AN ABSTRACT OF THE THESIS OF

Kristine Maree Neese for the degree of Bachelor of Science in Bioresource Research with the Sustainable Ecosystem option presented on 24 May 2004.
Title: Spatial and Temporal Distribution of Soil Mesofauna in a Managed Grassland Ecosystem

Abstract approved:

Jeffery J. Steiner

Little is known about upland agricultural grassland soil invertebrate composition and its contribution to ecosystem functioning. Soil-dwelling organisms play a central role in soil formation, plant nutrition, and are significant food contributors for organisms in several trophic levels. Information is needed about mesofauna seasonal population and composition trends throughout the soil profile to understand linkages between natural and anthropogenic influences in agricultural lands. There are no baseline data available that characterize species composition and behavior in agricultural landscapes or how to develop optimal sampling schedules. Also, there is little known about the impacts of soil physical properties (i.e. soil pH, moisture, temperature, and particle size distribution) and seasonal weather cycles on soil mesofauna activity.

Using Berlese-Tullgren extractors, soil-borne invertebrates were identified from the upper 30 cm in 5 cm increments every other week for one year in an undisturbed *Festuca rubra* L. 'Jaspar' grass seed ecosystem in the Silverton Hills, Marion County, Oregon, U.S.A. Species richness comprised 14 Collembola genera, 99 Acarina morpho-species, and 88 other invertebrate taxa comprising 19, 71, and 10% of the total number of specimens, respectively. The top 5 cm of soil contained the greatest abundance of species. Some arthropods were correlated with abiotic factors such as above-ground green and brown phytomass. Invertebrates spanned different but linked trophic levels. These findings identify key taxa, abiotic factors, and spatial and temporal templates for future analyses.

Spatial and Temporal Distribution of Soil Mesofauna in a Managed Grassland Ecosystem

by
Kristine Maree Neese

A THESIS PROJECT

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Bachelor of Science in Bioresource Research thesis of Kristine Maree Neese entitled *Spatial and Temporal Distribution of Soil Mesofauna in a Managed Grassland Ecosystem* presented May 26, 2004.

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I understand that my thesis will become part of the permanent collection of the OSU and Bioresource Research Library. My signature below authorizes release of my thesis to any reader upon request.

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Kristine Maree Neese, Author

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Introduction

Agriculture in the Pacific Northwest United States has come under increased scrutiny for its impact on natural resource quality. It is broadly suggested, although subject to debate, that diverse ecosystems are more stable and resistant to changes than systems lacking diversity (Naeem et al., 1994). If this is true, in the interest of long-term viability, the people and policies of a region should encourage diverse natural systems (Minor, 2003).

Environmental changes and anthropogenic activities can impact the intricate community of organisms in the soil (Naeem et al., 1994). There is a considerable amount of research that has focused on the effects of agricultural practices such as tillage, residue management and chemical use on arthropods residing in soil (Wardle et al., 1999). Tillage alters the structure of soil food-webs (Hendrix et al., 1986; Andren et al., 1990) and the composition and diversity of soil arthropod communities (Emmanual et al., 1985; Langerlof and Andren, 1991; Robertson et al., 1994). In Oregon's Willamette Valley, about 55% of agricultural land is in grass seed production and in 2001, approximately 88% was managed with conventional tillage techniques (Conservation Technology Information Center, 2002). Disturbance has a major influence on the ability of soil to receive and store water, cycle carbon and other nutrients, support plant growth, and support soil-dwelling organisms (Moore et al., 1993).

Soil fauna can be used as biological indicators, biological control agents, and as tools in soil formation, reclamation, and ecosystem management

(Earthwork Research Group, 2001). Arthropods comprise 90% of all species, dominating the diversity of flora and fauna and playing an important role in maintaining a balanced agroecosystem (Paoletti et al., 1999). The number of microarthropods in soil systems range upwards to 200,000 organisms per m^2, making them a significant constituent of the food web along with protozoa, nematodes and other small soil fauna that span several trophic levels (Crossley and Coleman, 1999).

Information is needed about soil-borne invertebrate seasonal population and composition trends throughout the soil profile to understand linkages between agricultural lands, riparian habitats, and other ecosystems. The management and policy needs of related disciplines are increasing the demand for soil arthropod information. Palaeoecologists require new data to interpret their fossil assemblages and environmental issues of agroecosystem management and environmental indicators. Global change research needs more complete knowledge of soil communities. (Behan-Pelletier, 1993)

Baseline data that characterize soil invertebrate species composition and behavior are rare in North American agricultural landscapes. These are needed to develop optimal sampling schedules and to begin determining the affects of soil physical properties, seasonal weather cycles, and agricultural practices on soil mesofauna activity and abundance. There have been great strides in the discovery and identification of soil organisms, but it has been estimated that a soil sample from anywhere in North America will contain one or more undescribed species (Behan-Pelletier, 1993). The most taxonomic and ecological data are available for the groups Collembola and Oribatida. Acari and Collembola account for about 90% of the microarthropods in most soil environments and can be classified as mesofauna with body widths ranging between 0.1 and 2mm and body lengths between 0.2 and 10 mm (Crossley and Coleman, 1999).

Morphospecies were not identified to a specific name but represent morphologically distinct entities (Blades and Maier, 1996). Correlations between arthropod life histories and with soil and weather physical data were also determined. These results will be extendable to satellite sites that will make this research broadly applicable to western Oregon agricultural and adjoining natural systems.

This project was designed to establish a baseline for soil-dwelling arthropods over an entire year in an agricultural grassland for use in basic research studies determining roles in nutrient cycling and habitat food chains. This research is novel for intensive agricultural systems in North America and will be used to: (i) determine the optimal sampling periods for satellite research sites in western Oregon grass seed and other agricultural and natural systems; (ii) identify guilds of fauna involved in residue decomposition & nutrient cycling; and (iii) associate mesofauna population fluctuations with environmental characteristics.

METHODS AND MATERIALS

Site Location

The research site was located in the Silverton Hills, 15.2 kilometers west of Sublimity, Marion County, Oregon (44°56'24.4"N, 122°45'17.5"W). The soil is mapped as Nekia-Jory silty clay loam (clayey, mixed, mesic, Xeric Haplohumults) characterized by 3 to 5% slopes and a moderate (4.5-5.5) to slightly acid (5.5-6.5) pH. The two-hectare site was part of a long-term USDA-ARS research project titled "Integrated Approaches to Sustainable Grass Seed Cropping Systems." The site was representative of a unique habitat in western Oregon in the environmentally sensitive Pudding Creek watershed. This research is applicable to the 200,000 ha grass seed industry that composes a significant portion of the western Oregon landscape.

The four 270 m^2 plot areas were established in 1992 by conventional farming practices using disturbance, chemical herbicides, and fertilizers. From 1993 to 2002, the plots had been rotated with wheat (var. Hill, *Triticum aestivum L.*), red clover (var. Kendland, *Trifolium pratense* L.), and presently creeping red fine fescue (var. Jaspar, *Festuca rubra* L.) that was established in 1997. These plots have been managed as a no-till system with maximal residue amounts returned after crop harvest since 1992. No tillage or soil amendment practices were applied the duration of this study.

Soil and Vegetation Description

Throughout the study, soil particle size and bulk density were determined in the field to calculate soil porosity. A water level meter (Slope Indicator Co., Seattle, WA) lowered in a lysimeter well (Timco Mfg. Inc, Prairie Du Sac, WI) measured soil water table levels above a depth of 2.4 m. Air temperature and relative humidity were recorded every two hours using a HOBO H8 Pro Series Temperature/Relative Humidity Meter (Onset Computer Corporation, Bourne, MA) housed within a Solar Radiation Shield (Davis Weather Station Accessories, Hayward, CA). Precipitation was recorded using a HOBO event data logger (no.H08-003-02) and collected in a self-emptying rain collector (Davis Weather Station Accessories, Hayward, CA) that was verified by a manual rain gauge. Soil temperature data were recorded every two hours with a HOBO H8 Pro Series, 4 Channel Pro Temp/External Temp and Sensor Cable (Onset Computer Corporation, Bourne, MA) at depths of 2.5, 10.8, 19.7, and 27.9 cm. Manual soil temperature readings (Omega Engineering, Inc., Stamford, CT) were taken at the depths of 2.5, 7.6, 12.7, 17.8, 22.9 and 27.9 cm in conjunction with soil core sampling. Soil temperatures for each depth were averaged for the 14 days prior to each sampling date to monitor fluctuations in temporal and spatial soil temperature.

Arthropod Sampling

Eight total soil cores (two per plot) were collected every 14 days using a stratified random sampling method beginning 30 January 2001 and ending 1

February 2002. All above-ground green and brown standing phytomass was collected from a 0.01 m^2 area. Plant population density, species identification, canopy height, and plant phenological development were recorded at the time of sampling (Southwood, 1975). The phytomass samples were brought back to the lab and dried at 60° C for 72 hours in an oven (Percival Environmental Chamber, Boone, IA). After drying, the samples were weighed for total dry phytomass amount.

A 7.6 cm diameter by 42 cm long soil sampling tube (Giddings Machine Company, Ft. Collins, CO) was driven into the ground and an intact soil core captured within six stackable internal aluminum sleeves, each being 7.6 cm in diameter by 5.0 cm in height. The sleeved core segments were carefully cut apart with a knife and packed in a 0.47 L sample tin (Forestry Suppliers Inc., Jackson, MS) fitted with a tight foam-lined lid, placed in a cooler, and brought back to the laboratory for arthropod extraction and soil analysis.

To determine the spatial variation among arthropod colonies across a collecting area, 22 samples from the upper 5.0 cm of the soil profile were collected from the corners and center of 1, 4, and 8 m^2 areas replicated three times in a preliminary study by methods described in Stohlgren et al. (1997).

Arthropod Extraction

The arthropods were sampled from the soil samples by carefully removing the cores from the tins, wrapping in cheese cloth and labeling, when they were then weighed and placed top-side-down in a modified Berlese-Tullgren type extractor for 72 hours. The extractor was fitted with a 25 W incandescent bulb placed approximately 25 cm above the core to drive the arthropods from the soil core (optimal conditions were determined by preliminary experiments). The extracted arthropods were captured in a 20 ml glass scintillation vial containing 5 ml of 750 ml L^{-1} ethyl alcohol with 100 ml L^{-1} glycerin for later enumeration and identification (Crossley and Blair, 1991). After extraction, all soil cores were dried to constant weight in an oven (Scientific Products, Evanston, Ill) at 105° C for 24 to 48 hours to determine gravimetric soil-water content (Klute, 1986).

Arthropod Soil Habitat Characteristics

Soil organic carbon content was measured once every four weeks by twice grinding (Custom Laboratory Equipment, Orange City, FL) and mixing the dried soil cores (Paige et al., 1986). A two gram sample was taken, dried in an envelope in an oven at 105° C for 24 hours (Scientific Products, Evanston, IL), and then incinerated for 16 hours in a 400° C muffler oven (Barnstead/Thermolyne, Dubuque, IA) to volatilize all organic material. Sixty grams of the original soil was sampled and archived for later physical measurements. To assess seasonal differences, soil pH was measured from soil core samples taken three months apart: warm-wet (22 May 2001), warm-dry (12 September 2001), and cold-wet (31 December 2001) conditions.

Root biomass was determined every four weeks from dried soil cores sampled in the alternate two weeks between soil organic matter content samples. Roots were separated from dried soil by presoaking the cores in water for 24 hours and then flushing with water through a Hubbard screen no. 10 over a 2 L collection tub. The captured roots and small pieces of organic matter were placed on pre-dried and weighed filter paper (Whatman no.1, 18.5 cm) under vacuum for 30 s to remove excess water, dried in a 105° C oven for 24 hours, and weighed.

Horwath's (1994) chloroform ($CHCl_3$) fumigation extraction method was used to determine soil microbial biomass. Forty-eight soil samples each were collected from a dry site environment (5 October 2001) and wet site (2 January 2002). For each sample, 20 g of field-moist soil were fumigated with chloroform for 48 h and 20 g left unfumigated. The samples were fumigated by placing the soil in a large vacuum desiccator lined with moist paper. A beaker with boiling chips containing 50 mL of ethanol free chloroform was placed in the desiccator and the samples exposed for 48 h after three evacuations to vigorously boil the chloroform. After completing the exposure, the beaker with chloroform and paper towel were removed, the residual chloroform vapor was removed by repeated evacuation. All soil samples were extracted with 100 mL of 0.5 K_2SO_4, shaken for 30 min at 350 rpm, filtered through a Whatman #1 filter, and analyzed using a Tekmar-Dorhmann Phoenix 8000 UV-Persulfate TOC analyzer (Kyoto, Japan).

Arthropod Identification and Enumeration

Soil arthropods were identified to the finest taxonomic resolution using descriptions in Christiansen and Bellinger (1998), Dindal (1990), and Moldenke and Fichter (1988) using a stereo microscope (Zeiss, West Germany) with a

KL1500 light source (SCHOTT) and magnifications ranging from 8x to 64x. Representative specimens of all distinguishable taxa were mounted and pinned or preserved to prepare reference specimens for study-specific identification keys. Specimens positioned dorsal side up were mounted in one to three drops of glycerin in the center of a 5 cm by 15 cm glass slide after excess ethanol had been blotted away. A 15 mm round cover slip was immediately placed over the specimen and the edge sealed with Polymount acrylic resin. If the specimen was large, two to three vinyl discs (0.5-1.0 mm thick) were used to prop up the cover slip. Slides were dried for 72 hours and a label attached to the upper right side. Unidentified taxa of interest were sent to experts for identification as needed. Taxa comprised of different age stages were combined. All soil fauna extracted were divided into three groups: Collembola (springtails), Acarina (mites), and other arthropods.

Calculations

Soil moisture (Brady and Weil, 1999) was calculated as:

$$SM = ((\text{Moist Soil}/\text{Dry Soil}) - 1) * 100$$

Soil pore (SP) space (Brady and Weil, 1999) as:

$$SP = 1 - (\text{Bulk Density (g cm}^{-3}) / \text{Particle Density (g cm}^{-3})).$$

Microbial biomass carbon (MBC) was calculated from the amount of CO_2 carbon extracted from fumigated and non-fumigated soil samples:

$$MBC = F\text{-}NF/k$$

Where, F = extractable C from fumigated samples, NF = extractable C from non-fumigated samples, and k = 0.41 (Nelson, 2002).

RESULTS

Soil & Ambient Conditions

There was very little variation in temperature among soil depths between 5 and 20 cm (Fig. 1). As expected, soil temperatures were greater during summer months. Soil temperatures were warmer at 28 cm, compared to temperatures at lesser soil depths during the autumn and winter (Fig. 1 and Appendix A).

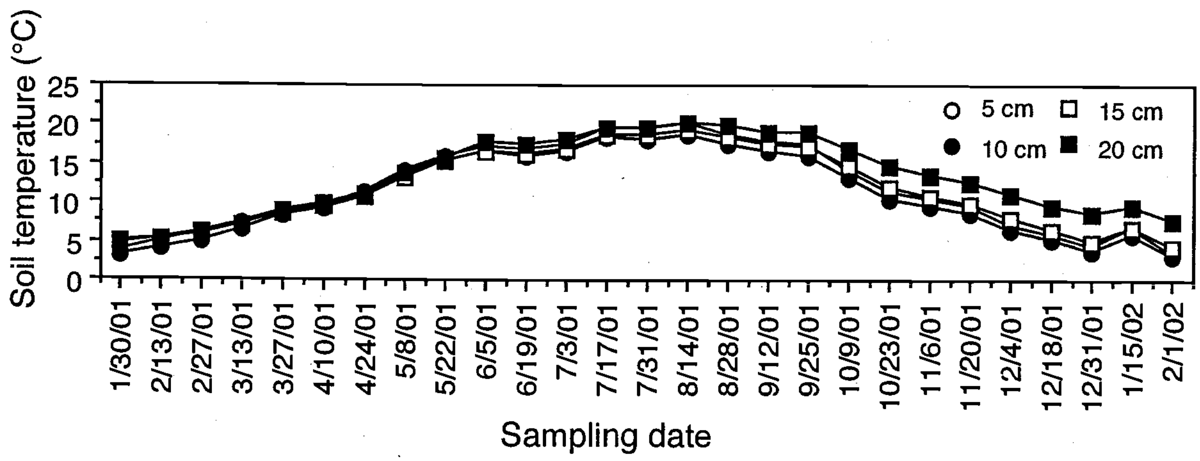


Figure 1. Temporal and spatial soil temperature averaged for 14 days prior to soil sampling date at four depths recorded every two hours using a four-channel HOBO sensor.

Soil moisture had greater fluctuations in the top 5 cm of soil, than at 5-10 cm, and remained fairly constant among the lower depths except for seasonal changes (Fig. 2). Soil moisture at all depths were correlated with the moisture of the soil located directly above ($r^2 \geq 0.94$) (Fig. 3). Changes in soil moisture in the top 10 cm followed individual precipitation events through the course of the study. Soil moisture in the top 5 cm of soil was dependent upon soil temperature ($p<0.001$).

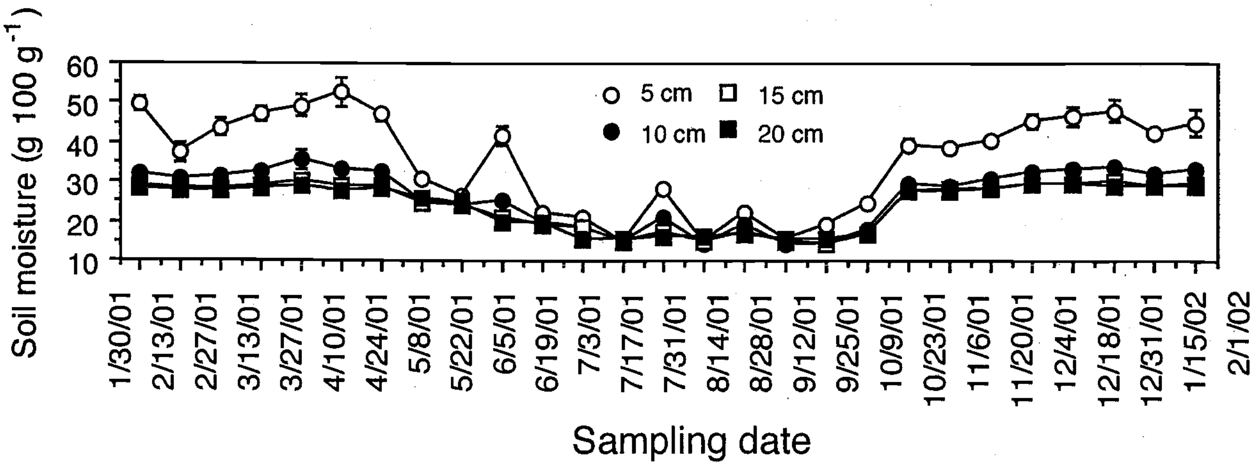


Figure 2. Percent soil moisture averaged from eight cores in 5 cm increments. Soil cores were those used for soil arthropod extraction.

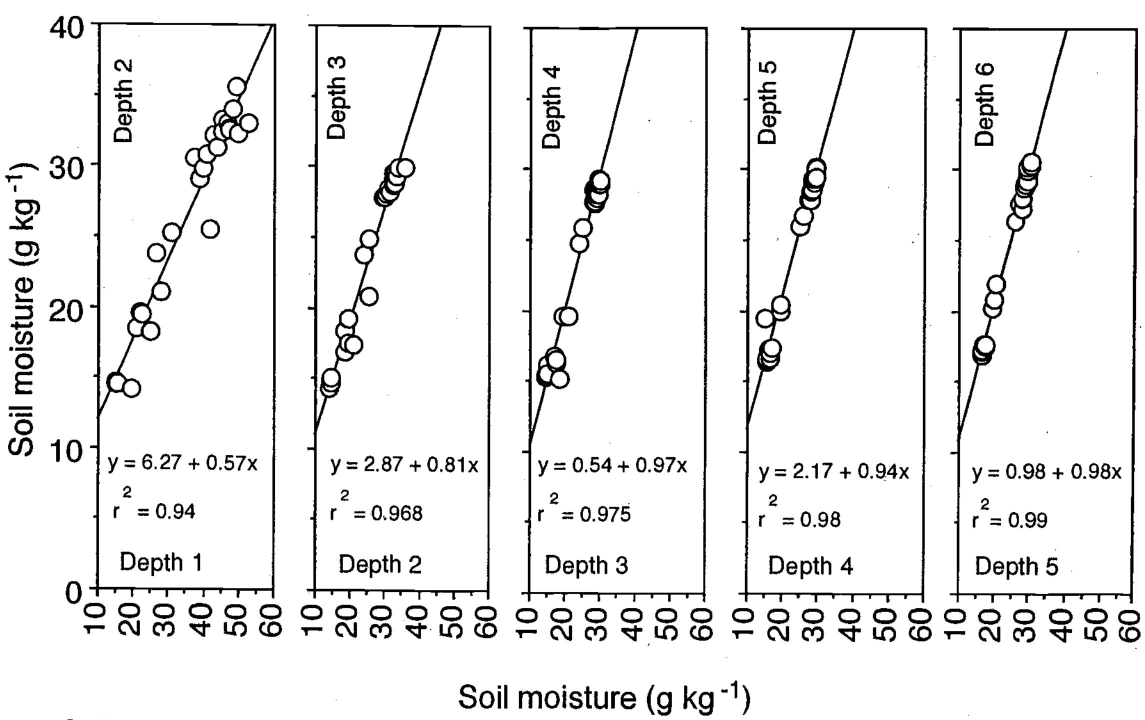


Figure 3. Percent soil moisture at each sampling depth compared to percent soil moisture of the sampling depth directly above.

Soil pH was similar among the three seasonal periods sampled (Fig. 4). The pH was most alkaline at 0-5 cm, became gradually more acidic to 20 cm, and then remained constant at all deeper depths. Mesofauna can indirectly increase pH through microbial N mineralization and a top dressing of lime at 2 tons per acre was applied 14 October 1998.

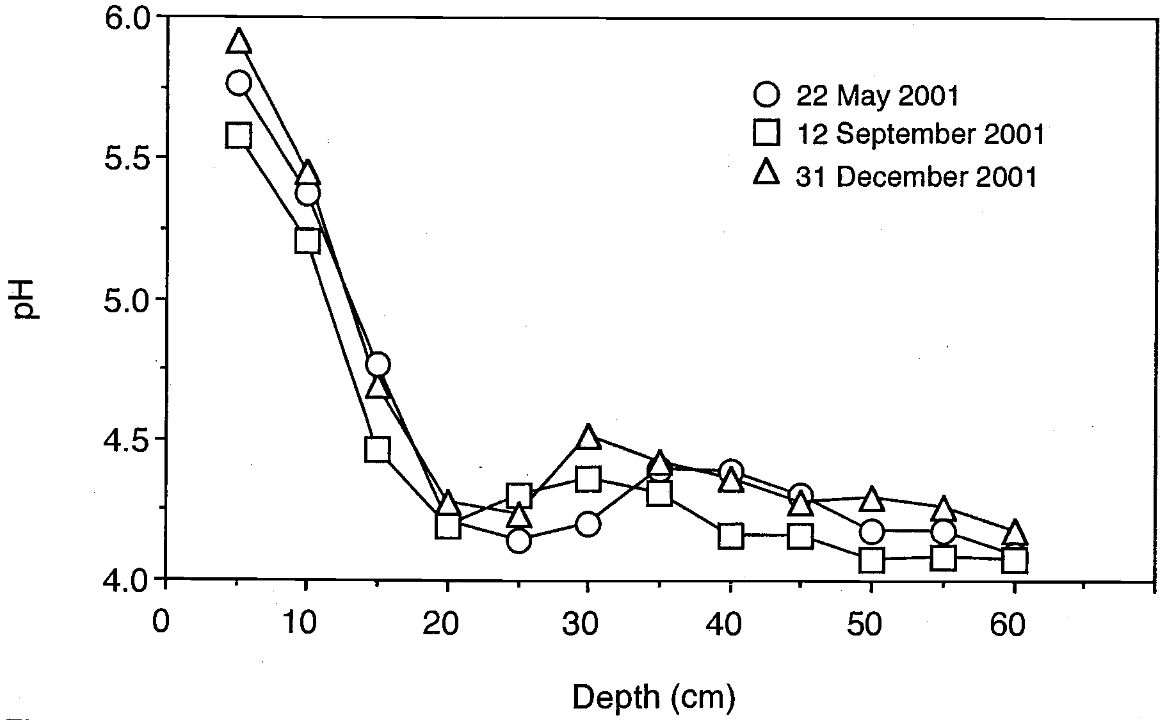


Figure 4. Average pH for each of 48 soil cores extracted in 5 cm increments down to 30 cm for three sample dates.

Pore space was similar among dry (5 October 2001) and wet seasons (4 January 2002) with dry season soil porosity slightly greater than the wet season soil (Fig. 5). Greater porosity below 20 cm probably reflects the transition from the Nekia soil series to the Jory soil series, with Jory containing a greater clay content that produces more micropores than the Nekia series soil.

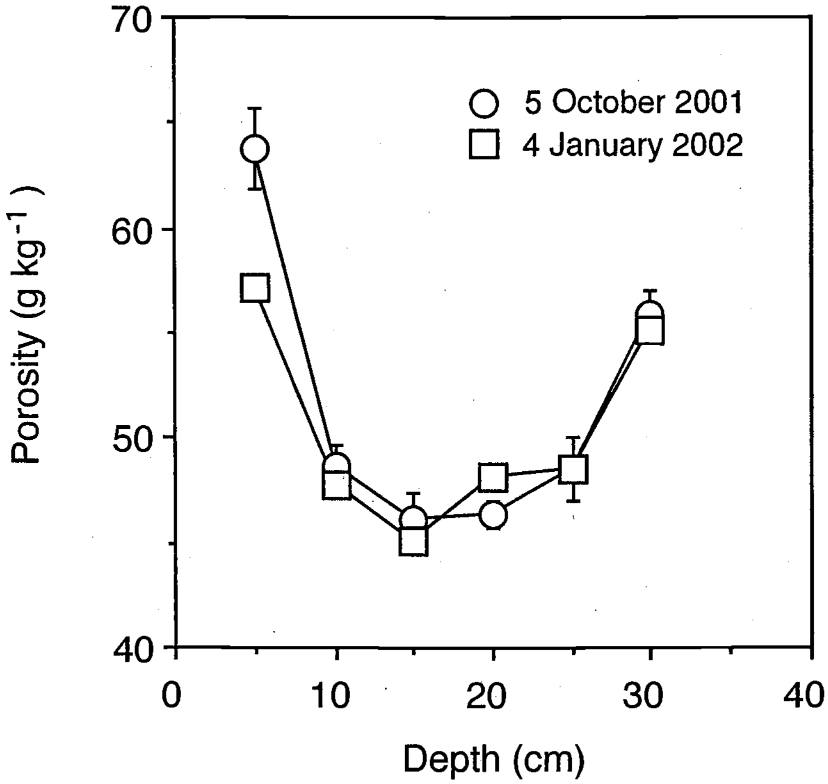


Figure 5. Average porosity, in 5 cm increments, of eight soil cores extracted 5 October 2001 and 4 January 2002 to represent dry and wet soil conditions.

Microbial Biomass Carbon (MBC) averaged 146.4 μg g^{-1}soil and -166.1 μg g^{-1} soil measured from total organic carbon (TOC) during the dry and wet seasons, respectively. MBC decreased from the dry season to the wet season indicating an increase in biological contributions to the carbon content through CO_2 respiration before the soil had been moistened. Total Nitrogen (TN) follows the same pattern on a smaller scale with an average of 17.1 μg g^{-1} soil flushed into the system in the dry season and 16.6 μg g^{-1} soil TN flushed out during the wet season.

However, organic carbon (OC) in the top 5 cm of soil fluctuated from 10.50 to 16.06%. Organic carbon remained relatively constant throughout the year with the exception of the late fall soil samples (Fig. 6). Root mass was also greatest in the top 5 cm of soil and decreased during the winter (Fig. 6).

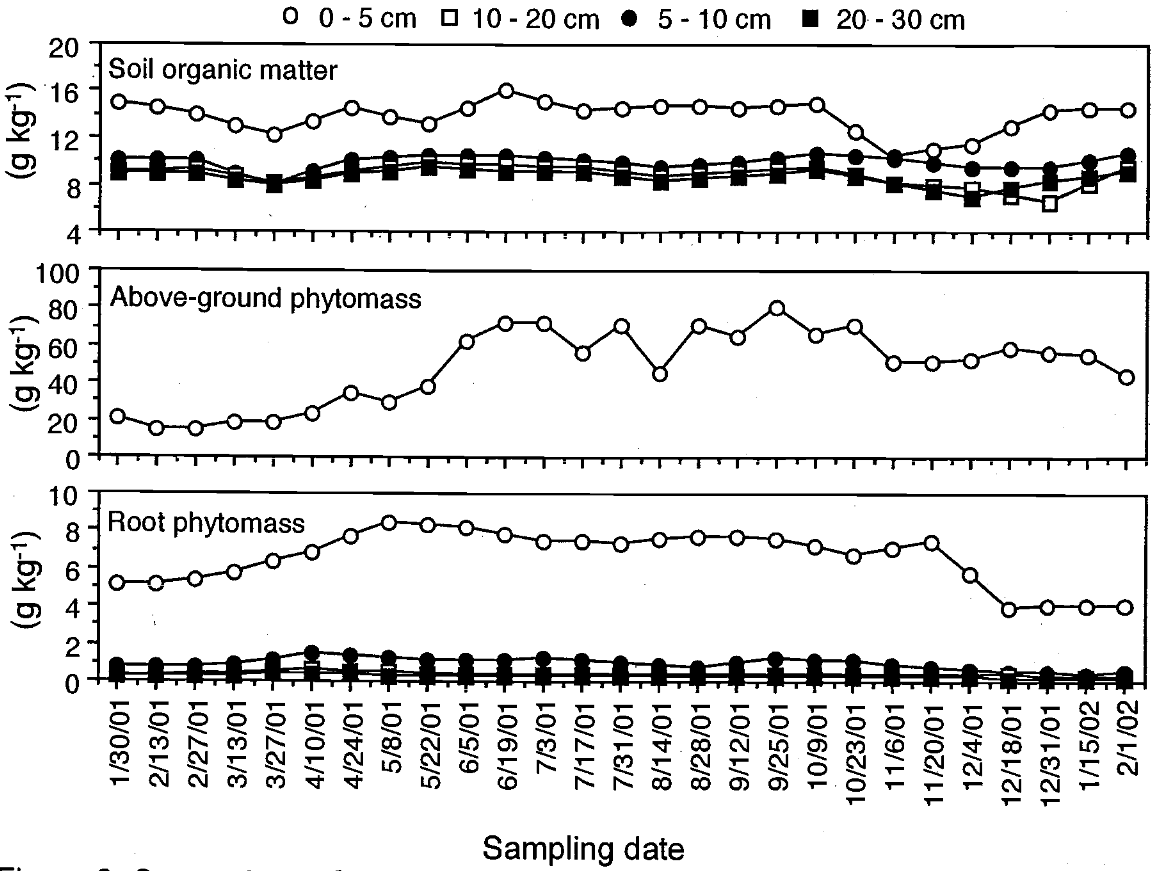


Figure 6. Comparison of averaged soil organic matter and root phytomass, extracted from the cores used for extraction of arthropods and dried at 105°C, and above-ground phytomass collected directly over the soil cores before sampling.

Above-ground green and brown standing phytomass averaged greater than 70% coverage throughout the year. Average above-ground phytomass followed predictable patterns of growth for *Festuca rubra* L. that remained the predominant species located on the experimental plots.

Total precipitation was 115.4 cm for the duration of the study. Precipitation was greatest in the winter with 16.2 cm and 20.5 cm accumulated the two weeks before 4 December 2001 and 1 February 2002, respectively (Fig. 7).

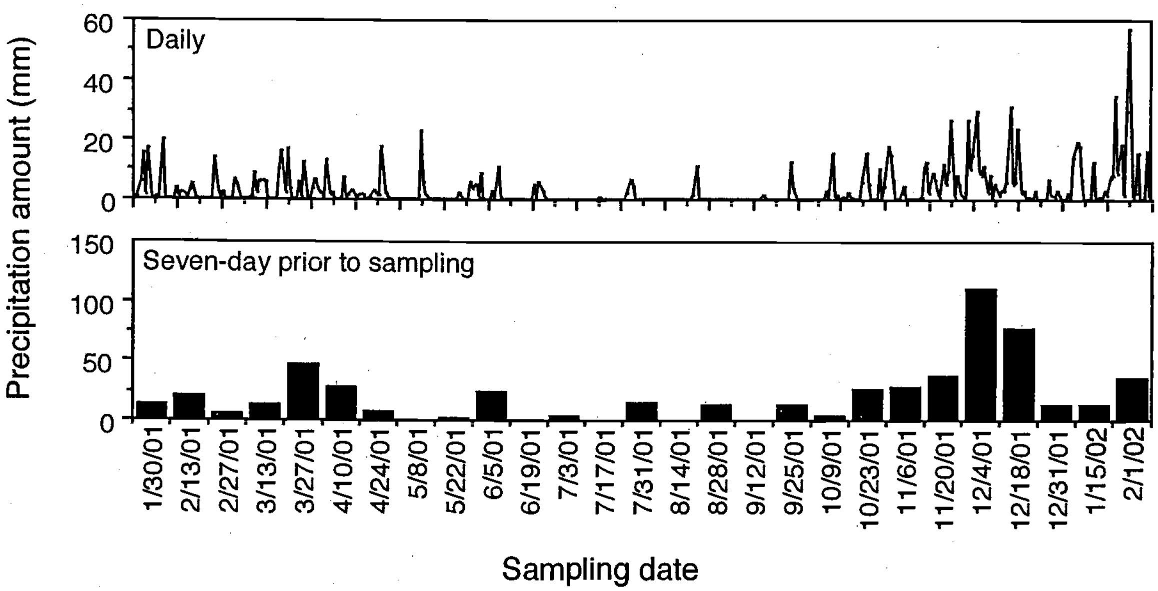


Figure 7. Daily precipitation recorded by HOBO sensor on a tipping bucket and accumulated precipitation for the seven days prior to sampling.

Invertebrates

An average of 193,559 m^{-2} total arthropods were extracted each sampling date. Mites were sampled in greatest abundance representing 71.1% of the total number of collected specimen. Collembola comprised 19.1% of the total organisms extracted and the remaining 9.8% were grouped as others.

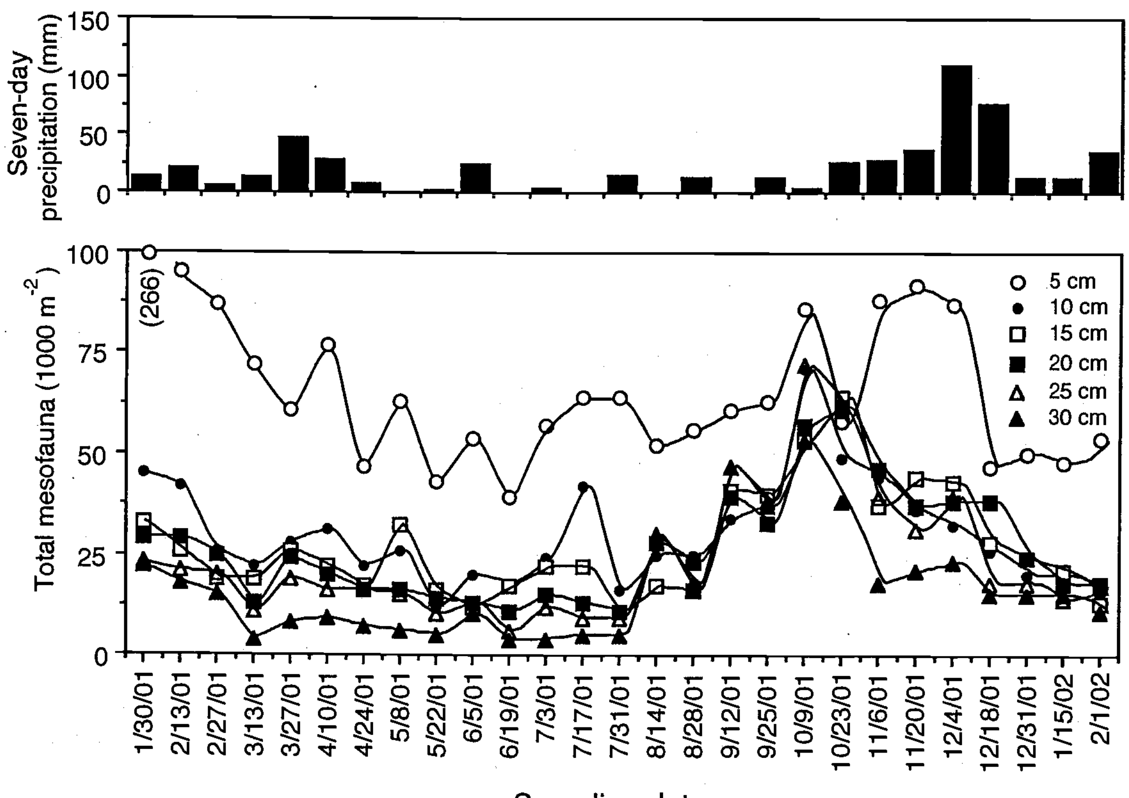


Figure 8. Total count of mesofauna sized organisms per m^2 extracted from soil cores in 5 cm increments to a depth of 30 cm for all eight cores extracted per sample date (x 10^{-3}) and accumulated precipitation for seven days prior to sampling.

Fewer organisms were found as the soil was sampled deeper in the profile (Fig.8). Collembola, with 71.8% of the total Collembolan population in the top 5 cm of soil, decreased to 8.8% at a depth of 5-10 cm. Mites and other taxa had a gradual decline in population density, yet the highest percent (28.7 and 25.6%, respectively) still remain in the top 5 cm.

As the total numbers of soil microarthropods fluctuated, the lower soil depths tended to parallel the pattern of the top 5 cm of soil (Fig. 8). Soil mesofauna abundance was greatest in the top 5 cm of soil, paralleling the activity of most abiotic indicators of soil biotic activity such as: soil pH, soil moisture, soil porosity, OC, and root mass.

Soil mesofauna general population trends followed precipitation for the site. There were more mesofauna in the top 5 cm of soil than all other dates with the exception of 23 October 2001 (Fig.8). At this time in October, mesofauna increased between 10 and 24 cm and was probably caused by the 1.5 and 0.5 cm of rain the day prior and day of sampling, respectively. The total number of mesofauna declined from the beginning of the study until the beginning of summer. There was a high number of organisms extracted from the soil cores collected 30 January 2001 compared to one year later (Fig. 8). Mesofauna population was greatest in October in soil depths greater than 5 cm. Mesofauna population in the top 5 cm was greatest in November (Fig. 8) as the major precipitation season began.

Some organisms dominated either spatial or temporal niches while other genera were found less frequently or in isolated samples. There were 30 Acari genera and 50 other morphospecies that had less than ten organisms found throughout the duration of the study (Fig. 9 and Appendix B).

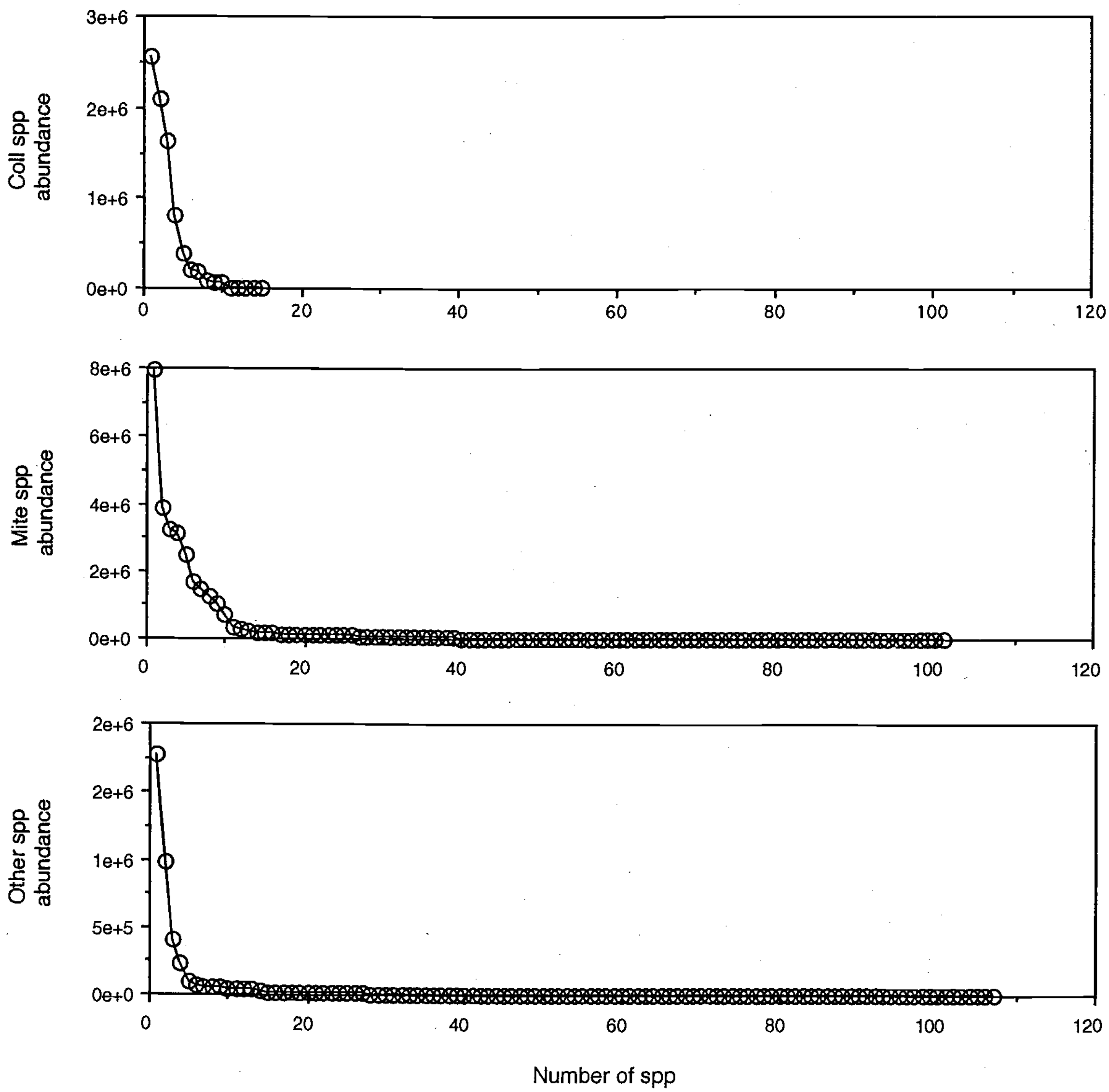
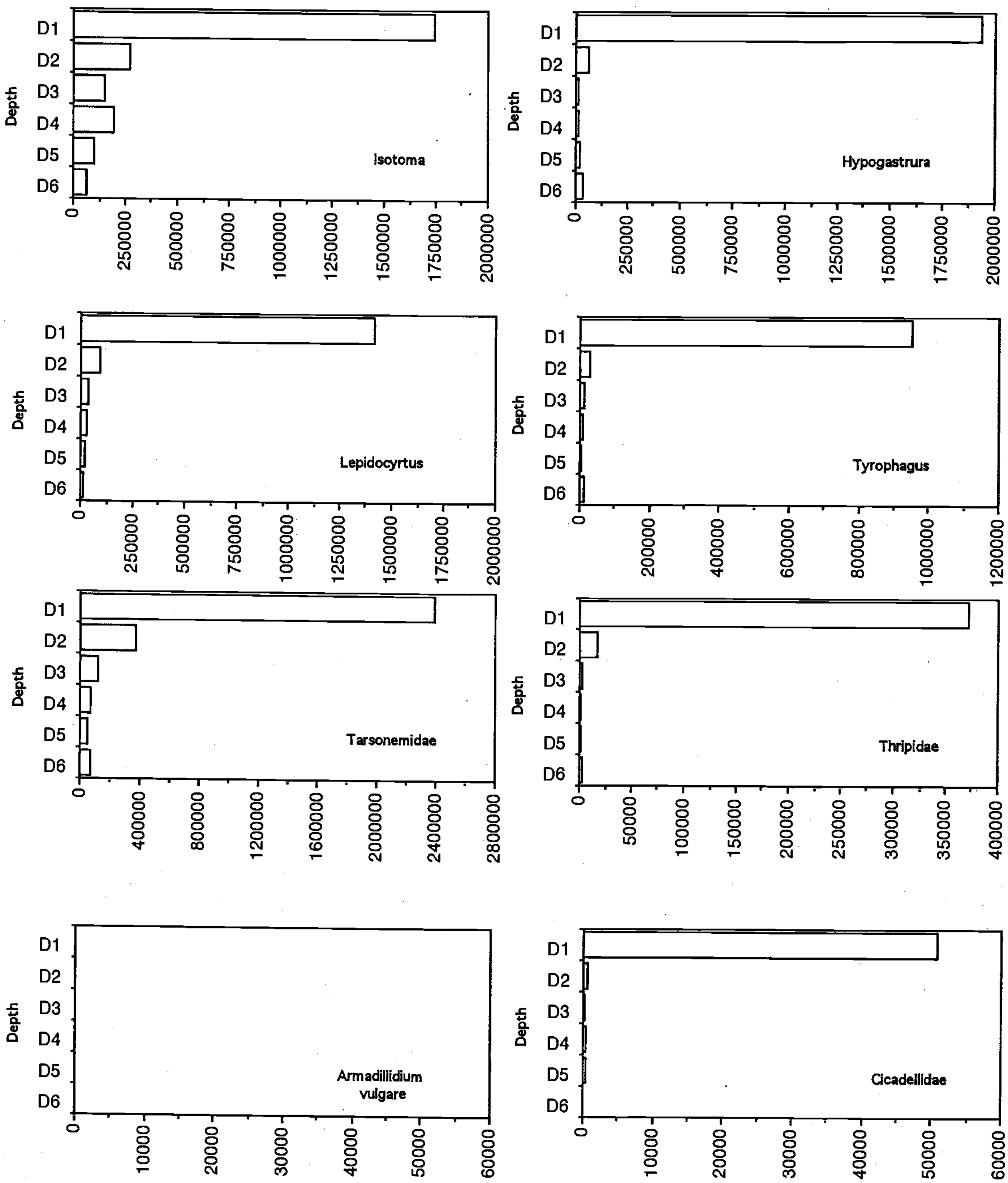


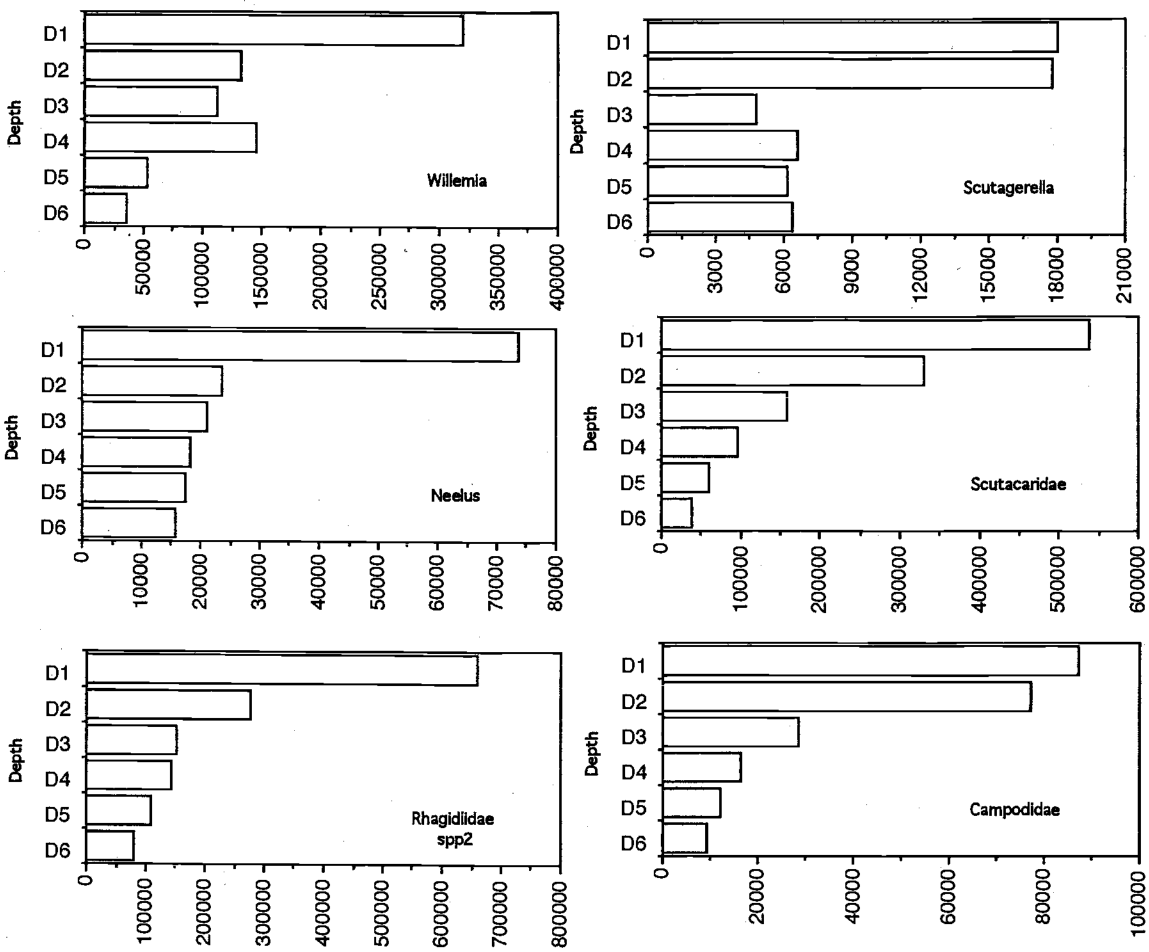
Figure 9. Abundance of arthropods grouped into Collembola, Mites, and other species.

Microarthropods may be grouped according to spacial derivation. Group 1 organisms, as organized by cluster analysis, predominately occupied the top 5 cm of soil (Fig. 10). Group 2 was dominant in the top 10 cm of soil yet were found throughout the soil profile. Microarthropods comprising Group 3 were found throughout the soil profile, but primarily resided in shallow soil depths. Group 4 organisms predominantly occupied soil depths greater than 10 cm.

Group 1


Isotoma
Hypogastrura
Lepidocyrtus
Tyrophagus
Tarsonemidae
Thripidae
Armadillidium vulgare
Cicadellidae
Depth
D1
D2
D3
D4
D5
D6

Group 2


Depth
D1
D2
D3
D4
D5
D6
Willemia
0
50000
100000
150000
200000
250000
300000
350000
400000
Scutagerella
0
3000
6000
9000
12000
15000
18000
21000
Neelus
0
10000
20000
30000
40000
50000
60000
70000
80000
Scutacaridae
0
100000
200000
300000
400000
500000
600000
Rhagidiidae
spp2
0
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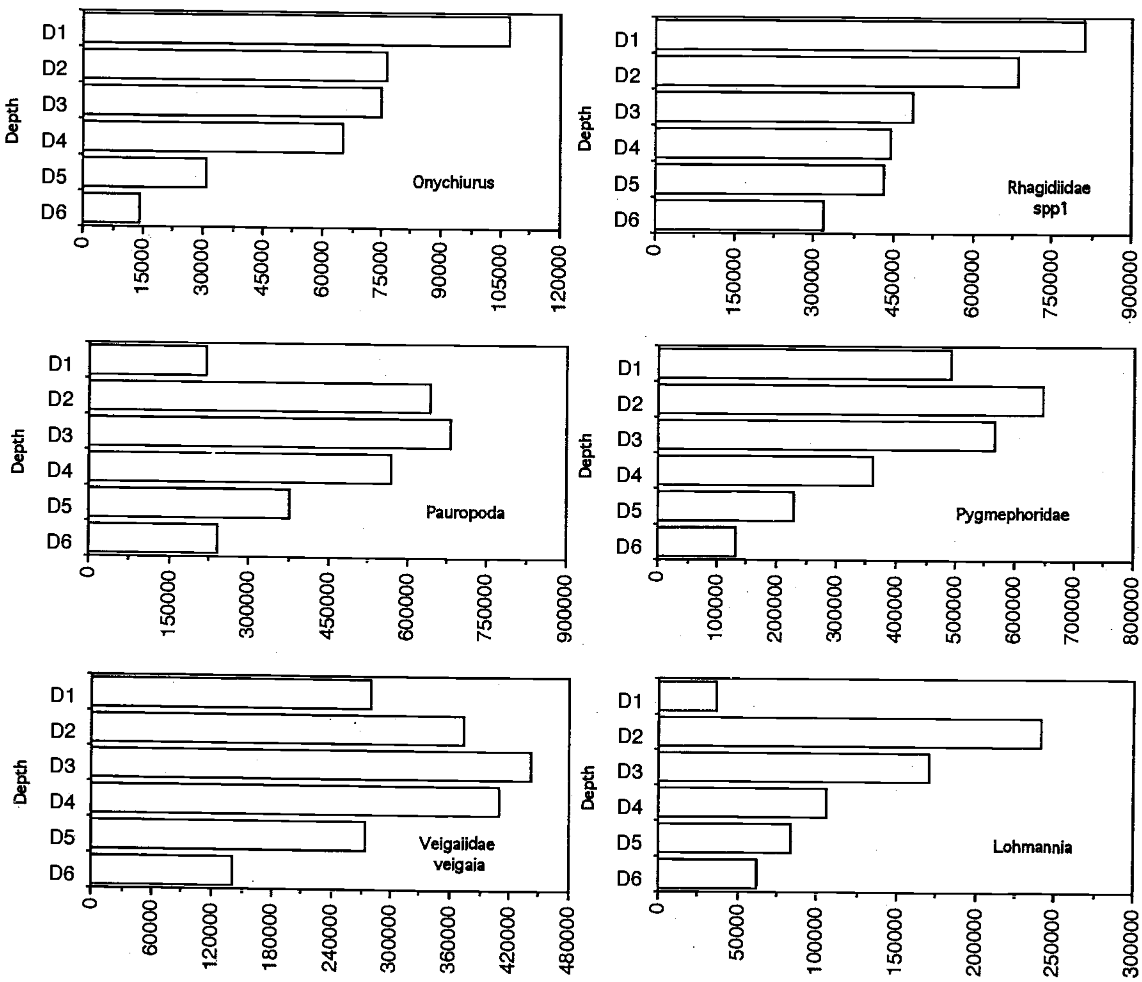
200000
300000
400000
500000
600000
700000
800000
Campodidae
0
20000
40000
60000
80000
100000

Group 3


Depth
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D2
D3
D4
D5
D6
Onychiurus
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300000
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750000
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1050000
1200000
Rhagidiidae spp1
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150000
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Pauropoda
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Pygmephoridae
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200000
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500000
600000
700000
800000
Veigaiidae veigaia
0
60000
120000
180000
240000
300000
360000
420000
480000
Lohmannia
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50000
100000
150000
200000
250000
300000

Group 4

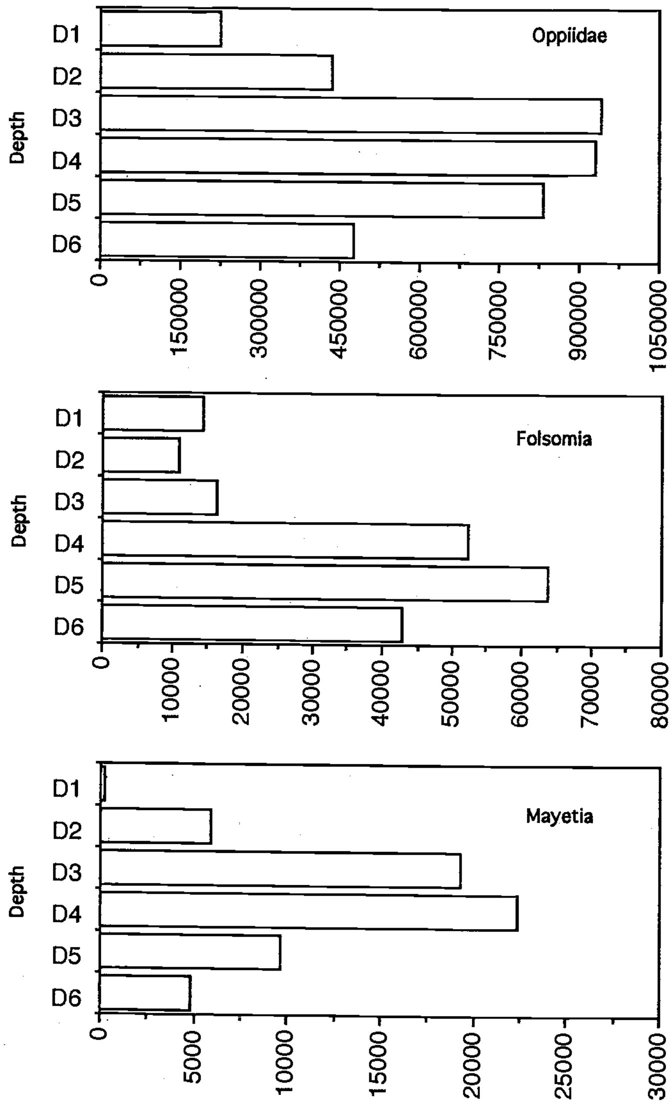

Figure 10. Groups of organisms based on cluster analysis and organized by predominant spacial dwelling.

Microarthropods may occupy the same spacial niche at different times throughout the year representing temporal niches. Hypogastrura dominate the top 5 cm of soil during the late fall and winter months. Lepidocyrtus peak in the early summer months and the first sample date, but are present throughout the year. Lepidocyrtus are greatest when Hypogastrura are lowest though both overlap through the fall months (Fig. 11).

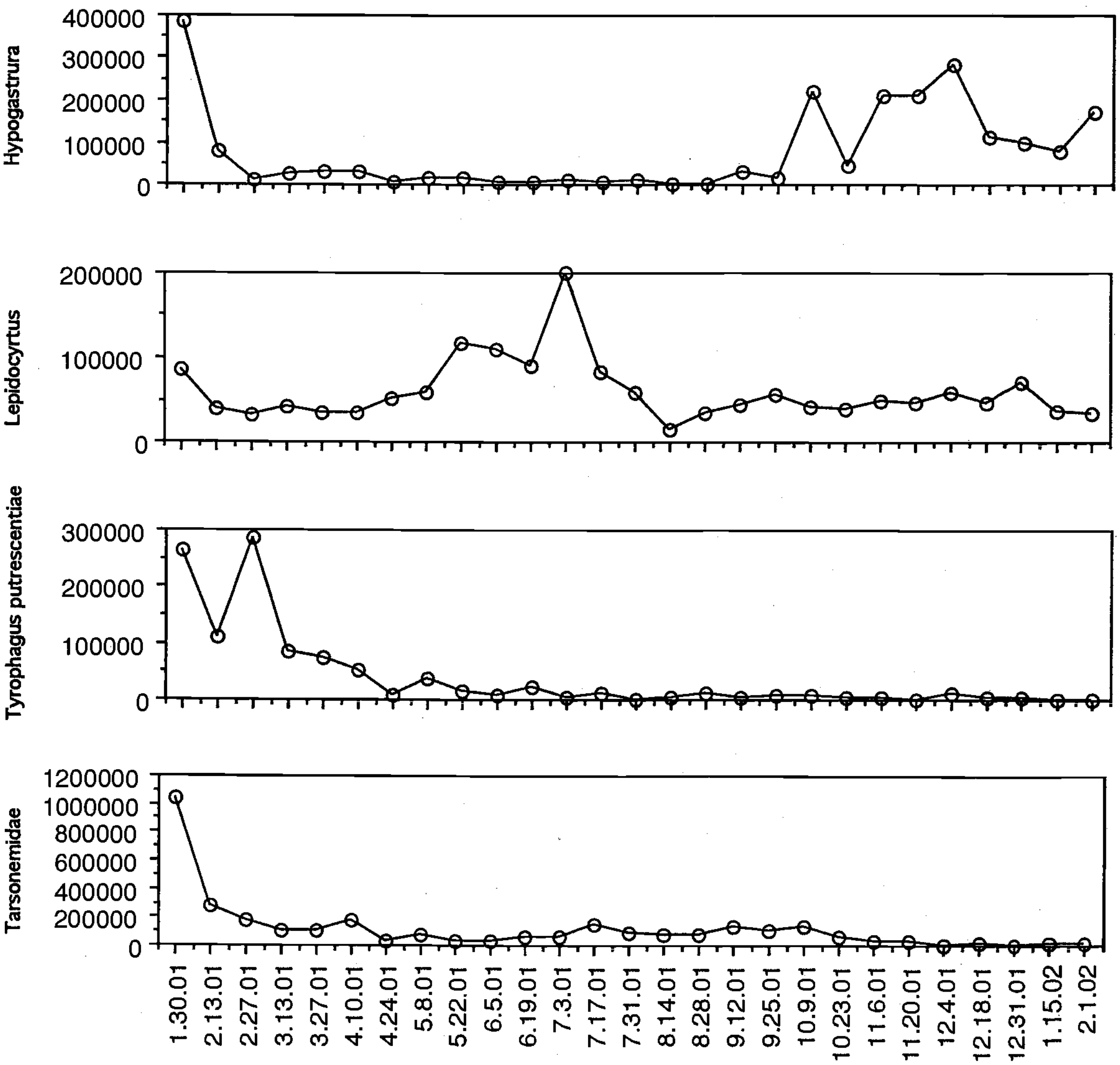

Figure 11. Total counts of Hypogastura, Lepidocyrtus, Tyrpohagus putrescentiae and Tarsonemidae per m2 of soil for each sampling date.

Some microarthropods, such as the mites omnivorous Tyrophagus putrescentiae and Tarsonemidae, respond to anthropogenic alterations. The sample site was harvested the fall prior to this study with 7159 kg/ha of chopped straw residue returned to the surface of the soil. Additionally, 63 lbs/A of N were applied on 9 March 2000 and again on 13 April 2000 while none was applied in 2001. Tyrophagus putrescentiae and Tarsonemidae are greatest after this alteration to vegetation (Fig. 11). Tyrophagus putrescentiae and Tarsonemidae are not present when the grass is left standing and not flail-chopped the following winter.

DISCUSSION

Disturbance on the site on the first sample date (30 January 2001) may have caused a decrease in the stable community. One explanation is the affect of 7159 kg/ha of chopped straw residue returned to the surface of the soil in the fall of 2000 and not during fall 2001. Additionally, N was applied the spring prior to this study but not during the year of sampling.

Lack of variation in mircoarthropod fluctuations among depths was unexpected because of prior research suggesting soil arthropods travel deeper in the soil to avoid detrimental ambient and soil physical alterations. Mild climate or sampling technique may have influenced microarthropod behavior.

Microarthropod total populations in the top 5 cm increased proportionately with one week prior precipitation events (Fig. 8). During dry periods, organism populations in the top 5 cm increase in response to precipitation events. Organisms dwelling lower than 5 cm lag increase in populations in response to organism increase in the top 5 cm or increase in soil moisture as top 5 cm soil moisture increases. Populations of mesofauna below 10 cm decrease as soil moisture increases and soil temperature decreases (Fig.1,2, and 8).

There have been research sites where Collembola alone were recorded in abundance of more than 200,000 m^{-2} (Kampichler et al., 2000), but no one has attempted to identify and quantify total populations of Collembola in a managed agricultural grassland in the U.S.A. An average of 193,559 m^{-2} total arthropods in this study reflects fewer microarthropods in a managed grassland than other ecosystems or ineffective sampling and extraction.

The greater number of Collembola in large abundance may be due to a stabilized community with the predominate genera crowding out the less abundant genera. Prey and predator relationships may also dictate the Collembola population abundance through preference of food or environmental constraints.

Acarina span several trophic levels and probably aggregate in some spatial niches dependant of food sources, while other genera can dwell throughout the soil profile or endure environmental fluxes.

The organisms found only a few times could represent anomalies or may have been found in small niches that do not represent the entire ecosystem. These organisms may increase in population when environmental stimulants are present or when competition declines. Due to only one year of sampling, these responses may have been overlooked.

Within the same soil samples, organisms were found distributed based on optimal abiotic and biotic conditions. Rhagidiidae and Isotoma occupy the same spatial niche with large quantity of organisms in the top 5 cm. Isotoma are fungal feeders and are probably feeding on the fungal hyphae around roots while Rhagidiidae are predators and may be feeding upon Isotoma. True subterranean collembola such as Folsomia are more prominent at deeper depths and Acarina and Coleoptera follow the same pattern with species such as Opiella and Mayetia, respectively.(Fig. 10)

Grouped organisms based on spatial distribution develop possible interactions between organisms dwelling at the same depth. Exploration of specific interactions is beyond the scope of this study but provides a tool for future satellite studies.

Soil acidity can affect Collembola populations (Salmon and Ponge, 1999) but mesofauna can also indirectly influence pH through microbial N mineralization (Vedder et al., 1996). In the top 5 cm of soil, pH and total number of Collembola were greatest suggesting an interaction between them (Fig. 4 and Fig. 8). Residual affects from liming on 14 October 1998 may also have influenced acidity.

The great fluctuation in surface OC in the top 5 cm was possibly caused by the variation in root mass throughout the growing season while deeper depths had little spatial and temporal variation in OC. Microarthropods not extracted from soil cores due to extraction technique may have contributed to OC.

Soil mesofauna reside in the pore spaces around soil particles. The greater porosity in the shallower soil may represent a habitat conducive to sustaining, and being maintained by, soil fauna (Fig. 5 and 8). As porosity is restricted, so is the mobility of some organisms not allowing passage deeper soil depths even though porosity increases as the soil transitions from the Jory to Nekia. The top 5 cm of soil also contained the greatest root mass. Root growth creates larger pores for habitation and sustenance for fungal feeders and saprophores.

CONCLUSIONS

Soil mesofauna primarily dwell in the top 5 cm of soil where root mass, and organic carbon, were also greatest and soil porosity highest. Most soil arthropods increased in total numbers of organisms during the cool, wet months of October and November, not during the active growing season. Soil mesofauna generally increased in response to soil moisture during the dry season with increased populations after precipitation events.

Acari and Collembola were the dominant mesofauna representing 71.1 and 19.1% of the total number of collected specimen throughout the study, respectively. Five springtail and ten mite genera were found in abundance greater than 1000, while all other organisms appeared in low frequencies.

Lower acidity in the top 5 cm where most microarthropods reside suggests an influence on N mineralization through the break down of organic matter leading to a natural decrease in acidity and economic benefits for growers.

Grouping mesofauna based on spatial distribution triggers discussion for future research on interactions between organisms and tolerable environmental factors. There are dominant genera spatially in the soil profile and greater populations at specified seasons creating a guide for future sampling of specific microarthopods.

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APPENDICES

Appendix A

Summary of soil, weather, above ground biomass and cover averaged from eight cores each sample date or averaged for 14 prior days.

Sample Date	Heat Units per sampling	Rainfall 14 days prior to sampling (cm)	Manual Rainfall (cm)	Soil Temp 2.54cm (°C) 14 days Mean	Soil Temp 10.80cm (°C) 14 days Mean	Soil Temp 19.69cm (°C) 14 days Mean	Soil Temp 27.94cm (°C) 14 days Mean	Avg. rH per sampling	Avg. Above Ground Biomass	Avg. % Ground Cover	Avg.0"-12" core dry weights
1/30/01	63.67	2.71	1.45	3.83	3.19	4.54	4.85	90.46	21.34	83.13%	63.49
2/13/01	59.85	6.03	1.80	4.89	4.03	5.13	5.34	88.05	14.59	77.25%	44.75
2/27/01	82.83	1.59	1.40	5.97	4.99	5.87	6.03	83.00	14.14	75.88%	69.95
3/13/01	99.70	3.04	2.75	7.26	6.35	7.01	7.12	83.99	17.73	76.88%	54.43
3/27/01	109.96	7.52	6.20	8.90	8.25	8.65	8.88	86.10	18.66	72.50%	49.19
4/10/01	83.35	5.05	5.50	9.49	9.06	9.30	9.82	90.06	22.61	94.38%	42.06
4/24/01	123.73	2.05	2.65	11.24	10.78	10.58	11.05	81.76	34.69	94.63%	67.86
5/8/01	156.78	2.69	2.25	13.91	13.40	13.20	13.60	75.42	29.60	74.38%	57.70
5/22/01	185.56	3.06	3.00	15.93	15.18	15.06	15.50	72.95	37.88	88.13%	102.36
6/5/01	194.65	2.71	2.20	17.17	16.50	16.60	17.58	74.03	61.70	93.75%	60.11
6/19/01	194.17	1.51	1.66	16.76	16.00	16.14	17.51	75.73	71.76	81.88%	77.86
7/3/01	227.03	1.45	1.38	17.41	16.58	16.88	18.08	74.63	71.68	87.13%	83.51
7/17/01	255.46	0.00	0.03	19.50	18.43	18.74	19.61	64.99	55.89	75.63%	68.44
7/31/01	242.35	0.04	1.63	19.37	18.11	18.49	19.51	74.23	70.74	86.13%	63.19
8/14/01	284.80	0.00	0.00	20.18	18.64	19.25	20.20	67.68	44.75	88.00%	62.36
8/28/01	246.93	1.33	1.50	18.68	17.32	18.34	19.71	75.25	70.38	85.63%	83.64
9/12/01	272.11	0.00	0.00	17.70	16.37	17.50	19.04	66.99	64.30	86.88%	68.75
9/25/01	228.97	1.35	0.34	17.29	15.93	17.19	18.82	71.91	80.30	90.63%	96.36
10/9/01	205.69	0.68	1.65	14.10	12.98	14.52	16.83	71.81	65.33	90.63%	80.76
10/23/01	145.44	4.70	4.50	11.36	10.37	11.96	14.60	88.83	70.28	74.63%	50.21
11/6/01	130.10	6.07	7.00	10.37	9.34	10.79	13.41	92.65	50.99	75.00%	54.26
11/20/01	129.29	6.15	6.05	9.28	8.42	9.81	12.54	89.44	51.43	82.88%	43.00
12/4/01	ND	16.22	14.80	7.05	6.47	7.87	10.91	ND	52.08	70.00%	75.60
12/18/01	110.16	9.87	12.50	5.90	5.24	6.45	9.52	81.29	57.96	77.50%	48.90
12/31/01	43.59	1.77	3.60	4.21	3.72	5.04	8.36	96.46	56.65	75.63%	88.38
1/15/02	94.64	7.34	7.20	6.59	5.80	6.83	9.63	94.79	54.28	86.25%	43.04
2/1/02	41.79	20.50	>15	3.52	3.11	4.27	7.59	95.55	44.26	81.25%	63.96

Appendix B

Compilation of all organisms summed and averaged for the 27 sample periods dating 30 January 2001 to 1 February 2002. The summation and average columns represent the total count of organisms extracted from eight soil samples (each 7.6 cm diameter and 5 cm deep) complied for all 27 sample dates. Appendix B illustrates: (i) the abundance of adult and younger life stages;(ii) predominant mesofauna in a managed grassland; (iii) spatial distribution of those organisms.

	0-5 cm		5-10 cm		10-15 cm		15-20 cm		20-25 cm		25-30 cm		
Collembola (family, genera, others unidentified)	Sums	Mean	Sums	Mean	Sums	Mean	Sums	Mean	Sums	Mean	Sums	Mean	Sum of All Depths
Isotoma imm	5530	395.00	924	34.22	401	14.85	529	19.59	290	10.74	199	7.37	7873
Hypogastrura A	6609	472.07	135	5.00	40	1.48	31	1.15	59	2.19	124	4.59	6998
Lepidocyrtus imm	3466	247.57	325	12.04	104	3.85	98	3.63	52	1.93	41	1.52	4086
Willemia (2 spines)	1457	104.07	606	22.44	513	19.00	664	24.59	239	8.85	166	6.15	3645
Isotoma A	2429	173.50	317	11.74	281	10.41	338	12.52	162	6.00	95	3.52	3622
Lepidocyrtus	2984	213.14	105	3.89	47	1.74	37	1.37	30	1.11	34	1.26	3237
Hypogastrura imm	2204	157.43	167	6.19	41	1.52	33	1.22	31	1.15	46	1.70	2522
Onychiurus	489	34.93	348	12.89	342	12.67	298	11.04	140	5.19	64	2.37	1681
Folsomia	65	4.64	49	1.81	74	2.74	238	8.81	291	10.78	195	7.22	912
Neelus	336	24.00	108	4.00	97	3.59	83	3.07	80	2.96	72	2.67	776
uncertain imm Collembola	122	8.71	80	2.96	54	2.00	56	2.07	39	1.44	41	1.52	392
Entomobrya	88	6.29	19	0.70	21	0.78	22	0.81	25	0.93	18	0.67	193
Sminthuridae	155	11.07	3	0.11	4	0.15	1	0.04	3	0.11	3	0.11	169
Sminthuridae imm	121	8.64	0	0.00	1	0.04	3	0.11	1	0.04	4	0.15	130
Entomobrya imm	27	1.93	13	0.48	10	0.37	8	0.30	4	0.15	5	0.19	67
Arrhopalites	3	0.21	11	0.41	11	0.41	8	0.30	3	0.11	7	0.26	43
Neanura	25	1.79	0	0.00	2	0.07	0	0.00	0	0.00	0	0.00	27
Tullbergia	0	0.00	4	0.15	0	0.00	1	0.04	0	0.00	0	0.00	5
Sinella or Tomoceridae	0	0.00	1	0.04	1	0.04	0	0.00	0	0.00	0	0.00	2
Paranura/Anurida	0	0.00	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00	1
Acarina (genera, spp. and morphospecies)													
Unidentified imm Mites	2336	166.86	4143	153.44	6084	225.33	7205	266.85	8851	327.81	6880	254.81	35499
Oppiidae/*Opiella* imm	1021	72.93	1984	73.48	4296	159.11	4244	157.19	3791	140.41	2170	80.37	17506
Rhagidiidae imm spp.1	3352	239.43	3036	112.44	2175	80.56	1997	73.96	1960	72.59	1443	53.44	13963
Tarsonemidae	10889	777.79	1682	62.30	534	19.78	298	11.04	236	8.74	321	11.89	13960
Pygmephoridae	2242	160.14	2944	109.04	2584	95.70	1639	60.70	1047	38.78	597	22.11	11053
Veigaiidae imm	869	31.04	1494	27.67	1919	35.54	1822	33.74	1208	22.37	619	11.46	7931
spiny gamasidae	3015	215.36	1261	46.70	689	25.52	656	24.30	500	18.52	360	13.33	6481
Scutataridae A	2449	174.93	1500	55.56	720	26.67	438	16.22	267	9.89	176	6.52	5550
Tyrophagus putrescentiae	4343	310.21	131	4.85	50	1.85	44	1.63	15	0.56	61	2.26	4644
Lohmannia imm	138	9.86	781	28.93	584	21.63	363	13.44	303	11.22	216	8.00	2385
Oppiidae/*Opiella* mid-sized	420	30.00	132	4.89	92	3.41	112	4.15	162	6.00	197	7.30	1115
Veigaiidae veigaia	408	29.14	212	7.85	94	3.48	48	1.78	40	1.48	20	0.74	822

Lohmannia	30	2.14	320	11.85	194	7.19	122	4.52	80	2.96	69	2.56	815
Eustigmaeus plumifer (Halbert) Stigmaeidae	700	50.00	50	1.85	8	0.30	7	0.26	3	0.11	4	0.15	772
unknown Oribatid sp. Imm	126	9.00	76	2.81	95	3.52	145	5.37	144	5.33	152	5.63	738
Nothrus imm	34	2.43	56	2.07	97	3.59	124	4.59	109	4.04	96	3.56	516
Rhagidiidae spp.1	343	24.50	90	3.33	34	1.26	24	0.89	9	0.33	15	0.56	515
Scheloribates elongate imm	184	13.14	84	3.11	32	1.19	39	1.44	67	2.48	53	1.96	459
Laelapidae Hypoaspis cf. aculeifer (Can.) imm	159	11.36	130	4.81	88	3.26	52	1.93	18	0.67	5	0.19	452
Ameroseius cf. corbiculus Ameroseiidae	403	28.79	3	0.11	0	0.00	3	0.11	0	0.00	1	0.04	410
short-haired very flat imm	12	0.86	366	13.56	2	0.07	1	0.04	2	0.07	5	0.19	388
Pilogalumna	358	25.57	2	0.07	1	0.04	0	0.00	0	0.00	2	0.07	363
gutter ridge gamasid imm	129	9.21	101	3.74	58	2.15	30	1.11	33	1.22	10	0.37	361
Bdellidae imm	326	23.29	12	0.44	11	0.41	7	0.26	0	0.00	2	0.07	358
unknown oribatid imm #1	9	0.64	24	0.89	45	1.67	52	1.93	92	3.41	117	4.33	339
Gamasida	232	16.57	56	2.07	22	0.81	11	0.41	11	0.41	6	0.22	338
Polyaspididae	251	17.93	62	2.30	6	0.22	4	0.15	2	0.07	3	0.11	328
Laelapidae Hypoaspis cf. aculeifer (Can.)	169	12.07	75	2.78	43	1.59	11	0.41	10	0.37	5	0.19	313
Zygoribatula	295	21.07	10	0.37	2	0.07	1	0.04	2	0.07	1	0.04	311
Veloppia imm	36	2.57	31	1.15	47	1.74	66	2.44	62	2.30	35	1.30	277
epilohmannia-like imm	6	0.43	53	1.96	38	1.41	43	1.59	69	2.56	60	2.22	269
thick-legged rhagidiid imm	168	12.00	58	2.15	16	0.59	5	0.19	11	0.41	7	0.26	265
Ascidae Arctoseius	102	7.29	47	1.74	45	1.67	42	1.56	16	0.59	8	0.30	260
mite unknown	234	16.71	9	0.33	5	0.19	8	0.30	1	0.04	2	0.07	259
eupodid-like body mite imm	168	12.00	43	1.59	17	0.63	10	0.37	9	0.33	6	0.22	253
eupodid-like w/ indent shoulder	32	2.29	18	0.67	31	1.15	55	2.04	53	1.96	64	2.37	253
Scheloribates elongate	3	0.21	12	0.44	55	2.04	57	2.11	64	2.37	46	1.70	237
mite unknown imm	183	13.07	24	0.89	15	0.56	4	0.15	3	0.11	2	0.07	231
curly legged rhagidiid imm	41	2.93	63	2.33	24	0.89	27	1.00	40	1.48	34	1.26	229
crusty gamasida	203	14.50	16	0.59	4	0.15	0	0.00	0	0.00	4	0.15	227
Veloppia	1	0.07	5	0.19	54	2.00	69	2.56	57	2.11	29	1.07	215
eupodid-like body mite	88	6.29	42	1.56	21	0.78	15	0.56	15	0.56	17	0.63	198
very flat gamasid	175	12.50	2	0.07	1	0.04	3	0.11	2	0.07	0	0.00	183
Ceratozetes sp.	67	4.79	92	3.41	8	0.30	9	0.33	5	0.19	1	0.04	182
gutter ridge gamasid	141	10.07	16	0.59	4	0.15	1	0.04	5	0.19	2	0.07	169
short-haired very flat A	7	0.50	148	5.48	0	0.00	0	0.00	1	0.04	1	0.04	157
Zercon-like tan	131	9.36	9	0.33	1	0.04	0	0.00	0	0.00	0	0.00	141
Rhagidiidae imm spp.2	110	7.86	8	0.30	3	0.11	3	0.11	1	0.04	3	0.11	128
green metallic spot imm	118	8.43	1	0.04	0	0.00	1	0.04	0	0.00	0	0.00	120
Polyaspididae imm	91	6.50	22	0.81	1	0.04	0	0.00	2	0.07	0	0.00	116
constricted waist gamasid	8	0.57	46	1.70	47	1.74	5	0.19	2	0.07	3	0.11	111
Bdellidae	90	6.43	2	0.07	2	0.07	0	0.00	3	0.11	0	0.00	97
Eupodidae imm	68	4.86	17	0.63	4	0.15	2	0.07	3	0.11	2	0.07	96
very flat gamasid imm	69	4.93	8	0.30	4	0.15	2	0.07	4	0.15	5	0.19	92
thick very flat mite	84	6.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04	85
Trachytes imm	36	2.57	5	0.19	4	0.15	11	0.41	14	0.52	12	0.44	82
Parasitidae *Pergamasus* spp.1	73	5.21	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00	74

thick very flat mite imm	69	4.93	1	0.04	2	0.07	0	0.00	0	0.00	2	0.07	74
Trachytes	5	0.36	5	0.19	10	0.37	18	0.67	19	0.70	17	0.63	74
Phthiracarus imm	66	4.71	4	0.15	2	0.07	0	0.00	0	0.00	0	0.00	72
air scoop mite	1	0.07	69	2.56	0	0.00	0	0.00	0	0.00	0	0.00	70
tan, dotted mite A	48	3.43	2	0.07	5	0.19	4	0.15	0	0.00	8	0.30	67
thick-legged rhagidiid A	39	2.79	7	0.26	6	0.22	6	0.22	2	0.07	2	0.07	62
cottage cheese mite imm	0	0.00	60	2.22	0	0.00	0	0.00	0	0.00	0	0.00	60
spiny back oribatid imm	1	0.07	3	0.11	1	0.04	8	0.30	20	0.74	26	0.96	59
long-haired mite	55	3.93	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	55
smooth, creamy gamasid imm	42	3.00	12	0.44	1	0.04	0	0.00	0	0.00	0	0.00	55
Tectocepheus	53	3.79	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04	54
Tectocepheus imm	45	3.21	1	0.04	1	0.04	0	0.00	2	0.07	0	0.00	49
Scheloribates round	26	1.86	0	0.00	0	0.00	15	0.56	6	0.22	0	0.00	47
crusty gamasida imm	37	2.64	2	0.07	3	0.11	1	0.04	1	0.04	0	0.00	44
Oppia	4	0.29	0	0.00	8	0.30	5	0.19	13	0.48	14	0.52	44
sutured question mark	43	3.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	43
Nothrus	0	0.00	0	0.00	2	0.07	15	0.56	11	0.41	10	0.37	38
Zercon-like tan imm	35	2.50	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00	36
tan, dotted mite imm	30	2.14	1	0.04	0	0.00	0	0.00	0	0.00	1	0.04	32
eupodid-like w/yellow blobs	24	1.71	0	0.00	0	0.00	5	0.19	2	0.07	0	0.00	31
pear-shaped w/ 4 spines oribatid	0	0.00	0	0.00	2	0.07	1	0.04	6	0.22	22	0.81	31
Uropodidae imm	1	0.07	2	0.07	1	0.04	1	0.04	10	0.37	15	0.56	30
Parasitidae *Pergamasus* imm spp.1	28	2.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	28
smooth, creamy gamasid A	26	1.86	1	0.04	1	0.04	0	0.00	0	0.00	0	0.00	28
green metallic spot A	25	1.79	0	0.00	0	0.00	0	0.00	0	0.00	2	0.07	27
sutured question mark imm	24	1.71	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	24
hairy eupodid	21	1.50	1	0.04	0	0.00	1	0.04	0	0.00	0	0.00	23
tiny, waisted, equal spine	1	0.07	10	0.37	5	0.19	3	0.11	1	0.04	3	0.11	23
Ameroseius cf. corbiculus Ameroseiidae imm	22	1.57	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	22
long-haired mite imm	20	1.43	0	0.00	0	0.00	0	0.00	1	0.04	0	0.00	21
spider gamasid	19	1.36	1	0.04	0	0.00	0	0.00	1	0.04	0	0.00	21
divided gamasid	19	1.36	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04	20
long-legged litte guy	5	0.36	2	0.07	2	0.07	5	0.19	4	0.15	2	0.07	20
Parasitidae *Pergamasus* male spp.1	19	1.36	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	19
hairy eupodid imm	13	0.93	1	0.04	0	0.00	0	0.00	4	0.15	0	0.00	18
concave gamasid	13	0.93	1	0.04	2	0.07	1	0.04	0	0.00	0	0.00	17
Parasitidae Pergamasus spp.2 imm	17	1.21	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	17
curly legs gamasid imm	16	1.14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	16
long-legged litte guy imm	9	0.64	1	0.04	2	0.07	2	0.07	0	0.00	2	0.07	16
Anystidae/*Anystis* imm	15	1.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	15
Eupodidae	15	1.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	15
goose neck gamasid imm	9	0.64	3	0.11	1	0.04	0	0.00	0	0.00	1	0.04	14
Zygoribatula imm	10	0.71	0	0.00	0	0.00	0	0.00	2	0.07	1	0.04	13
cottage cheese mite A	2	0.14	10	0.37	0	0.00	0	0.00	0	0.00	0	0.00	12
Parasitidae Pergamasus	11	0.79	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00	12

Parasitidae Pergamasus male A spp.4	11	0.79	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00	12
Scheloribates sp. Imm	7	0.50	2	0.07	0	0.00	0	0.00	1	0.04	2	0.07	12
cream-fuzz A	4	0.29	1	0.04	2	0.07	1	0.04	0	0.00	3	0.11	11
tan, hairy legged flat	6	0.43	2	0.07	2	0.07	0	0.00	0	0.00	1	0.04	11
elongate oribatid w/equal length hairs	7	0.50	0	0.00	1	0.04	0	0.00	0	0.00	1	0.04	9
oribatid clavate and wrinkled imm	8	0.57	0	0.00	0	0.00	0	0.00	1	0.04	0	0.00	9
Parasitidae Pergamasus spp.4	9	0.64	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	9
Scutataridae imm	0	0.00	1	0.04	3	0.11	2	0.07	2	0.07	1	0.04	9
spider gamasid A.	8	0.57	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00	9
baby Trachytes w/hairs	8	0.57	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	8
Epilohmannia cyclindrica	1	0.07	4	0.15	1	0.04	1	0.04	1	0.04	0	0.00	8
Parasitidae Pergamasus imm spp.4	6	0.43	2	0.07	0	0.00	0	0.00	0	0.00	0	0.00	8
Eustigmaeus plumifer A (Halbert) Stigmaeidae	6	0.43	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00	7
4 black spine oribatid	0	0.00	1	0.04	1	0.04	1	0.04	2	0.07	2	0.07	7
Tectocepheus (tan sp.)	7	0.50	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	7
Tyrophagus putrescentiae imm.	0	0.00	0	0.00	0	0.00	0	0.00	3	0.11	3	0.11	6
curly legs gamasid A	4	0.29	2	0.07	0	0.00	0	0.00	0	0.00	0	0.00	6
gamasid - narrow long leg	2	0.14	1	0.04	0	0.00	3	0.11	0	0.00	0	0.00	6
hairy leg eupodid-like	1	0.07	2	0.07	2	0.07	0	0.00	0	0.00	1	0.04	6
Pilogalumna imm	3	0.21	1	0.04	2	0.07	0	0.00	0	0.00	0	0.00	6
round oribatid w/ equal length hairs	0	0.00	0	0.00	1	0.04	3	0.11	0	0.00	2	0.07	6
Anystidae/*Anystis*	3	0.21	1	0.04	0	0.00	0	0.00	1	0.04	0	0.00	5
Uropodidae	2	0.14	2	0.07	0	0.00	0	0.00	0	0.00	1	0.04	5
longhair, clavate oribatid imm	1	0.07	0	0.00	0	0.00	1	0.04	1	0.04	1	0.04	4
gamasid - narrow long leg imm	1	0.07	2	0.07	0	0.00	0	0.00	0	0.00	0	0.00	3
goose neck gamasid	3	0.21	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3
long-legged very flat	1	0.07	0	0.00	0	0.00	1	0.04	0	0.00	1	0.04	3
Parasitidae Pergamasus spp.2	2	0.14	0	0.00	0	0.00	1	0.04	0	0.00	0	0.00	3
tan, hairy legged round	3	0.21	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3
uropodid w/ continual fringe	1	0.07	2	0.07	0	0.00	0	0.00	0	0.00	0	0.00	3
uropodid w/ interupted fringe	2	0.14	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00	3
curly legged rhagidiid A	2	0.14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2
mini-pergamasus w/hairs	2	0.14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2
oribatid w/long hairs, hair-like sensilla	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2	0.07	2
oribatid w/wrinkled back	2	0.14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2
Sphaerozetes	2	0.14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2
black hairy thing	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Ceratozetes sp. Imm	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04	1
concave gamasid imm	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04	1
divided gamasid imm	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
divided gamasid w/ long legs	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Epilohmannia cyclindrica imm	0	0.00	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00	1
eupodid-like body fuzzy	0	0.00	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00	1
flat backed mite	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1

gamasid - goose-neck like	0	0.00	0	0.00	1	0.04	0	0.00	0	0.00	0	0.00	1
oribatid ?	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04	0	0.00	1
oribatid section G?	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Parasitidae Pergamasus spp. 5	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Phthiracarus	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Rhagidiidae spp.2	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
round oribatid w/sm wings	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
snowman	0	0.00	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00	1
unknown oribatid imm #4	0	0.00	1	0.04	0	0.00	0	0.00	0	0.00	0	0.00	1
unknown Oribatid sp.	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Other taxa													
Pauropoda	564	40.29	1939	138.50	2182	155.86	1769	126.36	1006	71.86	541	20.04	8001
Pauropoda imm	427	30.50	986	70.43	928	66.29	829	59.21	714	51.00	561	20.78	4445
Thripidae imm	1696	121.14	76	5.43	10	0.71	4	0.29	7	0.50	12	0.44	1805
Campodidae A	398	28.43	352	25.14	131	9.36	75	5.36	56	4.00	42	1.56	1054
Solenopsis	39	2.79	338	24.14	0	0.00	44	3.14	0	0.00	0	0.00	421
Mayetia (mold beetle) A	1	0.07	27	1.93	88	6.29	102	7.29	44	3.14	22	0.81	284
Scutagerella (symphyllan)	79	5.64	79	5.64	22	1.57	29	2.07	25	1.79	26	0.96	260
Armadillidium vulgare	234	16.71	7	0.50	1	0.07	0	0.00	0	0.00	1	0.04	243
Cicadellidae imm	232	16.57	3	0.21	1	0.07	2	0.14	2	0.14	0	0.00	240
Psocoptera/*Liposcelis*	45	3.21	18	1.29	23	1.64	37	2.64	18	1.29	25	0.93	166
Subterranean Aphid	33	2.36	88	6.29	25	1.79	8	0.57	4	0.29	2	0.07	160
Plinthisus	155	11.07	0	0.00	0	0.00	1	0.07	0	0.00	0	0.00	156
Araneida (misc spiders)	130	9.29	6	0.43	5	0.36	4	0.29	4	0.29	5	0.19	154
Geophilomorph	29	2.07	31	2.21	44	3.14	28	2.00	12	0.86	5	0.19	149
Cecidomyidae (gall midges) larva	63	4.50	22	1.57	2	0.14	1	0.07	0	0.00	0	0.00	88
Tachyporus	69	4.93	2	0.14	0	0.00	0	0.00	0	0.00	0	0.00	71
Pseudococcidae	56	4.00	4	0.29	3	0.21	1	0.07	0	0.00	3	0.11	67
Leodidae	59	4.21	1	0.07	3	0.21	0	0.00	1	0.07	2	0.07	66
Plinthisus imm	33	2.36	1	0.07	3	0.21	5	0.36	1	0.07	13	0.48	56
Myrmicinae	1	0.07	1	0.07	0	0.00	0	0.00	0	0.00	45	1.67	47
Acanthomyops	34	2.43	12	0.86	0	0.00	0	0.00	0	0.00	0	0.00	46
un ID flies L	36	2.57	3	0.21	1	0.07	1	0.07	0	0.00	0	0.00	41
Lepidoptera imm	37	2.64	2	0.14	0	0.00	0	0.00	0	0.00	0	0.00	39
Chironomidae L	32	2.29	2	0.14	1	0.07	0	0.00	0	0.00	2	0.07	37
Root Weavil Larva	26	1.86	3	0.21	7	0.50	1	0.07	0	0.00	0	0.00	37
Aleocharine	32	2.29	0	0.00	0	0.00	0	0.00	1	0.07	1	0.04	34
Misc. Beetle	0	0.00	1	0.07	9	0.64	14	1.00	8	0.57	2	0.07	34
Japygidae	2	0.14	5	0.36	4	0.29	4	0.29	3	0.21	8	0.30	26
Unknown imm larva	0	0.00	24	1.71	0	0.00	0	0.00	0	0.00	0	0.00	24
Staphylinidae unID L	19	1.36	0	0.00	1	0.07	3	0.21	0	0.00	0	0.00	23
Geophilomorph imm	2	0.14	9	0.64	8	0.57	2	0.14	1	0.07	0	0.00	22
Thripidae A	18	1.29	1	0.07	0	0.00	1	0.07	0	0.00	1	0.04	21
2-ped-ant	15	1.07	5	0.36	0	0.00	0	0.00	0	0.00	0	0.00	20
Philonthus	19	1.36	0	0.00	1	0.07	0	0.00	0	0.00	0	0.00	20
Polyxenus A	3	0.21	6	0.43	1	0.07	5	0.36	4	0.29	1	0.04	20

Campodidae imm	3	0.21	3	0.21	3	0.21	7	0.50	0	0.00	0	0.00	16
Cecidomyidae (gall midges)	0	0.00	10	0.71	4	0.29	0	0.00	0	0.00	1	0.04	15
Misc. Coleoptera larva	8	0.57	1	0.07	1	0.07	3	0.21	2	0.14	0	0.00	15
Diapraeid Wasp A	3	0.21	6	0.43	0	0.00	5	0.36	0	0.00	0	0.00	14
Prenolepis	6	0.43	7	0.50	0	0.00	1	0.07	0	0.00	0	0.00	14
Mayetia (mold beetle) L?	0	0.00	0	0.00	4	0.29	7	0.50	1	0.07	1	0.04	13
microsiphon Aphididae	13	0.93	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	13
Cicadellidae adult	12	0.86	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	12
Psychodidae (moth flies)	1	0.07	4	0.29	2	0.14	2	0.14	2	0.14	1	0.04	12
Scutagerella (symphylian) imm	3	0.21	2	0.14	0	0.00	1	0.07	3	0.21	3	0.11	12
Otiorhyncus(root weevil)	9	0.64	0	0.00	0	0.00	1	0.07	0	0.00	0	0.00	10
Carabidae unID L	7	0.50	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	8
Enchytraeidae worm	5	0.36	1	0.07	0	0.00	1	0.07	0	0.00	1	0.04	8
Polyxenus imm	0	0.00	3	0.21	2	0.14	1	0.07	1	0.07	1	0.04	8
Red-eyed Diptera	6	0.43	1	0.07	1	0.07	0	0.00	0	0.00	0	0.00	8
Staphylinidae unID A. #1	8	0.57	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	8
Elateridae L	1	0.07	2	0.14	1	0.07	0	0.00	2	0.14	1	0.04	7
Fringed-Wing Hymenoptera A	4	0.29	3	0.21	0	0.00	0	0.00	0	0.00	0	0.00	7
Protura	0	0.00	0	0.00	0	0.00	2	0.07	3	0.11	2	0.07	7
Tenebrionid larva	4	0.29	1	0.07	1	0.07	1	0.07	0	0.00	0	0.00	7
C-Shaped Coleopteraian	6	0.43	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	6
Spiny Larva	5	0.36	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	5
un ID flies A	2	0.14	1	0.07	0	0.00	1	0.07	0	0.00	1	0.04	5
Acalypta (lace bug)	4	0.29	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	4
Otiorhyncus(root weevil) L	1	0.07	1	0.07	1	0.07	1	0.07	0	0.00	0	0.00	4
Lathrididae	3	0.21	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3
Misc. Hymenoptera	2	0.14	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04	3
Staphylinus	2	0.14	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	3
Xantholinus	3	0.21	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	3
Amara	2	0.14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2
Bradysia (cyarid fly)	0	0.00	0	0.00	0	0.00	0	0.00	1	0.07	1	0.04	2
Chironomidae A	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04	2
Dermaptera (earwigs)	0	0.00	1	0.07	0	0.00	0	0.00	0	0.00	1	0.04	2
Hemiptera "stink bug"	2	0.14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2
Hylasinus obscuris	2	0.14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2
Larva with beak	1	0.07	0	0.00	0	0.00	0	0.00	1	0.07	0	0.00	2
Lathridiae	2	0.14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2
Orange Staphylinid	1	0.07	0	0.00	0	0.00	0	0.00	1	0.07	0	0.00	2
Platygastera	2	0.14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2
Thripidae (Black) imm	2	0.14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2
Thripidae wide bodied A	1	0.07	0	0.00	1	0.07	0	0.00	0	0.00	0	0.00	2
Thripidae wide bodied imm	2	0.14	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	2
6 eyed diptera (pink)	0	0.00	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	1
Ants un ID	0	0.00	0	0.00	0	0.00	0	0.00	1	0.07	0	0.00	1
Apochtonius	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Cecidomyidae (gall midges) pupa	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1

Colored wasp	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04	1
Diptera small head, round w/ hair fringe	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Diptera w/curled antennae	0	0.00	0	0.00	0	0.00	1	0.07	0	0.00	0	0.00	1
Diptera w/plumed antennae	0	0.00	0	0.00	1	0.07	0	0.00	0	0.00	0	0.00	1
Elateridae	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Feather-wing optera	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Formica	0	0.00	0	0.00	0	0.00	0	0.00	1	0.07	0	0.00	1
Gelis	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Hemiptera ? imm	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Homoptera ? imm	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Ichneumanid A	0	0.00	0	0.00	1	0.07	0	0.00	0	0.00	0	0.00	1
lace wing imm	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Large antennae Hymenoptera	0	0.00	0	0.00	1	0.07	0	0.00	0	0.00	0	0.00	1
Misc. Hymenoptera nymph	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Obsidian wasp	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Powderpost (Scolytidae) imm	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04	1
Protura imm	0	0.00	0	0.00	0	0.00	0	0.00	1	0.04	0	0.00	1
Pterosticus	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Red Gelis-like	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Rhyncophorus(root weevil)	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Rhyncophorus(root weevil) L	0	0.00	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	1
Scarubaeid imm	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Staphylinidae unID A	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Stenus	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
Tachyporus-Like	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
tiny round wasp	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1
un ID Larva	1	0.07	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	1