Interim Report on an Ecological Survey of Terrestrial Insect Communities in the AOSERP Study Area

DESCRIPTIVE SUMMARY

Insects were collected from 12 sites representative of major habitat types in the oil sands development area. Quantitative sampling techniques permitted calculations of the amount (biomass) and number of insects per square meter in the soil and on foliage. Vegetation surveys showed the types and levels of herbivorous insect damage on dominant plants. Sampling procedures revealed patterns of insect distribution and abundance in plant communities.

A total of 161 families of insects were found represented in the specimens collected for this study. This list is not comprehensive due to the late start and short season spent on this project.

The average number of insects per square meter was 5,104 individuals, with a biomass of 0.82 grams oven dry weight, at the 12 sites. The range was 463 to 31,637 individuals m^{-2}, and 028 to 3.11 g m^{-2}. Most of these (92% of the biomass) were found in the soil. Fly (Diptera) larvae were the most abundant insect group, followed by ants (Hymenoptera, Formicidae), beetles (Coleoptera), moths (Lepidoptera), bugs (Hemiptera), springtails (Collembola) and miscellaneous other groups of insects.

The wettest habitats generally had the largest insect populations, and the driest had the least. The spruce bog, with low populations, was an exception to the wet habitats. The dry non-vegetated site had the second highest insect biomass but the lowest number of individuals collected.

Insect damage to the dominant plant species varied widely. Aspen (*Populus tremuloides*) leaves were the most heavily attacked in these surveys, having had an estimated 14.7% of each leaf removed. Stems of deciduous trees and shrubs bore scale insects and aphids, but had few galls. Spruce tree stems had many galls and the terminal

buds were often killed. Insect caused crown and tree mortality was not significant.

Analysis of the trophic structure of these insect communities showed that the largest group (in terms of biomass) was herbivores. Carnivores and saprovores were found to be almost equally abundant. However, sampling inefficiencies probably caused the saprovore importance to be underestimated. Most of the carnivores fed upon other insects.

The use of insects as environmental monitors is discussed specifically for the AOSERP study area. The threat posed by bark beetles (Scolytidae) attacks on weakened trees is considered.

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ABSTRACT

Between August 18 and September 30, 1978, insect communities of 12 homogeneous habitats, chosen as representative of the major vegetation types, were sampled in the Alberta Oil Sands Environmental Research Program (AOSERP) study area (56°21' to 58°00' N and 110°50' to 112°00' W). Soil and vegetation zones were quantitatively sampled, and insects and spiders collected were oven-dried and weighed. Additional samples were taken to show insect taxa present, relative abundance and vegetation damage levels. Collected insects were all determined to family level.

The biomass of insects collected averaged 0.82 g oven dry weight m^{-2}, and ranged from 0.28 (Jack Pine forest) to 3.11 (fen) grams. The majority of these were soil dwellers, as only 8% of the insect biomass was collected on foliage. Among the soil inhabitants, Diptera larvae were the group most commonly encountered, and contributed most to the biomass total. These were dominated by larvae of the families Fungivoridae (Mycetophilidae and Sciaridae), Chironomidae, Ceratopogonidae, and Anthomyiidae. Ants (Hymenoptera, Formicidae), were common in most habitats, and contributed significantly to the biomass total of several. Coleoptera and Lepidoptera were the third and fourth ranked contributors to biomass totals. Collembola, Heteroptera, Psocoptera, and miscellaneous insects were numerically abundant but did not usually contribute heavily to the biomass totals. The sites loosely followed a gradient of greatest biomass, numbers, and diversity in the wettest habitats, and lowest in the driest. Exceptions to this gradient were the wet black spruce bog, and the dry non-vegetated site. Spiders were abundant in all habitats, with standing crop biomasses from 0.03 to 0.20 g m^{-2}.

A total of 161 families of insects were found represented in the collections made. Specimens were collected of only four species of butterflies, *Boloria titania* Esper, *Nymphalis j-album* Boisduval, *Polygonia satyrus* Edwards, and *Speyeria atlantis* Edwards, while four other species were seen but not collected. The late start and short field period of this investigation dictate that these lists are not comprehensive.

Insect damage surveys showed great variation in the rates of insect attack on dominant plant species. Leaves of *Populus tremuloides* Michx., were most heavily damaged, with an estimated 14.7% of the leaf area removed. Leaves of *Cornus stolonifera* Michx. bore the greatest number of aphids, averaging 6.7 individuals per leaf. Few deciduous tree stems bore damage, except for galls on *Salix* sp., but galls and bud damage were common on spruce (*Picea mariana* (Mill.) and *glauca* (Moench)). Insect caused crown and tree mortality was not significant.

Trophic structure analysis showed that herbivores were the largest group of insects, followed closely by carnivores and an almost equal biomass of saprovores. Carnivores, which were mostly entomophagous, were over-represented in the quantitative samples due to their activity, while saprovores were under-represented. The ecological significance of the saprovore food chain is discussed as being a method of allowing protein concentration by microbes, which are consumed by these animals.

The use of insects as environmental monitors is discussed specifically for the AOSERP study area, including the outbreak potential of destructive bark beetles (Scolytidae).

ACKNOWLEDGEMENTS

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1. INTRODUCTION

The Alberta Oil Sands Environmental Research Program (AOSERP) commissioned this study of the terrestrial insect fauna of the AOSERP study area (Figure 1). The purpose of this study was to document the insect energy resources available to the biotic communities in the AOSERP study area, and to allow evaluation of the roles of insects in the food web. Data on insect populations and biomass were required as baseline ecosystem information for future reference.

The insect fauna of the AOSERP study area has been the subject of one preliminary environmental investigation by Porter and Lousier (1975). An outbreak of an aspen leaf moth was recently reported from the area (Wong and Melvin 1976). General studies of the insects of Alberta contain information on species found in the AOSERP area (Bowman 1951; Carr 1920; Strickland 1938a, b, 1939, 1946a, b, 1947, 1952, 1953). The Northern Forest Research Center in Edmonton is a source of information on forest insects of this area, and presently houses a collection of aquatic insects from an AOSERP aquatic environment study.

This study was approved in mid-July, and field work started on August 18, following the construction of extraction funnels and collecting equipment. Consequently, field investigation time was limited. To make optimal use of the remaining season, all study sites chosen were accessible by road. None were on areas presently under development for oil sands recovery.

1.1 OVERALL OBJECTIVES

The general objective of this study is to document the relative abundance of insect families that are present within the biotic communities of the AOSERP study area and to allow an evaluation of the roles of insects in the food web. This knowledge will be useful in the construction of a general ecological model of the AOSERP study area and in predicting the ultimate impact of the loss of any specific habitat type and/or insect group due to industrial activities.

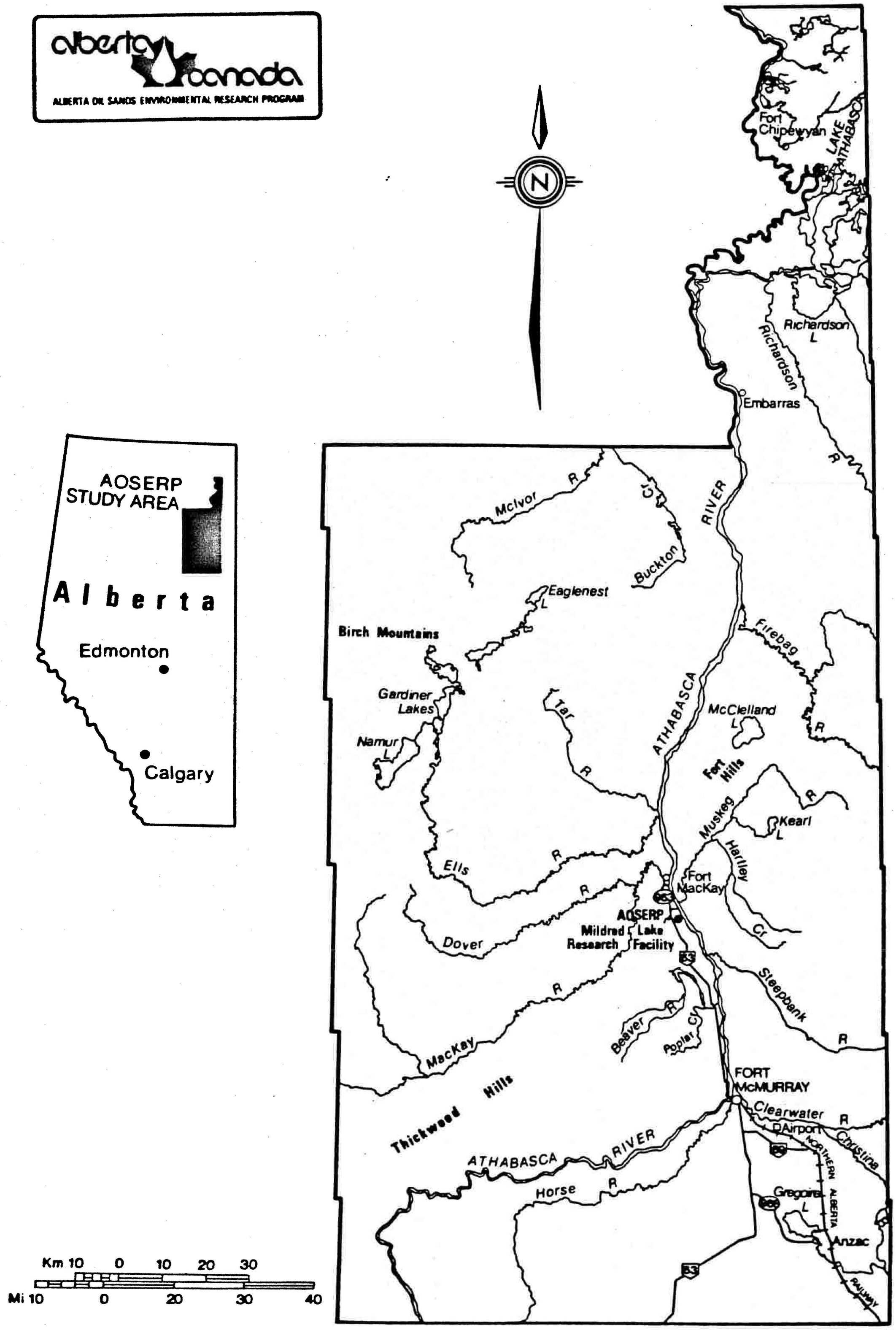

Figure 1. Location of the AOSERP study area.

The basic questions to be answered by this study are: what insects occur in each of the biotic communities, where are they located within the community, and what is their role within the community.

1.2 SPECIFIC OBJECTIVES

In order to meet the overall objectives, the following specific objectives were set:

1. to describe the taxonomic composition, seasonal occurrence and relative productivity of insect fauna in plant and soil-litter communities of the AOSERP study area.
2. to describe the relative proportions of taxonomic groups with herbivorous, entomophagous, and other food habits.
3. to describe how insect communities (different trophic groups) express such characteristics as community organization and association.
4. to determine if there are any unique areas (habitats) or insect groups with special biological characteristics that are detrimental or beneficial to the terrestrial ecosystem.

The approach and methods of this report are oriented to fulfill these objectives. However, due to the advanced season at the time of initiation of this study, the fulfillment of these objectives will have to await completion of a second field season of work.

2. MATERIALS AND METHODS

2.1 SAMPLE SITES

Sample sites were chosen preliminary to other activities. Fourteen main habitat types occur in the AOSERP area (Thompson et al. 1978). Representatives of twelve habitat types were found and selected for study along the Fort MacKay Road (Hwy 963) and the Thickwood Hills Road. Both areas were within the AOSERP study area boundaries, but beyond the direct influence of Great Canadian Oil Sands (G.C.O.S.) and Syncrude Canada Ltd. (Syncrude) plant emissions.

The locations of these study sites are shown by site number in Figures 2 and 3. These sites, in Thompson et al. (1978) terminology, are: (1) Riparian Forest, (2) White-spruce-Aspen Forest, Coniferous, (3) Aspen Forest, (4) Black Spruce Bog, (5) Mixed Coniferous Forest, (6) Mixed Forest, (7) Non-vegetated (here a road-fill scrape area), (8) Jack Pine Forest, (9) Semi-open Tamarack Bog, (10) Fen, (11) Lightly Forested Tamarack, and (12) Deciduous-shrub Wetland. Representative sites were not located for a recent burn, and an upland open community. The vegetation composition of all these sites is briefly described in Section 3.1 of this report.

2.2 INSECT SAMPLING

Insects occupy a diverse array of microhabitats, and consequently their populations must be sampled by different methods. Numerous techniques have been used to sample insects (cf. Southwood 1971). The methods described below were chosen for their suitability to the objectives of this study, and for their comparatively high collection efficiency for a broad range of insect taxa. The first samples were collected on August 18, and the last on September 30.

2.2.1 Tullgren Funnels

A bank of 45 Tullgren funnels, shown in Figure 4, was built for this study. Each funnel was a sheet metal cone, with a top diameter of 30.5 cm and exit diameter less than 1 cm. Soil cores to be extracted were put inverted or horizontally on a piece

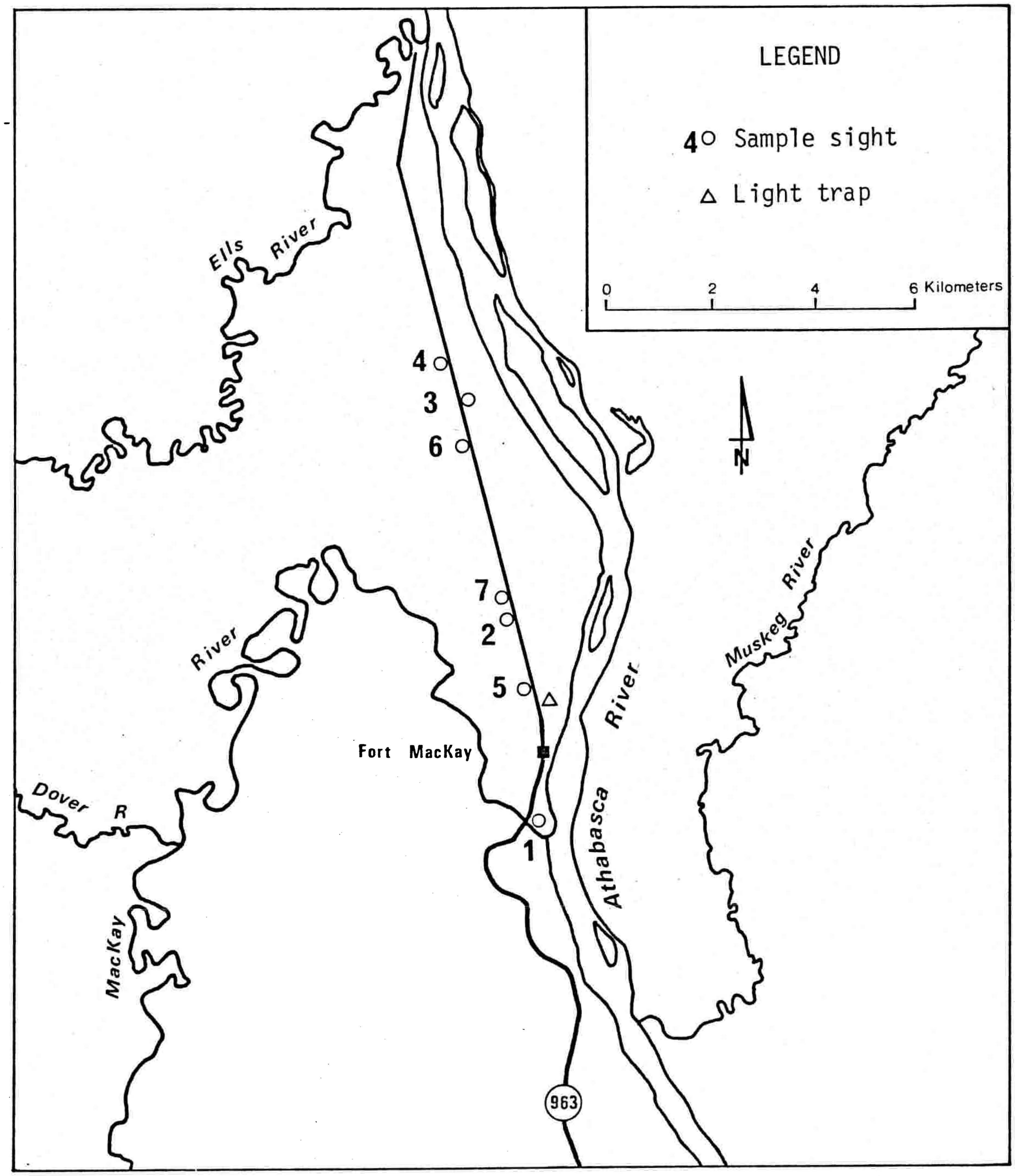

Figure 2. Location of study sites 1 to 7.

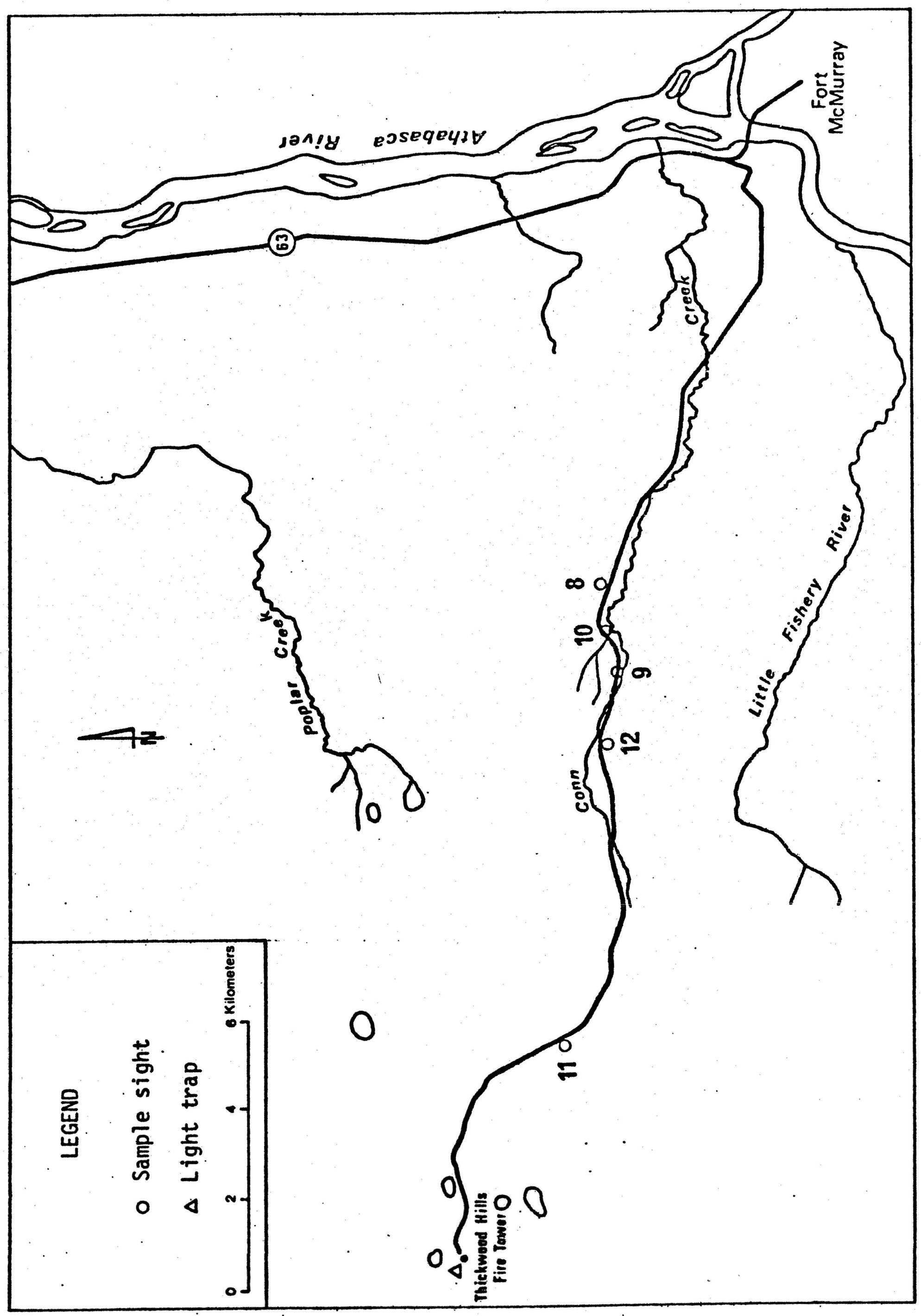

Figure 3. Location of study sites 8 to 12.

of paper the size of the sample, then placed on the uppermost of two 1/8" mesh circular wire screens. An unvented shield with a 25 watt light bulb tightly covered the funnel. A sample vial placed below collected the extracted invertebrates. Soil cores were extracted with heat for 72 hours, or until completely dry.

Six soil cores were collected for each Tullgren and O'Connor funnel sample. A 15 m knotted cord was stretched in each habitat, and a core was taken at each knot using a tapered bulb planting tool. Each core was placed in a plastic bag, and with few exceptions was in an extraction funnel within 6 hours. Cores were taken of the top 5 cm of soil, and comparative depth cores were taken to 10 and 15 cm. Sample dates for each habitat are given in Table 11 (see appendix).

2.2.2 O'Connor Funnels

Two stands, containing 45 total O'Connor funnels, were built for this study. These are illustrated in Figure 5. The funnels were constructed, and cores extracted in 2.5 cm units, as described by O'Connor (1962). Extraction times were doubled for all 12 Variac settings, so that a complete extraction required 6 hours. This modification was made to allow insect larvae longer time to escape the soil core than O'Connor allowed for enchytraeid worms.

2.2.3 Pyrethrum Spray

Foliage inhabiting arthropods can be collected with a pyrethrum spray system (Martin 1966). We sampled using this method, first with an oil based 0.332% pyrethrum plus 1.66% piperonyl butoxide solution, and later with a water based product diluted to the same strength. These were applied with a hand pump sprayer on randomly chosen trees and bushes at each sample site, except the non-vegetated and fen sites. The spray did not reach beyond 3 1/2 m on tall trees. The foliage was shaken, and stunned insects and spiders fell onto 1/2, 3/4 and 1 m^2 sheets spread beneath the sprayed area. This procedure is illustrated in Figure 6. Collected arthropods were preserved in alcohol.

Figure 4. Set of 45 Tullgren funnels used at Mildred Lake Research Facility to extract soil insects.

Figure 5. O'Connor funnel system used at Mildred Lake to extract soil insects in water with stepped heating from 60 watt light bulbs.

Figure 6. Pyrethrum spray technique showing insects being shaken from sprayed alder onto a 1 m^2 sheet funnel.


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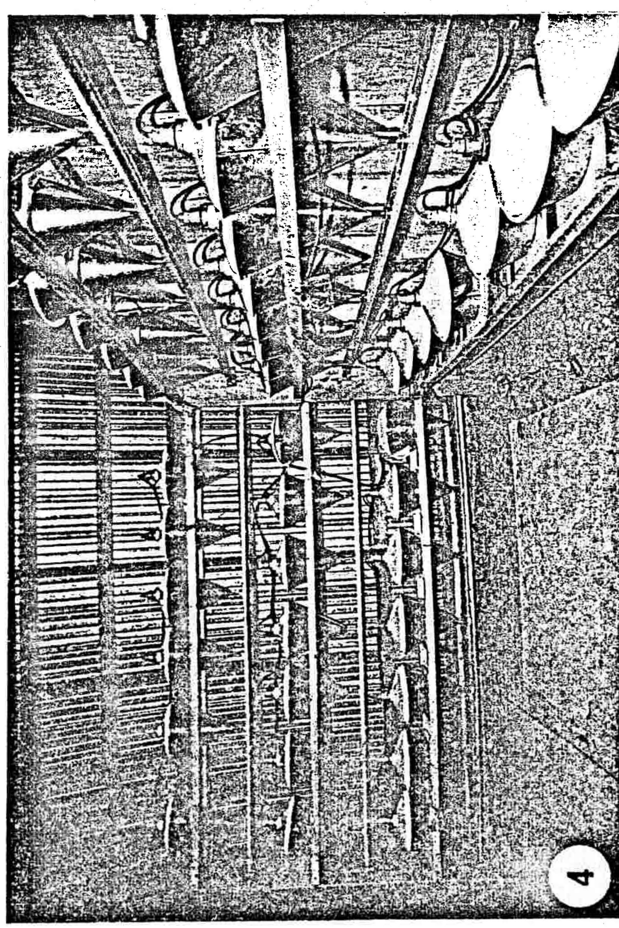
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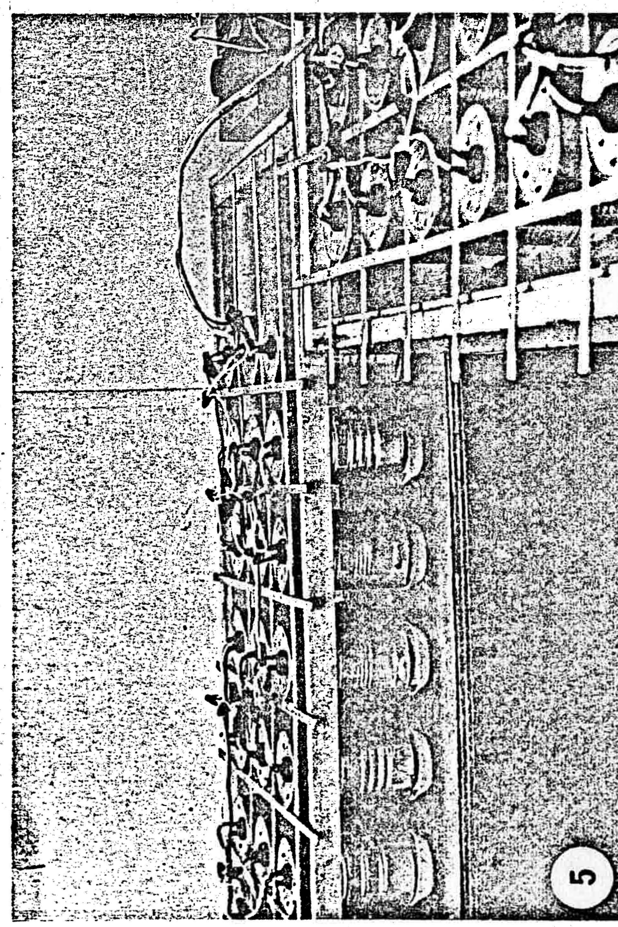
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2.2.4 Sweep Net Sampling

Sweep net samples were collected at head height and ground vegetation level from each site except the fen, where only low vegetation samples could be taken. A single sample consisted of 25 180° net sweeps, with a 30.5 cm diameter net, made while walking through undisturbed vegetation. Arthropods thus collected were stunned with ethyl acetate, then transferred to alcohol preservative.

Butterflies were netted when seen.

2.2.5 Pitfall Traps

Pitfall traps were made from 20 cm x 20 cm x 5 cm plastic freezer boxes. Tops were cut and moulded to make 8 sloped entries. Caulking was used to taper the edges of the tops for easier insect access. Four traps were buried with tops flush with ground level at each site, and were then filled with a 2% formalin solution plus several drops of liquid detergent. One such trap is shown in Figure 7. Collected arthropods were removed at approximately 10 day intervals.

2.2.6 Malaise Trap

A white nylon gause malaise trap was operated at the AOSERP Mildred Lake research facility. Insects collected in the trap were removed daily while we were at the site, and mounted or preserved for later examination.

2.2.7 Light Traps

Two modified New Jersey AC light traps (Figure 8) and one specially designed modified Robinson DC light trap (Figure 9) were used to collect night flying insects. All traps used a 15 watt fluorescent ultra violet lamp as an attractant. The trap at Mildred Lake operated nightly from August 19 to September 30. For various reasons the traps at the MacKay ranger station and the Thickwood Hills fire tower were operated sporadically.

2.2.8 Leaf Damage Survey

Leaves of 10 dominant shrub and tree species were inspected for insect damage and attached insects. Each sample consisted of 250 leaves randomly collected, 5 from any one stem, for a total of not more than 10 leaves from a single plant. For black spruce, 500 needles were examined. All were collected September 5 to 6. These were inspected in the laboratory for insect galls, mines, feeding scars, and attached insects such as scales. Causative agents of galls and damage were determined through keys and information in Wong et al. (1977) and Johnson and Lyon (1976).

2.2.9 Stem Damage Survey

The terminal 25 cm of branches of 10 dominant shrub and tree species were examined for insect inhabitats and damage. Two twigs or branches were randomly chosen on each plant, the terminal 25 cm measured with a piece of wire, and then inspected for insects and insect damage. Each sample consisted of 100 stem examinations. These examinations were made September 25 to 30.

2.2.10 Crown Damage Survey

Crowns of black and white spruce, jack pine, and poplar trees were inspected with 7.5X binoculars, or by direct sight, to assess bark beetle attack and infestation rates. Sets of 100 trees were examined and categorized as to tree height, crown condition, and insect damage symptoms, and crown mortality.

2.2.11 Subsequent Laboratory Procedures

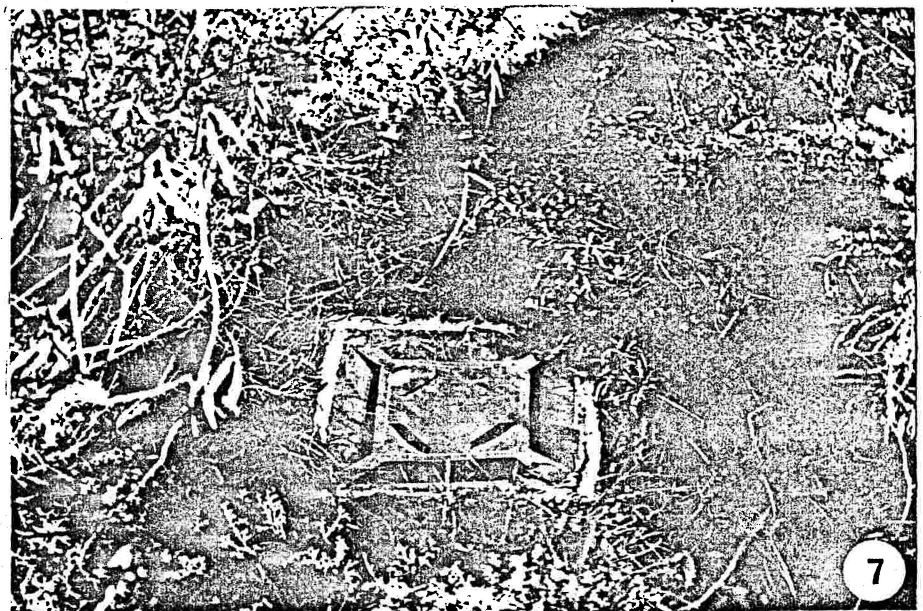
Samples brought to the laboratory were sorted by insect family and counted. They were then oven dried at 60°C for 72 hours, or until dry, and then weighed on a Sartorius balance accurate to 0.1 mg.

Weight loss from leaching of insect body fluids into alcohol was estimated. The alcohol in which light trap samples were stored was saved, filtered to remove debris, oven dried and weighed. This residue weight was then compared to the total mass of the insects originally preserved in the alcohol.

Figure 7. One of 50 modified plastic pitfall traps used to collect ground dwelling insects. This one, at the spruce bog site, was flooded under 5 cm of water following early September rains.

Figure 8. New Jersey light trap for crepuscular and nocturnal insects.

Figure 9. Modified Robinson battery powered light trap designed and built for AOSERP insect sampling.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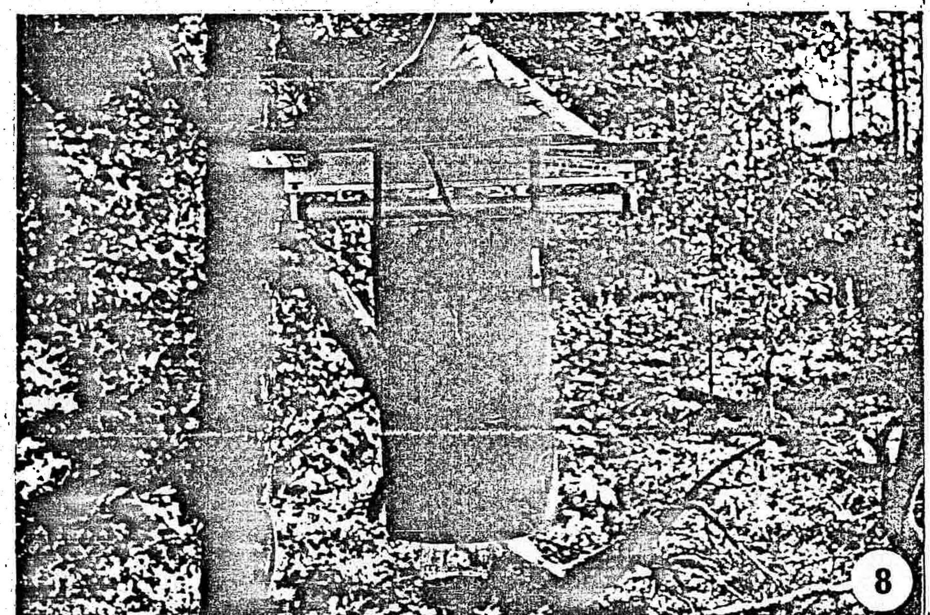
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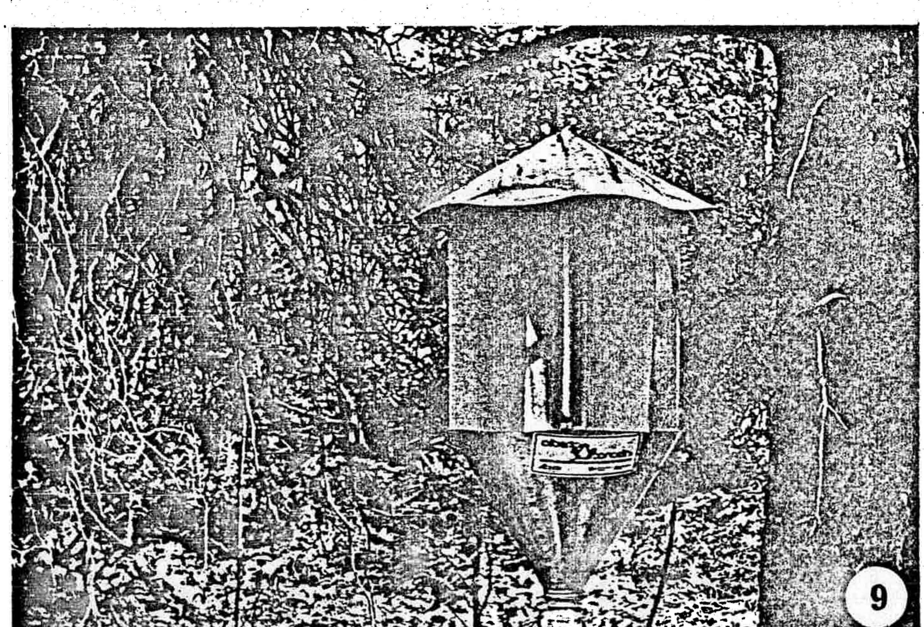
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3. RESULTS

3.1 INSECT POPULATIONS AND BIOMASS

Results of the Tullgren and O'Connor funnel extractions are given in Tables 12 to 23 (see appendix), as the average population standing crop and biomass m^{-2} for all insect families extracted, and as population numbers for spiders, mites, ticks, millipedes, snails, and enchytraeid worms. Where members of a family were extracted by both techniques, only the greater population is reported. The life stage -- immature or adult -- is noted for endopterygote insects. Fly larvae listed in the family Anthomyiidae probably belong to several families of cyclorraphid Diptera. Peterson's (1960) text, used for these larval determinations, keys to 26 families of cyclorrapha, while Borror and DeLong (1971) recognize 65 families in this same group. Consequently, the family Anthomyiidae is designated to be uncertain, and cyclorrapha information is shown both as totals, and below this, in brackets by families.

Vertical distributions of invertebrates in the top 7.5 cm of soil are given in Table 1. This information was obtained from O'Connor funnels only. It is given for 7 abundant taxa, which are shown to be heavily concentrated in the top 2.5 cm of soil.

Variation in the distribution of larvae of 4 Diptera families from sites 1, 6 and 12 is shown by data in Table 2. In 26 of 84 cases no larvae were found, and in 28 cases the population mean exceeded twice the standard error of the mean. Thus these insects have clumped, not random, distributions. It is therefore inappropriate to analyze their populations with parametric statistical methods. Clumped distributions require that large numbers of samples be taken to stabilize the population means.

The pyrethrum sample results are given in Tables 24 to 33 (see appendix). These data provide estimates of the above-ground standing crops of insects (by family) and spiders. Population biomass is given by order, and in brackets for dominant families within the order. Less abundant taxa biomass is shown under miscellaneous

Table 1. Vertical distribution of invertebrates in the top 7.5 cm of soil, from O'Connor funnel data. Results are expressed as percentages of the population inhabiting the upper half of the subsampled soil.

	Site	Enchytraeidae	DIPTERA:	Ceratopogonidae	Chironomidae	Fungivoridae	Empididae	Anthomyiidae	ACARINA
% of top 2.5 cm population found in top 1.25 cm	1	64		100	50	92	83	77	72
% of top 5.0 cm population found in top 2.5 cm		84		50	67	100	100	79	100
% top 2.5 cm in top 1.25	2	89		100	71	97		73	74
% top 5.0 cm in top 2.5		100		100	92	100		94	100
% top 2.5 cm in top 1.25	3								
% top 5.0 cm in top 2.5		88			100	100	100	100	100
% top 5.0 cm in top 2.5	4	73			84	56		100	57
% top 7.5 cm in top 5.0		83			100	90		100	55
% top 2.5 cm in top 1.25	5	89			a	58		69	81
% top 5.0 cm in top 2.5		60			58	100		83	88
% top 5.0 cm in top 2.5	6	90			100	100		100	
% top 2.5 cm in top 1.25	7	33			75				
% top 5.0 cm in top 2.5		78							
% top 2.5 cm in top 1.25	8	91			100	100		71	95
% top 5.0 cm in top 2.5		85			100	100		81	98
% top 5.0 cm in top 2.5	9	90		33	82	100	100	50	96
% top 5.0 cm in top 2.5	10	88		66	92	94		100	85
% top 2.5 cm in top 1.25	11	36		38	57	33	100	a	90
% top 5.0 cm in top 2.5		72			55	100		a	53
% top 2.5 cm in top 1.25	12	87		71	79	58		a	56
% top 5.0 cm in top 2.5		85		70	84	92			81
mean % of top 2.5 cm populations found in top 1.25		70		77	72	73	92	73	78
mean % of top 5.0 cm populations found in top 2.5		83		64	83	95	100	87	86

[a]Upper subsample contains no specimens, and lower sample does.

Table 2. Variation in the distribution of larvae of four Diptera families in O'Connor funnel samples from three sites. Results are expressed as sample means (of 6 cores) ± 2 Standard Errors of the mean.

Site	Date	Depth cm	Ceratopogonidae	Chironomidae	Fungivoridae	Anthomyiidae[a]
1	VIII-19	0-2.5	0.17 ± 0.14	0.67 ± 0.67	1.67 ± 1.0	0.5 ± 1.0
	VIII-24	0-2.5	0.17 ± 0.14	1.0 ± 0.73	1.17 ± 1.5	2.5 ± 1.5
		2.5-5.0	0.17 ± 0.14	0.5 ± 0.45	0	0.67± 0.67
	IX- 5	0-1.25	1.83 ± 2.9	0.67 ± 0.99	0.83 ± 0.61	4.17± 2.7
		1.25-2.5	0	0.5 ± 0.45	0.17 ± 0.14	0.33± 0.42
	IX-25	0-1.25	0	0	0	1.83± 1.1
		1.25-2.5	0	0.17 ± 0.14		1.5 ± 2.2
6	VIII-19	0-2.5	0	0	1.33 ± 1.9	0.33± 0.42
	VIII-31	0-2.5	0	0.67 ± 0.99	1.17 ± 0.96	0.5 ± 0.45
		2.5-5.0	0	0	0	0
	IX-23	0-2.5	0	1.17 ± 1.6	0.33 ± 0.42	0.17± 0.14
12	VIII-23	0-2.5	2.33 ± 2.5	4.33 ± 2.0	1.5 ± 1.2	0
	IX- 4	0-1.25	1.17 ± 0.96	1.83 ± 2.1	0.17 ± 0.14	0
		1.25-2.5	0.33 ± 0.42	1.0 ± 0.5	0.5 ± 0.45	0
		2.5-3.75	0.67 ± 0.99	0.67 ± 0.67	0	0.17± 0.14
		3.75-5.0	0.5 ± 0.69	0.5 ± 0.69	0	0.17± 0.14
	IX-24		1.0 ± 2.0	4.83 ± 2.75	0	1.17± 0.96
	IX-28	0-1.25	2.17 ± 2.1	6.83 ± 6.4	1.0 ± 1.6	0
		1.25-2.5	1.0 ± 1.0	1.0 ± 1.0	0.33 ± 0.42	0
		2.5-3.75	0.67 ± 0.67	0.67 ± 0.67	0	0
		3.75-5.0	0.17 ± 0.14	0.17 ± 0.14	0.17 ± 0.14	0

[a]Uncertainty

insects. One functional distinction should be recognized in the taxa listed here. Some insects, like members of the Hemiptera and Homoptera, are obligate foliage inhabitants, while others, like most of the Diptera, are transitory adults whose immature stages did not inhabit foliage.

Insect and spider standing crops at the 12 sample sites are reported in Tables 3 and 4. These data are summarized and combined from Tables 12 to 33 (in appendix), and increased by a factor of 1.16 (see 3.1 end). The fen (site 10) had the greatest number of insects m^{-2} (31,627) with a biomass of 3.11 grams (oven dry weight) even without an above-ground standing crop estimate. The non-vegetated area (site 7) had the smallest insect population, 463 individuals m^{-2}, but the second largest biomass due to the extraction of a large moth in the Tullgren funnels. The average per site was 5,104 individuals weighing 0.84 g m^{-2}. Standing crop numbers were overwhelmingly (92% of total) dominated by the soil inhabitants, but individuals found above ground were heavier, and totalled 4 to 33% of the soil insect biomass. Spider populations from the soil cores are surface and immediately above-surface vegetation dwellers. These populations tended to be greater than the foliage populations, but the foliage biomass frequently exceeded that of the soil dwellers. In the semi-open tamarack bog (site 9), the total spider biomass was 52% of the total insect biomass, the highest percentage that spiders represented of the insect biomass at any site.

Sweep net sample results are given in Tables 34 and 35 (see appendix). These data show a seasonal trend in the reduction of insect numbers and biomass, while the spider biomass increased slightly over the same period. At the 10 sites where head height and ground vegetation sweeps were taken, the ground sweeps picked up 1.64 times more insect biomass than the higher foliage sweeps.

The light trap results are shown in Figure 10. These data show a gradual reduction in the biomass and numbers of insects caught over the season, similar to the sweep samples, but this trend is obscured by low initial collections. The peak moth collections were made between August 25 and September 10, during

Table 3. Summary of standing crop numbers m^{-2} of insects and spiders at AOSERP study sites.

	Individuals m^{-2} at site No.[a]:											
	1	2	3	4	5	6	7	8	9	10	11	12
INSECTA	3134	3556	3990	2213	2891	1549	463	1157	4212	31637	2337	4103
soil	3111	3540	3986	2208	2865	1542	463	1146	4201	31637	2311	4074
foliage	23	16	4	5	26	7		11	11		26	29
COLLEMBOLA	761	184	658	297	318	351	0	229	106	211	264	509
soil	761	184	658	297	317	351	0	228	106	211	264	508
foliage	+	+	0	+	1	+		1	+		+	1
PSOCOPTERA	8	32	26	2	14	19	0	0	1	0	1	2
soil	0	26	26	0	0	18	0	0	0	0	0	0
foliage	8	6	+	2	14	1		+	1		1	2
HEMIPTERA	22	31	67	70	39	37	13	267	92	53	71	19
soil	13	26	66	70	35	35	13	264	88	53	53	0
foliage	9	5	1	+	4	2		3	4		18	19
(Aphididae)	5	4	1	0	2	1		1	2		15	12
COLEOPTERA	73	92	395	105	105	175	93	108	288	105	459	265
soil	72	92	395	105	105	174	93	105	286	105	457	263
foliage	1	+	+	+	+	1		3	2		2	2
LEPIDOPTERA	1	66	93	176	1	35	40	0	35	18	37	53
soil	0	66	93	176	0	35	40	0	35	18	35	53
foliage	1	+	+	+	1	+		+	+		2	+
DIPTERA	2217	3055	2502	1392	2184	878	251	500	3653	29583	1416	3060
soil	2213	3053	2500	1390	2179	876	251	496	3650	29583	1414	3057
foliage	4	2	2	2	5	2		4	3		2	3
HYMENOPTERA	27	81	248	153	161	35	53	36	18	1667	72	159
soil	26	80	248	152	159	35	53	35	18	1667	70	158
(Formicidae)	0	40	105	117	88	18	0	18	0	1649	53	140
foliage	1	1	+	1	2	+		1	+		2	1
(Formicidae)	0	0	0	0	0	+		0	0		+	+
(Tenthredinidae)	+	+		0	0	+		0	+		1	+
miscellaneous insects												
soil	26	13	0	18	70	18	13	18	18	0	18	35
foliage	+	+	+	0	+	+		+	+		+	+
ARANEIDA												
soil	53	158	105	176	105	70	79	88	184	70	298	281
foliage	9	7	2	4	13	6		4	5		7	4

[a]rounding off to nearest intergers may cause slight discrepancies with Tables 12 to 32 data.

+ means less than 0.5

Table 4. Summary of standing crop biomass m^{-2} (mg oven dry weight) of insects and spiders at AOSERP study sites.

	Site Number											
	1	2	3	4	5	6	7	8	9	10	11	12
INSECTA	391[a]	689	777	498	408	405	1,166	281	460	3,113	1,012	668
soil	324	576	751	479	325	330	1,166	231	416	3,113	862	505
foliage	67	113	26	19	83	75		50	44		150	163
COLLEMBOLA												
soil	17	5	20	6	6	14	0	22	6	14	4	2
PSOCOPTERA												
foliage	4	2	0	2	17	3		1	1		2	5
HEMIPTERA					31				29			76
soil	+				22				16			0
foliage	24	79	12	2	9	13		6	13		53	76
(Aphididae)	5	3				2		2	3		35	15
COLEOPTERA	60	58	358	56	59	103	200	56	124	37	262	149
soil	51	56	356	49	55	98	200	45	103	37	254	100
foliage	9	2	2	7	4	5		11	21		8	49
LEPIDOPTERA	17	236	94	114	7	63	891	7	15		54	29
soil	0	226	92	112	0	57	891	0	14		8	22
foliage	17	10	2	2	7	6		7	1		46	7
DIPTERA	253	225	170	148	159	140	72	113	248	588	139	204
soil	247	217	163	143	122	118	72	95	246	588	134	194
foliage	6	8	7	5	37	22		18	2		5	10
HYMENOPTERA		69	105	131	116							207
soil		58	104	130	112							193
(Formicidae)	0	35	82	119	85		0		0	2,445	450	171
foliage	6	11	1	1	4	23		2	3		36	14
(Formicidae)	0	0	0	0	0	3		0	0		2	7
(Tenthredinidae)	2	10	0	0	0	10		0	2		3	4
miscellaneous insects												
soil	9	14	17	39	8	43	3	69	31	29	12	4
foliage	1	1	2	0	5	3		5	3		0	2
ARANEIDA	176	87	32	30	96	199	47	55	243	35	99	201
soil	122	44	5	9	33	126	47	26	213	35	55	177
foliage	54	43	27	21	63	73		29	30		44	24

[a] Biomass totals may differ slightly from Tables 12 to 32 data (times 1.16) due to rounding off subtotals here to nearest integer.

+No entry signifies presence, with biomass included under miscellaneous insects.

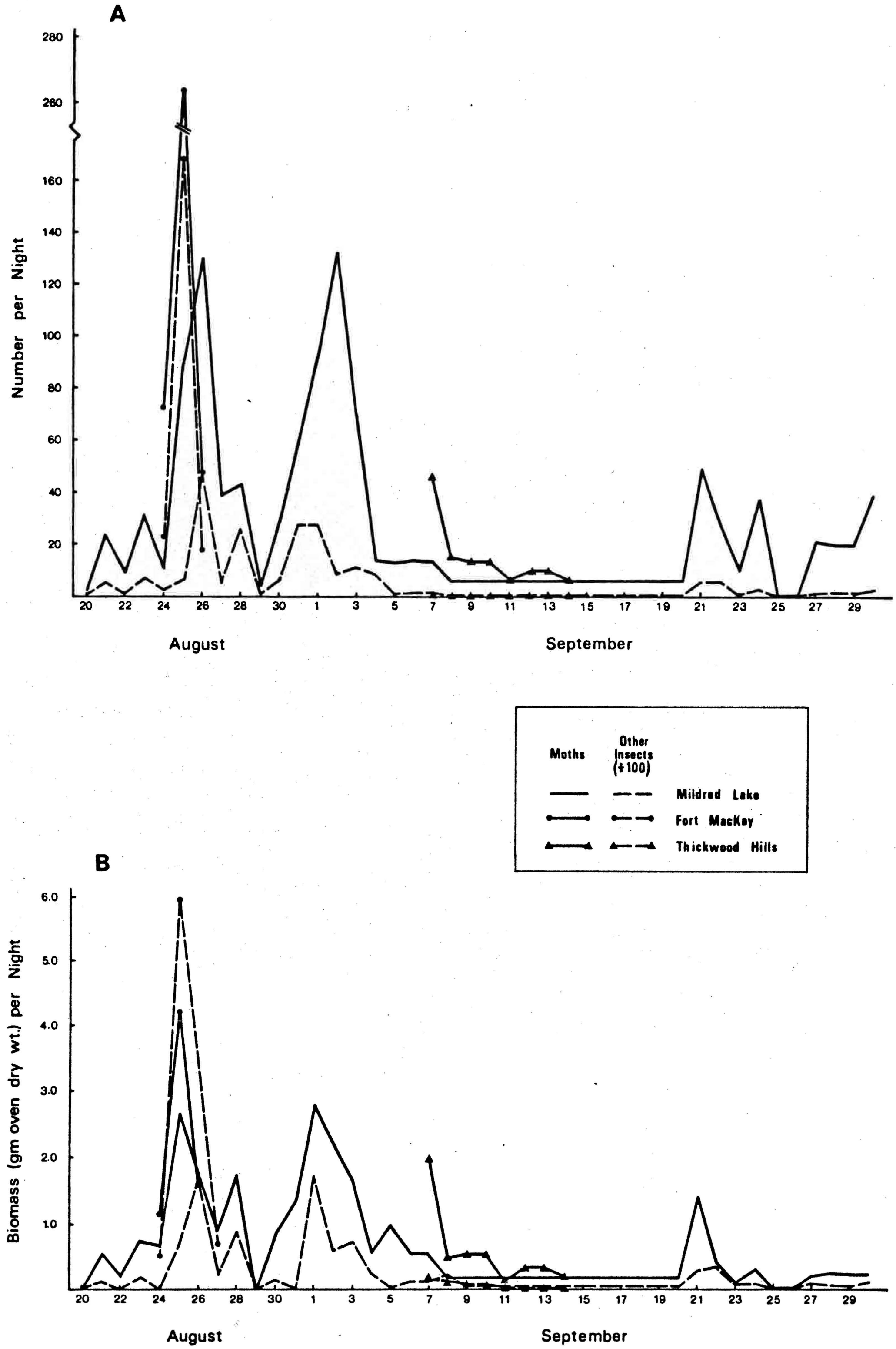


Figure 10. Light trap results from Mildred Lake, Fort MacKay ranger's house, and Thickwood Hills lookout tower. A. Numbers of moths, and other insects (99% Diptera) captured nightly. B. Biomass of these insects.

which, 17 night period there were only 4 nights without rain. September 1, the peak moth catch night, had a night minimum temperature of 12°C, the warmest night during the light trap period (A.E.S. meteorological records, Mildred Lake Research Facility). The 9.6 mm of rain this day did not dampen the flying spirits of these moths, but caused warm conditions which in turn caused the greatest moth flight activity. The remaining light trapped insects at Mildred Lake were 99% Diptera, primarily members of the Chironomidae, Mycetophilidae, and Sciaridae. Other taxa collected include Trichoptera, Hymenoptera, Psocoptera, Coleoptera, Neuroptera, and Ephemeroptera. The Fort MacKay light trap produced higher collections and more diverse taxa during its short period of operation. Trap results from Thickwood Hills, lowest of the three sites, may be due to placement of this trap beside a shed (thus halving its attractant area) and a dim light due to weak batteries.

Among the Diptera, larvae belonging to the nematocera families Sciaridae and Mycetophilidae (collectively called Fungivoridae as larvae by Peterson, 1960), Chironomidae, and Ceratopogonidae dominated soil invertebrate populations. Adults of these were collected by sweep netting, but not in notable quantities. The light traps, however, attracted large numbers of sciarids, mycetophilids, and chironomids. Thus, the abundance of three of these families is substantiated by the light trap data, which also shows that they are active at night. Ceratopogonid adults were infrequently found. They must either appear earlier in the season, or they had behavior patterns which caused them to be missed in our samples. If this latter case pertains, these biting flies will not be mammalian blood suckers, but may be insect feeders.

The alcohol preservative from the 36 containers of light trap specimens was saved in an enamel tray. This yielded 1.45 liters of urine-colored fluid (plus an unknown loss from evaporation), which was dried in a foil boat. The tacky darkened residue, after 3 days of being oven dried at 60°C, weighed 8.664 g. The total oven dried biomass of insects preserved in this fluid for 3 months was 55.04 g. Therefore, the alcohol-leached fat represents a 13.6% loss from the total 63.71 g, and the oven dried insect biomass must be corrected by a factor of 1.16 to obtain oven dry biomass at time of capture.

3.2 Insect Taxa Found In The AOSERP Study Area

A preliminary list of the families of insects found represented in the AOSERP study area, particularly at the 12 study sites, is presented in Table 5. This list of 161 families was compiled from specimens collected after the first frost (August 18), and is not comprehensive. Adult insects often have brief lifespans and emerge over comparatively short intervals. Taxa which appeared in spring and summer may not be included on this list in spite of their abundance in the area. Uncommon groups of insects remain to be found.

Lepidoptera are poorly represented in our collection. Despite a concerted effort to collect them, only eight species of butterflies were noted, and only four were actually collected. The four species taken were *Boloria titania* Esper, *Nymphalis j-album* Boisduval, *Polygonia satyrus* Edwards, and *Speyeria atlantis* Edwards, all members of the family Nymphalidae. Two other nymphalids, *Nymphalis milberti* Latreille, *N. antiopa* L., and two pierids, *Colias* sp. and *Pieris* sp., were seen but not collected. More Lepidoptera might have been collected, but the Malaise trap used was defective and caught few insects, and the New Jersey light trap fans mutilated the moths.

Only larval sawflies were collected, so adults are presumed to have been more abundant earlier in the season. The Apocrita were parasites, with a few exceptions, such as the ants (Formicidae) and seed wasps (some Chalcididae). Larvae of a rare parasite, *Gonotopus bicolor* Ashmead (Dryinidae), were found protruding through the bodies of leafhoppers (Cicadellidae).

3.3 Insect Damage Surveys

The leaf damage survey, reported in Table 6, showed great variation in the rates of insect attack on the leaves of different plants. Virtually all dogwood *(Cornus stolonifera)* (note: all plant species names are taken from Moss 1959) leaves bore insect scars, while only 20% of blueberry (*Vaccinium*

Table 5. Families of insects in terrestrial habitats within the AOSERP study area.

Taxon	this study	Porter, Lousier 1975
COLLEMBOLA		
Entomobryidae	+	
Isotomidae	+	+
Onychiuridae	+	+
Poduridae	+	+
Sminthuridae	+	+
EPHEMEROPTERA		
Ephemerellidae	+	+
ODONATA		
Aeshnidae		+
Coenagrionidae	+	+
Libellulidae	+	+
ORTHOPTERA		
Acrididae	+	+
Tetrigidae	+	+
PLECOPTERA		
Nemouridae	+	+
Taeniopterygidae	+	
PSOCOPTERA		
Pseudocaeciliidae	+	
Psocidae	+	+
THYSANOPTERA		
Phlaeothripidae	+	
Thripidae	+	
HEMIPTERA		
Aradidae	+	+
Gerridae	+	
Lygaeidae	+	
Miridae	+	+
Nabidae	+	
Pentatomidae	+	+
Saldidae	+	
Tingidae	+	+
HOMOPTERA		
Aphididae	+	+
Cercopidae	+	+
Chermidae	+	+
Cicadellidae	+	+
Cicadidae	+	+
Cixiidae		+
Coccidae	+	
Delphacidae	+	
Fulgoridae	+	
Pseudococcidae	+	
Psyllidae	+	+
COLEOPTERA		
Anobiidae	+	
Anthicidae	+	+
Anthribidae	+	
Buprestidae	+	+
Byrrhidae	+	+
Cantharidae	+	+
Carabidae	+	+
Cerambycidae	+	+
Chrysomelidae	+	+
Cicindelidae	+	
Cleridae		+
Coccinellidae	+	+
Colydiidae	+	+
Cryptophagidae	+	
Cucujidae	+	+
Curculionidae	+	+
Dytiscidae	+	
Elateridae	+	+
Eucnemidae		+
Helodidae	+	+
Histeridae	+	+

continued...

Table 5. Continued

Taxon	this study	Porter, Lousier 1975		this study	Porter, Lousier 1975
Hydrophilidae	+		DIPTERA		
Lampyridae	+	+	Agromyzidae	+	
Lathridiidae	+		Anisopodidae		+
Leptodiridae	+		Anthomyiidae	+	+
Lycidae		+	Anthomyzidae	+	
Melandryidae	+		Asilidae	+	+
Mordellidae	+	+	Bibionidae	+	+
Mycetophagidae	+		Bombyliidae	+	+
Nitidulidae	+	+	Calliphoridae	+	
Orthoperidae	+		Cecidomyiidae	+	+
Pedilidae		+	Ceratopogonidae	+	+
Phalacridae	+		Chamaemyiidae	+	
Pselaphidae	+		Chaoboridae	+	+
Scaphidiidae	+		Chironomidae	+	+
Scarabaeidae	+	+	Chloropidae	+	+
Scolytidae	+		Clusiidae	+	
Silphidae	+		Conopidae		+
Staphylinidae	+	+	Culicidae	+	+
Tenebrionidae	+	+	Cuterebridae	+	
NEUROPTERA			Dixidae	+	+
Chrysopidae	+		Dolichopodidae	+	+
Hemerobiidae	+	+	Drosophilidae	+	
TRICHOPTERA			Empididae	+	+
Limnephilidae	+	+	Ephydridae	+	
LEPIDOPTERA			Heleomyzidae	+	
Arctiidae	+		Lonchopteridae	+	
Cosmopterygidae	+		Milichiidae	+	
Geometridae	+	+	Muscidae	+	+
Gracilariidae	+	+	Mycetophilidae	+	+
Hepialidae		+	Otitidae	+	
Lycaenidae		+	Phoridae	+	+
Nepticulidae		+	Piophilidae	+	
Noctuidae	+	+	Pipunculidae	+	+
Notodontidae	+		Psychodidae	+	+
Nymphalidae	+		Ptychopteridae	?	
Olethreutidae		+	Rhagionidae	+	
Pieridae	+	+	Sarcophagidae	+	
Pterophoridae	+	+	Scatopsidae	+	
Pyralidae	+		Sciaridae	+	+
Tineidae	+				
Tortricidae	+				

continued...

Table 5. Concluded

Taxon	this study	Porter, Lousier 1975		this study	Porter, Lousier 1975
Sciomyzidae	+	+	Scelionidae		+
Sepsidae	+	+	Sphecidae	+	+
Simuliidae	+	+	Tenthredinidae	+	+
Stratiomyidae	+	+	Torymidae	+	+
Syrphidae	+	+	Trichogrammatidae	+	
Tabanidae	+	+	Vespidae	+	
Tachinidae	+	+			
Therevidae	+	+			
Tipulidae	+	+	Orders	16	14
Trichoceridae	+				
Trixoscelididae	?		Families	161	111
SIPHONAPTERA					
Leptosyllidae	+				
Ceratophyllidae	+				
HYMENOPTERA					
Apidae	+	+			
Argidae		+			
Braconidae	+	+			
Ceraphronidae	+				
Chalcididae		+			
Chrysididae	+	+			
Colletidae		+			
Cynipidae	+				
Diapriidae	+	+			
Diprionidae	+	+			
Dryinidae	+				
Encyrtidae	+				
Eucharitidae		+			
Eulophidae	+	+			
Eupelmidae	+				
Eurytomidae	+				
Formicidae	+	+			
Halictidae	+	+			
Ichneumonidae	+	+			
Megachilidae	+	+			
Mymaridae	+				
Perilampidae		+			
Platygasteridae	+				
Pompilidae	+	+			
Proctotrupidae	+	+			
Pteromalidae	+	+			

Table 6. Insect damage and insects evident on mature leaves of dominant plants collected in the AOSERP study area.

	No. leaves	Insect damaged	Ribbed... or Holed..	$\bar{x}$/ Leaf	Edges chewed	Leaf Area missing % Average	No. Insect Galls[a]	No. Insect mines	Leaves Rolled	Phytophagous insect larvae	Aphids or No. leaves	Psocids per leaf
Alnus crispa	250	92	27	3.0	30	4.3	0	37	2	0	61	1.7
Betula papyrifera	250	131	70	1.3	17	3.4	44[a]	3	0	1	26	1.4
Cornus stolonifera	250	249	220	12.6	25	4.9	0	0	2	8	172	6.7
Populus balsamifera	250	179	142	3.2	50	5.1	10	2	5	5	178	4.6
Populus tremuloides	250	174	100	2.1	111	14.7	17	9	6	8	64	2.0
Salix sp.	250	182	86	1.9	89	10.6	55[a]	3	0	16	22	7.9
Shepherdia canadensis	250	184	17	1.4	68	6.4	0	0	0	0	1	1
Viburnum trilobum	250	99	62	4.6	50	8.0	0	1	0	1	172	1.5
Vaccinium myrtilloides	250	51	11	2.9	33	13.2	0	2	0	0	0	0
Picea mariana	500[b]	6	0	0	0	0	0	5	0	0	0	0

[a] Gall totals on *Betula papyrifera* and *Salix* sp. are mite and insect caused; these are primarily mite galls

[b] needles

myrtilloides) leaves were attacked, and 1% of black spruce (*Picea mariana*) needles bore attack scars. The estimated area missing for attacked leaves was highest for aspen (*Populus tremuloides*), leaves at 14.7%, and second highest with blueberry leaves, at 13.2%. Altogether the estimated area missing for attacked deciduous leaves was 7.8%, while for the single conifer this was 0. It was often difficult to separate insect damage from mite damage, or other causes, particularly when deciding the cause of small holes. Also, mite and insect galls were not separated for willow (*Salix* sp.) and birch (*Betula papyrifera*) leaves. Aphids and psocids were abundant on the deciduous leaves. Some probably wandered from their parent leaf during storage, before being counted, but most appeared to remain clumped on this original leaf. The heaviest overall infestation occurred in dogwood leaves, 172 of which bore an average 6.7 aphids (also including some psocids). Scars left by these insects were not recognizable (with any certainty), except where a gall was made, but they do cause some net loss to the vitality of a leaf. Examples of these types of leaf damage are shown in Figures 11 to 14.

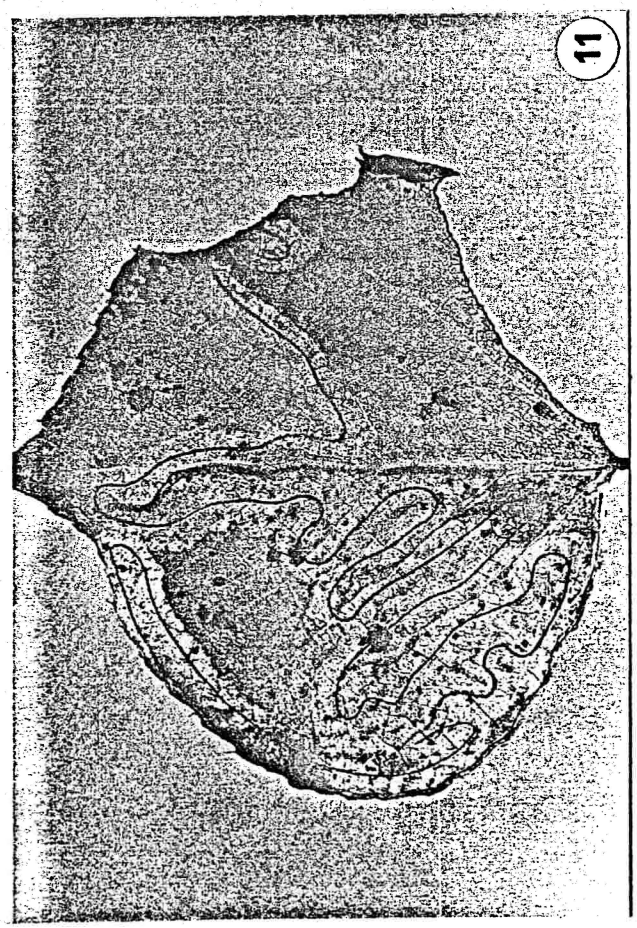
The stem damage survey, in Table 7, shows that few stems of deciduous plants bore insect damage. *Salix* sp. was the one exception, with 8 galls on 7 stems. Conifer tree stems were much more heavily attacked, with 34% bearing insect caused scars. For both spruce species, the bulk of these scars were galls (79), followed by bud damage (57). Bud death caused a difficulty in definition of the terminal 25 cm of a stem, since live leaders continue to grow while others have been killed and cease growth. Thus, for spruce, the terminal 25 cm means a total length of 25 cm of stem, including several terminals, at the end of a single branch. Jack pine (*Pinus banksiana*) bore scars at old staminate cone portions which were thought to be insect chewing. This conclusion remains tentative until confirmed by observations in spring. No scale insects were found on alder (*Alnus crispa*) and rose (*Rosa acicularis*) stems, while 1 to 66 were found on stems of the remaining deciduous tree species. Insect and spider predators found during this survey are also listed in Table 7. Examples of stem damage are shown in Figures 15 to 18.

Figure 11. Example of damage caused by insects in the AOSERP study area. Leaf mine by larva of *Phyllocnistis populiella* (Chambers) (Lepidoptera), and leaf border removed, on aspen poplar.

Figure 12. Example of damage caused by insects in the AOSERP study area. Galls of cecidomyiid fly larvae on aspen poplar leaf.

Figure 13. Example of damage caused by insects in the AOSERP study area. Galls of the aphid *Parathecabius populimonilis* (Riley) on balsam poplar leaves.

Figure 14. Example of damage caused by insects in the AOSERP study area. Damage to alder leaf caused by larvae and adults of the beetle *Altica ambiens* (LeConte) (Chrysomelidae).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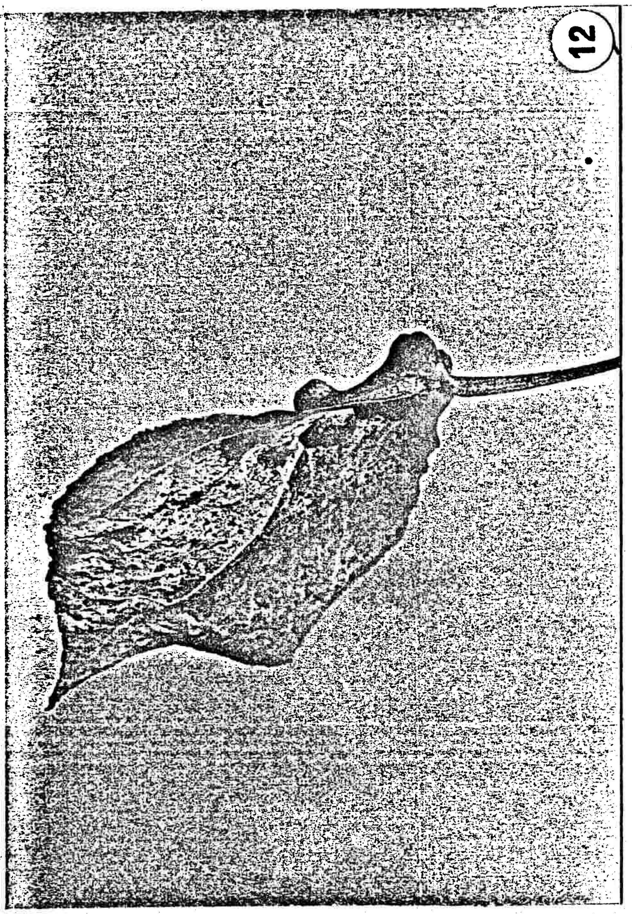
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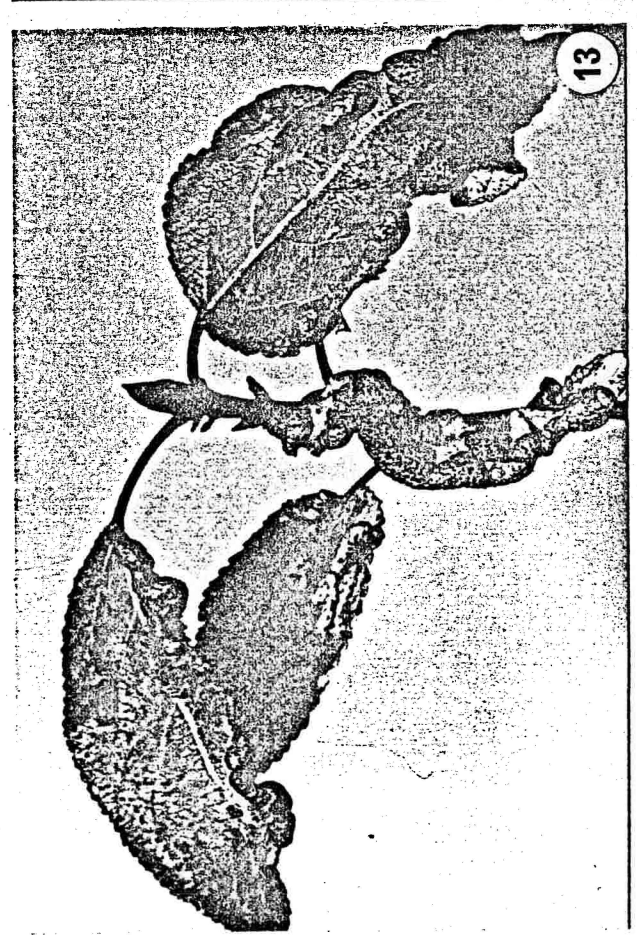
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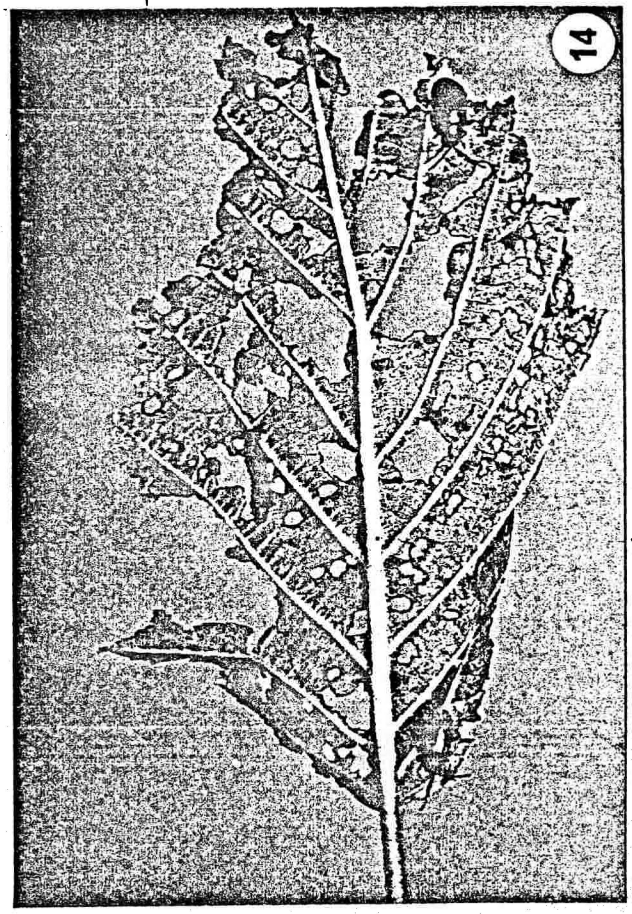
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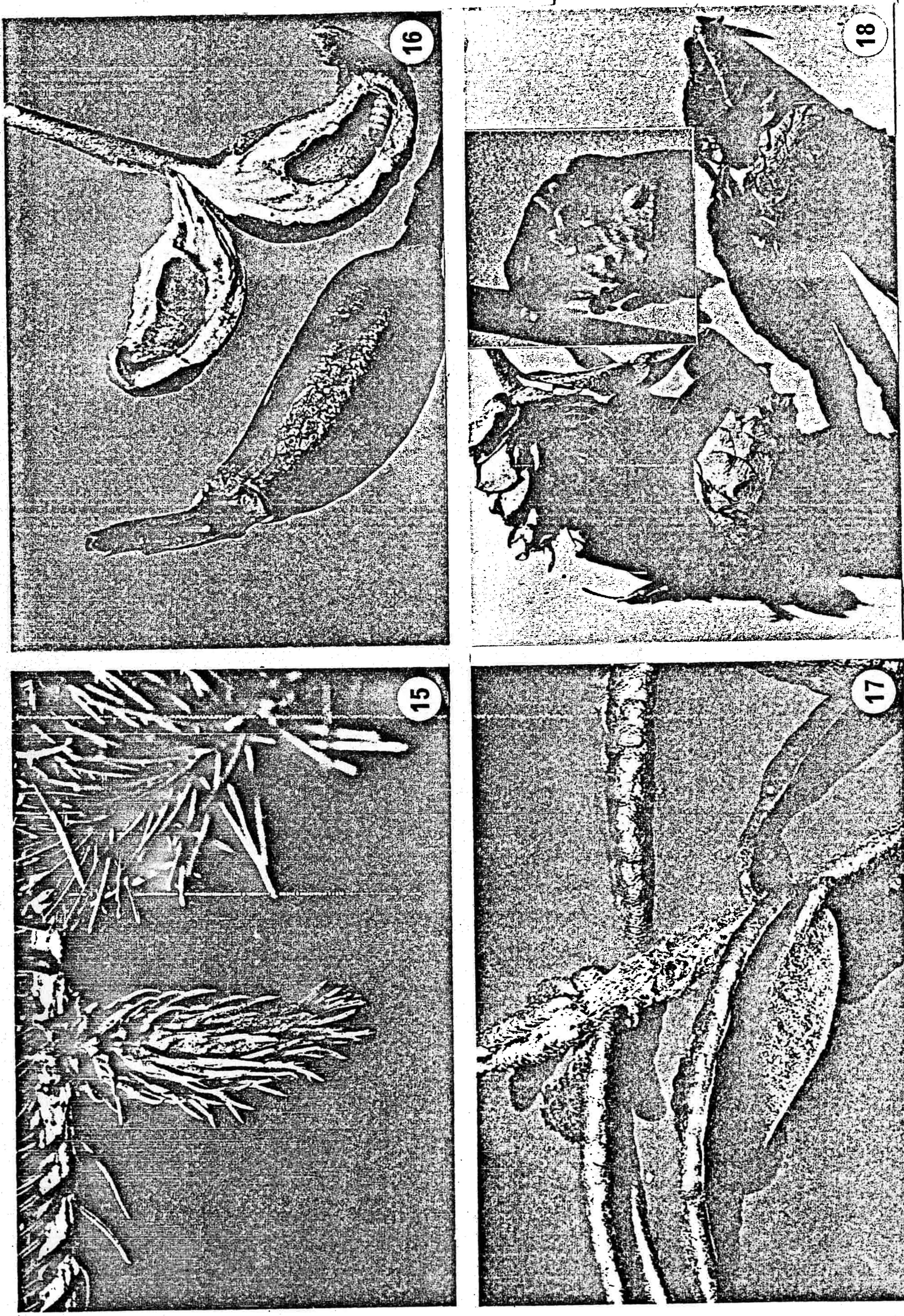
Figure 15. Example of damage caused by insects in the AOSERP study area. Gall of the pine leaf chermid, *Pineus pinifoliae* (Fitch), of white spruce needles.

Figure 16. Example of damage caused by insects in the AOSERP study area. Gall of cecidomyiid midge *Mayetiola* sp. on *Salix* sp.

Figure 17. Example of damage caused by insects in the AOSERP study area. Gall on stem of *Ledum groenlandicum* (Oeder) caused by unidentified insect.

Figure 18. Example of damage caused by insects in the AOSERP study area. Willow cone galls made by larvae of cecidomyiid midge *Rhabdophaga strobiloides* (Osten Sacken), also occupied (insert) by Lepidoptera and Hymenoptera larvae.



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16
17
18

Table 7. Insect predators and damage evident on the terminal 25 cm of branches of dominant plants in the AOSERP study area.

	Stems	Undamaged by Insects	Insect galls	Bud Damage	with Needles Mined or Cut	scale insects	Predators: Chrysopid larva	Coccinellid	Syrphid larva	Arneida
Alnus crispa	100	100								
Cornus stolonifera	100	100				1				5
Ledum groenlandicum	100	99	1			5				
Rosa acicularis	100	100								1
Salix sp.	100	93	8			11			2	
Shepherdia canadensis	100	100				66		1		
Viburnum trilobum	100	100				3				3
Picea glauca	100	66	33	18	2		1			2
P. glauca	100	61	29	18	7					
P. mariana	100	55	17	21	16					2
Pinus banksiana	100	85		8	a					6
P. banksiana	80	63		1	a	3				4

[a] Needle loss by staminate cone bearing and insect feeding were not distinguishable.

Tree damage is evaluated in Table 8. No tree crowns were found killed by beetle attack. Close inspection of small trees revealed that leader terminal buds were often killed by small insect larvae, apparently cecidomyiid flies. However, laterals rapidly became leaders, and trees continued to grow, albeit with a slight deflection from the vertical. Some terminals of spruce trees were denuded, bore cancerous clumps, or were abnormally spindly, the causes of which remain unknown to the authors.

3.4 INSECT FAUNA OF THE STUDY SITES

The insect fauna of each habitat is composed of generalists found throughout the sample sites, and specialists that are restricted in distribution. This can be seen from data in Tables 12 to 33 (see appendix), and the data base for the families represented in Tables 34 and 35 (see appendix). Larval Diptera, particularly members of the Fungivoridae and Anthomyiidae, ants (Hymenoptera, Formicidae), and Collembola (Onychiuridae and Poduridae) were abundant at almost every site. In this section, selected taxa are emphasized to characterize insect community organization and association of each site. Section numbers here correspond to our site numbers.

3.4.1 Riparian Forest

This habitat is on a river flood plain. Mud found in and under the bark of balsam poplars was evidence that MacKay River flood waters reached 2 1/4 m above the soil surface at the sample site. Large dead trees strewn over the area, and broken tree trunks, testified to the water's force. Below a thin layer of decaying leaves was 1 cm of clay, underlain by sand. Greenery occurred in four layers: a tree canopy of balsam poplar *(Populus balsamea)* and occasional paper birch *(Betula papyrifera)*, a shrub layer of high bush cranberry *(Viburnum trilobum)* and red osier dogwood *(Cornus stolonifera)*, with willow *(Salix* sp.) closer to the river, a herb layer of horsetails *(Equisetum* sp.), and a ground cover of mosses. The river 30 m away created humid conditions, which favorably affect many insects.

Table 8. Tree damage survey in the AOSERP study area, with particular attention to insect caused damage. Samples consist of 100 observations.

Tree species	Location	Height	Crowns Healthy	Damaged or deformed	Survey by
Picea mariana	site 4	≤ 15 m	86 87	area below crown often denuded, cause unknown	JR[a]
P. mariana	site 8	< 10 m	88	Terminal buds killed by insects, but trees recovered.	JR
P. mariana	Ells River	≤ 10 m	99	1 mistletoe	GH[b]
P. glauca + *P. mariana*	site 3	≤ 15 m	93	4 clumped crowns, 3 long spindly leaders	JR
P. g. + *P. m.*	site 2	10-20 m	97	2 shade killed; 1 crown with yellowed needles, possibly beetle damaged	GH
P. g. + *P. m.*	site 6	≤ 10 m	98	1 mistletoe; 1 broken top	JR
P. g. + *P. m.*	Ells River	≤ 15 m	100		GH
P. g. + *P. m.*	site 5	≤ 10 m	100		GH
Pinus banksiana	site 5	10-20 m	95	5 wind damaged crowns	GH
Pinus banksiana	site 8	≤ 10 m	99	1 leader broken	JR
Pinus banksiana	Ells River	10-25 m	100		GH
Populus tremuloides	Ells River	15-20 m	98	1 dead tree; 1 dying, leaves with insect damage	GH
Populus tremuloides	site 5	2-15 m	92	trees killed through competition	GH

[a] James Ryan
[b] Gerald Hilchie

Insect populations were diverse and abundant here, evidence of insect dispersal and colonization ability. Collembola populations here were the highest measured, and the most diverse of the 12 sites, with four families represented. A predaceous lampyrid larva was collected in the soil survey, and others were seen here. The bark of all dead trees examined bore buprestid beetle galleries in the cambium layer, and round holes in the wood from cerambycid and scolytid larvae. Carpenter ant galleries were observed in several tree trunks, but soil dwelling ants were not found in the extracted soil cores. The number of Diptera and Hymenoptera specimens was within the range of variation of the other sites.

3.4.2 White Spruce-Aspen Forest, Coniferous

This habitat is one of three forms which have similar vegetation. Here the tallest trees were 20 m white spruce (*Picea glauca*), with a few specimens of somewhat shorter jackpine (*Pinus banksiana*). The several specimens of aspen (*Populus tremuloides*) in the center and upslope of the site were 2 1/2 to 6 m tall, while birch (*Betula* sp.), and alder (*Alnus crispa*) comprised the rest of the shrubs. The moss-herb substratum consisted of grasses, bunchberry (*Cornus canadensis*), blueberry (*Vaccinium myrtilloides*), and many mosses forming a thick ground cover.

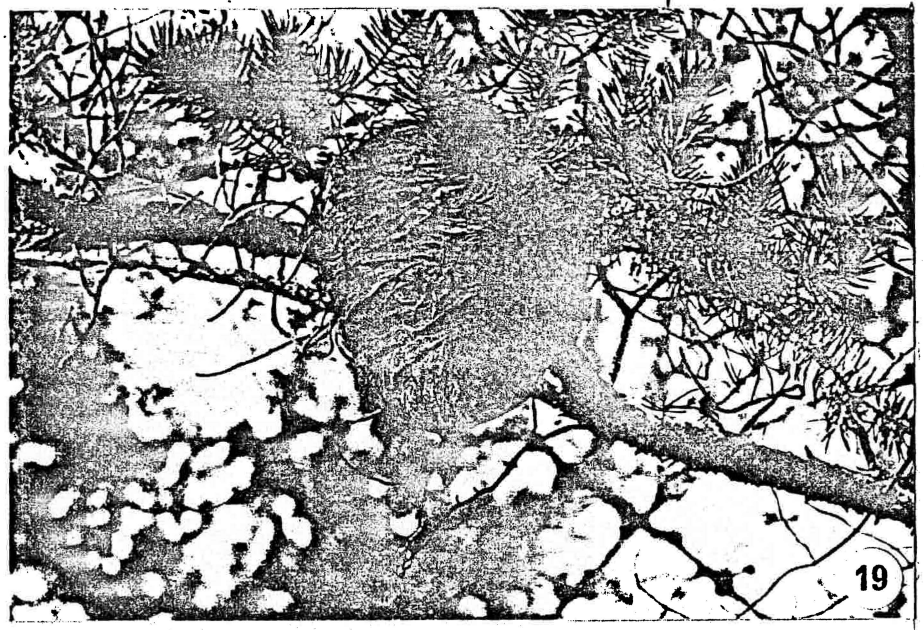
Members of an unusual family of insects collected in this habitat were the flat aradid bugs (Hemiptera) found in a pyrethrum sample. Aphids were abundant on the undersides of aspen leaves in late August, when 10% of the leaves examined (not Table 6 data) bore more than 12 aphids. Rhagionid and dolichopodid (Diptera) larvae were recovered in soil samples here, but were usually not found elsewhere.

Just 20 m below this site was a paper wasp nest, shown in Figure 19, made by a colony of bald-faced hornets, *Vespula maculata* (L.). By September 6, the founding queen and most workers had abandoned this nest, so it was collected and examined. The nest was 29 cm high by 23 cm wide, and contained 5 new/young queens, 1 worker, and 4 drones. It had 4 tiers of combs.

Figure 19. Wasp nest made by a colony of *Vespula maculata* (L.).

Figure 20. Wasp nest in ground made by a colony of *Vespula* sp.

Figure 21. Mushroom (*Hebeloma* sp.) heavily attacked by Fungivorid fly larvae (arrows) and staphylinid beetles.



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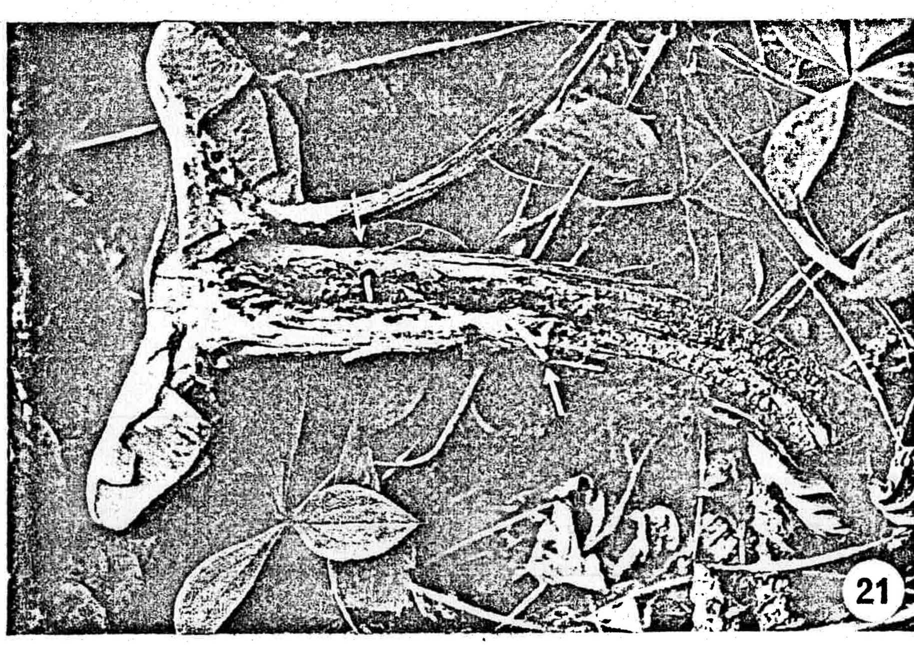

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Cells in the first comb had produced 2 to 3 wasps each, judging from the capped layers of remains at the bottom of each cell. The second and third combs, at 14 cm and 13 cm in diameter, were larger than the 12 cm top comb, but cells here had been used only once, and 194 cells had not been used at all. The bottom comb was 5 cm in diameter, and no adults had emerged from its 52 cells, although 17 were occupied by larvae. The combs had 987 cells altogether, of which 713 had produced more than 1,000 adult wasps. These progeny were the offspring of one overwintered queen active since spring. Another colony of smaller wasps, *Vespula* sp., shown in Figure 20 occupied a hole 35 m above this site. Wasps such as these might be found at the drier habitats investigated. They are scavengers and insect predators.

3.4.3 Aspen Forest

This habitat was dominated by aspen about 12 m tall, among which there was an occasional 5 to 8 m black spruce. The shrub layer averaged 1 m tall and was composed largely of buffalo-berry *(Shepherdia canadensis)*, rose *(Rosa acicularis)* and some willow. The herb layer consisted of grasses, bunch berry, blue-berry, scattered mosses, and in September, many mushrooms.

Insects were slightly more abundant here than in the other two (site 2 and 6) aspen forest communities. The total insect biomass of 756 mg contrasts sharply with the spider biomass of 31 mg. It appears that the available habitat for spiders and their webs is reduced in this forest, and consequently they have had less impact on insect populations than at the other aspen sites. This site had the smallest foliage insect biomass of the three, which implies either that the peak of adult insect abundance occurred earlier in the year, or that many insects were active in the tree canopy.

Collembola populations here were the second highest, and the carabid beetle populations were the highest, of all 12 sites. Collembola are dietary components of many species of carabid larvae and adults. A delphacid planthopper was collected here, while these were uncommon elsewhere.

Mushrooms were abundant in this habitat in September. These are a highly nutritious food, and were heavily attacked by insects. Collembola were found feeding on the gills, and staphylinid beetles fed inside the stem and cap. Fungivorid larvae, which dominate soil insect populations at almost every site, were also abundant in mushrooms, as can be seen in Figure 21. In the soil they feed on fungal mycelia, while a mushroom body is a dense concentration of mycelia. Hence what appears to be an unique phenomenon of maggots in mushrooms is actually an explicit example of the normal food habits of these soil dwelling larvae.

3.4.4 Black Spruce Bog

This spruce bog was dominated exclusively by black spruce trees 2 to 8 m tall. The low shrub layer consisted of Labrador tea (*Ledum groenlandicum*) and rushes (*Juncus* sp.), while the ground cover was dense moss and lichens. The high water table was often visible in pockets on the uneven surface of piled organic debris.

This habitat tended to have a low diversity of insects, although their biomass was about average. Five of six sweep samples gathered insects belonging to seven or less families. The pyrethrum foliage samples produced the smallest number of insects, with the lowest biomass, of the 12 sites. The combined spider biomass was also the lowest of the 12 sites, verifying the low insect figures, and suggesting that insect production here is lower than at the other sites. These figures contrast sharply with the richness of the other wet habitats, like sites 9, 10, and 12. The brown water of this bog appears to have adversely affected insect populations.

3.4.5 Mixed Coniferous Forest

The mixed coniferous forest site was composed of 2 to 10 m black spruce, 20 m jack pine, and 8 to 10 m white spruce. There was no shrub layer. The ground layer vegetation was dominated by moss, lichens, grasses, and blueberry. Fallen trees were common on the sandy soil surface.

Insect populations here were intermediate to those of similar habitats. One live jack pine tree bore a scar free of bark with numerous buprestid beetle galleries. The surrounding bark was growing inward to cover this bare patch. Buprestidae, Cerambycidae, and Scolytidae are the most notable of several beetle families whose members attack dead and weakened trees, particularly conifers. Recently killed trees attract large numbers of these beetles, and their wasp parasites.

3.4.6 Mixed Forest

This is the third aspen forest type. The tree layer here consisted of 5 to 12 m aspen, 2 to 6 m black and white spruce, and occasional 12 m jack pine. The shrub layer was well developed, with 2.5 m alder, some 2 m willow, 2 m dogwood (*Cornus stolonifera*), 1 m rose, and occasional 0.5 m Labrador tea and blueberry. The herb layer consisted of twin-flower (*Linnaea borealis*), some firewood (*Epilobium angustifolium*) and grasses. The ground surface was largely covered with dead leaves.

Insect population numbers and biomass in this habitat were intermediate to similar dry forest sites. Some insect inhabitants that were found include soft scales (Coccidae) on grass stems. Several adjacent stems bore up to 14 scales, which tended to be packed together and resembled white mold. Scales collected in early September proved to be masses of eggs beneath the body of the mother. These soon hatched into tiny crawlers, which would have dispersed by walking to other plants before settling to develop into a scale. Two parasitic chalcidoid wasps, and a fly, were reared from the egg clusters. An ant mound was dug up, but by September 6 the colony had retreated deeply into the ground, and no ants were found down to a depth of 35 cm.

3.4.7 Non-vegetated

This road-fill scrape would appear to be non-vegetated from an aerial photograph, but close examination showed that it had a thin cover of 1 m tall clover (*Melilotus alba*) and fireweed, various annuals, and some grasses.

This habitat contained the lowest number of insects of all 12 sites. However, the insect biomass was second only to that of the fen. This appears to be an artifact due to the extraction of a single large moth from a soil core. Vegetation sweeps yielded somewhat greater than average numbers and biomass of insects, due to the capture of several large bumblebees and numerous tiny wasps and flies. No Collembola were collected here, but they were found at every other site. Large bumblebees were abundant on the thin foliage. Wasps used the open sand for nesting, including the sphecid wasps (*Ammophila* sp., *Cercerus* sp., *Crabro* sp., and *Podalonia* sp.), and spider wasps (Pompilidae). Since these are predatory wasps, they influence the surrounding habitat through their hunting. The insect composition of this non-vegetated habitat was unusual. There were fewer but larger, and frequently interesting, insects. This area was definitely not void of insect life.

3.4.8 Jack Pine Forest

Jack pine trees 6 to 8 m tall dominated this habitat, but 2 to 6 m black spruce were about five times as abundant on its fringes. Several aspen were 2 to 6 m. There was no shrub layer here. Ground vegetation consisted of lichens, some moss, and *Vaccinium* sp.. The soil was fine sand.

Insect populations were below average in this comparatively arid habitat. Fly larvae populations were lower here than anywhere else except at the non-vegetated site. No ants were found here, although the sandy soil appeared suitable for ground colonies. This partly reflects the low productivity of vegetation on the well drained sand. Foliage inhabiting Collembola belonged to the families Entomobryidae and Sminthuridae, while soil Collembola were mostly Isotomidae and Onychiuridae. This was true for all habitats. Chermids (Homoptera), which are conifer-feeding aphids, were more abundant here than at other sites. More beetles and small adult flies were captured on the foliage here than at the other sites. Helodids were the most abundant of these beetles, but since their larvae are aquatic (Arnett 1971) they were resting on the vegetation rather than feeding on it.

3.4.9 Semi-open Tamarack Bog

Vegetation in this habitat was rather diverse. The woody plants were 1 to 3 m tamarack, 1 to 5 m black spruce, 2 to 3 m willow, and 1 to 2 m birch. Mosses, lichens, and diverse vascular plants formed a dense surface mat over organic debris. Water frequently pooled in troughs.

Fly larvae were abundant in the soil at this habitat, and spiders were more abundant here than at any other site. This follows a pattern of fly dominance at the aquatic sites, except for the spruce bog, and of spider predators to feed on these flies. Psocoptera were uncommon here compared to other sites, showing their habitat preference for trees with broad leaves. Ants were uncommon here due to a shortage of suitable dry nest sites. Few parasitic Hymenoptera were netted.

3.4.10 Fen

The fen vegetation was almost exclusively sedges, with an occasional 1 m birch. The roots of these sedges formed a thick organic mat which floated on the surface of a shallow pool. Water was always visible, and pooled up wherever weight forced the floating mat under.

Fly populations reached their highest in the fen. The biomass of each group of larvae was high, including that of the Ceratopogonidae. Members of this family of biting flies may significantly attack other insects. One mosquito larva was washed into a pitfall trap here. Sweep samples confirmed the overwhelming abundance of flies, and parasitic wasps, in this habitat.

These insects represent a large potential food source for insectivorous amphibians, birds, and shrews. Ants were also quite abundant here. They came from a single core through an ant colony, whose members were concentrated at the surface of the fen vegetation. Their biomass was 79% of the total insect biomass here. This shows the effect that clumped distributions of insect populations have on a random sampling program.

3.4.11 Lightly Forested Tamarack

The vegetation at this site was quite similar to that of the semi-open tamarack bog. There was very little standing surface water here, and soil was found at the forest floor surface or just beneath organic debris, except in hummocks.

Adult beetles contributed significantly to the insect biomass of this site. These were carabids and staphylinids, which are scavengers, predators and fungivores, and fungivorous Pselaphidae. Ants again made a major contribution to the insect biomass. Phytophagous insects, notably Lepidoptera and sawflies (Hymenoptera, Symphyta), were expected to be more abundant here and at the semi-open tamarack site than at other conifer sites, because tamarack are deciduous and grow new needles each year. Other conifers do not annually shed their needles, which consequently are woodier and less palatable. However, this prediction was not supported by data from the two tamarack sites this year.

3.4.12 Deciduous-shrub Wetland

Shrub vegetation at this site was 2 to 3.5 m alder and 1 to 3.5 m willow. A thin herb understory was mostly horsetails and grasses. Moss formed a more or less continuous ground cover, except for temporal pools of water. This site had once been forested, but these trees were killed by a fire which left fallen trees scattered across it.

Diptera larvae were again the dominant insects at this habitat, followed closely in biomass by the ants. Leafhoppers (Cicadellidae) and other Heteroptera made the third most significant group in terms of their biomass. These insects feed on flowing sap. Most of the *Gonotopus bicolor* Ashmead (Dryinidae), parasites of leafhoppers, were found in this habitat. Chrysomelid beetle adults and larvae were common on alder leaves here, but these dropped to the ground when disturbed, and could be under-represented in foliage samples. Altogether the beetles were the fourth ranked insect group by biomass. Sweep samples indicated that the insects at this site were more diverse than the average of the sites.

4. DISCUSSION

4.1 STANDING CROP NUMBERS AND BIOMASS

To determine standing crops of insects at the 12 study sites, we quantitatively sampled soil at every site, and foliage at 10 sites, to produce the data in Tables 3 and 4. These data are experimentally determined, but they underestimate the actual standing crops of insects. This proposition is proven to some extent by our own data. Storage of specimens in alcohol caused weight loss, and for light trap specimens it was determined that specimens at capture weighed 1.16 times their alcohol storage weight. Therefore the biomass of invertebrates reported in Table 4 was increased 1.16 times from the weights given in Tables 12 to 33 (see appendix). The leaf and stem damage surveys revealed the presence of gall and scale insects, which were not collected by the pyrethrum spray technique. Aphids were abundant on leaves, but the largest number found with the pyrethrum technique was 15 individuals m^{-2}, signifying extremely low collection rates.

Other investigators have analyzed the inefficiency of soil extraction techniques. Edwards and Fletcher (1971) showed conclusively that the techniques commonly used to extract soil invertebrates varied in efficiency, and that Tullgren funnels such as we used recovered fewer invertebrates than did MacFadyen high gradient funnels. Porter and Lousier (1975) extracted soil invertebrates from the AOSERP study area with a MacFadyen system, and reported Collembola populations of 1,300 to 2,300 m^{-2}. The soil dwelling Collembola populations we report there are 0 to 761 individuals m^{-2} for the 12 investigated sites. Inefficiency in sorting is an inherent problem. Willard (1972) found that his technicians recovered 67% of 1.5 mm beetle larvae he added to soil samples. He also reported a recovery rate of 48% of the enchytraeid worms added to soil cores, and subsequently extracted in O'Connor funnels.

Further inefficiencies are inherent in insect sampling procedures. Individuals are killed and injured while cutting and handling soil cores. Unknown numbers simply do not leave the core.

Large winged insects occasionally flew from pyrethrum soaked foliage and landed elsewhere. A great source of inaccuracy, illustrated in Figure 22, is the habitat area unsampled with pyrethrum. Tree foliage was sampled to 3 m; low foliage, and foliage taller than 3 m, were unsampled. There are no adequate methods available for sampling insect populations of these habitat layers, and the inadequate methods available are extremely labor intensive.

The actual standing crops of insects may easily be twice the biomass, and more than twice the number, that we report. This reflects the present technology of insect population studies. The impact of insects on the rest of the ecosystem could be more accurately assessed if sampling techniques were better. We report what was seen and measured, but with the understanding that these data understate the significance of the insect fauna.

4.2 TROPHIC STRUCTURE OF INSECT COMMUNITIES

The trophic structure of an insect community varies with the habitat. Much entomological literature deals with agricultural insects. This abundant literature can lead to general concepts about the structure of insect communities that emphasize destructive phytophagous insects and their parasites, but which do not necessarily apply to insect communities of undisturbed areas. For example, conclusions about the insect fauna associated with cultivated collards (Root 1973) emphasize herbivores, parasites and predators. However, these plants were grown in cultivated soil, were irrigated and fertilized for rapid growth, and the plants were harvested at maturity. The soil insect community was disrupted by cultivation, the food resource was of high quality for herbivores, the diversity and quantity (especially for soil insects) of available food was reduced, and the community equilibration time was minimal. AOSERP vegetation conditions are quite unlike agricultural environments.

Within natural forest habitats, the trophic structure of the crown strata (Martin 1966), foliage canopy (Whitaker 1952; Reichle et al. 1973), and soil insect communities (Englemann 1968; Edwards et al. 1970) have been examined. The field layer insect

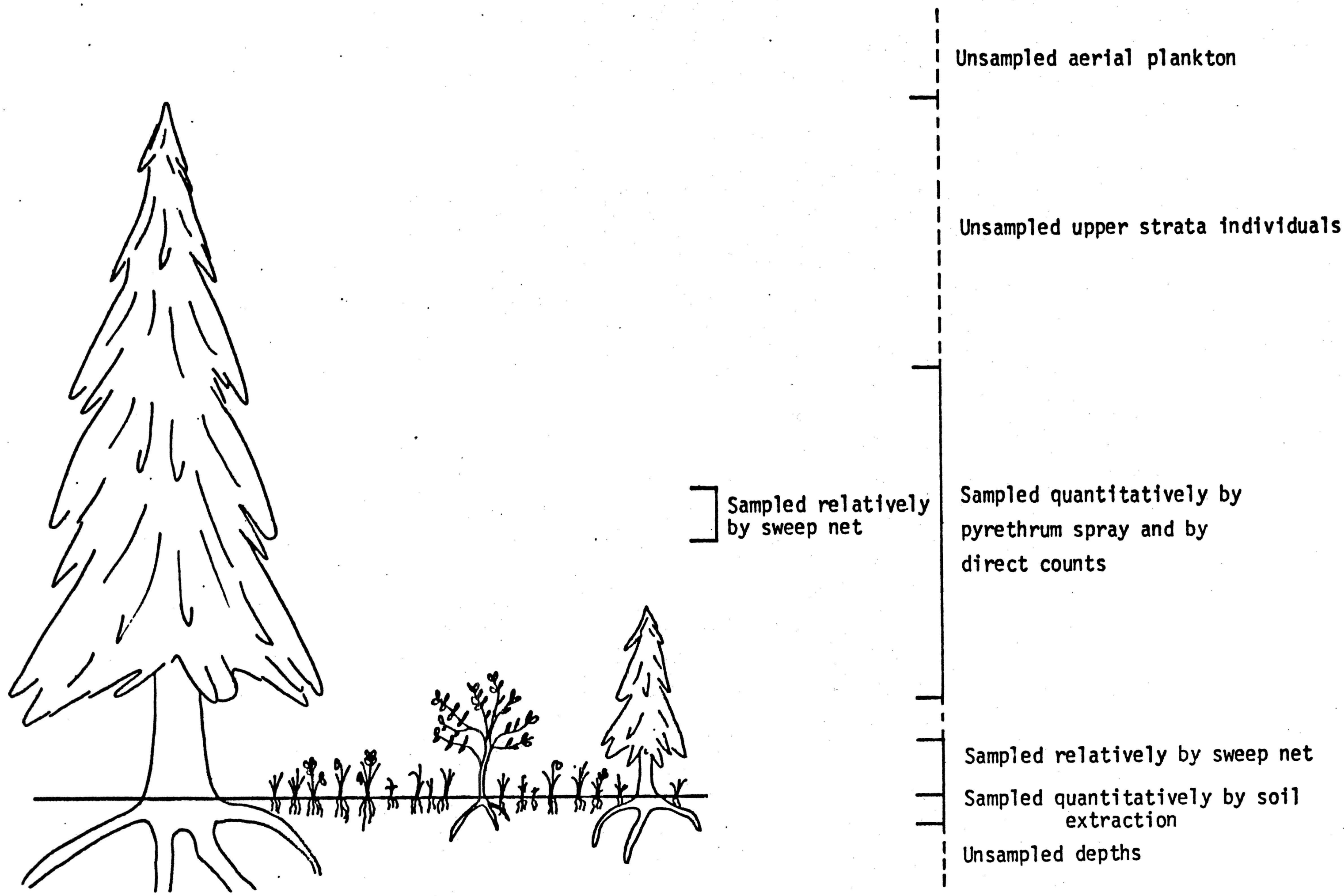

Figure 22. Habitat areas sampled in this survey versus those left unsampled.

fauna of a grassland (e.g. Evans and Murdoch 1968) may offer a parallel to the structure of the field layer fauna of forest understory vegetation. Trophic structures described in the cited above-ground investigations emphasize herbivore and parasite populations, while the soil studies focus heavily on saprovore interactions. A study of an Arctic ecosystem (Ryan 1977), where the complexity of interactions in the ecosystem were reduced, demonstrated that the main energy flow pathway of arctic insects was a decomposition food chain in the soil.

The trophic structure of AOSERP insect communities must be examined through literature on the feeding habits of these insects. We recognize three trophic groups here: Herbivores, Carnivores, and Saprovores. Herbivores are insects which consume and digest plant tissue, which is usually live or recently killed. Carnivorous insect lifestyles are variable (Ealey et al. in prep.), and include direct predation, internal parasitism which ultimately causes death to the host, and short term parasitism such as blood feeding by mosquitos. Predation may be opportunistic but not necessary for survival, as in the case of autogenous mosquitos which do not require a blood meal to produce eggs. Sporadic cannibalism and predation may be observed in insects which are not obligate carnivores. Many categories can be used to describe the remaining feeding habit types, but these will be limited here to the category of saprovore. A saprovore is an organism which requires some microbial action on its food before it is digested. Consumption of dead meat falls into a gray zone between the definition of carnivore and saprovore. Some larval muscoid Diptera have pharyngeal ridges which sieve fluid and bacteria sized particles, and exclude larger food chunks (Dowding 1967). In a putrid corpse these larvae appear to feed on flesh, but may in fact derive significant nutrition from bacteria and bacterial wastes. These larvae would be called carnivores if found in meat, and saprovores if found in soil litter. The actual diets of individuals of soil dwelling species may be quite complex, and include vegetable matter and freshly killed microinvertebrates as well as microbial products.

The trophic structure of insects at the 12 AOSERP sites was evaluated through combining the biomass data of Table 4 with feeding habit information from Borror and DeLong (1971). Feeding habits were evaluated for the insect families listed in Table 5, then summarized by order. The proportions used are given in Table 9.A. This information multiplied by Table 4 biomasses gives an estimate of the biomass of herbivores, carnivores, and saprovores at each site.

The results of these calculations are given by site, and site totals, in Table 9.B. The accumulated total of herbivores is 3.84 g, of saprovores 2.83 g, and of carnivores insects 2.94 g. Adding 1.30 g of spiders makes the carnivorous arthropod total 4.24 g. The total prey biomass of herbivores and saprovores was 6.67 g. The ratio of carnivore to prey biomass was 0.65.

The total biomass of the 12 sites is convenient to discuss, as it represents the AOSERP area ecosystem. The discussion of this totalled set of data can be compared to data from individual sites.

The ratio of insectivorous arthropods to prey appears to exceed theoretical limits. Waldbauer (1968) reviewed insect feeding studies and presents data to show that insects convert about 65% of digested food into body tissue. Since all prey insects cannot be captured, nor can they be 100% consumed and digested, the carnivore to prey biomass ratio (0.65) is too high. There are several reasons why this ratio was obtained. Carnivores actively hunt their food, while prey insects tend to conceal and not expose themselves to danger until mating and dispersal activities. Thus carnivores are more likely to be collected than prey insects, just as they are more likely to be exposed to and killed by insecticides than are the phytophagous insects that they feed upon (VandenBosch and Messenger 1973). We have indicated that the standing crop biomass of insects may be double the values given here due to inherent sampling inefficiencies, and habitat layers remaining unsampled. A larger standing crop of prey insects would reduce the ratio of carnivore to prey biomass to theoretically acceptable levels. This exercise demonstrates that the carnivore

Table 9. Evaluation of trophic levels of quantitatively sampled insect populations at 12 AOSERP study sites.

A. Percentage of population energy derived at each trophic level

Taxon	Herbivore	Saprovore	Carnivore
Collembola		100	
Psocoptera	10	90	
Heteroptera	80		20
Coleoptera	10	60	30
Lepidoptera	100		
Diptera	20	70	10
Hymenoptera	10		90
Formicidae	40		60
Tenthredinidae	100		
ARANEIDA			100

B. Estimate of biomass (mg) produced at each trophic level (= A *x* standing crops)

Site	Herbivore	Saprovore	Carnivore: Insect	Spider
1	96.0	233.7	26.0	233.7
2	376.6	199.1	98.1	87.0
3	208.1	389.6	196.7	32.0
4	199.8	145.0	114.5	30.0
5	108.3	168.0	124.6	96.0
6	124.2	176.5	58.3	199.0
7	925.4	170.4	67.2	47.0
8	40.3	135.6	31.1	55.0
9	102.4	254.9	68.7	243.0
10	1099.3	447.8	1536.9	35.0
11	337.5	260.3	402.2	99.0
12	224.1	248.7	213.0	201.0
Total:	3842	2829.6	2937.3	1300.0

$$\frac{\text{carnivores}}{\text{potential prey}} = \frac{2.94\text{ g} + 1.30\text{ g}}{3.84\text{ g} + 2.83\text{ g}} = \frac{4.24}{6.67} = 0.65$$

trophic level may be over-emphasized relative to other trophic levels due to sampling bias. It also argues that the carnivore trophic level is exploited to near theoretical limits, supporting the proposition that insects are their own worst enemies.

Herbivory is the most heavily exploited trophic level. Foliage feeding, seed gathering, and sapsucking insects form the bulk of this trophic group. Pollen and nectar feeding, and the consumption of other plant parts, appear to be less significant phenomena.

The saprovore trophic level was well represented, with nearly as many saprovore insects (2.83 g) as carnivore insects (2.94 g). Animals in this group came predominantly from the soil, the habitat zone least efficiently sampled. Why should a large biomass of insects be found in this trophic level, one level removed from the primary production source? Why are there not more phytophagous insects and only a small biomass of saprovore insects? The answer exists in the nutritional requirements of animals versus the composition of vegetation. Animals are protein based organisms. Protein must be obtained from the diet, as animals cannot manufacture it themselves. Plants are cellulose structures. The plant world consists largely of wood, as in plant cell walls, lignin, bark and xylem, etc. Protein is concentrated in the living, growing parts of plants, such as leaves, flowers, seeds, roots, and the cambium layer of bark. Plant protein is present in limited supply, protected by cellulose walls, while carbohydrates are available far in excess of the requirements of animals. Fungi and bacteria decompose vegetation, oxidizing carbohydrates, weakening wood structure, and concentrating protein in their own bodies. These microbes are then fed upon by saprovore insects. Thus while insect saprovores are at least one trophic level removed from the primary food source, carbohydrate energy loss is not dietarily important to them. This saprovore pathway results in easier accessibility of protein food.

This exercise required generalizations about insect feeding habits. These may be disputed, especially the percent contribution to the diet of each trophic level. However, this approach does demonstrate that the relative importance of carnivores may be over-estimated in ecosystem studies. It offers evidence that the role of saprovores may be under-estimated. These testable hypotheses represent a challenge to traditional concepts of herbivore-carnivore dominance of the trophic structure of an ecosystem.

4.3 INSECTS AS ENVIRONMENTAL MONITORS

The field of environmental monitoring to evaluate man-caused changes is quite new. The International Biological Program recently generated ecosystem studies in environments all over the world, as part of a program to quantitatively evaluate the structure of ecosystems. These study sites were situated in areas unlikely to be disturbed for long periods of time, so environmental changes could be measured on a global scale in the future. Insects have much potential as environmental monitors. For example, fruit flies, *Drosophila melanogaster* Meigen, have been used as experimental animals in genetics for years. By analogy, flies in natural environments have potential as monitors of mutagenic and teratogenic compounds, such as might occur in chemical dump sites.

In this study, insect numbers and biomass are being environmentally monitored. Major changes in the taxonomic composition of these insects, or changes (particularly reductions) in insect numbers and biomass, indicate environmental changes. Evaluation of these changes may be difficult because of the complexity of events in any ecosystem. Insect distributions are highly contagious, which causes great variability in data, and reduced predictive significance of data means. The solution to this problem appears to lie in taking large numbers of samples, and in evaluating insects on a trophic level basis so that while taxa may vary, equivalent functions within the ecosystem can be examined, which should stabilize fluctuations.

In their evaluation of insects as environmental monitors for the Syncrude lease, Porter and Lousier (1975) offered several suggestions. We dispute the value of some of these, including the use of the dung beetle (*Aphodius* sp.) and two species of March flies as environmental monitors. However, we have initiated a program to monitor species of carabid beetles at the 12 AOSERP habitats, as these authors suggested. They also suggested that pollutant SO_2 gas could weaken trees in the AOSERP study area, making them susceptible to insect attack (Stark et al. 1968; Wong et al. 1973). Among the insect groups likely to be involved in such attacks, the bark beetle family Scolytidae is the most potentially damaging to trees. For example, between 1939 to 1953 an estimated 11.25 x 10^6 m^3 of spruce were destroyed in a bark beetle outbreak in Colorado (Borden 1971). Because these beetles are so potentially damaging, the tree damage survey (Table 8) was initiated to determine present beetle infestation levels. None were found in this survey. A list of the species of bark beetle likely to occur in the AOSERP study area, prepared from data in Bright (1976), is presented in Table 10. These data are preliminary steps in a program to monitor populations of these potentially destructive insects.

Table 10. Bark beetles (Scolytidae) which may occur in the AOSERP study area (from Bright, 1976).

Bark Beetle	Tree Host: *Abies balsamea*	*Larix laricina*	*Picea glauca*	*Picea mariana*	*Pinus banksiana*	*Populus tremuloides*	*Salix* spp.
Carphoborus andersoni			+	+			None in AOSERP area
C. carri			+		+		
C. sansoni			+				
Cryphalus ruficollis	+		+	+			
Crypturgus borealis			+	+			
C. pusillus	?		?				
Dendroctonus murrayanae			+		+		
D. punctatus		+	+				
D. rufipennis			+				
D. simplex		+					
D. valens		+	+		+		
Dryocetes affaber		+	+	+			
D. autographus		+	+	+			
Gnathotrichus materiarius	?		?		?		
Hylurgops pinifex complex		+	+	+	+		
Ips borealis			+	+			
I. perroti					+		
I. perturbatus			+	+	+		
I. pini					+		
Orthotomicus caelatus		+	+	+	+		
Orthotomides lasiocarpa		+					
Phloeosinus pini			+	+	+		
Pityogenes hopkinsi			+		+		
P. plagiatus plagiatus				+	+		
Pityokeines minutus	+						
P. sparsus	+						
Pityophthorus albertensis			+				
P. intextus			+	+	+		
Polygraphus rufipennis	+	+	+		+		
Scierus annectans			+	+			
Scolytus piceae	+	+	+	+			
Trypodendron lineatum	+	+	+	+	+		
T. retusum						+	
T. rufitarsus			+		+		

5. CONCLUSIONS

Natural insect communities of the AOSERP study area form a complex, loosely ordered continuum of populations. These, like vegetation communities, are influenced most strongly by moisture. A gradient from wettest to driest habitat is loosely paralleled by a gradient of insect numbers, biomass, and diversity in these same habitats, the fen being the wettest, and jack pine and non-vegetated the driest sites on this gradient. Exceptions to this gradient are the depauperate spruce bog, and the great biomass and diversity of the non-vegetated site. The dominant families of insects are represented at nearly all sites. Among soil insect populations these include the Collembola families Onychiuridae, and Isotomidae, and Diptera families Chironomidae, Fungivoridae (=Mycetophilidae and Sciaridae), Ceratopogonidae, and Anthomyiidae. Greater variation exists in family diversity and population numbers of foliage inhabiting insects.

The trophic level to which the largest biomass of AOSERP study area insects belong is herbivore. The biomass of carnivorous and saprovorous insects is quite similar. This, however, overemphasizes the significance of carnivores, which are more active than prey and more frequently collected. Saprovore insects dwell primarily in soil and exploit fungi and bacteria as concentrated sources of protein food.

The present state of the insect fauna of 12 habitats are described. This is baseline data for comparison with future habitat changes.

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7. APPENDICES

These appendices present data that is summarized in the main body of the report. Data in Tables 11 to 32 refer to invertebrate populations reported in Tables 1 to 4, particularly the last two of these tables, Tables 11 to 23 refer to soil invertebrates, and Tables 24 to 32 refer to above-ground insect populations. Tables 33 to 34 contain sweep net sample data, another method to sample above-ground insect populations.

Table 11. Sample dates for O'Connor and Tullgren funnel soil extractions.

Habitat	Soil Cores Extracted: O'Connor Funnels	Soil Cores Extracted: Tullgren Funnels	Habitat	Soil Cores Extracted: O'Connor Funnels	Soil Cores Extracted: Tullgren Funnels
Riparian Forest	VIII-19	VIII-19	Non-vegetated	VIII-21	VIII-21
	-24	-24		-26	-26
	IX- 5	IX- 5		IX- 3	IX- 3
	-25	-25		-27	-27
White Spruce-Aspen Forest	VIII-19	VIII-19	Jackpine Forest	VIII-21	VIII-18
	-24	-24		-27	-27
	IX- 6	IX- 6		IX-20	IX-20
	-25	-25		-29	
Aspen Forest	VIII-19	VIII-19	Semi-open Tamarack Bog	VIII-20	VIII-18
	-25	-25		-29	-29
	IX- 2	IX- 2		IX-24	-24
	-21	-21			
Black Spruce Bog	VIII-19	VIII-19	Fen	VIII-23	VIII-23
	-21	IX- 1		-30	-30
	IX- 1	-21		IX-20	IX-20
	-21				
Mixed Coniferous Forest	VIII-21	VIII-21	Lightly Forested Tamarack	VIII-23	VIII-23
	IX- 6	IX- 6		IX- 5	IX- 5
	-23	-23		-20	-20
	-27			-29	
Mixed Forest	VIII-19	VIII-19	Deciduous-shrub Wetland	VIII-23	VIII-23
	-31	-31		IX- 4	IX- 4
	IX-23	IX-23		-24	-24
				-28	

Table 12. Invertebrate population numbers and biomass (oven dry weight) per meter-square, determined by O'Connor and Tullgren funnel extractions. Riparian Forest (Site 1).

Taxon	Life stage Immature/Adult	Funnel Type	Individuals m^{-2} to 2.5 cm	Individuals m^{-2} estim. to 5.0 cm	Biomass m^{-2} mg oven dry weight
INSECTA					
COLLEMBOLA	IA	T	761		14.5
Poduridae	IA	T	79		
Onychiuridae	IA	T	26		
Isotomidae	IA	T	642		
Sminthuridae	IA	T	13		
THYSANOPTERA					
Thripidae	A	T	26		
HOMOPTERA					
Chermidae	A	T	13		
COLEOPTERA					
Carabidae	I	T	60		21.8
Scarabaeidae	A	T	6		
Lampyridae	I	0	6	6	21.8
DIPTERA					
Ceratopogonidae	I	0	227	455	
Chironomidae	I	0	237	357	61.8
Bibionidae	I	0	92	92	
Fungivoridae	I	0	303	303	
Empididae	I	0	120	120	59.3
Dolichopodidae	I	0	13	13	
Cyclorrapha-all[a]	I	0	893	1209	26.3
(Anthomyiidae only)[b]	I	0	856	1083	
Trichoceridae	A	T	13		
Psychodidae	A	T	26		
Culicidae	A	T	90		
Mycetophilidae	A	T	66		
Sciaridae	A	T	66		65.8
Scatopsidae	A	T	13.		
Cecidomyiidae	A	T	13		
Stratiomyiidae	A	T	13		
Phoridae	A	T	13		
Calliphoridae	A	T	13		
HYMENOPTERA					
Braconidae	A	T	26		
miscellaneous insects		T			7.9
total insects					279
ARANEIDA	IA	T	53		105.3
ACARINA	IA	T	8682		
PSEUDOSCORPIONIDA	I	0	13		
DIPLOPODA	I	0	40		
MOLLUSCA	I	0	26		
OLIGOCHAETA					
Enchytraeidae	IA	0	8274	9888	

[a] Includes Anthomyiidae, Muscoidea
[b] Uncertainty

Table 13. Invertebrate population numbers and biomass (oven dry weight) per meter-square, determined by O'Connor and Tullgren funnel extractions. White Spruce-Aspen Forest (Site 2).

Taxon	Life stage Immature/Adult	Funnel Type	Individuals m^{-2} to 2.5 cm	Individuals m^{-2} estim. to 5.0 cm	Biomass m^{-2} mg oven dry weight
INSECTA					
COLLEMBOLA	IA	T	184		4.0
Poduridae	IA	T	13		
Isotomidae	IA	T	158		
Entomobryidae	IA	T	13		
PSOCOPTERA					
Psocidae	I	T	26		
THYSANOPTERA					
Thripidae	A	T	13		
HEMIPTERA					
Miridae	I	T	13		
HOMOPTERA					
Aphididae	I	T	13		
COLEOPTERA					
Elateridae	I	0	26		10.5
Carabidae	I	T	26		
Staphylinidae	I	T	13		38.1
Scarabaeidae	A	T	26		
LEPIDOPTERA					
Pterophoridae	A	T	66		195
DIPTERA					
Ceratopogonidae	I	0	40	40	
Chironomidae	I	0	263	287	42.1
Fungivoridae	I	0	1118	1118	
Rhagionidae	I	0	13	13	
Dolichopodidae	I	0	13	13	2.6
Cyclorrapha-all[a]	I	0	619	644	47.4
(Anthomyiidae-only)[b]	I	0	552	575	
Psychodidae	A	T	66		
Culicidae	A	T	26		
Mycetophilidae	A	T	53		
Sciaridae	A	T	118		94.7
Cecidomyiidae	A	T	66		
Anthomyiidae	A	T	40		
Muscidae	A	T	26		
other Muscoidea	A	T	40		
HYMENOPTERA					
Braconidae	A	T	26		19.7
Ichneumonidae	A	T	13		
Formicidae	A	T	40		30.3
miscellaneous insects		T			11.8
total insects					496
ARANEIDA	IA	T	158		38.1
ACARINA	IA	0	594	594	
MOLLUSCA	I	0	53		
OLIGOCHAETA					
Enchytraeidae	IA	0	2920	2993	

[a] Includes Anthomyiidae, Muscoidea
[b] Uncertainty

Table 14. Invertebrate population numbers and biomass (oven dry weight) per meter-square, determined by O'Connor and Tullgren funnel extractions. Aspen Forest (Site 3).

Taxon	Life stage Immature/Adult	Funnel Type	Individuals m^{-2} to 2.5 cm	Individuals m^{-2} estim. to 5.0 cm	Biomass m^{-2} mg oven dry weight
INSECTA					
COLLEMBOLA	IA	T	658		17.1
Onychiuridae	IA	T	53		
Isotomidae	IA	T	592		
Entomobryidae	IA	T	13		
PSOCOPTERA					
Psocidae	I	T	26		
HOMOPTERA					
Aphididae	A	T	13		
Chermidae	A	T	26		
Psyllidae	A	T	13		
Fulgoridae	A	T	13		
COLEOPTERA					
Carabidae	I	T	329 }		
Staphylinidae	I	T	13 }		307
Scarabaeidae	I	T	13 }		
Staphylinidae	A	T	13		
Cryptophagidae	A	T	13		
Scarabaeidae	A	T	13		
LEPIDOPTERA					
Geometridae	I	T	13 }		18.4
unknown	I	T	26 }		
Tineidae	A	T	13 }		60.5
Pterophoridae	A	T	40 }		
DIPTERA					
Psychodidae	I	O	53	53 }	
Chironomidae	I	O	237	237 }	38.2
Fungivoridae	I	O	1275	1275 }	
Empididae	I	O	40	40	5.0
Cyclorrapha-all[a]	I	O	539	552 }	
(Phoridae)	I	O	120	133 }	28.9
(Anthomyiidae)[b]	I	O	369	369 }	
Tipulidae	I	T	13		
Culicidae	A	T	53 }		
Mycetophilidae	A	T	40 }		
Sciaridae	A	T	118 }		
Cecidomyiidae	A	T	40 }		68.4
Phoridae	A	T	26 }		
Agromyzidae	A	T	13 }		
Muscidae	A	T	40 }		
Calliphoridae	A	T	13 }		
HYMENOPTERA					
Proctotrupidae	A	T	13 }		
Eurytomidae	A	T	118 }		18.4
Braconidae	A	T	13 }		
Formicidae	A	T	104		71
miscellaneous insects		T			14.5
total insects					647
ARANEIDA	IA	T	105		3.9
ACARINA	IA	T	159		
DIPLOPODA	I	O	26		
OLIGOCHAETA					
Enchytraeidae	I	O	1316	1493	

[a]Includes Sepsidae, Phoridae, Anthomyiidae
[b] Uncertainty

Table 15. Invertebrate population numbers and biomass (oven dry weight) per meter-square, determined by O'Connor and Tullgren funnel extractions. Black Spruce Bog (Site 4).

Taxon	Life stage Immature/Adult	Funnel Type	Individuals m^{-2} to 2.5 cm	Individuals m^{-2} estim. to 5.0 cm	Biomass m^{-2} mg oven dry weight
INSECTA					
COLLEMBOLA			297		5.0
Poduridae	IA	T	104		
Isotomidae	IA	T	193		
THYSANOPTERA					
Thripidae	A	T	18		
HEMIPTERA					
Miridae	IA	T	35		
HOMOPTERA					
Cicadellidea	I	T	18		
Cercopidae	I	T	18		
COLEOPTERA					42.1
Carabidae	I	T	18		
Elateridae	I	T	18		
Staphylinidae	A	T	18		
Nitidulidae	A	T	35		
Pselaphidae	A	0	18		
LEPIDOPTERA					
Geometridae	I	0	18		0.7
Pterophoridae	A	T	158		96
DIPTERA					
Ceratopogonidae	I	0	13		
Chironomidae	I	0	515	609	27.6
Fungivoridae	I	0	410	726	
Therevidae	I	0	13		1.3
Dolichopodidae	I	0	13		
Cyclorrapha-all[a]	I	0	120		5.3
(Anthomyiidae only)[b]	I	0	120	183	
Culicidae	A	T	18		
Sciaridae	A	T	130		
Mycetophilidae	A	T	35		
Cecidomyiidae	A	T	18		89.5
Anthomyiidae	A	T	70		
Muscidae	A	T	35		
HYMENOPTERA					
Torymidae	A	T	18		
Braconidae	A	T	18		8.8
Formicidae	A	T	117		103
miscellaneous insects		T			33.3
total insects					413
ARANEIDA		T	176		7.9
ACARINA		T	1964		
"Ticks"		0	13		
OLIGOCHAETA					
Enchytraeidae		0	1894	2368	

[a]Includes Anthomyiidae, Muscoidea
[b] Uncertainty

Table 16. Invertebrate population numbers and biomass (oven dry weight) per meter-square, determined by O'Connor and Tullgren funnel extractions. Mixed Coniferous Forest (Site 5).

Taxon	Life stage Immature/Adult	Funnel Type	Individuals m^{-2} to 2.5 cm	Individuals m^{-2} estim. to 5.0 cm	Biomass m^{-2} mg oven dry weight
INSECTA					
COLLEMBOLA	IA	T	317		5.3
Poduridae	IA	T	18		
Onychiuridae	IA	T	140		
Isotomidae	IA	T	159		
THYSANOPTERA					
Thripidae	A	T	70		7.0
HOMOPTERA					
Aphididae	I	T	35		19.3
COLEOPTERA					28.1
Carabidae	I	T	88		
Staphylinidae	A	T	18		
DIPTERA					
Tipulidae	I	0	13	13	13.2
Chironomidae	I	0	436	755 }	40.8
Fungivoridae	I	0	698	698 }	
Bibionidae	I	0	13	13	3.9
Anthomyiidae[a]	I	0	395	455	27.6
Culicidae	A	T	18 }		
Psychodidae	A	T	18 }		
Mycetophilidae	A	T	70 }		19.3
Sciaridae	A	T	70 }		
Cecidomyiidae	A	T	18 }		
Anthomyiidae	A	T	18 }		
HYMENOPTERA					
Formicidae	A	T	88		73.7
Pteromalidae	A	T	18 }		22.8
Braconidae	A	T	53 }		
total insects					261
ARANEIDA	A	T	105		28.1
ACARINA	IA	0	708	802	
MOLLUSCA	I	0	13		
OLIGOCHAETA					
Enchytraeidae	IA	0	1474	2456	

[a]Uncertainty

Table 17. Invertebrate population numbers and biomass (oven dry weight) per meter-square, determined by O'Connor and Tullgren funnel extractions. Mixed Forest (Site 6).

Taxon	Life stage Immature/Adult	Funnel Type	Individuals m^{-2} to 2.5 cm	Individuals m^{-2} estim. to 5.0 cm	Biomass m^{-2} mg oven dry weight
INSECTA					
COLLEMBOLA	IA	T	351		12.3
Onychiuridae	IA	T	158		
Isotomidae	IA	T	158		
Entomobryidae	IA	T	35		
PSOCOPTERA					
Psocidae	IA	T	18		
THYSANOPTERA					
Thripidae	A	T	18		
HEMIPTERA					
Lygaeidae	A	T	18		
unknown	I	T	18		
COLEOPTERA					
Carabidae	I	T	104		31.6
Staphylinidae	A	T	70		52.6
LEPIDOPTERA					
Pterophoridae	A	T	35		49.1
DIPTERA					
Psychodidae	I	0	18	18 }	
Chironomidae	I	0	193	193 }	19.3
Fungivoridae	I	0	297	297 }	
Dolichopodidae	I	0	18	18 }	7.0
unknown Brachycera	I	0	18	18 }	
Cyclorrapha-all[a]	I	0	158	224	5.3
(Anthomyiidae)[b]	I	0	104	104	
Mycetophilidae	A	T	18 }		
Sciaridae	A	T	140 }		70.2
Cecidomyiidae	A	T	18 }		
HYMENOPTERA					
Eurytomidae	A	T	18		
Formicidae	A	T	18		
miscellaneous insects					36.8
total insects					284
ARANEIDA	IA	T	70		109
ACARINA	IA	0	1367		
OLIGOCHAETA					
Enchytraeidae	IA	0	1193	1332	

[a] Includes Anthomyiidae, Muscoidea
[b] Uncertainty

Table 18. Invertebrate population numbers and biomass (oven dry weight) per meter-square, determined by O'Connor and Tullgren funnel extractions. Non-Vegetated (Site 7).

Taxon	Life stage Immature/Adult	Funnel Type	Individuals m^{-2} to 2.5 cm	Individuals m^{-2} estim. to 5.0 cm	Biomass m^{-2}, mg oven dry weight
INSECTA					
THYSANOPTERA					
Thripidae	A	T	13		
HOMOPTERA					
Aphididae	I	T	13		
COLEOPTERA					172
Carabidae	A	T	13		
Staphylinidae	A	T	26		
Byrrhidae	A	T	13		
Nitidulidae	A	T	40		
LEPIDOPTERA					768
Notodontidae	A	T	13		
Pterophoridae	A	T	26		
DIPTERA					
Chironomidae	I	0	53	53	
Fungivoridae	I	0	13	13	10.5
Psychodidae	A	T	13		
Mycetophilidae	A	T	40		
Sciaridae	A	T	79		38.2
Cecidomyiidae	A	T	26		
Muscidae	A	T	13		
Anthomyiidae	A	T	13		
HYMENOPTERA					13.2
Braconidae	A	T	40		
Eurytomidae	A	T	13		
miscellaneous insects					2.6
total insects					1005
ARANEIDA	IA	T	79		40.8
ACARINA	IA	0	26	26	
OLIGOCHAETA					
Enchytraeidae	IA	0	133	170	

Table 19. Invertebrate population numbers and biomass (oven dry weight) per meter-square, determined by O'Connor and Tullgren funnel extractions. Jack pine Forest (Site 8).

Taxon	Life stage Immature/Adult	Funnel Type	Individuals m^{-2} to 2.5 cm	Individuals m^{-2} estim. to 5.0 cm	Biomass m^{-2} mg oven dry weight
INSECTA					
COLLEMBOLA	IA		228		19.3
Onchiuridae	IA	T	140		
Isotomidae	IA	T	88		
THYSANOPTERA					
Thripidae	A	T	18		
HEMIPTERA	I	T	18		
HOMOPTERA					
Chermidae	IA	T	246		24.6
COLEOPTERA					38.6
Carabidae	I	T	53		
Staphylinidae	IA	T	53		
Elateridae	I	0	13	13	
DIPTERA					
Chironomidae	I	0	92	92 }	
Fungivoridae	I	0	66	66 }	40.8
Bibionidae	I	0	26	26 }	
Cyclorrapha-all[a]	I	0	224	272	3.9
(Anthomyiidae only)[b]	I	0	199	272	
Mycetophilidae	A	T	35 }		
Sciaridae	A	T	18 }		36.8
Anthomyiidae	A	T	35 }		
HYMENOPTERA					
Eurytomidae	A		18		
Formicidae	A		18		
miscellaneous insects		T			35.1
total insects					199
ARANEIDA	IA	T	88		22.8
ACARINA	IA	T	2385		
OLIGOCHAETA					
Enchytraeidae	IA	0	3640	4262	

[a]Includes Muscidae, Anthomyiidae
[b] Uncertainty

Table 20. Invertebrate population numbers and biomass (oven dry weight) per meter-square, determined by O'Connor and Tullgren funnel extractions. Semi-open Tamarack Bog (Site 9).

Taxon	Life stage Immature/Adult	Funnel Type	Individuals m^{-2} to 2.5 cm	Individuals m^{-2} estim. to 5.0 cm	Biomass m^{-2} mg oven dry weight
INSECTA					
COLLEMBOLA			106		5.3
Poduridae	IA	T	18		
Onychiuridae	IA	T	18		
Isotomidae	IA	T	70		
THYSANOPTERA					
Thripidae	A	T	18		
HEMIPTERA	I	T	18		
HOMOPTERA					14
Aphididae	A	T	18		
Chermidae	A	T	53		
COLEOPTERA					
Elateridae	I	O	35	35	17.1
Carabidae	IA	T	105 }		
Staphylinidae	A	T	105 }		71.9
Pselaphidae	A	T	18 }		
Cryptophagidae	A	T	18 }		
LEPIDOPTERA					
Geometridae	I	T	35		12.3
DIPTERA					
Ceratopogonidae	I	O	527	1579 }	
Chironomidae	I	O	2699	3315 }	51.3
Bibionidae	I	O	35	35 }	
Fungivoridae	I	O	177	177 }	
Empididae	I	O	18	18	19.7
Cyclorrapha-all[a]	I	O	53	123	84.2
(Anthomyiidae only)[b]	I	O	105	246	
Tipulidae	I	T	18		
Psychodidae	A	T	18 }		
Culicidae	A	T	18 }		
Mycetophilidae	A	T	18 }		56.1
Sciaridae	A	T	35 }		
Cecidomyiidae	A	T	18 }		
Muscoidea	A	T	18 }		
HYMENOPTERA					
Braconidae	A	T	18		
miscellaneous insects					26.3
total insects					358
ARANEIDA	IA	T	386		184
ACARINA	IA	O	9087	9282	
OLIGOCHAETA					
Enchytraeidae	IA	O	7924	8776	

[a]Includes Anthomyiidae, Muscoidea
[b]Uncertainty

Table 21. Invertebrate population numbers and biomass (oven dry weight) per meter-square, determined by O'Connor and Tullgren funnel extractions. Fen (Site 10).

Taxon	Life stage Immature/Adult	Funnel Type	Individuals m^{-2} to 2.5 cm	Individuals m^{-2} estim. to 5.0 cm	Biomass m^{-2} mg oven dry weight
INSECTA					
COLLEMBOLA			211		12.3
Poduridae	IA	T	158		
Onychiuridae	IA	T	18		
Isotomidae	IA	T	35		
HEMIPTERA					
Saldidae	A	T	18		
HOMOPTERA					
Cercopidae	A	T	18		
Chermidae	A	T	18		
COLEOPTERA					33.3
Carabidae	A	T	35		
Staphylinidae	A	T	18		
Orthoperidae	A	T	35		
Cryptophagidae	A	T	18		
LEPIDOPTERA					
Pterophoridae	A	T	18		
DIPTERA					
Psychodidae	I	O	7040	7735	
Ceratopogonidae	I	O	12312	18595	
Chironomidae	I	O	8776	9597	282.4
Bibionidae	I	O	18	18	
Fungivoridae	I	O	649	688	
Dolichopodidae	I	O	139	139	12.3
Muscidae	I	O	18	18	21.0
Anthomyiidae[a]	I	O	123	123	
Bibionidae	A	T	70		
Mycetophilidae	A	T	35		
Sciaridae	A	T	333		191.2
Cecidomyiidae	A	T	35		
Anthomyiidae	A	T	35		
HYMENOPTERA					
Cynipidae	A	T	18		
Formicidae	A	T	1649		2108
miscellaneous insects					24.6
total insects					2685
ARANEIDA	IA	T	70		29.8
ACARINA	IA	O	2402	2841	
CRUSTACEA					
COPEPODA	IA	O	4546		
OSTRACODA	IA	O	2314		
OLIGOCHAETA					
Enchytraeidae	IA	O	1124	1282	

[a]Uncertainty

Table 22. Invertebrate population numbers and biomass (oven dry weight) per meter-square, determined by O'Connor and Tullgren funnel extractions. Lightly Forested Tamarack (Site 11).

Taxon	Life stage Immature/Adult	Funnel Type	Individuals m^{-2} to 2.5 cm	Individuals m^{-2} estim. to 5.0 cm	Biomass m^{-2} mg oven dry weight
INSECTA					
COLLEMBOLA			264		3.5
Onychiuridae	IA	T	88		
Isotomidae	IA	T	176		
THYSANOPTERA					
Thripidae	IA	T	18		
HOMOPTERA					
Cercopidae	IA	T	18		
Chermidae	IA	T	35		
COLEOPTERA					
Carabidae	I	T	53		
Staphylinidae	I	T	18		8.8
Elateridae	I	T	18		
Carabidae	A	T	53		
Staphylinidae	A	T	35		210.5
Pselaphidae	A	T	281		
LEPIDOPTERA					
Geometridae	I	T	18		7.0
unknown	I	T	18		
DIPTERA					
Ceratopogonidae	I	O	328	328	
Chironomidae	I	O	290	530	25.0
Fungivoridae	I	O	211	211	
Empididae	I	O	13	18	13.2
Cyclorrapha-all[a]	I	O	327	631	
(Anthomyiidae only)[b]	I	O	158	158	
Psychodidae	A	T	35		
Culicidae	A	T	18		
Simuliidae	A	T	18		77.2
Bibionidae	A	T	18		
Sciaridae	A	T	70		
Cecidomyiidae	A	T	35		
Anthomyiidae	A	T	53		
HYMENOPTERA					
Pteromalidae	A	T	18		
Formicidae	A	T	53		387.6
miscellaneous insects					10.5
total insects					743
ARANEIDA	IA	T	298		47.4
ACARINA	IA	O	17008	31976	
OLIGOCHAETA					
Enchytraeidae	IA	O	1698	2365	

[a]Includes Anthomyiidae, Muscoidea
[b] Uncertainty

Table 23. Invertebrate population numbers and biomass (oven dry weight) per meter-square, determined by O'Connor and Tullgren funnel extractions. Deciduous-shrub Wetland (Site 12).

Taxon	Life stage Immature/Adult	Funnel Type	Individuals m^{-2} to 2.5 cm	Individuals m^{-2} estim. to 5.0 cm	Biomass m^{-2} mg oven dry weight
INSECTA					
COLLEMBOLA			508		1.8
Poduridae	IA	T	35		
Onychiuridae	IA	T	105		
Isotomidae	IA	T	368		
THYSANOPTERA					
Thripidae	A	T	35		
COLEOPTERA					
Carabidae	I	T	105		29.8
Carabidae	A	T	35		
Hydrophilidae	A	T	18		
Limnebiidae	A	T	35		56.1
Staphylinidae	A	T	35		
Mycetaeidae	A	T	35		
LEPIDOPTERA					
Geometridae	I	T	18		7.0
Pterophoridae	A	T	18		12.3
Tineidae	A	T	18		
DIPTERA					
Ceratopogonidae	I	O	789	1127	
Chironomidae	I	O	1566	1859	53.9
Bibionidae	I	O	13	13	
Fungivoridae	I	O	278	300	
Cyclorrapha-all[a]	I	O	183	183	11.8
(Anthomyiidae only)[b]	I	O	92	92	
Psychodidae	A	T	18		
Culicidae	A	T	88		
Simuliidae	A	T	18		101.7
Bibionidae	A	T	18		
Mycetophilidae	A	T	70		
Sciaridae	A	T	18		
HYMENOPTERA					
Braconidae	A	T	18		10.5
Formicidae	A	T	140		147.3
miscellaneous insects					3.5
total insects					435
ARANEIDA	IA	T	281		152.6
ACARINA	IA	O	3315	3757	
OLIGOCHAETA					
Enchytraeidae	IA	O	5051	5935	

[a] Includes Anthomyiidae, Muscoidea, Muscidae
[b] Uncertainty

Table 24. Arthropod above-ground standing crops, as estimated by 10 m^2 pyrethrum spray samples (4 replicates, each an average of 2.5 m^2) of foliage. Riparian Forest (Site 1).

Taxon	VIII-24 Individuals m^{-2}	VIII-24 Biomass m^{-2} mg (oven dry)	IX-25 Individuals m^{-2}	IX-25 Biomass m^{-2} mg (oven dry)
INSECTA				
COLLEMBOLA				
Entomobryidae	0.2			
Sminthuridae	0.1			
PSOCOPTERA		5.5		1.1
Pseudocaeciliidae	0.3			
Psocidae	10.7		0.3	
THYSANOPTERA				
Thripidae	0.4			
HEMIPTERA		18.2		
Miridae	0.1			
Pentatomidae	0.2			
unknown nymph	0.1			
HOMOPTERA		21.4		2.1
Aphididae	8.4	(7.3)	0.7	
Cercopidae	0.2			
Cicadellidae	7.3	(11.6)	0.3	
Pseudococcidae	0.2			
Psyllidae	0.4		0.1	
NEUROPTERA				
Chrysopidae	0.1			
COLEOPTERA		7.6		8.6
Chrysomelidae	1.0		0.8	
Coccinellidae			0.1	
Curculionidae	0.1			
Helodidae			0.1	
Lampyridae			0.2	
Lathridiidae	0.2			
LEPIDOPTERA		19.5		10.0
Pterophoridae			0.1	(1.5)
Geometridae larvae	2.2		0.1 }	(8.5)
undet. larvae	0.3		0.2 }	
DIPTERA		4.5		5.2
Agromyzidae	0.1			
Anthomyiidae	0.2			
Bibionidae			0.9	
Cecidomyiidae	0.3			
Ceratopogonidae	0.1			
Chamaemyiidae			0.1	
Chironomidae	0.3			
Chloropidae	0.1		0.1	
Culicidae	0.2			
Empididae	0.1			
Muscidae	0.2			
Mycetophilidae	0.3		0.1	
Phoridae	1.7		0.1	
Sciaridae	2.0		0.1	
Simuliidae	0.1			
HYMENOPTERA		9.3		1.4
Diapriidae	0.3			
Encyrtidae	0.1			
Eurytomidae	0.1		0.1	
Ichneumonidae	1.2		0.1	
Platygasteridae	0.1			
Pteromalidae	0.5			
Tenthredinidae	0.2	(3.6)		
Torymidae			0.1	
miscellaneous insects		1.4		
total insects	40.7	87.4	4.7	28.4
ARANEIDA	14.0	43.0	4.3	49.3
ACARINA	8.1		0.3	

Table 25. Arthropod above-ground standing crops, as estimated by 10 m^2 pyrethrum spray samples (4 replicates, each an average of 2.5 m^2) of foliage. White Spruce-Aspen Forest (Site 2).

	VIII-24		IX-6	
Taxon	Individuals m^{-2}	Biomass m^{-2} mg (oven dry)	Individuals m^{-2}	Biomass m^{-2} mg (oven dry)
INSECTA				
COLLEMBOLA				
Sminthuridae	0.1			
PSOCOPTERA		2.7		0.4
Pseudocaeciliidae			0.2	
Psocidae	4.2		8.2	
THYSANOPTERA				
Thripidae			0.3	
HEMIPTERA		21.5		104.1
Aradidae	0.1			
Miridae	0.1		0.1	
Pentatomidae	0.2		0.9	
undet. nymph			0.2	
HOMOPTERA		6.9		4.2
Aphididae	3.8	(3.0)	3.3	
Chermidae			0.1	
Cicadellidae	1.0			
Fulgoridae	0.1			
Pseudococcidae	0.1			
Psyllidae	0.4			
NEUROPTERA				1.1
Chrysopidae larvae	0.1		0.2	
COLEOPTERA		0.8		3.4
Carabidae			0.1	
Chrysomelidae	0.1			
Coccinellidae larva	0.1			
Lathridiidae	0.1		0.1	
LEPIDOPTERA		3.1		13.4
Geometridae larvae			0.3	
undet. larvae	0.4		0.2	
DIPTERA		9.8		3.9
Anthomyiidae	0.1		0.2	
Bibionidae	0.1			
Cecidomyiidae	0.1			
Chamaemyiidae	0.1			
Culicidae	0.1			
Dolichopodidae	0.2			
Lonchopteridae	0.1			
Muscidae	0.1			
Mycetophilidae	0.1		0.8	
Phoridae	0.6		0.8	
Sciaridae	1.2			
undet. larvae			0.2	1.4
HYMENOPTERA		16.5		2.5
Braconidae			0.1	
Cynipidae			0.2	
Diapriidae	0.1			
Eulophidae	0.1			
Eupelmidae			0.1	
Ichneumonidae			0.6	
Proctotrupidae	0.1			
Pteromalidae	0.1		0.5	
Tenthredinidae larvae	0.2	(16.0)	0.1	0.8
miscellaneous insects		0.3		0.5
total insects	14.3	61.6	17.8	133.5
ARANEIDA	6.1	30.6	7.6	44.3
ACARINA	1.2		1.1	

Table 26. Arthropod above-ground standing crops, as estimated by 10 m^2 pyrethrum spray samples (4 replicates, each an average of 2.5 m^2) of foliage. Aspen Forest (Site 3) and Black Spruce Bog (Site 4).

Taxon	Aspen Forest IX-2 Individuals m^{-2}	Aspen Forest IX-2 Biomass m^{-2} mg (oven dry)	Black Spruce Bog VIII-21 Individuals m^{-2}	Black Spruce Bog VIII-21 Biomass m^{-2} mg (oven dry)
INSECTA				
COLLEMBOLA				
Sminthuridae			0.3	
PSOCOPTERA		0.2		1.9
Psocidae	0.1		1.6	
HEMIPTERA		4.1		
Delphacidae	0.1			
Miridae			0.1	
Pentatomidae	0.3			
Nabidae	0.1			
HOMOPTERA		6.2		2.0
Aphididae	0.7			
Cercopidae	0.1			
Cicadellidae	0.1		0.3	
NEUROPTERA		1.9		
Crysopidae larva	0.1			
Hemerobiidae	0.1			
COLEOPTERA		1.4		5.8
Lathridiidae	0.1			
Lampyridae			0.1	
LEPIDOPTERA		1.4		1.8
Arctiidae larva			0.1	
Pyralidae	0.1			
DIPTERA		6.3		4.0
Anthomyiidae	0.2			
Cecidomyiidae	0.1		0.1	
Chironomidae	0.1			
Chloropidae			0.2	
Empididae	0.1			
Muscidae	0.3		0.5	
Mycetophilidae	0.2		1.0	
Phoridae	0.1			
Simuliidae	0.1		0.3	
Sciaridae	0.7			
unknown (damaged)				
HYMENOPTERA		1.0		1.1
Diapriidae	0.1			
Encyrtidae	0.1			
Eulophidae			0.1	
Eurytomidae			0.2	
Pteromalidae			0.2	
miscellaneous insects				0.1
total insects	4.0	22.5	5.1	16.7
ARANEIDA	2.3	23.1	3.6	18.2
ACARINA	0.1		2.0	

Table 27. Arthropod above-ground standing crops, as estimated by 10 m^2 pyrethrum spray samples (4 replicates, each an average of 2.5 m^2) of foliage. Mixed Coniferous Forest (Site 5).

	VIII-21		IX-6	
Taxon	Individuals m^{-2}	Biomass m^{-2} mg (oven dry)	Individuals m^{-2}	Biomass m^{-2} mg (oven dry)
INSECTA				
COLLEMBOLA				
Entomobryidae	0.3		0.3	
Isotomidae	0.3			
Sminthuridae	0.2			
PSOCOPTERA		14.2		14.3
Pseudocaeciliidae	3.9		0.4	
Psocidae	18.2		4.9	
THYSANOPTERA				
Thripidae			0.1	
HEMIPTERA		1.7		
Lygaeidae			0.5	
Miridae	0.1			
undet. nymph			0.2	
HOMOPTERA		5.0		8.1
Aphididae	2.2		2.2	
Cicadellidae	0.1		0.3	
Psyllidae			0.6	
NEUROPTERA		3.5		4.6
Chrysopidae	0.2		0.1	
Hemerobiidae			0.2	
COLEOPTERA		3.0		3.8
Cantharidae larva	0.1			
Coccinellidae			0.1	
Helodidae	0.3		0.1	
Lathridiidae				
LEPIDOPTERA		9.7		3.0
Gelechiidae	0.1			
Geometridae larvae	0.4			
Pyralidae	0.5		0.4	
undet. larva	0.2			
DIPTERA		24.4		39.5
Anthomyiidae	0.4		0.1	
Cecidomyiidae	0.3			
Ceratopogonidae	0.2			
Chironomidae			0.2	
Clusiidae	0.1			
Culicidae	0.1			
Muscidae	0.5		0.3	
Mycetophilidae	0.9		1.3	
Phoridae	1.5		0.1	
Psychodidae	0.1			
Sciaridae	1.6		0.8	
Simuliidae	0.5		0.1	
Syrphidae			0.6	
Tachinidae	0.1			
Tipulidae	0.3		0.1	
HYMENOPTERA		3.0		3.2
Braconidae	0.1		0.9	
Chalcididae?	0.2			
Cynipidae	0.1		0.2	
Encyrtidae			0.1	
Eulophidae	1.1			
Eurytomidae	0.2			
Ichneumonidae	0.3		0.1	
Pteromalidae	0.2		0.4	
miscellaneous insects		0.5		0.5
total insects	36.0	65.0	15.7	77.0
ARANEIDA	16.8	11.0	9.0	97.2
ACARINA	7.9		1.6	

Table 28. Arthropod above-ground standing crop, as estimated by 10 m^2 pyrethrum spray samples (4 replicates, each an average of 2.5 m^2) of foliage. Mixed Forest (Site 6).

Taxon	VIII-31 Individuals m^{-2}	VIII-31 Biomass m^{-2} mg (oven dry)	IX-27 Individuals m^{-2}	IX-27 Biomass m^{-2} mg (oven dry)
INSECTA				
COLLEMBOLA				
Entomobryidae			0.2	
Sminthuridae	0.1			
PSOCOPTERA		2.4		3.1
Psocidae	0.8		1.1	
HEMIPTERA		9.1		4.6
Miridae	0.2		0.1	
Pentatomidae	0.1			
HOMOPTERA		5.3		2.9
Aphididae	0.5		1.6	(2.9)
Cercopidae			0.1	
Cicadellidae			0.1	
Delphacidae	0.2			
Fulgoridae	0.1			
Pseudococcidae			0.3	
Psyllidae	0.2			
NEUROPTERA				4.7
Chrysopidae			0.1	
COLEOPTERA		1.4		6.6
Coccinellidae	0.1		0.1	
Curculionidae	0.1			
Helodidae			0.6	
Lathridiidae	0.1			
LEPIDOPTERA		9.2		1.9
Arctiidae larvae			0.2	
Geometridae larvae	0.2			
DIPTERA		3.7		33.4
Bibionidae			0.2	
Clusiidae			0.1	
Dolichopodidae	0.1			
Heleomyzidae			0.5	
Muscidae	0.1			
Muscoidea			0.1	
Mycetophilidae	0.2			
Phoridae	0.3		0.3	
Sciaridae	0.8		1.0	
Simuliidae	0.2		0.2	
Syrphidae			0.2	
Tachinidae			0.1	
HYMENOPTERA		25.6		14.8
Braconidae			0.2	
Cynipidae			0.1	
Diapriidae	0.1		0.1	
Encyrtidae	0.1			
Eulophidae			0.1	
Eurytomidae			0.6	
Formicidae	0.4	(6.0)		
Ichneumonidae	0.2		0.8	
Proctotrupidae	0.1			
Pteromalidae			0.3	
Tenthredinidae larvae	0.2	(17.1)		
miscellaneous insects		0.1		0.6
total insects	5.5	56.8	9.4	72.6
ARANEIDA	2.5	35.1	8.7	91.2
ACARINA	0.9		0.2	

Table 29. Arthropod above-ground standing crops, as estimated by 10 m^2 pyrethrum spray samples (4 replicates, each an average of 2.5 m^2) of foliage. Jack pine Forest (Site 8).

Taxon	VIII-26 Individuals m^{-2}	VIII-26 Biomass m^{-2} mg (oven dry)	IX-26 Individuals m^{-2}	IX-26 Biomass m^{-2} mg (oven dry)
INSECTA				
COLLEMBOLA				
Entomobryidae	1.0			
Sminthuridae	0.1			
ORTHOPTERA				7.2
Tetrigidae			0.1	
PSOCOPTERA		0.2		0.7
Psocidae	0.2		0.2	
HEMIPTERA		2.4		1.2
Miridae	0.1		0.1	
Pentatomidae	3.3			
Nabidae			0.2	
HOMOPTERA		2.7		4.2
Aphididae	0.1		0.9	(3.1)
Cicadellidae	0.1		0.1	
Fulgoridae	0.3		0.1	
Psyllidae	0.1		0.2	
undet. nymph	0.4			
NEUROPTERA				
Chrysopidae larvae			0.1	
COLEOPTERA		2.0		16.6
Helodidae	0.3		4.7	
LEPIDOPTERA		9.4		2.7
Geometridae larvae	0.1		0.1	
Pyralidae	0.2			
DIPTERA		6.4		24.6
Anthomyiidae			0.3	
Bibionidae			2.3	
Cecidomyiidae			0.1	
Chironomidae	0.1			
Chloropidae	0.2			
Dolichopodidae			0.1	
Empididae	0.2			
Muscidae	0.5			
Muscoidea	0.1			
Mycetophilidae	0.7		0.6	
Phoridae	0.5			
Sciaridae	0.6		1.1	
Sciomyzidae			0.2	
HYMENOPTERA		0.9		1.3
Braconidae	0.2			
Eulophidae	0.1			
Ichneumonidae			0.3	
Pteromalidae	0.2		0.4	
miscellaneous insects				1.5
total insects	9.7	24.0	12.2	60.0
ARANEIDA	2.8	15.4	6.1	33.8
ACARINA	0.1		0.7	

Table 30. Arthropod above-ground standing crops, as estimated by 10 m^2 pyrethrum spray samples (4 replicates, each an average of 2.5 m^2) of foliage. Semi-open Tamarack Bog (Site 9).

	VIII-23	
Taxon	Individuals m^{-2}	Biomass m^{-2} mg (oven dry)
INSECTA		
COLLEMBOLA		
Entomobryidae	0.1	
EPHEMEROPTERA		
Ephemerellidae	0.1	
PLECOPTERA		
Taeniopterygidae	0.1	
PSOCOPTERA		0.9
Psocidae	1.3	
THYSANOPTERA		
Thripidae	0.1	
HOMOPTERA		10.8
Aphididae	2.1	(2.4)
Cercopidae	0.1	
Cicadellidae	0.5	
Fulgoridae	0.2	
Psyllidae	0.8	
COLEOPTERA		18.3
Chrysomelidae	0.1	
Curculionidae	0.1	
Helodidae	2.0	
Lampyridae	0.1	
Lathridiidae	0.1	
LEPIDOPTERA		0.9
Geometridae larva	0.1	
DIPTERA		2.0
Cecidomyiidae	0.2	
Chamaemyiidae?	0.1	
Chironomidae	0.2	
Chloropidae	0.1	
Muscidae	0.4	
Mycetophilidae	1.0	
Otitidae	0.1	
Phoridae	0.4	
Sciaridae	0.2	
HYMENOPTERA		2.9
Ichneumonidae	0.1	
Pteromalidae	0.1	
Tenthredinidae larvae	0.2	(2.0)
miscellaneous insects		2.9
total insects	11.0	38.7
ARANEIDA	4.6	25.5
ACARINA	0.4	

Table 31. Arthropod above-ground standing crops, as estimated by 10 m^2 pyrethrum spray samples (4 replicates, each average of 2.5 m^2) of foliage. Lightly Forested Tamarack (Site 11).

Taxon	VIII-23 Individuals m^{-2}	VIII-23 Biomass m^{-2} mg (oven dry)	IX-28 Individuals m^{-2}	IX-28 Biomass m^{-2} mg (oven dry)
INSECTA				
COLLEMBOLA				
Entomobryidae			0.2	
PSOCOPTERA		1.9		1.1
Psocidae	0.4		0.7	
HEMIPTERA		8.2		5.5
Aradidae	0.2			
Miridae	2.0		0.6	
Nabidae			0.1	
HOMOPTERA		41.3		36.7
Aphididae	19.5	(27.3)	10.8	(33.0)
Cicadellidae	0.3		0.7	
Delphacidae	0.3			
Fulgoridae	0.9			
Psyllidae	0.8		0.1	
NEUROPTERA				
Chrysopidae	0.1			
COLEOPTERA		0.9		12.9
Coccinellidae	0.3		0.1	
Helodidae	1.4		2.9	
Hydrophilidae	0.1			
Lampyridae	0.1			
LEPIDOPTERA		11.4		68.7
Geometridae larvae	1.0			
Noctuidae			0.2	
Pyralidae	0.2			
undet. larva	0.1			
DIPTERA		6.4		2.5
Agromyzidae	0.1		0.8	
Cecidomyiidae	0.1		0.2	
Clusiidae			0.1	
Drosophilidae	0.2			
Muscidae	0.6		0.1	
Mycetophilidae	0.3		0.7	
Phoridae			0.1	
Rhagionidae	0.1			
Syrphidae larvae	0.2			
Tipulidae			0.1	
unknown larva			0.1	
HYMENOPTERA		9.5		53.1
Braconidae	0.1			
Diapriidae	0.1			
Eupelmidae			0.1	
Eurytomidae			0.3	
Formicidae	0.1	(3.1)		
Ichneumonidae	0.2		0.8	
Pteromalidae	0.1		0.6	
Tenthredinidae	1.0	(5.3)		
Vespidae			0.3	(46.1)
miscellaneous insects		0.1		0.1
total insects	30.9	79.7	20.7	180.6
ARANEIDA	8.2	43.7	5.7	32.3
ACARINA	0.3			

Table 32. Arthropod above-ground standing crops, as estimated by 10 m^2 pyrethrum spray samples (4 replicates, each an average of 2.5 m^2) of foliage. Deciduous-shrub Wetland (Site 12).

Taxon	VIII-23		IX-26	
	Individuals m^{-2}	Biomass m^{-2} mg (oven dry)	Individuals m^{-2}	Biomass m^{-2} mg (oven dry)
INSECTA				
COLLEMBOLA				
Entomobryidae	1.1			
ORTHOPTERA				
Acrididae			0.1	
PLECOPTERA		9.6		
Nemouridae	1.9			
PSOCOPTERA		4.8		3.6
Pseudocaecilidae	1.2			
Psocidae	1.5		1.1	
THYSANOPTERA				
Phlaeothripidae	0.7		0.3	
HEMIPTERA		5.8		23.6
Lygaeidae	0.3			
Miridae	0.3		0.8	
Pentatomidae			0.2	
undet. nymph	0.1		0.1	
HOMOPTERA		46.7		55.3
Aphididae	16.6	(5.9)	7.4	(20.6)
Cicadellidae	2.9	(26.4)	1.1	
Delphacidae	0.1		0.1	
Fulgoridae	2.7		1.6	
Psyllidae	2.5		1.4	
NEUROPTERA				
Chrysopidae larva	0.1			
COLEOPTERA		19.2		64.6
Chrysomelidae	0.2		1.2	
Coccinellidae	0.3		0.1	
Helodidae	0.3		1.2	
Lampyridae	0.1			
Lathridiidae	0.1		0.1	
Leptodiridae			0.1	
Staphylinidae			0.1	
LEPIDOPTERA		6.5		6.1
Pyralidae	0.1		0.1	
undet. larvae	0.4	(4.4)	0.1	(3.3)
DIPTERA		10.5		6.8
Bibionidae			0.1	
Cecidomyiidae			0.2	
Chironomidae	0.2			
Clusiidae			0.2	
Culicidae	0.1			
Dolichopodidae	0.1			
Drosophilidae	0.1			
Empididae	0.2			
Heleomyzidae	0.1		0.1	
Muscidae				
Mycetophilidae	0.1		0.3	
Phoridae	0.6			
Sciaridae	1.1		0.7	
Sciomyzidae	0.1			
Tachinidae			0.1	
Trichoceridae	0.7			
HYMENOPTERA		22.4		1.0
Cynipidae	0.2			
Eulophidae	0.1			
Formicidae	0.5	(12.4)		
Ichneumonidae	0.3		0.2	
Proctotrupidae	0.1			
Pteromalidae	0.3			
Torymidae	0.1			
Tenthredinidae	0.8	(7.3)		
miscellaneous insects		1.7		1.6
total insects	38.8	127.3	19.1	162.6
ARANEIDA	5.2	23.1	3.5	18.7
ACARINA	1.4		0.2	

Table 33. Sweep net sample results. Number of families represented in twenty five 180° ground and head sweep samples.

Site	Date	Level[a]	Collembola	Psocoptera	Thysanoptera	Hemiptera	Homoptera	Neuroptera	Coleoptera	Lepidoptera	Diptera	Hymenoptera	Insect Families
Riparian Forest	VIII-19	G		2		2	4	1			11	7	27
		H	1	2		1	3		1	2	7	8	25
	VIII-24	G	1	1			4			1	6	7	20
		H	1	1			2		1	1	5	3	14
	IX-25	G	1	1			3		1		5	1	12
		H					3	1		1	2	1	8
white Spruce-Aspen Forest	VIII-19	G		2		1	2				13	10	28
		H		1		1	2				5	1	10
	VIII-24	G		1			3				7	5	16
		H		1			2			1	4	2	10
	IX-6	G	1	1		2	3		2	1	7	7	24
		H	1	1			2			1	5	5	15
	IX-25	G	1	2			1		2		4	6	16
		H	1				2				2		5
Aspen Forest	VIII-19	G	1	1			2	1			8	12	25
		H	1	1		1	3			1	9	8	24
	IX-2	G	1	1			3		1		4	5	15
		H				1	1				4	4	10
	IX-21	G		1		1	1	1		1	6	2	13
		H				1					3		4
Spruce Bog	VIII-19	G	1	1			3				7	6	18
		H	1	1			1				3	1	7
	IX-1	G									1		1
		H	1								1		2
	IX-21	G					1		1		3	1	6
		H	1				1					1	3

continued...

Table 33. Continued.

Site	Date	Level[a]	Collembola	Psocoptera	Tysanoptera	Hemiptera	Homoptera	Neuroptera	Coleoptera	Lepidoptera	Diptera	Hymenoptera	Insect Families
Mixed Coniferous Forest	VIII-21	G	1	1		1	3				6	4	16
		H		2			1				2	2	7
	IX-6	G	1	1			2		1		6	7	18
		H	2	2		1	2	1	1		4	4	17
	IX-27	G	1	1		1	2	1	1		4	2	13
		H	1	1			1		1		2		6
Mixed Forest	VIII-19	G	1				2				4	6	13
		H	1	1		1	3			2	8	6	21
	VIII-31	G				3					5	3	11
		H		1		2	3			1	8	6	21
	IX-27	G	1			1	4				4	2	12
		H					2		1		4	2	9
Non-vegetated	VIII-21	G				2	3			1	9	8	23
		H			1		1		1		6	3	12
	IX-3	G				2	2		1		7	8	20
	IX-27	G	1						1		3		6
		H					1		1		2	1	4
Jackpine	VIII-18	G	1				2				8	4	15
		H					2				6	3	11
	VIII-27	G				1					6	4	11
		H	1			1	1			1	6	4	14
	IX-20	G				1					5		6
		H							1	1	5	2	9
	IX-26	G	1			1					8	1	11
		H	1			1	1	1			4		8

continued...

Table 33. Concluded.

Site	Date	Level[a]	Collembola	Psocoptera	Thysanoptera	Hemiptera	Homoptera	Neuroptera	Coleoptera	Lepidoptera	Diptera	Hymenoptera	Insect Families
Semi-open Tamarack Bog	VIII-18	G	1				2				6	3	12
		H	1	1			2			1	4	2	11
	VIII-29	G		1			2		1		2	2	8
		H					2		2		2	1	7
	IX-26	G		1			1		1		1		4
		H		1			3		1		1	1	7
Fen	VIII-20	G	2	1	2	2	4		5	1	21	9	47
	VIII-30	G	2		2	1	3		2		8	6	24
	IX-20	G		1			3		5		10	1	20
Lightly Forested Tamarack	VIII-23	G	1	1		2	3				1	6	14
		H	1	1			2				1	4	9
	IX-5	G	1				2			1	3	5	13[b]
		H	2				3				3	2	10
	IX-20	G									2	1	3
		H					2		2		4		8
	IX-26	G	1				3		1		5	2	12
		H	1	1			3		1		3	1	10
Deciduous-shrub wetland	VIII-23	G	1		2		4		2		10	11	31[b]
		H	1	1			4				4	1	11
	IX-5	G	1		1		4			1	6	3	16
		H	1	1			3		1		6	4	16
	IX-26	G	1	1		1	3		1		8	3	18
		H				1	3	1	2		2		9

[a]ground and head height.

[b]plus a trichopteran and plecopteran, respectively.

Table 34. Sweep net sample results. Number of specimens collected in twenty five 180° ground and head height sweep samples, and the insect biomass.

Site	Date	Level[a]	Collembola	Psocoptera	Thysanoptera	Hemiptera	Homoptera	Neuroptera	Coleoptera	Lepidoptera	Diptera	Hymenoptera	Araneida	Total Insects	Total Insect mass (mg oven dry)
Riparian Forest	VIII-19	G		10		33	8	1			43	25	16	120	26.2
		H	5	13		1	34		1	6	103	21	8	184	32.2
	VIII-24	G	4	9			21			1	29	10	14	74	8.2
		H	2	17			38		1	1	117	3	16	177	12.1
	IX-25	G	2	3			5		1		15	1	22	27	7.8
		H					25	1		1	12	4	25	43	9.5
white Spruce-Aspen Forest	VIII-19	G		4		1	10				103	51	15	169	21.2
		H		3		1	3				27	1	6	35	10.7
	VIII-24	G		1			4				52	18	4	75	12.0
		H		3			2			1	16	3	2	25	7.3
	IX-6	G	4	4		2	13		2	2	45	25	14	97	14.7
		H	1	1			98			1	21	7	9	129	9.7
	IX-25	G	3	4			7		2		34	12	41	62	18.1
		H	1				18				27		11	46	15.9
Aspen Forest	VIII-19	G	6	3			6	1			78	44	5	138	11.7
		H	2	1		1	6			1	29	19	14	59	14.7
	IX-2	G	1	1			3		1		15	13	25	34	7.8
		H				1	1				6	7	2	15	6.0
	IX-21	G		1		2	1	1		1	20	2	9	28	13.8
		H				1					4		8	5	3.5
Spruce bog	VIII-19	G	5	1			8				23	16	5	52	6.0
		H	2	1			1				7	3	2	14	1.9
	IX-1	G									2		4	2	0.3
		H	2								1			3	0.5
	IX-21	G					2		1		4	2	6	9	6.6
		H	1				1					2	2	4	0.2

continued...

Table 34. Continued.

Site	Date	Level[a]	Collembola	Psocoptera	Thysanoptera	Hemiptera	Homoptera	Neuroptera	Coleoptera	Lepidoptera	Diptera	Hymenoptera	Araneida	Total Insects	Total Insect mass (mg oven dry)
Mixed Coniferous Forest	VIII-21	G	2	1		1	4				18	7		33	8.4
		H		2			1				3	2		8	3.4
	IX-6	G	8	1			4		1		39	20	7	73	9.6
		H	5	4		1	4	1	1		18	6	5	40	8.1
	IX-27	G	18	4		1	5	1	1		11	2	34	43	4.8
		H	7	6			21		1		9		6	44	4.1
Mixed Forest	VIII-19	G	2				2				21	12	2	37	4.8
		H	1	1		2	22			4	29	13	8	72	27.6
	VIII-31	G				4					12	8	1	24	45.1
		H		4		3	5			1	38	12	22	63	18.3
	IX-27	G	7			2	4				30	2	15	45	12.4
		H					9		1		13	3	3	26	6.1
Non-vegetated	VIII-21	G				5	25			1	25	10	1	66	12.7
		H			1		7		1		11	4	1	24	45.6
	IX-3	G				2	4		1		25	16	5	48	12.0
	IX-27	G	1				2		1		6		1	10	0.8
		H							1		2	1	2	4	1.5
Jackpine	VIII-18	G	1				2				25	12	4	40	6.4
		H					3				84	3		90	103.9
	VIII-27	G				3					7	6	8	16	12.2
		H	1			1	1			1	7	9	2	20	8.2
	IX-20	G				1					48		5	49	29.0
		H							1	1	14	2	3	18	13.4
	IX-26	G	1			1					22	2	2	26	5.2
		H	1			1	1	1			15		6	19	7.0

continued...

Table 34. Concluded.

Site	Date	Level[a]	Collombola	Psocoptera	Thysanoptera	Hemiptera	Homoptera	Neuroptera	Coleoptera	Lepidoptera	Diptera	Hymenoptera	Araneida	Total Insects	Total Insect mass (mg oven dry)
Semi-open Tamarack Bog	VIII-18	G	5				4				17	3		29	9.0
		H	1	1			4			1	65	2	2	74	5.6
	VIII-29	G		1			7		3		2	2	10	15	10.5
		H					2		2		2	1	6	7	6.3
	IX-26	G		1			1		1		1		2	4	1.3
		H		1			18		5		2	1	3	27	12.0
Fen	VIII-22	G	17	3	6	15	144		10	1	191	96	4	484	82.8
	VIII-30	G	2		11	2	59		3		39	36	10	152	58.4
	IX-20	G		1			21		11		51	1	4	85	35.8
Lightly Forested Tamarack	VIII-23	G	4	1		2	8				1	8	6	24	5.0
		H	3	2			8				1	4	1	18	9.5
	IX-5	G	14				4			1	52	7	2	78	7.8
		H	13				24				3	5	2	45	5.3
	IX-20	G									3	4	2	7	2.4
		H					3		4		4		5	11	6.1
	IX-26	G	4				9		1		94	3	5	111	7.4
		H	6	1			15		1		14	1	4	38	7.6
Deciduous-shrub wetland	VIII-23	G	2		3		13		2		50	29	12	99	22.6
		H	1	1			28				9	2	2	41	11.5
	IX-5	G	3		1		11			1	37	6	10	59	8.6
		H	4	1			50		2		50	5	8	112	23.4
	IX-26	G	1	1		2	7		1		21	4	6	37	9.0
		H				1	34	1	3		15		3	54	12.2

[a] ground and head height.