	0.13
2.0	8.1	0.25	15.0	0.13
3.0	12.9	0.23	28.0	0.11
4.5	19.3	0.23	60.0	0.08
7.0	28.3	0.25	84.0	0.08
9.0	49.5	0.18	108.7	0.08
12.0	77.5	0.15	133.8	0.09

Field Methods

In 1997 and 1998 I set traps between 1200 hrs and 1630 hrs, and retrieved them 24 hours later from a 14' boat with a 9.9 hp outboard motor. The motor was adjusted to its highest tilt position when sampling the littoral zone to prevent mixing of benthos. At the beginning of each season, I measured water depth along the west and east sites with a portable depth sounder mounted at the stern of the boat. In the spring of 1997, I used a rangefinder to measure the distance from shore that each trap was set (Table 7). During spring 1998, I used these distances to re-position traps.

1995 pre-deforestation sampling (Parker 1996)

In 1995, fifteen emergence traps were deployed on each of six days. Five traps, one at each water depth (0.5, 1.0, 3.0, 4.5, 7.0 meters) were stationed perpendicular to the west and east shoreline in linear transect lines extending into the littoral zone and profundal zones. Five additional traps were randomly deployed at the north site at a uniform depth. Chironomidae density, taxon richness and depth distribution were estimated during July and August in the 1995 baseline survey. These data were used to describe the pre-disturbance insect community at L42.

1997 and 1998 post-deforestation sampling

In 1997, 336 emergence traps were deployed over 14 days from 27 May through 15 September. In 1998, 312 emergence traps were deployed over 13 days from 3 May through 9 September. Traps were deployed on either a weekly or bi-weekly basis. The post-deforestation experimental design consisted of two factors: water depth (0.5, 1.0, 2.0, 3.0, 4.5, 7.0, 9.0, 12.0 meters), and timber harvest shoreline treatment (clearcut with riparian buffer strip intact (west

site), and clearcut to shoreline (east site)). Inter-trap variability was estimated at the clearcut littoral embayment (north site) where traps were deployed at a uniform depth.

Emergence trap construction

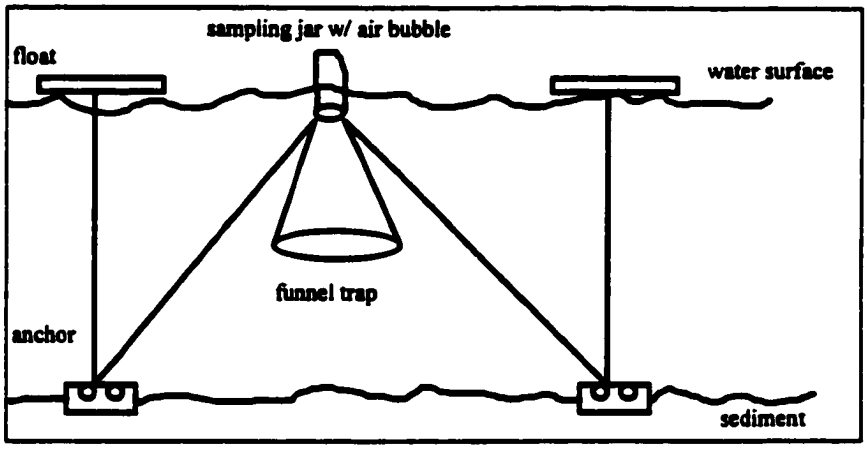
Emergence traps were made from Vivac® plastic, a heat moldable, ultra violet resistant plexi-glass type material bonded with "Weld-on-Three®" solvent (Parker 1996). Traps were designed after Davies (1984) but we increased the basal area from 0.1 m^2 to 0.28 m^2 to increase the likelihood of collecting rare species. Rubber cement, contact cement, silicone, and ABS plumbing cement did not bond Vivac®.

Five emergence traps were constructed from one 4 X 8 foot sheet of Vivac®. Each trap was formed into a funnel shape and held together with two C-clamps, one at the neck and one at the base. Bonding solvent was applied to the 1.0 cm overlapping seam using a glass-stirring rod. Traps dried outdoors for one hour before clamps were removed. I cut a 0.5 m diameter hole into a 1.0 X 1.0 m piece of plywood to hold each trap for neck molding. With the trap inverted, I molded the neck of each trap using a 500 mL PET sample bottle with attached pipe clamp and a household paint stripper gun. As the Vivac® cooled, I trimmed the necks of each trap until the bottle fit snugly. Each trap neck was fitted with a stainless steel pipe clamp, two 15 inch lengths of 125 lbs. test monofilament, a 63 mm diameter hollowed out plastic PET jar lid and two sections of polyester cord anchor line. A polyester float line with fluorescent green or yellow spray-painted styrofoam buoys, and two bricks were attached to each anchor line (Figure 3).

Techniques of trap setting and sample retrieval

I deployed and collected traps upwind of the boat to decrease the likelihood of driving over float and anchor lines. I set traps by screwing the sample bottle into the removable plastic

FIG. 3. Deployment of aquatic insect lentic emergence trap (basal area = 0.28 m^2)



lid and tightened it within the pipe clamp with a Phillips screwdriver attached to my watchstrap. While reversing in lowest throttle position, I dropped one anchor line overboard and set it taut at 45 ° from the surface of the water. After shifting into neutral I filled the trap with water leaving half the volume of the sampling jar with an air bubble to provide buoyancy. While in reverse, I tossed the second anchor overboard, dragging the float line until only the sample bottle was visible above the water's surface. I wrapped red electrical tape around the perimeter of each sampling jar to alert other researchers that traps were deployed, and to make the bottles easier to relocate.

I retrieved traps 24 hrs later by approaching them head on with the boat in lowest forward throttle position. On windy days, the forward momentum was counter balanced by reversing. I loosened the pipe clamp and unscrewed the sample bottles from the plastic ring under water ensuring the bottle was held upright until it was capped. I replaced the plastic ring in the neck of the trap and tightened the pipe clamp. With the sample bottle removed, the trap sank to the bottom of the lake, and could be retrieved by pulling on a float line for the next setting.

Laboratory Methods

Upon arrival at the lab I carefully added small amounts of 99.7 % ethyl alcohol (EtOH) to each sampling jar by uncapping the PET bottle and raising the lid just wide enough to insert the squirt bottle spout into the jar. I gently swirled the bottle to ensure all insects were in contact with the alcohol and rendered flightless. I emptied the contents of each sample into a white sorting tray. I counted and keyed insects to order under a Wild M3C dissecting microscope at 16X, using Merritt and Cummins (1996), and Borror et al. (1989). I then transferred insects into

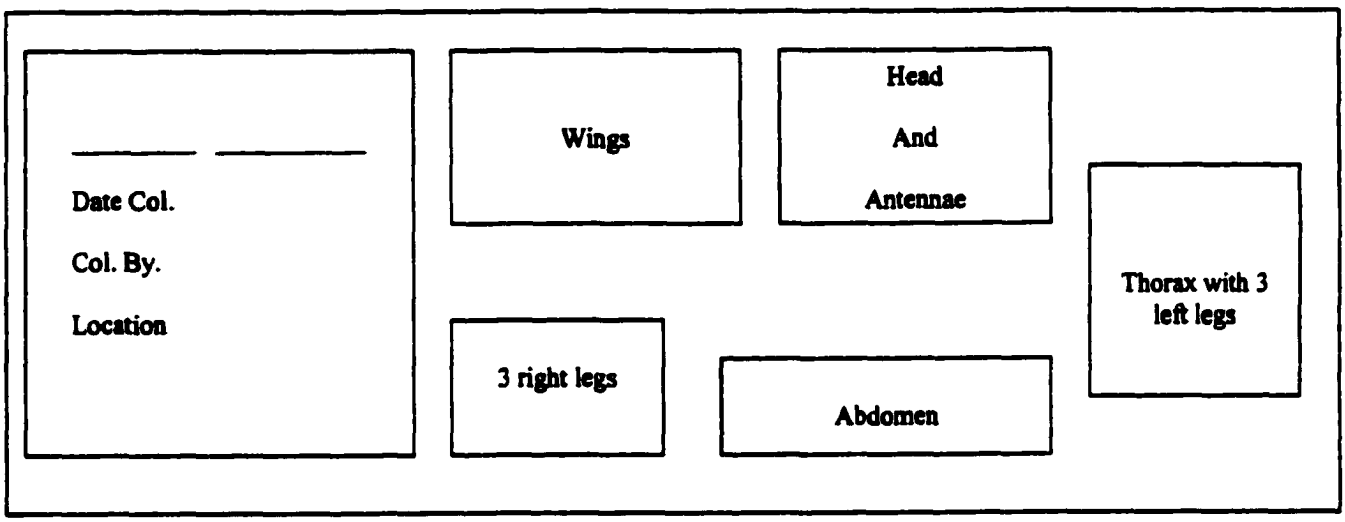
25 mL glass scintillation vials filled with 70 % EtOH, and labeled vials according to depth and site.

Insects collected in July and August of 1995, 1997 and 1998 not belonging to the family Chironomidae were isolated from the samples and grouped according to order. Chironomidae gender was observed via transmitted light by examining the hypopygium and head tegma in a plastic Petri dish containing 70 % EtOH at 40X. I placed two pieces of Kimwipe® beneath the Petri dish to absorb EtOH and to facilitate movement across the microscope stage. I identified specimens with reduced antennae or those lacking plumose antennae as female (Oliver 1971). I meticulously examined and grouped male chironomids into morphogroups according to head, thorax and abdomen colour, density of hair on abdomen, morphology of caudal end, total body length (head to end abdomen), wing colour and pattern, and gross appearance of legs. A reference collection comprised of 52 male morphogroups was created by randomly selecting 2 to 4 males of each morphogroup from the July and August 1995, 1997 and 1998 samples.

Chironomidae Identification

Bohdan Bilyj (BIOTAX Consulting, Weston, Ontario) identified the male chironomid reference collection. He examined chironomids by making a temporary glycerin mount of the hypopygium by a full-body dissection (Figure 4). Bilyj prepared microscope slide museum mounts by dehydration, tissue clearing and preservation (Appendix 1). Morphogroups were identified to species when possible. Some of my morphogroup vials contained genera belonging to more than one subfamily. When this occurred, all genera (example: Tanytarsus-Dicrotendipes-Nilothauma) or all subfamilies (example: Orthocladiinae-Chironominae grp.) were

FIG. 4. Arrangement of chironomid appendages on microscope slide. Structures were positioned with the dorsal side up.



listed in the identification of the morphogroup although it is not known exactly how many of each genus or subfamily were collected.

Microscope slides were examined at up to 1000X with a high powered Leitz Diaplan compound microscope with drawing tube and Wild-Photoautomat MPS45 attachment. I used light and dark phase photomicroscopy to record diversity in genitalia.

Data analysis

ANOVA's were computed, unless stated otherwise, using 2 factors: bathymetric distribution and site with five (0.5, 1.0, 3.0, 4.5, 7.0 meters) and three (north, west, east sites) levels respectively, using two-way factorial analysis of variance (ANOVA) (Appendix 2 and 3). Since the treatment combinations are unreplicated, this factorial experiment provides no pure estimate of variance (σ^2) as there are zero degrees of freedom associated with experimental error, and as such, there is no test for interaction effects (Appendix 4) (Hurlbert 1984). Following the guidelines of a Conservative Test, a test of significance for only the main effects is possible (Brown 1995). If the F-ratio was less than the F critical value, the null hypothesis was not rejected. The chance of committing a Type II error with a conservative test is rather high (Zar 1994). This fact was taken into consideration for each conservative test and data were analyzed by executing multiple one-way ANOVA's.

To test the ANOVA assumptions that 1) the population from which the experimental units are drawn is normally distributed and 2) all samples from the parent populations have the same variance, a normal probability plot (Appendix 5A) and y by x dotplot (Appendix 5B) were produced. The data were then normalized with the squareroot transformation.

To test the hypothesis that the rate of chironomid emergence did not differ between years, a one-way ANOVA with year as the single factor was computed. To test the hypotheses that Chironomidae bathymetric distribution and site preference did not differ within each year (1995, 1997 and 1998) during July and August, and May through September 1997 and 1998, separate two-way ANOVA's with bathymetric distribution and site as factors were computed. To determine if bathymetric distribution varied within each site, in a given year, separate one-way ANOVA's for the west and east site, with bathymetric distribution as the single factor was computed. Least significant difference post-hoc tests were constructed for all significant main effects. All differences were considered significant at $p<0.05$. Data were analyzed using Data Desk 6.0 for IBM compatible computers. Complete ANOVA tables for the July and August 1995, 1997 and 1998 subsample and May to September 1997 and 1998 post-deforestation period are included in the Appendices (Appendices 6 to 16 and 17 to 24 respectively).

RESULTS

Totals of 1,054, 1,672 and 1,287 macroinvertebrates emerging from benthos were collected from the littoral and profundal zones at three sites, over six, fourteen and thirteen sampling days during the ice-free seasons of 1995, 1997, and 1998, respectively. Sample size was increased from 90 traps in 1995 to 336 in 1997 and 312 in 1998. From 2 July to 19 August, Chironomidae was the most abundant taxon, comprising 96 %, 95 % and 96 % of the total catch in 1995, 1997 and 1998, respectively.

Chironomidae density

Chironomid density declined after experimental watershed deforestation. There were 62 % more chironomids collected during July and August in 1995 (pre-deforestation) than in 1997 (one year post-deforestation). The number of chironomids collected in 1995 was more than two times greater than those collected in 1998 (two years post-deforestation), based on equal sampling effort between years (Figure 5). Statistically significant differences are summarized in Table 8.

Emergence was not uniform among seasons. In 1995, chironomid median density peaked 4 August with a minor peak 7 July (Figure 5). In 1997, emergence peaked on 4 June, 25 June and 23 July. Chironomidae median density decreased steadily from 6 August until the final collection on 16 September 1997. This decrease coincided with cooler air temperatures and high winds. In 1998, chironomid median density peaked on 3 May, 21 June and 19 August (Figure 5). Density was relatively uniform from 1 July until 13 August. The lowest seasonal median density of chironomids emerging from benthos in 1998 was observed in mid fall when insect counts plummeted 27 August (Figure 5).

FIG. 5. Boxplot showing pre-harvest (July to August 1995) and post-harvest (May to September 1997, 1998) adult Chironomidae emergence patterns at L42. Depths and sites are pooled. The bottom, middle, and top of each box represent the 25th, 50th, and 75th percentiles of each set of observations. The vertical lines at the top and bottom of each box extend to the maximum and minimum observations, excluding observations of more than 1.5 box-lengths from the 25th or 75th percentile. Number of observations in each box is shown along the x-axis.

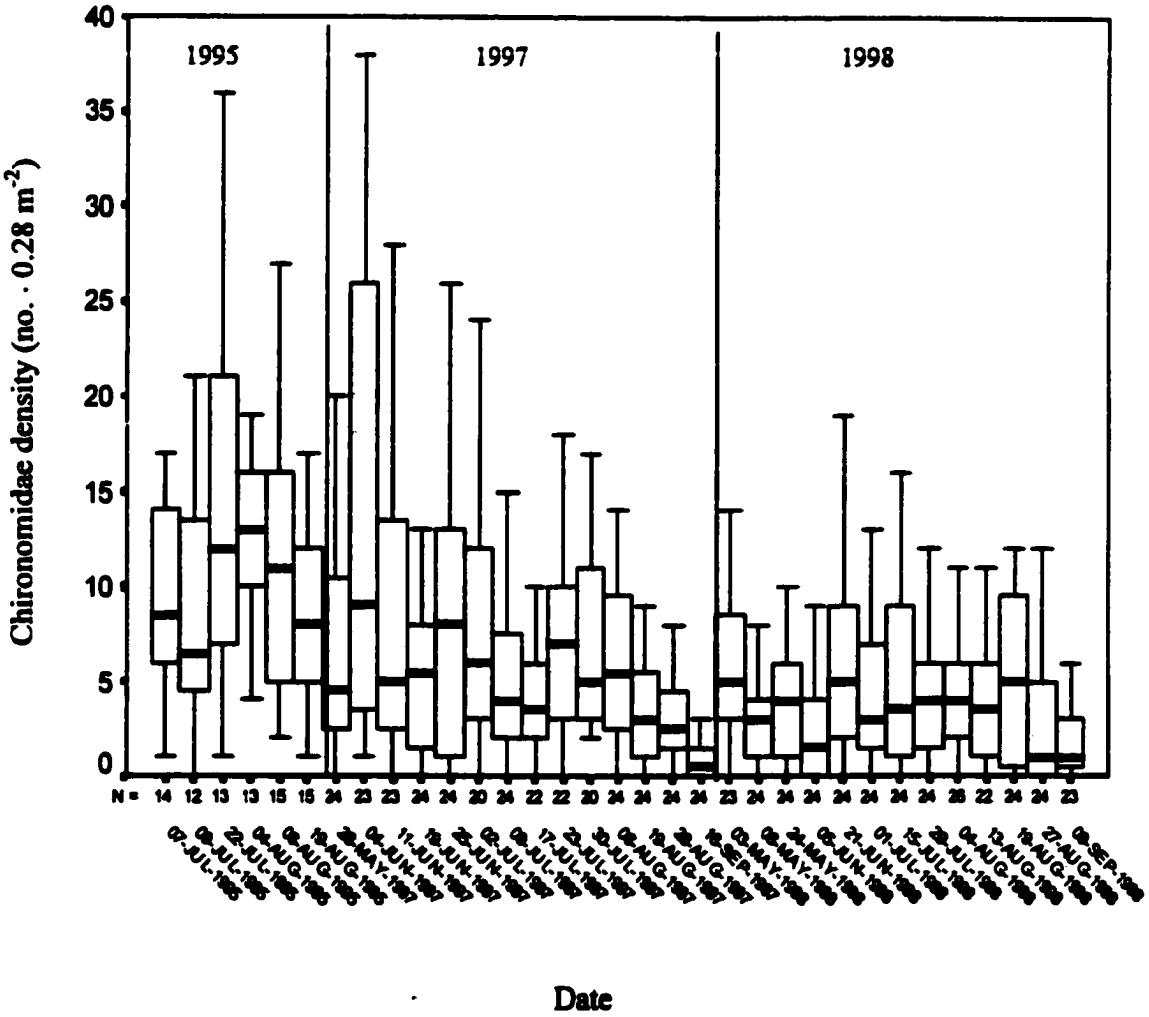


TABLE 8. Summary of significant p values from one-way ANOVA tables with year, site or depth as factors. The response variable was the squareroot transformation of the rate of chironomid emergence (no. · 0.28 m^{-2} · d^{-1}). "X" indicates data subset used in ANOVA computation.

Sampling interval	Year	Site			Depth (m)	
		N	W	E		
July to August	'97 vs '95 $p < 0.01$	X	X	X	N/A	
	'98 vs '95 $p < 0.01$	X	X	X	N/A	
July to August	'95, '97, and '98 $p = 0.05$	X			N/A	
	'97 vs '95 $p = 0.04$	X			N/A	
	'98 vs '95 $p = 0.03$	X			N/A	
July to August	'95		X		All depths	$p < 0.01$
			X		1.0 vs 0.5	$p = 0.02$
			X		4.5 vs 0.5	$p = 0.02$
			X		7.0 vs 1.0	$p < 0.01$
			X		7.0 vs 4.5	$p < 0.01$
July to August	'97		X		All depths	$p < 0.01$
			X		4.5 vs 0.5	$p < 0.01$
			X		4.5 vs 1.0	$p < 0.01$
			X		4.5 vs 3.0	$p < 0.01$
			X		7.0 vs 0.5	$p = 0.02$
			X		7.0 vs 4.5	$p < 0.01$
July to August	'97			X	All depths	$p = 0.05$
				X	1.0 vs 0.5	$p = 0.03$
				X	7.0 vs 1.0	$p < 0.01$
July to August	'98			X	All depths	$p = 0.15$
				X	7.0 vs 0.5	$p = 0.01$
				X	7.0 vs 3.0	$p = 0.05$
May to September	'97 vs '98 $p < 0.01$	X	X	X	N/A	
May to September	'97 vs '98 $p = 0.03$	X			N/A	

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Month	Year	Site			Depth (m)	
		N	W	E		
May to September	'97		X		All depths	$p < 0.01$
					2.0 vs 0.5	$p = 0.01$
					4.5 vs 0.5	$p < 0.01$
					4.5 vs 1.0	$p < 0.01$
					4.5 vs 3.0	$p = 0.02$
					7.0 vs 2.0	$p = 0.04$
					7.0 vs 4.5	$p < 0.01$
					9.0 vs 1.0	$p = 0.03$
					9.0 vs 2.0	$p < 0.01$
					9.0 vs 3.0	$p = 0.03$
					9.0 vs 4.5	$p < 0.01$
					12.0 vs 0.5	$p < 0.01$
					12.0 vs 1.0	$p < 0.01$
					12.0 vs 2.0	$p < 0.01$
					12.0 vs 3.0	$p < 0.01$
					12.0 vs 4.5	$p < 0.01$
					12.0 vs 7.0	$p < 0.01$
May to September	'98		X		All depths	$p < 0.01$
					2.0 vs 0.5	$p = 0.02$
					3.0 vs 0.5	$p = 0.02$
					3.0 vs 1.0	$p = 0.04$
					7.0 vs 2.0	$p < 0.01$
					7.0 vs 3.0	$p < 0.01$
					7.0 vs 4.5	$p = 0.05$
					9.0 vs 1.0	$p = 0.02$
					9.0 vs 2.0	$p < 0.01$
					9.0 vs 3.0	$p < 0.01$
					9.0 vs 4.5	$p < 0.01$
					12.0 vs 0.5	$p < 0.01$
					12.0 vs 1.0	$p < 0.01$
					12.0 vs 2.0	$p < 0.01$
					12.0 vs 3.0	$p < 0.01$
					12.0 vs 4.5	$p < 0.01$
					12.0 vs 7.0	$p < 0.01$

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Month	Year	Site			Depth (m)	
		N	W	E		
May to September	'97			X	All depths	$p < 0.01$
					1.0 vs 0.5	$p < 0.01$
					2.0 vs 1.0	$p < 0.01$
					3.0 vs 1.0	$p < 0.01$
					4.5 vs 1.0	$p < 0.01$
					7.0 vs 0.5	$p = 0.02$
					7.0 vs 1.0	$p < 0.01$
					7.0 vs 2.0	$p = 0.03$
					9.0 vs 0.5	$p < 0.01$
					9.0 vs 1.0	$p < 0.01$
					9.0 vs 2.0	$p = 0.02$
					12.0 vs 0.5	$p < 0.01$
					12.0 vs 1.0	$p < 0.01$
					12.0 vs 2.0	$p < 0.01$
					12.0 vs 3.0	$p = 0.02$
					12.0 vs 4.5	$p = 0.02$
May to September	'98			X	All depths	$p < 0.01$
					7.0 vs 0.5	$p < 0.01$
					7.0 vs 1.0	$p = 0.05$
					7.0 vs 3.0	$p < 0.01$
					9.0 vs 0.5	$p = 0.02$
					9.0 vs 3.0	$p = 0.02$
					12.0 vs 0.5	$p < 0.01$
					12.0 vs 1.0	$p < 0.01$
					12.0 vs 2.0	$p < 0.01$
					12.0 vs 3.0	$p < 0.01$
					12.0 vs 4.5	$p < 0.01$
					12.0 vs 9.0	$p = 0.02$

Chironomidae mean density was more variable among sites during July and August during the pre-deforestation period than in each year following catchment deforestation (Table 9). Of the three sites, mean density (no. chironomids · 0.28 m^{-2} ± S.E.) was higher (16.23 ± 2.93) at the west site before the commencement of logging than at the north (10.89 ± 1.57) and east (9.41 ± 1.05) site. Variability with respect to chironomid mean density between sites was lessened in 1997 (7.00 ± 0.96 vs 6.41 ± 0.99 vs 7.43 ± 1.42; north, west and east sites respectively) after 71 % of the upland forest and 42 % of the riparian zone of L42 was clearcut. In 1998, the riparian buffer strip along the west site was clearcut resulting in a total of 61 % riparian zone deforestation. This reduction in vegetation paralleled the decline in chironomid mean density from the west (4.89 ± 0.69) and east (3.84 ± 0.48) site (Table 9). When chironomids were collected at regular weekly intervals in 1997 and 1998 during May through September, annual mean density among sites was not significantly different (Table 10).

Chironomidae depth distribution

The depth of water from which the majority of chironomids emerged after logging differed from pre-logging distributions (Tables 9 and 10). Without the influence of logging, July and August 1995 mean density of chironomids emerging from benthos (no. chironomids · 0.28 m^{-2} ± S.E.) from the west site was more common at 1.0 m (28.4 ± 7.44) and 4.5 m (28.75 ± 8.83) than at 0.5 m (8.67 ± 1.67) and 7.0 m (4.83 ± 1.08) (Table 9). Pre-logging emergence from the east site was dominant at the littoral depths of 0.5 m (12.00 ± 3.62) and 1.0 m (12.40 ± 1.69). In 1997, one year post-logging emergence from the west site was significantly higher at 4.5 m (13.67 ± 1.91) than at any other depths ($p<0.01$) and emergence from the east site was most abundant at 1.0 m (14.67 ± 5.16) (Table 8). In 1998, July and August emergence from the

TABLE 9. Mean density ± S.E. of chironomids (no. chironomids · 0.28 m^{-2} · d^{-1}) emerging from L42 benthos during July and August 1995, 1997 and 1998.

Year[a]	Site	Depth of water (m)					Mean density with depths pooled
		0.5	1.0	3.0	4.5	7.0	
1995	N[b]						10.89 ± 1.57
	W	8.67 ± 1.67	28.40 ± 7.44	16.80 ± 6.76	28.75 ± 8.83	4.83 ± 1.08	16.23 ± 2.93
	E	12.00 ± 3.62	12.40 ± 1.69	6.40 ± 1.03	7.33 ± 1.15	9.33 ± 2.87	9.41 ± 1.05
						Grand mean density =	12.11 ± 1.17
1997	N[b]						7.00 ± 0.96
	W	2.60 ± 1.21	3.00 ± 1.05	5.20 ± 0.97	13.67 ± 1.91	6.17 ± 1.35	6.41 ± 0.99
	E	6.17 ± 3.57	14.67 ± 5.16	6.17 ± 1.08	7.50 ± 1.54	2.67 ± 0.56	7.43 ± 1.42
						Grand mean density =	6.97 ± 0.66
1998	N[b]						7.10 ± 1.03
	W	3.40 ± 0.81	4.60 ± 1.40	4.40 ± 0.87	3.67 ± 0.99	3.00 ± 1.08	4.89 ± 0.69
	E	6.83 ± 1.42	5.17 ± 2.24	5.60 ± 1.50	4.33 ± 1.02	2.20 ± 0.80	3.84 ± 0.45
						Grand mean density =	5.37 ± 0.48

[a]N= 6 emergence traps were deployed at each depth per site per year.
[b]All emergence traps at the north site were deployed in 0.2 to 1.0 m depths of water.

TABLE 10. Mean density ± S.E. of chironomids (no. chironomids · 0.28 m^{-2}· d^{-1}) emerging from L42 benthos during May through September 1997 and 1998.

Year	Site	Depth of water (m)								Mean density with depths pooled
		0.5	1.0	2.0	3.0	4.5	7.0	9.0	12.0	
1997[a]	N[b]									7.33 ± 0.67
	W	4.79 ± 2.05	7.61 ± 2.60	9.36 ± 1.67	7.58 ± 2.25	13.71 ± 2.46	4.57 ± 0.94	2.75 ± 0.74	1.00 ± 0.69	6.51 ± 0.73
	E	9.08 ± 3.10	18.43 ± 5.46	8.00 ± 2.14	5.07 ± 0.86	5.31 ± 1.10	2.64 ± 0.64	3.31 ± 1.40	1.23 ± 0.30	6.70 ± 0.99
										Grand mean density = 6.85 ± 0.46
1998[c]	N[b]									5.38 ± 0.47
	W	2.62 ± 0.56	3.54 ± 0.80	6.08 ± 1.12	6.45 ± 1.36	4.62 ± 0.98	2.23 ± 0.53	1.23 ± 0.43	0.31 ± 0.17	3.32 ± 0.34
	E	5.69 ± 0.88	5.25 ± 1.44	4.17 ± 1.50	6.08 ± 1.18	3.23 ± 0.63	2.62 ± 0.76	3.00 ± 0.87	0.62 ± 0.18	3.81 ± 0.38
										Grand mean density = 4.18 ± 0.24

[a]In 1997, N=14 emergence traps were deployed per depth per site.
[b]All emergence traps at the north site were deployed in 0.2 to 1.0 m depths of water.
[c]In 1998, N=13 emergence traps were deployed per depth per site.

west site was relatively equally distributed among all depths (range 3.00 ± 1.08 to 4.60 ± 1.40), and more prevalent from the east site in the littoral zone at depths of 3.0 m or less (range 5.60 ± 1.50 to 6.83 ± 1.42) (Table 9).

Independent of timber harvest, chironomid density was higher in the littoral zone (depths of water from 0.5 m to 4.5 m) than in the profundal zone (depths of water from 7.0 m to 12.0 m) during May through September 1997 and 1998 (Table 10). Chironomid depth distribution differed between the west and east site ($p<0.01$) (Table 8). In 1997, mean density (no. chironomids · 0.28 m^{-2}· d^{-1} ± S.E.) from the west site was highest at 4.5 m (13.71 ± 2.46) and lowest at 12.0 m (1.00 ± 0.69). At the east site, emergence was highest at 1.0 m (18.43 ± 5.46) and lowest at 12.0 m (1.23 ± 0.30). The trend in 1998 was similar to that in 1997 in which chironomid density decreased with a corresponding increase in water depth (Table 10).

Chironomidae taxa richness

Chironomid taxa richness decreased after logging. Three subfamilies were collected in each year with Chironominae most abundant (Figure 6). A summary of trophic relationships for each subfamily is reported in Table 11. A shift in chironomid trophic levels was evident after catchment deforestation. Tanypodinae was least abundant in 1995 but the percent of each annual catch of this subfamily increased with an increase in catchment deforestation (Figure 6). The percent catch of Orthocladiinae, on the other hand, decreased with a corresponding increase in timber harvest (Figure 6).

Chironomid subfamily richness also differed among sites between years during July and August. Before logging, Orthocladiinae was dominant at the west site followed by Chironominae (Figure 7). After the upland catchment was clearcut in 1997, the percent catch of

FIG. 6. Chironomidae subfamily composition (% of catch) during July to August 1995 (pre-deforestation), 1997 (1 yr. post-cut), and 1998 (2 yrs. post-cut). All depths and sites are pooled (N = 270 traps total). Percent catch is less than 100 % when unidentified or damaged specimens were collected. [TP = Tanypodinae; OTP = Orthocladiinae-Tanypodinae complex.; OC = Orthocladiinae; OCH = Orthocladiinae-Chironominae grp.; CH = Chironominae]

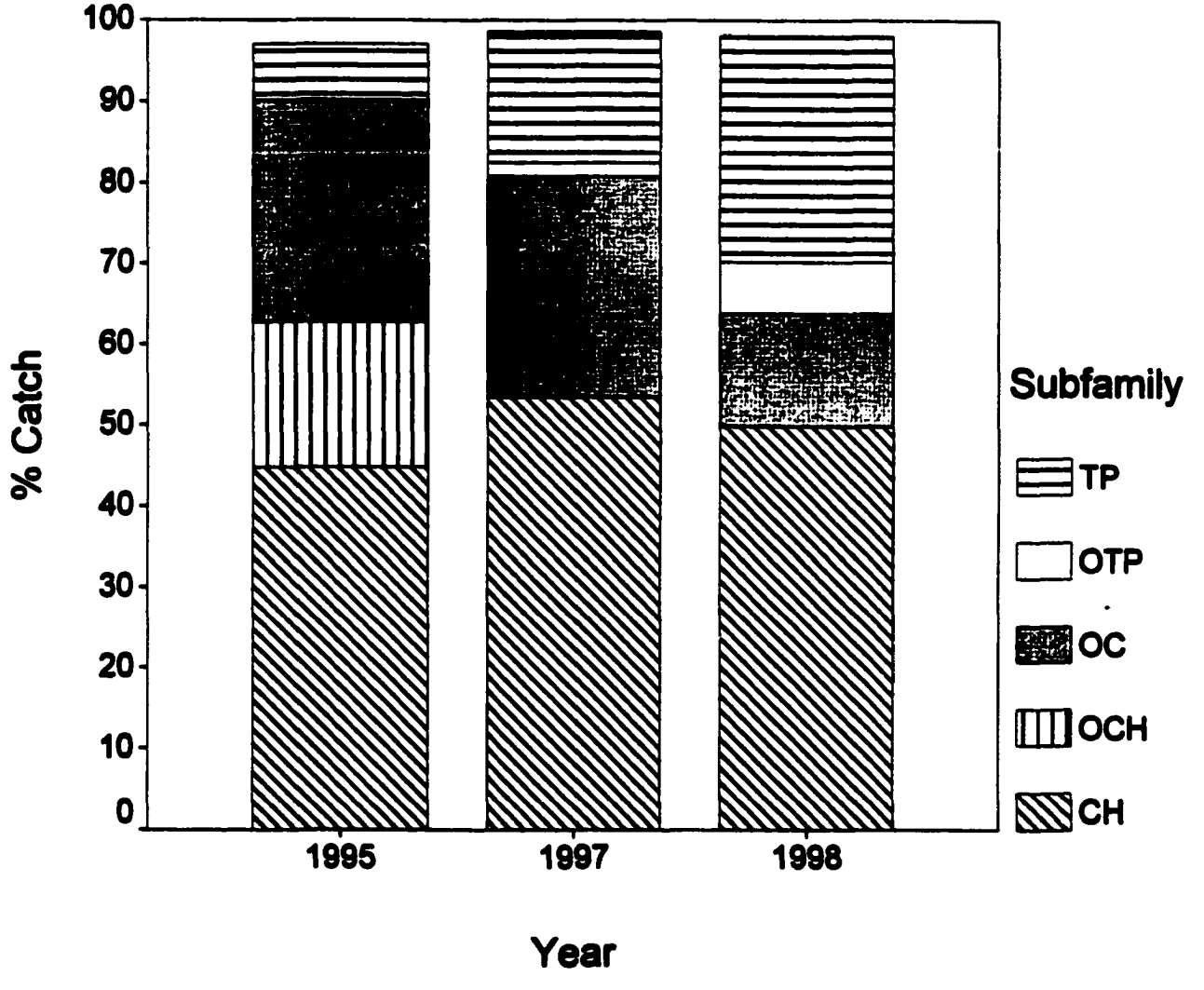


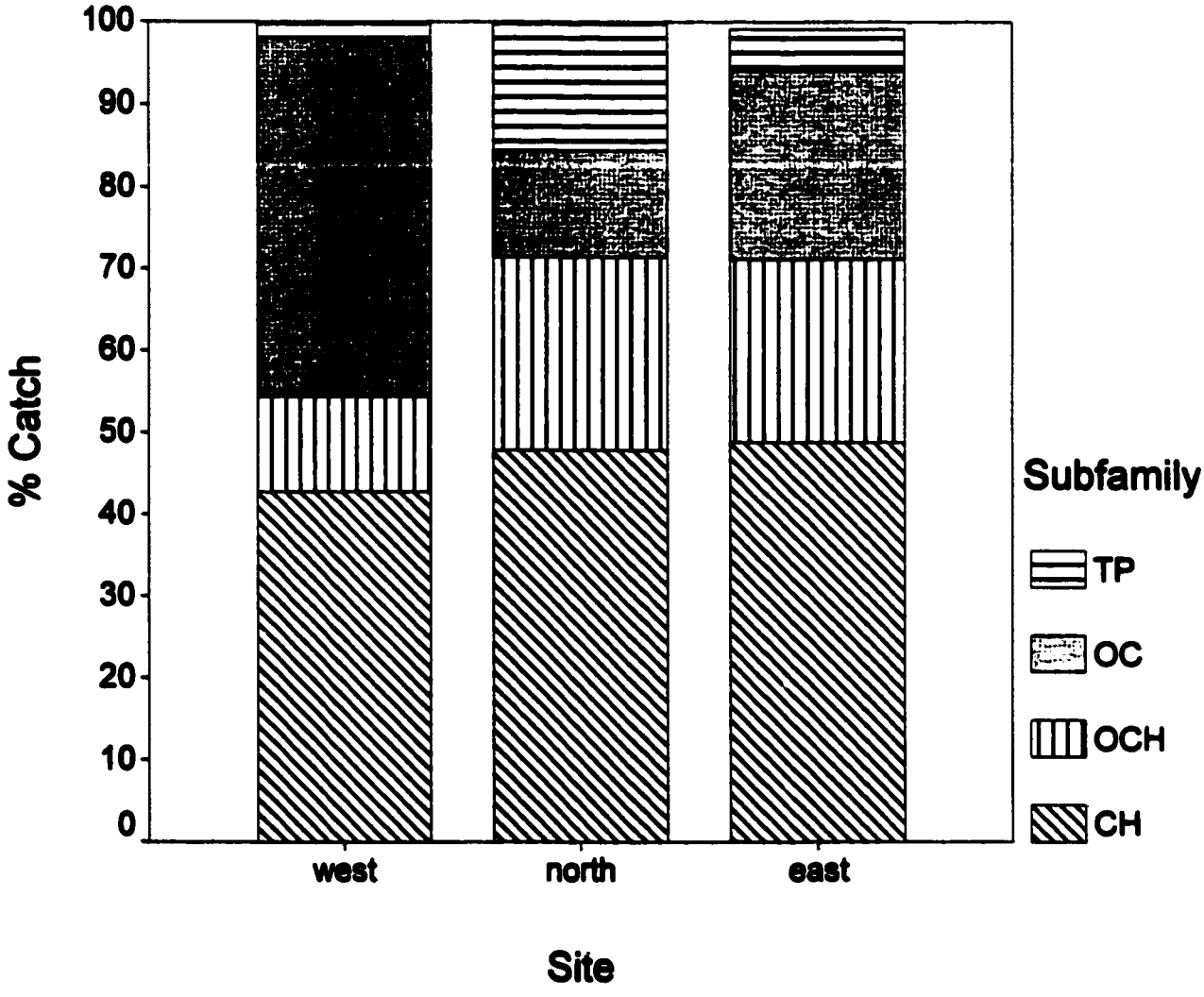
TABLE 11. Summary of ecological data for Chironomidae collected from L42 (Merritt and Cummins 1996).

Taxa	Habitat	Habit	Trophic Relationship
Chironomidae	Essentially all types of aquatic habitats, including littoral and profundal zones of headwater, oligotrophic lake 42	Generally burrowers (most are tube builders)	Generally two types: 1) collectors- gatherers and filterers 2) predators (engulfers and piercers)
Tanypodinae	All types of lentic and lotic habitats	Generally sprawlers- swimmers (very active predators, not tube builders)	Generally predators (engulfers and piercers)
Ablabesmyia	Lentic- littoral zone (errosional and depositional)	Sprawlers	Predators (engulfers and piercers) (rotifera, microcrustacea, Chironomidae). Collectors- gatherers (early instars)
Clinotanypus	Lentic- littoral zone	Generally burowers	Predators (engulfers; oligochaeta, Ostracoda, Chironomidae)
Labrundinia	Lentic- littoral	Sprawlers	Predators (engulfers and piercers, Oligochaeta, Cladocera, Ostracoda)
Larsia	Lentic- littoral	Sprawlers	Predators (engulfers)
Procladius	Lentic- profundal, some littoral	Sprawlers	Predators (engulfers; Protozoa, microcrustacea, Ephemeroptera, Ceratopogonidae, Gastrotricha), collectors-gatherers (winter and early instars)
Orthocladiinae	Lentic representatives common in oligotrophic lakes	Generally burrowers (tube builders)	Generally collectors-gatherers, scrapers
Corynoneura	Lentic- littoral zone (some instar primarily planktonic)	Sprawlers	Collectors-gatherers
Cricotopus	Lentic- vascular hydrophytes (and algal mats, sediments, detritus)	Clingers (tube builders), burrowers (miners and tube builders)	Shredders- herbivores (miners and chewers), collectors-gatherers (detritus and algae)
Heterotanytarsus	Lentic- littoral		
Nanocladius	Lentic- littoral	Sprawlers	Collectors-gatherers
Parakiefferiella	Lentic- littoral	Sprawlers	Collectors-gatherers
Psectrocladius	Lentic- littoral	Sprawlers, burrowers	Collectors-gatherers, shredders-herbivores
Chironominae	Lentic- littoral and profundal	Generally burrowers and clingers	Generally collectors-gatherers and collectors-filterers
Chironomini	Generally lentic- littoral and profundal	Generally burrowers	Generally collectors-gatherers

Continued:

Taxa	Habitat	Habit	Trophic Relationship
Chironominae	Lentic- littoral and profundal	Generally burrowers and clingers	Generally collectors-gatherers and collectors-filterers
Chironomini	Generally lentic- littoral and profundal	Generally burrowers	Generally collectors-gatherers
Chironomus	Lentic- littoral and profundal	Burrowers (tube builders)	Collectors-gatherers (a few filteres), shredders-herbivores (miners)
Cladopelma	Lentic- littoral	Burrowers	Collectors-gatherers
Cryptochironomous	Lentic- littoral and profundal	Sprawlers, burrowers	Predators (engulfers of Protozoa, microcrustacea, Chironomidae and piercers of Oligochaeta)
Dicrotendipes	Lentic- littoral (wide range of microhabitats)	Burrowers	Collectors-gatherers, filterers, scrapers
Lauterborniella	Lentic- littoral and profundal	Climbers-sprawlers-clingers, burrowers (portable sand tube builders)	Collectors-gatherers
Microtendipes	Lentic- littoral	Clingers (net spinners)	Collectors-filterers and gatherers
Nilothauma	Lotic- depositional		
Paracladopelma	Lentic- littoral	Sprawlers	
Paralauterborniella	Lentic- vascular hydrophytes	Clingers (tube builders on plants)	Collectors-gatherers
Polypedilum	Lentic- vascular hydrophytes (floating zone)	Climbers, clingers	Shredders-herbivores (miners), collectors-gatherers, filterers, predators (engulfers)
Tribelos	Lentic	Burrowers (wood miners)	Collectors-gatherers
Tanytarsini	Generally lotic, some lentic- littoral	Generally burrowers or clingers (tube builders)	Generally collectors-filterers and gatherers
Cladotanytarsus	Lentic- vascular hydrophytes		Collectors-gatherers and filterers
Constempellina	Lotic- errosional		
Paratanytarsus	Lentic- littoral	Sprawlers	
Stempellinella	Lentic- littoral	Sprawlers	
Tanytarsus	Lentic- vascular hydrophytes (floating zone) and profundal	Climbers, clingers (net spinners)	Collectors-filterers and gatherers, a few scrapers

FIG. 7. Pre-deforestation Chironomidae subfamily composition (% of catch) at the north, west, and east site, July to August 1995. All depths are pooled (N = 90 traps total). Percent catch is less than 100 % when unidentified or damaged specimens were collected. [TP = Tanypodinae; OTP = Orthocladiinae-Tanypodinae complex.; OC = Orthocladiinae; OCH = Orthocladiinae–Chironominae complex.; CH = Chironominae]



Orthocladiinae decreased and Tanypodinae increased (Figure 8). The pre-deforestation subfamily chironomid composition at the north site shifted in favor of a predominantly Tanypodinae and Chironominae community two years after catchment deforestation (Figure 9). Although three chironomid subfamilies were present at the east site in each year, it is difficult to discern a subfamily shift post-deforestation because subfamily complexes overlapped the percent catch of individual subfamilies.

Chironomid genera and species richness were more diverse before catchment deforestation (1995) (Table 12), than one year (1997) (Table 13), and two years (1998) (Table 14) after experimental cutting. Genus complexes (example: Tanytarsus-Dicrotentipes-Nilothauma) were common in each year and as such, richness may be more important when qualified than when quantified. The total number of each genus and genus complex emerging from the north, west, and east site was variable between years (Table 15). However, there were only three to five common genera from each site to which 80 % of the total catch belonged (Table 15). With the exception of Cladopelma, Clinotanypus, Larisa, Paracladopelma, and Tribelos, there were two or more specimens of each genus and genus complex collected between 1995 and 1998. Tables describing chironomid depth distribution and seasonal emergence patterns for each genus and genus complex were noted according to site and year (Appendices 25 to 33).

Natural history observations

Non-chironomid macroinvertebrates

Site and timber harvest treatment did not appear to affect mean density of non-chironomid macroinvertebrates. However, there were seasonal differences among density. The

FIG. 8. Post-deforestation Chironomidae subfamily composition (% of catch) at the north (clearcut littoral embayment), west (clearcut with riparian buffer strip), and east (clearcut to shoreline) site July to August 1997. All depths are pooled (N = 90 traps). [TP = Tanypodinae; OTP = Orthocladiinae-Tanypodinae complex.; OC = Orthocladiinae; OCH = Orthocladiinae-Chironominae complex.; CH = Chironominae]

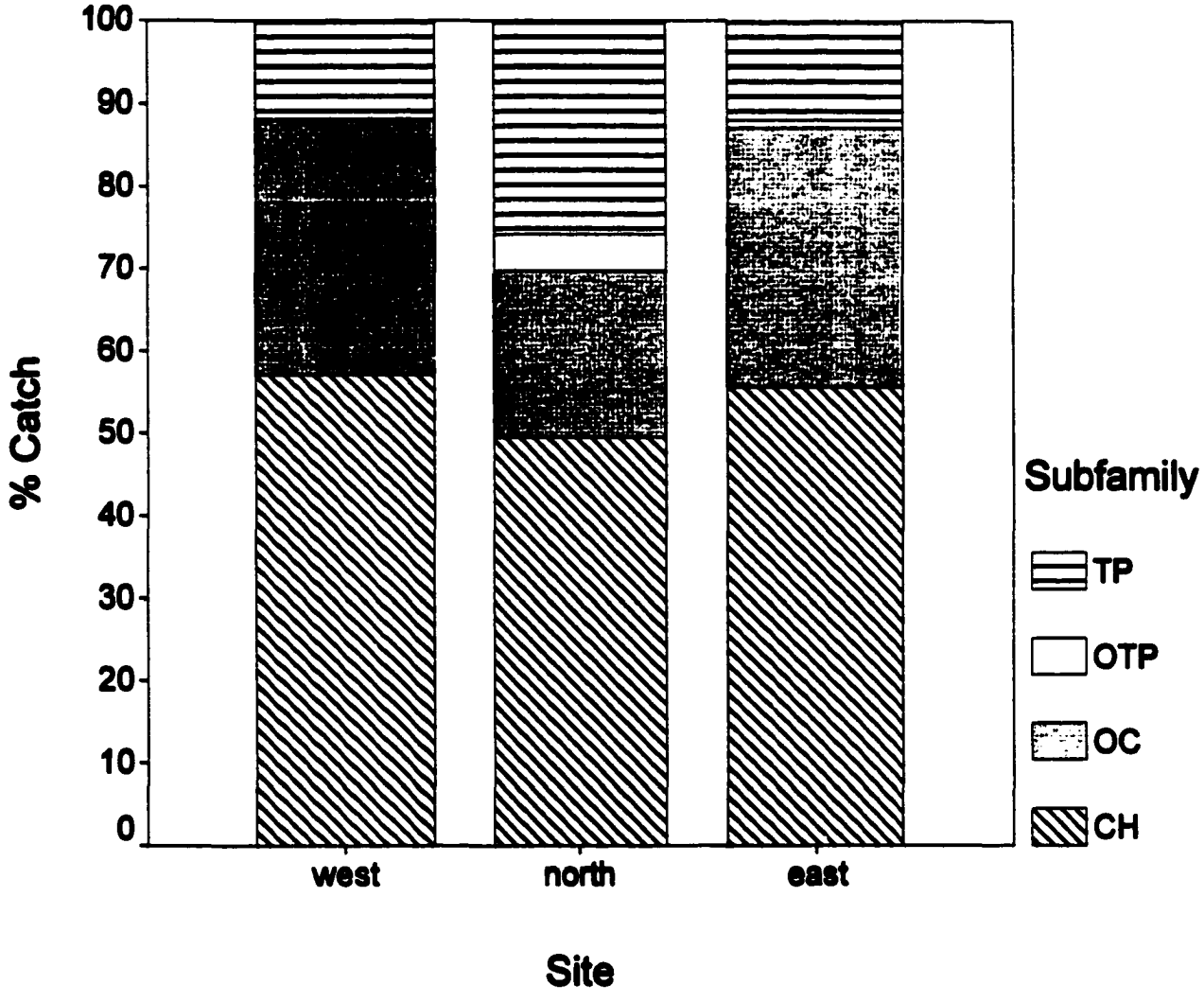


FIG. 9. Post-deforestation Chironomidae subfamily composition (% of catch) at the north (clearcut littoral embayment), west (clearcut with riparian buffer strip), and east (clearcut to shoreline) site July to August 1998. All depths are pooled (N = 90 traps total). [TP = Tanypodinae; OTP = Orthocladiinae-Tanypodinae complex.; OC = Orthocladiinae; OCH = Orthocladiinae-Chironominae complex.; CH = Chironominae]

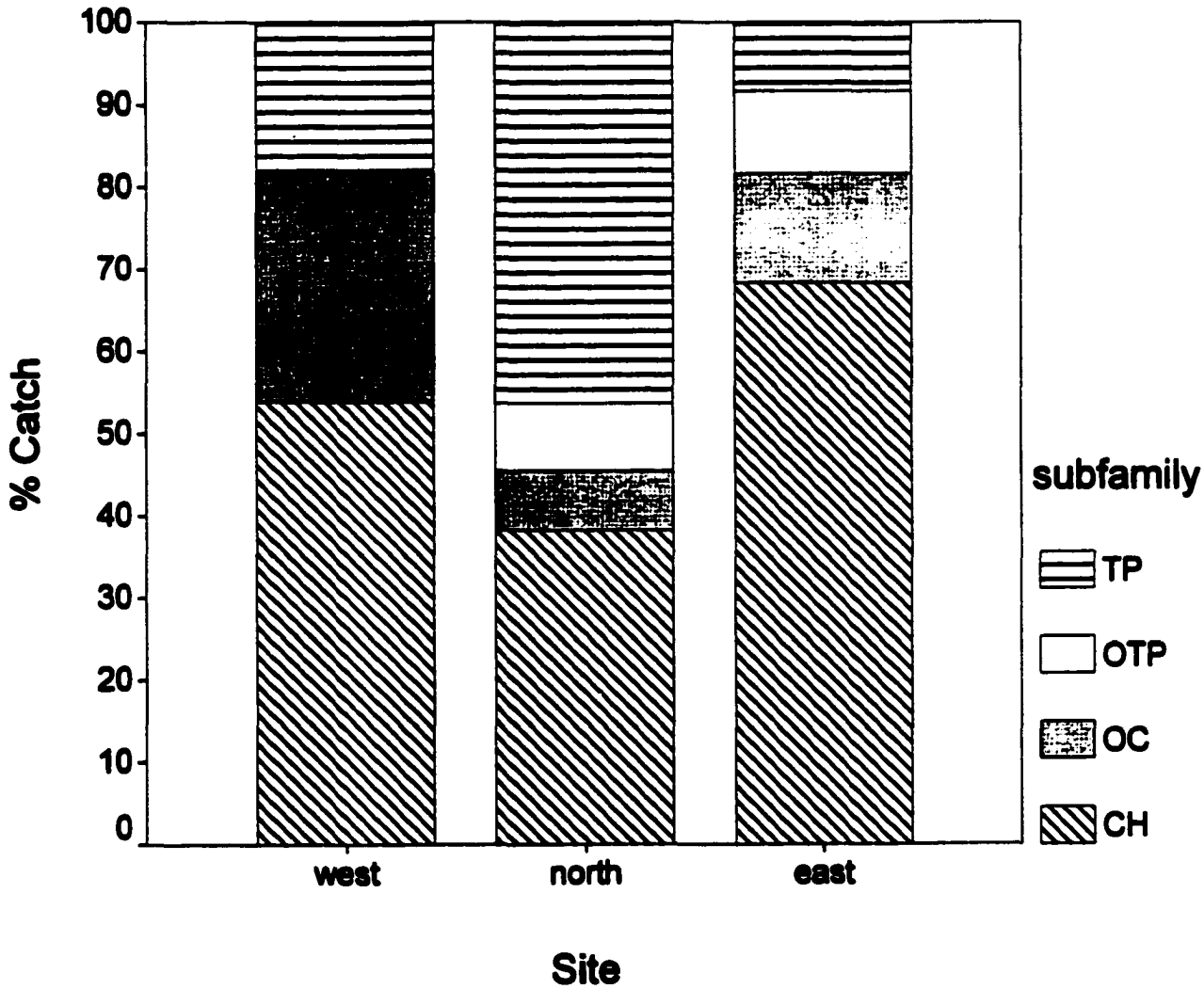


TABLE 12. 1995 male Chironomidae community composition. Fifteen emergence traps were deployed in the littoral and profundal zone of L42 for six twenty-four hour periods.

Subfamily	Tribe	No. genera	Genera	No. species	Species	% of annual catch (actual no. collected)
Tanypodinae		2	Ablabesmyia, Procladius	6	A. aspera, A. mallochi, A. parajanta, P. sublettei, P. bellus, P. denticulatus	7 (36)
Orthocladiinae		3	Nanocladius, Corynoneura, Psectrocladius	8	N. rectinervis, C. celeripes, C. fittkaui, C. scutellata, C. arctica, C. lacustris, P. limbatellus, P. simulans	27 (143)
Chironominae	Chironomini	5	Dicrotendipes, Cryptochironomous, Chironomus, Polypedilum, Tribelos	9	D. modestus, D. leucoscelis, C. sorex, C. longipes, C. maturus complex, P. nubeculosum, P. tritum, P. scalaenum, T. jucundum	2 (12)
	Tanytarsini	3	Paratanytarsus, Stempellinella, Tanytarsus	8	P. tenuis, S. undescr., S. bausei, S. leptocelloides, T. recurvatus, T. eminulus, T. mendax, T. signatus	18 (93)
	Chironomini -Tanytarsini grp.	9	Tanytarsus, Nilothauma, Dicrotendipes, Constempellina, Lauterborniella, Paralauterborniella, Paratanytarsus, Psectrocladius, Cladotanytarsus	12	T. eminulus, T. mendax, N. mirabile, N. undescr., D. modestus, C. rodesta, L. agrayloides, P. nigrohalteralis, P. tenuis, Ps. limbatellus, Cl. fusiformis	25 (128)

Subfamily	Tribe	No. genera	Genera	No. species	Species	% of annual catch (actual no. collected)
Orthocladiinae-Chironominae grp.		6	Paralauterborniella Parakiefferella, Stempellinella, Heterotanytarsus, Constempellina, Cricotopus, Cladotanytarsus	7	P. coronata, S. undescr., S. bausei, H. nudalus, Co. rodesta, Cr. politus, Cl. fusiformis,	18 (94)
Unidentified, damaged male Chironomidae						3 (15)
Total		21[a]		41[b]		100 (521)

[a] Total genera richness for 1995 July and August L42 male chironomid community
[b] Total species richness for 1995 July and August L42 male chironomid community

TABLE 13. 1997 male Chironomidae community composition. Fifteen emergence traps were deployed in the littoral and profundal zone of L42 for six twenty-four hour periods.

Subfamily	Tribe	No. genera	Genera	No. species	Species	% annual catch (actual no. collected)
Tanypodinae		5	Ablabesmyia, Procladius, Labrundinia, Larisa, Clinotanypus	9	A. aspera, A. mallochi, A. parajanta, P. sublettei, P. bellus, P. denticulatus, L. piosella, L. canadensis, C. pinguis	16 (46)
Orthocladiinae		4	Nanocladius, Corynoneura, Psectrocladius, Heterotanytarsus	9	N. rectinervis, C. celeripes, C. fittkaui, C. scutellata, C. arctica, C. lacustris, P. limbatellus, P. simulans, H. nudalus	27 (78)
Chironominae	Chironomini	4	Dicrotendipes, Polypedilum, Microtendipes, Cladopelma	7	D. modestus, D. leucoscelis, P. nubeculosum, P. tritum, P. scalaenum M. pedellus, C. amachaerum,	5 (15)
	Tanytarsini	2	Stempellinella, Tanytarsus	7	S. undescr., S. bausei, S. leptocelloides, T. recurvatus, T. eminulus, T. mendax, T. signatus	20 (57)
	Chironomini -Tanytarsini grp.	6	Tanytarsus, Nilothauma, Dicrotendipes, Constempellina, Paralauterborniella, Polypedilum	7	T. eminulus, T. mendax, N. mirabile, D. modestus, C. rodesta, Pa. nigrohalteralis, Po. simulans,	28 (80)

Subfamily	Tribe	No. genera	Genera	No. species	Species	% annual catch (actual no. collected)
Orthocladiinae-Tanypodinae grp.		2	Procladius, Cricotopus	3	P. sublettei, P. bellus, C. politus,	2 (5)
Unidentified, damaged male Chironomidae						1 (4)
Total		19[a]		36[b]		100 (285)

[a] Total genera richness for 1997 July and August L42 male chironomid community
[b] Total species richness for 1997 July and August L42 male chironomid community

TABLE 14. 1998 male Chironomidae community composition. Fifteen emergence traps were deployed in the littoral and profundal zone of L42 for six twenty-four hour periods.

Subfamily	Tribe	No. genera	Genera	No. species	Species	% annual catch (actual no. collected)
Tanypodinae		2	Ablabesmyia, Procladius	6	A. aspera, A. mallochi, A. parajanta, P. sublettei, P. bellus, P. denticulatus	30 (60)
Orthocladiinae		2	Corynoneura, Psectrocladius	7	C. celeripes, C. fittkaui, C. scutellata, C. arctica, C. lacustris, P. limbatellus, P. simulans	14 (30)
Chironominae	Chironomini	4	Dicrotendipes, Microtendipes, Chironomus, Paracladopelma	6	D. modestus, D. leucoscelis, M. pedellus, C. maturus complex, C. longipes, P. galaptera	5 (10)
	Tanytarsini	2	Stempellinella, Tanytarsus	7	S. undescr., S. bausei, S. leptocelloides, T. recurvatus, T. eminulus, T. mendax, T. signatus	30 (64)
	Chironomini -Tanytarsini grp.	6	Tanytarsus, Nilothauma, Cladotanytarsus, Constempellina, Paralauterborniella, Polypedilum	7	T. eminulus, T. mendax, N. mirabile, Cl. fusiformis, C. rodesta, Pa. nigrohalteralis, Po. simulans,	15 (33)
Orthocladiinae-Tanypodinae grp.		2	Procladius, Cricotopus	3	P. sublettei, P. bellus, C. politus,	6 (14)

Subfamily	Tribe	No. genera	Genera	No. species	Species	% annual catch (actual no. collected)
Unidentified, damaged male Chironomidae						2 (4)
Total		16[a]		32[b]		100 (215)

[a] **Total genera richness for 1998 July and August L42 male chironomid community**
[b] **Total species richness for 1998 July and August L42 male chironomid community**

TABLE 15. Chironomidae genera richness and catch counts during July and August from the north, west and east site at L42.

Genus	1995			1997			1998		
	N	W	E	N	W	E	N	W	E
Ablabesmyia	14	2	7	1	2	4	8	8	2
Chironomus	0	1	0	0	0	0	0	1	1
Chironomus-Dicrotendipes	0	3	0	0	0	0	0	0	0
Cladopelma	0	0	0	1	0	1	0	0	0
Clinotanypus	0	0	0	1	0	0	0	0	0
Constempellina-Lauterborniella-Paralauterborniella	1	19	18	0	0	0	0	0	0
Corynoneura	2	0	8	13	21	23	7	15	7
Cricotopus-Cladotanytarsus-Constempellina	1	1	1	0	0	0	0	0	0
Dicrotendipes	0	0	0	0	2	6	0	0	4
Dicrotendipes-Cryptochironomus	0	3	2	0	0	0	0	0	0
Heterotanytarsus	0	0	0	0	1	0	0	0	0
Heterotanytarsus-Paralauterborniella	4	7	3	0	0	0	0	0	0
Larsia	0	0	0	1	0	0	0	0	0
Microtendipes	0	0	0	0	3	0	2	1	0
Nanocladius-Corynoneura	18	87	24	1	3	0	0	0	0
Paracladopelma	0	0	0	0	0	0	0	1	0
Parakiefferella-Stempellinella	33	16	28	0	0	0	0	0	0
Paralauterborniella-Polypedilum-Constempellina	0	0	0	1	7	11	3	0	5
Paratanytarsus	50	5	1	0	0	0	0	0	0
Paratanytarsus-Nilothauma-Psectrocladius-Cladotanytarsus	9	1	3	0	0	0	0	0	0
Polypedilum	1	1	0	0	2	0	0	0	0
Procladius	11	2	0	18	7	2	37	2	3
Procladius-Cricotopus	0	0	0	4	0	1	8	0	6
Procladius-Labrundinia	0	0	0	2	1	2	0	0	0
Psectrocladius	1	3	0	4	1	7	0	0	1
Stempellinella	7	10	17	10	16	17	7	4	8
Tanytarsus	1	2	0	5	2	7	19	7	19
Tanytarsus-Dicrotendipes-Nilothauma	8	42	27	27	16	27	0	0	0
Tanytarsus-Nilothauma-Cladotanytarsus	0	0	0	0	0	0	6	15	4
Tribelos	0	1	0	0	0	0	0	0	0
Total number of genera per site per year:	18	21	18	17	15	14	12	10	14
Total number of genera per year:		21			19			16	

mean density (no. individuals · 0.28 m^{-2}· d^{-1}) of macroinvertebrates that emerged from benthos during the July and August subsample period (0.3, 0.4, 0.2; 1995, 1997, and 1998 respectively) (Table 16) was higher than the May through September period (0.2, 0.1; 1997 and 1998 respectively) (Table 17).

Protandry

Logging did not have an effect on chironomid protandry based on 24 hour sampling. Approximately one male chironomid emerged for every female chironomid during July through August in 1995, 1997 and 1998 (Table 16).

Chironomid egg masses

Chironomid egg masses were collected in both 1997 and 1998 from the submerged ventral surface of trap floats, buoy lines, brick anchors and Nuphar varigatum. Eggs were enveloped in a clear, transparent gelatinous matrix. Each matrix measured 45 cm in length. Within the matrix were successive rings of eight green ovoid eggs. Undeveloped eggs were green and mature eggs were brown. On 24 June 1997, egg masses which where attached to bricks in 0.5 m water were brought back to the lab. Each mass was placed in a PET jar in lake water, with an air stone and battery operated air pump and set on a windowsill. On 8 July 1998, chironomid larvae hatched from the brown egg mass. Larvae had two dark eyespots and two prominent vertical bands on the dorsum of the head. Black mandibles with a dark brown comb were also present. Larvae were active swimmers and did not build tubes or cases. Some larvae were examined live in a Petri dish under 16X using a dissecting microscope and transmitted light. All larvae lay quiescent after one minute of exposure to the external light source.

TABLE 16. Pre- (1995) and post-deforestation (1997 and 1998) insect emergence summary during July to August for the north, west, and east site on L42. All depths are pooled. Data are averages for the six-day period when traps were deployed.

Year	Site	No. valid (%) traps[a]	Chironomidae sex ratio male: female	Mean density other aquatic insects · 0.28 m^{-2} [b]
1995 (pre-cut)	north	28 (93)	1.0 : 0.9	0.3
	west	26 (87)	1.0 : 1.0	0.3
	east	27 (90)	1.0 : 0.8	0.2
1997 (1 yr. post-cut)	north	30 (100)	0.7 : 1.0	0.5
	west	27 (90)	1.0 : 1.0	0.3
	east	30 (100)	1.0 : 1.0	0.3
1998 (2 yrs. post-cut)	north	30 (100)	0.9 : 1.0	0.4
	west	25 (83)	1.0 : 0.8	0.2
	east	28 (93)	0.8 : 1.0	0.1

[a] A total of 30 emergence traps were deployed over six days at each site in each year. Valid traps are those which did not capsize in rough weather.

[b] Other aquatic insects include Emphemeroptera, Trichoptera, Corixidae, Gerridae, Ceratopogonidae, and Chaoboridae.

TABLE 17. Post-deforestation (1997 and 1998) insect emergence summary during May to September from the north, west and east site on L42. All depths are pooled. Data are averages for the May to September period.

Year	Site	No. valid (%) traps[a]	Mean no. other aquatic insects · 0.28 m^{-2} [b]
1997	north	108 (96)	0.2
	west	106 (95)	0.2
	east	108 (96)	0.1
1998	north	104 (100)	0.2
	west	102 (98)	0.1
	east	102 (98)	0.1

[a] A total of 112 emergence traps were deployed at each site over 14 days in 1997. In 1998, 104 traps were deployed at each site over 13 days. Valid traps are those which did not capsize in rough weather.
[b] Other aquatic insects include Emphemeroptera, Trichoptera, Corixidae, Gerridae, Ceratopogonidae, and Chaoboridae.

On 9 September 1997, 100 cm long transparent gelatinous egg masses were collected. Brown ovoid eggs were randomly arranged within the matrix. Egg masses were brought back to the lab and hatched after three weeks. These chironomid larvae built cases within three days from hatching. Although there was no visible debris in the collected lake water, all larvae built sedentary cases that opened anteriorly.

In an attempt to raise both green and brown chironomid eggs to the first, second, third, and fourth larval instar, two larvae of each type were transferred to 5 mL vials. This trial was unsuccessful after two weeks under laboratory conditions, as all larvae perished.

Mermithid nematodes

The abdomens of a few adult chironomids were infected with a roundworm parasite. At 40X under the dissecting microscope, mermithid nematodes were located spiraled internally along the entire length of the abdomen. Transmitted light permitted easy identification of infected larvae. In some cases, the anterior end of the nematode was protruding through the mid-dorsal tergites. In all cases, nematodes were opaque white. One parasitized adult specimen (Chironomus) from the reference collection had both male and female characteristics. The abdomen was broad like that of a female, lacked antennae, but possessed male genitalia. This morphogroup is commonly referred to as an intersex (Rempel 1940).

Watermite infestations

Watermites were abundant in July 1995 and 1997. Adult chironomids were parasitized most commonly around the head, antennae and thorax. It was common to see large masses of mites encompassing both antennae. Both male and female chironomids were infected, but only

during early June. General observation suggested that only Corynoneura were infected. These adults were small bodied (~3.0 mm in length) and transparent yellow.

Hydra colonies

Hydra was common in 1998 during the end of August and early September. Many Hydra (approximately 200) were collected when submerged traps were recovered from 9.0 and 12.0 metre depths along the west shore (clearcut with riparian buffer strip).

Specimens were brought back to the lab for general interest purposes. As an experiment, I fed live chironomid bloodworm larvae to the Hydra. Within a few minutes, larvae were stung by the nematocysts from Hydra tentacles and engulfed. Two days following initial feeding, ruptured chironomid haemoglobin was still visible within the Hydra body cavity.

DISCUSSION

Chironomidae density and natural variation

The density of chironomids emerging from lake benthos declined after experimental upland and riparian deforestation. After equal sampling effort during July and August, 1995 emergence was 62 % greater than 1997 emergence, and two and a half times greater than 1998 emergence abundance. In addition, 1997 May to September weekly emergence was 70 % higher than 1998 equal sampling effort. This annual decrease coincided with a progressive increase in upland and riparian deforestation. Rosenberg et al. (1995) trapped adult chironomids 200 km west of L42 from May through September (1984 to 1989) from Experimental Lakes Area L239 fen. They too, found significant yearly differences in adult emergence abundance; 1985 had higher emergence than 1986, and 1987 had higher emergence than 1988.

Trap-to-trap variability was significant at L42 in 1995, 1997 and 1998 at the west and east site. Patchy distribution of Chironomidae on preferred substrates and depth distributions likely caused significant intertrap variability. However, as I increased the number of replicate traps from 5 to 8 at the north site at 0.5 m depths, intertrap variability decreased significantly. Temporally, weekly differences in emergence abundance also occurred during July and August. This was likely due to a decrease in genera richness from 21 in 1995 to 19 in 1997 and to 16 genera in 1998.

Strong temporal differences in emergence occur naturally over the course of a season and year-to-year variability may be pronounced (Rosenberg et al. 1995). Variation in chironomid abundance also exists among other groups of lakes. Harvey and McArdle (1986) found chironomid abundance to be nearly five times greater in two of three acid lakes than in two reference lakes within the same year. Rosenberg et al. (1995) trapped adult chironomids from

May through September (1984 to 1989) from ELA L239 fen. Trap-to-trap variability was significant from 1984 to 1988. The significant year by week interaction term in 1987 and 1988 data resulted from higher counts early and late in the 1987 season, but higher counts in mid-season in 1988. Air temperatures and precipitation at ELA were highly variable from year-to-year (Beaty and Lyng 1988), and likely played a role in emergence abundance.

Catchment deforestation

In 1995, before experimental logging at L42, adult chironomids were more abundant when emerging from fine organic substrate (north site) than from a combination of cobbles and fine organic material (west and east site). Two years later, after 71 % and 42 % watershed and riparian deforestation, chironomid density was nearly uniform among sites. This result was unexpected because the lowest densities were found at the west site, which had a clearcut upland with riparian buffer strip intact. The two other sites, which had their corresponding shoreline clearcut including the removal of the riparian buffer strip had higher chironomid densities. The rate of chironomid emergence continued to decline when an additional 20 % of the riparian buffer strip was clearcut the following year. However, for no apparent reason, there was again a greater decrease in chironomid density from the shoreline that contained a buffer strip than from the two clearcut to shoreline sites.

Sedimentation

Aquatic sediment deposition has been associated with nutrient enrichment (Mattingly et al. 1981), and species composition in aquatic invertebrates (Rasmussen and Rowan 1997). The introduction of particulate material on aquatic insects may be quite serious. The organisms can be affected directly, such as when food collection or respiration is obstructed, or indirectly, such

as when depletion of the resources on which they depend occurs. Suspended or sedimented material can be deleterious because these substances reduce light penetration and consequently plant growth, bury hard surfaces, and fill interstices within the substrate.

Steedman and France (1999) distributed floating litter traps and terrestrial litterfall traps among undisturbed, buffer strip and clearcut riparian zones on four boreal forest lakes in northwestern Ontario. Terrestrial litterfall traps averaged $34 gm^{-2}yr^{-1}$ from clearcut riparian shores compared to only $2 gm^{-2}yr^{-1}$ from forested shoreline buffer strips, and $4 gm^{-2}yr^{-1}$ from upland forest. Steedman and France (1999) also monitored sediment deposition on L26, which retained all riparian forest, 3 km n-w of L42 (clearcut to the shoreline). Reduced post-logging mineral and organic sedimentation was attributed to dry weather and low catchment runoff in 1997. Long-term sedimentation rates in northwestern Ontario are more strongly associated with regional precipitation and runoff trends than with catchment disturbance by clearcutting (Steedman et al. 1999) or fire (Blais et al. 1998).

Steedman and France (1999) demonstrated that elevated sediment deposition at experimental L42 (clearcut to shoreline) was correlated with increased littoral wind energy and wave turbulence one year following deforestation of 61 % of the catchment riparian boundary. Aquatic sedimentation deposition was measured in L42 from 1995 through 1998, before, during and after clearcutting. Mean pre-harvest (1995 and 1996) sediment accumulation on L42 was 0.5 g per littoral zone granite tile (1 cm thick and 15 cm on a side). Mean post-harvest (1997 and 1998) sediment accumulation was 2.0 g per tile (Steedman and France 1999). This increase in sediment is likely responsible for a shift in chironomid subfamily distribution toward fewer Orthocladiinae and more Tanypodinae at L42.

Overall, Chironominae was the most abundant subfamily at L42, but subfamily distribution was variable among sites and year. Before logging, Orthocladiinae was dominant at the west site, which was comprised of cobbles and fine organic material. Chironominae was dominant at both the north and east site, which were comprised of fine organic material, and rubble and fine organic material, respectively. The first year after logging (1997) revealed a decrease in orthoclads at the west site and an increase in Tanypodinae at the north and east site. In 1998, a total of 74 % of the upland and 61 % of the riparian buffer strip around L42 was clearcut. The north and east site shorelines were experimentally clearcut including removal of riparian vegetation. Coincidentally, there was a significant increase in the number of predatory tanypods following deforestation.

Inorganic sediment recovered from the littoral tiles of L42 had particle sizes similar to the terrestrial aeolian sediment, primarily comprising fine to medium sand, with some silt and coarse sand. Tiles showed an increase in post-logging sedimentation (1.6 g / tile vs 0.3 g / tile) particularly in sand-sized particles potentially of aeolian origin (Steedman and France 1999). Tiles with highest sediment content were located towards the north end of L42 (clearcut littoral embayment). This is the same area in which a significant increase in predatory free-living tanypods was observed in 1998. Organic material was also elevated on tiles post-cut (0.4 g / tile vs 0.2 g / tile) (Steedman and France 1999). Organic material may have originated from aeolian deposition of terrestrial humus particles from the clearcut, from the logging slash deposited in the littoral zone, or from increased periphyton growth, attributed to loss of shade from the removal of riparian vegetation.

The two species of Chironomidae that were apparently favored by increased sedimentation in the Bay of Quinte, Stempellina sp. and Abiskomyia sp., inhabit cases that they

can transport across the bottom (Warwick 1980 a). A transportable case may enable larvae to exploit food resources in the sediment-water interface, whereas the tubes of more sedentary chironomid species would be clogged by sedimentation deposits (Grimas and Wiederholm 1979).

Water temperature

Complete loss of littoral shade increased near shore water temperatures in 1997 and 1998 at L42. Water surface temperatures increased by 0.1 °C in 1997 and by 0.5 °C in 1998 compared to the mean pre-logging surface temperature (21.6 °C) during July and August in 1995 when traps were deployed. Small changes from 2 to 4 °C in other lakes have been shown to affect lake thermal structure and physical properties (Schindler et al. 1980), invertebrate growth, primary production, and detrital decomposition (Webster and Waide 1982, and Rempel and Carter 1987).

Steedman et al. (1998) suggest that increases of up to 0.5 to 1.0 °C in daily maximum water temperature, and decreases of about 0.2 °C in daily minimum temperatures can be expected in small boreal lakes following riparian deforestation. They also suggested that hourly water temperature patterns were primarily associated with hourly patterns of solar energy, while day-to-day water temperature patterns were associated only with air temperature.

Depth distribution

Depth distribution was variable between site and year and differed among taxa. Chironomids preferred littoral depths (0.5, 1.0, 2.0, 3.0 and 4.5) to depths of 7.0, 9.0 and 12.0 m. Ninety percent of annual adult Chironomidae emergence from L42 arose from 0.5 m to 4.5 m depths of water in July and August 1995, and from 0.5 to 7.0 m depths during May through September 1997 and 1998. Corynoneura-Nanocladius was more frequent at 1.0, 3.0 and 4.5 m depths whereas Tanytarsus , Parakiefferella-Stempellinella, and Procladius-Cricotopus were

collected more often at 3.0, 4.5 and 7.0 m depths. Occasionally, only a few individuals of each genus (Tribelos, Labrundinia, Cladopelma, Paracladopelma, Larsia, Cladopelma) were collected in a year, thus it would be unreasonable to suggest that a particular genus had a depth distribution preference.

Davies (1980) collected adult chironomids once weekly for a 24-hr period at ELA at different depths and shoreline combinations. Emergence from a given depth was highly variable when measured at different locations around each lake on any single collection date. Cladotanytarsus fusiformis showed the narrowest range of depth preference (Bilyj and Davies 1989). More than 80 % of annual emergence was restricted to 0.5 m and 1.0 m. Other species of Cladotanytarsus emerged sporadically from 0.5 m to 5.0 m. No Cladotanytarsus species emerged at depths greater than 7.0 m.

L42 chironomid emergence from the littoral region was usually dominated by small individuals, whereas the percentage of larger individuals in the catch increased steadily with depth. Although chironomids were not identified from May through September 1997 and 1998 at 9.0 and 12.0 m depths, casual observation revealed that profundal species were larger than littoral species. Small Diptera made up the majority of emergence in ELA oligotrophic lakes (L223, L224) while larger individuals were more common in eutrophic lakes (L226 NE, L227) (Davies 1980).

Bilyj and Davies (1989) suggested that the rate of chironomid emergence gradually declines with increasing water depth. This theory was partially supported at L42. In 1997, the mean density (no. individuals $\cdot$ 0.28 $m^{-2} \cdot d^{-1} \pm$ S.E) of adult chironomids emerging from the east site (clearcut to shoreline) at 1.0 m depths was 18 $\pm$ 5, compared to 5 $\pm$ 1 at 4.5 m and 1 $\pm$ 0.3 at 12.0 m. However, this was not the trend at the west side of the lake (clearcut with riparian buffer

strip intact) where density was lowest at 12.0 m (1 ± 0.7) and highest at 4.5 m (14 ± 2). It is important to note that the slope bathymetry at the west site was, however, considerably more steep than at the east site, and thus was likely responsible for the difference in adult chironomid density.

Larval migration

Cowell and Hudson (1968) determined that chironomid larvae migrate to avoid disturbance. Horizontal migration was noted as chironomid density increased from depths of 1.2 m to 7.6 m. Post-logging chironomid densities at L42 increased at sublittoral depths of 3.0 m and 4.5 m compared to previous high pre-logging densities at 0.5 m and 1.0 m. This phenomenon could possibly be an indication of horizontal movement by larvae in response to avoidance of sediment deposition attributed to clearcut logging.

Emergence

Voltinism

Voltinism refers to the number of generations that an insect population completes in one year. Oliver (1971) suggested that the majority of chironomids from cold temperate regions demonstrate two generations per year (bivoltine). In higher taxa, Orthocladiinae include more species with multivoltine life cycles, Chironominae have few multivoltine cycles and the Tanypodinae have 1 to 3 generations per year. Oliver (1971) characterized orthoclads as being cold-adapted, and capable of rapid development, while species of Chironominae are warm-adapted. A general observation is that species with small body size (Corynoneura, Nanocladius and Tanytarsus) tend to complete more generations in a year than those with a large body (Chironomus spp.) (Armitage et al. 1995).

Intraspecific variation in voltinism exists within the Chironomidae. Chironomus plumosus is multivoltine in the littoral zone but univoltine in the profundal zone of lakes (Terek and Losos 1979). Interspecific variation in emergence patterns is also common in chironomids. Patterns of emergence vary temporally and spatially depending on growth and development of the larva. Some of the factors that affect larval development include water temperature, food supply, oxygen concentration, pH, and photoperiod (Armitage et al. 1995).

Observation of adult emergence patterns alone is insufficient to establish the voltinism of a particular species (Armitage et al. 1995). The number of emergence peaks observed does not necessarily correspond to voltinism if there are different cohorts within a population. Therefore, to be able to determine L42 chironomid voltinism, it is necessary to collect information on larval chironomid growth and development based on proportions of larval instar stages through each year.

June to August is the major period of adult emergence for univoltine chironomid species including Psectrocladius limbatellus, Paracladopelma nigritula and Procladius signatus from subarctic Lake Thingvallavatn which is ice bound from December until April. Spring emergence (2-3 weeks after ice-melt in May/June) in a subarctic lake in northwestern Canada (Moore 1979) was dominated by univoltine species including Procladius, Heterotanytarsus, Parakiefferiella, Polypedilum, Micropsectra and Tanytarsus. All of these five genera were collected at L42 from 1995 to 1998.

Bilyj and Davies (1989) investigated ecological parameters affecting Cladotanytarsus for eleven continuous years at ELA L223. C. tribelos exhibited a univoltine life cycle with synchronous emergence that lasted for 1 to 2 weeks and occurred between mid May and early June of each year. C. fusiformis emergence extended over a 4 week period annually and usually

peaked during the last week of June. ELA is approximately 200 km west of L42, and as such it is probable that L42 chironomids exhibit a univoltine cycle as well.

Bivoltine species emerge during spring and summer / early autumn. Dicrotendipes modestus and Polypedilum nubeculosum exhibited spring emergence in May / June and summer emergence in August, while the second generation emerged in September / October in Lake Esrom, Denmark (Jonsson 1985). Similarly, Cladotanytarsus, Tanytarsus mendax (Potter and Learner 1974), and Cricotopus (LeSage and Harrison 1980) had two emergence periods, first in May / June and second in September/October in Salem Creek in southern Ontario. All of these genera were sampled sporadically from L42 during July and August. Emergence was continuous at L42 and could be attributed to overlapping generations of univoltine and bivoltine species.

Synchronicity

Chironomids exhibited taxon-specific emergence patterns at L42. Some species such as Stempellinella and Corynoneura emerged at low densities over a few weeks, while others emerged within a few days. Synchronous emergence relates to the duration of the larval period, which is affected by temperature, oxygen concentration, photoperiod, water level and food resources. Emergence from the north site was highly synchronous in 1995 by Paratanytarsus, in 1997 by Procladius and Tanytarsus, and in 1998 by Procladius. Chironomid emergence from the west and east site was synchronous in 1995 by Nanocladius-Corynoneura only. After experimental timber harvest, there were no taxa with highly synchronous emergence at the west and east site.

Synchronicity increases the chances of sexual encounters and hence reproductive success. In the northern hemisphere, Orthocladiinae emerge during the spring and autumn, whereas

Chironominae and Tanypodinae are abundant during summer (Rempel and Harrison 1987) with Tanypodinae often dominant in autumn. Within the seasonal patterns of emergence, there are also daily rhythms. Few chironomids emerge evenly throughout the day. Environmental cues for the timing of emergence have been attributed to changes in light intensity and water temperatures.

Diel emergence patterns for Chironomidae tribes have been summarized by Learner and Pickering (1990). Chironomini species exhibit a crepuscular or nocturnal pattern, whereas Tanytarsini emerge at dusk with less abundant emergence at dawn and early morning, and Orthocladiini appear to emerge during daylight hours with peaks in early morning or late afternoon / early evening. I deployed traps for a full 24-hrs period to avoid differences in diel emergence patterns.

Dispersal by wind

Most dispersal of chironomids is passive and modified by factors such as wind direction and speed (Armitage et al. 1995). Watershed deforestation and perhaps more importantly riparian deforestation, may be detrimental to the formation of swarms. Most male chironomids engage in aerial swarming as a typical mating behavior. Swarms are formed almost immediately after eclosion but the occurrence and location of swarms is affected by wind speed and direction, light intensity and humidity (Armitage et al. 1995). Swarms are frequent with wind speeds less than 11 km / hr and temperatures greater than 10 °C. Actual wind speed in excess of 15 km / hr prevented swarming (Armitage et al. 1995). The position of male chironomid swarms is related to a marker, or landmark that contrasts against the ground or sky. Trees and riparian vegetation

are usual markers because they have sharp boundaries (LeSage and Harrison 1980). Catchment deforestation may therefore have a negative impact on the success of swarm formation.

Summary

If logging were detrimental to the aquatic environment, we would expect changes to be detected first via water chemistry and secondly by lake biota. Post-logging (May 1991 to August 1996) epilimnetic water chemistry medians were similar to the post deforestation (August 1996 to 1997) period at L42. These data suggest that logging did not eutrophicate L42. However, there may be a lag effect of the consequences of riparian deforestation on water chemistry. Given that long-term sedimentation rates in northwestern Ontario are more strongly associated with regional precipitation and runoff trends than with catchment disturbance by clearcutting, it is probable that it may take more than two years after the commencement of logging to identify subtle changes within the stable L42 environment (Steedman et al. 1999).

After monitoring insects on either a weekly or bi-weekly basis I determined that chironomid emergence is synchronous and as such, once weekly sampling may not be sufficient to estimate density and genus richness. As well, L42 chironomids may be univoltine, bivoltine or multivoltine. Pre-logging voltinism was not measured during May through September, and as such, I could not determine if post-logging voltinism was affected by logging. We do know that chironomid density was significantly lower after riparian and upland deforestation, but we do not know what pre-deforestation seasonal variation is for the L42 chironomid community. Therefore, it is difficult to distinguish natural variation from the potential impact of clearcut logging on Chironomidae density.

Chironomids typically emerged soon after ice out in early spring (May) and they continued to emerge until late fall (mid September). Chironomids were collected in 1997 and 1998 during this period but only during July and August in 1995. Post-deforestation genera richness could therefore not be compared with the full seasonal pre-deforestation community. This suggests that genera richness summaries during July and August 1995, 1997 and 1998 should not be extrapolated to conclude that logging does not affect the aquatic insect community.

Should logging companies request to cut around boreal forest lakes, I propose that they leave a buffer strip around the perimeter of each lake. The presence of a buffer strip reduces wind velocity, prevents water-borne sedimentation of aquatic habitats by protecting soils (particularly surficial organic layers), retards the velocity of overland flow, captures bedload, and reduces aeolian sediment transport (France 1997 a). A buffer strip would also enable chironomid swarm formations resulting in continued reproduction, and as such, perhaps post-logging chironomid densities and richness would not vary significantly from pre-logging communities.

Chironomids can be used as effective indicators of ecosystem health. An ideal scenario would include monitoring aquatic insects for multiple years before, during and after catchment deforestation. However, it would still be beneficial to continue the aquatic insect monitoring component of the Coldwater Lakes Experimental Watersheds program for an additional five years or more, including a study of immature insects. This long-term post-deforestation study would be invaluable to entomologists worldwide and at the same time educate foresters about the significance of aquatic insects as biological monitors in small boreal forest lakes. Convincing evidence has yet to be published about long-term adult chironomid population dynamics in undisturbed lakes and no known studies have utilized adult chironomids as indicators of

ecosystem degradation following experimental upland and riparian deforestation around oligotrophic boreal forest lakes.

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APPENDICES

APPENDIX 1. Preservation series for adult chironomid mounting on microscope slides.

1. Dissect chironomid in 70 % EtOH in glass Petri dish under stereoscope at 16X. Gently tease wings, one antenna, three legs (hind, mid and fore), head, abdomen and thorax until individual structures are separated from body.
2. Add head with one antenna, thorax with 3 legs and abdomen to 10 % potassium hydroxide (KOH). Let sit overnight at room temperature.
3. Place wings, loose antenna, three legs and all structures in (#2) into glacial acetic acid (GAA) for twenty minutes.
4. Expose all structures to absolute (anhydrous) ethyl alcohol for fifteen minutes.
5. Apply one drop of Euparal mounting medium onto microscope slide.
6. Place one structure onto Euparal and add an additional drop.
7. Cover structure with a 12 mm round cover slip.
8. Repeat steps 6 and 7 with remaining chironomid structures.
9. Dry slide in oven at 40 °C for five days or until Euparal has hardened.

(After Al Weins personal comments April 1997).

APPENDIX 2. Model equation used in the factorial analysis of variance of the rate of Chironomidae emergence and the description of model parameters.

Model $Y_{ijk} = \mu + S_i + D_j + SD_{ij} + \varepsilon_{(ij)k}$

where $i = 1, 2, 3$; $j = 1, 2, \ldots, 5$; $k = 1$

Parameter	Definition
Y_{ijk}	= the rate of chironomid emergence
μ	= the overall mean
S_i	= the fixed effect of the i^{th} site
D_j	= the fixed effect of the j^{th} depth of water
SD_{ij}	= the interaction effect of the i^{th} site and the j^{th} depth of water
$\varepsilon_{(ij)k}$	= The random effect of the k^{th} of 1 experimental unit in the ij^{th} site combination. The $\varepsilon_{(ij)k}$ are assumed to be IID $N(0, \sigma^2)$

APPENDIX 3. Expected mean squares table and associated degrees of freedom used in parameter estimation in the factorial analysis of variance of rate of chironomid emergence

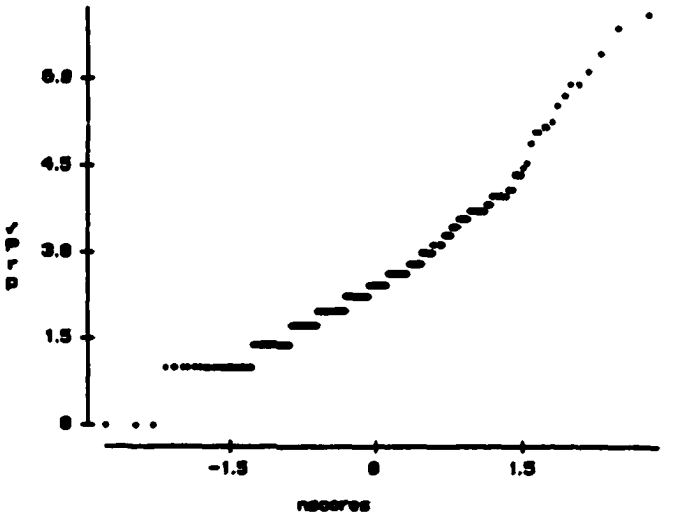
Parameter	Expected Mean Squares	Degrees of freedom
S_i	$\sigma^2 + 5\,\phi\,(S)$	1
D_j	$\sigma^2 + 2\,\phi\,(D)$	4
SD_{ij}	$\sigma^2 + 1\,\phi\,(SD)$	4
$\varepsilon_{(ij)k}$	σ^2	0
Total		2(5) – 1 = 9

APPENDIX 4. Tests of hypotheses used in the factorial analysis of variance of rate of chironomid emergence.

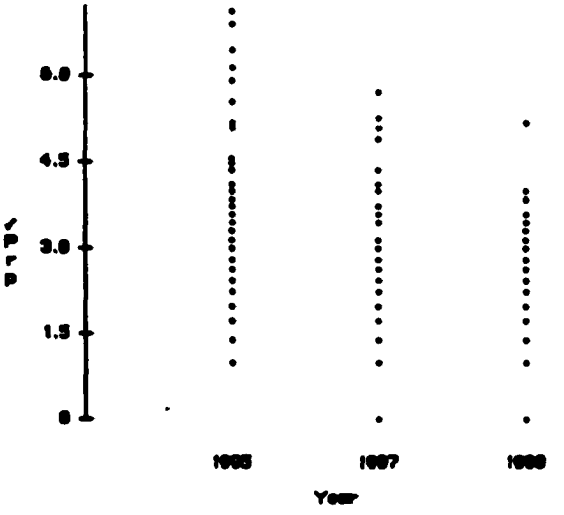
Hypothesis	Test statistic	Reference distribution
ϕ (S)	MS (S) / MS (SD)	F (1, 4)
ϕ (D)	MS (D) / MS (SD)	F (4, 4)
ϕ (SD)	NO TEST	

APPENDIX 5 A-B. A. Normal probability plot using the squareroot transformation of the dependent variable (rate of chironomid emergence = no. · 0.28 m^{-2} · d^{-1}). B. Y x X Dotplot (count / year) to check homogeneity of variance.

A



B



APPENDIX 6. ANOVA table for July to August 1995, 1997, and 1998 with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and year as the main effect.

Source	df	Sums of Squares	Mean Square	F-ratio	probability
Year	2	49.09	24.54	19.55	< 0.01 *
Error	248	311.42	1.26		
Total	250	360.50			

Least significant difference post-hoc tests

Factor (year)	Difference	std. err.	probability
1997 - 1995	-0.77	0.17	< 0.01 *
1998 - 1995	-1.06	0.18	< 0.01 *
1998 - 1997	-0.29	0.17	0.10

*denotes significance with α at 0.05

APPENDIX 7. ANOVA table for July to August 1995, 1997, and 1998 at the north site with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and year as the main effect.

Source	df	Sums of Squares	Mean Square	F-ratio	probability
Year	2	6.73	3.36	2.85	0.05 *
Error	85	100.38	1.18		
Total	87	107.12			

Least significant difference post-hoc tests

Factor (year)	Difference	std. err.	probability
1997 vs 1995	-0.56	0.28	0.04 *
1998 vs 1995	-0.61	0.28	0.03 *
1998 vs 1997	-0.04	0.28	0.86

* denotes significance with α at 0.05

APPENDIX 8. ANOVA table for July to August 1995 with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and site (west and east) and depth distribution (0.5, 1.0, 3.0, 4.5, 7.0 m) as the main effects.

Source	df	Sums of Squares	Mean Square	F-ratio	$F_{critical}$
site	1	0.45	0.45	0.4/6.3 =0.06	$F_{0.05(1),1,4}$=7.71
depth	4	9.37	2.34	2.3/6.3=0.37	$F_{0.05(1),1,4}$=7.71
site*depth	4	25.23	6.31	NO TEST	
Error	47	32.87	0		
Total	56	70.86			

APPENDIX 9. ANOVA table for July to August 1995 at the west site with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and with depth distribution (0.5, 1.0, 3.0, 4.5, 7.0 m) as the main effect.

Source	df	Sums of Squares	Mean Square	F-ratio	probability
Depth	4	36.94	9.23	4.64	< 0.01 *
Error	21	41.76	1.99		
Total	25	78.70			

Least significant difference post-hoc tests

Factor (depth)	Difference	std. err.	probability
1 - 0.5	2.23	0.85	0.02 *
3 - 0.5	0.83	0.85	0.34
3 - 1	-1.40	0.89	0.13
4.5 - 0.5	2.22	0.91	0.02 *
4.5 - 1	-0.02	0.95	0.99
4.5 - 3	1.38	0.95	0.16
7 - 0.5	-0.77	0.81	0.35
7 - 1	-3.01	0.85	< 0.01 *
7 - 3	-1.60	0.85	0.07
7 - 4.5	-2.99	0.91	< 0.01 *

*denotes significance with α at 0.05

APPENDIX 10. ANOVA table for July to August 1995 at the east site with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and depth distribution (0.5, 1.0, 3.0, 4.5, 7.0 m) as the main effect.

Source	df	Sums of Squares	Mean Square	F-ratio	probability
Depth	4	3.31	0.83	0.91	0.48
Error	22	19.97	0.91		
Total	26	23.28			

APPENDIX 11. ANOVA table for July to August 1997 with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and site (west and east) and depth distribution (0.5, 1.0, 3.0, 4.5, 7.0 m) as the main effects.

Source	df	Sums of Squares	Mean Square	F-ratio	$F_{critical}$
Site *	1	0.69	0.69	0.69/4.06=0.17	$F_{0.05(1),1,4}$=7.71
Depth *	4	13.71	3.42	3.4/4.06=0.84	$F_{0.05(1),1,4}$=7.71
Sitex Depth	4	16.24	4.06	NO TEST	
Error	47	39.06	0		
Total	56	69.43			

*denotes a Conservative Test

APPENDIX 12. ANOVA table for July to August 1997 at the west site with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and depth distribution (0.5, 1.0, 3.0, 4.5, 7.0 m) as the main effect.

Source	df	Sums of Squares	Mean Square	F-ratio	probability
Depth	4	17.93	4.48	8.75	< 0.01 *
Error	22	11.28	0.51		
Total	26	29.21			

Least significant post-hoc tests

Factor (depth)	Difference	std. err.	probability.
1 - 0.5	0.28	0.45	0.53
3 - 0.5	0.89	0.45	0.06
3 - 1	0.61	0.45	0.19
4.5 - 0.5	2.30	0.43	< 0.01 *
4.5 - 1	2.02	0.43	< 0.01 *
4.5 - 3	1.41	0.43	< 0.01 *
7 - 0.5	1.07	0.43	0.02 *
7 - 1	0.79	0.43	0.08
7 - 3	0.18	0.43	0.67
7 - 4.5	-1.23	0.41	< 0.01 *

*denotes significance with α at 0.05

APPENDIX 13. ANOVA table for July to August 1997 at the east site with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and depth distribution (0.5, 1.0, 3.0, 4.5, 7.0 m) as the main effect.

Source	df	Sums of Squares	Mean Square	F-ratio	probability
Depth	4	12.05	3.01	2.71	0.05 *
Error	25	27.79	1.11		
Total	29	39.85			

Least significant difference post-hoc tests

Factor (depth)	Difference	std. err.	probability.
1 - 0.5	1.36	0.60	0.03 *
3 - 0.5	0.28	0.60	0.64
3 - 1	-1.08	0.60	0.08
4.5 - 0.5	0.50	0.60	0.41
4.5 - 1	-0.85	0.60	0.17
4.5 - 3	0.22	0.60	0.71
7 - 0.5	-0.56	0.60	0.36
7 - 1	-1.92	0.60	< 0.01 *
7 - 3	-0.84	0.60	0.17
7 - 4.5	-1.07	0.60	0.08

*denotes significance with α at 0.05

APPENDIX 14. ANOVA table for July to August 1998 with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and site (west and east) and depth distribution (0.5, 1.0, 3.0, 4.5, 7.0 m) as the main effects.

Source	df	Sums of Squares	Mean Square	F-ratio	$F_{critical}$
Site *	1	0.33	0.33	0.3/0.4=0.75	$F_{0.05(1),1,4}$=7.71
Depth *	4	3.20	0.80	0.8/0.4=2	$F_{0.05(1),1,4}$=7.71
Depth x Site	4	1.66	0.41	NO TEST	
Error	43	21.92	0		
Total	52	27.61			

*denotes a Conservative Test

APPENDIX 15. ANOVA table for July to August 1998 at the west site with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and depth distribution (0.5, 1.0, 3.0, 4.5, 7.0 m) as the main effect.

Source	df	Sums of Squares	Mean Square	F-ratio	probability
Depth	4	0.60	0.15	0.41	0.79
Error	20	7.28	0.36		
Total	24	7.89			

APPENDIX 16. ANOVA table for July to August 1998 at the east site with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and depth distribution (0.5, 1.0, 3.0, 4.5, 7.0 m) as the main effect.

Source	df	Sums of Squares	Mean Square	F-ratio	probability
Depth	4	4.68	1.17	1.84	0.15
Error	23	14.63	0.63		
Total	27	19.32			

Least significant difference post-hoc tests

Factor (depth)	Difference	std. err.	probability
1 - 0.5	-0.47	0.46	0.31
3 - 0.5	-0.25	0.48	0.59
3 - 1	0.21	0.48	0.65
4.5 - 0.5	-0.55	0.46	0.24
4.5 - 1	-0.07	0.46	0.87
4.5 - 3	-0.29	0.48	0.55
7 - 0.5	-1.25	0.48	0.01 *
7 - 1	-0.78	0.48	0.11
7 - 3	-1.00	0.50	0.06 *
7 - 4.5	-0.70	0.48	0.15

*denotes significance with α at 0.05

APPENDIX 17. ANOVA table for May to September 1997 and 1998 with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and year as the main effect.

Source	df	Sums of Squares	Mean Square	F-ratio	probability
Year	1	38.54	38.54	23.79	< 0.01 *
Error	628	1017.09	1.61		
Total	629	1055.63			

* denotes significance with α at 0.05

APPENDIX 18. ANOVA table for May to September 1997 and 1998 at the north site with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and year as the main effect.

Source	df	Sums of Squares	Mean Square	F-ratio	probability
Year	1	6.81	6.81	4.74	0.03 *
Error	210	301.50	1.43		
Total	211	308.31			

* denotes significance with α at 0.05

APPENDIX 19. ANOVA table for May to September 1997 with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and site (west and east) and depth distribution (0.5, 1.0, 2.0, 3.0, 4.5, 7.0, 9.0, 12.0) as the main effects.

Source	df	Sums of Squares	Mean Square	F-ratio	$F_{critical}$
Site *	1	0.010	0.01	0.0/5.5=0.01	$F_{0.05(1),1,7}$=5.59
Depth *	7	122.33	17.47	17.5/5.5=3.2	$F_{0.05(1),1,7}$=5.59
Depth x Site	7	38.50	5.50	NO TEST	
Error	198	292.79	0		
Total	213	456.192			

*denotes a Conservative Test

APPENDIX 20. ANOVA table for May to September 1997 at the west site with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and depth distribution (0.5, 1.0, 2.0, 3.0, 4.5, 7.0, 9.0 and 12.0 m) as the main effect.

Source	df	Sums of Squares	Mean Square	F-ratio	probability
Depth	7	80.37	11.48	8.25	< 0.01 *
Error	98	136.32	1.39		
Total	105	216.701			

Least significant difference post-hoc tests

Factor (depth)	Difference	std. err.	probability
1 - 0.5	0.62	0.45	0.17
2 - 0.5	1.15	0.44	0.01 *
2 - 1	0.53	0.45	0.24
3 - 0.5	0.68	0.46	0.14
3 - 1	0.05	0.47	0.89
3 - 2	-0.47	0.46	0.30
4.5 - 0.5	1.76	0.44	< 0.01 *
4.5 - 1	1.14	0.45	0.01 *
4.5 - 2	0.60	0.44	0.17
4.5 - 3	1.08	0.46	0.02 *
7 - 0.5	0.23	0.44	0.60
7 - 1	-0.38	0.45	0.39
7 - 2	-0.92	0.44	0.04 *
7 - 3	-0.44	0.46	0.33
7 - 4.5	-1.53	0.44	< 0.01 *
9 - 0.5	-0.36	0.46	0.437418
9 - 1	-0.98	0.47	0.03 *
9 - 2	-1.52	0.46	< 0.01 *
9 - 3	-1.04	0.48	0.03 *
9 - 4.5	-2.12	0.46	< 0.01 *
9 - 7	-0.59	0.46	0.20
12 - 0.5	-1.24	0.45	< 0.01 *
12 - 1	-1.86	0.46	< 0.01 *
12 - 2	-2.40	0.45	< 0.01 *
12 - 3	-1.92	0.47	< 0.01 *
12 - 4.5	-3.00	0.45	< 0.01 *
12 - 7	-1.47	0.45	< 0.01 *
12 - 9	-0.88	0.47	0.06

*denotes significance with α at 0.05

APPENDIX 21. ANOVA table for May to September 1997 at the east site with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and depth distribution (0.5, 1.0, 2.0, 3.0, 4.5, 7.0, 9.0 and 12.0 m) as the main effect.

Source	df	Sums of Squares	Mean Square	F-ratio	probability
Depth	7	83.01	11.85	7.57	<0.01 *
Error	100	156.47	1.56		
Total	107	239.48			

Least significant difference post-hoc tests

Factor (depth)	Difference	std. err.	probability
1 - 0.5	1.26	0.48	< 0.01 *
2 - 0.5	-0.11	0.48	0.80
2 - 1	-1.38	0.47	< 0.01 *
3 - 0.5	-0.53	0.48	0.27
3 - 1	-1.79	0.47	< 0.01 *
3 - 2	-0.41	0.47	0.38
4.5 - 0.5	-0.49	0.49	0.31
4.5 - 1	-1.76	0.48	< 0.01 *
4.5 - 2	-0.37	0.48	0.43
4.5 - 3	0.03	0.48	0.94
7 - 0.5	-1.15	0.48	0.02 *
7 - 1	-2.42	0.47	< 0.01 *
7 - 2	-1.03	0.47	0.03 *
7 - 3	-0.62	0.47	0.18
7 - 4.5	-0.66	0.48	0.17
9 - 0.5	-1.32	0.49	< 0.01 *
9 - 1	-2.59	0.48	<0.01 *
9 - 2	-1.20	0.48	0.02 *
9 - 3	-0.79	0.48	0.10
9 - 4.5	-0.83	0.49	0.09
9 - 7	-0.17	0.48	0.72
12 - 0.5	-1.71	0.49	< 0.01 *
12 - 1	-2.97	0.48	< 0.01 *
12 - 2	-1.59	0.48	< 0.01 *
12 - 3	-1.18	0.48	0.02 *
12 - 4.5	-1.21	0.49	0.02 *
12 - 7	-0.55	0.48	0.24
12 - 9	-0.38	0.49	0.43

*denotes significance with α at 0.05

APPENDIX 22. ANOVA table for May to September 1998 with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and site (west and east) and depth distribution (0.5, 1.0, 2.0, 3.0, 4.5, 7.0, 9.0, 12.0) as the main effects.

Source	df	Sums of Squares	Mean Square	F-ratio	$F_{critical}$
Site *	1	1.22	1.22	1.2/1.6=0.75	$F_{0.05(1),1,7}$=5.59
Depth *	7	64.38	9.19	9.2/1.6=5.75	$F_{0.05(1),1,7}$=5.59
Site x Depth	7	10.97	1.56	NO TEST	
Error	188	160.78	0		
Total	203	237.66			

*denotes a Conservative Test

APPENDIX 23. ANOVA table for May to September 1998 at the west site with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and depth distribution (0.5, 1.0, 2.0, 3.0, 4.5, 7.0, 9.0 and 12.0 m) as the main effect.

Source	df	Sums of Squares	Mean Square	F-ratio	probability
Depth	7	45.19	6.45	8.15	<0.01 *
Error	94	74.46	0.79		
Total	101	119.65			

Least significant difference post-hoc tests

Factor (depth)	Difference	std. err.	probability
1 - 0.5	0.18	0.34	0.60
2 - 0.5	0.84	0.34	0.02 *
2 - 1	0.66	0.34	0.06
3 - 0.5	0.90	0.36	0.02 *
3 - 1	0.72	0.36	0.04 *
3 - 2	0.06	0.36	0.86
4.5 - 0.5	0.50	0.34	0.14
4.5 - 1	0.32	0.34	0.34
4.5 - 2	-0.33	0.34	0.33
4.5 - 3	-0.39	0.36	0.27
7 - 0.5	-0.16	0.34	0.64
7 - 1	-0.34	0.34	0.32
7 - 2	-1.00	0.34	< 0.01 *
7 - 3	-1.07	0.36	< 0.01 *
7 - 4.5	-0.67	0.34	0.05 *
9 - 0.5	-0.64	0.34	0.06
9 - 1	-0.82	0.34	0.02 *
9 - 2	-1.48	0.34	< 0.01 *
9 - 3	-1.55	0.36	< 0.01 *
9 - 4.5	-1.15	0.34	< 0.01 *
9 - 7	-0.48	0.34	0.17
12 - 0.5	-1.16	0.34	< 0.01 *
12 - 1	-1.34	0.34	< 0.01 *
12 - 2	-2.00	0.34	< 0.01 *
12 - 3	-2.06	0.36	< 0.01 *
12 - 4.5	-1.66	0.34	< 0.01 *
12 - 7	-0.99	0.34	< 0.01 *
12 - 9	-0.51	0.34	0.14

*denotes significance with α at 0.05

APPENDIX 24. ANOVA table for May to September 1998 at the east site with rate of Chironomidae emergence (no. · 0.28 m^{-2} · d^{-1}) as the response variable and depth distribution (0.5, 1.0, 2.0, 3.0, 4.5, 7.0, 9.0 and 12.0 m) as the main effect.

Source	df	Sums of Squares	Mean Square	F-ratio	probability
Depth	7	30.24	4.32	4.70	< 0.01 *
Error	94	86.32	0.91		
Total	101	116.57			

Least significant difference post-hoc tests

Factor (depth)	Difference	std. err.	probability
1 - 0.5	-0.26	0.38	0.49
2 - 0.5	-0.64	0.38	0.09
2 - 1	-0.37	0.39	0.34
3 - 0.5	0.02	0.37	0.94
3 - 1	0.28	0.38	0.45
3 - 2	0.66	0.38	0.08
4.5 - 0.5	-0.69	0.37	0.06
4.5 - 1	-0.42	0.38	0.27
4.5 - 2	-0.05	0.38	0.89
4.5 - 3	-0.71	0.37	0.06
7 - 0.5	-1.01	0.37	< 0.01 *
7 - 1	-0.74	0.38	0.05 *
7 - 2	-0.37	0.38	0.33
7 - 3	-1.03	0.37	< 0.01 *
7 - 4.5	-0.31	0.37	0.39
9 - 0.5	-0.87	0.37	0.02 *
9 - 1	-0.60	0.38	0.11
9 - 2	-0.23	0.38	0.54
9 - 3	-0.89	0.37	0.02 *
9 - 4.5	-0.18	0.37	0.63
9 - 7	0.13	0.37	0.71
12 - 0.5	-1.71	0.37	< 0.01*
12 - 1	-1.44	0.38	< 0.01 *
12 - 2	-1.07	0.38	< 0.01 *
12 - 3	-1.73	0.37	< 0.01 *
12 - 4.5	-1.02	0.37	< 0.01 *
12 - 7	-0.70	0.37	0.06
12 - 9	-0.84	0.37	0.02 *

*denotes significance with α at 0.05

PPENDIX 25. Pre-deforestation aquatic insect taxon richness from July to August, 1995 at the north site (pre-clearcut littoral embayment). The response ıriable is the rate of chironomid emergence (no. · 0.28 m^{-2} · d^{-1}).

Taxon	Set # (Date)	1 (July 7)					Total	2 (July 9)					Total	3 (July 22)					Total
	Replicate trap	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5	
Ablabesmyia		0	0	1	0	0	1	0	0	0	0		0	1	0	0	1	0	2
Constempellina-Lauterborniella-Paralauterborniella		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Corynoneura		2	0	0	0	0	2	0	0	0	0		0	0	0	0	0	0	0
Cricotopus-Cladotanytarsus-Constempellina		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Heterotanytarsus-Paralauterborniella		3	0	0	0	0	3	0	0	0	1		1	0	0	0	0	0	0
Nanocladius-Corynoneura		0	0	1	0	0	1	0	2	0	6		8	0	1	0	0	0	1
Parakiefferella-Stempellinella		4	0	0	3	3	10	0	1	6	3		10	3	0	1	1	0	5
Paratanytarsus		3	0	0	0	0	3	0	0	4	0		4	1	0	0	0	2	3
Paratanytarsus-Nilothauma-Psectrocladius-Cladotanytarsus		0	0	0	0	0	0	0	0	0	0		0	0	0	5	0	0	5
Polypedilum		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Procladius		0	0	0	1	0	1	0	0	0	0		0	0	0	4	1	2	7
Psectrocladius		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Stempellinella		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Tanytarsus		0	1	0	0	0	1	0	0	0	0		0	0	0	0	0	0	0
Tanytarsus-Dicrotendipes-Nilothauma		0	0	0	0	0	0	0	1	1	1		3	0	0	0	0	0	0
Male Chironomidae		12	1	2	4	3	22	0	4	11	11		26	5	1	10	3	4	23
Female Chironomidae		3	0	4	3	6	16	5	7	3	5		20	9	0	11	6	4	30
Unidentified damaged Chironomidae		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
Chironomidae pupa		0	0	0	0	0	0	0	1	0	0		1	0	0	0	0	0	0
Ceratopogonidae		0	0	0	0	0	0	1	0	0	0		1	0	0	0	0	0	0
Ephemeroptera		0	0	0	0	0	0	1	0	0	2		3	0	0	0	0	1	1
Other		0	0	0	0	0	0	0	1	0	0		1	0	0	0	0	0	0
Trichoptera		0	1	0	0	0	1	1	0	0	1		2	0	0	2	0	0	2

Continued

Taxon	Set # (Date)	4 (August 4)					Total	5 (August 6)					Total	6 (August 19)					Total	Grand Total
	Replicate trap	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		
Ablabesmyia		0	0	1	2	0	4	1	2	0	2	0	5	0	2	1	0		3	14
Constempellina-Lauterborniella-Paralauterborniella		0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0		0	1
Corynoneura		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	2
Cricotopus-Cladotanytarsus-Constempellina		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0		1	1
Heterotanytarsus-Paralauterborniella		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	4
Nanocladius-Corynoneura		1	1	0	2	1	5	0	0	0	0	1	1	0	1	1	0		2	18
Parakiefferella-Stempellinella		4	0	0	0	2	6	0	0	0	1	1	2	0	0	0	0		0	33
Paratanytarsus		2	0	1	0	0	3	0	0	0	0	0	0	0	0	15	22		37	50
Paratanytarsus-Nilothauma-Psectrocladius-Cladotanytarsus		0	0	0	1	0	1	1	1	0	1	0	3	0	0	0	0		0	9
Polypedilum		0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0		0	1
Procladius		0	0	0	0	0	0	0	1	1	1	0	3	0	0	0	0		0	11
Psectrocladius		0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0		0	1
Stempellinella		0	0	0	2	1	3	0	0	0	4	0	4	0	0	0	0		0	7
Tanytarsus		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	1
Tanytarsus-Dicrotendipes-Nilothauma		0	1	0	0	0	1	0	0	0	1	0	1	0	3	0	0		3	8
Male Chironomidae		7	3	3	8	4	25	2	5	1	11	3	22	0	7	17	22		46	164
Female Chironomidae		7	1	8	6	5	27	1	4	1	8	1	15	1	6	10	16		33	141
Unidentified damaged Chironomidae		0	0	0	0	0	0	0	1	0	1	0	2	0	0	0	0		0	2
Chironomidae pupa		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0		1	2
Ceratopogonidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	1
Ephemeroptera		0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0		0	5
Other		0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	0		1	3
Trichoptera		2	0	0	1	3	6	0	0	2	1	0	3	0	1	0	0		1	15

PPENDIX 26. Post-deforestation aquatic insect taxon richness from July to August, 1997 at the north site (clearcut littoral embayment). The response ariable is the rate of chironomid emergence (no. · 0.28 m^{-2} · d^{-1}).

Taxon	Set # (Date)	1 (July 2)					Total	2 (July 9)					Total	3 (July 23)					Total
	Replicate trap	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5	
Ablabesmyia		0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Cladopelma		0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Clinotanypus		0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Corynoneura		0	0	0	1	0	1	0	0	0	0	0	0	1	0	1	2	1	5
Larsia		0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Nanocladius-Corynoneura		0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Paralauterborniella-Polypedilum-Constempellina		0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Procladius		0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	5	1	11
Procladius-Cricotopus		0	1	0	0	1	2	0	0	0	0	0	0	1	0	1	0	0	2
Procladius-Labrundinia		0	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0
Psectrocladius		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stempellinella		0	2	1	0	0	3	0	0	0	1	1	2	1	0	0	0	1	2
Tanytarsus		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Tanytarsus-Dicrotendipes-Nilothauma		1	1	1	0	2	5	6	1	0	1	1	9	3	0	0	1	2	6
Male Chironomidae		1	5	2	2	6	16	7	1	0	3	3	14	8	0	6	8	5	27
Female Chironomidae		1	4	3	5	1	14	1	3	4	1	1	10	5	1	2	2	1	11
Chironomidae larva		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomidae pupa		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Other		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera		1	1	0	0	2	4	2	0	0	1	0	3	0	0	1	0	0	1

Continued

Taxon	Set # (Date)	4 (July 30)					Total	5 (August 6)					Total	6 (August 19)					Total	Grand Total
	Replicate trap	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		
Ablabesmyia		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Cladopelma		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Clinotanypus		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Corynoneura		1	0	0	1	1	3	0	1	0	0	2	3	0	1	0	0	0	1	1
Larsia		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Nanocladius-Corynoneura		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Paralauterborniella-Polypedilum-Constempellina		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Procladius		0	1	0	1	1	3	1	1	0	1	0	3	0	1	0	0	0	1	1
Procladius-Cricotopus		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Procladius-Labrundinia		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Psectrocladius		0	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	
Stempellinella		0	0	0	0	1	1	0	2	0	0	0	2	0	0	0	0	0	0	1
Tanytarsus		0	0	2	0	0	2	0	0	0	0	2	2	0	0	0	0	0	0	
Tanytarsus-Dicrotendipes-Nilothauma		0	0	0	0	2	2	0	0	1	2	0	3	0	1	0	0	1	2	2
Male Chironomidae		1	1	2	2	9	15	1	4	1	3	4	13	0	3	0	0	1	4	8
Female Chironomidae		1	2	2	10	17	32	5	6	1	3	4	19	3	13	3	3	13	35	12
Chironomidae larva		0	0	0	0	0	0	0	1	0	0	1	2	0	0	0	0	0	0	
Chironomidae pupa		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Other		0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	4	
Trichoptera		0	0	0	0	0	0	2	0	0	0	2	4	0	0	0	0	0	0	1

PPENDIX 27. Post-deforestation aquatic insect taxa richness from July to August, 1998 at the north site (clearcut littoral embayment). The response riable is the rate of chironomid emergence (no. · 0.28 m^{-2} · d^{-1}).

Taxon	Set # (Date)	1 (July 2)					Total	2 (July 16)					Total	3 (July 29)					Total
	Replicate trap	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5	
Ablabesmyia		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Corynoneura		1	0	0	1	0	2	0	0	0	1	0	1	0	0	1	2	1	4
Microtendipes		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Paralauterborniella-Polypedilum-Constempellina		0	0	0	0	0	0	0	0	1	2	0	3	0	0	0	0	0	0
Procladius		0	0	0	0	0	0	8	3	6	15	3	35	0	0	0	0	0	0
Procladius-Cricotopus		0	0	0	0	0	0	1	1	0	0	0	2	0	0	1	1	0	2
Stempellinella		1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1
Tanytarsus		3	2	2	2	6	15	0	2	0	0	1	3	0	0	0	0	0	0
Tanytarsus-Nilothauma-Cladotanytarsus		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Male Chironomidae		5	2	2	3	6	18	9	6	7	18	4	44	0	1	2	4	2	9
Female Chironomidae		6	6	3	2	0	17	6	9	3	9	5	32	2	0	4	3	2	11
Unidentified damaged Chironomidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomidae larva		0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1
Ceratopogonidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera		0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera		1	0	1	0	1	3	0	0	0	0	1	1	0	0	0	0	0	0
Other		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1

Continued

Taxon	Set # (Date)	4 (August 5)					Total	5 (August 13)					Total	6 (August 19)					Total	Grand Total
	Replicate trap	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		
Ablabesmyia		0	0	0	0	1	1	0	1	2	2	1	6	0	0	0	0	0	0	8
Corynoneura		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Microtendipes		0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2
Paralauterborniella-Polypedilum-Constempellina		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Procladius		0	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	37
Procladius-Cricotopus		0	1	0	1	1	3	1	0	0	0	0	1	0	0	0	0	0	0	8
Stempellinella		0	0	0	2	0	2	0	0	1	0	0	1	0	0	0	1	1	2	7
Tanytarsus		1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	19
Tanytarsus-Nilothauma-Cladotanytarsus		0	1	0	0	0	1	0	1	0	2	0	3	0	0	0	1	1	2	6
Male Chironomidae		1	4	1	4	3	13	1	2	3	4	1	11	0	0	0	2	2	4	99
Female Chironomidae		1	1	0	8	3	13	0	2	4	6	4	16	1	13	0	8	3	25	114
Unidentified damaged Chironomidae		0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Chironomidae larva		0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	2	4
Ceratopogonidae		0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1
Ephemeroptera		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Trichoptera		0	0	1	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	6
Other		0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2

APPENDIX 28. Pre-deforestation aquatic insect taxon richness and depth distribution from July to August, 1995 at the west site (pre-clearcut with riparian buffer strip). The response variable is the rate of chironomid emergence (no. · 0.28 m^{-2} · d^{-1}).

Taxon	Set # (Date)	1 (July 7)					Total	2 (July 9)					Total	3 (July 22)					Total
	Depth (m)	0.5	1	3	4.5	7		0.5	1	3	4.5	7		0.5	1	3	4.5	7	
Ablabesmyia		0	0	1		0	1	1	0	0		0	1	0			0	0	0
Chironomus		0	0	0		0	0	0	0	0		1	1	0			0	0	0
Chironomous-Dicrotendipes		2	0	0		0	2	0	1	0		0	1	0			0	0	0
Constempellina-Lauterborniella-Paralauterborniella		0	0	0		0	0	0	0	0		0	0	0			1	0	1
Cricotopus-Cladotanytarsus-Constempellina		0	0	0		0	0	0	0	0		0	0	0			0	0	0
Dicrotendipes-Cryptochironomous		0	0	0		0	0	0	0	0		0	0	0			0	0	0
Heterotanytarsus-Paralauterborniella		0	0	1		0	1	0	0	0		3	3	2			0	1	3
Nanocladius-Corynoneura		2	9	1		0	12	3	2	0		0	5	0			17	0	17
Parakiefferella-Stempellinella		3	3	0		0	6	2	5	0		0	7	0			2	0	2
Paratanytarsus		0	0	0		0	0	0	0	0		2	2	0			0	0	0
Paratanytarsus-Nilothauma-Psectrocladius-Cladotanytarsus		0	0	0		0	0	0	0	0		0	0	0			0	0	0
Polypedilum		0	0	0		0	0	0	0	0		0	0	0			0	0	0
Procladius		0	0	0		1	1	0	0	0		0	0	1			0	0	1
Psectrocladius		0	0	0		1	1	0	0	0		0	0	0			1	0	1
Stempellinella		0	3	0		0	3	0	0	0		0	0	0			0	0	0
Tanytarsus		0	2	0		0	2	0	0	0		0	0	0			0	0	0
Tanytarsus-Dicrotendipes-Nilothauma		0	2	1		0	3	0	0	0		0	0	1			0	0	1
Tribelos		0	1	0		0	1	0	0	0		0	0	0			0	0	0
Male Chironomidae		7	20	8		2	37	6	8	0		6	20	4			21	1	26
Female Chironomidae		3	15	5		4	27	1	9	1		2	13	3			14	0	17
Chironomidae larva		0	0	1		0	1	0	0	0		0	0	0			0	0	0
Chironomidae pupa		2	0	0		1	3	0	0	0		0	0	0			0	0	0
Ephemeroptera		0	0	0		0	0	0	0	0		0	0	0			0	0	0
Other		0	0	0		0	0	0	0	1		0	1	0			1	1	2
Trichoptera		0	0	0		0	0	0	0	0		0	0	0			0	0	0

Continued

Taxon	Set # (Date)	4 (August 4)					Total	5 (August 6)					Total	6 (August 19)					Total	Grand Total
	Depth (m)	0.5	1	3	4.5	7		0.5	1	3	4.5	7		0.5	1	3	4.5	7		
Ablabesmyia		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Chironomus		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Chironomous-Dicrotendipes		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Constempellina-Lauterborniella-Paralauterborniella		0	6	1	1	1	9	0	1	5	3	0	9	0	0	0	0	0	0	19
Cricotopus-Cladotanytarsus-Constempellina		0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Dicrotendipes-Cryptochironomous		0	1	0	0	0	1	2	0	0	0	0	2	0	0	0	0	0	0	3
Heterotanytarsus-Paralauterborniella		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Nanocladius-Corynoneura		2	11	15	13	1	42	0	3	0	2	0	5	0	1	0	5	0	6	87
Parakiefferella-Stempellinella		0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	16
Paratanytarsus		0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3	5
Paratanytarsus-Nilothauma-Psectrocladius-Cladotanytarsus		0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Polypedilum		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1
Procladius		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Psectrocladius		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	3
Stempellinella		0	0	1	1	1	3	0	0	0	1	1	2	1	1	0	0	0	2	10
Tanytarsus		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Tanytarsus-Dicrotendipes-Nilothauma		8	13	1	1	0	23	0	7	3	1	0	11	2	1	0	1	0	4	42
Tribelos		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Male Chironomidae		10	32	18	19	3	82	2	11	8	13	1	35	4	3	3	6	0	16	216
Female Chironomidae		6	19	24	29	4	82	2	20	6	13	2	43	4	5	11	0	4	24	206
Chironomidae larva		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Chironomidae pupa		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Ephemeroptera		0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	0	0	1	2
Other		1	0	0	0	0	1	0	1	0	1	0	2	0	0	0	0	0	0	6
Trichoptera		0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1

APPENDIX 29. Post-deforestation aquatic insect taxon richness and depth distribution from July to August, 1997 at the west site (clearcut with riparian buffer strip). The response variable is the rate of chironomid emergence (no. · 0.28 m^{-2} · d^{-1}).

Taxon	Set # (Date)	1 (July 2)					Total	2 (July 9)					Total	3 (July 23)					Total
	Depth (m)	0.5	1	3	4.5	7		0.5	1	3	4.5	7		0.5	1	3	4.5	7	
Ablabesmyia		0			0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Corynoneura		0			1	0	1	0	1	1	0	5	7	1	1	1	2	1	6
Dicrotendipes		0			0	0	0	0	0	1	0	0	1	0	1	0	0	0	1
Heterotanytarsus		0			0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Microtendipes		0			1	2	3	0	0	0	0	0	0	0	0	0	0	0	0
Nanocladius-Corynoneura		0			3	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Paralauterborniella-Polypedilum-Constempellina		0			0	0	0	0	0	0	0	0	0	0	0	0	1	2	3
Polypedilum		1			0	0	1	0	0	0	0	0	0	0	0	1	0	0	1
Procladius		0			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Procladius-Labrundinia		0			0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Psectrocladius		0			1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Stempellinella		1			1	0	2	0	0	0	2	0	2	0	0	3	2	0	5
Tanytarsus		0			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tanytarsus-Dicrotendipes-Nilothauma		1			1	0	2	0	0	0	2	1	3	2	0	0	1	0	3
Male Chironomidae		3			8	4	15	0	1	2	5	7	15	3	2	5	6	3	19
Female Chironomidae		2			11	3	16	1	0	0	3	5	9	3	0	2	10	1	16
Chironomidae pupa		0			0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
Chaoboridae		0			0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera		0			0	0	0	1	1	0	0	0	2	0	1	0	0	0	1
Trichoptera		1			0	0	1	0	1	0	0	0	1	1	0	0	0	0	1

Continued

Taxon	Set # (Date)	4 (July 30)					Total	5 (August 6)					Total	6 (August 19)					Total	Grand Total
	Depth (m)	0.5	1	3	4.5	7		0.5	1	3	4.5	7		0.5	1	3	4.5	7		
Ablabesmyia			0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2
Corynoneura			1	2	1	0	4	0	0	1	1	0	2	0	0	0	1	0	1	21
Dicrotendipes			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Heterotanytarsus			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Microtendipes			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Nanocladius-Corynoneura			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Paralauterborniella-Polypedilum-Constempellina			0	0	2	1	3	0	0	0	1	0	1	0	0	0	0	0	0	7
Polypedilum			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Procladius			0	0	0	0	0	0	2	1	3	1	7	0	0	0	0	0	0	7
Procladius-Labrundinia			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Psectrocladius			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Stempellinella			0	0	2	1	3	0	0	0	1	0	1	0	0	1	0	2	3	16
Tanytarsus			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2
Tanytarsus-Dicrotendipes-Nilothauma			1	0	3	0	4	0	0	1	0	0	1	0	0	1	2	0	3	16
Male Chironomidae			2	2	8	2	14	0	2	3	6	1	12	0	1	2	3	4	10	85
Female Chironomidae			3	2	9	2	16	1	4	4	8	2	19	0	0	4	5	3	12	88
Chironomidae pupa			0	1	0	0	1	0	0	0	0	0	0	0	0	1	1	0	2	4
Chaoboridae			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ephemeroptera			0	0		0	0	0	0	0	0	0	0	1	0	0	0	0	1	4
Trichoptera			0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	4

APPENDIX 30. Post-deforestation aquatic insect taxon richness and depth distribution from July to August, 1998 at the west site (clearcut with riparian buffer strip). The response variable is the rate of chironomid emergence (no. · 0.28 m^{-2} · d^{-1}).

Taxon	Set # (Date)	1 (July 2)					Total	2 (July 16)					Total	3 (July 29)					Total
	Depth (m)	0.5	1	3	4.5	7		0.5	1	3	4.5	7		0.5	1	3	4.5	7	
Ablabesmyia		0	0	1	0	0	1	0	0	0			0	0	0	2	0		2
Chironomus		0	0	1	0	0	1	0	0	0			0	0	0	0	0		0
Corynoneura		1	0	1	3	1	6	0	0	2			2	0	1	0	1		2
Microtendipes		0	0	0	0	0	0	0	0	0			0	0	0	0	0		0
Paracladopelma		0	0	0	0	0	0	0	0	0			0	0	0	0	0		0
Procladius		0	0	0	0	0	0	1	0	0			1	0	0	0	0		0
Stempellinella		0	1	0	0	0	1	0	0	0			0	1	1	0	0		2
Tanytarsus		0	0	0	0	0	0	1	1	0			2	2	0	0	0		2
Tanytarsus-Nilothauma-Cladotanytarsus		0	0	0	0	0	0	0	0	0			0	0	0	0	0		0
Male Chironomidae		1	1	3	3	1	9	2	1	2			5	3	2	2	1		8
Female Chironomidae		0	2	0	4	2	8	0	1	3			4	0	5	3	0		8
Chironomidae pupa		0	0	0	0	1	1	0	0	0			0	0	0	0	0		0
Ceratopogonidae		0	0	0	0	0	0	0	0	0			0	1	0	0	0		1
Ephemeroptera		0	0	0	0	0	0	0	0	0			0	0	0	1	0		1
Trichoptera		0	1	0	0	0	1	0	0	0			0	0	0	0	0		0

Continued

Taxon	Set # (Date)	4 (August 5)					Total	5 (August 13)					Total	6 (August 19)					Total	Grand Total
	Depth (m)	0.5	1	3	4.5	7		0.5	1	3	4.5	7		0.5	1	3	4.5	7		
Ablabesmyia		0	0	0	1	2	3	0	0		0	1	1	0	1	0	0		1	8
Chironomus		0	0	0	0	0	0	0	0		0	0	0	0	0	0	0		0	1
Corynoneura		1	2	0	0	0	3	0	0		0	0	0	1	0	1	0		2	15
Microtendipes		0	0	1	0	0	1	0	0		0	0	0	0	0	0	0		0	1
Paracladopelma		0	0	0	0	0	0	0	0		0	1	1	0	0	0	0		0	1
Procladius		0	0	0	0	0	0	0	0		0	1	1	0	0	0	0		0	2
Stempellinella		0	0	0	0	0	0	0	0		0	0	0	1	0	0	0		1	4
Tanytarsus		0	0	0	0	0	0	2	0		0	1	3	0	0	0	0		0	7
Tanytarsus-Nilothauma-Cladotanytarsus		0	1	3	0	0	4	0	3		1	0	4	0	5	2	0		7	15
Male Chironomidae		1	3	4	1	2	11	2	3		1	4	10	2	6	3	0		11	54
Female Chironomidae		3	1	1	2	0	7	1	1		0	2	4	4	4	3	1		12	43
Chironomidae pupa		0	0	0	0	0	0	0	0		0	0	0	0	0	0	0		0	1
Ceratopogonidae		0	0	0	0	0	0	0	0		0	0	0	0	0	0	0		0	1
Ephemeroptera		0	0	0	0	0	0	0	0		0	0	0	0	0	0	0		0	1
Trichoptera		0	0	0	0	0	0	0	0		0	0	0	0	0	0	0		0	1

PPENDIX 31. Pre-deforestation aquatic insect taxon richness and depth distribution from July to August, 1995 at the east site (pre - clearcut to shoreline). ıe response variable is the rate of chironomid emergence (no. · 0.28 m^{-2} · d^{-1}).

Taxon	Set # (Date)	1 (July 7)					Total	2 (July 9)					Total	3 (July 22)					Total
	Depth (m)	0.5	1	3	4.5	7		0.5	1	3	4.5	7		0.5	1	3	4.5	7	
Ablabesmyia		0	0	0	1	0	1	0		0	0	0	0		0		1	0	1
Constempellina-Lauterborniella-Paralauterborniella		0	0	0	0	0	0	0		0	0	0	0		0		0	0	0
Corynoneura		0	7	0	0	1	8	0		0	0	0	0		0		0	0	0
Cricotopus-Cladotanytarsus-Constempellina		0	0	0	0	0	0	0		0	0	0	0		0		0	0	0
Dicrotendipes-Cryptochironomous		0	0	0	0	0	0	0		0	0	0	0		0		0	0	0
Heterotanytarsus-Paralauterborniella		0	0	0	2	0	2	0		0	0	0	0		0		0	0	0
Nanocladius-Corynoneura		0	0	1	0	0	1	0		0	0	0	0		1		0	3	4
Parakiefferella-Stempellinella		0	1	0	0	0	1	0		2	0	0	2		1		8	3	12
Paratanytarsus		0	0	0	0	0	0	0		0	0	0	0		0		0	0	0
Paratanytarsus-Nilothauma-Psectrocladius-Cladotanytarsus		0	0	0	0	0	0	4		0	0	0	0		0		0	0	0
Stempellinella		1	2	2	0	1	6	0		0	0	2	6		0		0	0	0
Tanytarsus-Dicrotendipes-Nilothauma		0	0	0	1	0	1	4		0	0	0	0		2		0	1	3
Male Chironomidae		1	10	3	4	2	20	2		2	0	2	8		4		9	7	20
Female Chironomidae		0	4	4	4	0	12	0		2	4	0	8		2		3	6	11
Unidentified damaged Chironomidae		0	0	0	0	0	0	0		0	0	0	0		0		0	0	0
Chironomidae pupa		0	0	0	0	0	0	0		0	0	0	0		0		0	0	0
Ephemeroptera		0	0	0	0	0	0	0		0	0	0	0		0		0	0	0
Trichoptera		0	0	0	0	0	0	0		0	0	0	0		0		0	1	1
Other		0	0	0	0	0	0	0		0	0	0	0		0		0	0	0

Continued

Taxon	Set # (Date)	4 (August 4)					Total	5 (August 6)					Total	6 (August19)					Total	Grand Total
	Depth (m)	0.5	1	3	4.5	7		0.5	1	3	4.5	7		0.5	1	3	4.5	7		
Ablabesmyia		1	0	0	0	0	1	2	0	0	0	0	2	0	0	2	0	0	2	7
Constempellina-Lauterborniella-Paralauterborniella		0	0	2	3	6	11	3	2	0	0	0	5	2	0	0	0	0	2	18
Corynoneura		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Cricotopus-Cladotanytarsus-Constempellina		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Dicrotendipes-Cryptochironomous		0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	2
Heterotanytarsus-Paralauterborniella		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	3
Nanocladius-Corynoneura		4	4	1	0	2	11	0	3	0	0	2	5	1	2	0	0	0	3	24
Parakiefferella-Stempellinella		1	0	1	0	3	5	0	1	1	3	3	8	0	0	0	0	0	0	28
Paratanytarsus		0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Paratanytarsus-Nilothauma-Psectrocladius-Cladotanytarsus		0	0	0	0	0	0	3	0	0	0	0	3	0	0	0	0	0	0	3
Stempellinella		0	0	0	0	0	0	0	0	0	0	0	0	1	3	1	0	0	5	17
Tanytarsus-Dicrotendipes-Nilothauma		0	1	2	0	0	3	0	3	0	1	3	7	6	3	1	0	3	13	27
Male Chironomidae		6	5	8	3	11	33	9	9	3	4	8	33	11	8	4	0	4	27	141
Female Chironomidae		11	8	2	4	8	33	7	7	2	4	6	26	9	5	2	5	2	23	113
Unidentified damaged Chironomidae		0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	0	2
Chironomidae pupa		0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	2
Ephemeroptera		0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Trichoptera		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Other		0	0	2	0	0	2	0	0	0	1	0	1	0	0	0	0	0	0	3

APPENDIX 32. Post-deforestation aquatic insect taxon richness and depth distribution from July to August, 1997 at the east site (clearcut to shoreline). The response variable is the rate of chironomid emergence (no. · 0.28 m^{-2} · d^{-1}).

Taxon	Set # (Date)	1 (July 2)					Total	2 (July 9)					Total	3 (July 23)					Total
	Depth (m)	0.5	1	3	4.5	7		0.5	1	3	4.5	7		0.5	1	3	4.5	7	
Ablabesmyia		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cladopelma		0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Corynoneura		0	7	1	0	0	8	0	0	0	0	0	0	0	0	0	1	1	2
Dicrotendipes		0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Procladius		0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	1
Psectrocladius		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Procladius-Cricotopus		0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Procladius-Labrundinia		0	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Paralauterborniella-Polypedilum-Constempellina		0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1
Stempellinella		0	3	0	0	0	3	0	2	1	3	0	6	1	1	0	0	0	2
Tanytarsus		0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Tanytarsus-Dicrotendipes-Nilothauma		2	5	0	2	0	9	0	2	0	0	0	2	1	0	1	0	0	2
Male Chironomidae		2	19	4	2	1	28	1	4	2	3	0	10	2	1	1	2	2	8
Female Chironomidae		0	14	0	1	2	17	1	5	3	7	2	18	1	6	6	3	1	17
Unidentified damaged Chironomidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomidae pupa		1	2	0	2	0	5	1	0	0	1	0	2	1	1	1	0	0	3
Ephemeroptera		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Ceratopogonidae		0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Trichoptera		0	1	0	0	0	1	2	0	0	0	0	2	0	0	0	0	0	0
Other		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Continued

Taxon	Set # (Date)	4 (July 30)					Total	5 (August 6)					Total	6 (August 19)					Total	Grand Total
	Depth (m)	0.5	1	3	4.5	7		0.5	1	3	4.5	7		0.5	1	3	4.5	7		
Ablabesmyia		0	3	0	0	0	3	0	1	0	0	0	1	0	0	0	0	0	0	4
Cladopelma		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Corynoneura		0	5	0	1	0	6	5	0	0	0	0	5	1	0	0	1	0	2	23
Dicrotendipes		0	0	0	0	0	0	5	0	0	0	0	5	0	0	0	0	0	0	6
Paralauterborniella-Polypedilum-Constempellina		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Procladius		0	0	1	0	0	1	0	0	1	0	1	2	0	0	0	1	1	2	7
Procladius-Cricotopus		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Procladius-Labrundinia		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Psectrocladius		0	8	0	0	0	8	1	0	1	0	0	2	0	1	0	0	0	1	11
Stempellinella		1	0	1	1	0	3	0	0	0	2	0	2	0	0	1	0	0	1	17
Tanytarsus		0	0	2	0	0	2	0	2	0	0	0	2	0	0	0	2	0	2	7
Tanytarsus-Dicrotendipes-Nilothauma		0	2	2	1	1	6	3	1	0	3	0	7	0	0	0	1	0	1	27
Male Chironomidae		1	18	6	3	1	29	14	4	2	5	1	26	1	1	1	6	1	10	111
Female Chironomidae		2	10	4	2	4	22	10	5	6	4	1	26	2	1	2	7	0	12	112
Chironomidae pupa		0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	11
Unidentified damaged Chironomidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
Ceratopogonidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ephemeroptera		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Trichoptera		0	1	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	5
Other		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1

APPENDIX 33. Post-deforestation aquatic insect taxon richness and depth distribution from July to August, 1998 at the east site (clearcut to shoreline). The response variable is the rate of chironomid emergence (no. · 0.28 m^{-2} · d^{-1}).

Taxon	Set # (Date)	1 (July 1)					Total	2 (16 July)					Total	3 (July 29)					Total
	Depth (m)	0.5	1	3	4.5	7		0.5	1	3	4.5	7		0.5	1	3	4.5	7	
Ablabesmyia		0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	2
Chironomus		0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Corynoneura		0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	1	5
Dicrotendipes		1	0	0	0	0	1	0	0	0	0	0	0	0	3	0	0	0	3
Psectrocladius		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Procladius		0	0	0	0	0	0	0	0	3	0	0	3	0	0	0	0	0	0
Procladius-Cricotopus		0	0	0	0	0	0	0	0	2	2	1	5	0	0	0	1	0	1
Paralauterborniella-Polypedilum-Constempellina		0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2	0	2
Stempellinella		0	1	0	0	0	1	1	0	0	0	0	1	0	0	0	1	0	1
Tanytarsus		0	0	0	1	0	1	1	0	0	0	0	1	3	2	3	0	1	9
Tanytarsus-Nilothauma-Cladotanytarsus		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Male Chironomidae		1	1	1	1	0	4	3	0	5	2	1	11	4	10	3	4	2	23
Female Chironomidae		3	2	1	0	0	6	2	1	1	3	1	8	7	6	1	3	2	19
Unidentified damaged Chironomidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomidae pupa		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratopogonidae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2

Continued

Taxon	Set # (Date)	4 (August 5)					Total	5 (August 13)					Total	6 (August 19)					Total	Grand Total
	Depth (m)	0.5	1	3	4.5	7		0.5	1	3	4.5	7		0.5	1	3	4.5	7		
Ablabesmyia		0	0	0	0		0	0	0		0	0	0	0	0	0	0	0	0	2
Chironomus		0	0	0	0		0	0	0		0	0	0	0	0	0	0	0	0	1
Corynoneura		0	0	0	0		0	1	0		0	0	1	0	0	0	1	0	1	7
Dicrotendipes		0	0	0	0		0	0	0		0	0	0	0	0	0	0	0	0	4
Psectrocladius		1	0	0	0		1	0	0		0	0	0	0	0	0	0	0	0	1
Procladius		0	0	0	0		0	0	0		0	0	0	0	0	0	0	0	0	3
Procladius-Cricotopus		0	0	0	0		0	0	0		0	0	0	0	0	0	0	0	0	6
Paralauterborniella-Polypedilum-Constempellina		0	0	0	0		0	1	0		0	0	1	1	0	0	0	0	1	5
Stempellinella		1	0	1	0		2	0	0		2	0	2	0	0	0	1	0	1	8
Tanytarsus		1	1	2	0		4	1	3		0	0	4	0	0	0	0	0	0	19
Tanytarsus-Nilothauma-Cladotanytarsus		0	0	0	0		0	1	0		0	0	1	1	0	2	0	0	3	4
Male Chironomidae		3	1	3	0		7	5	3		2	0	10	3	0	2	2	0	7	62
Female Chironomidae		0	3	8	2		13	2	2		2	1	7	8	2	3	5	4	22	75
Unidentified damaged Chironomidae		0	0	0	0		0	0	0		0	0	0	1	0	0	0	0	1	1
Chironomidae pupa		0	0	0	1		1	0	0		0	0	0	0	0	0	0	0	0	1
Ceratopogonidae		0	0	0	0		0	0	0		1	0	1	0	0	0	0	0	0	1
Ephemeroptera		0	0	0	0		0	0	0		0	0	0	0	0	0	0	0	0	2