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T.L. Wagner

W.J. Mattson

J.A. Witter

A SURVEY OF SOIL INVERTEBRATES IN TWO ASPEN FORESTS IN NORTHERN MINNESOTA

T. L. Wagner, *Graduate Student*
University of Maine, Orono, Maine

W. J. Mattson, *Principal Insect Ecologist*
North Central Forest Experiment Station, St. Paul, Minnesota

and **J. A. Witter,** *Associate Professor*
University of Michigan, Ann Arbor, Michigan

Productivity of ecosystems depends to a large extent on the quantity of available nutrients. In natural ecosystems, much of the nutrient stock is unavailable because it is bound in live and dead organic matter. Additions to the pool of available nutrients come from several sources, but the largest and most important one is dead organic matter. Therefore, the productivity of ecosystems is often said to be related to the rate of nutrient release from, or the mineralization of, organic litter (Ghilarov 1971, Satchell 1974).

An abundant and diverse complex of soil fauna and microflora live on the dead organic matter in terrestrial ecosystems. These fauna and flora interact in manifold ways to facilitate and enhance the rate of mineralization of organic debris and the development of soil structure. The consensus is that soil fauna, by themselves, cannot mineralize litter because most animals lack the enzymes systems necessary to break down the majority of compounds in litter. Mineralization, then, is accomplished primarily by the soil microflora interacting with soil animals. Other contributions by soil fauna have been reviewed by Crossley (1977) and Satchell (1974).

Soil fauna are often classified according to their body sizes: microfauna (size<0.2 mm), mesofauna (0.2 mm <size<10 mm), and macrofauna (size>10 mm) (Wallwork 1970). The microfauna are mainly protozoans; whereas the mesofauna include a tremendous variety of animals: nematodes, a plethora of arthropods, small molluscs, and Enchytraeidae worms. The macrofauna contain the larger elements of the arthropods, molluscs, enchytraeids, lumbricid worms, and the soil dwelling vertebrates.

The abundance and composition of soil litter fauna vary in relation to many factors; some of which are the physical environment, the parent mineral substrates, the vegetation, and other organisms. For example, Satchell (1974) cited a report which speculated that faunal biomass is temperature-limited in boreal and higher latitudes, moisture-limited in arid zones, and food-limited in tropical zones because of competition from microbes. In other zones, it may be limited by combinations of temperature, base-poor soils, oxygen tension, acidity, and food supply.

Patterns of species compositions for a wide variety of ecosystems are now recognizable. For example, in acidic soil-litter substrates (mor soils) where the dominant vegetation is often coniferous or ericaceous, the most abundant soil animals are mites, Collembola, enchytraeid worms, and such insects as beetles. At the other end of the spectrum where the soil-litter substrate is neutral to slightly alkaline (mull soils) and the dominant vegetation is deciduous angiosperms, the most significant soil animals are lumbricid worms, myriopods, isopods, large groups of beetles and flies, and lastly mites and Collembola

(Wallwork 1970). In soil-litter substrates that are intermediate between the classic mor and mull types, the soil animals have intermediate compositions.

Trembling aspen, *Populus tremuloides,* is a predominant tree in the vegetation of the Great Lakes Region — usually forming nearly pure stands or occurring as occasional, residual individuals in forests dominated by other species. About one-third of the commercial forests in the Lake States are dominated by aspen trees. Aspen occurs on a wide variety of soil types, from sandy outwash plains to moist loams (Graham *et al.* 1963). The best aspen forests seem to occur where the soil texture is fine (high silts and clay contents) and the water tables are within a few feet of the surface (Fralish 1972). The understory vegetation usually consists of a rich variety of deciduous shrubs and herbs, as well as seedlings and saplings of various deciduous and coniferous tree species (Ohmann and Ream 1971).

Aspen leaf litter and that of its associated shrubs and herbs tend to have a medium-high calcium content compared with coniferous litter (Henry 1973). This should promote the development of neutral soils, and more mull-like rather than mor-like populations of soil invertebrates and microorganisms. The rate of decomposition of aspen foliage is somewhat intermediate between fast species such as alders, elms, and ashes, and slow species such as beech, most oaks, and conifers (Wallwork 1970, Cummins 1974).

Some of the factors which influence the rate at which leaves naturally decompose are its C/N ratio, polyphenolic content, calcium concentration, and the ambient temperature and moisture conditions. For example, high C/N ratios and polyphenolic contents, and low temperatures and moisture conditions all retard decomposition rates.

Although aspen ecosystems are prominent in the Great Lakes Region and parts of Canada and Alaska, knowledge about organisms and processes operating in the soil-litter milieu of such ecosystems is just beginning to accumulate (Carter and Cragg 1976, Mitchell and Parkinson 1976, Visser and Parkinson 1975). The purpose of the present exploratory study was to (1) identify the major soil-litter invertebrates found in two aspen forests in northern Minnesota, and (2) to measure their population densities whenever possible, thereby providing baseline knowledge for future investigations.

MATERIALS AND METHODS

We intensively sampled two aspen stands (hereafter referred to as Black River and Pine Stump) in Koochiching County, Minnesota, during the summer of 1972. Both plots had been previously selected for studies of forest tent caterpillar-aspen ecosystem interactions. Plot size was arbitrarily set at 10 hectares and each was subdivided into 4 quadrats of equal size. All samples were taken from five randomly located subplots (20 by 20 m) within each quadrat.

Vegetation in the plots was analyzed, soils were classified[1], and we measured: (1) soil horizon depths on nearly 180 soil cores from each plot and (2) soil pH from the mid-point of the soil horizons (02, A2, and B) of the soil cores using a Hellige-Truog soil reaction test kit.

To recover soil invertebrates from the soil-litter milieu, we employed three standard techniques: (1) dry funnel extraction, (2) hand sorting of sieved soil, and (3) pitfall traps. The first technique is usually employed for recovering small mesofauna whereas the second and third techniques are employed for recovering large mesofauna and macrofauna. General reviews of these methods can be found in Macfadyen (1962) and Edwards and Fletcher (1971).

Dry Funnel Method

Description of apparatus

Two funnel extracting units of the Tullgren type were designed to accommodate 30 soil core samples each. Black plastic drain pipe sections (3.80 cm in diameter by 17.85 cm long) were used to hold the soil core samples. Sixteen mesh/in^2 hardware cloth was glued to one end of each pipe section to hold the

[1]*Paul Nyberg, USDA Soil Conservation Service, Grand Rapids, Minnesota.*

soil core in place. The circumference of the mesh screen was larger than the tube to which it was attached and slightly smaller than the maximum diameter of the funnel on which it rested. The screen kept the holding tube away from the funnel and allowed for the dissipation of free, moist air as each core sample dried. This prevented moisture from building up on the inside wall of the funnel and ultimately increased the yields of the unit. Attached to the bottom of each funnel was a 22 ml vial which contained 95 percent ethyl alcohol as a killing and preserving agent.

A heat and light source above the soil cores was supplied by 9-watt, 120-volt, outdoor Christmas tree incandescent light bulbs. Individual bulbs were fit centrally into the closed end of beverage cans. The cans were positioned over the top of the plastic holding tubes so that each bulb was approximately 4.5 cm from the top of a soil core sample. Temperatures were maintained at ca. 40 C at the top of the soil during the 120-hour extracting period.

The soil core sampler was designed to extract a soil core 3.15 cm in diameter by 47.3 cm long. One face of the chrome plated tubing of the sampler was open, giving an undisturbed picture of the soil profile. This open face provided the means for removing the soil core intact from the sampler.

Sampling methods

Five randomly picked 20- by 20-m subplots in each quadrat supplied all soil core samples. These subplots were further divided into 100 2- by 2-m^2 sub-subplots. Three such plots were chosen randomly, without replacement, from within each subplot. One soil core sample was taken from each sub-subplot during each of three sampling periods. This yielded 60 core samples for each stand on each sampling date. The sampling dates for the Pine Stump stand were June 12, July 11, and August 6. The sampling dates for the Black River stand were June 19, July 17, and August 12. Core samples were immediately placed intact into the plastic tubes with the litter end resting on the screen. The open end of the tube was sealed with a cork and the screen end was covered with tin foil.

Hand-Sorting Method

From each of the 20 subplots, we collected 1 square block of soil (30.4 by 30.4 by 15.3 cm) in mid-June, July, and August, to recover the larger mesofauna and macrofauna. The sample points within subplots were picked randomly as were the soil core samples. The soil blocks were passed through three sieves having mesh sizes of 4, 16, and 64 per square inch. All fauna were preserved in 95 percent ethanol.

Pitfall Method

Ten pitfall traps were placed near the center of each study stand in a linear series 20 m apart. Each trap (a can, 10.2 cm wide and 12.0 cm deep, a screen retrieving plunger, and a rainshield hood) was buried in the ground, and partially filled with antifreeze. Traps were emptied every 13 days. Collection dates were July 16, 29, and August 11 at Pine Stump; and July 17, 30, and August 12 at Black River.

STUDY PLOT DESCRIPTIONS

Both study plots were dominated by trembling aspen, *P. tremuloides,* trees that were between 35 to 40 years old. Total tree basal area/acre was about 97 $feet^2$ (22.3 m^2/ha) at Pine Stump and 116 $feet^2$ (26.7 m^2/ha) at Black River. Other less abundant tree associates were balsam poplar *P. balsamifera,* paper birch, *Betula papyifera,* black ash, *Fraxinus nigra,* and balsam fir, *Abies balsamea* (table 2, Appendix).

Common shrubs in both plots were beaked hazel, *Corylus cornuta,* red-osier dogwood, *Cornus stolonifera,* chokecherry, *Prunus virginiana,* and arrowwood, *Viburnum rafinesquianum.* However, Black River shrubs were predominantly hazel, dogwood, alder-leafed buckthorn, *Rhamnus alnifolia,* and tag alder, *Alnus rugosa.* Pine Stump shrubs were predominantly hazel, arrowwood, and chokecherry. Shrub densities averaged about 10,000/acre (24,000/ha) at Black River and about 6,600/acre (16,302/ha) at Pine Stump.

Herbaceous vegetation was grossly similar in both study plots. Species having frequencies of occurrence (FO) of $\geqslant$50 percent at both areas were the following: dwarf raspberry, *Rubus pubescens,* false lily of the valley, *Mianthemum canadense,* bunchberry, *Cornus canadensis,* and wild sarsaparilla, *Aralia* *nudicaulis*. Pine Stump, in addition, had an abundance (FO = 92 percent) of large leaf aster, *Aster macrophyllus*, which was uncommon at Black River (FO ≤10 percent). Herbaceous standing crops averaged 35 g/m² dry weight and 75 g/m² dry weight in midsummer at Black River and Pine Stump, respectively.

Surface soils (A,B horizons) in both plots were clay loams, silt loams, silty-clay loams, and fine sandy loams. The substratum or C horizons were usually clay, clay loams, silty and clayey loams or loam glacial tills. Drainage was moderate to poor in most of the soils examined because of the heavy subsoils and substrata.

The undecomposed litter layer (01) was about 1.4 cm deep at Black River and 3.4 cm at Pine Stump (table 1, Appendix). The partially decomposed litter layer (02) and the mineral surface soils (A) were between 6 to 8 cm and 11 to 14 cm deep, respectively, at both areas. Although the 01 layer was deeper at Pine Stump, the 02 and A horizons were consistently wider at Black River (8.5 vs. 6.4 and 14.3 vs. 10.9 cm).

All soil horizons tended to be slightly acidic (5.7 to 6.6) except at Black River where the B horizon was neutral (7.25). Generally pH values increased from the surface to the lower soil horizons. Furthermore, the Black River soils had significantly higher pH values than the Pine Stump soils.

RESULTS AND DISCUSSION

All of our samples (core, block, and pitfall) yielded 4 phyla, 7 classes, 23 orders, and 134 families of invertebrates (see List of Invertebrates, Appendix). Listed in order of decreasing taxonomic diversity, the four phyla were: Arthropoda, Mollusca, Annelida, and Nematoda. Arthropoda contained 5 of the 7 classes, 19 of the 23 orders, and 125 of the 134 families. Insecta was the single largest class containing 11 orders and 84 families. This is a minimal estimate of the taxonomic variety of soil fauna because we could not identify all of the organisms. For example, only a 3 percent subsample of the total mite collection was identified by specialists and none of the spiders nor Nematodes have yet been identified. In fact, none of our sampling methods was valid for Nematodes so they are grossly underrepresented in this study.

The ensuing reports will discuss the biology and ecology of the major groups of soil invertebrates. The sequence in which they are covered reflects only their alphabetical order displayed in table 3.

Oligochaeta: Opisthopora

Annelids are probably the best known of all soil animals. The dominant families in the temperate zones are Enchytraeidae (potworms) and Lumbricidae (earthworms). Enchytraeids are small (most species <1 cm) pale worms that thrive in acidic, organic soils. Lumbricids, on the other hand, are many-fold larger than enchytraeids and reach their greatest densities in neutral to slightly alkaline soils. Light and medium loams usually have greater numbers and species of earthworms than do clays and alluvial soils (Lofty 1974).

Earthworms are entirely saprophagous. They feed on many kinds of plant litter but prefer plant debris with high nitrogen and sugar levels and low polyphenol levels — just like most other saprophages. Oligochaetes have an important effect on litter breakdown and soil structure through such activities as: (1) fragmenting plant debris into smaller particles, (2) incorporating fragmented and decomposed plant debris into lower soil horizons, (3) dumping feces (cast material) onto soil surface and litter layers, (4) enhancing activity of microorganisms and (5) facilitating the formation of stable organo-mineral complexes in the soil.

Two species of earthworms were dominant in the study stands: *Dendrobaena octaedra* a small, nonburrowing, acid-tolerant species which showed a preference for the upper organic layers; and *Allolobophora trapezoides* a larger, burrowing species which was often found deep within the soil. Two incidental species were also recovered: *Dendrobaena rubida* and *Octolasion tyrtaeum*.

The density of *Dendroboena* spp. was twice as great (124 vs. 60 m²) at Pine Stump stand as at Black River. On the other hand, the density of the burrowing earthworm, *A. trapezoides*, was determined to be 0 at Pine Stump and 9/m² at Black River. These densities were comparable to those reported by Wallwork (1970) for earthworms in woodland mull-soils (73 to 493/m²). We have no explanation for the scarcity of *A. trapezoides* at Pine Stump except that soil conditions may have been too acidic for it. Differences in densities of *Dendrobaena* between stands may be related to the presence of twice as much surface litter and the lack of *A. trapezoides* at Pine Stump. *A trapezoides* may create unfavorable conditions for *Dendrobaena* by rapidly consuming their food (litter) and thereby destroying their micro-environment, 01, 02 (organic) layers.

A. trapezoides probably has more effect on soil structure than *Dendrobaena* spp. because of its burrowing habits. For example, the soils at Black River were typically well granulated and the A1 horizons were very dark, especially in quadrats 1 and 2 which had greatest densities of *A. trapezoides*. This dark coloration is due to the incorporation of organic matter from the litter layer into the subsurface soil — probably due to the activities of *A. trapezoides*. These worms may have been responsible for the shallow litter layer at Black River which was only half of that at Pine Stump.

Arachnida: Acari

Mites constitute one of the largest, most diverse and perhaps most abundant group of soil-inhabiting arthropods. For example, there are 4 major suborders: Acaridei (= Astigmata), Prostigmata, Mesostigmata, and Oribatei (= Cryptostigmata) together having several hundred families of soil-inhabiting mites (Wallwork 1970). Among these families, one can find a broad range of feeding habits: detritus, fungal, bacterial, and protozoan feeders as well as insect and mite predators and parasites. In forest soils the majority of detritus and micro-organism feeders belong to the Oribatei (Ghilarov 1971, Butcher and Snider 1971).

Densities of mites range from about 60,000 to over 200,000/m² in forest soils (Ghilarov 1971, Wallwork 1970, Harding and Stuttard 1974). Because of their microscopic size, they contribute less to mixing of soil layers than do earthworms. Their main contributions to litter decomposition are through the comminution of organic material and interactions with soil-microorganisms, especially fungi (Mitchell and Parkinson 1976).

In this study we found all of the 4 major suborders, 36 families and 53 species from 6 Tullgren core samples randomly selected from each stand. Recall that 180 Tullgren samples were collected from each stand. The partial list of species (table 3, Appendix) probably represents as little as 25 percent of the total numbers of species present.[2] If our small sample is indeed representative, then the most common species were *Oppiella nova* (Oppidae), *Synchthonius crenulatus* (Brachychthoniidae), *Tectocepheus velatus* (Tectocepheidae), *Suctobelba* spp. (Suctobelbidae), *Cocceupodes* spp. (Eupodidae), and *Rhagidia* spp. (Rhagidiiae). The first four genera belong to the Oribatei and the last two genera to the Prostigmata. Almost half of all species (26/53) belonged to the Oribatei.

Average population densities (based on June, July, and August samples) were about 87,000 and 94,000/m² at Black River and Pine Stump, respectively (fig. 1, Appendix). Densities were lowest in the June samples and highest in most cases in August, presumably due to either vertical population movements or rapid reproduction during the summer. Between June and August populations approximately doubled from about 50,000/m² to 100,000/m². Seasonal variations in mite densities are well known, but most evidence indicates that peaks occur during fall and winter months, and troughs occur during summer months (Wallwork 1970). If this is true, then the mite densities observed in our study plots may represent only the lower extreme of the annual spectrum of densities.

Variations in population densities also occurred among different quadrats (fig. 1, Appendix). Such variations were not related to the depth and/or pH of the 01 and 02 (organic matter) layers. Probably they reflected variations in litter moisture contents, or some other unmeasured variable, or were simply a result of the sampling techniques.

Arachnida: Araneida

Spiders are perhaps the best known of all arachnids. They occur in a wide variety of habitats and many families have a close association with the soil-litter environment. They are strictly predators. The impact of their predation on the soil-dwelling invertebrates is poorly known.

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[2]*Personal communication with Mr. Roy A. Norton, 1973.*

The Pine Stump stand had more than twice as many spiders (24.9 vs. 9.6/m²) as the Black River stand, according to soil sieve samples (table 4, Appendix). Although there was variation among quadrats the data indicate that population densities tended to decline from June to August. For example, overall mean densities in August were only 60 to 80 percent of those recorded in June.

Pitfall traps, which caught the larger spiders, revealed that Black River may have been slightly more productive or may have had more active species (117 vs. 82) than Pine Stump. These data represent only a 1-month period, mid-July to mid-August.

Arachnida: Chelonethida

Pseudoscorpions are often found in moist, soil-litter environments, but usually are not very abundant (Wallwork 1970). Pseudoscorpions, like spiders, are strictly zoophagous, feeding on such animals as Collembola, other small insects, mites, myriapods, and enchytraeid worms. Three species *Microbisium brunneum, M. confusum,* and *Mundochtonius rossi)* were found. *M. brunneum,* a species with a wide range of geographic distribution in eastern Canada and the northern United States, is typically associated with acidic environments, such as tamarack, *Larix laricina,* bogs (Hoff 1949). It was recovered from only the Pine Stump stand. *M. confusum,* another widely distributed species with a range extending farther to the south than *M. brunneum,* was recorded from both stands. It is commonly found in forest litter or soil, and in decaying logs or stumps (Hoff 1949). Although it sometimes occurs with *M. brunneum* on wet sites in northern Illinois, it apparently prefers drier uplands.[3] It can be separated from the latter by its smaller body and palp size (Hoff 1949).

M. rossi, also a common northern pseudoscorpion, was present in both stands. It prefers the same type of habitat as *M. confusum.*

Densities of pseudoscorpions were 2- to 4-fold greater (e.g., 100 vs. 450/m²) at Pine Stump than at Black River (fig. 2). Such differences may reflect difference in the abundance of prey between the two stands. In both stands, highest population densities occurred in July and lowest densities occurred in June. About 60 to 85 percent of the individuals were immatures at both Pine Stump and Black River.

Arachnida: Phalangida

Harvestmen are common in the surface litter layer of many forests. They are primarily zoophagous, feeding on a wide variety of insects, such as fly and beetle larvae, and other invertebrates. They are highly prone to desiccation and require a continuous source of free drinking water. Therefore, most species are found in areas with high humidity and peak activity often occurs in the evening (Wallwork 1970).

We recovered six species of harvestmen: *Leiobunum calcar, L. politum, L. ventricosum, Sabacon crassipalpe, Crosbycus dasycnemus,* and *Odiellus pictus pictus,* from pitfall traps. We captured more than twice (138 vs. 57) as many harvestmen at Pine Stump than we did at Black River.

The most abundant species at Pine Stump and Black River were *L. calcar, L. politum,* and *O. pictus pictus. S. crassipalpe* was recovered only at Black River, and *C. dasychemus* was recovered only at Pine Stump.

Chilopoda: Geophilomorpha and Lithobiomorpha

Most centipedes are very susceptible to desiccation and, therefore, are usually confined to moist, but not wet, micro-environments. For example, the Geophilomorpha, which are essentially subterranean, were usually found below the litter surface in the 02 and A2 soil horizons, in small groups of 2 to 5. On the other hand, the Lithobiomorpha are heavy-bodied forms which cannot burrow like the slender Geophilomorpha and so are usually found in existing soil pore space — under surface litter, beneath fresh plant debris, under logs, and stones.

The chilopods are predaceous and feed on a wide variety of insects, mites, spiders, nematodes, and molluscs (Wallwork 1970).

[3]*Personal communication with Dr. William Muchmore, 1973.*

Centipede densities were 6.3/m² at Black River and 5.2/m² at Pine Stump. Two-thirds at Black River and 2/5 at Pine Stump were lithobiomorphs. All others were geophilomorphs.

Diplopoda: Polydesmida and Iuliformia

Millipedes, like centipedes, do not possess a very efficient waterproofing layer on their cuticles and, therefore, most are susceptible to desiccation. Millipedes typically live in the soil-organic layers among leaves, rotting wood, and under stones. Some can burrow into the lower litter and upper mineral layers. Unlike centipedes, however, millipedes are phytophagous and saprophagous (Edwards 1974). They are known to consume large quantities of leaves and appear to show a preference for plant species having high calcium concentrations. Their feeding promotes litter breakdown through comminution of plant debris (McBrayer 1973).

Our samples revealed 2 orders of millipedes: the round-backed form, Iuliforma, and the flat-backed form, Polydesmida. The former are burrowers, whereas the latter are not.

Black River had roughly 5-fold more (4.5 vs. 0.9/m²) millipedes than did Pine Stump, based on soil sieve samples. Two-thirds were polydesmids at Black River, whereas only one individual from all samples at Pine Stump belonged to this order. All other specimens found were the burrowing iuliforms. These data suggest that the litter layer at Pine Stump may have been too dry for the Polydesmids. Moreover, at Black River, most polydesmids (68 percent) came from quadrat 1 which was wetter than all other quadrats. Another reason for the differences in abundance of polydesmids between stands could be differences in soil pH. Diplopods are usually more abundant in calcareous rather than in base deficient soils such as occurred at Pine Stump (Wallwork 1970).

Insecta: Coleoptera

Beetles are often the most abundant and varied group of soil-inhabiting macro-arthropods (Wallwork 1970). The six most common families of beetles found in the soil-litter milieu are usually Carabidae (zoophagous), Staphylindidae (zoophagous and saprophagous), Elateridae (zoophagous and saprophagous), Scarabaeidae (phytophagous and saprophagous), Silphidae (saprophagous), and Pselaphidae (zoophagous). Most beetles occupy the uppermost part of the litter environment where their major ecological roles are the comminution of organic debris and predation.

Our samples revealed 22 different families of beetles in the soil-litter environment (table 3, Appendix). The numerically dominant taxa were clearly Staphylinidae (rove beetles), Carabidae (ground beetles), Elateridae (click beetles), and Cantharidae (soldier beetles) (table 5, Appendix). Interestingly, these families are comprised primarily of predaceous forms except for Elateridae which also has many saprophagous forms.

Densities of beetle larvae (all species) were slightly higher at Black River than at Pine Stump (432 vs. 328/m²), based on the funnel method (table 6, Appendix), just as were densities of beetle adults (19 vs. 16/m²). The funnel method suggested that beetle densities tend to increase from June to August. On the other hand, the soil sieve method, which recovers larger larval forms, did not corroborate this pattern: beetle densities increased at Black River and decreased over time at Pine Stump.

Insecta: Collembola

Collembola or springtails are usually the most abundant insect order occurring in soil-litter environments. Population densities vary with ecosystems but are known to range from 5,000/m² to 200,000/m² (Wallwork 1970, Harding and Stuttard 1974). In many respects, springtails are ecologically similar to mites — particularly to the predominantly saprophagous Oribatei. For example, both groups have similar physical environmental requirements, and both occupy primarily the upper organic layers, especially the zone of active decomposition (Wallwork 1970). Neither mites nor springtails can burrow and so use the existing soil spaces. Their diets are probably very similar also, consuming fungal hyphae, spores, bacteria, pollen, algae, feces, and plant debris. Many springtails can be classified as opportunists because they are not specialized consumers.

Thirty-seven species (belonging to nine families) of springtails were identified from a randomly selected subset (60/180) of samples (table 7, Appendix). The subsample represented a cross-section of samples from every quadrat on each of the three sample dates. Sixty percent of the individuals at Black River and 71 percent at Pine Stump were positively identified to species level. The remaining specimens could not be identified because they were immatures. It should be noted that the Tullgren samples are biased in favor of the edaphic forms. Surface and litter dwelling forms may be inaccurately represented.

Folsomia candida (Isotomidae) was the most abundant springtail found at both areas (table 8). It is a white, eyeless, soil form. Other very common species were: *Tullbergia eollis, Arrhopalites benitus,* and *Isotoma olivacea.* These 4 species comprised 61 percent of the total numbers of specimens at both areas. Two other species *(Guthriella vetusta* and *Tomocerus vulgaris)* were very numerous (each comprising 5 to 10 percent of total population) at Black River, but were scarce (<1 percent) at Pine Stump.

Average population densities for the Black River and Pine Stump stands were 16,882 and 14,208/m², respectively (fig. 3). In both stands population densities appeared to peak in July. The highest densities observed were about 28,000/m² and 32,000/m² at Pine Stump and Black River, respectively.

Insecta: Diptera

Diptera or flies probably rank closely to the beetles in their importance in the soil-litter milieu (Wallwork 1970). Unlike the beetles, though, only the immature or larval stages of flies are functional members of the soil community. Adult flies usually leave the community and few feed within it. The primitive flies, Nematocera, are predominantly saprophagous or fungivorous. The more advanced Brachycera are predominantly predaceous, and the most advanced Cyclorropha are carrion feeders, coprophagous, saprophagous and parasitic. In general, Diptera require a very moist environment, so their abundance and importance decrease from moist to dry environments.

Twelve families of Diptera were identified from our soil samples (table 8, Appendix). This is a conservative estimate of the taxonomic diversity of Diptera because many immature specimens could not be identified (15 percent at Black River and 43 percent at Pine Stump). At Black River the most common flies were in order of decreasing abundance: Bibionidae, Cecidomyiidae, and Stratiomyiidae. At Pine Stump, we found no Bibionidae in our samples but we knew they occur there. As at Black River, the other two most abundant families were Cecidomyiidae and Stratiomyiidae. The soil dwelling form of these three families are probably all saprophages.

Black River had nearly four times (1,154 vs. 428/m²) as many fly larvae as did Pine Stump. This difference was due to the great numbers of Bibionidae found at Black River but not at Pine Stump. Edwards (1974) reported a study of Diptera in Danish woodlands which found from 232 to 1,076 larvae/m².

Insecta: Hymenoptera

Ants (Formicidae) constitute the most important soil-litter dwelling forms of this order. They are common in a variety of environments; from deserts to moist woodlands. Feeding habits of ants are highly varied: carnivorous, phytophagous, fungivorous, xylophagous, saprophagous, and granivorous. All ants are soil insects and many develop nests within the ground. Through tunneling, carrying food, and culturing fungi, they (1) mix plant debris with soil material, (2) cause local increases in the abundance of some important nutrients, and (3) increase soil pore space and aggregate formation.

Twelve ant species were observed in one or both of the stands (table 9, Appendix). Most are woodland species. Two of the 12 were carpenter ants, *Camponotus herculeanus* and *C. noveboracensis. C. herculeanus* was found only at Black River, but *C. noveboracensis* was common in both areas. We found nests of *C. noveboracensis* in standing-dead, aspen trees. It is known to nest in fallen logs and occasionally within the soil proper (Wheeler and Wheeler 1963). Standing-dead aspen trees are almost invariably attacked and such hollowed trees are highly susceptible to wind breakage.

Dolichoderus taschemberg, a shiny black, medium-sized ant, was found only in the Pine Stump stand. It forms very large colonies in wooded areas. We observed only two nests; both had concave mounds and were covered with bits of dead balsam fir needles, and other leaves.

Formica fusca and *F. marcida,* two very similar species in appearance and habits, were recorded from both stands.[4] Their nests are typically made in fallen logs, rotting stumps, or mounds of soil. However, most mounds were associated with decaying wood. *F. fusca* was more abundant of the two species.

F. ulkei, although not observed or collected in either stand, is present near the edge of the Black River stand in a field, and has the potential of moving into small openings within the forest (Wheeler and Wheeler 1963). It is included in this discussion because of its probable presence within this stand. It is a large red and black ant which builds rounded or conical mounds within the soil.

Lasius alienus, a small dark brown ant, was found only in the Black River stand, where it appears to be rare. This species prefers well shaded woodlands where it typically nests in rotting logs or stumps (Wheeler and Wheeler 1963).

Stenamma diecki, a small brown ant, prefers damp wooded areas where it builds small nests common in wood or leaf mold (Wheeler and Wheeler 1963). This ant was observed in small colonies in leaf mold on old, abandoned *Formica* spp. mounds. It is moderately common in both stands.

Tapinoma sessile, a small dark brown to black ant, was observed only once in the Black River stand. It appears to be rare. Wheeler and Wheeler (1963) state that probably no ant surpasses *T. sessile* in the diversity of its nesting sites.

Insecta: Mecoptera

The eruciform larvae of the panorpa group of common scorpion flies are active scavengers in the litter and upper soil layers. Their chief food is dead insects. The pupae are also rather active, and can move up through the soil to allow the adults to escape (Kevan 1962). These insects are temporary soil members. One *Panorpa helena* adult and one *P. subfurcata* adult were casually collected in June. Larvae were recovered only from pitfall traps — six from Pine Stump and only one from Black River.

Insecta: Orthoptera

The very common, but elusive, spotted camel cricket, *Ceuthophilus maculatus* (Gryllacrididae), was collected from pitfall traps in both stands. This insect is strictly nocturnal, spending the days hidden in dark moist places of the litter environment. According to the literature, it prefers the drier woodlands. Zoogeographic evidence suggests that the northern prairie belt was its original habitat. It is an omnivorous feeder (Hubbell 1936).

Nearly four times (51 vs. 14) as many crickets were recovered from Pine Stump as from Black River. Over twice as many males as females were recovered. Records indicate, however, that the sex ratio is typically equal so perhaps males were more prone to being trapped than females (Hubbell 1936). Immatures increased in numbers from June through August. For example, no immature individuals were recovered during June, only two were found in July, and eleven in August. The crickets overwinter primarily in the egg stage (Hubbell 1936).

Insecta: Psocoptera

Few members of this insect are actually litter-inhabiting. Accordingly they are probably of minor importance in the edaphic community. Members representing the suborders Eupsocida and Troctomorpha were recovered from both study stands. Winged eupsocids were the most abundant. All the Troctomorpha belonged to the family Liposcelidae and were taken from soil core samples. These individuals were wingless and probably belonged to the genus *Liposcelis.* They are probably litter-inhabiting.

Insecta: Thysanoptera

Many members of this order are transient soil-inhabitants. Some species spend their pupal stage in the soil whereas adults and larvae of still other species may hibernate in the upper soil or litter layers. Some thrips, however, are more closely tied

[4] *The* Formica fusca *group has recently been completely revised, but to date the work is not published. The identification of* F. fusca *and* F. marcida *are based on older work (personal communication with Dr. Gordon Ayre, 1973). We experienced a great deal of difficulty separating these species, and as a result, recorded them as one.*

to the litter environment because they feed on fungal hyphae or on small invertebrates (Kevan 1962). Members of this order probably contribute very little to the soil community. The few individuals recovered belonged to families Thripidae and Phloeothripidae.

Mollusca: Gastropoda

This phylum consists predominantly of marine organisms. Some have invaded the terrestrial environment apparently via the fresh water route. These are the common snails and slugs or Gastropods. The abundance and diversity of terrestrial molluscs appear to be greatest in woodland habitats but the greatest biomasses may occur in open grassland habitats (Mason 1974). Mollusc populations in brown earth and mature podzol soils are generally small ($<1/m^2$). However, where the soil is calcareous and loosely packed and surface vegetation is abundant, population densities may reach $60/m^2$ (Wallwork 1970). Terrestrial molluscs seem to exhibit a preference for calcareous, neutral to alkaline, soil-litter milieus.

Snails and slugs have diverse feeding habitats. Many are omnivorous or generalized feeders (Mason 1974); others are phytophagous, fungivorous, carnivorous, xylophagous, and saprophagous feeding on both plant and animal remains. Many genera of gastropods have cellulases, quite unlike most other terrestrial animals, so that they can break down and utilize the obiquitous cellulose in plant remains.

We recovered 13 species representing eight families of slugs and snails (table 10, Appendix). All are terrestrial species except one, *Lymnaeca catascorpium,* which is a freshwater snail. Both areas had eight species of snails and two species of slugs, but Pine Stump's snail population density was four-fold greater ($17/m^2$ vs. $4/m^2$) than Black River's based only on soil sieve samples.

Discus cronkhitei anthony, a small brown snail with heliciform shell, was the most abundant species comprising ~50 percent of the total snails found at Pine Stump (table 10, Appendix). It comprised less than 20 percent of the population at Black River. It is widely distributed throughout the eastern United States and southern Canada and prefers moist woodlands (Burch 1962). Generally it was found under debris on the forest floor.

The next most common and the largest snail at Pine Stump was *Succinea ovalis.* During the day it lives under leaves and other debris on the forest floor, but will often climb trees during wet weather (Baker 1939). Sample data indicate that its population density was $7/m^2$.

The three most common snails at Black River were *Cionella lubrica, D. cronkhitei* anthony, and *Retinella electrina* — altogether comprising about 75 percent of the individuals found.

Two species of slugs, *Ceroceras reticulatum* and *D. laeve,* were common in both stands. These species are not native to North America. They were recovered only from pitfall traps, so it was not possible to estimate their absolute population densities.

SUMMARY

The aspen forests in this study had substantial populations of small mesofauna and only meager populations of large mesofauna and macrofauna. In this respect, the aspen forests resembled mor rather than mull-like sites. For example, the myripods, isopods, molluscs, and lumbricid annelids, which are prominent in mull sites, were scarce in our study plots. Instead, the prominent organisms were mites, Collembolla, flies, and beetles. A scarcity of large, burrowing mesofauna and macrofauna is usually reflected in a restricted distribution of soil organic matter, a lower degree of organo-mineral mixing, and lower amounts of crumb formation (Wallwork 1970). This was certainly evident at Pine Stump but not so at Black River, presumably because of the presence of the burrowing earthworm, *Allolobophora trapezoides,* and greater numbers of burrowing millipedes.

Both study plots had similar numbers of soil invertebrates, as shown in the tabulation below, but the species compositions were slightly different.

Soil invertebrates	Black River stand	Pine Stump stand
	(mean numbers/m²)	
Lumbricidae	70	124
Acari	87,214	93,653
Araneida	10	25
Chelonethida	108	313
Diplopoda	4	1
Chilopoda	6	5
Coleoptera	433	327
Collembola	19,157	14,108
Diptera	1,505	427
Mollusca	4	17

For example, Pine Stump had more individuals of those species that were acid tolerant, (*Dendrobeana* spp., *Microbisium brunneum)* and fewer of those that were hydrophilous or very sensitive to desiccation (Lithobiomorpha centipedes, polydesmid millipedes, etc.).

Soil pH samples revealed that the soils at Black River were more basic and less acid than soils at Pine Stump. In addition, the vegetation and general observation indicated that Black River soils were wetter and less subject to desiccation during the summer months. These conditions probably account for the differences in species composition between study plots.

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APPENDIX

Table 1. —*Average soil depth[1] and pH and their respective ranges for the 01 (undecomposed litter), the 02 (decomposed organic material down to the humus layer), the A2 (mineral surface soil), and the B (subsoil) horizons for each quadrat of both study stands*

Soil horizon characteristics	Q1	Q2	Q3	Q4	Stand mean
BLACK RIVER STAND					
01 Horizon					
$\bar{x}$ Depth (cm)	1.44	1.44	1.34	1.41	1.41
Range (cm)	0.5-8.0	0.5-8.5	0.5-4.5	0.5-7.0	0.5-8.5
02 Horizon					
$\bar{x}$ Depth (cm)	8.91	7.98	8.98	8.10	8.49
Range (cm)	2.5-24.0	3.0-23.0	6.0-15.0	5.0-15.0	2.5-24.0
$\bar{x}$ pH	6.70	6.55	6.50	6.62	6.59
Range	6.0-7.2	6.2-7.0	6.0-7.0	6.0-7.0	6.0-7.2
A2 Horizon					
$\bar{x}$ Depth (cm)	15.98	15.29	13.28	12.67	14.31
Range (cm)	0.0-23.0	0.0-27.0	0.0-24.0	0.0-21.0	0.0-27.0
$\bar{x}$ pH	6.80	6.48	6.66	6.63	6.64
Range	5.7-7.5	6.2-6.7	6.0-7.5	6.2-7.0	5.7-7.5
B Horizon					
$\bar{x}$ pH	7.87	7.50	7.52	7.72	7.65
Range	7.5-8.0	7.0-8.0	7.0-8.0	6.7-8.0	6.7-8.0
PINE STUMP STAND					
01 Horizon					
$\bar{x}$ Depth (cm)	4.00	3.17	2.80	3.57	3.39
Range (cm)	2.0-8.0	0.5-7.0	1.0-5.5	1.5-5.5	0.5-8.0
02 Horizon					
$\bar{x}$ Depth (cm)	8.27	5.94	5.43	5.97	6.40
Range (cm)	3.5-24.0	0.0-14.0	0.0-14.5	0.0-9.0	0.0-24.0
$\bar{x}$ pH	6.00	5.90	6.28	6.20	6.10
Range	5.8-6.3	4.5-6.0	5.2-7.0	6.0-7.0	4.5-7.0
A2 Horizon					
$\bar{x}$ Depth (cm)	12.31	11.60	10.04	9.63	10.90
Range	0.0-23.0	0.0-21.0	0.0-16.0	0.0-14.5	0.0-23.0
$\bar{x}$ pH	6.05	5.36	5.88	5.60	5.72
Range	5.8-6.3	4.8-6.0	5.5-6.1	5.5-6.0	4.8-6.3
B Horizon					
$\bar{x}$ pH	7.00	6.30	6.14	5.50	6.24
Range	5.5-8.0	5.3-8.0	5.5-6.8	4.8-6.0	4.8-8.0

[1]Soil depth averages are based on the number of occurrences recorded for any given horizon.

Table 2. —*Forest stand table showing numbers and basal areas of different tree species at Black River and Pine Stump study plots*

Tree stocking	Tree species					
	Populus tremuloides	*Populus balsamifera*	*Abies balsamea*	*Betula papyrifera*	*Fraxinus nigra*	Totals/ acre
BLACK RIVER						
Number of stems/acre	584.0	75.0	92.0	--	89.0	840.0
Basal area/acre	101.0	12.0	.5	--	2.5	116.0
PINE STUMP						
Number of stems/acre	736.0	25.0	33.0	54.0	--	848.0
Basal area/acre	91.0	2.5	1.5	2.0	--	97.0

Table 3. — *A systematic list of all invertebrates found (identified to the lowest taxon possible)*

PHYLUM ANNELIDA

Class Oligocheata
  Order Opisthopora
    Family Lumbricidae
      Allolobophora trapezoides
      Dendrobaena octaedra
      D. rubida
      Octolasion tyrtaeum

PHYLUM ARTHROPODA

Class Arachnida
  Order Acari
    Suborder Acaridei (=Astigmata)
      Superfamily Acaroidea
        Family Acaridae
          Tyrophagus sp.
      Superfamily Anoetoidea
        Family Anoetidae
          Histiosoma sp.
    Suborder Mesostigmata
      Superfamily Parasitoidea
        Family Ascidae
          Asca aphidioides
          A. garmani
        Family Crytolaelapidae
          Gamasellus sp.
        Family Digamasellidae
          Digamasellus sp.
        Family Laelapidae
          Hypoaspis sp.
        Family Phytoseiidae
          Amblyseius krantzi
        Family Podocinidae
          Podocinum pacificum
        Family Zerconidae
          Parazercon radiata
          Zercon sp.
      Superfamily Sejoidea
        Family Sejidae
          Sejus sp.
    Suborder Oribatei (=Cryptostigmata)
      Superfamily Carabodoidea
        Family Tectocepheidae
          Tectocepheus velatus
      Superfamily Cepheoidea
        Family Cepheidae
          Cepheus corae
      Superfamily Ceratozetoidea
        Family Ceratozetidae
          Ceratozetes sp.
          Fuscozetes bidentatus
          Propelops sp.
      Superfamily Damaeoidea
        Family Belbidae
          Belba sp.
      Superfamily Hypochthonoidea
        Family Brachychthoniidae
          Brachychthonius semiornatus
          Brachychthonius sp.
          Liochthonius sp.
          Synchthonius crenulatus
        Family Eniochthoniidae
          Hypochthoniella borealis
      Superfamily Mesoplophoroidea
        Family Mesoplophoridae
          Archoplophora laevis
      Superfamily Nothroidea
        Family Camisiidae
          Platynothrus sp.
        Family Malaconothridae
          Malaconothrus sp.
        Family Nothridae
          Nothrus sp.
      Superfamily Oppioidea
        Family Oppiidae
          Oppia sp.
          Oppiella nova
          Quadroppia sp.
        Family Suctobelbidae
          Suctobelba (2 spp.)
      Superfamily Oribatelloidea
        Family Achipteriidae
          Anachipteria sp.
      Superfamily Oribatuloidea
        Family Haplozetidae
          Xylobates sp.
        Family Oribatulidae
          Scheloribates sp.
        Family Oripodidae
          Oripoda sp.
      Superfamily Phthiracaroidea
        Family Phythiracaridae
          Phthiracarus setosellum
          Steganacarus diaphanum
      Superfamily Zetorchestoidea
        Family Gustaviidae
          Gustavia sp.
    Suborder Prostigmata
      Superfamily Bdelloidea

Family Cunaxidae
Cunaxa sp.
Superfamily Eupodoidea
Family Eupodidae
Cocceupodes (2 spp.)
Eupodes sp.
Family Rhagidiiae
Coccorhagidia sp.
Rhagidia longisensilliba
Rhagidia sp.
Superfamily Pachygnathoidea (=Endeostigmata)
Family Alicorhagiidae
Alicorhagia sp.
Family Pachygnathidae
Bimichaelia sp.
Pachygnathus sp.
Superfamily Tarsonemoidea (=Tarsonemini)
Family Pyemotidae
Bakerdania sp.
Microdispus obovatus
Family Scutacaridae
Scutacarus sp.
Family Tarsonemidae
Tarsonemus sp.
Order Araneida
Order Chelonethida (=Pseudoscorpionida)
Suborder Diploshyronida
Family Neobisiidae
Microbisium brunneum
M. confusum
Suborder Heterosphyronida
Family Chthoniidae
Mundochthonius rossi
Order Phalangida
Suborder Palpatores
Family Ischyropsalidae
Sabacon crassipalpe
Family Nemastomatidae
Crosbycus dasycnemus
Family Phalangidae
Leiobunum calcar
L. politum Weed
L. ventricosum
Odiellus pictus pictus
Class Chilopoda
Order Geophilomorpha
Order Lithobiomorpha
Class Crustacea
Order Eucopepoda
Class Diplopoda
Order Polydesmida
Class Insecta
Order Coleoptera
Suborder Adephaga
Family Carabidae
Agronum decentis
A. gratiosum
A. mutatum
A. puncticeps
A. retractum
Synuchus impunctatus
Bembidion sp.
Calosoma frigidum
Sphaeroderus lecontei
Acupalpus sp.
Bradycellus sp.
Harpalus pleuriticus
Harpalus sp.

Lebi tricolor
Badister sp.
Badister reflexus
Pterostichus adstrictus
P. coracinus
Trechus apicalis
Family Noteridae
Suborder Polyphaga
Superfamily Cantharoidea
Family Cantharidae
Cantharis fraxini
C. nigriceps
Family Lampyridae
Ellychnia corrusca autumnalis
Superfamily Chrysomeloidea
Family Chrysomelidae
Altica maybe *ignita*
Crepidodera nana
Oedionychis subvittata
Phratora americana
Bassareur mammifer sellatus
Superfamily Cucujoidea
Family Endomychidae
Danae testacea
Family Erotylidae
Triplax thoracica
Family Lathridiidae
Melanophthalma sp.
Family Nitidulidae
Epuraea rufa
Superfamily Curculionoidea
Family Curculionidae
Brachyrhinus ovatus
Superfamily Elateroidea

Family Elateridae
Dalopius sp.
Superfamily Hydrophiloidea
Family Histeridae
Hister depurator
Family Hydrophilidae
Anacaena sp.
Cymbiodyta fimbriata
Hydrobius fuscipes
Superfamily Scarabaeoidea
Family Scarabaeidae
Aphodius fimetarius
Aphodius sp.
Geotrupes semiopacus
Superfamily Staphylinoidea
Family Leiodidae
Anisotoma sp.
Family Leptodiridae
Colon sp.
Family Orthoperidae
Family Pselaphidae
Family Ptiliidae
Family Staphylinidae
Lathrobium probably *brevipenne*
L. probably *simplex*
Lathrobium sp.
Rugilus dentatus
Ontholestes cingulata
Philonthus cyanipennis
P. lomatus
P. probably *micans*
Philonthus sp.
Quedius molochinus
Q. peregrinus
Staphylinus badipes
Lordithon cincticollis
Lordithon sp.
Bryoporus rufescens
Tachinus pallipes
Tachyporus maybe *elegan*
Tachyporus spp.
Family Silphidae
Nicrophorus sayi
N. tomentosus
N. vespilloides
Superfamily Tenebrionoidea
Family Alleculidae
Isomira quadristriata
Order Collembola
Suborder Arthropleona
Superfamily Entomobryoidea
Family Entomobryidae
Entomobrya quinquelineata
E. unostrigata
Entomobryoides purpurascens
Lepidocyrtus lignorum
L. paradoxus
L. violaceous
Orchesella ainsliei
Willowsia buski
W. plantani nigromaculata
Family Isotomidae
Anurophorus laricus
Isotoma near *finitima*
I. muskegis
I. nigrifrons
I. notabilis
I. olivacea
I. trispinata
I. viridis
Isotominella minor
Folsomia candida
Guthriella vetusta
Proisotoma minuta
Family Tomoceridae
Tomocerus flavescens
T. vulgaris
Superfamily Hypogastruroidea
Family Hypogastruridae
Hypogastrura nivicola
Family Onychiuridae
Hymenaphorura similis
Protaphorura pseudarmatus
Tullbergia collis
Suborder Neoarthropleona
Family Anuridae
Anurida tullbergi
Aphoromma granaria
Family Neanuridae
Micranurida pygmaea
Neanura muscorum
Pseudachorutes aureofasciatus
Suborder Symphypleona
Family Neelidae
Megalothorax albus
Neelus minutus
Family Sminthuridae
Arrhopalites benitus
Sminthurinus sp.
Sphyrotheca minnesotensis
Ptenothrix marmorata
Sminthurides lepus
S. occultus
Order Diptera
Suborder Brachycera
Superfamily Empidoidea

Family Dolichopidae
Family Empididae
Superfamily Tabanoidea
Family Stratiomyiidae
Family Tabanidae
Suborder Cyclorrhapha
Superfamily Muscoidea
Family Anthomyiidae
Fannia sp.
Family Muscidae
Superfamily Oestroidea
Family Sarcophagidae
Family Tachinidae
Superfamily Phoroidea
Family Phoridae
Superfamily Sciomyzoidea
Family Dryomyzidae
Superfamily Syrphoidea
Family Syrphidae
Microdon sp.
Family Helemoyzidae
Suborder Nematocera
Superfamily Bibionoidea
Family Bibionidae
Superfamily Culicoidea
Family Chironomidae (=Tendipedidae)
Family Culicidae
Family Simuliidae
Superfamily Mycetophiloidea
Family Cecidomyiidae
Family Sciaridae
Superfamily Tipuloidea
Family Tipulidae
Order Hemiptera
Suborder Geocorizae
Family Aradidae
Family Largidae
Family Miridae
Family Nabidae
Family Pentatomidae
Family Tingidae
Order Homoptera
Suborder Auchenorrhyncha
Superfamily Cicadoidea
Family Cercopidae
Family Cicadellidae
Superfamily Fulgoroidea
Family Delphacidae
Suborder Sternorrhyncha
Superfamily Aphidoidea
Family Aphididae
Superfamily Coccidea
Family Coccoidea
Superfamily Psylloidea
Family Psyllidae
Order Hymenoptera
Suborder Apocrita
Superfamily Cynipoidea
Family Cynipidae
Superfamily Ichneumonoidea
Family Braconidae
Bracon sp.
Meteorus sp.
Macrocentrus sp.
Apanteles sp.
Family Ichneumonidae
Pleolophus indistinctus
Gelis sp.
Phygadeuon spp.
Phaeogenes sp. s.l.
Cratichneumon sp.
Vulgichneumon terinalis
Dialipsis communis
Oxytorus antennatus
Orthocentrus spurius
O. frontator
Picrostigeus sp.
Stenomacrus sp.
Hyposoter popofensis
Coccygomimus pedalis
Ephialtes annulicornis
Aniseres sp.
Hyperacmus crassicornis
Megastylus sp.
Chriodes sp.
Superfamily Proctotrupoidea
Family Diapriidae
Family Platygasteridae
Family Proctotrupidae (=Serphidae)
Family Scelionidae
Superfamily Scoliodea
Family Formicidae
Dolichoderus taschenbergi
Tapinoma sessile
Camponotus herculeanus
C. noveboracensis
Formica fusca
F. marcida
F. probably *sanquinea subnuda*
F. ulkei
Lasius alienus
Myrmica probably *brevinodis*
M. probably *emeryana*
Stenamma diecki
Superfamily Tenthredinoidea

Family Tenthredinidae
Superfamily Vespoidea
Family Pompilidae (=Psammocharidae)
Family Vespidae
Vespula sp.
Order Lepidoptera
Superfamily Geometroidea
Family Geometridae
Superfamily Noctuoidea
Family Artiidae
Family Noctuidae
Superfamily Sphingoidea
Family Sphingidae
Superfamily Pyralidoidea
Family Pyralidae
Order Mecoptera
Family Panorpidae
Panorpa helena
P. subfurcata
Panorpa sp.
Order Orthoptera
Suborder Caelifera
Family Acrididae
Melanopus islandicus
Suborder Ensifera
Family Gryllacrididae
Ceuthophilus macultus
Order Psocoptera
Suborder Eupsocida
Suborder Troctomorpha
Family Liposcelidae
Liposcelis sp.
Order Thysanoptera
Suborder Terebrantia
Family Thripidae
Suborder Tubulifera
Family Phloeothripidae

PHYLUM MOLLUSCA
Class Gastropoda
Order Basommatophora
Family Carychiidae
Carychium exiguum
Order Pulmonata
Family Lymnaeidae
Lymnaea catascorpium
Order Stylommatophora
Suborder Heterurethra
Family Succineidae
Succinea ovalis
Suborder Orthurethra
Family Cionellidae
Cionella lubrica
Family Strobilopsidae
Strobilops labyrinthica
Suborder Sigmurethra
Family Endodontidae
Anguispira altermata
Discus cronkhitei anthonyi
Family Limacidae
Deroceras reticulatum
D. laeva
Family Zonitidae
Euconulus fulvus
Retinella electrina
Vitina limpida Gould
Zonitoides arboreus

PHYLUM NEMATODA

Table 4. — *Spiders occurring in different quadrats of both study stands — based on soil block sieve samples*

Month of sampling	Quadrats Q1	Q2	Q3	Q4	Average per quadrat
BLACK RIVER STAND					
	number/m²				
June	10.8	6.5	21.6	13.0	13.0
July	8.7	8.7	6.5	8.7	8.1
August	8.7	0.0	17.3	4.3	7.6
Average/month	9.4	5.0	15.1	8.7	9.6
PINE STUMP STAND					
June	26.0	34.6	8.7	36.8	26.5
July	34.6	17.3	32.5	23.8	27.1
August	13.0	21.6	28.1	21.6	21.1
Average/month	24.5	24.5	23.1	27.4	24.9

Table 5. — *Beetle larvae collected in each study stand — based on soil sieve and Tullgren funnel extraction methods*
(In number/m^2)

Families of juvenile beetles	Sieving method: Black River stand	Sieving method: Pine Stump stand	Funnel method: Black River stand	Funnel method: Pine Stump stand
Cantharidae	0.7	0.0	72.1	114.6
Carabidae	2.9	1.4	21.6	30.6
Chrysomelidae	0.2	0.0	0.0	0.0
Curculionidae	0.2	0.0	0.0	0.0
Elateridae	1.8	9.7	14.4	68.7
Lampyridae	0.7	1.1	0.0	0.0
Orthoperidae	0.0	0.0	14.4	0.0
Scarabaeidae	4.9	0.4	0.0	0.0
Silphidae	0.0	0.2	0.0	0.0
Staphylinidae	2.5	2.9	64.9	30.6
Unknown larvae	0.0	0.0	245.1	84.0
Total larvae	13.9	15.7	432.5	328.0
Total pupae	1.3	1.1	0.0	0.0

Table 6. — *Beetle larvae occurring in different quadrats of both study stands — based on soil block sieve and Tullgren funnel extraction methods*

Month	Sampling method[1]	Quadrats: Q1	Q2	Q3	Q4	Average per quadrat
BLACK RIVER STAND						
		- - - Number/m^2 - - -				
June	SM	4	11	15	13	11
	FM	183	0	513	513	310
July	SM	6	17	6	15	11
	FM	428	684	855	257	556
August	SM	6	11	54	6	19
	FM	257	1,112	257	85	428
Average/month	SM	6	13	25	11	14
	FM	292	612	542	285	432
PINE STUMP STAND						
June	SM	24	19	30	15	22
	FM	99	275	183	513	275
July	SM	26	15	13	19	18
	FM	275	642	0	257	293
August	SM	11	4	9	2	6
	FM	513	275	642	275	420
Average/month	SM	20	13	17	12	16
	FM	305	397	257	350	328

[1]SM = Sieving Method; FM = Funnel Method.

Table 7. — *Collembolan species found within Tullgren core samples in both study stands*
(In number/m²)

Species	Black River	Pine Stump
Family Entomobryidae:		
Entomobrya quinquelineata	21	21
E. unostrigata	0	21
Lepidocyrtus lignorum	86	150
L. paradoxus	0	21
L. violaceous	257	0
Orchesella ainsliei	0	21
Willowsia buski	235	278
W. platani nigromaculata	64	0
Family Isotomidae:		
Anurophorus laricus	21	364
Isotoma near finitima	86	257
I. nigrifrons	0	21
I. notabilis	364	471
I. olivacea	385	1,797
I. trispinata	150	471
I. viridis	107	86
Isotominella minor	21	0
Folsomia candida	2,459	2,652
Guthriella vetusta	1,133	0
Proisotoma minuta	21	150
Family Tomoceridae:		
Tomocerus flavescens	321	299
T. vulgaris	684	86
Family Hypogastruridae:		
Hypogastrura nivicola	0	235
Family Onychiuridae:		
Hymenaphorura similis	64	278
Protaphorura pseudarmatus	86	0
Tullbergia collis	2,951	941
Family Anuridae:		
Anurida tullbergi	43	21
Aphoromma granaria	107	428
Family Neanuridae:		
Micranurida pygmaea	43	86
Neanura muscorum	21	0
Pseudachorutes aureofasciatus millsi	21	0
Family Neelidae:		
Megalothorax albus	299	171
Neelus minutus	43	21
Family Sminthuridae:		
Arrhopalites benitus	1,155	620
Sphyrotheca minnesotensis	21	0
Ptenothrix marmorata	21	0
Sminthurides lepus	0	86
S. occultus	171	0

Table 8. — *Fly larvae by family for each study stand and sampling method*
(In number/m²)

Families of fly larvae	Funnel method		Sieving method	
	Black River Stand	Pine Stump Stand	Black River Stand	Pine Stump Stand
Anthomyiidae	7	8	--	--
Bibionidae	1,009	--	3.0	--
Cecidomyiidae	209	92	--	--
Chironomidae	--	15	--	--
Dolichopidae	--	--	--	1
Muscidae	--	--	0.5	1
Sciaridae	--	--	--	4
Stratiomyiidae	36	115	--	--
Tabanidae	14	8	--	2
Tipulidae	--	8	0.2	3
Unknowns	238	183	0.4	1
Total larvae	1,514	428	4.0	12

Table 9. — *Ant species collected by different sample methods*[1]

Ant Species	Pitfall Method		Sieving Method		Total Observations		Field Observations	
	Black River stand	Pine Stump stand	Black River stand	Pine Stump stand	Black River stand	Pine Stump stand	Black River stand	Pine Stump stand
Camponotus herculeanus	1	0	0	0	1	0	[2]-	-
C. noviboracensis	12	2	0	1	12	3	[3]+	+
Dolichoderus taschenbergi	0	1	0	2	0	3	-	2
Formica fusca + F. marcida	15	10	0	1	15	11	+	+
F. probably sanguinea subnuda	1	4	0	0	1	4	-	-
F. ulkei	0	0	0	0	0	0	1	-
Lasius alienus	3	0	0	0	3	0	-	-
Myrmica probably brevinodis	6	0	0	1	6	1	-	-
M. probably emeryana	14	15	15	8	29	23	+	+
Stenamma diecki	0	2	0	2	1	5	-	-
Tapinoma sessile	0	0	0	0	0	0	1	-

[1]The Tullgren Funnel Method is not listed separately but its results are included in the total observation column.
[2]- = No field observations.
[3]+ = A number of specimens casually observed in the field during the summer but not counted.

Table 10. — *Gastropoda species collected by different sampling methods in both study stands*

Gastropod species	Pitfall method		Sieving method[1]	
	Black River stand	Pine Stump stand	Black River stand	Pine Stump stand
Anguispira alternata	0	0	1	0
Carychium exiguum	0	0	0	0
Cionella lubrica	0	0	9	4
Detoceras reticulatum	4	14	0	0
D. laeve	34	14	0	0
Discus cronkhitei anthonyi	3	68	5	46
Euconulus fulvus	0	1	0	0
Lymnaea catascorpium	0	0	1	0
Retinella electrina	5	9	4	11
Strobilops labyrinthica	0	9	0	0
Succinea ovalis	2	11	1	37
Vitrina limpida	0	0	[2]+	+
Zonitoides arboreus	0	0	1	0

[1]The soil block sieving method did not select for most snails in a very precise manner. All snails, except *Succinea ovalis*, were small and occupied a niche not easily accessible by this technique. Therefore, the numbers representing each species for this method are not very accurate. They do, however, represent a datum to fix relative abundance to. Due to its large size, the numbers representing *S. ovalis* for this technique should be considered accurate.
[2]+=Sample location information lost for the three specimens found.

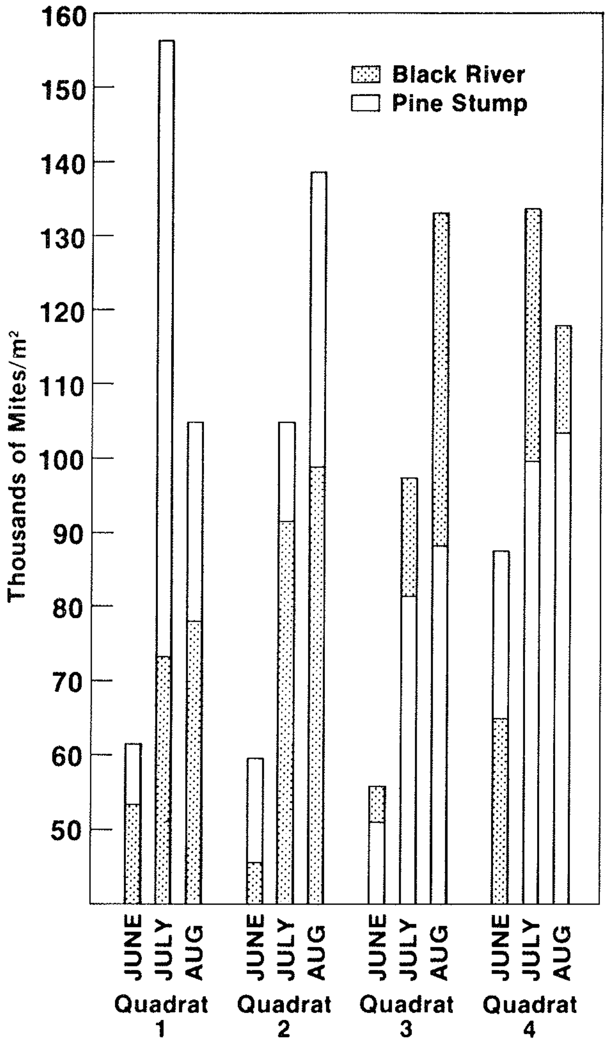

Figure 1. — *Mean numbers of mites in different quadrats at Black River and Pine Stump during June, July, and August — based entirely on Tullgren core samples.*

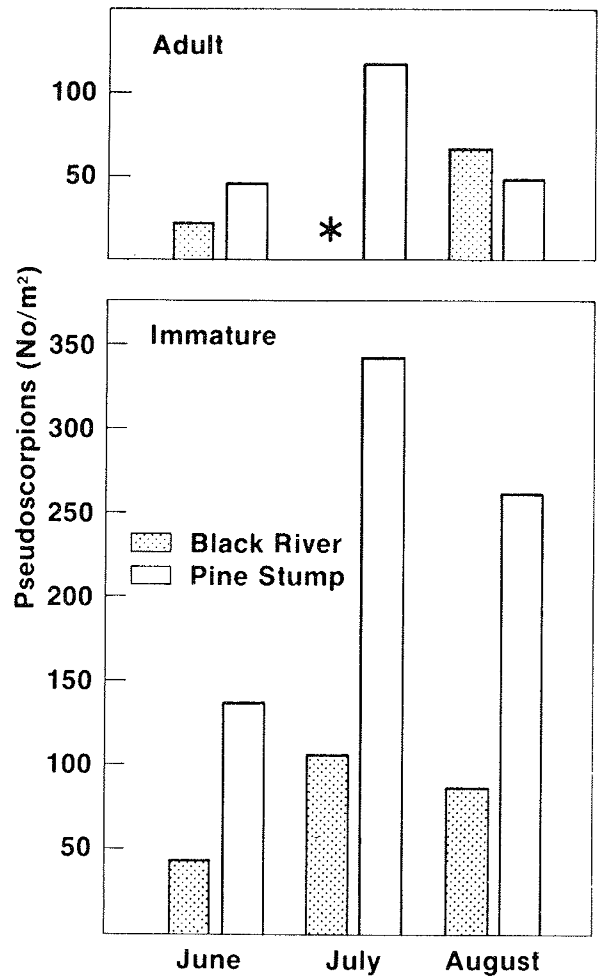

Figure 2. — *Mean numbers of adult and immature pseudoscorpions in Black River and Pine Stump stands during June, July, and August — based on Tullgren samples.*

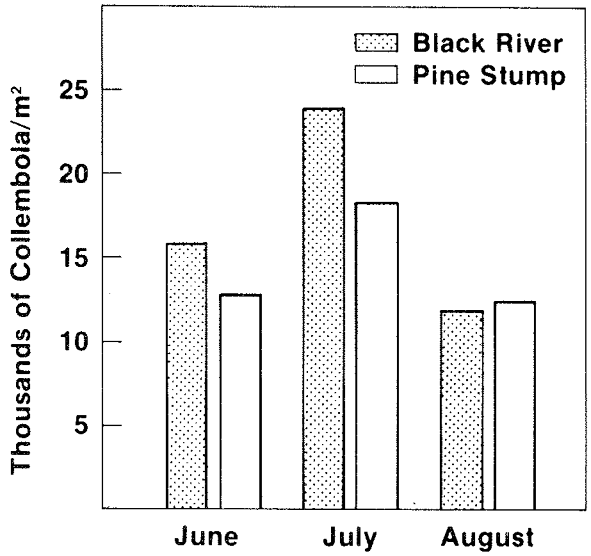

Figure 3. — *Mean numbers of Collembola in Black River and Pine Stump stands during June, July, and August — based on Tullgren samples.*

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