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# Localized Effects of Coarse Woody Material on Soil Oribatid Communities Diminish over 700 Years of Stand Development in Black-Spruce-Feathermoss Forests

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**Abstract:** In the black-spruce clay-belt region of Western Québec, soil nutrients are limited due to paludification. Under paludified conditions, nutrient subsidies from decomposing surface coarse woody material (CWM) may be important particularly during the later stages of ecosystem development when deadwood from senescent trees has accumulated. For soil organisms, CWM can alter microclimatic conditions and resource availability. We compared abundance and species richness of oribatid mites below or adjacent to CWM across a chronosequence which spans *ca.* 700 years of stand development. We hypothesized that oribatid abundance and richness would be greater under the logs, particularly in later stages of forest development when logs may act as localized sources of carbon and nutrients in the paludified substrate. However, oribatid density was lower directly under CWM than adjacent to CWM but these differences were attenuated with time. We suggest that oribatids may be affected by soil compaction and also that such microarthropods are most likely feeding on recently fallen leaf litter, which may be rendered inaccessible by the presence of overlying CWM. This may also explain the progressive decline in oribatid density and diversity with time, which are presumably caused by decreases in litter availability due to self-thinning and *Sphagnum* growth. This is also supported by changes of different oribatid trophic groups, as litter feeders maintain different numbers relative to CWM with time while more generalist fungi feeders only show differences related to position in the beginning of the succession.

## 1. Introduction

In the prolonged absence of major disturbance, forest ecosystems may pass through a retrogressive phase whereby overall productivity declines in response to a long-term net loss of nutrients such as phosphorus (P) [1,2]. Along with declines in nutrients, retrogression provokes compositional changes in both soil microbes and forest litter, which in turn affects decomposition rates [1,3,4]. The effects of reduced productivity in older stands extend further into decomposer-based food webs as evidenced by reductions of soil macroarthropods and nematodes [5]. In some boreal ecosystems, sequestration of nutrients in deep, paludified organic horizons may resemble retrogression in relatively short periods (*ca.* 1000 years) [6,7]. In these ecosystems, growth of *Sphagnum* combined with rising water tables and cold temperatures result in an increasing proportion of nutrients immobilized in poorly decomposing organic matter as stands age [8]. Black-spruce (*Picea mariana* (P. Mill.) B.S.P) feathermoss forests of the clay-belt region of Western Québec are often prone to paludification in the absence of fire [9] and are some of the most nutrient limited forests known [10]. In this region, surface deadwood decreases radically after 260 years after fire (unpublished results). However, buried wood resulting from paludification increases steadily as stands progress to old-growth.

Under such conditions, detrital inputs of coarse woody material (CWM) deposited on the forest floor surface may have localized effects on soils and soil communities. Unlike poorly decomposing *Sphagnum* [11], mineralization of CWM provides a localized source of carbon (C) [12,13]. In nearby boreal mixedwood forests, the release of nitrogen (N) and P from CWM occurred in quantities consistent with annual immobilization rates by trees [13]. While these releases of nutrients varied by individual tree species, they were generally greater in later stages of decay, suggesting that successional dynamics and stand development would also be important factors in determining when CWM would influence below ground communities [8]. In agricultural field trials and microcosm experiments, detrital deposition of basic metabolic building blocks such as C, N and P are important drivers for soil food webs [14]. In addition to potential changes in C and nutrients, CWM may directly affect forest soils by modifying soil moisture and temperature [15,16].

Several studies from forest ecosystems have suggested limited effects of potential CWM nutrient releases on soil communities. In early successional aspen (*Populus tremuloides* Michx.) stands in Eastern Canada, Déchêne and Buddle [17] compared soil mites collected adjacent to and ~1 m from aspen logs. Although they observed slightly significant effects of distance to CWM on richness (higher close to the logs) they did not observe effects on abundance or composition of soil mites. In late successional forests in the Pacific Northwest of the United States, Marra and Edmonds [18] compared soil invertebrates adjacent to and ~1 m from western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) logs in intermediate decay stages. They found that soil depth and stand management were more important factors determining the density, species richness and composition of soil invertebrates than was the location relative to individual pieces of CWM [18]. Neither of these studies included soil communities

located beneath CWM. However, Evans *et al.* [19], which compared soil microarthropods beneath and adjacent to red beech (*Nothofagus fusca* (Hook.f.) Oerst.) CWM in New Zealand. They concluded that for several taxa, proximity to CWM was an important factor, although the limited taxonomic resolution of this study significantly curtails inferences as to how CWM is affecting soil biota [19]. While these studies suggest that belowground effects of CWM on soil mites may be limited, all provide individual "snapshots" of soil communities during a specific period within different successional processes. Greater understanding of the relevance of CWM for belowground biota necessitates studies that reflect longer-term deadwood dynamics and stand succession.

Here, we compare below-ground assemblages of oribatid mites collected below and adjacent to CWM throughout a chronosequence of black spruce stands spanning more than 700 years of stand development. Unlike previous studies, where available soil C and nutrients are relatively accessible to detrital consumers, in older, heavily paludified stands where retrogression is occurring, C and nutrients are immobilized by abundant *Sphagnum* mosses. If CWM provides substantial nutrient and C subsidies to underlying soil communities in paludified forests, we hypothesize soil oribatids should be more abundant and diverse in the forest floor underlying the CWM within later stages of forest development affected by paludification.

## 2. Materials and Methods

### 2.1. Study Site

In the boreal claybelt region of Western Québec, stand-replacing wildfires are the principal natural disturbance. Following wildfire, stand development is characterized by changes in stand-structure rather than shifts in overstory species composition [20,21]. Older stands have multiple cohorts of trees, numerous canopy gaps and very thick organic horizons (>1 m) composed of *Sphagnum* mosses [22,23]. In later, old-growth stages bryophytes cover much of the forest floor in some cases nearly covering CWM by aggressive growth of *Spahgnum* spp. [24,25]. We sampled soil microarthropods from a chronosequence of 10 black spruce (*Picea mariana*) stands (49°00′–50°00′ N; 78°30′–79°30′ W). These stands ranged from 60–718 years' time since fire (TSF) and together represented all major structural phases of stand development in this region [8,21] except stand initiation: (1) stem exclusion, with stand growth and self-thinning; (2) old growth, with decreasing tree abundance due to paludification and high structural diversity; and (3) retrogression, where overall productivity declines (Table 1). The soils in this region are characterized as organic with clay surficial deposits [26]. Mean annual temperature is −0.7 °C and annual precipitation is 905.5 mm [27].

**Table 1.** Characteristics of a chronosequence black-spruce/feather moss stands used in this study [1].

| Stand | Time since fire | Chronosequence stage | Basal area (m²/ha) | CWM volume (m³/ha) | Bryophyte thickness (cm) |
|-------|-----------------|----------------------|--------------------|--------------------|--------------------------|
| N4 | 60 | 1 | 39.59 | 7.44 | 26.65 |
| N23 | 94 | 1 | 46.00 | 19.73 | 15.15 |
| S1 | 95 | 1 | 45.03 | 5.66 | 22.40 |
| Ch75 | 133 | 2 | 25.93 | 8.67 | 44.70 |
| N18 | 134 | 2 | 35.55 | 8.53 | 46.40 |
| N8 | 183 | 2 | 34.51 | 24.92 | 43.15 |
| POP | 183 | 2 | 13.86 | 53.61 | 48.05 |
| L22 | 283 | 2 | 21.25 | 57.18 | 49.45 |
| N50 | 373 | 2 | 19.65 | 47.80 | 48.30 |
| N6 | 718 | 3 | 21.70 | 33.84 | 58.75 |

[1] Additional information on stands is available [21,23].

## 2.2. Sampling Design

We collected paired soil cores (6 cm diameter, 7 cm depth) below and 50 cm adjacent to black spruce CWM at 2 locations within each stand resulting in the collection of 40 soil cores. Logs ranged between 5.5 and 16.4 cm diameter (mean 10.3 cm) and included different decay stages (mean wood density 0.28 g/cm³). Microarthropods were extracted by washing soil cores [28]. In boreal forests, earthworms are scarce while soil microarthropods are important detrital consumers that are linked with decomposition in soils [29]. Samples were soaked in KOH solution to separate microarthropods from the substrate, washed and sieved through 500 μm and 250 μm filters. All specimens were conserved in 70% ethanol. Arthropods were sorted from the remaining debris, counted and classified, although due to the scarce abundance of most groups only oribatids were used for research purposes. Oribatid mites were identified to the species level, e.g., [30–32], and the most abundant species where classified into four trophic groups; litter feeders, fungi feeders, plant tissue [33–37] and unspecified, when species identification or trophic level could not be assigned (Appendix Table A1).

For each pair of soil cores, we recorded diameter and wood density of the log covering the soil core. A cylindrical sample of each log was collected to measure wood density. We dried each sample to constant mass then measured volume using water-displacement [38]. We also measured sample moisture (obtained gravimetrically) for all samples. We also used tree basal area, CWM volume and thickness of the bryophyte layer within each stand for community level analyses (Table 1). These data were provided by J. Jacobs.

## 2.3. Statistical Analyses

We compared adult oribatid densities (number of species/gram of dry soil) using a series of hierarchical linear mixed models. In these models, position relative to CWM (under or adjacent) and age of the stand were fixed factors and location was the random factor [39]. We compared densities of all oribatid species combined as four separate feeding groups. In these models we log-transformed both oribatid density and stand age. Linear mixed models were fit by restricted maximum likelihood (R version 2.11.1) [40].

We estimated species richness of oribatids using individual-based rarefaction [41]. Rarefaction curves were produced from pooled abundances of samples taken below and adjacent to CWM and among three different stand stages (based in forest development stages; 60–95 years after fire or first stage of stand development, 133–373 years or old growth, 718 years or long term; Table 1) using the Vegan Community Ecology Package (R package version 1.13).

We also compared oribatid density within each soil core with soil moisture, diameter of logs and density of wood (log variables only for soil cores taken under CWM) using Pearson-product moment correlations. Correlation analysis was also used to test for relationships between oribatid density and basal area, CWM volume and bryophyte thickness within each stand.

## 3. Results

### 3.1. Soil Microarthropod Community

We collected 1180 Acari (824 Oribatida including immature stages), 292 Collembola, and 83 other microarthropods composed of Thysanoptera, Homoptera (Aphidae), and larval stages of Coleoptera and Diptera. A total of 704 adult oribatid mites were collected, representing 39 different species (Appendix Table A1). The most abundant species was *Atropacarus striculus* (C.L. Koch, 1835), a litter feeder Ptyctima, followed by two species of the genera *Nothrus* and *Hermannia*, respectively. *Scheloribates pallidulus* (C.L. Koch, 1841), which feeds on plant tissues, and *Eniochthonius minutissimus* (Berlese, 1903), a typical fungi feeder, were also very abundant.

### 3.2. Oribatid Distribution

Position relative to CWM and, to a lesser extent, stand age were important factors determining overall mite density (Table 2). As it is shown in Figure 1, mite densities were higher adjacent to CWM than under CWM (Table 2). Although density of oribatids decreases with time in both positions relative to CWM, the interaction of both variables, position and age, was not significant (Table 2 and Figure 1).
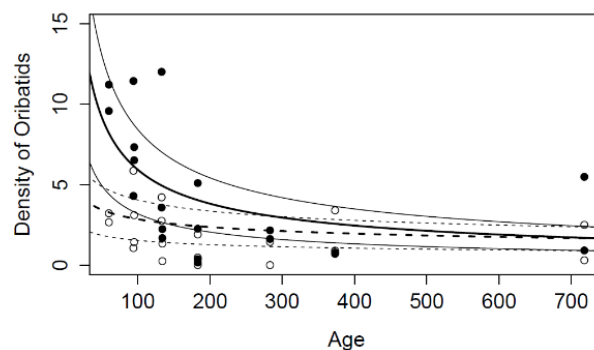


**Figure 1.** Total density of adult oribatids (individuals/g of dry substrate) plotted against stand age (years since fire). Black dots correspond to adjacent position relative to coarse woody material (CWM) and open circles to samples under CWM. The solid line corresponds to the line of predicted values for adjacent samples while the dashed line corresponds with the predicted values from the mixed model for samples under CWM. Thinner lines represent error intervals for each line of predicted values.

Oribatid species richness estimated from rarefaction curves was also higher in samples adjacent to CWM than those taken beneath CWM, although these differences were relatively small (Figure 2a) and reflect the larger numbers of individuals found in samples collected adjacent to CWM. Although oribatid species richness increased with stand development from first (Stage 1) to old growth stages (Stage 2), it clearly decreases at the long-term stage (Stage 3) (Figure 2b).

**Table 2.** Coefficients of the linear mixed effect model fit by restricted maximum likelihood for adult oribatid densities (log transformed) including age of stand (log transformed), position of sample relative to CWM and the interaction as explanatory variables.

| Parameter | Value | Std. Error | DF ** | t-value | p-value |
|---|---|---|---|---|---|
| **Total Oribatids** | | | | | |
| Intercept (Position Adjacent *) | 4.71 | 1.22 | 27 | 3.85 | 0.0007 |
| Age | −0.64 | 0.23 | 8 | −2.71 | 0.0268 |
| Position Under | −2.41 | 1.15 | 27 | −2.10 | 0.0451 |
| Age:Position Under | 0.36 | 0.22 | 27 | 1.65 | 0.1103 |
| **Litter feeders** | | | | | |
| Intercept (Position Adjacent) | 1.86 | 0.77 | 27 | 2.41 | 0.0232 |
| Age | −0.25 | 0.15 | 8 | −1.66 | 0.1344 |
| Position Under | −0.95 | 0.61 | 27 | −1.55 | 0.1320 |
| Age:Position Under | 0.11 | 0.12 | 27 | 0.96 | 0.3439 |
| **Fungi feeders** | | | | | |
| Intercept (Position Adjacent) | 2.23 | 0.57 | 27 | 3.88 | 0.0006 |
| Age | −0.37 | 0.11 | 8 | −3.36 | 0.0100 |
| Position Under | −2.36 | 0.76 | 27 | −3.12 | 0.0043 |
| Age:Position Under | 0.42 | 0.14 | 27 | 2.92 | 0.0070 |

* Refers to the reference condition used in linear mixed model for presentation of fixed effect parameters;
** refers to degrees of freedom associated with the denominator.



(a)　　　　　　　　　　　　　　　　(b)
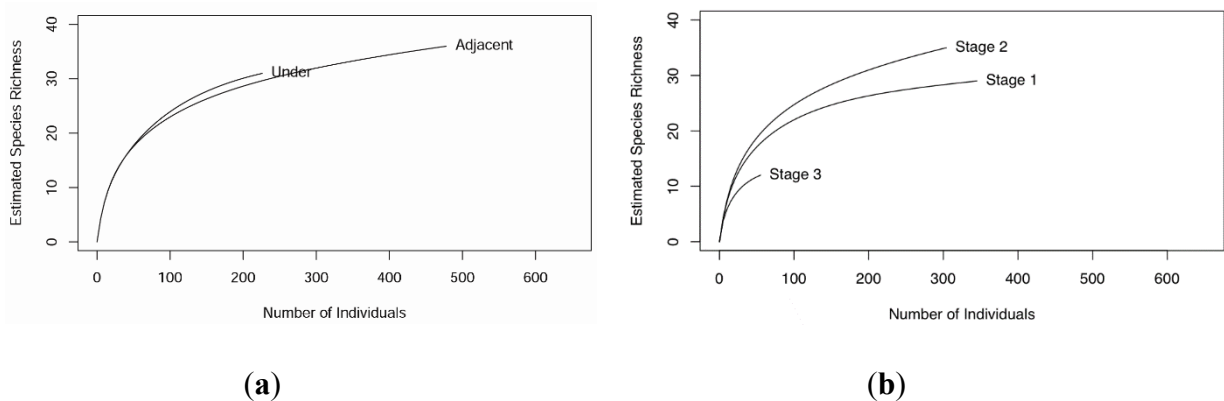
**Figure 2.** Rarefaction curves depicting estimated number of oribatid species per number of individuals sampled grouped among (**a**) both under and adjacent CWM positions and (**b**) among the three chronosequence stages (Stage 1: 60–95 years after fire. Stage 2: 133–373 years. Stage 3: 718 years). Standard error bars for these rarefaction curves overlap through most of the range and are omitted for clarity.

When densities of the different oribatid trophic groups were compared between both positions relative to CWM and stand age, only litter and fungi feeders showed significant slopes (Table 2). Fungal feeders were less abundant under CWM than adjacent to CWM and decreased with stand age with a pronounced decline in the first stage followed by a steady decrease during the old-growth phase (Figure 3). We also observed a significant interaction between position and stand age whereby differences in fungal feeders relative to CWM diminish as stands age (Figure 3). Density of litter feeders did not significantly differ in position relative to CWM or with stand age (Table 2). However, while not strongly supported in our model, our data suggests that density of litter feeding is less under CWM (Figure 3).



| (a) | (b) |
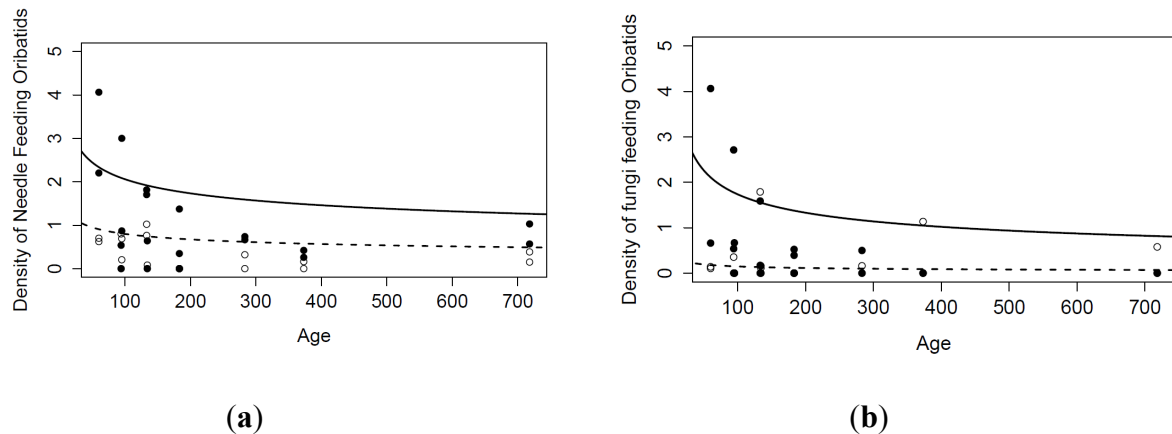
**Figure 3.** Density (individuals/g of dry substrate) of (**a**) litter feeder and (**b**) fungi feeder oribatids plotted against stand age (years since fire). Black dots correspond to adjacent position relative to CWM and open circles to samples under CWM. The solid line corresponds to the line of predicted values for adjacent samples while the dashed line corresponds with the predicted values from the mixed model for samples under CWM.

*3.3. Microclimatic and Environmental Factors Related to Oribatid Density*

Oribatid abundance in soil cores collected underneath CWM was negatively correlated with CWM diameter but showed no relation with wood density (Table 3). Oribatid density was positively correlated with moisture (Table 3), meaning that higher moisture showed higher density of oribatids. Moisture was lower in samples collected under CWM than those collected in adjacent exposed forest floor (mean moisture under CWM was 75.7% *versus* 80.3% in adjacent samples). At the stand level, oribatid density was only significantly correlated with CWM volume (Table 4). Where log volume was greater, fewer oribatids were found.

**Table 3.** Pearson-product moment correlations between adult oribatid density (log transformed) and environmental variables measured in individual soil cores.

| Variable | Oribatid density (individuals/g of dry substrate) | | |
|---|---|---|---|
| | Rho* | *t*-value | *p*-value |
| CWM Diameter [1] | −0.463 | −2.153 | 0.04599 |
| CWM Density [1] | −0.014 | −0.059 | 0.95360 |
| Moisture [2] | 0.343 | 2.2202 | 0.03261 |

[1] Spearman tests based on *df* = 17 with only samples collected from beneath CWM included in the analysis; [2] Spearman tests based on *df* = 37 with all samples used in the analysis; * Spearman's rank correlation coefficient.

**Table 4.** Pearson-product moment correlations between adult oribatid density (log transformed) and stand-level measurements for basal area, volume of coarse woody material and organic layer thickness (tests based on *df* = 8).

| Variable | Oribatid density (individuals/g of dry substrate) | | |
|---|---|---|---|
| | Rho* | *t*-value | *p*-value |
| Basal Area (m$^2$/ha) | 0.573 | 1.975 | 0.0837 |
| CWM Volume (m$^3$/ha) | −0.704 | −2.807 | 0.0230 |
| Organic layer thickness (cm) | −0.452 | −1.434 | 0.1895 |

* Spearman's rank correlation coefficient.

## 4. Discussion

In our study, abundance and richness of oribatids were greatly reduced compared to other temperate and boreal forest ecosystems, e.g., [42–44]. For particular taxonomic groups of arthropods such as ground beetles, black spruce forests undergoing paludification have markedly reduced densities [45,46]. Moreover, forest retrogression has been linked to further reductions of already dwindling population numbers, e.g., [5].

Over the long timeframe encompassed with our chronosequence, we observed a decrease in oribatid density and species richness that is concordant with a generalized community response during retrogression [5,7]. Studies of forest microarthropods that span shorter ecological timeframes have produced a variety of responses in density and species richness. For example, in spruce forests between 25 and 180 years, the temporal pattern of oribatid abundance showed no differences [47], declines [48], or increases, which were attributed to temporal variations in soil characteristics [49]. These studies showed less variability in species richness among successional stages [47,48] than ours. As we expected, microarthropods should indirectly respond to the overall productivity decline due to the sequestration of nutrients in deep paludified horizons [6]. However, contrary to our expectations, it seems that CWM does not provide an alternative source of C and nutrients to these soil arthropods, even in later stages of ecosystem development.

In contrast, in our study the density of soil oribatids living under CWM were reduced even in the later, more retrogressive stages of ecosystem development. This is in contrast to previous studies, which

have demonstrated few direct effects of CWM on soil fauna communities [17–19]. In our initial hypothesis, we expected CWM to be a significant source of C and other nutrients, which could in turn influence microbial activity directly beneath [50] and potentially increase abundance and diversity of microbial grazers [51]. However, nutrient releases from CWM may be being rapidly immobilized by underlying *Sphagnum* [52,53], potentially limiting any sort of enrichment to any underlying trophic levels and minimizing resource availability beneath or adjacent to CWM. Increased decay of CWM has been related to increased abundance and diversity of microarthropods inhabiting inside the log [51,54]. However, wood density, a direct measure of wood decay and a strong proxy of palatability of wood to specialist feeders, did not affect soil mites in our study. This suggests that decomposition effects are likely limited only to resident species within logs and not to underlying soil communities further confirming trends reported elsewhere [54,55]. This further limits the likelihood that increases in buried wood commonly reported in paludified stands [24] would affect soil communities outside of decaying logs.

Differences in oribatid abundances could be also related to moss compaction due to the weight of the CWM. Compaction could affect the volume of pores and spaces among mosses were the mites inhabit, which are related to mite abundance [56]. Although the selected logs were not big enough (between 5.5 and 16.4 cm diameter) to greatly affect moss compaction, we cannot readily dismiss compaction as a possible explanation for differences in oribatid abundance, especially considering the significant effect of log diameter on oribatid numbers.

Finally, we doubt moisture is related to differences in spatial distribution relative to CWM in these black-spruce feathermoss ecosystems. While drought has been shown to be a critical factor affecting oribatid mite distribution [57,58], samples both adjacent and under CWM showed very high moisture levels (between 62% and 91% of water content) and are not likely to be a limiting factor for these microarthropods [59]. While temperature was not measured for each sample, soil temperature in the study area is low [23] but within the reported tolerance of oribatids [59].

We propose an alternative hypothesis where oribatids may be preferentially responding to litter deposition. Oribatids inhabiting the soil have, in most cases, preferences for decaying litter [35]. More specifically, certain oribatids (as *E. minutissimus* and most Ptyctima) depend on fungi associated with forest litter as a source of calcium for the formation of their cuticle [36]. In paludified forests, litter deposition decreases with losses in stand productivity that occur as stands age. Further losses of leaf litter will be incurred as *Sphagnum* growth rates increase. These factors conspire to create a limited window of accessibility to litter deposited on the surface. If litter deposition on the forest floor surface is indeed important for oribatids, CWM may effectively block access to deposited needles similar to an umbrella. The negative correlation between log diameter and oribatid abundance supports this hypothesis as larger pieces of CWM present a bigger obstacle for deposition of new litter.

The interaction between stand age and position relative to CWM could be also explained by a decrease in the importance of the umbrella effect of CWM. Fungi feeders show differences of position only in the beginning of the succession, when fungi growing on litter are most likely rich and abundant. This heterogeneous trophic group is in fact considered to feed also partly on decomposing litter material [35]. However, fungi feeders do not show differences in later states of ecosystem development, when litter is scarce and probably poor in nutrient content. Rather, we hypothesize that the large quantities of mycorrhizal fungi present in CWM and on roots present throughout succession in the black spruce [60]

allows fungi feeders to maintain the same levels of abundance in both positions in later stages of stand development.

## 5. Conclusions

Our results suggest limited influence of CWM as a source of C and nutrients or as a microhabitat refuge to forest floor oribatids in black spruce-feather moss forests prone to paludification. Differences in oribatid density relative to CWM may be related to a combination of soil compaction due to logs weight and differences in food availability between the substrate under and adjacent to the logs. Moreover, different distribution patterns between litter and fungi feeders as well as the long-term decreases in oribatid abundance and diversity suggest that oribatids are responding primarily to litter supply rather than CWM.

## Acknowledgements

## Author Contribution

Enrique Doblas-Miranda and Timothy Work conceived and designed the study; Enrique Ddoblas-Miranda performed the field and laboratory work, including oribatid identification; Enrique Doblas-Miranda and Timothy Work analyzed the data and wrote the paper.

## Conflicts of Interest

The authors declare no conflict of interest.

## Appendix

**Table A1.** Number of individuals and relative abundance of the 39 Oribatid species found and trophic guild of the 8 most abundant species.

| Family | Species | *N* | Relative Abundance % | Trophic guild |
|---|---|---|---|---|
| Hypochthoniidae | *Hypochthonius rufulus* C.L. Koch, 1835 | 4 | 0.57 | |
| Eniochthoniidae | *Eniochthonius minutissimus* (Berlese, 1903) | 55 | 7.81 | Fungi |
| Phthiracaridae | *Atropacarus striculus* (C.L. Koch, 1835) | 111 | 15.77 | Litter |
| | *Phthiracarus* sp. | 17 | 2.41 | |
| Oribotritiidae | *Protoribotritia canadaris* Jacot, 1938 | 9 | 1.28 | |
| Euphthiracaridae | *Rhysotritia ardua* (C.L. Koch, 1841) | 40 | 5.68 | Litter |
| Nothridae | *Nothrus* sp. | 80 | 11.36 | Unspecif. |
| Camisiidae | *Camisia lapponica* (Trägårdh, 1910) | 11 | 1.56 | |
| | *Camisia* sp. 2 | 6 | 0.85 | |
| Trhypochthoniidae | *Trhypochthonius tectorum* (Berlese, 1896) | 27 | 3.84 | |

**Table A1.** *Cont.*

| Family | Species | N | Relative Abundance % | Trophic guild |
|---|---|---|---|---|
| Nanhermanniidae | *Nanhermannia elegantula* Berlese, 1913 | 5 | 0.71 | |
| | *Nanhermannia* sp. 2 | 30 | 4.26 | Fungi |
| Hermanniidae | *Hermannia* sp. | 76 | 10.80 | Unspecif. |
| Plateremaeidae | *Allodamaeus* sp. | 11 | 1.56 | |
| Damaeidae | *Belba* sp. | 8 | 1.14 | |
| Cepheidae | *Cepheus corae* Jacot, 1928 | 2 | 0.28 | |
| Eremaeidae | *Eremaeus* sp. | 1 | 0.14 | |
| | *Tenuilaoides* sp. 1 | 1 | 0.14 | |
| Tenuialidae | *Tenuilaoides* sp. 2 | 19 | 2.70 | |
| | *Tenuilaoides* sp. 3 | 1 | 0.14 | |
| Peloppiidae | *Ceratoppia quaridentata arctica* Hammer, 1955 | 10 | 1.42 | |
| Carabodidae | *Carabodes* sp. | 6 | 0.85 | |
| | *Carabodidae* sp. 2 | 4 | 0.57 | |
| | *Oppia* sp. | 27 | 3.84 | |
| Oppiidae | *Oppiidae* sp. 2 | 1 | 0.14 | |
| | *Oppiidae* sp. 3 | 5 | 0.71 | |
| Thyrisomidae | *Banksinoma spinifera* (Hammer, 1952) | 3 | 0.43 | |
| Cymbaeremaeidae | *Scapheremaeus palustris* (Sellnick, 1924) | 2 | 0.28 | |
| | *Achipteria* sp. | 1 | 0.14 | |
| Achipteriidae | *Parachipteria bella* (Sellnick, 1928) | 3 | 0.43 | |
| | *Achipteriidae* sp. 3 | 1 | 0.14 | |
| | *Achipteriidae* sp. 4 | 8 | 1.14 | |
| Phenopelopidae | *Peloptulus* sp. | 6 | 0.85 | |
| Scheloribatidae | *Scheloribates pallidulus* (C.L. Koch, 1841) | 59 | 8.38 | Plant tiss. |
| Oribatulidae | *Eporibatula modesta* (Banks, 1904) | 1 | 0.14 | |
| | *Phauloppia boletorum* (Ewing, 1913) | 17 | 2.41 | |
| Haplozetidae | *Xylobates* sp. | 3 | 0.43 | |
| Galumnidae | *Pergalumna* sp. 1 | 30 | 4.26 | Unspecif. |
| | *Pergalumna* sp. 2 | 3 | 0.43 | |

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