A Survey of SOIL INVERTEBRATES in two Aspen Forests in northern Minnesota.

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CONTENTS

Materials and Methods .................................................. 2
Study Plot Descriptions .................................................. 3
Results and Discussion .................................................. 4
Summary ......................................................................... 10
Literature Cited .............................................................. 11
Appendix .......................................................................... 13

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

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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.
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 classified¹, 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-Truong 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/in² hardware cloth was glued to one end of each pipe section to hold the

¹Paul Nyberg, USDA Soil Conservation Service, Grand Rapids, Minnesota.
were immediately placed intact into the plastic 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 subplot supplied all soil core samples. These subplots were further divided into 100 2- by 2-m² 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 meso-fauna 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 retaining 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 feet² (22.3 m²/ha) at Pine Stump and 116 feet² (26.7 m²/ha) at Black River. Other less abundant tree associates were balsam poplar *P. balsamifera*, paper birch, *Betula papyrifera*, 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-leaved 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 >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*.
**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 under-represented 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, non-burrowing, 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 *Dendrobaena* spp. was twice as great (124 vs. 60 m⁻²) 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_ among 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, Meso-stigmata, 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. (Rhagidiidae). 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.

²Personal 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 bruneum, *M. confusum*, and Mundochtonius rossi were found. *M. bruneum*, 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. bruneum*, 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. bruneum* on wet sites in northern Illinois, it apparently prefers drier uplands.* 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 occurs in the evening (Wallwork 1970).

We recovered six species of harvestmen: Leiodunum 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. dasychenus* 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).
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), Staphylinididae (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 eolii, 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 vulgaria) 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 Cyclororrhapha 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. noviboracensis. C. herculeanus was found only at Black River, but C. noviboracensis was common in both areas. We found nests of C. noviboracensis 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. 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 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: Pscoptera**

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
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 mollusks appear to be greatest in woodland habitats but the greatest biomasses may occur in open grassland habitats (Mason 1974). Mollusk populations in brown earth and mature podzol soils are generally small (<1/m²). However, where the soil is calcareous and loosely packed and surface vegetation is abundant, population densities may reach 60/m² (Wallwork 1970). Terrestrial mollusks 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 ubiquitous cellulose in plant remains.

We recovered 13 species representing eight families of slugs and snails (table 10, Appendix). All are terrestrial species except one, *Lymnaea 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/m² vs. 4/m²) than Black River's based only on soil sieve samples.

*Discus cronhitei* 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/m².

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

Two species of slugs, *Cercoceras 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 myriopods, 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.
For example, Pine Stump had more individuals of those species that were acid tolerant, (Dendrobeta spp., Microbistum 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.

LITERATURE CITED


Crossley, D. A., Jr. 1977. The roles of saprophagous arthropods in forest soils. In The role of arthropods in forest ecosystems, life sciences Symp.

Proc. W. J. Mattson, ed. Springer Verlag, Heidelberg, Germany. [In press.]


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 quadrant of both study stands

<table>
<thead>
<tr>
<th>Soil horizon</th>
<th>01 Horizon</th>
<th>02 Horizon</th>
<th>A2 Horizon</th>
<th>B Horizon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (cm)</td>
<td>1.44</td>
<td>8.91</td>
<td>15.98</td>
<td>7.87</td>
</tr>
<tr>
<td>pH</td>
<td>6.70</td>
<td>6.80</td>
<td>6.80</td>
<td>7.50</td>
</tr>
<tr>
<td>Range (cm)</td>
<td>0.5-8.0</td>
<td>2.5-24.0</td>
<td>0.0-23.0</td>
<td>5.7-7.5</td>
</tr>
</tbody>
</table>

BLACK RIVER STAND

<table>
<thead>
<tr>
<th>Soil characteristics</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Horizon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depth (cm)</td>
<td>4.00</td>
<td>2.0-8.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>6.00</td>
<td>5.8-6.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range (cm)</td>
<td>2.0-8.0</td>
<td>5.8-6.3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil horizon</th>
<th>02 Horizon</th>
<th>A2 Horizon</th>
<th>B Horizon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (cm)</td>
<td>8.27</td>
<td>12.31</td>
<td>7.00</td>
</tr>
<tr>
<td>pH</td>
<td>6.00</td>
<td>6.05</td>
<td>7.00</td>
</tr>
<tr>
<td>Range (cm)</td>
<td>3.5-24.0</td>
<td>0.0-23.0</td>
<td>5.5-8.0</td>
</tr>
</tbody>
</table>

PINE STUMP STAND

<table>
<thead>
<tr>
<th>Soil horizon</th>
<th>01 Horizon</th>
<th>02 Horizon</th>
<th>A2 Horizon</th>
<th>B Horizon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth (cm)</td>
<td>4.00</td>
<td>8.27</td>
<td>12.31</td>
<td>7.00</td>
</tr>
<tr>
<td>pH</td>
<td>6.00</td>
<td>6.05</td>
<td>6.00</td>
<td>7.00</td>
</tr>
<tr>
<td>Range (cm)</td>
<td>2.0-8.0</td>
<td>3.5-24.0</td>
<td>0.0-23.0</td>
<td>5.5-8.0</td>
</tr>
</tbody>
</table>

^1Soil 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

<table>
<thead>
<tr>
<th>Tree species</th>
<th>Black River</th>
<th>Pine Stump</th>
</tr>
</thead>
<tbody>
<tr>
<td>Populus</td>
<td>584.0</td>
<td>101.0</td>
</tr>
<tr>
<td>Abies</td>
<td>75.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Betula</td>
<td>92.0</td>
<td>.5</td>
</tr>
<tr>
<td>Fraxinus</td>
<td>89.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Totals</td>
<td>840.0</td>
<td>116.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of stems/acre</th>
<th>Black River</th>
<th>Pine Stump</th>
</tr>
</thead>
<tbody>
<tr>
<td>584.0</td>
<td>75.0</td>
<td>101.0</td>
</tr>
<tr>
<td>75.0</td>
<td>92.0</td>
<td>12.0</td>
</tr>
<tr>
<td>92.0</td>
<td>59.0</td>
<td>.5</td>
</tr>
</tbody>
</table>

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<tr>
<th>Number of stems/acre</th>
<th>Black River</th>
<th>Pine Stump</th>
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</thead>
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<tr>
<td>840.0</td>
<td>116.0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Basal area/acre</th>
<th>Black River</th>
<th>Pine Stump</th>
</tr>
</thead>
<tbody>
<tr>
<td>584.0</td>
<td>75.0</td>
<td>101.0</td>
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<tr>
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</tbody>
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</thead>
<tbody>
<tr>
<td>840.0</td>
<td>116.0</td>
<td></td>
</tr>
</tbody>
</table>
Table 3. — A systematic list of all invertebrates found (identified to the lowest taxon possible)

| PHYLUM ANNELIDA | Fuscozetes bidentatus  |
| Class Oligochaeta | Propelops sp. |
| Order Opisthobora | Superfamily Damaeoida |
| Family Lumbricidae | Family Belbidae |
| Alolobophora trapesoides | Belba sp. |
| Dendrobaena octaedra | Superfamily Hypochthonoidea |
| Octolasion tyrtaeum | Family Brachychthoniidae |
| | Brachychthonius semiorbatus |
| | Brachychthonius sp. |
| | Liochthonius sp. |
| | Synchthonyus arenulatus |
| | Family Eniochthoniidae |
| | Hypochthoniella borealis |
| | Superfamily Mesoplophoroidea |
| | Family Mesoplophoridae |
| | Archopliphora laevis |
| | Superfamily Nothroida |
| | Family Canisidae |
| | Platynothrus sp. |
| | Family Malacothonididae |
| | Malacothonrus sp. |
| | Family Nothridae |
| | Nothrus sp. |
| | Superfamily Oppioidea |
| | Family Oppiidae |
| | Oppia sp. |
| | Oppiella nova |
| | Quadrroppia sp. |
| | Family Suctobelbidae |
| | Suctobelba (2 spp.) |
| | Superfamily Oribatelloidea |
| | Family Achipteridae |
| | Anachipteria sp. |
| | Superfamily Oribatuloidea |
| | Family Maliozetidae |
| | Xylobates sp. |
| | Family Oribatulidae |
| | Schelortibates sp. |
| | Family Oripodidae |
| | Oripoda sp. |
| | Superfamily Phthiracaroidea |
| | Family Phythiracarididae |
| | Phthiracarus setosellum |
| | Steganacarus diaphanum |
| | Superfamily Zetorchestoidea |
| | Family Gustaviidae |
| | Gustavia sp. |
| | Suborder Prostigmata |
| | Superfamily Bdelloidea |

| PHYLUM ARTHROPODA | Suborder Acari |
| Class Arachnida | Suborder Acaridei (=Astigmata) |
| Order Acari | Superfamily Acaroidea |
| | Family Acaridae |
| | Tyrophagus sp. |
| | Superfamily Anoetoidea |
| | Family Anoetidae |
| | Histiosoma sp. |
| | Suborder Mesostigmatic |
| | Superfamily Parasitoidea |
| | Family Ascidae |
| | Asca aphidioides |
| | A. garmani |
| | Family Cryolaelapidae |
| | Gamasellus sp. |
| | Family Digamasellidae |
| | Digamasellus sp. |
| | Family Laelapidae |
| | Gynoaeus sp. |
| | Family Phytoseiidae |
| | Amblyseius krantzi |
| | Family Podocinidae |
| | Podocinus pacificum |
| | Family Zeronidae |
| | Paramerson radiata |
| | Zercon sp. |
| | Superfamily Sejoidea |
| | Family Sejidae |
| | Sejus sp. |
| | Suborder Oribatei (=Cryptostigmata) |
| | Superfamily Carabodoidea |
| | Family Tectocephidae |
| | Tectocephus velatus |
| | Superfamily Cepheoidea |
| | Family Cepheidae |
| | Cepheus corae |
| | Superfamily Ceratozetoidea |
| | Family Ceratozetidae |
| | Ceratozetes sp. |
Family Cunaxidae  
Cunaxa sp.

Superfamily Eupodoidea
Family Eupodidae  
Cocoecupodes (2 spp.)  
Eupodes sp.

Family Rhagidiidae  
Coccorhagidia sp.  
Rhagidia longisensilliba  
Rhagidia sp.

Superfamily Pachygnathoidea  
(=Endeostigmata)
Family Alicorhagidae  
Alicorhagia sp.

Family Pachygnathidae  
Bimichaelia sp.  
Pachygnathus sp.

Superfamily Tarsonemoidea  
(=Tarsonemini)
Family Pyemotidae  
Bakerdania sp.  
Microdiapus obovatus

Family Scutacaridae  
Scutacarus sp.

Family Tarsonemidae  
Tarsonemus sp.

Order Araneida
Order Chelonehtida (=Pseudoscorpionida)
Suborder Diploshyronida
Family Neobisiidae  
Microbisium brunneum  
M. confusum

Suborder Heterosphyronida
Family Chthoniidae  
Mundochthonius rossi

Order Phalangida
Suborder Palpatores
Family Ischyropsalidae  
Sabaon 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. retractorum  
Synochus impunctatus  
Bembidion sp.  
Calosoma frigidum  
Sphaeroderus lecontei  
Acupalpus sp.  
Bradycellus sp.  
Harpalus pleuriticus  
Harpalus sp.

Suborder Polyphaga
Superfamily Cantharoidea
Family Cantharidae  
Cantharis fraxini  
C. nigriceps

Family Lampyridae  
Ellychnia corrusca autumnalis

Superfamily Chrysomeloidae
Family Chrysomelidae  
Altica maybe ignita  
Crepidotera nana  
Oedionychis subvittata  
Phratora americana  
Basseur marmifera sellatus

Superfamily Cucujoidae
Family Endomychidae  
Danae testacea

Family Erotylidae  
Triplax thoracica

Family Lathridiidae  
Melanophthalma sp.

Family Nitidulidae  
Euparea rufa

Superfamily Curculionoidea
Family Curculionidae  
Brachyrhinus ovatus

Superfamily Elateroidea
Family Elateridae  
Daloptus sp.
Superfamily Hydrophiloidea  
Family Histeridae  
Hister depurator  
Family Hydrophilidae  
Anacaena sp.  
Cymbiodyta fimbriata  
Hydrobius fusipes
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 cineticoiillis  
Lordithon sp.  
Bryopus rufescens  
Tachinus pallipes  
Tachyporus maybe elegant  
Tachyporus spp.
Family Silphidae  
Microphorus sayi  
N. tomentosus  
N. vespiglioides
Superfamily Tenebrionoidea  
Family Alleculidae  
Isomira quadristriata
Order Collembola  
Suborder Arthropleona  
Superfamily Entomobryoidea  
Family Entomobryidae  
Entomobrya quinquelineata  
E. unostrigata  
Entomobryoides purpurascens  
Lepidocterus lignorum  
L. paradoxus  
L. violaceus  
Orodesella ainsliei  
Willowsia buski  
W. plantani nigromaculata
Family Isotomidae  
Anurophorus liricus  
Isotoma near finitima  
I. muskegis  
I. nigrifrons  
I. notabilis  
I. olivacea  
I. trispinata  
I. viridis  
Isotominella minor  
Poisomia candida  
Guthriella vetuata  
Pseudotoma minutu
Family Tomoceridae  
Tomocerus flavescens  
T. vulgaris
Superfamily Hypogastruroidea  
Family Hypogastruridae  
Hypogastrura nivicola  
Family Onychluridae  
Hymenaphorura similis  
Protaphorura pseudarmatus  
Tullbergia coolls
Suborder Neoarthropleona  
Family Anuridae  
Anurida tullbergi  
Aphoromma granaria
Family Neanuridae  
Neanura muscorum  
Pseudachorutes aureofasciatus
Suborder Symphypleona  
Family Neelidae  
Megalothorax albus  
Neelus minutus  
N. tomentosus  
N. vespiglioides
Superfamily Tenebrionoidea  
Family Alleculidae  
Isomira quadristriata
Order Collembola  
Suborder Arthropleona  
Superfamily Entomobryoidea  
Family Entomobryidae  
Entomobrya quinquelineata
Family Dolichopidae
Family Empididae
Superfamily Tabanoidea
Family Stratiomyiidae
Family Tabanidae
Suborder Cyclorrhapha
Superfamily Muscoidae
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 Culicoidae
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.
  *Phygaedon* spp.
  *Phaeogenes* sp. s.l.
  *Craticlthemon* sp.
  *Vulgithelemon* terinalis
  *Dialipenis communis*
  *Oxytarsus antennatus*
  *Orthocentrus* spurious
  *O. frontator*
  *Pierostigmes* sp.
  *Stenomacrus* sp.
  *Hyposoter* popofensis
  *Coccygomimus* pedalis
  *Ephialtes annulicornis*
  *Anisoses* sp.
  *Hyperacmus crassicornis*
  *Megaestylus* sp.
  *Chrodes* sp.
Superfamily Proctotrupoidea
Family Diapriidae
Family Platygasteridae
Family Proctotrupoidea (=Serphidae)
Family Scelionidae
Superfamily Scoliodea
Family Formicidae
  *Dolichoderus* taschenbergi
  *Tapinoma* sessile
  *Camponotus* herculeanus
  *C. noveboracensis*
  *Formica* fusca
  *F. maroida*
  *F. probably sanquinea submuda*
  *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 Arctiidae
Family Noctuidae
Superfamily Sphingoidea
Family Sphingidae
Superfamily Pyralidoidea
Family Pyralidae

Order Mecoptera
Family Panorpidae
_Panorpa_ helena
_F. subfurcata_
_Panorpa_ sp.

Order Orthoptera
Suborder Caelifera
Family Acrididae
_Melanopus islandicus_
Suborder Ensifera
Family Gryllacrididae
_Geothephilus maculatus_

Order Psocoptera
Suborder Eupsocida
Suborder Troctomorpha
Family Liposcelidae
_Liposcelis_ sp.

Order Thysanoptera
Suborder Terebrantia

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**Family Thripidae**
Suborder Tubulifera
Family Phloeothripidae

**PHYLUM MOLLUSCA**
Class Gastropoda
Order Basommatophora
Family Carychiidae
_Carychiium exiguum_

Order Pulmonata
Family Lymnaeidae
_Lymnaea catascopium_

Order Stylommatophora
Suborder Heterurethra
Family Succineidae
_Succinea ovalis_
Suborder Orthurethra
Family Cionellidae
_Cionella lubrica_
Family Strobilopsidae
_Strobilope labyrinthica_
Suborder Sigmurethra
Family Endodontidae
_Anguispira alternata_
Family Limacidae
_Discus ornkhitei anthonyi_
Family Limacidae
_Deroceras reticulatum_
_D. laeva_
Family Zonitidae
_Euconulus fulvus_
_Retinella electrina_
_Victina limpida Gould_
_Zonitoides arboreus_

**PHYLUM NEMATODA**

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

<table>
<thead>
<tr>
<th>BLACK RIVER STAND</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Month of sampling</td>
<td></td>
<td>Quadrats</td>
<td></td>
<td>Average per</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
<td>Q4</td>
<td>quadrat</td>
</tr>
<tr>
<td>June</td>
<td>10.8 6.5 21.6 13.0 13.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>8.7 8.7 6.5 8.7 8.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August</td>
<td>8.7 0.0 17.3 4.3 7.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average/month</td>
<td>9.4 5.0 15.1 8.7 9.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FINE STUMP STAND</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>26.0 34.6 8.7 36.8 26.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td>34.6 17.3 32.5 23.8 27.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August</td>
<td>13.0 21.6 20.1 21.6 21.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average/month</td>
<td>24.5 24.5 23.1 27.4 24.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

18
Table 5. — *Beetle larvae collected in each study stand — based on soil sieve and Tullgren funnel extraction methods*  
(In number/m²)

<table>
<thead>
<tr>
<th>Families of beetles</th>
<th>Sieving method</th>
<th>Funnel method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>juvenile stand</td>
<td>juvenile stand</td>
</tr>
<tr>
<td>Cantharidae</td>
<td>0.7</td>
<td>0.0</td>
</tr>
<tr>
<td>Carabidae</td>
<td>2.9</td>
<td>1.4</td>
</tr>
<tr>
<td>Chrysomelidae</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Curculionidae</td>
<td>0.2</td>
<td>0.0</td>
</tr>
<tr>
<td>Elateridae</td>
<td>1.6</td>
<td>9.7</td>
</tr>
<tr>
<td>Lampyridae</td>
<td>0.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Orthoperidae</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Scarabaeidae</td>
<td>4.9</td>
<td>0.4</td>
</tr>
<tr>
<td>Silphidae</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Staphylinidae</td>
<td>2.5</td>
<td>2.9</td>
</tr>
<tr>
<td>Unknown larvae</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Total larvae</td>
<td>13.9</td>
<td>15.7</td>
</tr>
<tr>
<td>Total pupae</td>
<td>1.3</td>
<td>1.1</td>
</tr>
</tbody>
</table>

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

**BLACK RIVER STAND**

<table>
<thead>
<tr>
<th>Month</th>
<th>Sampling method</th>
<th>Quadrats</th>
<th>Average per quadrant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SM</td>
<td>01</td>
<td>02</td>
</tr>
<tr>
<td>June</td>
<td>4</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>July</td>
<td>SM</td>
<td>183</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>FM</td>
<td>6</td>
<td>17</td>
</tr>
<tr>
<td>August</td>
<td>SM</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>FM</td>
<td>257</td>
<td>1,122</td>
</tr>
</tbody>
</table>

| Average/month | SM | 6 | 13 | 25 | 11 | 14 |    |
|               | FM | 292 | 612 | 542 | 285 | 432 |    |
| 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 | 17 | 17 | 12 | 16 |    |
|               | FM | 305 | 397 | 257 | 350 | 328 |    |

1SM = Sieving Method; FM = Funnel Method.
Table 7. — Collembolan species found within Tallgren core samples in both study stands
(In number/m²)

<table>
<thead>
<tr>
<th>Species</th>
<th>Black</th>
<th>Pine</th>
<th>River</th>
<th>Stump</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family Entomobryidae:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entomobrya quinquelineata</td>
<td>21</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. unostrigata</td>
<td>0</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lepidocyrtus lignorum</td>
<td>86</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L. paradoxus</td>
<td>0</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L. violaceus</td>
<td>257</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orchesella ansieie</td>
<td>0</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Willowsia buksi</td>
<td>235</td>
<td>278</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W. platani nigromaculata</td>
<td>64</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family Isothoridae:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'Anurophorus laricus</td>
<td>21</td>
<td>364</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isotoma near finitaear</td>
<td>86</td>
<td>257</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. nigrifrons</td>
<td>0</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. notabilis</td>
<td>364</td>
<td>471</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. olivacea</td>
<td>385</td>
<td>1,797</td>
<td></td>
<td></td>
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<tr>
<td>I. trispinata</td>
<td>150</td>
<td>471</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. viridiss</td>
<td>107</td>
<td>86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isotominella minor</td>
<td>21</td>
<td>0</td>
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<td></td>
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<tr>
<td>Folsonia candida</td>
<td>2,459</td>
<td>2,652</td>
<td></td>
<td></td>
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<tr>
<td>Guthriella vetusta</td>
<td>1,133</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proisotoma minuta</td>
<td>21</td>
<td>150</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family Tomoceridae:</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomocerus flavescens</td>
<td>321</td>
<td>299</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T. vulgaris</td>
<td>694</td>
<td>86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family Hypogastruridae:</td>
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<td></td>
<td></td>
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<tr>
<td>Hypogastrura nivicola</td>
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<td>235</td>
<td></td>
<td></td>
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<tr>
<td>Family Onychiuridae:</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Hymenaphorura similis</td>
<td>64</td>
<td>278</td>
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<td></td>
</tr>
<tr>
<td>Protaphorura pseudarmatus</td>
<td>86</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Tullbergia collis</td>
<td>2,951</td>
<td>941</td>
<td></td>
<td></td>
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<tr>
<td>Family Anuridae:</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anurida tullbergi</td>
<td>43</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aphoromma granaria</td>
<td>107</td>
<td>428</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family Neanuridae:</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Micranurida pygmaea</td>
<td>43</td>
<td>86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neanura muscorum</td>
<td>21</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pseudachorutes aureofasciatus millsi</td>
<td>21</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family Neelidae:</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Megalothorax albus</td>
<td>299</td>
<td>171</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neelus minutus</td>
<td>43</td>
<td>21</td>
<td></td>
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<tr>
<td>Family Sminthuridae:</td>
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<td></td>
<td></td>
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<td>Arthropalites benitus</td>
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<td>620</td>
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<tr>
<td>Sphyrotheca minnesotensis</td>
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<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ptenothrix marmorata</td>
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<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sminthurides lepus</td>
<td>0</td>
<td>86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S. Occultus</td>
<td>171</td>
<td>0</td>
<td></td>
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</table>
Table 8. — Fly larvae by family for each study stand and sampling method
(In number/m²)

<table>
<thead>
<tr>
<th>Families of fly larvae</th>
<th>Funnel method</th>
<th>Sieving method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Black River</td>
<td>Pine Stump</td>
</tr>
<tr>
<td></td>
<td>Stand</td>
<td>Stand</td>
</tr>
<tr>
<td>Anthomyiidae</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Bibionidae</td>
<td>1,009</td>
<td>--</td>
</tr>
<tr>
<td>Cecidomyiidae</td>
<td>209</td>
<td>92</td>
</tr>
<tr>
<td>Chironomidae</td>
<td>--</td>
<td>15</td>
</tr>
<tr>
<td>Dolichopodidae</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Muscidae</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Sciaridae</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Stratiomyiidae</td>
<td>36</td>
<td>115</td>
</tr>
<tr>
<td>Tabanidae</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>Tipulidae</td>
<td>--</td>
<td>8</td>
</tr>
<tr>
<td>Unknowns</td>
<td>238</td>
<td>183</td>
</tr>
<tr>
<td>Total larvae</td>
<td>1,514</td>
<td>428</td>
</tr>
</tbody>
</table>

Table 9. — Ant species collected by different sample methods

<table>
<thead>
<tr>
<th>Ant Species</th>
<th>Pitfall Method</th>
<th>Sieving Method</th>
<th>Total Observations</th>
<th>Field Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Camponotus herculeanus</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C. novoboracensis</td>
<td>12</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Dolichoderus taschenbergi</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>Formica fusca + F. marcida</td>
<td>15</td>
<td>10</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td>F. probably sanguinea subnuda</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Lasius alienus</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Myrmica probably brevinodis</td>
<td>6</td>
<td>0</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>M. probably emeryana</td>
<td>14</td>
<td>15</td>
<td>29</td>
<td>23</td>
</tr>
<tr>
<td>Stegmaeus diecki</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Tapinoma sessile</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

1The 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

<table>
<thead>
<tr>
<th>Gastropoda species</th>
<th>Pitfall method</th>
<th>Sieving method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Black River</td>
<td>Pine Stump</td>
</tr>
<tr>
<td></td>
<td>Stand</td>
<td>Stand</td>
</tr>
<tr>
<td>Auguliptra alternata</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Carychiun exigum</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chionella lubrica</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Detoceras reticulatum</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>D. laeve</td>
<td>34</td>
<td>14</td>
</tr>
<tr>
<td>Discus crookshitei anthony</td>
<td>3</td>
<td>68</td>
</tr>
<tr>
<td>Eucamplus fulvus</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Lymnasie catascropium</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Retinella electra</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Strobilops labiatus</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Succinea ovalis</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Vitrea limpidae</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Zonitoides #torres</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

1The 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.

The survey in Koochiching County revealed 4 phyla, 7 classes, 23 orders, and 134 families of invertebrates. Insecta was the largest class having 11 orders and 84 families. Mites and Collembolla were most numerous averaging 90,000 and 16,000/m², respectively, during summer.

OXFORD: 114.68:142(776). KEY WORDS: Mites, Collembolla, Molluscs, earthworms, Populus.
Nature is beautiful... leave only your footprints.