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Degradation of organic matter in Swiss Alpine pasture and forest soils: Microbial community dynamics as a function of soil type and temperature during a one-year experiment.

GEO 511 Master's Thesis

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Abstract

Assessing the sensitivity of soil microbes to climatic variations, this study investigated the impacts of increasing temperatures on soil microbial communities and soil respiration in subalpine forests and pasture soils in Jaun, Switzerland. This research uses phospholipid fatty acid analysis (PLFA) to elucidate the variations in microbial biomass, community structure, and soil carbon dynamics. This study investigated the effects of increasing temperatures on microbial communities and activities, as well as carbon degradation in pasture and forest soils in a subalpine region. The results indicated that increasing temperatures significantly increased soil respiration, enhanced microbial activity and organic matter decomposition, and altered the composition of microbial communities. Furthermore, differences in the composition of microbial communities between forest and pasture soils were observed, with forest soil exhibiting a higher fungi-to-bacteria ratio and a higher proportion of saprotrophic fungi, particularly in scenarios with litter addition. Additionally, an increase in Gram-positive bacteria and a decrease in the total amount of PLFA with rising temperatures were observed in both forest and pasture soils. These findings underscored the critical role of soil microbial responses with increasing temperatures and their potential implications for carbon cycling in subalpine soils under anticipated future climate scenarios.

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Abbreviations

AMF	*Arbuscular Mycorrhizal Fungi*
C/N	*Carbon to Nitrogen Ratio*
C–H	*Carbon-Hydrogen*
CH_4	*Methan*
$CHCl_3$	*Chloroform*
CO_2	*Carbon Dioxide*
DOC	*Dissolved Organic Carbon*
DRIFT	*Diffuse Reflectance Infrared Fourier Transform*
F/B	*Fungi to Bacteria Ratio*
GC	*Gas Chromatography*
GC-FID	*Gas Chromatography Flame Ionization Detector*
GC-MS	*Gas Chromatography Mass Spectrometer*
GN	*Gram-Negative*
GP	*Gram-Positive*
GP/AMF	*Gram-positive to Arbuscular Mycorrhizal Fungi Ratio*
GP/GN	*Gram-Positive to Gram-Negative Ratio*
HT	*High Temperature*
IQ-SASS	*Improved Quantitative Source Assessment of Organic Matter in Soils and Sediments*
m.a.s.l.	*Meters Above See Level*
MeOH	*Methanol*
N_2O	*Nitrous Oxide*
Na_2SO_4	*Sodium Sulfate*
NaOH	*Sodium Hydroxide*
PLFA	*Phospholipid Fatty Acid*
SOC	*Soil Organic Carbon*
SOM	*Soil Organic Matter*
VPDB	*Vienna Pee Dee Belemnite*
WRB	*World Reference Base for Soil Resource*
$\delta^{13}C$	*Stable Carbon Isotope*

1. Introduction

Soil constitutes the primary reservoir of organic carbon in terrestrial ecosystems and plays a pivotal role in the carbon cycle (Streit et al., 2014). Soil microorganisms are essential in the breakdown of organic matter and the cycling of nutrients (Haugwitz et al., 2014; Kaviya et al., 2019). Microorganisms in the soil act as the foremost biological decomposers and constitute a crucial yet relatively small reservoir that processes most of the organic matter found within the soil (Van Veen and Kuikman, 1990). In boreal and temperate forest soils, microorganisms such as fungi and bacteria are the principal decomposers (Berg and McClaugherty, 2014). These microbial groups decompose cellulose, hemicellulose, and various recalcitrant compounds such as lignin (Berg and McClaugherty, 2014). The microbial decomposition of soil organic matter results in the release of greenhouse gases, such as CO_2, CH_4, and N_2O, during soil respiration (Xu and Shang, 2016; Yiqi and Zhou, 2010). Therefore, the microorganisms play a pivotal role in the positive feedback loop in the global climate (Jansson and Hofmockel, 2020). The distribution of soil microorganisms is characterized by a complex interplay of chemical factors, such as nutrient availability and the composition of organic matter, and physical factors, including moisture content and temperature (Castro et al., 2010; Stotzky and Pramer, 1972). It's crucial to note that microbial processes are highly sensitive to changes in temperature, which affect growth and respiration (Bárcenas-Moreno et al., 2009). Additionally, increasing temperatures often reduce the moisture content of the soil and impair the ability of microorganisms to survive and disperse, as well as their capacity to colonize new soil areas (Islam et al., 2020).

While it is widely accepted that climate change is likely to accelerate the decomposition of soil organic matter (SOM) by soil microorganisms, the exact mechanisms involved are still not fully understood (Leirós et al., 1999). For instance, in subalpine regions, lower temperatures have been observed to slow down the decomposition of SOM by soil microorganisms (Hagedorn et al., 2010), resulting in a significant accumulation of labile SOM and soil organic carbon (SOC), which are more susceptible to the impacts of increasing temperatures (D'Alò et al., 2021; Leifeld et al., 2009). However, the extent and speed at which SOM decomposition by soil microorganisms increases under altered climatic conditions, remains a topic of ongoing research (Ofiti et al., 2021). Temperature is a critical factor affecting the activity and composition of soil microbial communities (Pettersson and Bååth, 2003). Increasing temperatures can produce selective pressure on soil microbes and cause alterations in the microbial community composition (Wu et al., 2024).

The phospholipid fatty acid (PLFA) analysis approach examined specific lipids found in the cell membranes of soil microorganisms, allowing for the estimation of microbial biomass and its community structures (Willers et al., 2015). The PLFA analysis in laboratory incubation is a valuable tool for studying the SOM decomposition and the temperature responses of microorganisms interacting with SOM (Feng and Simpson, 2009). The use of PLFAs compared to other biomarkers lies in their ability to indicate the presence of living organisms; this is because they undergo rapid hydrolysis when the cell dies (Yao et al., 2015). The PLFA method enables the detection of various soil microbes, such as saprotrophic fungi, arbuscular mycorrhizal fungi (AMF), Gram-positive (GP) and Gram-negative (GN) bacteria, and actinobacteria (Willers et al., 2015). Previous studies have demonstrated that forest and pasture soils differ in the composition of their microbial communities, with forest soils exhibiting an increased proportion of saprotrophic fungi and a higher fungi-to-bacteria (F/B) ratio (Francisco et al., 2016). The higher abundance of fungi in forest soils compared to pasture soils is attributed to the composition of the litter, which typically contains more chemically resistant carbon compounds in forests than in pastures (Prescott, 2010). Fungi primarily decompose the cellulose and hemicellulose components of wood, which is why they are more abundant in forest soils (Berg and McClaugherty, 2014). Moreover, alpine pasture soils have a higher proportion of Gram-positive compared to Gram-negative bacteria than forest soils (Francisco et al., 2016). Gram-negative and Gram-positive bacteria prefer plant-derived carbon as their carbon source, and Gram-positive bacteria utilize more carbon sources derived from SOM. In contrast, Gram-negative bacteria predominantly use plant biomass (Kramer and Gleixner, 2008). Previous research has also indicated that the relative proportions of Gram-positive and Gram-negative bacteria rise with increasing temperatures (Creamer et al., 2015).

Through an incubation experiment, this study contributes to advancing our understanding of how increased temperatures alter microbial communities and soil respiration in forest and pasture soils within the subalpine region of Jaun, Switzerland.

Research questions and hypotheses:

- How do increasing temperatures affect the soil respiration rates in forest and pasture soils?

It is assumed that increasing temperatures will lead to higher soil respiration. Resulting from increased microbial activity and accelerated carbon degradation (Carey et al., 2016).

- How does litter addition influence the microbial community compositions in forest and pasture soils?

The addition of litter is presumed to induce changes in the composition of microbial communities within forest and pasture soils. Specifically, it is hypothesized that the addition of litter results in a higher Fungal-to-Bacterial (F/B) ratio in both forest and pasture samples.

- How do microbial communities in forest and pasture soils change with increasing temperatures?

The assumption is, that an increase in temperature will results in a higher ratio of Gram-positive to Gram-negative (GP/GN) bacteria in forest and pasture soils.

To test these hypotheses, the incubated samples from forest and pasture, collected throughout the one-year incubation experiment, will be analysed using the PLFA method. The findings are intended to contribute to a better understanding of future climatic changes and their impacts in subalpine regions of Switzerland, enhancing the ability to make more accurate assessments.

2. Material and methods

2.1 Study site

The samples were taken from a specific south-facing slope in Jaun (Figure 1) in the canton of Fribourg in Switzerland (N; 46°37'03.1"E; 7°16'03.9) at an altitude of 1485 m.a.s.l. (Speckert et al., 2023). The soil under investigation has been categorized following the WRB (2014) guidelines as *Leptic Eutric Cambisol* with a clayey composition for both pasture and forest soils. The pasture soil contains 60% clay, 30% silt, and 8% sand, while the forest soil contains 50% clay, 35% silt, and 12% sand. The mean air temperature is 11.4°C in summer and 0.6°C in winter (Hiltbrunner et al., 2013). The forest primarily consisted of the coniferous species Norway Spruce *(Picea abies L.)*, while the pasture soil was predominantly characterized by herbaceous species with ribgrass *(Plantago lanceolata L.)* (Speckert et al., 2023).

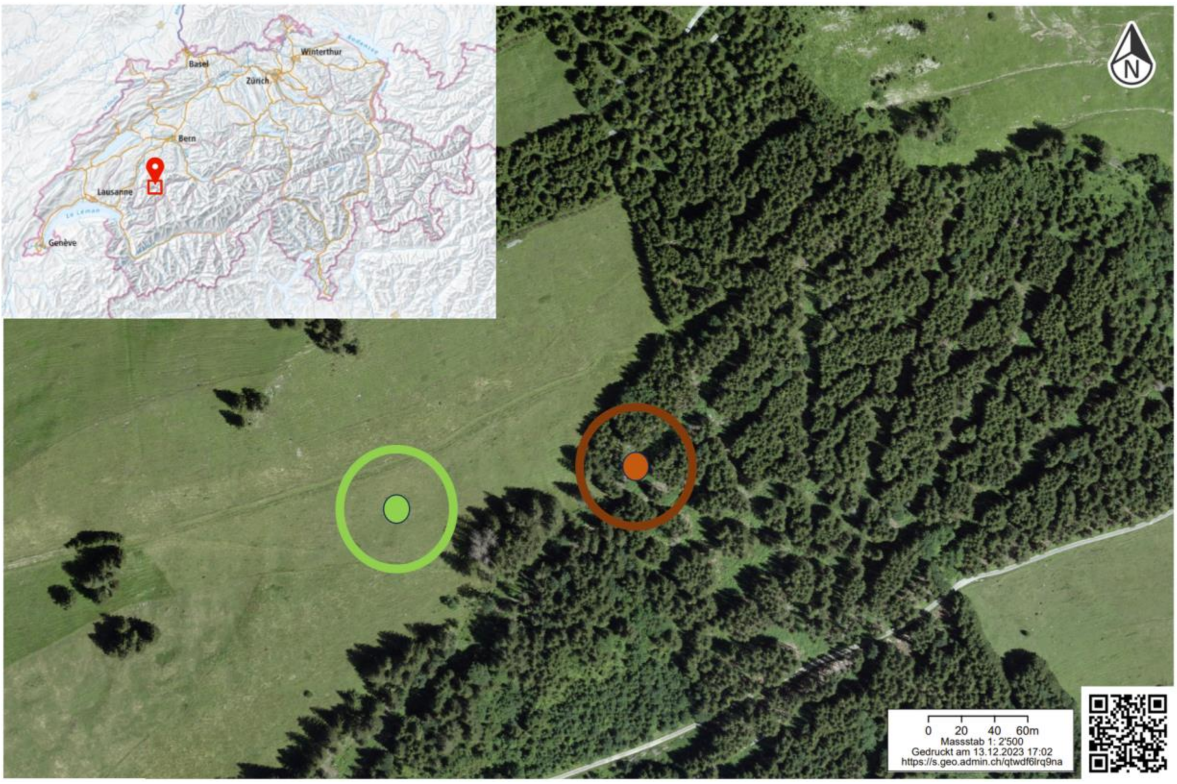

Figure 1: Sampling site in Jaun in the canton of Fribourg in Switzerland, the green circle indicates the pasture, and the brown circle the forest sampling site (Source: Swisstopo.ch).

2.2 Incubation experiment

The incubation project was conducted by Tatjana Carina Speckert and Guido Lars Bruno Wiesenberg in 2021. It is part of the Improved Quantitative Source Assessment of Organic Matter in Soils and Sediments Using Molecular Markers and Inverse Modelling (IQ-SASS) project. Soil samples from pasture and forest sites in Jaun were collected (Figure 1). The collected soil samples were prepared and placed into glass beakers (Figure 2a). These beakers were subsequently positioned inside 1L glass jars (Figure 2b). This arrangement was then pre-incubated for 14-days to stabilize the conditions.

As part of the experiment, ^{13}C-enriched litter (*Lolium perenne L.* litter) was cultivated under controlled laboratory conditions to ensure consistent isotopic enrichment. After the 14- days pre-incubation NaOH traps were installed into the 1L jars (Figure 2b). The CO_2 flux measurements were conducted using these NaOH traps, with the replacement frequency of the traps adjusted as required throughout of the study. The soil samples collected from forest and pasture sites were divided into two distinct categories: a control group and a treatment group with litter addition. Each category comprised 24 jars for the control group and 48 jars for the treatment group, which received ^{13}C-enriched litter. Additionally, there were 12 empty jars included in the study. The addition of litter to the samples marks the beginning of the experiment at t=0. The glass jars, including those containing the samples, the empty control jars, and the jars with added ^{13}C-enriched litter, along with the NaOH traps (Figure 2b), were incubated at three different temperatures to simulate varying climatic conditions: 12.5°C, representing the mean air temperature from March to September at the site, and two increased temperatures of +4°C (16.5°C) and +8°C (20.5°C) (Figure 2c). The moisture level was maintained at about 30% to ensure microbial activity. During the experiment, soil samples were collected at six specific intervals: immediately after the 14-day pre-incubation period (marked as t=0) and subsequently at 28, 56, 168, and 359 days. Soil organic carbon and total nitrogen levels, as well as the stable carbon isotope (δ^{13}C) composition were measured using a Thermo Fisher Scientific Flash HT Elemental Analyzer connected to a Delta V Plus isotope ratio mass spectrometer through ConFlo IV (Thermo Fisher Scientific, Bremen, Germany). The δ^{13}C values are reported per mil (‰) units relative to the Vienna Pee Dee Belemnite (VPDB) standard.

Figure 2: Glass beakers containing 50 g of homogenized soil were prepared for the incubation experiment (a). Arrangement of water, the NaOH trap (in brown glass), and the mineral soil within the incubation jar (b). The placement of jars within one of the incubation chambers (c). Photographs by Guido Lars Bruno Wiesenberg and Tatjana Carina Speckert (2021).

2.3 Analytical methods

2.3.1 Phospholipid fatty acid analysis

The PLFA analysis was conducted by using a modified approach based on the methods described by Wiesenberg and Zosso (2019). For the analysis, exactly 4 grams of milled soil material was weighed into centrifuge tubes. A mixture of extraction solutions was added to the soil samples, consisting of 80 ml of citric acid buffer, 200 ml of methanol (MeOH), and 100 ml of chloroform ($CHCl_3$) was added, maintaining a ratio of 1:2:0.8 ($CHCl_3$: MeOH: citric acid buffer). Additionally, 50 µl of PC 19:0 PLFA (internal standard, concentration = 1.047 mg/ml) dissolved in chloroform ($CHCl_3$) was added (Figure 3a). The soil samples with the added extraction solution and PC 19:0 standard was shaked in centrifuge tubes for 2 hours and then centrifuged for 10 minutes, after that, the supernatant was transferred to separation funnels (Figure 3b). This process was repeated three times, with an additional 10 ml of extraction solution added after each cycle. Afterward, the organic phase separated overnight in the funnels (Figure 3b). The lower phase, containing the PLFAs, was drained into a 100 ml round-bottom flask. The PLFA solution was then concentrated to approximately 100 µl using a Büchi Multivap at 45°C and 500 mbar. Subsequently, the lipid fractions were separated using a column packed with activated silica gel with a pore size of 60 Angstroms (Å) in a 6 ml glass syringe, separated into neutral lipids, glycolipids, and phospholipids. The phospholipid fraction was further purified of water residues through a 1 g Na_2SO_4 column. All fractions were dried under a nitrogen stream and then weighed. The methylation technique was implemented following the procedures described by Wiesenberg and Gocke (2017), the phospholipid fractions were treated with a boron trifluoride-methanol solution and 50 µl of D_{39}:C_{20} standard was added and then heated at 63°C and neutralized with Millipore water. This process converts the lipids into methyl ester forms for gas chromatography analysis.

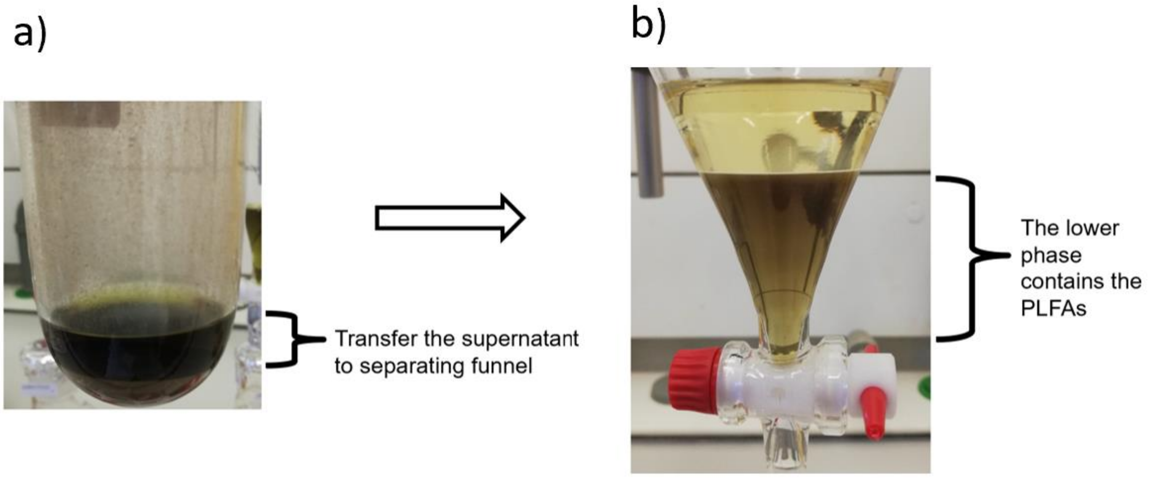

Figure 3: Soil samples with the added extraction solution (a). Transferred supernatant in separation funnels (b), after they stand overnight. Photographs by Philipp Zürcher (2023).

2.3.2 Gas chromatography and mass spectrometry

The methylated fatty acids were transferred into GC autosampler vials with inlet and subsequently measured on a gas chromatography flame ionization detector (GC-FID; 7890B Agilent Technologies, Inc.) and on a gas chromatography mass spectrometer (GC-MS; 5973 Agilent Technologies, Inc.). Depending on the concentration of fatty acids present in the samples, between 1 to 3 µl were injected into the GC-FID or GC-MS for analysis. The settings for the GC-FID and GC-MS were adapted from Wiesenberg and Gocke (2017). A column of 50 m × 0.2 mm × 0.33 µm dimensions and a temperature protocol starts at 50°C, maintaining this temperature for 4 minutes, then to 150°C at a rate of 10°C/min. Subsequent incremental increases followed: 2°C per minute up to 160°C, 0.5°C/min to 170°C, 0.2°C/min and from 170°C to 190°C, and finally, 2°C per minute advancing from 190°C to 210°C, culminating at 320°C where it was sustained for 15 min. The identification of the target compounds was achieved by comparing the mass spectra with an external standard and referencing the NIST mass spectra library. The target compounds were assigned according to the criteria established by Willers et al. (2015), encompassing specific compounds for different microorganisms such as Gram-positive bacteria (GP; $iC_{14:0}$, $iC_{15:0}$, $aC_{15:0}$, $iC_{16:0}$, $aC_{16:0}$, $iC_{17:0}$, $aC_{17:0}$), Gram-negative bacteria (GN; $C_{16:1\omega7c}$, $C_{16:1\omega9c}$, $C_{18:1\omega9t}$, $C_{18:1\omega5c}$, $cyC_{18:0}$,

$C_{19:0}$, $C_{20:0}$, $C_{20:1\omega9c}$), arbuscular mycorrhizal fungi (AMF) ($C_{16:1\ \omega5c}$), saprotrophic fungi ($C_{18:2\omega9c}$), and actinobacteria (10Me$C_{16:0}$, 10Me$C_{18:0}$).

2.3.3 Infrared spectroscopy

Complementary to the PLFA analysis, diffuse reflectance infrared Fourier transform (DRIFT) spectroscopy was performed to obtain a more comprehensive overview of the overall chemical compositions of the respective soil samples (Haberhauer and Gerzabek, 1999). To evaluate the composition of SOM from the pasture and forest samples, a 6 mg sample of finely ground soil was analysed by using DRIFT spectroscopy. Mid-infrared spectra were analysed in a range from 4000 to 400 cm^{-1} with an average of 16 scans per sample at a resolution of 4 cm^{-1}. The infrared absorption peaks were identified and associated with specific functional groups, including aliphatic C–H at 2900 cm^{-1}, aromatic esters and carbonyl/carboxyl groups at 1735–1720 cm^{-1}, aromatic C–C bonds at 1660–1600 and 1430–1380 cm^{-1}, lignin-like compounds at 1515–1500 cm^{-1}, phenolic and cellulose substances at 1260–1210 cm^{-1}, and aromatic C–H structures at 880, 805, and 745 cm^{-1} (Ofiti et al., 2021).

2.3.4 Phospholipid fatty acid indices

Various ratios were calculated to investigate changes in the microbial communities of forest and pasture samples in relation to increased temperatures. The fungi-to-bacteria (F/B) ratio can indicate stress, for example, with increasing temperatures, where fungi are generally more sensitive to such environmental changes than bacteria (Bailey et al., 2002; Haugwitz et al., 2014). This ratio was calculated using the PLFA biomass of fungi (saprotrophic fungi and AMF) divided by the PLFA biomass of bacteria (GP, GN, actinobacteria). The ratio of Gram-positive to Gram-negative bacteria (GP/GN) was also calculated; this ratio increases under stress conditions such as increasing temperatures (Fanin et al., 2019). The GP/GN ratio was also calculated to investigate how the proportions of GP to GN change with increasing temperatures. This involved dividing the PLFA biomass of GP by that of GN. Additionally, the GP/AMF ratio was calculated to observe how the proportions of GP to AMF change under increasing temperatures. This ratio was determined by dividing the PLFA biomass of GP by that of AMF.

2.3.5 Statistical Analysis

The data analysis was conducted using R Software version 4.2.3 (R Core Team, 2023) in a comprehensive manner. This includes a two-way ANOVA ($p < 0.05$) to determine if there was a significant variance between the control and with litter addition in pasture and forest samples with respect to increasing temperatures, followed by a Tukey HSD post-hoc test (adjusted $p < 0.95$). The analysis of PLFAs was carried out in single measurements ($n = 1$). Pearson correlation ($p < 0.95$) was used to assess correlations with increasing temperatures.

3. Results

3.1 Carbon to nitrogen ratio

During the initial 14 days of the experiment, the carbon-to-nitrogen (C/N) ratio in the forest control samples increased across all three temperatures, as shown in figure 4a. At 12.5°C, the C/N ratio increased by 14% (from 12.46 ± 0.11 to 14.24 ± 1.02), at 16.5°C it increased by 10% (from 12.47 to 13.69 ± 0.19), and at 20.5°C by 7% (from 12.58 ± 0.50 to 13.46 ± 0.30). Following this period, the C/N ratio began to diminish over the next two weeks: it declined by 3% (from 14.24 ± 1.02 to 13.87 ± 0.01) at 12.5°C, by 0.5% (from 13.69 ± 0.19 to 13.65 ± 0.68) at 16.5°C, and by 1% (from 13.46 ± 0.30 to 13.32 ± 0.06) at 20.5°C. Until the end of the experiment, further reduction were recorded: 20% (from 13.87 ± 0.01 to 11.05 ± 1.68) at 12.5°C, 10% (from 13.65 ± 0.68 to 12.32 ± 0.46) at 16.5°C, and 11% (from 13.32 ± 0.06 to 11.82 ± 0.61) at 20.5°C. Statistical analysis indicated no significant differences in C/N ratios between the temperature settings (p-values ranging from 0.586 to 0.957).

In the initial 14 days of the experiment, the C/N ratio in the forest samples with litter addition demonstrated significant decreases ($p < 0.001$) across all temperature settings, as shown in Figure 4b. Specifically, the C/N ratio at 12.5°C decreased by 15% (from 13.56 ± 0.02 to 11.59 ± 0.45), at 16.5°C by 14% (from 13.56 ± 0.42 to 11.68 ± 0.22), and at 20.5°C by 19% (from 13.86 to 11.16 ± 0.32). Following this initial decline, the C/N ratio at 12.5°C continued to decrease by 7% (to 10.77 ± 0.26) and at 16.5°C by 7% (to 10.87 ± 0.21) up to day 28. In contrast, at 20.5°C, the C/N ratio slightly increased by 4% (to 11.66 ± 0.72). Until the end of the experiment, the C/N ratio had continued to increase in all three temperatures: at 12.5°C by 14% (to 12.28 ± 0.38), at 16.5°C also by 14% (to 12.44 ± 0.41), and at 20.5°C by 5% (to 12.21 ± 0.41). Statistical analysis revealed no significant differences in the C/N ratio among the temperature profiles during the study period. Between 12.5°C and 16.5°C ($p = 0.428$), between 12.5°C and 20.5°C ($p = 0.337$), and between 20.5°C and 16.5°C ($p = 0.974$). However, the differences between the forest control samples and those with litter addition were statistically significant at 12.5°C ($p < 0.01$), 16.5°C ($p < 0.001$), and 20.5°C ($p < 0.05$).

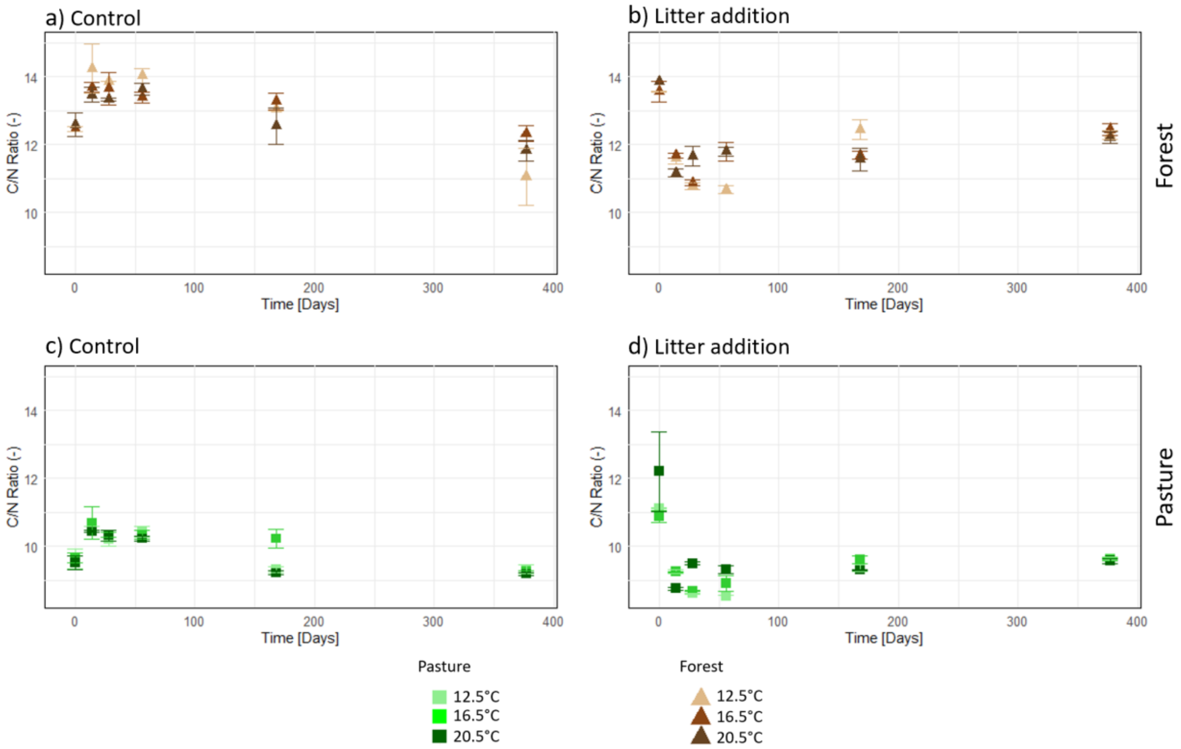

Figure 4: The C/N ratio of forest and pasture samples control and with litter addition. Forest control (a), forest with litter addition (b), pasture control (c), pasture with litter addition (d). The x-axis of the graph displayed the time in days, showcasing the duration of the experiment. The y-axis represents the C/N ratio (-).

In the initial 14 days of the experiment, the C/N ratio in the pasture control samples showed a increase across all three temperature conditions ($p < 0.001$), as shown in figure 4c. Specifically, the C/N ratio at 12.5°C increased by 9% (from 9.63 ± 0.39 to 10.53 ± 0.09), at 16.5°C by 11% (from 9.65 ± 0.21 to 10.69 ± 0.69), and at 20.5°C by 10% (from 9.52 ± 0.29 to 10.44 ± 0.04). Subsequently, from day 14 to 28, there was a reduction in the C/N ratio at 12.5°C by 3% (to 10.21 ± 0.30), and at 16.5°C by 3% (to 10.34 ± 0.09), and at 20.5°C by 1% (to 10.31 ± 0.24). Until the end of the experiment, further reductions were observed; at 12.5°C by 9% (to 9.32 ± 0.25), at 16.5°C by 11% (to 9.26 ± 0.06), and at 20.5°C also by 11% (to 9.18 ± 0.11). The differences among the temperatures were not significant, between 12.5°C and 16.5°C ($p = 0.993$), between 12.5°C and 20.5°C ($p = 0.998$), between 20.5°C and 16.5°C ($p = 0.930$).

Conversely, in the pasture samples with litter addition, the C/N ratio decreased significantly within the first 14 days across all temperatures ($p < 0.001$) as shown in figure 4d. At 12.5°C, the decrease was 17% (from 11.13 ± 0.03 to 9.24 ± 0.17), at 16.5°C 15% (from 10.88 ± 0.25

to 9.24 ± 0.05), and at 20.5°C 28% (from 12.21 ± 1.66 to 8.75 ± 0.13). From day 14 to 28, the reduction persisted at 12.5°C by 7% (to 8.60 ± 0.06), at 16.5°C by 6% (to 8.68 ± 0.05), and at 20.5°C it increases by 22% (to 9.49 ± 0.10). Towards the end of the study period, there was an increase in the C/N ratio at 12.5°C by 12% (to 9.63 ± 0.12) and at 16.5°C by 4% (to 9.61 ± 0.13), a slight increase of 2% occurred at 20.5°C (to 9.56 ± 0.17). The interactions between different temperatures were not significant, between 12.5°C and 16.5°C ($p = 0.998$), between 12.5°C and 20.5°C ($p = 0.731$), between 20.5°C and 16.5°C ($p = 0.970$). However, the comparisons between the pasture control samples and those with litter addition at 16.5°C revealed a statistically significant difference ($p < 0.05$). In contrast, at 12.5°C ($p = 0.053$) and 20.5°C ($p = 0.798$), no significant differences were detected.

3.2 Stable carbon isotopes

The δ^{13}C values showed significant decreases ($p < 0.001$) in forest samples with litter addition across all temperatures within the first 14 days of the experiment, as illustrated in figure 5a. At 16.5°C, there was a decrease of 42% from 532.02 ± 83.09‰ to 307.01 ± 9.26‰. At 12.5°C, the decrease was 27% from 508.22 ± 28.01‰ to 368.57 ± 34.09‰, and at 20.5°C, the decrease was 22% from 370.78‰ to 289.23 ± 18.36‰. From day 14 to day 28, the values continued to decline: at 16.5°C by 9% to 280.07 ± 15.91‰, at 20.5°C by 10% to 259.88 ± 13.32‰, and at 12.5°C by 17% to 305.69 ± 10.86‰. From day 28 until the end of the experiment, δ^{13}C values decreased further: by 58% to 177.73 ± 11.39‰ at 16.5°C, by 50% to 173.35 ± 25.38‰ at 20.5°C, and by 41% to 216.71 ± 32.42‰ at 12.5°C.

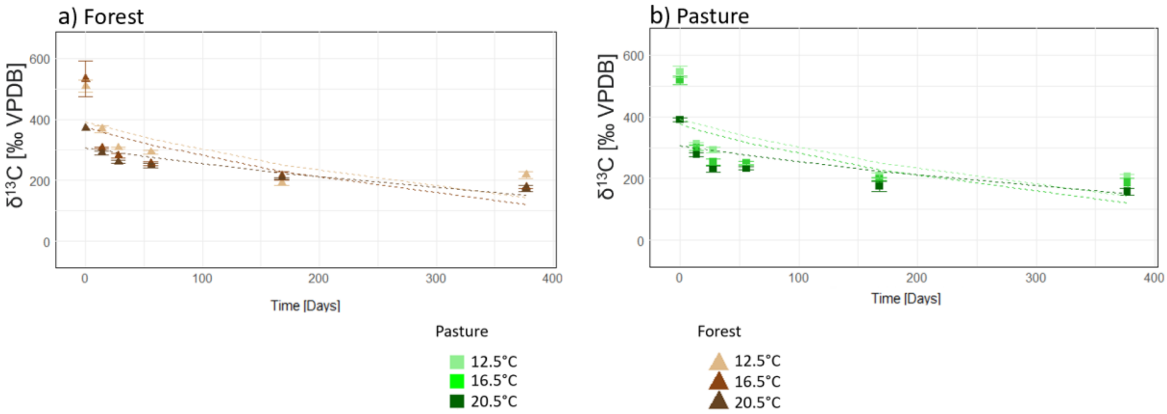

Figure 5: Values of δ^{13}C during the one-year incubation experiment for the samples with litter addition. Forest (a), pasture (b). The x-axis of the graph displayed the time in days, showcasing the duration of the experiment. The y-axis represents δ^{13}C values in ‰ VPDB.

Significant decreases in δ^{13}C were observed ($p < 0.001$) across all temperatures in pasture samples with litter addition within the first 14 days of the experiment, as shown in figure 5b. At 12.5°C, the values decreased by 43% from 545.98 ± 26.92‰ to 312.27 ± 13.42‰. At

16.5°C, the decrease was 42% from 517.98 ± 19.97‰ to 299.63 ± 26.64‰, and at 20.5°C, it was 29% from 390.73 ± 10.16‰ to 276.50 ± 19.94‰. From day 14 to day 28, further declines were noted: at 12.5°C by 6% to 292.90 ± 26.19‰, at 16.5°C by 16% to 252.74 ± 22.77‰, and at 20.5°C by 17% to 230.46 ± 25.14‰. From day 28 to the end of the experiment, $\delta^{13}C$ values continued to decrease: by 32% to 157.44 ± 26.73‰ at 20.5°C, by 29% to 207.05 ± 14.83‰ at 12.5°C, and by 27% to 184.83 ± 38.93‰ at 16.5°C.

Compared to the natural $\delta^{13}C$ abundance in the forest and pasture control samples, which ranged between -25.66 ± 0.26‰ and -26.77 ± 0.00‰ throughout the experiment, the $\delta^{13}C$ values in groups with litter addition remained significantly higher ($p < 0.001$) over the incubation period.

3.3 Infrared spectroscopy

At the start of the experiment, the forest control samples displayed a similar composition at 12.5°C and 20.5°C (Figure 6a, c, e). The proportion of phenolic cellulose was 4.09% at 12.5°C and 3.56% at 20.5°C, reflecting a difference of approximately 13%. At 16.5°C, phenolic cellulose with a higher proportion of 17.65%, which was 64% higher than at 12.5°C ($p = 0.916$) and 80% higher than at 20.5°C ($p = 0.942$). Moreover, at 16.5°C, the proportion of aliphatic C-H was lower at 1.88% compared to 9.57% at 12.5°C ($p = 0.922$) and 8.65% at 20.5°C ($p = 0.922$). After 28 days of incubation, the differences in the composition of carbon compounds diminished, with only minor variations. By the end of the experiment, the proportion of phenolic cellulose was higher at 16.5°C, recording 12.29% compared to 4.14% at 12.5°C ($p = 0.994$) and 4.17% at 20.5°C ($p = 0.982$).

The forest samples with litter addition with a comparable composition of organic carbon compounds at 12.5°C and 20.5°C at the beginning of the experiment (Figure 6b, d, f). Specifically, the proportion of phenolic cellulose was 17.02% at 12.5°C and 19.27% at 20.5°C, indicating a difference of approximately 13%. At 16.5°C, the proportion of phenolic cellulose was lower, recorded at 3.4% compared to 17.02% at 12.5°C ($p = 0.923$) and 19.27% at 20.5°C ($p = 0.923$). Furthermore, at 16.5°C, a higher proportion of aliphatic C-H was observed at 9.91%, compared to 3.02% at 12.5°C ($p = 0.918$) and 2.72% at 20.5°C ($p = 0.972$).

Compared to the control, the forest samples with litter addition exhibited higher proportions of phenolic cellulose at the beginning of the experiment. At 12.5°C, the phenolic cellulose in the with litter addition samples was 17.02%, compared to 4.09% in the control ($p = 0.932$). At 20.5°C, the proportion was 19.26%, also higher than the 3.55% observed in the control (p = 0.932). Additionally, the proportion of lignin residues was higher with litter addition; at 12.5°C, it was 3.02%, compared to 1.46% in the control (p = 0.916). At 20.5°C, it was 3.34%, compared to 0.86% in the control (p = 0.925). Conversely, at 16.5°C, the proportion of lignin residues was lower at 1.72%, compared to 3.18% in the control (p = 0.961).

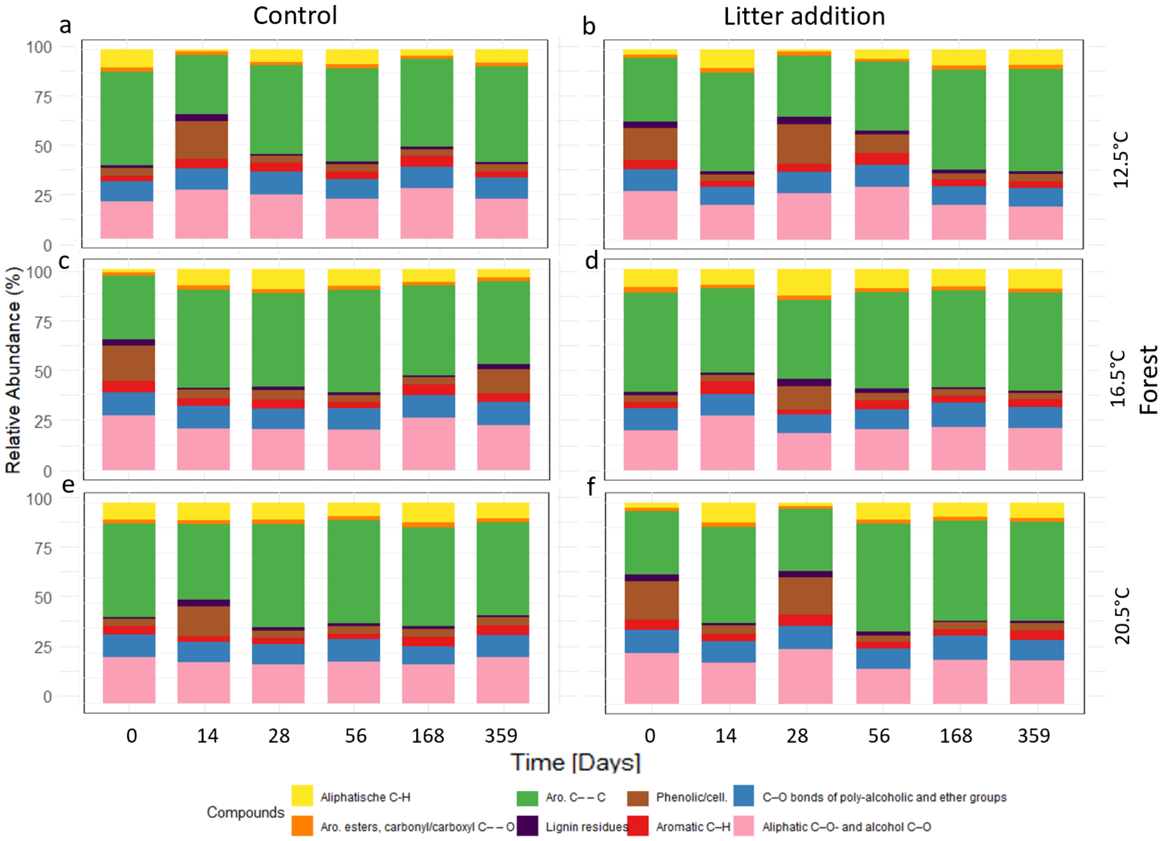

Figure 6: Carbon compounds of forest samples. The control samples (a, c, e), samples with litter addition (b, d, f). For the three different temperatures (12.5°C, 16.5°C and 20.5°C). The x-axis of the graph displayed the time in days, showcasing the duration of the experiment. The y-axis represents the relative abundance of the different carbon compounds.

In the pasture control samples, the initial proportion of phenolic cellulose was highest at 20.5°C, with 3.87%, followed by 12.5°C, with 3.86%, and the lowest at 16.5°C, with 3.66% (Figure 7a, c, e). By day 14 of the experiment, the proportion of phenolic cellulose increased across all three temperatures: from 3.86% to 16.49% at 12.5°C, from 3.66% to 14.09% at 16.5°C, and from 3.87% to 15.71% at 20.5°C. Similarly, the proportion of lignin residues increased by day 14 at all temperatures: from 0.95% to 3.08% at 12.5°C, from 0.95% to 3.38% at 16.5°C, and from 0.82% to 3.03% at 20.5°C.

In the pasture samples with litter addition, the initial content of phenolic cellulose was highest at 20.5°C, with 17.65%, and then at 12.5°C, with 15.24%, with a difference of approximately 11% (Figure 7b, d, f). The lowest content was at 16.5°C, with 3.13%, representing a decrease (p = 0.923) of approximately 12% compared to 12.5°C. The highest initial proportion of aliphatic C-H was observed at 16.5°C, with 13.71%, compared to 12.5°C, with 5.69%, representing a decrease ($p = 0.803$) of approximately 8%, the lowest proportion was at 20.5°C, with 3.73%.

Compared to the control, the pasture samples with litter addition shown an initial increase ($p = 0.708$) in the proportion of phenolic cellulose by approximately 12% at 12.5°C, and by approximately 14% at 20.5°C ($p = 0.688$). At 16.5°C, there was a decrease of approximately 0.3%.

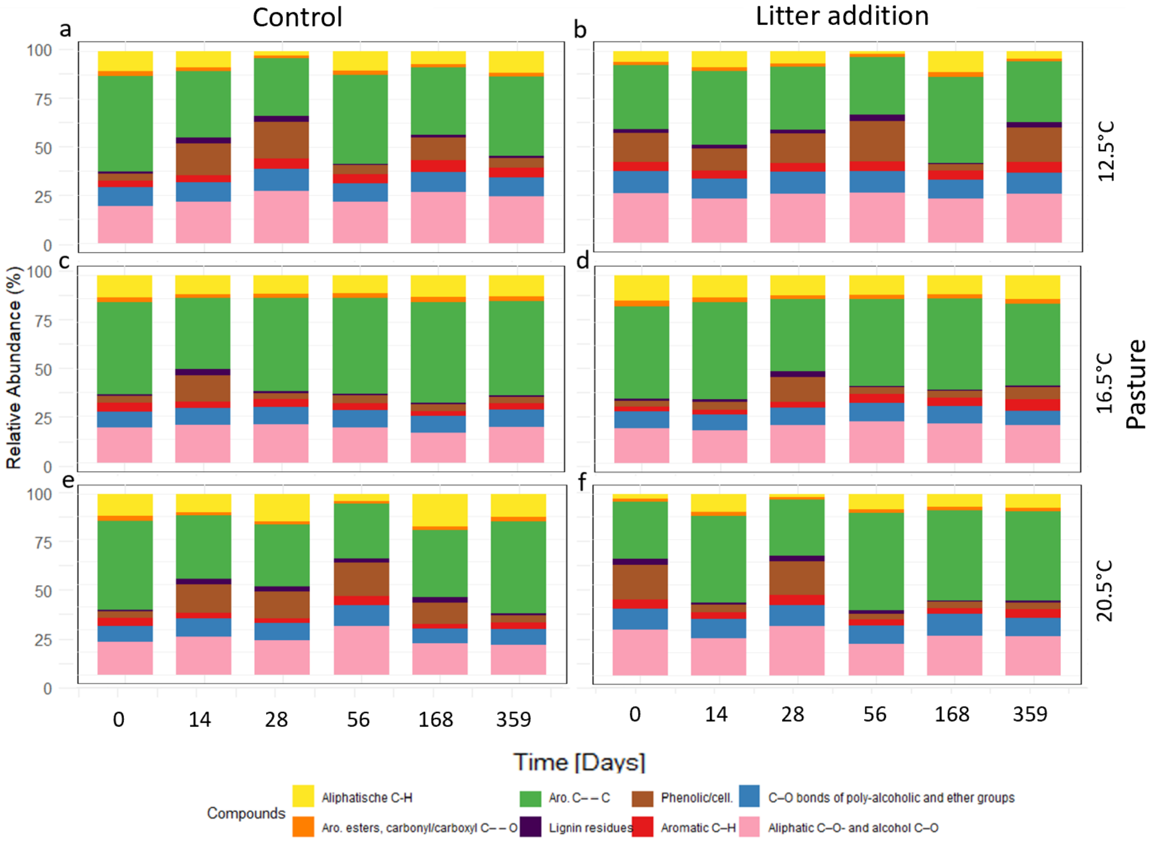

Figure 7: Carbon compounds of pasture samples. The control samples (a, c, e), samples with litter addition (b, d, f). For the three different temperatures (12.5°C, 16.5°C and 20.5°C). The x-axis of the graph displayed the time in days, showcasing the duration of the observation of experiment. The y-axis represents the relative abundance of the different carbon compounds.

3.4 Soil respiration

With increasing temperatures, the summarized basal respiration in the forest and pasture control samples indicated a weak correlation ($r = 0.150$, $p = 0.102$) (Figure 8a). The highest summarized basal respiration in the control was observed in the pasture at a temperature of 16.5°C, with 6.85 g C-CO_2, followed by a decrease ($p = 0.996$) of approximately 3% at 20.5°C, with 6.64 g C-CO_2, and then by a decrease ($p = 0.972$) of approximately 6% at 12.5°C, with 6.26 g C-CO_2. The lowest summarized basal respiration in the control occurred in the forest at 12.5°C, with 5.34 g C-CO_2, with no significant differences ($p = 0.756$) to the pasture at the same temperature. Summarized basal respiration in the forest control was highest at 20.5°C, with 6.62 g C-CO_2, exhibiting a slight difference ($p = 0.998$) of approximately 0.3% to the pasture at 20.5°C, with 6.64 g C-CO_2. Notably, the respiration rate in the forest at 20.5°C began to increase by approximately 11% from day 215, from 5.36 g C-CO_2 to day 249, with 5.93 g C-CO_2, and by approximately 9% to day 277, with 6.48 g C-CO_2.

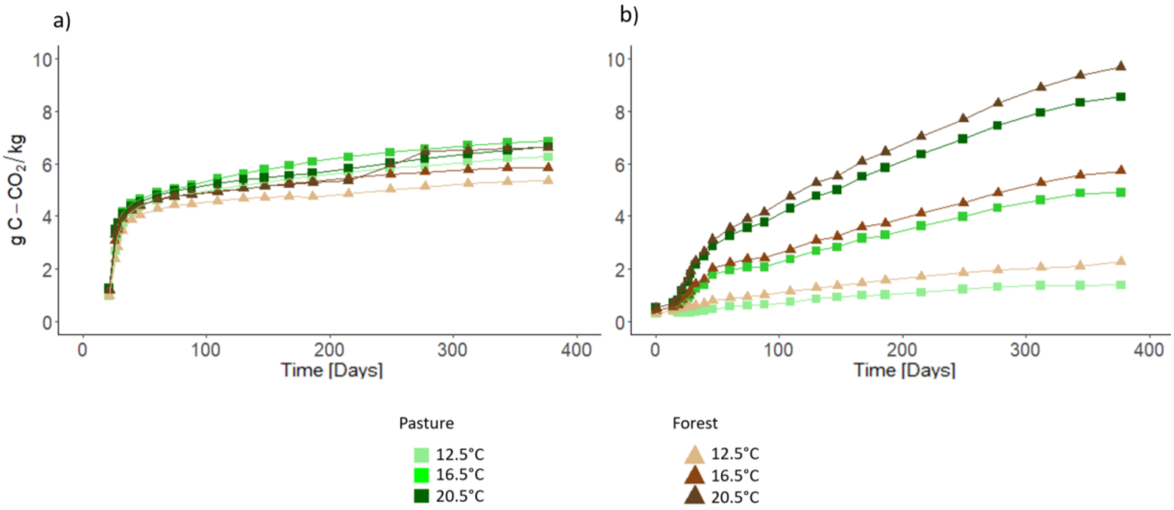

Figure 8: Summarized basal soil respiration data from the control samples (a). Summarized basal soil respiration data with litter addition minus the summarized basal soil respiration from the control (b). The x-axis of the graph displayed the time in days, showcasing the duration of the observation of experiment. The y-axis represents the soil respiration rates, indicating the released amount of carbon dioxide (CO_2).

The summarized basal soil respiration rates with litter addition were the highest across all three temperatures in the forest (Figure 8b). Pasture and forest respiration rates significantly increased ($r = 0.605$, $p < 0.001$) with increasing temperatures. Notably, at 20.5°C, the forest displayed the highest respiration rates, at 9.69 g C-CO_2, compared to the pasture at the same temperature, which was 8.54 g C-CO_2, a decrease ($p = 0.969$) of approximately 13%. In contrast, the lowest temperature of 12.5°C resulted in the lowest respiration rates for the forest, at 2.28 g C-CO_2, and for the pasture, at 1.4 g C-CO_2, with a difference ($p = 0.980$) of approximately 60%.

3.5 Phospholipid fatty acids

In the initial phase, the microbial community composition of the forest control samples (Figure 9a, c, e) showed no significant differences between 12.5°C and 16.5°C for both Gram-positive bacteria ($p = 0.662$) and Gram-negative bacteria ($p = 0.288$). Between 20.5°C and 12.5°C, a significant increase ($p < 0.05$) in Gram-positive bacteria and a decrease ($p < 0.05$) in Gram-negative bacteria were observed. The proportion of Gram-positive bacteria increased from 41.4% at 12.5°C to 42.4% at 16.5°C and further to 57.2% at 20.5°C, an increase of 16%. Gram-negative bacteria decreased from 38.7% at 12.5°C to 36.7% at 16.5°C, and to 25.8% at 20.5°C. Initially, no differences in AMF were noted between 12.5°C and 16.5°C, both registering a proportion of approximately 0.04%. However, this proportion decreased by 50% to 0.02% at 20.5°C. The proportion of actinobacteria showed minimal differences: 0.13% at 12.5°C, 0.15% at 16.5°C, and 0.13% at 20.5°C. Saprotrophic fungi decreased with increasing temperatures: 0.020% at 12.5°C, 0.015% at 16.5°C, and a 60% decrease to 0.006% at 20.5°C compared to 16.5°C. Over the 359 days until the experiment's end, the proportion of Gram-positive bacteria in the forest control samples at 12.5°C increased by 12% to 53.2%. Similarly, at 16.5°C, it increased by 13% to 54.8%. At 20.5°C, there was a slight decrease of 3%, resulting in a final proportion of 54.6%.

Initially, the microbial community composition of the forest samples with litter addition (Figure 9b, d, f) showed no significant differences for Gram-positive bacteria between the temperatures at 12.5°C and 16.5°C ($p = 0.414$), and between 12.5°C and 20.5°C ($p = 0.333$). The proportions of Gram-positive bacteria were 41.6% at 12.5°C, 40.6% at 16.5°C, and increased to 48.0% at 20.5°C, marking an increase of 6% compared to 12.5°C. For Gram-negative bacteria, the proportions were 35.3% at 12.5°C, 35.4% at 16.5°C, and 32.2% at 20.5°C. Initially, no differences in arbuscular mycorrhizal fungi (AMF) were noted between 12.5°C and 16.5°C, both recording a proportion of approximately 0.03%. The proportion decreased by approximately 30% to 0.02% at 20.5°C. The proportion of actinobacteria with no difference between 12.5°C and 16.5°C, both achieved 0.10%, but at 20.5°C, it increased by approximately 20% to 0.12%. The proportion of saprotrophic fungi initially increased with rising temperatures, from 0.097% at 12.5°C to 0.101% at 16.5°C. However, there was a subsequent decrease of approximately 53% to 0.047% at 20.5°C. Over the 359-day period until the end of the experiment, the proportion of Gram-positive bacteria in the forest samples with litter addition at 12.5°C increased by 19% to 59.4%. Similarly, at 16.5°C, it increased by 19% to 67.3%, and at 20.5°C, there was an increase of 12% to 59.7%. The comparison of the forest control samples to those with litter addition in the initial phase revealed different results. The proportion of saprotrophic fungi significantly increased with litter addition. At 12.5°C, there was an increase of 390% from 2% to 9.8%. Similarly, at 16.5°C, the increase was 540% from 1.6% to 10.2%, and at 20.5°C, there was an increase of 585% from 0.7% to 4.8%.

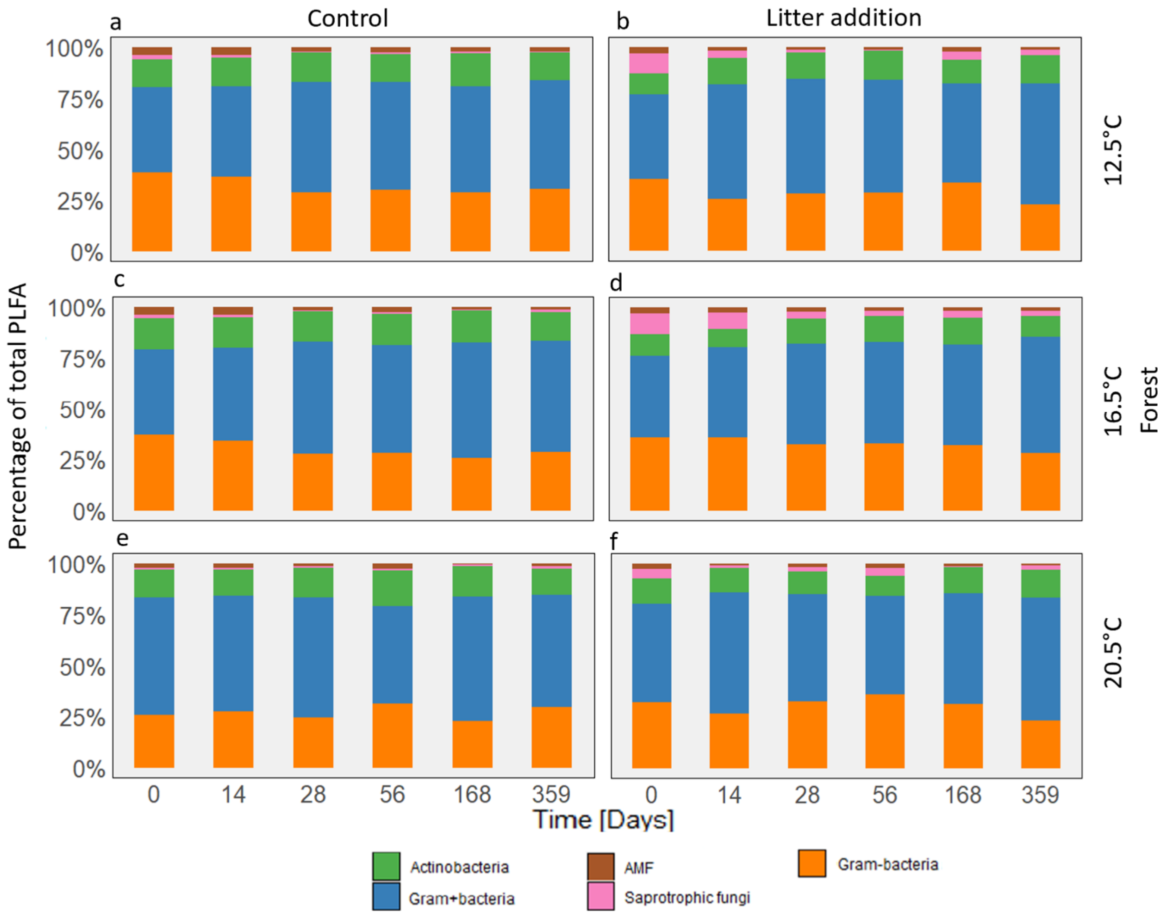

Figure 9: PLFA analysis of the forest samples, the control samples (a, c, e) and the samples with litter addition (b, d, f). For the three different temperatures (12.5°C, 16.5°C and 20.5°C). The x-axis of the graph displayed the time in days, showcasing the duration of the experiment. The y-axis represents the relative abundance of total PLFA.

During the initial phase, the analysis of forest control samples (Figure 10a, c, e) revealed a varied distribution of total PLFA content measured in nmol/g^{-1}. The highest content was found at 16.5°C, with 349.09 nmol/g^{-1}. This was higher than at 12.5°C, which recorded 193.87 nmol/g^{-1}, and more than the lowest measurement of 120.70 nmol/g^{-1} at 20.5°C. By the end of the sampling period, the highest total PLFA content shifted to 12.5°C, with 175.56 nmol/g^{-1}, with a decrease to 104.31 nmol/g^{-1} at 20.5°C and further to 99.74 nmol/g^{-1} at 16.5°C.

The forest samples with litter addition (Figure 10b, d, f) displayed a different trend in the initial phase. The highest PLFA content was also at 16.5°C but at a lower level of 251.34 nmol/g^{-1}, followed by 210.38 nmol/g^{-1} at 12.5°C. The smallest content was observed at 20.5°C, still maintaining 201.73 nmol/g^{-1}. As the study progressed to its final sampling, PLFA content was highest at 12.5°C with 132.41 nmol/g^{-1}, then at 16.5°C with 117.45 nmol/g^{-1}, and lowest at 20.5°C, which recorded 91.51 nmol/g^{-1}.

A comparative analysis between the initial PLFA contents in the forest control and those with litter addition unveils notable differences. At 12.5°C, control samples with a 9% lower PLFA content (193.87 nmol/g^{-1}) compared to the samples with litter addition (210.38 nmol/g^{-1}). In contrast, at 16.5°C, control samples exhibited a 40% higher PLFA content (349.09 nmol/g^{-1}) than the those with litter addition (251.34 nmol/g^{-1}). Additionally, at 20.5°C, the samples with litter addition had an 84% higher PLFA content (191.51 nmol/g^{-1}) compared to the control samples (104.31 nmol/g^{-1}).

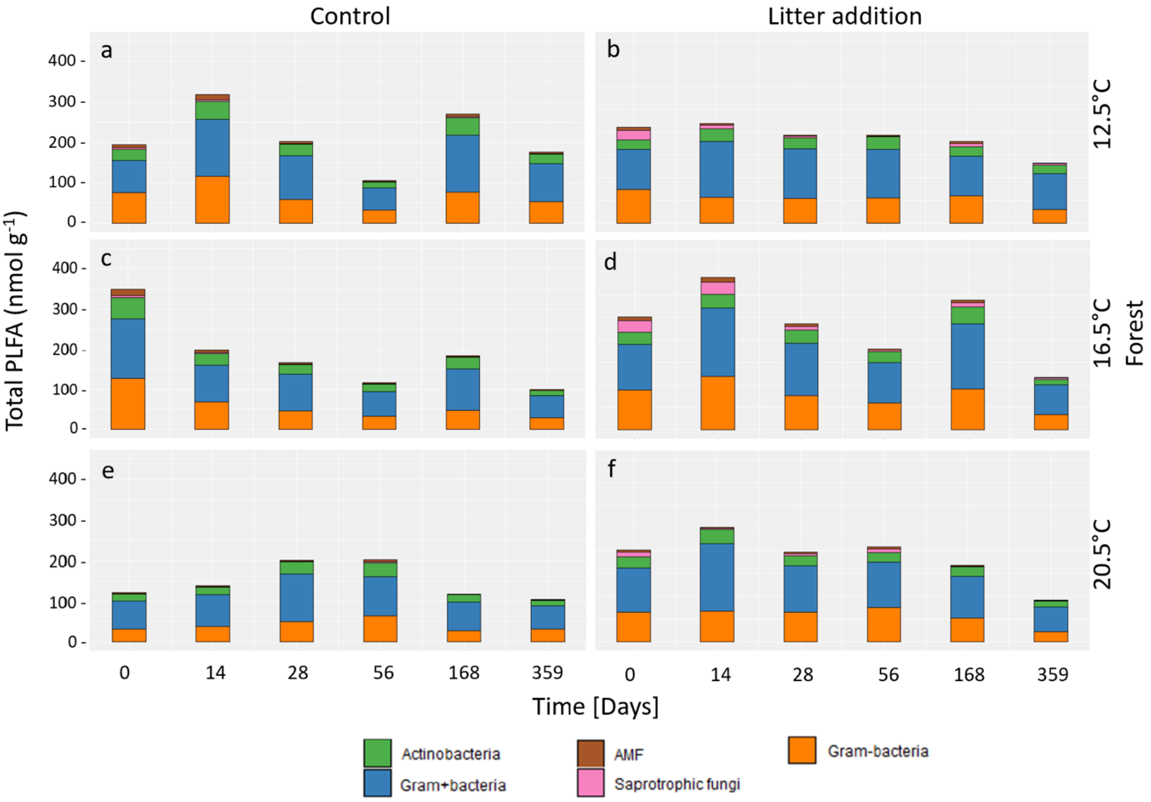

Figure 10: Total PLFA content of the forest samples, the control samples (a, c, e) and the samples with litter addition (b, d, f). The x-axis of the graph displayed the time in days, showcasing the duration of the experiment. The y-axis represents the total PLFA in nmol g^{-1}.

In the initial phase, analysis of the pasture control samples (Figure 11a, c, e) revealed variations in microbial communities across different temperatures. At 16.5°C, Gram-positive bacteria were 41.3%, increasing slightly to 42.7% at 12.5°C and reaching 49.2% at 20.5°C, marking a 7% increase compared to 16.5°C. Conversely, Gram-negative bacteria initially rose from 38.7% at 12.5°C to 39.4% at 16.5°C, and decreased to 33.3% at 20.5°C. The proportion of AMF remained stable at around 0.04% between 12.5°C and 16.5°C, but decreased by 25% to 0.03% at 20.5°C. Actinobacteria proportions stayed consistent at 0.13% across all temperatures. Saprotrophic fungi exhibited dynamic changes, increasing by 40% from 0.013% at 12.5°C to 0.018% at 16.5°C, then decreasing by 55% to 0.008% at 20.5°C.

Until the end of the experiment, Gram-positive bacteria in the control samples rose by 19% to 61.6% at 12.5°C, 20% to 61.2% at 16.5°C, and 8% to 57.0% at 20.5°C. In the initial phase, the samples with litter addition (Figure 11b, d, f), the proportion of Gram-positive bacteria were 43.8% at 12.5°C, decreased to 41.4% at 16.5°C, and then increased to 46.4% at 20.5°C. This represented a 3% increase from 12.5°C and a 5% from 16.5°C. Gram-negative bacteria displayed minor fluctuations, with 35.9% at 12.5°C, decreasing to 33.0% at 16.5°C, and slightly rising to 34.1% at 20.5°C. At the beginning, AMF remained constant at 0.03% across all temperatures. The proportion of actinobacteria was uniform at 0.11% at both 12.5°C and 20.5°C, with a modest increase of 8% to 0.12% at 16.5°C. In contrast, saprotrophic fungi increased by 65% from 0.060% at 12.5°C to 0.099% at 16.5°C, then decreased by 50% to 0.051% at 20.5°C. Until the end of the experiment, the proportion of Gram-positive bacteria in pasture samples with litter addition exhibited significant increases: of 19% to 62.8% at 12.5°C, of 28.0% to 69.4% at 16.5°C, and of 22.0% to 68.8% at 20.5°C. A comparison between control samples and those with litter addition showed differences,

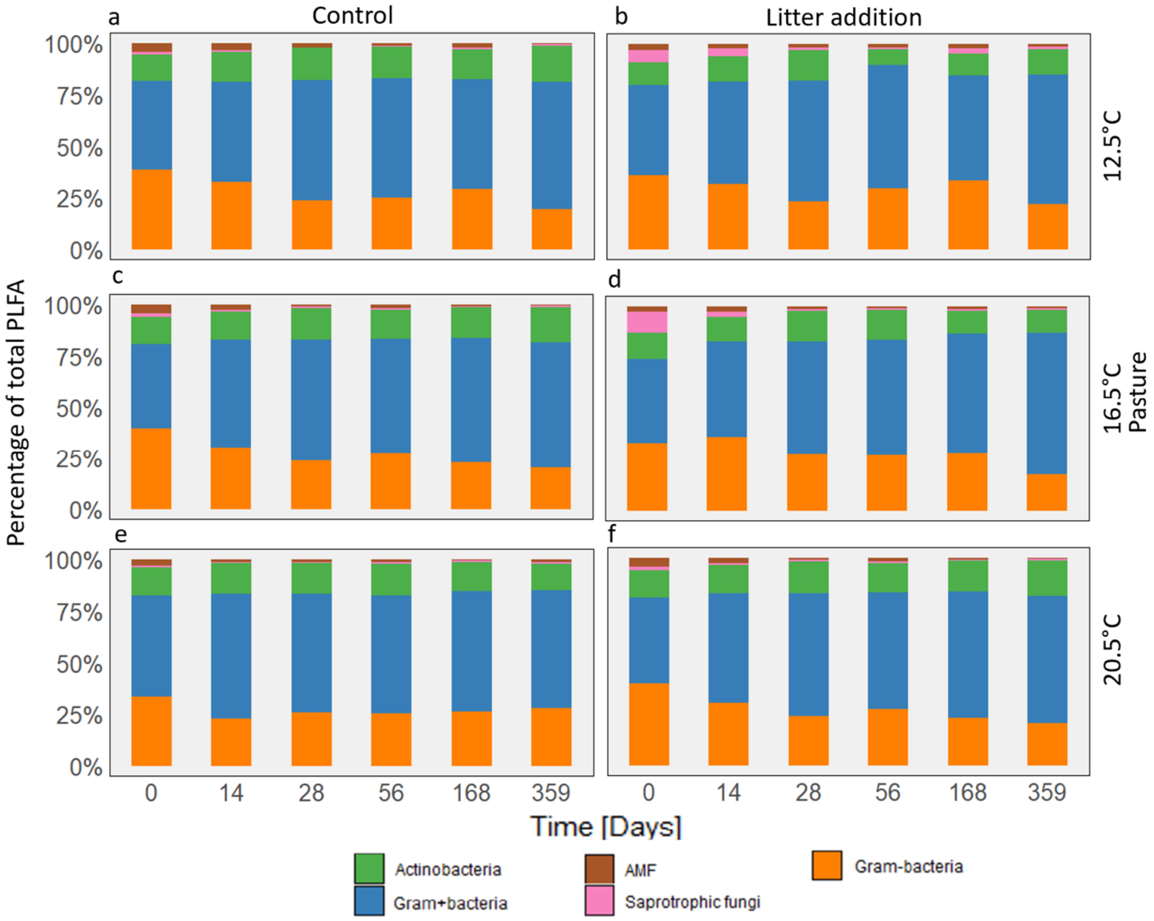

Figure 11: PLFA analysis of the pasture samples, the control samples (a, c, e) and the samples with litter addition (b, d, f). For the three different temperatures (12.5°C, 16.5°C and 20.5°C). The x-axis of the graph displayed the time in days, showcasing the duration of the experiment. The y-axis represents the relative abundance of total PLFA.

especially in the proportions of saprotrophic fungi. At 12.5°C, fungi proportions increased from 1.3% in the control to 6% with litter, and at 16.5°C from 1.8% to 10.0%, with a similar trend observed at 20.5°C, from 0.8% to 5.2%. in the control to 6% with litter, and at 16.5°C from 1.8% to 10.0%, with a similar trend observed at 20.5°C, from 0.8% to 5.2% (Figure 11).

In the initial phase of the experiment, the analysis of pasture control samples (Figure 12a, c, e) revealed that the total PLFA content, measured in nmol/g^{-1}, was highest at 12.5°C with 233.68 nmol/g^{-1}. It decreased to 200.65 nmol/g^{-1} at 16.5°C and was lowest at 20.5°C with 194.35 nmol/g^{-1}. By the final sampling, the pattern had shifted; the highest values were recorded at 20.5°C with 205.31 nmol/g^{-1}, followed by 16.5°C at 155.60 nmol/g^{-1}, and the lowest at 12.5°C with 145.44 nmol/g^{-1}.

In contrast, the pasture samples with litter addition (Figure 12b, d, f) initially exhibited a different trend. The highest total PLFA content was at 16.5°C, with 395.75 nmol/g^{-1}, followed by 12.5°C at 350.50 nmol/g^{-1}, and the lowest at 20.5°C with 298.22 nmol/g^{-1}. At the end of the experiment, the highest content remained at 16.5°C with 317.33 nmol/g^{-1}, with a significantly decrease at 12.5°C to 167.72 nmol/g^{-1} and even at 20.5°C to 106.51 nmol/g^{-1}.

When comparing the initial PLFA contents between the pasture control samples and those with litter addition, the control samples consistently had lower PLFA contents. At 12.5°C, the control content was 233.68 nmol/g^{-1} compared to 350.50 nmol/g^{-1} in the with litter addition samples. At 16.5°C, the difference was even more pronounced, with the control at 200.65 nmol/g^{-1} versus 395.75 nmol/g^{-1} in the samples with litter addition. Similarly, at 20.5°C, the control with 194.35 nmol/g^{-1} compared to 298.22 nmol/g^{-1} in the samples with litter addition. At the end of the experiment, the highest PLFA content in the control samples was at 20.5°C with 205.31 nmol/g$^{-1,}$ whereas, in the samples with litter addition, it was at 16.5°C with 317.33 nmol/g^{-1}.

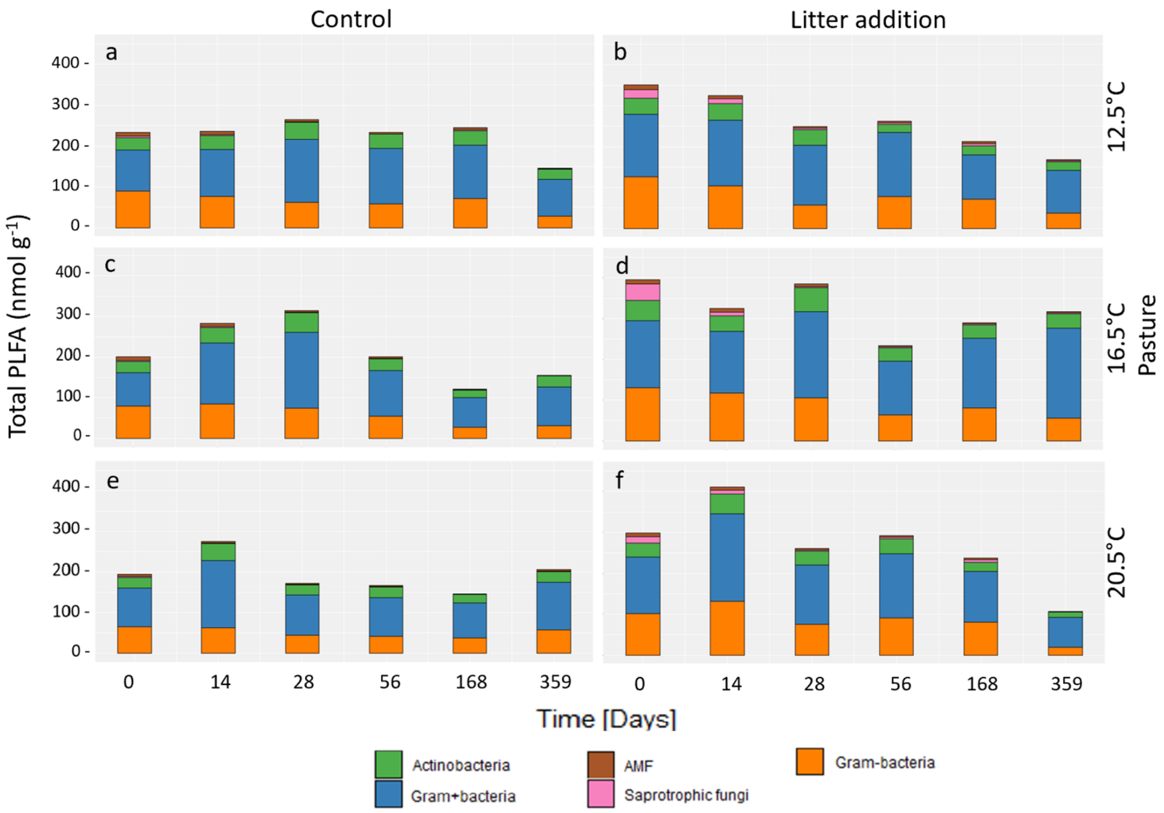

Figure 12: Total PLFA content of the pasture samples, the control samples (a, c, e) and the samples with litter addition (b, d, f). The x-axis of the graph displayed the time in days, showcasing the duration of the experiment. The y-axis represents the total PLFA in nmol g^{-1}.

3.6 Total amount of phospholipid fatty acids

In the forest control samples (Figure 13a), the summarized total PLFA content throughout the incubation period was highest with 1633.29 nmol/g^{-1} at 12.5°C, followed by 1563.85 nmol/g^{-1} at 16.5°C, and then 988.07 nmol/g^{-1} at 20.5°C. A negative correlation ($r = -0.911$, $p = 0.271$) was observed between increasing temperatures and the total PLFA content.

In the forest samples with litter addition (Figure 13b), the summarized total PLFA content was highest with 1412.78 nmol/g^{-1} at 16.5°C, followed by 1128.29 nmol/g^{-1} at 12.5°C, and lowest by 1118.45 nmol/g^{-1} at 20.5°C. A negative correlation ($r = -0.981$, $p = 0.271$) was observed between increasing temperatures and the total PLFA content.

Comparatively, the total PLFA content of the forest control samples was higher at 12.5°C and 16.5°C than those with litter addition (Figure 13a, b). At 12.5°C, there was a decrease of 31% in the samples with litter addition, and at 16.5°C, a decrease of 10%. And at 20.5°C, an increase of 13% was observed in the samples with litter addition.

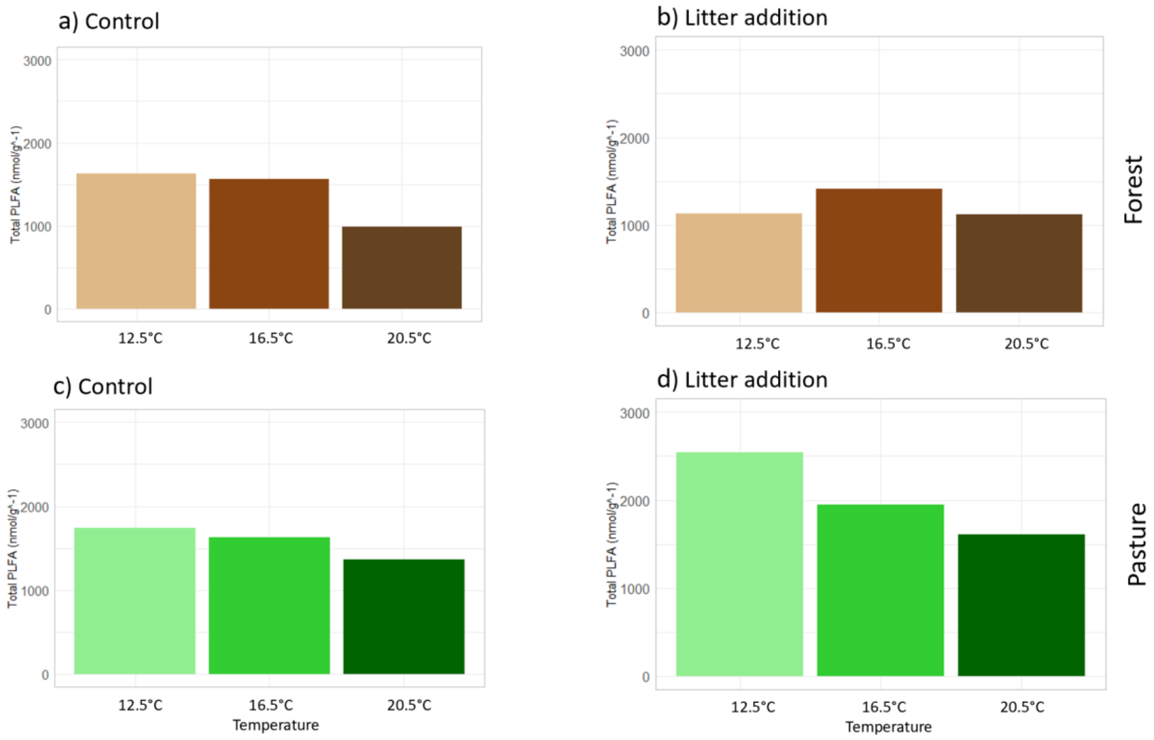

Figure 13: Total summarized total PLFA of forest samples (a, b), and pasture samples (c, d), over the incubation period of 359 days. The x-axes display the different temperatures, and the y-axes the total amount of PLFA in nmol/g^{-1}.

In the pasture control samples, as shown in figure 13c, the highest summarized total PLFA content over the incubation period was 1738.49 nmol/g^{-1} at 12.5°C, followed by 1630.44 nmol/g^{-1} at 16.5°C, and then 1363.72 nmol/g^{-1} at 20.5°C. A negative correlation (r = -0.971, p = 0.152) was observed between increasing temperatures and the total PLFA content.

In the pasture samples with litter addition, shown in figure 13d, the summarized total PLFA content was highest at 2543.08 nmol/g^{-1} at 12.5°C, followed by 1944.69 nmol/g^{-1}at 16.5°C, and was lowest at 1606.78 nmol/g^{-1} at 20.5°C. A negative correlation (r = -0.987, p = 0.101) was noted between increasing temperatures and the total PLFA content.

In comparison, the total PLFA content of the pasture control samples compared to those with litter addition an increase of about 45% at 12.5°C, 19% at 16.5°C, and 18% at 20.5°C in the samples with litter addition (Figure 13c, d).

When comparing pasture and forest control samples, the total PLFA content was higher in the pasture, showing an increase of about 6% at 12.5°C, 4% at 16.5°C, and 40% at 20.5°C (Figure 13a, c). Similarly, comparing the samples with litter addition from pasture and forest, the total PLFA content was also higher in the pasture, with increases of about 125% at 12.5°C, 38% at 16.5°C, and 44% at 20.5°C (Figure 13b, d).

3.7 Fungi to bacteria ratio

In the forest control samples (Figure 14a), the F/B ratios at the beginning of the experiment were 0.098 at 12.5°C and 0.091 at 16.5°C, a decrease of 7% from 12.5°C to 16.5°C. The lowest ratio was observed at 20.5°C with 0.047, which represented a 50% decrease compared to 12.5°C. A decreasing trend in the F/B ratios was noted throughout the experiment across all three temperatures. By the end of the experiment, the F/B ratios for all three temperature scenarios aligned closely, ranging from 0.042 to 0.045.

In the forest samples with litter addition (Figure 14b), there was an increase in the F/B ratios at the beginning of the experiment compared to the control. The F/B ratios in the forest samples with litter addition were 0.223 at 12.5°C and 0.232 at 16.5°C; these ratios were closely aligned, with a difference of 4%. At 20.5°C, the F/B ratio was lower at 0.118, indicating a decrease of approximately 50% compared to the ratio at 12.5°C. In the middle of the experiment (day 168), the highest F/B ratio in samples with litter addition was recorded at 12.5°C at 0.102, marking a decrease of 55% compared to the beginning, while the lowest was at 20.5°C at 0.028, also with a decrease of 75% compared to the beginning. The F/B ratios converged towards the end of the experiment, ranging between 0.050 to 0.068.

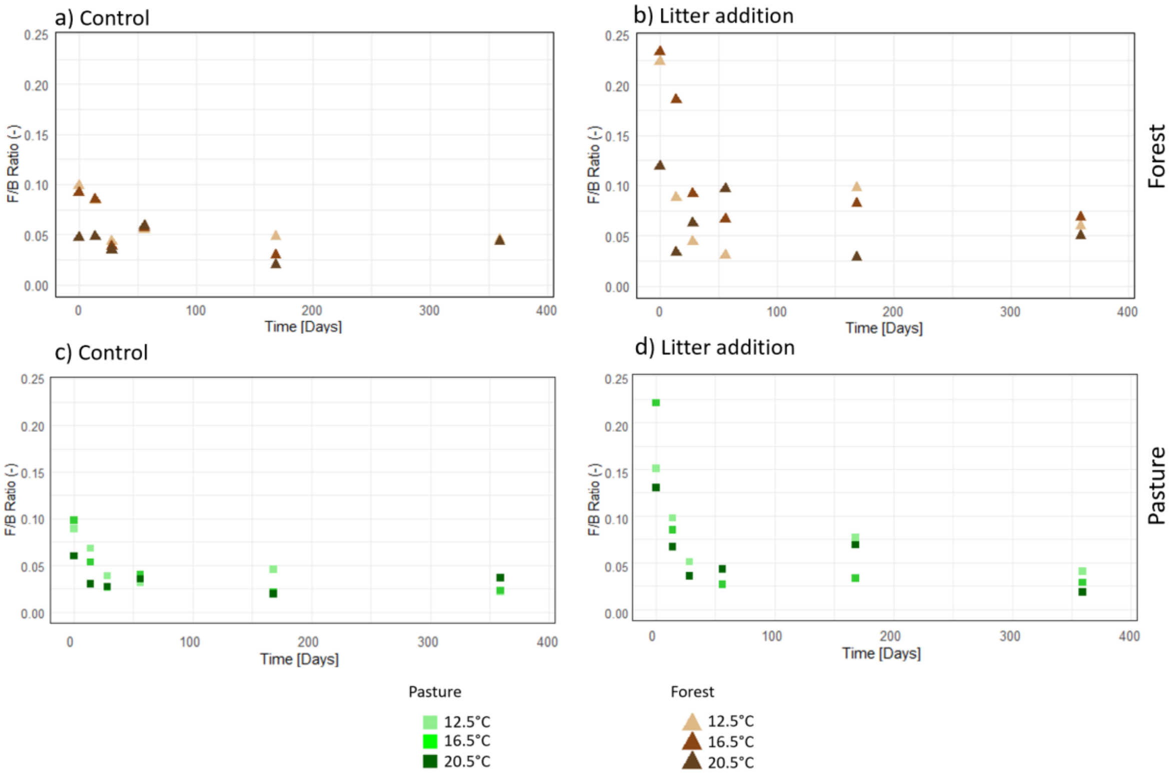

Figure 14: The fungi to bacteria (F/B) ratio of forest and pasture samples, the control samples (a, c) and the samples with litter addition (b, d). The x-axis of the graph displayed the time in days, showcasing the duration of the experiment. The y-axis represents the F/B ratio (-).

In the initial phase of the experiment, the pasture control samples (Figure 14c) displayed the highest F/B ratio at 16.5°C, recorded were 0.098, and then at 12.5°C, with 0.089, with a difference of 9%. The lowest ratio was observed at 0.060 at 20.5°C, indicating a 30% decrease compared to 12.5°C. By the end of the experiment, the F/B ratios for all three temperature scenarios came closer together, ranging from 0.021 to 0.036.

In the pasture samples with litter addition (Figure 14d), the highest F/B ratio at the beginning was 0.221 at 16.5°C, which then decreased by 30% to 0.150 at 12.5°C. The lowest ratio was 0.130 at 20.5°C, with a 15% decrease from 12.5°C. Notably, the highest temperature corresponded with the lowest F/B ratio. After that, the F/B ratios decreased and came closer together towards the end of the experiment. Where the highest ratio was subsequently observed with 0.040 at 12.5°C, reflecting a 75% decrease from the beginning. Additionally, the lowest ratio was recorded at 20.5°C, with 0.018, marking an 85% decrease from the beginning.

3.8 Gram-positive to Gram-negative ratio

In the forest control samples (Figure 15a), the GP/GN ratio at the beginning was highest at 20.5°C with a value of 2.22, followed by 1.15 at 16.5°C, and the lowest was 1.08 at 12.5°C, indicating a 50% decrease from 20.5°C. Until the middle of the experiment, the GP/GN ratio increased at 12.5°C by 67% to 1.81, at 16.5°C by 91% to 2.19, and at 20.5°C by 19% to 2.65. From the middle to the end of the experiment, the GP/GN ratio decreased at 12.5°C by 4% to 1.75, at 16.5°C by 12% to 1.92, and at 20.5°C by 31% to 1.83.

In the forest samples with litter addition (Figure 15b), the highest initial GP/GN ratio was 1.49 at 20.5°C, then 1.18 at 12.5°C, and the lowest was 1.15 at 16.5°C, which was 50% lower than at 20.5°C. The GP/GN ratio increased until the middle of the experiment by approximately 23% to 1.45 at 12.5°C, 37% to 1.58 at 16.5°C, and 16% to 1.73 at 20.5°C. Subsequently, from the midpoint to the end of the experiment, the GP/GN ratio increased by 80% to 2.61 at 12.5°C, 29% to 2.04 at 16.5°C, and 48% to 2.55 at 20.5°C.

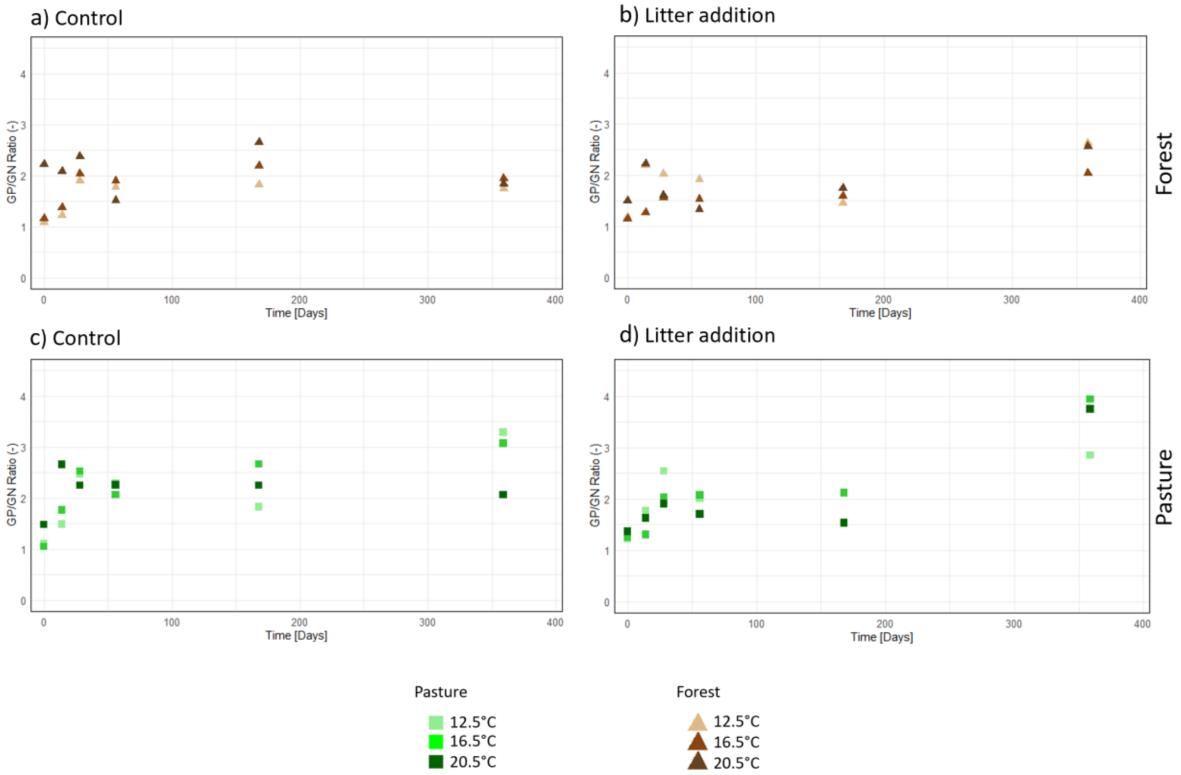

Figure 15: The Gram-positive to Gram-negative bacteria (GP/GN) ratio of forest and pasture samples. The control samples (a, c), and the samples with litter addition (b, d). The x-axis of the graph displayed the time in days, showcasing the duration of the experiment. The y-axis represents the GP/GN ratio (-).

In the pasture control samples (Figure 15c), the initial GP/GN ratio was highest at 20.5°C with 1.48 and then at 12.5°C with 1.11. The lowest was at 16.5°C with 1.05, a decrease of 30% compared to 20.5°C. Until the middle of the experiment, the GP/GN ratio at 12.5°C had increased by 63% to 1.81, at 16.5°C by 153% to 2.66, and at 20.5°C by 51% to 2.24. From the middle to the end of the experiment, the ratio at 20.5°C decreased by 8% to 2.05, while at 12.5°C, it increased by 75% to 3.17, and at 16.5°C by 13% to 3.02.

In the pasture samples with litter addition (Figure 15d), the highest initial GP/GN ratio was at 20.5°C with 1.36, followed by 1.23 at 16.5°C, and the lowest was at 12.5°C with 1.22, a decrease of 10% compared to 20.5°C. The GP/GN ratio until the middle of the experiment increased by 25% to 1.53 at 12.5°C, by 71% to 2.11 at 16.5°C, and by 12% to 1.52 at 20.5°C. Subsequently, until the end of the experiment, the GP/GN ratio further increased by 86% to 2.85 at 12.5°C, by 87% to 3.94 at 16.5°C, and by 147% to 3.75 at 20.5°C.

3.9 Gram-positive to arbuscular mycorrhizal fungi ratio

At the beginning of the experiment, the GP/AMF ratio in the forest control samples (Figure 16a) was highest at 20.5°C with a ratio of 23.87, followed by 16.5°C with 10.06. The lowest ratio was at 12.5°C with 9.98, marking a 138% decrease compared to 20.5°C. Until the middle of the experiment, the GP/AMF ratio at 12.5°C had increased by 119% to 21.96, at

16.5°C by 297% to 39.95, and at 20.5°C by 242% to 81.56. From the middle to the end of the experiment, the ratio at 12.5°C increased further by 8% to 23.78, while at 16.5°C it decreased by 13% to 34.63, and at 20.5°C it decreased by 59% to 33.39.

In the forest samples with litter addition (Figure 16b), the initial GP/AMF ratio was highest at 20.5°C with 18.82, followed by 12.5°C with 13.04. The lowest ratio was at 16.5°C with 12.55, showing a 35% decrease compared to 20.5°C. Until the middle of the experiment, the GP/AMF ratio at 20.5°C increased by 95% to 36.66, at 16.5°C by 112% to 26.65, and at 12.5°C by 72% to 22.48. At the end of the experiment, the ratios had increased further, with a 50% increase at 20.5°C to 54.97, 16% at 16.5°C to 30.82, and 78% at 12.5°C to 40.07.

Comparing the forest control samples to those with litter addition (Figures 16a, b), the GP/AMF ratio at the beginning was 30% higher at 12.5°C with litter addition and 25% higher at 16.5°C. However, at 20.5°C, there was a 21% decrease in the samples with litter addition compared to the control. In the middle of the experiment, there was a marginal increase of 2% at 12.5°C in the samples with litter addition, but at 16.5°C, there was a 33% decrease, and at 20.5°C a decrease of 55% compared to the control. At the end of the experiment, the GP/AMF ratios in the samples with litter addition with a significant increase of 69% at 12.5°C and 65% at 20.5°C. Only at 16.5°C was there a decrease of 11% in the samples with litter addition compared to the control.

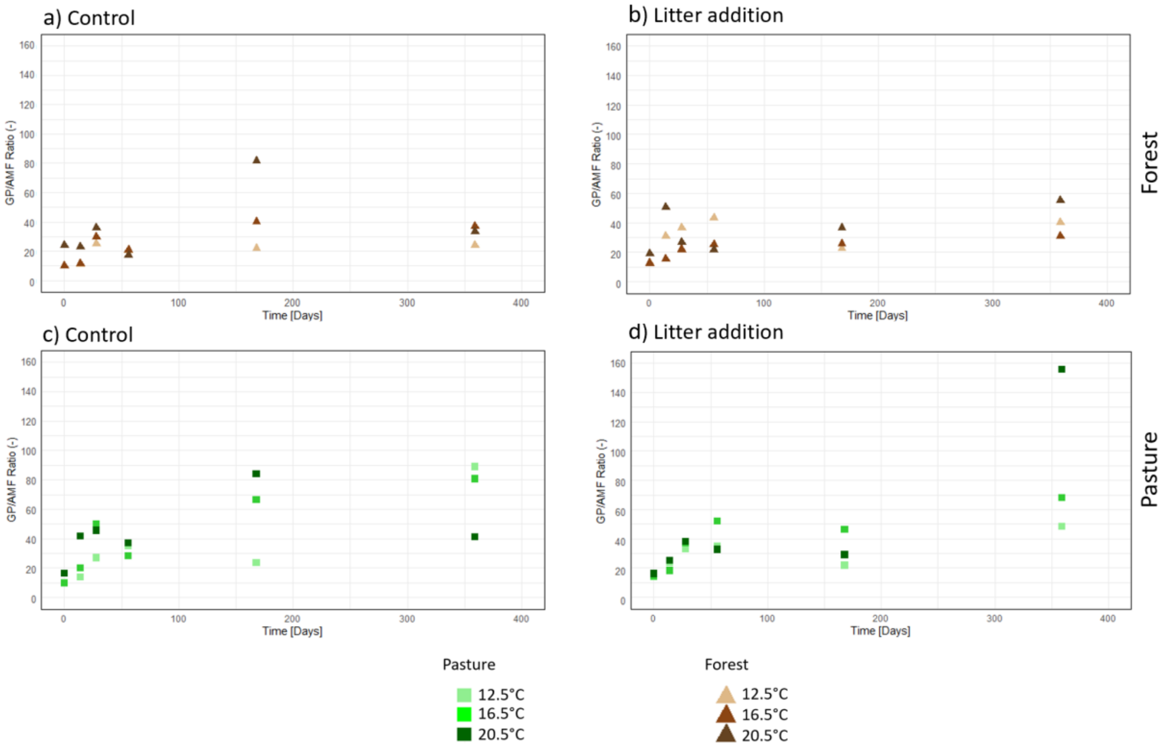

Figure 16:The Gram-positive to arbuscular mycorrhiza fungi (GP/AMF) ratio of forest and pasture samples. The control samples (a, c), the samples with litter addition (b, d). The x-axis of the graph displayed the time in days, showcasing the duration of the experiment. The y-axis represents the GP/AMF ratio (-).

At the beginning of the experiment, in the pasture control samples (Figure 16c), the GP/AMF ratio was 9.97 at 12.5°C and 9.59 at 16.5°C, with a small difference of 4%. The highest ratio was observed at 20.5°C, at 16.35, which represented a 64% increase compared to 12.5°C. By the middle of the experiment, the GP/AMF ratio at 12.5°C had increased by 135% to 23.53, at 16.5°C by 592% to 66.39, and at 20.5°C by 414% to 84.04. From the middle to the end of the experiment, the GP/AMF ratio at 12.5°C further increased by 277% to 88.83, while at 16.5°C it increased by 22% to 80.66. Conversely, at 20.5°C, there was a decrease of 51% to 40.98.

In the pasture samples with litter addition (Figure 16d), the initial GP/AMF ratio was highest at 20.5°C with 16.18, followed by 14.52 at 16.5°C. The lowest ratio was at 12.5°C with 13.99, with a 14% decrease compared to 20.5°C. In the middle of the experiment, the GP/AMF ratios at 12.5°C had increased by 55% to 21.80, at 16.5°C by 218% to 46.24, and at 20.5°C by 79% to 28.94. From the middle to the end of the experiment, the GP/AMF ratio at 12.5°C increased by 121% to 48.28, at 16.5°C by 47% to 68.05, and at 20.5°C dramatically by 438% to 155.79.

Comparing the GP/AMF ratios from the pasture control samples to those with litter addition at the beginning of the experiment, there was a decrease in the samples with litter addition by approximately 15% at 12.5°C and 1% at 20.5°C. Only at 16.5°C was there an increase of 51% with litter addition. In the middle of the experiment, the GP/AMF ratios in the samples with litter addition with a decrease of 7% at 12.5°C, 30% at 16.5°C, and 65% at 20.5°C compared to the control. At the end of the experiment, the GP/AMF ratios in samples with litter addition decreased by 46% at 12.5°C and 16% at 16.5°C. However, at 20.5°C, there was an increase of 156% compared to the control.

4. Discussion

4.1 Carbon to nitrogen ratios and stable isotopes

The analysis of the C/N ratios revealed a higher C/N ratio in forest compared to the pasture samples (Figure 4). These findings, consistent with previous research on C/N ratios in pasture and forest soils across Europe, indicate that the C/N ratio in forests is higher than in pasture soils (Cotrufo et al., 2019). Forests typically contained a richer layer of organic materials, such as leaves, needles, and wood, which were rich in carbon but relatively low in nitrogen (Prescott, 2010). These materials decomposed more slowly, leading to a higher C/N ratio in forest compared to pasture soils (Ostrowska and Porębska, 2015).

This study further observed no significant changes in C/N ratios between pasture and forest soil with increasing temperatures (Figure 4). However, it was noted that the C/N ratio in both pasture and forest with litter addition decreased within the first two weeks of the experiment (Figure 4b, d). The C/N ratio is an important measure for modelling decomposition rates (Dubeux Jr. et al., 2006). This could indicate that much of the carbon added through litter was quickly decomposed by soil microorganisms within the first 14 days. This assumption is supported by a drop in $\delta^{13}C$ values for both forest and pasture samples with litter addition, also within the first two weeks of the incubation experiment (Figure 5). The easily degradable carbon source that was added through litter decomposed quickly by microorganisms, which could explain the rapid drop in the C/N ratio as well as in the $\delta^{13}C$ values. A study by Prescott (2010) concluded, that the two main factors determining the decomposition rate are primarily litter quality, the C/N ratio, and the total nutrient content of the litter.

In this study, lower $\delta^{13}C$ values were observed at 20.5°C in forest and pasture soils with litter addition, especially at the beginning of the experiment. This result may be an artifact of the two-week pre-incubation period, during which some of the $\delta^{13}C$ may have been degraded by microorganisms, with a potential acceleration at 20.5°C. Previous studies have demonstrated that the metabolic rate of soil microorganisms increases due to lower activation energy at higher temperatures (Qu et al., 2024). However, the differences at 12.5°C and 16.5°C were negligible (Figure 5).

4.2 Differences in carbon compound compositions

The results indicate that all investigated pasture samples contained a higher proportion of aliphatic C-H compounds compared to forest samples (Figure 6 & 7). This might be a consequence of different vegetation covers between pasture and forest areas, influencing the composition of litter deposited on the soil surface (Berg and McClaugherty, 2014). The vegetation in the pasture consists of grasses that are rich in aliphatic hydrocarbon compounds (Berg and McClaugherty, 2014). This could contribute to the higher levels of these compounds in both the control and litter addition groups compared to the forest soil. Furthermore, pasture samples contained a higher proportion of phenolic cellulose compounds compared to forest, in both control and litter addition samples. The content was only lower in pasture samples at 16.5°C in the control and at 20.5°C with litter addition compared to the forest samples (Figure 6 & 7).

Additionally, higher proportions of lignin were observed in forest samples compared to pasture samples, both in the control and with litter addition. Except at 12.5°C with litter addition and at 20.5°C in the control where the lignin content was higher in the pasture than in forest samples.

A plausible explanation for the generally higher lignin values in forest samples is the frequent input of materials, such as wood residues, into the topsoil layer in forests, thereby tending to increase the lignin content (Berg and McClaugherty, 2014). Forests typically hosts a variety of trees and shrubs, which contain significant amounts of lignin in their cell walls, providing structural integrity to stems, branches, and roots (Berg and McClaugherty, 2014). This lignin-rich plant debris accumulates as leaf litter, which decomposes slowly due to its complex aromatic polymer structure (Berg and McClaugherty, 2014).

4.3 Increasing temperatures and their effects on soil respiration

The observation in the forest and pasture control samples indicates a weak correlation ($r = 0.150$, $p = 0.102$) between higher temperatures and increasing soil respiration. The soil respiration was higher in pasture than in forest samples, except for the temperature at 20.5°C where the soil respiration was equal (Figure 8a). Other studies investigating the disparity in soil respiration between pasture and forest soils in Northeastern Nova Scotia, Canada, have similarly observed higher soil respiration rates in pasture soils compared to forest soils (Kellman et al., 2007). The study suggests that the increased soil respiration is attributed to the chemical composition and susceptibility to decomposition of the SOC pool (Kellman et al., 2007). The analysis of the carbon compounds revealed a higher proportion of aliphatic C-H compounds in the pasture samples than in the forest control samples (Figure 6 & 7). These easily degradable carbon compounds could possibly explain the higher soil respiration rates observed in the pasture control samples. This hypothesis is supported by a long-term field study that observed increased soil respiration in the presence of higher concentrations of aliphatic C-H compounds in the soil (Šimon, 2005).

A significant increase ($r = 0.605$, $p < 0.001$) in soil respiration was observed in forest and pasture samples with litter addition with increasing temperatures (Figure 8b). In a 270-day incubation experiment at 25°C conducted in China, it was observed that increased litter addition significantly accelerates decomposition rates and CO_2 emissions from the soil (Li et al., 2015). Similarly, a study in a 125-year-old Norway spruce *(Picea abies)* forest in Achenkirch, Austria, found that a +4°C soil warming increased soil respiration (Schindlbacher et al., 2012). A 63-day incubation experiment indicated that higher temperatures enhanced SOC mineralization but also reduces dissolved organic carbon (DOC) in the soil, leading to increases in soil respiration by approximately 30% between 20°C and 30°C, and around 57% from 30°C to 40°C (Zheng et al., 2023). This increase in soil respiration could be attributed to both the accelerated metabolic rates due to kinetic changes and alterations in substrate availability caused by warming (Qu et al., 2024). This increase in soil respiration can also be linked to the decreased activation energy required for microbial processes in the soil, which accelerates their metabolism as temperatures increase (Lloyd and Taylor, 1994). In this study, the $\delta^{13}C$ values at the beginning of the experiment for both forest and pasture samples were lowest at a temperature of 20.5°C, showing a significant difference compared to temperatures of 12.5°C and 16.5°C (Figure 5). The lower $\delta^{13}C$ values at the start of the experiment could be attributed to enhanced SOC mineralization at increasing temperatures.

In all temperature ranges for all samples with litter addition, soil respiration was consistently higher in the forest compared to the pasture soil (Figure 8b). A field study, conducted within a northern temperate climate zone, examining differences between forest and pasture soils, concluded that more carbon accumulates in forest than in pasture soils (Jeong et al., 2018). Based on the C/N ratio investigated in this study of forest and pasture samples with litter addition, it was evident that the C/N ratio in the forest samples was consistently higher compared to the pasture (Figure 4b, d). Therefore, the higher availability of carbon in the forest samples could therefore potentially explain the increased soil respiration observed in the forest samples with litter addition. However, this assumption does not clarify why soil respiration in the pasture control was higher than in the forest control samples (Figure 8a), despite the C/N ratio was also higher in the forest in these cases (Figure 4a, c).

This led to the conclusion that in this study, the higher C/N ratio in the forest samples was not the cause of the increased soil respiration observed in the forest samples with litter addition. It was possible that the readily available carbon, which had been introduced through litter addition, was decomposed more effectively in the forest than in the pasture soil. Another Study conducted using a large-scale meta-analysis on litter addition to the soil respiration of forest recorded a substantial increase in coniferous forests with litter addition of about 50% (Zhang et al., 2020). They concluded that litter inputs can influence soil respiration directly through labile carbon availability and, indirectly, through the activity of soil microorganisms and modifications in soil microclimate (Zhang et al., 2020). The forest samples with litter addition contains a higher proportion of saprotrophic fungi, which could have contributed to the degradation of aliphatic C-H compounds, leading to increased soil respiration. A study indicates that saprotrophic fungi have a high potential for breaking down aliphatic C-H compounds (Ceci et al., 2019).

4.4 Litter effects on microbial communities

The investigation of microbial communities by PLFA analysis revealed an increased presence of saprotrophic fungi in forest and pasture soils with litter addition, especially at the beginning of the experiment (Figure 9b, d, f & 11b, d, f). Studies have already indicated that the addition of litter, is likely to result in an increase in saprotrophic fungi, this is due to the abundance of fresh plant-derived carbon, which supports the growth of saprotrophic fungi (Zosso et al., 2021). These findings of increased abundance of saprotrophic fungi are further supported by the higher F/B ratio observed in the forest and pasture samples with litter addition at the beginning of the incubation experiment (Figure 14b, d). The proportion of saprotrophic decreases from the beginning until day 28 in both forest and pasture samples with litter addition (Figure 14b, d). One possible explanation for the decrease could be attributed to nitrogen-rich conditions, which are more favourable for bacteria than for fungi. Earlier studies have concluded that bacteria are more competitive than fungi’s, especially under nitrogen-rich conditions (Meidute et al., 2008). This assumption is further supported by the decrease in the C/N ratio in the pasture and forest samples with litter addition (Figure 4b, d), particularly noticeable in the first two weeks of incubation, which indicates a shift towards nitrogen-rich conditions.

4.5 Increasing temperatures and microbial communities

During the initial two weeks of incubation, the GP/GN (Figure 15) ratio increased in forest and pasture samples across both control and litter addition groups. However, a slight decrease was observed only in the forest control at 20.5°C. Additionally, within this timeframe, higher GP/GN ratios were associated with higher temperatures. Notably, the exceptions were observed at 12.5°C in both the forest and pasture samples with litter addition, where the ratios were close to those at 20.5°C. A previous study which incubated soil samples from a sandy, mixed, frigid Typic Haplorthod from a northern hardwood ecosystem in western Lower Michigan, for 16 weeks under three temperature scenarios of 5°C, 15°C, and 25°C, also observed an increase in Gram-positive bacteria with rising temperatures (Zogg et al., 1997). However, previous field studies from Stillberg, near Davos, Switzerland, at an elevation of 2180 m.a.s.l. after one year of soil warming at +4°C, have indicated a 0.5% higher proportion of Gram-positive bacteria in warmed soils compared to unwarmed ones (Streit et al., 2014). This assumption of a higher proportion of Gram-positive bacteria during increasing temperatures is also supported by the data from the GP/AMF (Figure 16), which indicates a similar pattern to the GP/GN ratio.

Total PLFA concentration is commonly used as an indicator of soil microbial biomass (Frostegård et al., 1993). The results of the total PLFA in nmol/g^{-1} (Figure 13) indicate a general decline with increasing temperatures, except for the forest with litter addition, where the total amount at 12.5°C was lower than at 16.5°C. Previous studies have also shown that microbial biomass tends to be lower with increasing temperatures. A study by Joergensen et al. (1990) incubated grassland soil for 240 days at three temperatures: 15°C, 25°C, and 35°C. The decline in biomass was least at 15°C and most significant at 35°C, with the mortality rate of microorganisms also increasing at higher temperatures. Similar results were observed in another incubation experiment that incubated two forest soils and one agricultural soil for 56 days at temperatures of 4°C, 15°C, 25°C, and 35°C, the decrease in microbial biomass was greatest at 35°C (Wu et al., 2010).

5. Conclusion and outlook

Forest soils consistently demonstrated higher C/N ratios than pasture soils, largely due to the accumulation of organic matter such as leaves and wood. A significant finding was the rapid decline in both C/N ratios and $\delta^{13}C$ values within the first two weeks of the incubation experiment with litter addition, suggesting rapid microbial decomposition of the added organic matter. Soil respiration patterns varied markedly between the two soil types, with forest samples showing higher respiration rates across all temperatures when litter was added, indicating a stronger microbial response to organic matter inputs. In contrast, higher respiration rates in control pasture soils were possibly due to the prevalence of easily degradable aliphatic C-H compounds.

The study also found that rising temperatures significantly increased soil respiration, enhanced microbial activity and organic matter decomposition, and altered microbial community composition. Notably, forest soil exhibited a higher fungi-to-bacteria ratio and a greater proportion of saprotrophic fungi, especially with litter addition. Both forest and pasture soils showed an increase in Gram-positive bacteria and a decrease in total PLFA with increasing temperatures, highlighting the sensitivity of microbial communities to thermal changes.

By estimating the responses of soil microbial communities to thermal stress, this investigation contributed to the broader knowledge base required to anticipate and mitigate the impacts of climate change on subalpine ecosystems. This enhanced comprehension is useful for devising strategies aimed at preserving the functionality and health of future soils in subalpine regions.

6. Limitations

It was important to note that an incubation experiment represents a simplified depiction of reality and cannot be directly extrapolated to natural environments. In natural settings, various factors such as dry periods or heavy rainfall could occur, potentially leading to significant variations in the results, particularly concerning carbon decomposition and soil respiration. These environmental variables can influence microbial activity and soil chemistry, which are not replicated in an incubation experiment. Furthermore, differences in sample handling and analytical procedures by different operators could lead to discrepancies. Laboratory conditions and the use of varying equipment might also contribute to these differences. Moreover, the PLFA analysis was conducted without replicates, making it more challenging to perform statistical tests. Conducting additional replicates of the analysis could provide added value and potentially increase the accuracy of the study.

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Appendix

Table I: Soil respiration data from the one-year incubation experiment from pasture und forest soil.

Temperature (°C)	Soil Type	Treatment	Time (Days)	Respiration (C-CO_2 /kg)
12.5	Forest	Control	0	
12.5	Forest	Control	14	
12.5	Forest	Control	18	
12.5	Forest	Control	21	0.98
12.5	Forest	Control	26	2.37
12.5	Forest	Control	28	2.83
12.5	Forest	Control	32	3.45
12.5	Forest	Control	39	3.87
12.5	Forest	Control	46	4.05
12.5	Forest	Control	60	4.27
12.5	Forest	Control	74	4.41
12.5	Forest	Control	88	4.47
12.5	Forest	Control	109	4.58
12.5	Forest	Control	130	4.67
12.5	Forest	Control	147	4.71
12.5	Forest	Control	167	4.74
12.5	Forest	Control	186	4.73
12.5	Forest	Control	215	4.86
12.5	Forest	Control	249	5.01
12.5	Forest	Control	277	5.12
12.5	Forest	Control	312	5.25
12.5	Forest	Control	344	5.32
12.5	Forest	Control	377	5.34
12.5	Forest	Litter Addition	0	0.31
12.5	Forest	Litter Addition	14	0.43
12.5	Forest	Litter Addition	18	0.44
12.5	Forest	Litter Addition	21	0.48
12.5	Forest	Litter Addition	26	0.58
12.5	Forest	Litter Addition	28	0.57
12.5	Forest	Litter Addition	32	0.62
12.5	Forest	Litter Addition	39	0.7
12.5	Forest	Litter Addition	46	0.8
12.5	Forest	Litter Addition	60	0.89
12.5	Forest	Litter Addition	74	0.95
12.5	Forest	Litter Addition	88	1.02
12.5	Forest	Litter Addition	109	1.15
12.5	Forest	Litter Addition	130	1.28
12.5	Forest	Litter Addition	147	1.37
12.5	Forest	Litter Addition	167	1.48
12.5	Forest	Litter Addition	186	1.59
12.5	Forest	Litter Addition	215	1.73

12.5	Forest	Litter Addition	249	1.87
12.5	Forest	Litter Addition	277	1.97
12.5	Forest	Litter Addition	312	2.06
12.5	Forest	Litter Addition	344	2.12
12.5	Forest	Litter Addition	377	2.28
12.5	Pasture	Control	0	
12.5	Pasture	Control	14	
12.5	Pasture	Control	18	
12.5	Pasture	Control	21	0.97
12.5	Pasture	Control	26	2.7
12.5	Pasture	Control	28	3.19
12.5	Pasture	Control	32	3.73
12.5	Pasture	Control	39	4.16
12.5	Pasture	Control	46	4.37
12.5	Pasture	Control	60	4.6
12.5	Pasture	Control	74	4.76
12.5	Pasture	Control	88	4.86
12.5	Pasture	Control	109	5.04
12.5	Pasture	Control	130	5.19
12.5	Pasture	Control	147	5.3
12.5	Pasture	Control	167	5.42
12.5	Pasture	Control	186	5.52
12.5	Pasture	Control	215	5.68
12.5	Pasture	Control	249	5.83
12.5	Pasture	Control	277	5.9
12.5	Pasture	Control	312	6.07
12.5	Pasture	Control	344	6.21
12.5	Pasture	Control	377	6.26
12.5	Pasture	Litter Addition	0	0.31
12.5	Pasture	Litter Addition	14	0.42
12.5	Pasture	Litter Addition	18	0.35
12.5	Pasture	Litter Addition	21	0.36
12.5	Pasture	Litter Addition	26	0.41
12.5	Pasture	Litter Addition	28	0.36
12.5	Pasture	Litter Addition	32	0.38
12.5	Pasture	Litter Addition	39	0.42
12.5	Pasture	Litter Addition	46	0.47
12.5	Pasture	Litter Addition	60	0.58
12.5	Pasture	Litter Addition	74	0.62
12.5	Pasture	Litter Addition	88	0.65
12.5	Pasture	Litter Addition	109	0.76
12.5	Pasture	Litter Addition	130	0.87
12.5	Pasture	Litter Addition	147	0.94
12.5	Pasture	Litter Addition	167	1
12.5	Pasture	Litter Addition	186	1.03

12.5	Pasture	Litter Addition	215	1.12
12.5	Pasture	Litter Addition	249	1.23
12.5	Pasture	Litter Addition	277	1.33
12.5	Pasture	Litter Addition	312	1.37
12.5	Pasture	Litter Addition	344	1.37
12.5	Pasture	Litter Addition	377	1.4
16.5	Forest	Control	0	
16.5	Forest	Control	14	
16.5	Forest	Control	18	
16.5	Forest	Control	21	1.19
16.5	Forest	Control	26	3.08
16.5	Forest	Control	28	3.48
16.5	Forest	Control	32	3.89
16.5	Forest	Control	39	4.21
16.5	Forest	Control	46	4.4
16.5	Forest	Control	60	4.65
16.5	Forest	Control	74	4.78
16.5	Forest	Control	88	4.84
16.5	Forest	Control	109	4.97
16.5	Forest	Control	130	5.05
16.5	Forest	Control	147	5.15
16.5	Forest	Control	167	5.26
16.5	Forest	Control	186	5.33
16.5	Forest	Control	215	5.45
16.5	Forest	Control	249	5.59
16.5	Forest	Control	277	5.68
16.5	Forest	Control	312	5.77
16.5	Forest	Control	344	5.84
16.5	Forest	Control	377	5.84
16.5	Forest	Litter Addition	0	0.43
16.5	Forest	Litter Addition	14	0.57
16.5	Forest	Litter Addition	18	0.63
16.5	Forest	Litter Addition	21	0.84
16.5	Forest	Litter Addition	26	1.03
16.5	Forest	Litter Addition	28	1.17
16.5	Forest	Litter Addition	32	1.45
16.5	Forest	Litter Addition	39	1.61
16.5	Forest	Litter Addition	46	2.03
16.5	Forest	Litter Addition	60	2.23
16.5	Forest	Litter Addition	74	2.38
16.5	Forest	Litter Addition	88	2.42
16.5	Forest	Litter Addition	109	2.74
16.5	Forest	Litter Addition	130	3.09
16.5	Forest	Litter Addition	147	3.24
16.5	Forest	Litter Addition	167	3.58

16.5	Forest	Litter Addition	186	3.72
16.5	Forest	Litter Addition	215	4.11
16.5	Forest	Litter Addition	249	4.51
16.5	Forest	Litter Addition	277	4.9
16.5	Forest	Litter Addition	312	5.28
16.5	Forest	Litter Addition	344	5.56
16.5	Forest	Litter Addition	377	5.72
16.5	Pasture	Control	0	
16.5	Pasture	Control	14	
16.5	Pasture	Control	18	
16.5	Pasture	Control	21	1.25
16.5	Pasture	Control	26	3.34
16.5	Pasture	Control	28	3.74
16.5	Pasture	Control	32	4.15
16.5	Pasture	Control	39	4.47
16.5	Pasture	Control	46	4.65
16.5	Pasture	Control	60	4.89
16.5	Pasture	Control	74	5.05
16.5	Pasture	Control	88	5.18
16.5	Pasture	Control	109	5.42
16.5	Pasture	Control	130	5.62
16.5	Pasture	Control	147	5.77
16.5	Pasture	Control	167	5.93
16.5	Pasture	Control	186	6.08
16.5	Pasture	Control	215	6.26
16.5	Pasture	Control	249	6.43
16.5	Pasture	Control	277	6.56
16.5	Pasture	Control	312	6.7
16.5	Pasture	Control	344	6.8
16.5	Pasture	Control	377	6.85
16.5	Pasture	Litter Addition	0	0.43
16.5	Pasture	Litter Addition	14	0.56
16.5	Pasture	Litter Addition	18	0.58
16.5	Pasture	Litter Addition	21	0.76
16.5	Pasture	Litter Addition	26	0.9
16.5	Pasture	Litter Addition	28	1.02
16.5	Pasture	Litter Addition	32	1.27
16.5	Pasture	Litter Addition	39	1.41
16.5	Pasture	Litter Addition	46	1.79
16.5	Pasture	Litter Addition	60	1.96
16.5	Pasture	Litter Addition	74	2.08
16.5	Pasture	Litter Addition	88	2.08
16.5	Pasture	Litter Addition	109	2.38
16.5	Pasture	Litter Addition	130	2.7
16.5	Pasture	Litter Addition	147	2.84

16.5	Pasture	Litter Addition	167	3.17
16.5	Pasture	Litter Addition	186	3.29
16.5	Pasture	Litter Addition	215	3.63
16.5	Pasture	Litter Addition	249	3.98
16.5	Pasture	Litter Addition	277	4.32
16.5	Pasture	Litter Addition	312	4.62
16.5	Pasture	Litter Addition	344	4.87
16.5	Pasture	Litter Addition	377	4.89
20.5	Forest	Control	0	
20.5	Forest	Control	14	
20.5	Forest	Control	18	
20.5	Forest	Control	21	1.21
20.5	Forest	Control	26	3.34
20.5	Forest	Control	28	3.62
20.5	Forest	Control	32	4.02
20.5	Forest	Control	39	4.28
20.5	Forest	Control	46	4.43
20.5	Forest	Control	60	4.63
20.5	Forest	Control	74	4.75
20.5	Forest	Control	88	4.82
20.5	Forest	Control	109	4.93
20.5	Forest	Control	130	5.05
20.5	Forest	Control	147	5.14
20.5	Forest	Control	167	5.21
20.5	Forest	Control	186	5.28
20.5	Forest	Control	215	5.36
20.5	Forest	Control	249	5.93
20.5	Forest	Control	277	6.48
20.5	Forest	Control	312	6.52
20.5	Forest	Control	344	6.58
20.5	Forest	Control	377	6.62
20.5	Forest	Litter Addition	0	0.53
20.5	Forest	Litter Addition	14	0.72
20.5	Forest	Litter Addition	18	0.87
20.5	Forest	Litter Addition	21	1.25
20.5	Forest	Litter Addition	26	1.62
20.5	Forest	Litter Addition	28	1.93
20.5	Forest	Litter Addition	32	2.3
20.5	Forest	Litter Addition	39	2.66
20.5	Forest	Litter Addition	46	3.11
20.5	Forest	Litter Addition	60	3.53
20.5	Forest	Litter Addition	74	3.89
20.5	Forest	Litter Addition	88	4.15
20.5	Forest	Litter Addition	109	4.74
20.5	Forest	Litter Addition	130	5.28

20.5	Forest	Litter Addition	147	5.52
20.5	Forest	Litter Addition	167	6.08
20.5	Forest	Litter Addition	186	6.45
20.5	Forest	Litter Addition	215	7.04
20.5	Forest	Litter Addition	249	7.69
20.5	Forest	Litter Addition	277	8.31
20.5	Forest	Litter Addition	312	8.91
20.5	Forest	Litter Addition	344	9.37
20.5	Forest	Litter Addition	377	9.69
20.5	Pasture	Control	0	
20.5	Pasture	Control	14	
20.5	Pasture	Control	18	
20.5	Pasture	Control	21	1.27
20.5	Pasture	Control	26	3.49
20.5	Pasture	Control	28	3.76
20.5	Pasture	Control	32	4.1
20.5	Pasture	Control	39	4.36
20.5	Pasture	Control	46	4.54
20.5	Pasture	Control	60	4.79
20.5	Pasture	Control	74	4.97
20.5	Pasture	Control	88	5.08
20.5	Pasture	Control	109	5.25
20.5	Pasture	Control	130	5.4
20.5	Pasture	Control	147	5.46
20.5	Pasture	Control	167	5.55
20.5	Pasture	Control	186	5.65
20.5	Pasture	Control	215	5.81
20.5	Pasture	Control	249	6.03
20.5	Pasture	Control	277	6.19
20.5	Pasture	Control	312	6.36
20.5	Pasture	Control	344	6.5
20.5	Pasture	Control	377	6.64
20.5	Pasture	Litter Addition	0	0.54
20.5	Pasture	Litter Addition	14	0.71
20.5	Pasture	Litter Addition	18	0.82
20.5	Pasture	Litter Addition	21	1.18
20.5	Pasture	Litter Addition	26	1.52
20.5	Pasture	Litter Addition	28	1.82
20.5	Pasture	Litter Addition	32	2.16
20.5	Pasture	Litter Addition	39	2.49
20.5	Pasture	Litter Addition	46	2.89
20.5	Pasture	Litter Addition	60	3.26
20.5	Pasture	Litter Addition	74	3.56
20.5	Pasture	Litter Addition	88	3.77
20.5	Pasture	Litter Addition	109	4.29

20.5	Pasture	Litter Addition	130	4.77
20.5	Pasture	Litter Addition	147	5.01
20.5	Pasture	Litter Addition	167	5.51
20.5	Pasture	Litter Addition	186	5.85
20.5	Pasture	Litter Addition	215	6.36
20.5	Pasture	Litter Addition	249	6.93
20.5	Pasture	Litter Addition	277	7.45
20.5	Pasture	Litter Addition	312	7.95
20.5	Pasture	Litter Addition	344	8.33
20.5	Pasture	Litter Addition	377	8.54

Table II: Nitrogen (N), carbon (C), and δ^{13}C values from the one-year incubation experiment.

Temperature (°C)	**Soil Type**	**Treatment**	**Time (Days)**	**C (%)**	**N (%)**	**C/N**	**δ^{13}C**
12.5	Forest	Control	0	4.39	0.35	12.54	-25.78
12.5	Forest	Control	0	4.21	0.34	12.38	-25.91
12.5	Forest	Control	14	4.4	0.33	13.52	-25.7
12.5	Forest	Control	14	4.7	0.31	14.97	-25.69
12.5	Forest	Control	28	4.41	0.32	13.86	-25.72
12.5	Forest	Control	28	4.55	0.33	13.88	-25.71
12.5	Forest	Control	56	4.6	0.32	14.24	-25.8
12.5	Forest	Control	56	4.29	0.31	13.81	-25.72
12.5	Forest	Control	168	4.41	0.34	13.09	-25.88
12.5	Forest	Control	168	4.01	0.31	13	-25.74
12.5	Forest	Control	359	4.04	0.33	12.24	-25.75
12.5	Forest	Control	359	4.21	0.33	12.76	-25.8
12.5	Forest	Control	359	4.41	0.46	9.59	-25.88
12.5	Forest	Control	359	4.72	0.49	9.63	-25.89
16.5	Forest	Control	0	4.24	0.34	12.47	-25.84
16.5	Forest	Control	14	4.46	0.32	13.83	-25.9
16.5	Forest	Control	14	4.41	0.33	13.55	-25.75
16.5	Forest	Control	28	4.16	0.32	13.17	-25.77
16.5	Forest	Control	28	4.64	0.33	14.14	-25.67
16.5	Forest	Control	56	4.39	0.32	13.54	-25.89
16.5	Forest	Control	56	4.27	0.32	13.22	-25.79
16.5	Forest	Control	168	4.46	0.33	13.53	-25.88
16.5	Forest	Control	168	4.09	0.31	13.02	-25.89
16.5	Forest	Control	359	4.26	0.33	12.91	-26.08
16.5	Forest	Control	359	4.36	0.35	12.46	-25.72
16.5	Forest	Control	359	4.24	0.35	12.11	-25.91
16.5	Forest	Control	359	4.02	0.34	11.82	-25.68
20.5	Forest	Control	0	4.36	0.34	12.94	-25.75
20.5	Forest	Control	0	4.28	0.35	12.23	-25.77
20.5	Forest	Control	14	4.65	0.34	13.68	-25.76

20.5	Forest	Control	14	4.38	0.33	13.25	-25.79
20.5	Forest	Control	28	3.88	0.29	13.28	-25.48
20.5	Forest	Control	28	4.4	0.33	13.37	-25.85
20.5	Forest	Control	56	4.37	0.32	13.8	-25.86
20.5	Forest	Control	56	4.37	0.32	13.47	-25.83
20.5	Forest	Control	168	4.08	0.34	12	-25.88
20.5	Forest	Control	168	4.58	0.35	13.09	-25.89
20.5	Forest	Control	359	4.19	0.35	11.97	-25.88
20.5	Forest	Control	359	3.94	0.34	11.59	-25.8
20.5	Forest	Control	359	3.34	0.3	11.13	-25.69
20.5	Forest	Control	359	4.28	0.34	12.59	-26.1
12.5	Forest	Litter Addition	0	5.14	0.38	13.55	488.41
12.5	Forest	Litter Addition	0	5.31	0.39	13.58	528.03
12.5	Forest	Litter Addition	14	4.94	0.42	11.9	376.39
12.5	Forest	Litter Addition	14	5.32	0.47	11.26	382.63
12.5	Forest	Litter Addition	14	5.11	0.44	11.57	352.3
12.5	Forest	Litter Addition	14	4.89	0.44	11.15	339.61
12.5	Forest	Litter Addition	14	5.11	0.43	11.79	368.44
12.5	Forest	Litter Addition	14	4.91	0.44	11.19	370.35
12.5	Forest	Litter Addition	14	4.8	0.42	11.4	436.61
12.5	Forest	Litter Addition	14	5.29	0.42	12.51	322.29
12.5	Forest	Litter Addition	28	4.8	0.45	10.6	307.62
12.5	Forest	Litter Addition	28	4.8	0.44	10.95	311.78
12.5	Forest	Litter Addition	28	4.61	0.43	10.71	298.02
12.5	Forest	Litter Addition	28	5	0.48	10.37	319.32
12.5	Forest	Litter Addition	28	4.98	0.45	11.05	288.54
12.5	Forest	Litter Addition	28	4.9	0.45	10.98	308.89
12.5	Forest	Litter Addition	56	5.01	0.46	10.93	275.77
12.5	Forest	Litter Addition	56	5.09	0.5	10.23	283.44
12.5	Forest	Litter Addition	56	4.9	0.47	10.54	297.77
12.5	Forest	Litter Addition	56	4.85	0.46	10.6	319.55
12.5	Forest	Litter Addition	56	5.25	0.48	10.96	283.06
12.5	Forest	Litter Addition	56	4.99	0.46	10.73	288.41
12.5	Forest	Litter Addition	168	4.7	0.35	13.44	184.39
12.5	Forest	Litter Addition	168	4.43	0.33	13.36	198.99
12.5	Forest	Litter Addition	168	4.98	0.42	11.96	203.78
12.5	Forest	Litter Addition	168	4.74	0.4	11.93	217.1
12.5	Forest	Litter Addition	168	4.8	0.4	12.08	148.38
12.5	Forest	Litter Addition	168	4.73	0.4	11.9	202.6
12.5	Forest	Litter Addition	359	4.8	0.4	12.08	148.38
12.5	Forest	Litter Addition	359	4.73	0.4	11.9	202.6
12.5	Forest	Litter Addition	359	4.62	0.38	12.16	233.1
12.5	Forest	Litter Addition	359	4.53	0.37	12.24	232.5
12.5	Forest	Litter Addition	359	4.61	0.39	11.82	233.2
12.5	Forest	Litter Addition	359	4.73	0.38	12.45	254.2

12.5	Forest	Litter Addition	359	3.99	0.31	12.87	226.9
12.5	Forest	Litter Addition	359	4.72	0.37	12.76	202.8
16.5	Forest	Litter Addition	0	5.71	0.41	13.86	590.78
16.5	Forest	Litter Addition	0	5.66	0.43	13.26	473.26
16.5	Forest	Litter Addition	14	4.72	0.4	11.73	298.25
16.5	Forest	Litter Addition	14	5.01	0.42	11.81	307.45
16.5	Forest	Litter Addition	14	5.09	0.43	11.78	301.26
16.5	Forest	Litter Addition	14	5.06	0.43	11.82	321.63
16.5	Forest	Litter Addition	14	5.11	0.43	11.97	295.59
16.5	Forest	Litter Addition	14	5.06	0.45	11.36	318.6
16.5	Forest	Litter Addition	14	4.88	0.43	11.34	304.14
16.5	Forest	Litter Addition	14	4.87	0.42	11.65	309.18
16.5	Forest	Litter Addition	28	5.48	0.5	10.96	310.45
16.5	Forest	Litter Addition	28	4.75	0.45	10.58	269.27
16.5	Forest	Litter Addition	28	4.96	0.46	10.77	280.88
16.5	Forest	Litter Addition	28	5	0.46	10.93	275.73
16.5	Forest	Litter Addition	28	4.8	0.44	10.8	278.34
16.5	Forest	Litter Addition	28	5.04	0.45	11.21	265.79
16.5	Forest	Litter Addition	56	5.01	0.41	12.2	250.33
16.5	Forest	Litter Addition	56	5	0.48	10.49	250.33
16.5	Forest	Litter Addition	56	5.13	0.42	12.16	242.7
16.5	Forest	Litter Addition	56	4.72	0.39	12.23	278.69
16.5	Forest	Litter Addition	56	4.79	0.4	12.01	264.48
16.5	Forest	Litter Addition	56	4.96	0.42	11.68	241.9
16.5	Forest	Litter Addition	168	4.56	0.39	11.63	206.16
16.5	Forest	Litter Addition	168	4.76	0.4	11.76	191.1
16.5	Forest	Litter Addition	168	4.69	0.41	11.39	278.69
16.5	Forest	Litter Addition	168	4.9	0.43	11.53	188.39
16.5	Forest	Litter Addition	168	5.05	0.42	12.14	206.37
16.5	Forest	Litter Addition	168	4.72	0.4	11.7	210.03
16.5	Forest	Litter Addition	359	4.43	0.38	11.66	168.5
16.5	Forest	Litter Addition	359	4.9	0.39	12.56	187.8
16.5	Forest	Litter Addition	359	4.97	0.39	12.74	167.1
16.5	Forest	Litter Addition	359	4.85	0.39	12.44	166.5
16.5	Forest	Litter Addition	359	4.62	0.36	12.83	187.3
16.5	Forest	Litter Addition	359	4.61	0.37	12.46	189.2
20.5	Forest	Litter Addition	0	5.35	0.39	13.86	370.78
20.5	Forest	Litter Addition	14	4.64	0.42	11.13	274.22
20.5	Forest	Litter Addition	14	5.12	0.44	11.6	265.65
20.5	Forest	Litter Addition	14	5.43	0.47	11.59	317.33
20.5	Forest	Litter Addition	14	4.98	0.44	11.2	310.71
20.5	Forest	Litter Addition	14	4.91	0.44	11.14	276.67
20.5	Forest	Litter Addition	14	4.67	0.42	10.99	279.66
20.5	Forest	Litter Addition	14	4.9	0.44	11.05	291.93
20.5	Forest	Litter Addition	14	4.89	0.46	10.61	297.7

20.5	Forest	Litter Addition	28	5.21	0.4	13.12	246.4
20.5	Forest	Litter Addition	28	4.72	0.42	11.18	274.25
20.5	Forest	Litter Addition	28	5.07	0.44	11.42	269.54
20.5	Forest	Litter Addition	28	4.78	0.42	11.43	269.69
20.5	Forest	Litter Addition	28	4.77	0.42	11.25	242.51
20.5	Forest	Litter Addition	28	4.74	0.41	11.58	256.93
20.5	Forest	Litter Addition	56	4.81	0.41	11.6	232.21
20.5	Forest	Litter Addition	56	5.06	0.43	11.84	251.38
20.5	Forest	Litter Addition	56	4.73	0.39	12.22	278.58
20.5	Forest	Litter Addition	56	4.89	0.43	11.32	239.59
20.5	Forest	Litter Addition	56	4.68	0.4	11.75	241.98
20.5	Forest	Litter Addition	56	4.98	0.41	12.07	239.86
20.5	Forest	Litter Addition	168	4.72	0.4	11.88	208.87
20.5	Forest	Litter Addition	168	4.84	0.43	11.23	203.52
20.5	Forest	Litter Addition	359	4.44	0.37	12	187.5
20.5	Forest	Litter Addition	359	4.82	0.41	11.76	219
20.5	Forest	Litter Addition	359	4.67	0.39	11.97	155.1
20.5	Forest	Litter Addition	359	4.99	0.41	12.17	157.4
20.5	Forest	Litter Addition	359	4.36	0.35	12.46	163.9
20.5	Forest	Litter Addition	359	4.26	0.33	12.91	157.2
12.5	Pasture	Control	0	4.56	0.46	9.91	-26.77
12.5	Pasture	Control	0	4.58	0.49	9.35	-26.73
12.5	Pasture	Control	14	4.71	0.44	10.59	-26.37
12.5	Pasture	Control	14	4.6	0.44	10.46	-26.56
12.5	Pasture	Control	28	4.56	0.46	10	-26.62
12.5	Pasture	Control	28	4.51	0.43	10.42	-26.56
12.5	Pasture	Control	56	4.47	0.42	10.58	-26.58
12.5	Pasture	Control	56	4.43	0.43	10.28	-26.5
12.5	Pasture	Control	168	4.42	0.47	9.4	-26.63
12.5	Pasture	Control	168	4.43	0.48	9.23	-26.57
12.5	Pasture	Control	359	4.58	0.48	9.54	-26.7
12.5	Pasture	Control	359	4.25	0.45	9.44	-26.69
12.5	Pasture	Control	359	4.77	0.51	9.35	-26.68
12.5	Pasture	Control	359	4.3	0.48	8.96	-26.64
16.5	Pasture	Control	0	4.51	0.46	9.8	-26.77
16.5	Pasture	Control	0	4.56	0.48	9.5	-26.75
16.5	Pasture	Control	14	4.91	0.44	11.17	-26.65
16.5	Pasture	Control	14	4.69	0.46	10.2	-26.54
16.5	Pasture	Control	28	4.28	0.41	10.41	-26.55
16.5	Pasture	Control	28	4.56	0.44	10.28	-26.67
16.5	Pasture	Control	56	4.66	0.46	10.21	-26.61
16.5	Pasture	Control	56	4.57	0.44	10.48	-26.66
16.5	Pasture	Control	168	4.76	0.45	10.49	-26.63
16.5	Pasture	Control	168	4.45	0.45	9.95	-26.64
16.5	Pasture	Control	359	4.1	0.44	9.32	-26.72

16.5	Pasture	Control	359	4.37	0.47	9.3	-26.67
16.5	Pasture	Control	359	4.61	0.5	9.22	-26.71
16.5	Pasture	Control	359	4.14	0.45	9.2	-26.66
20.5	Pasture	Control	0	4.57	0.47	9.72	-26.66
20.5	Pasture	Control	0	4.56	0.49	9.31	-26.6
20.5	Pasture	Control	14	4.6	0.44	10.41	-26.69
20.5	Pasture	Control	14	4.73	0.45	10.46	-26.61
20.5	Pasture	Control	28	4.54	0.45	10.14	-26.53
20.5	Pasture	Control	28	4.56	0.43	10.48	-26.68
20.5	Pasture	Control	56	4.48	0.44	10.29	-26.68
20.5	Pasture	Control	56	4.56	0.45	10.15	-26.61
20.5	Pasture	Control	168	4.45	0.48	9.27	-26.67
20.5	Pasture	Control	168	4.3	0.47	9.15	-26.51
20.5	Pasture	Control	359	4.48	0.48	9.33	-26.67
20.5	Pasture	Control	359	4.29	0.47	9.13	-26.69
20.5	Pasture	Control	359	4.4	0.48	9.17	-26.48
20.5	Pasture	Control	359	4.45	0.49	9.08	-26.68
12.5	Pasture	Litter Addition	0	5.8	0.52	11.11	526.94
12.5	Pasture	Litter Addition	0	5.92	0.53	11.15	565.02
12.5	Pasture	Litter Addition	14	4.74	0.51	9.34	293.04
12.5	Pasture	Litter Addition	14	4.83	0.53	9.14	325.39
12.5	Pasture	Litter Addition	14	5.02	0.53	9.39	311.21
12.5	Pasture	Litter Addition	14	5.08	0.56	9.06	297.56
12.5	Pasture	Litter Addition	14	4.63	0.5	9.25	315.22
12.5	Pasture	Litter Addition	14	5.25	0.58	8.99	324.25
12.5	Pasture	Litter Addition	14	5.01	0.53	9.47	302.97
12.5	Pasture	Litter Addition	14	5.23	0.56	9.3	328.49
12.5	Pasture	Litter Addition	28	4.94	0.58	8.59	329.44
12.5	Pasture	Litter Addition	28	5.25	0.61	8.65	298.57
12.5	Pasture	Litter Addition	28	5.04	0.59	8.48	283.27
12.5	Pasture	Litter Addition	28	4.98	0.58	8.62	282.29
12.5	Pasture	Litter Addition	28	5.03	0.58	8.61	253.49
12.5	Pasture	Litter Addition	28	4.88	0.57	8.63	310.39
12.5	Pasture	Litter Addition	56	4.88	0.58	8.39	248.72
12.5	Pasture	Litter Addition	56	4.87	0.57	8.55	255.01
12.5	Pasture	Litter Addition	56	4.69	0.54	8.62	229.94
12.5	Pasture	Litter Addition	56	5.11	0.6	8.53	257.47
12.5	Pasture	Litter Addition	56	4.83	0.56	8.63	255.43
12.5	Pasture	Litter Addition	56	5.01	0.6	8.41	251.91
12.5	Pasture	Litter Addition	168	4.82	0.52	9.34	212.12
12.5	Pasture	Litter Addition	168	4.95	0.52	9.61	214.25
12.5	Pasture	Litter Addition	168	4.94	0.53	9.29	181.4
12.5	Pasture	Litter Addition	168	4.77	0.52	9.25	189.36
12.5	Pasture	Litter Addition	168	5.17	0.53	9.78	231.85
12.5	Pasture	Litter Addition	168	5.04	0.56	8.93	223.01

12.5	Pasture	Litter Addition	359	4.88	0.5	9.76	207.8
12.5	Pasture	Litter Addition	359	4.81	0.5	9.62	203.4
12.5	Pasture	Litter Addition	359	4.99	0.51	9.78	183.6
12.5	Pasture	Litter Addition	359	5.09	0.53	9.6	226.3
12.5	Pasture	Litter Addition	359	4.65	0.49	9.49	202.2
12.5	Pasture	Litter Addition	359	4.87	0.51	9.55	219
16.5	Pasture	Litter Addition	0	5.92	0.55	10.7	532.11
16.5	Pasture	Litter Addition	0	5.87	0.53	11.05	503.86
16.5	Pasture	Litter Addition	14	3.96	0.43	9.22	314.06
16.5	Pasture	Litter Addition	14	5.13	0.55	9.25	304.77
16.5	Pasture	Litter Addition	14	4.89	0.53	9.18	327.51
16.5	Pasture	Litter Addition	14	4.78	0.51	9.33	306.28
16.5	Pasture	Litter Addition	14	5.18	0.56	9.28	327.06
16.5	Pasture	Litter Addition	14	4.71	0.51	9.24	295.07
16.5	Pasture	Litter Addition	14	5.05	0.55	9.17	251.67
16.5	Pasture	Litter Addition	14	4.93	0.53	9.28	270.66
16.5	Pasture	Litter Addition	28	4.84	0.55	8.75	220.36
16.5	Pasture	Litter Addition	28	4.99	0.58	8.64	230.86
16.5	Pasture	Litter Addition	28	4.72	0.55	8.62	253.13
16.5	Pasture	Litter Addition	28	4.8	0.56	8.64	263.44
16.5	Pasture	Litter Addition	28	4.98	0.57	8.72	271.27
16.5	Pasture	Litter Addition	28	4.81	0.55	8.71	277.4
16.5	Pasture	Litter Addition	56	4.85	0.58	8.4	244.72
16.5	Pasture	Litter Addition	56	5.14	0.55	9.39	250.12
16.5	Pasture	Litter Addition	56	5.14	0.61	8.43	258.37
16.5	Pasture	Litter Addition	56	5.13	0.52	9.23	262.85
16.5	Pasture	Litter Addition	56	4.78	0.57	8.34	252.67
16.5	Pasture	Litter Addition	56	4.94	0.51	9.6	221.03
16.5	Pasture	Litter Addition	168	4.84	0.51	9.58	192.84
16.5	Pasture	Litter Addition	168	4.96	0.49	10.12	226.87
16.5	Pasture	Litter Addition	168	4.83	0.52	9.38	189.69
16.5	Pasture	Litter Addition	168	4.8	0.5	9.69	196.1
16.5	Pasture	Litter Addition	168	4.85	0.5	9.63	191.53
16.5	Pasture	Litter Addition	168	5.55	0.6	9.21	189.16
16.5	Pasture	Litter Addition	359	4.69	0.49	9.57	179.5
16.5	Pasture	Litter Addition	359	4.64	0.49	9.47	171.1
16.5	Pasture	Litter Addition	359	4.5	0.46	9.78	257.5
16.5	Pasture	Litter Addition	359	4.87	0.5	9.74	145.8
16.5	Pasture	Litter Addition	359	4.81	0.5	9.62	192.6
16.5	Pasture	Litter Addition	359	4.37	0.46	9.5	162.5
20.5	Pasture	Litter Addition	0	5.42	0.49	11.03	397.92
20.5	Pasture	Litter Addition	0	5.39	0.4	13.38	383.55
20.5	Pasture	Litter Addition	14	4.71	0.54	8.67	271.33
20.5	Pasture	Litter Addition	14	4.7	0.55	8.57	309.6
20.5	Pasture	Litter Addition	14	5.07	0.58	8.71	294.63

20.5	Pasture	Litter Addition	14	5.18	0.59	8.78	264.14
20.5	Pasture	Litter Addition	14	5	0.57	8.82	283.08
20.5	Pasture	Litter Addition	14	4.98	0.57	8.67	282.83
20.5	Pasture	Litter Addition	14	4.91	0.56	8.77	250.63
20.5	Pasture	Litter Addition	14	5.15	0.57	9.02	255.79
20.5	Pasture	Litter Addition	28	5.05	0.54	9.34	256.49
20.5	Pasture	Litter Addition	28	4.73	0.5	9.52	201.07
20.5	Pasture	Litter Addition	28	4.77	0.51	9.43	210.26
20.5	Pasture	Litter Addition	28	4.99	0.52	9.63	212.31
20.5	Pasture	Litter Addition	28	4.9	0.52	9.44	248.89
20.5	Pasture	Litter Addition	28	4.93	0.52	9.55	253.74
20.5	Pasture	Litter Addition	56	4.78	0.54	8.82	231.68
20.5	Pasture	Litter Addition	56	4.94	0.54	9.14	239.64
20.5	Pasture	Litter Addition	56	4.73	0.5	9.54	234.68
20.5	Pasture	Litter Addition	56	4.86	0.52	9.33	239.29
20.5	Pasture	Litter Addition	56	4.95	0.52	9.59	241.02
20.5	Pasture	Litter Addition	56	4.67	0.49	9.49	206.37
20.5	Pasture	Litter Addition	168	4.56	0.49	9.31	157.5
20.5	Pasture	Litter Addition	168	4.73	0.51	9.27	189.6
20.5	Pasture	Litter Addition	359	4.1	0.43	9.53	140.2
20.5	Pasture	Litter Addition	359	4.74	0.5	9.48	149.1
20.5	Pasture	Litter Addition	359	4.63	0.49	9.45	193.4
20.5	Pasture	Litter Addition	359	4.69	0.5	9.38	189.2
20.5	Pasture	Litter Addition	359	4.58	0.47	9.74	139.3
20.5	Pasture	Litter Addition	359	4.61	0.47	9.81	133.44

Table III: DRIFT analysis data from the one-year incubation experiment. Grouped by carbon compounds: Aliphatic carbon-hydrogen (C-H) (Aliph. C-H), Aromatic esters and carbonyl/carboxyl (C=O/OH) (Aro. Ester C—O), Aromatic carbon-carbon (C-C) (Aromatic C-C), Lignin-like residues (Lignin. Res), Phenolic substances and cellulose (Phenol. Cell), Aromatic carbon-hydrogen (C-H) (Aromatic C-H), Aliphatic C—O and alcohol C—O (Aliph. Alc. C—O), C—O bonds of ploy-alcoholic and ether groups (Poly. Alc and Ether C—O).

Temperature (°C)	Soil Type	Treatment	Time (Days)	Compound	Percentage (%)
12.5	Forest	Control	0	Aliph. Alc. C-O	19.4476
12.5	Forest	Control	14	Aliph. Alc. C-O	25.8271
12.5	Forest	Control	28	Aliph. Alc. C-O	23.2798
12.5	Forest	Control	56	Aliph. Alc. C-O	20.8348
12.5	Forest	Control	168	Aliph. Alc. C-O	26.7160
12.5	Forest	Control	359	Aliph. Alc. C-O	20.2596
12.5	Forest	Litter Addition	0	Aliph. Alc. C-O	25.5879
12.5	Forest	Litter Addition	14	Aliph. Alc. C-O	18.1380
12.5	Forest	Litter Addition	28	Aliph. Alc. C-O	24.3817
12.5	Forest	Litter Addition	56	Aliph. Alc. C-O	27.8120
12.5	Forest	Litter Addition	168	Aliph. Alc. C-O	18.2892
12.5	Forest	Litter Addition	359	Aliph. Alc. C-O	17.2970
12.5	Forest	Control	0	Aliphat. C-H	9.5767
12.5	Forest	Control	14	Aliphat. C-H	1.3316

12.5	Forest	Control	28	Aliphat. C-H	6.8751
12.5	Forest	Control	56	Aliphat. C-H	8.0203
12.5	Forest	Control	168	Aliphat. C-H	3.5984
12.5	Forest	Control	359	Aliphat. C-H	8.6143
12.5	Forest	Litter Addition	0	Aliphat. C-H	3.0209
12.5	Forest	Litter Addition	14	Aliphat. C-H	9.9094
12.5	Forest	Litter Addition	28	Aliphat. C-H	1.2562
12.5	Forest	Litter Addition	56	Aliphat. C-H	5.1162
12.5	Forest	Litter Addition	168	Aliphat. C-H	8.5807
12.5	Forest	Litter Addition	359	Aliphat. C-H	8.3557
12.5	Forest	Control	0	Aro. Ester C--O	2.4468
12.5	Forest	Control	14	Aro. Ester C--O	1.7651
12.5	Forest	Control	28	Aro. Ester C--O	1.7971
12.5	Forest	Control	56	Aro. Ester C--O	2.0748
12.5	Forest	Control	168	Aro. Ester C--O	1.5483
12.5	Forest	Control	359	Aro. Ester C--O	1.8596
12.5	Forest	Litter Addition	0	Aro. Ester C--O	1.6243
12.5	Forest	Litter Addition	14	Aro. Ester C--O	2.4400
12.5	Forest	Litter Addition	28	Aro. Ester C--O	2.1411
12.5	Forest	Litter Addition	56	Aro. Ester C--O	1.5343
12.5	Forest	Litter Addition	168	Aro. Ester C--O	2.3380
12.5	Forest	Litter Addition	359	Aro. Ester C--O	2.2232
12.5	Forest	Control	0	Aromatic C-C	49.2599
12.5	Forest	Control	14	Aromatic C-C	31.2284
12.5	Forest	Control	28	Aromatic C-C	46.7722
12.5	Forest	Control	56	Aromatic C-C	49.2165
12.5	Forest	Control	168	Aromatic C-C	46.3685
12.5	Forest	Control	359	Aromatic C-C	50.6652
12.5	Forest	Litter Addition	0	Aromatic C-C	33.4589
12.5	Forest	Litter Addition	14	Aromatic C-C	51.7064
12.5	Forest	Litter Addition	28	Aromatic C-C	32.0452
12.5	Forest	Litter Addition	56	Aromatic C-C	36.1525
12.5	Forest	Litter Addition	168	Aromatic C-C	52.4214
12.5	Forest	Litter Addition	359	Aromatic C-C	53.4481
12.5	Forest	Control	0	Aromatic C-H	3.0070
12.5	Forest	Control	14	Aromatic C-H	4.9768
12.5	Forest	Control	28	Aromatic C-H	4.8809
12.5	Forest	Control	56	Aromatic C-H	4.1403
12.5	Forest	Control	168	Aromatic C-H	5.7915
12.5	Forest	Control	359	Aromatic C-H	2.9644
12.5	Forest	Litter Addition	0	Aromatic C-H	4.7656
12.5	Forest	Litter Addition	14	Aromatic C-H	3.1202
12.5	Forest	Litter Addition	28	Aromatic C-H	4.4181
12.5	Forest	Litter Addition	56	Aromatic C-H	6.3417
12.5	Forest	Litter Addition	168	Aromatic C-H	3.4537

12.5	Forest	Litter Addition	359	Aromatic C-H	3.2409
12.5	Forest	Control	0	Lignin res.	1.4640
12.5	Forest	Control	14	Lignin res.	3.7034
12.5	Forest	Control	28	Lignin res.	0.9444
12.5	Forest	Control	56	Lignin res.	1.5010
12.5	Forest	Control	168	Lignin res.	1.4032
12.5	Forest	Control	359	Lignin res.	1.1841
12.5	Forest	Litter Addition	0	Lignin res.	3.2015
12.5	Forest	Litter Addition	14	Lignin res.	1.8247
12.5	Forest	Litter Addition	28	Lignin res.	4.0054
12.5	Forest	Litter Addition	56	Lignin res.	1.8469
12.5	Forest	Litter Addition	168	Lignin res.	1.9974
12.5	Forest	Litter Addition	359	Lignin res.	1.6539
12.5	Forest	Control	0	Phenol. Cell.	4.0911
12.5	Forest	Control	14	Phenol. Cell.	19.9491
12.5	Forest	Control	28	Phenol. Cell.	3.5662
12.5	Forest	Control	56	Phenol. Cell.	3.8218
12.5	Forest	Control	168	Phenol. Cell.	3.3645
12.5	Forest	Control	359	Phenol. Cell.	3.5021
12.5	Forest	Litter Addition	0	Phenol. Cell.	17.0228
12.5	Forest	Litter Addition	14	Phenol. Cell.	3.2938
12.5	Forest	Litter Addition	28	Phenol. Cell.	20.6485
12.5	Forest	Litter Addition	56	Phenol. Cell.	9.8683
12.5	Forest	Litter Addition	168	Phenol. Cell.	3.1297
12.5	Forest	Litter Addition	359	Phenol. Cell.	3.9211
12.5	Forest	Control	0	Poly. Alc. and Ether C-O	10.7068
12.5	Forest	Control	14	Poly. Alc. and Ether C-O	11.2185
12.5	Forest	Control	28	Poly. Alc. and Ether C-O	11.8843
12.5	Forest	Control	56	Poly. Alc. and Ether C-O	10.3905
12.5	Forest	Control	168	Poly. Alc. and Ether C-O	11.2096
12.5	Forest	Control	359	Poly. Alc. and Ether C-O	10.9507
12.5	Forest	Litter Addition	0	Poly. Alc. and Ether C-O	11.3181
12.5	Forest	Litter Addition	14	Poly. Alc. and Ether C-O	9.5675
12.5	Forest	Litter Addition	28	Poly. Alc. and Ether C-O	11.1038
12.5	Forest	Litter Addition	56	Poly. Alc. and Ether C-O	11.3282
12.5	Forest	Litter Addition	168	Poly. Alc. and Ether C-O	9.7899
12.5	Forest	Litter Addition	359	Poly. Alc. and Ether C-O	9.8601
12.5	Pasture	Control	0	Aliph. Alc. C-O	19.3356
12.5	Pasture	Control	14	Aliph. Alc. C-O	21.5802
12.5	Pasture	Control	28	Aliph. Alc. C-O	27.1636
12.5	Pasture	Control	56	Aliph. Alc. C-O	21.6266
12.5	Pasture	Control	168	Aliph. Alc. C-O	26.4987
12.5	Pasture	Control	359	Aliph. Alc. C-O	25.0098
12.5	Pasture	Litter Addition	0	Aliph. Alc. C-O	25.7301
12.5	Pasture	Litter Addition	14	Aliph. Alc. C-O	26.2925

12.5	Pasture	Litter Addition	28	Aliph. Alc. C-O	21.1788
12.5	Pasture	Litter Addition	56	Aliph. Alc. C-O	1.6176
12.5	Pasture	Litter Addition	168	Aliph. Alc. C-O	11.1928
12.5	Pasture	Litter Addition	359	Aliph. Alc. C-O	3.9295
12.5	Pasture	Control	0	Aliphat. C-H	10.5250
12.5	Pasture	Control	14	Aliphat. C-H	8.6646
12.5	Pasture	Control	28	Aliphat. C-H	2.3625
12.5	Pasture	Control	56	Aliphat. C-H	10.2122
12.5	Pasture	Control	168	Aliphat. C-H	6.8643
12.5	Pasture	Control	359	Aliphat. C-H	12.0118
12.5	Pasture	Litter Addition	0	Aliphat. C-H	5.6928
12.5	Pasture	Litter Addition	14	Aliphat. C-H	2.3361
12.5	Pasture	Litter Addition	28	Aliphat. C-H	6.4643
12.5	Pasture	Litter Addition	56	Aliphat. C-H	1.6569
12.5	Pasture	Litter Addition	168	Aliphat. C-H	2.3628
12.5	Pasture	Litter Addition	359	Aliphat. C-H	1.5137
12.5	Pasture	Control	0	Aro. Ester C--O	2.4059
12.5	Pasture	Control	14	Aro. Ester C--O	1.8466
12.5	Pasture	Control	28	Aro. Ester C--O	1.3472
12.5	Pasture	Control	56	Aro. Ester C--O	2.2585
12.5	Pasture	Control	168	Aro. Ester C--O	1.5870
12.5	Pasture	Control	359	Aro. Ester C--O	1.7280
12.5	Pasture	Litter Addition	0	Aro. Ester C--O	1.6243
12.5	Pasture	Litter Addition	14	Aro. Ester C--O	1.4740
12.5	Pasture	Litter Addition	28	Aro. Ester C--O	32.9793
12.5	Pasture	Litter Addition	56	Aro. Ester C--O	30.0365
12.5	Pasture	Litter Addition	168	Aro. Ester C--O	44.9242
12.5	Pasture	Litter Addition	359	Aro. Ester C--O	31.8427
12.5	Pasture	Control	0	Aromatic C-C	49.8859
12.5	Pasture	Control	14	Aromatic C-C	34.6016
12.5	Pasture	Control	28	Aromatic C-C	30.1810
12.5	Pasture	Control	56	Aromatic C-C	46.2451
12.5	Pasture	Control	168	Aromatic C-C	35.2430
12.5	Pasture	Control	359	Aromatic C-C	37.7033
12.5	Pasture	Litter Addition	0	Aromatic C-C	33.6058
12.5	Pasture	Litter Addition	14	Aromatic C-C	29.3571
12.5	Pasture	Litter Addition	28	Aromatic C-C	1.9454
12.5	Pasture	Litter Addition	56	Aromatic C-C	3.4253
12.5	Pasture	Litter Addition	168	Aromatic C-C	0.6945
12.5	Pasture	Litter Addition	359	Aromatic C-C	2.7505
12.5	Pasture	Control	0	Aromatic C-H	3.5793
12.5	Pasture	Control	14	Aromatic C-H	3.5547
12.5	Pasture	Control	28	Aromatic C-H	5.4977
12.5	Pasture	Control	56	Aromatic C-H	4.7359
12.5	Pasture	Control	168	Aromatic C-H	6.1675

12.5	Pasture	Control	359	Aromatic C-H	5.5320
12.5	Pasture	Litter Addition	0	Aromatic C-H	4.6825
12.5	Pasture	Litter Addition	14	Aromatic C-H	4.8226
12.5	Pasture	Litter Addition	28	Aromatic C-H	11.6481
12.5	Pasture	Litter Addition	56	Aromatic C-H	11.3345
12.5	Pasture	Litter Addition	168	Aromatic C-H	9.8972
12.5	Pasture	Litter Addition	359	Aromatic C-H	10.9343
12.5	Pasture	Control	0	Lignin res.	0.9559
12.5	Pasture	Control	14	Lignin res.	3.0835
12.5	Pasture	Control	28	Lignin res.	2.9085
12.5	Pasture	Control	56	Lignin res.	0.7468
12.5	Pasture	Control	168	Lignin res.	1.2282
12.5	Pasture	Control	359	Lignin res.	1.3740
12.5	Pasture	Litter Addition	0	Lignin res.	1.9155
12.5	Pasture	Litter Addition	14	Lignin res.	3.1156
12.5	Pasture	Litter Addition	28	Lignin res.	15.4169
12.5	Pasture	Litter Addition	56	Lignin res.	20.9486
12.5	Pasture	Litter Addition	168	Lignin res.	3.2607
12.5	Pasture	Litter Addition	359	Lignin res.	18.0353
12.5	Pasture	Control	0	Phenol. Cell.	3.6816
12.5	Pasture	Control	14	Phenol. Cell.	16.4994
12.5	Pasture	Control	28	Phenol. Cell.	19.1587
12.5	Pasture	Control	56	Phenol. Cell.	4.6330
12.5	Pasture	Control	168	Phenol. Cell.	11.8417
12.5	Pasture	Control	359	Phenol. Cell.	6.8281
12.5	Pasture	Litter Addition	0	Phenol. Cell.	15.2408
12.5	Pasture	Litter Addition	14	Phenol. Cell.	20.9396
12.5	Pasture	Litter Addition	28	Phenol. Cell.	4.5024
12.5	Pasture	Litter Addition	56	Phenol. Cell.	5.0110
12.5	Pasture	Litter Addition	168	Phenol. Cell.	4.8664
12.5	Pasture	Litter Addition	359	Phenol. Cell.	5.4464
12.5	Pasture	Control	0	Poly. Alc. and Ether C-O	9.6310
12.5	Pasture	Control	14	Poly. Alc. and Ether C-O	10.1694
12.5	Pasture	Control	28	Poly. Alc. and Ether C-O	11.3807
12.5	Pasture	Control	56	Poly. Alc. and Ether C-O	9.5419
12.5	Pasture	Control	168	Poly. Alc. and Ether C-O	10.5696
12.5	Pasture	Control	359	Poly. Alc. and Ether C-O	9.8131
12.5	Pasture	Litter Addition	0	Poly. Alc. and Ether C-O	11.5082
12.5	Pasture	Litter Addition	14	Poly. Alc. and Ether C-O	11.6625
12.5	Pasture	Litter Addition	28	Poly. Alc. and Ether C-O	25.3746
12.5	Pasture	Litter Addition	56	Poly. Alc. and Ether C-O	25.9695
12.5	Pasture	Litter Addition	168	Poly. Alc. and Ether C-O	22.8015
12.5	Pasture	Litter Addition	359	Poly. Alc. and Ether C-O	25.5476
16.5	Forest	Control	0	Aliph. Alc. C-O	26.9826
16.5	Forest	Control	14	Aliph. Alc. C-O	20.7134

16.5	Forest	Control	28	Aliph. Alc. C-O	20.5092
16.5	Forest	Control	56	Aliph. Alc. C-O	20.0732
16.5	Forest	Control	168	Aliph. Alc. C-O	25.8021
16.5	Forest	Control	359	Aliph. Alc. C-O	19.8080
16.5	Forest	Litter Addition	0	Aliph. Alc. C-O	19.7792
16.5	Forest	Litter Addition	14	Aliph. Alc. C-O	26.9358
16.5	Forest	Litter Addition	28	Aliph. Alc. C-O	18.3081
16.5	Forest	Litter Addition	56	Aliph. Alc. C-O	20.4700
16.5	Forest	Litter Addition	168	Aliph. Alc. C-O	21.6440
16.5	Forest	Litter Addition	359	Aliph. Alc. C-O	20.9164
16.5	Forest	Control	0	Aliphat. C-H	1.8831
16.5	Forest	Control	14	Aliphat. C-H	8.3629
16.5	Forest	Control	28	Aliphat. C-H	10.1136
16.5	Forest	Control	56	Aliphat. C-H	8.5898
16.5	Forest	Control	168	Aliphat. C-H	6.5307
16.5	Forest	Control	359	Aliphat. C-H	7.8933
16.5	Forest	Litter Addition	0	Aliphat. C-H	9.1975
16.5	Forest	Litter Addition	14	Aliphat. C-H	7.9036
16.5	Forest	Litter Addition	28	Aliphat. C-H	13.4165
16.5	Forest	Litter Addition	56	Aliphat. C-H	9.7356
16.5	Forest	Litter Addition	168	Aliphat. C-H	8.9449
16.5	Forest	Litter Addition	359	Aliphat. C-H	9.8597
16.5	Forest	Control	0	Aro. Ester C--O	1.5002
16.5	Forest	Control	14	Aro. Ester C--O	2.0513
16.5	Forest	Control	28	Aro. Ester C--O	2.1315
16.5	Forest	Control	56	Aro. Ester C--O	1.9551
16.5	Forest	Control	168	Aro. Ester C--O	1.6396
16.5	Forest	Control	359	Aro. Ester C--O	1.8976
16.5	Forest	Litter Addition	0	Aro. Ester C--O	2.5877
16.5	Forest	Litter Addition	14	Aro. Ester C--O	1.7934
16.5	Forest	Litter Addition	28	Aro. Ester C--O	2.1980
16.5	Forest	Litter Addition	56	Aro. Ester C--O	1.9237
16.5	Forest	Litter Addition	168	Aro. Ester C--O	1.9260
16.5	Forest	Litter Addition	359	Aro. Ester C--O	2.0210
16.5	Forest	Control	0	Aromatic C-C	31.8648
16.5	Forest	Control	14	Aromatic C-C	48.9223
16.5	Forest	Control	28	Aromatic C-C	46.6843
16.5	Forest	Control	56	Aromatic C-C	51.0308
16.5	Forest	Control	168	Aromatic C-C	44.9112
16.5	Forest	Control	359	Aromatic C-C	50.5223
16.5	Forest	Litter Addition	0	Aromatic C-C	49.5038
16.5	Forest	Litter Addition	14	Aromatic C-C	41.9580
16.5	Forest	Litter Addition	28	Aromatic C-C	39.3126
16.5	Forest	Litter Addition	56	Aromatic C-C	47.9433
16.5	Forest	Litter Addition	168	Aromatic C-C	48.1458

16.5	Forest	Litter Addition	359	Aromatic C-C	48.7726
16.5	Forest	Control	0	Aromatic C-H	5.5130
16.5	Forest	Control	14	Aromatic C-H	3.7760
16.5	Forest	Control	28	Aromatic C-H	4.6832
16.5	Forest	Control	56	Aromatic C-H	3.1962
16.5	Forest	Control	168	Aromatic C-H	5.2959
16.5	Forest	Control	359	Aromatic C-H	3.4385
16.5	Forest	Litter Addition	0	Aromatic C-H	3.0272
16.5	Forest	Litter Addition	14	Aromatic C-H	6.6650
16.5	Forest	Litter Addition	28	Aromatic C-H	2.4423
16.5	Forest	Litter Addition	56	Aromatic C-H	4.5337
16.5	Forest	Litter Addition	168	Aromatic C-H	3.1369
16.5	Forest	Litter Addition	359	Aromatic C-H	3.9808
16.5	Forest	Control	0	Lignin res.	3.1820
16.5	Forest	Control	14	Lignin res.	0.8695
16.5	Forest	Control	28	Lignin res.	1.6552
16.5	Forest	Control	56	Lignin res.	1.3401
16.5	Forest	Control	168	Lignin res.	0.8962
16.5	Forest	Control	359	Lignin res.	1.2006
16.5	Forest	Litter Addition	0	Lignin res.	1.7245
16.5	Forest	Litter Addition	14	Lignin res.	1.3438
16.5	Forest	Litter Addition	28	Lignin res.	3.6566
16.5	Forest	Litter Addition	56	Lignin res.	2.2784
16.5	Forest	Litter Addition	168	Lignin res.	0.7840
16.5	Forest	Litter Addition	359	Lignin res.	1.1520
16.5	Forest	Control	0	Phenol. Cell.	17.6505
16.5	Forest	Control	14	Phenol. Cell.	4.4497
16.5	Forest	Control	28	Phenol. Cell.	4.6238
16.5	Forest	Control	56	Phenol. Cell.	3.4840
16.5	Forest	Control	168	Phenol. Cell.	3.7358
16.5	Forest	Control	359	Phenol. Cell.	3.9758
16.5	Forest	Litter Addition	0	Phenol. Cell.	3.4029
16.5	Forest	Litter Addition	14	Phenol. Cell.	2.9003
16.5	Forest	Litter Addition	28	Phenol. Cell.	11.6197
16.5	Forest	Litter Addition	56	Phenol. Cell.	3.6747
16.5	Forest	Litter Addition	168	Phenol. Cell.	3.6164
16.5	Forest	Litter Addition	359	Phenol. Cell.	3.1211
16.5	Forest	Control	0	Poly. Alc. and Ether C-O	11.4239
16.5	Forest	Control	14	Poly. Alc. and Ether C-O	10.8549
16.5	Forest	Control	28	Poly. Alc. and Ether C-O	9.5992
16.5	Forest	Control	56	Poly. Alc. and Ether C-O	10.3308
16.5	Forest	Control	168	Poly. Alc. and Ether C-O	11.1885
16.5	Forest	Control	359	Poly. Alc. and Ether C-O	11.2639
16.5	Forest	Litter Addition	0	Poly. Alc. and Ether C-O	10.7773
16.5	Forest	Litter Addition	14	Poly. Alc. and Ether C-O	10.5000

16.5	Forest	Litter Addition	28	Poly. Alc. and Ether C-O	9.0463
16.5	Forest	Litter Addition	56	Poly. Alc. and Ether C-O	9.4404
16.5	Forest	Litter Addition	168	Poly. Alc. and Ether C-O	11.8020
16.5	Forest	Litter Addition	359	Poly. Alc. and Ether C-O	10.1765
16.5	Pasture	Control	0	Aliph. Alc. C-O	18.8235
16.5	Pasture	Control	14	Aliph. Alc. C-O	20.0814
16.5	Pasture	Control	28	Aliph. Alc. C-O	11.3807
16.5	Pasture	Control	56	Aliph. Alc. C-O	18.6007
16.5	Pasture	Control	168	Aliph. Alc. C-O	16.0159
16.5	Pasture	Control	359	Aliph. Alc. C-O	17.2006
16.5	Pasture	Litter Addition	0	Aliph. Alc. C-O	18.3792
16.5	Pasture	Litter Addition	14	Aliph. Alc. C-O	17.3993
16.5	Pasture	Litter Addition	56	Aliph. Alc. C-O	10.4098
16.5	Pasture	Litter Addition	168	Aliph. Alc. C-O	10.2122
16.5	Pasture	Litter Addition	359	Aliph. Alc. C-O	12.6299
16.5	Pasture	Control	0	Aliphat. C-H	11.9872
16.5	Pasture	Control	14	Aliphat. C-H	10.2655
16.5	Pasture	Control	28	Aliphat. C-H	11.4391
16.5	Pasture	Control	56	Aliphat. C-H	9.5373
16.5	Pasture	Control	168	Aliphat. C-H	11.6524
16.5	Pasture	Control	359	Aliphat. C-H	12.1626
16.5	Pasture	Litter Addition	0	Aliphat. C-H	13.7196
16.5	Pasture	Litter Addition	14	Aliphat. C-H	11.8276
16.5	Pasture	Litter Addition	28	Aliphat. C-H	10.6876
16.5	Pasture	Litter Addition	28	Aliphat. C-H	2.0883
16.5	Pasture	Litter Addition	56	Aliphat. C-H	2.4493
16.5	Pasture	Litter Addition	168	Aliphat. C-H	2.1342
16.5	Pasture	Litter Addition	359	Aliphat. C-H	2.6538
16.5	Pasture	Control	0	Aro. Ester C--O	2.4135
16.5	Pasture	Control	14	Aro. Ester C--O	2.0238
16.5	Pasture	Control	28	Aro. Ester C--O	2.8467
16.5	Pasture	Control	56	Aro. Ester C--O	2.5998
16.5	Pasture	Control	168	Aro. Ester C--O	2.6658
16.5	Pasture	Control	359	Aro. Ester C--O	2.6208
16.5	Pasture	Litter Addition	0	Aro. Ester C--O	2.9088
16.5	Pasture	Litter Addition	14	Aro. Ester C--O	2.6442
16.5	Pasture	Litter Addition	28	Aro. Ester C--O	38.5043
16.5	Pasture	Litter Addition	56	Aro. Ester C--O	46.2247
16.5	Pasture	Litter Addition	168	Aro. Ester C--O	48.7345
16.5	Pasture	Litter Addition	359	Aro. Ester C--O	43.5283
16.5	Pasture	Control	0	Aromatic C-C	49.1156
16.5	Pasture	Control	14	Aromatic C-C	37.6857
16.5	Pasture	Control	28	Aromatic C-C	57.7483
16.5	Pasture	Control	56	Aromatic C-C	51.0867
16.5	Pasture	Control	168	Aromatic C-C	53.6463

16.5	Pasture	Control	359	Aromatic C-C	51.3626
16.5	Pasture	Litter Addition	0	Aromatic C-C	49.1220
16.5	Pasture	Litter Addition	14	Aromatic C-C	51.7789
16.5	Pasture	Litter Addition	28	Aromatic C-C	3.1673
16.5	Pasture	Litter Addition	56	Aromatic C-C	0.6509
16.5	Pasture	Litter Addition	168	Aromatic C-C	0.4258
16.5	Pasture	Litter Addition	359	Aromatic C-C	0.7847
16.5	Pasture	Control	0	Aromatic C-H	4.7776
16.5	Pasture	Control	14	Aromatic C-H	3.4464
16.5	Pasture	Control	28	Aromatic C-H	3.2629
16.5	Pasture	Control	56	Aromatic C-H	3.6382
16.5	Pasture	Control	168	Aromatic C-H	2.7009
16.5	Pasture	Control	359	Aromatic C-H	3.2488
16.5	Pasture	Litter Addition	0	Aromatic C-H	2.4406
16.5	Pasture	Litter Addition	14	Aromatic C-H	2.5455
16.5	Pasture	Litter Addition	28	Aromatic C-H	9.3226
16.5	Pasture	Litter Addition	56	Aromatic C-H	10.0211
16.5	Pasture	Litter Addition	168	Aromatic C-H	9.4405
16.5	Pasture	Litter Addition	359	Aromatic C-H	7.7507
16.5	Pasture	Control	0	Lignin res.	0.9518
16.5	Pasture	Control	14	Lignin res.	3.3876
16.5	Pasture	Control	28	Lignin res.	1.1017
16.5	Pasture	Control	56	Lignin res.	0.8771
16.5	Pasture	Control	168	Lignin res.	0.9830
16.5	Pasture	Control	359	Lignin res.	0.8455
16.5	Pasture	Litter Addition	0	Lignin res.	1.2481
16.5	Pasture	Litter Addition	14	Lignin res.	1.3503
16.5	Pasture	Litter Addition	28	Lignin res.	12.9422
16.5	Pasture	Litter Addition	56	Lignin res.	3.4819
16.5	Pasture	Litter Addition	168	Lignin res.	3.7946
16.5	Pasture	Litter Addition	359	Lignin res.	6.5140
16.5	Pasture	Control	0	Phenol. Cell.	3.6647
16.5	Pasture	Control	14	Phenol. Cell.	14.0956
16.5	Pasture	Control	28	Phenol. Cell.	4.0333
16.5	Pasture	Control	56	Phenol. Cell.	4.2533
16.5	Pasture	Control	168	Phenol. Cell.	3.5944
16.5	Pasture	Control	359	Phenol. Cell.	3.5242
16.5	Pasture	Litter Addition	0	Phenol. Cell.	3.1371
16.5	Pasture	Litter Addition	14	Phenol. Cell.	3.9990
16.5	Pasture	Litter Addition	28	Phenol. Cell.	3.0975
16.5	Pasture	Litter Addition	56	Phenol. Cell.	4.8041
16.5	Pasture	Litter Addition	168	Phenol. Cell.	4.3991
16.5	Pasture	Litter Addition	359	Phenol. Cell.	6.0735
16.5	Pasture	Control	0	Poly. Alc. and Ether C-O	8.2661
16.5	Pasture	Control	14	Poly. Alc. and Ether C-O	9.0139

16.5	Pasture	Control	28	Poly. Alc. and Ether C-O	7.3040
16.5	Pasture	Control	56	Poly. Alc. and Ether C-O	9.4069
16.5	Pasture	Control	168	Poly. Alc. and Ether C-O	8.7414
16.5	Pasture	Control	359	Poly. Alc. and Ether C-O	9.0350
16.5	Pasture	Litter Addition	0	Poly. Alc. and Ether C-O	9.0445
16.5	Pasture	Litter Addition	14	Poly. Alc. and Ether C-O	8.4552
16.5	Pasture	Litter Addition	28	Poly. Alc. and Ether C-O	26.2616
16.5	Pasture	Litter Addition	56	Poly. Alc. and Ether C-O	21.9583
16.5	Pasture	Litter Addition	168	Poly. Alc. and Ether C-O	20.8591
16.5	Pasture	Litter Addition	359	Poly. Alc. and Ether C-O	20.0652
20.5	Forest	Control	0	Aliph. Alc. C-O	22.9303
20.5	Forest	Control	14	Aliph. Alc. C-O	20.5144
20.5	Forest	Control	28	Aliph. Alc. C-O	19.3090
20.5	Forest	Control	56	Aliph. Alc. C-O	20.7078
20.5	Forest	Control	168	Aliph. Alc. C-O	19.2615
20.5	Forest	Control	359	Aliph. Alc. C-O	24.4642
20.5	Forest	Litter Addition	0	Aliph. Alc. C-O	25.3091
20.5	Forest	Litter Addition	14	Aliph. Alc. C-O	20.2849
20.5	Forest	Litter Addition	28	Aliph. Alc. C-O	27.1251
20.5	Forest	Litter Addition	56	Aliph. Alc. C-O	17.2785
20.5	Forest	Litter Addition	168	Aliph. Alc. C-O	21.6953
20.5	Forest	Litter Addition	359	Aliph. Alc. C-O	21.4458
20.5	Forest	Control	0	Aliphat. C-H	8.6517
20.5	Forest	Control	14	Aliphat. C-H	8.9307
20.5	Forest	Control	28	Aliphat. C-H	8.6298
20.5	Forest	Control	56	Aliphat. C-H	6.7558
20.5	Forest	Control	168	Aliphat. C-H	9.9480
20.5	Forest	Control	359	Aliphat. C-H	7.1501
20.5	Forest	Litter Addition	0	Aliphat. C-H	2.7207
20.5	Forest	Litter Addition	14	Aliphat. C-H	9.9733
20.5	Forest	Litter Addition	28	Aliphat. C-H	1.7777
20.5	Forest	Litter Addition	56	Aliphat. C-H	8.4249
20.5	Forest	Litter Addition	168	Aliphat. C-H	7.0605
20.5	Forest	Litter Addition	359	Aliphat. C-H	7.7978
20.5	Forest	Control	0	Aro. Ester C--O	1.9290
20.5	Forest	Control	14	Aro. Ester C--O	1.8904
20.5	Forest	Control	28	Aro. Ester C--O	2.0727
20.5	Forest	Control	56	Aro. Ester C--O	1.9529
20.5	Forest	Control	168	Aro. Ester C--O	2.4011
20.5	Forest	Control	359	Aro. Ester C--O	1.7963
20.5	Forest	Litter Addition	0	Aro. Ester C--O	1.5314
20.5	Forest	Litter Addition	14	Aro. Ester C--O	2.1588
20.5	Forest	Litter Addition	28	Aro. Ester C--O	1.3295
20.5	Forest	Litter Addition	56	Aro. Ester C--O	2.2022
20.5	Forest	Litter Addition	168	Aro. Ester C--O	2.0590

20.5	Forest	Litter Addition	359	Aro. Ester C--O	1.8746
20.5	Forest	Control	0	Aromatic C-C	46.6001
20.5	Forest	Control	14	Aromatic C-C	37.6067
20.5	Forest	Control	28	Aromatic C-C	51.4087
20.5	Forest	Control	56	Aromatic C-C	51.4275
20.5	Forest	Control	168	Aromatic C-C	49.3732
20.5	Forest	Control	359	Aromatic C-C	44.7641
20.5	Forest	Litter Addition	0	Aromatic C-C	31.5245
20.5	Forest	Litter Addition	14	Aromatic C-C	47.7954
20.5	Forest	Litter Addition	28	Aromatic C-C	30.8942
20.5	Forest	Litter Addition	56	Aromatic C-C	53.5057
20.5	Forest	Litter Addition	168	Aromatic C-C	49.6278
20.5	Forest	Litter Addition	359	Aromatic C-C	49.2118
20.5	Forest	Control	0	Aromatic C-H	4.1378
20.5	Forest	Control	14	Aromatic C-H	2.8924
20.5	Forest	Control	28	Aromatic C-H	3.0629
20.5	Forest	Control	56	Aromatic C-H	2.7437
20.5	Forest	Control	168	Aromatic C-H	4.8587
20.5	Forest	Control	359	Aromatic C-H	5.0722
20.5	Forest	Litter Addition	0	Aromatic C-H	4.9764
20.5	Forest	Litter Addition	14	Aromatic C-H	3.6616
20.5	Forest	Litter Addition	28	Aromatic C-H	5.5346
20.5	Forest	Litter Addition	56	Aromatic C-H	3.1906
20.5	Forest	Litter Addition	168	Aromatic C-H	3.2782
20.5	Forest	Litter Addition	359	Aromatic C-H	4.8153
20.5	Forest	Control	0	Lignin res.	0.8635
20.5	Forest	Control	14	Lignin res.	3.3899
20.5	Forest	Control	28	Lignin res.	1.7487
20.5	Forest	Control	56	Lignin res.	1.5636
20.5	Forest	Control	168	Lignin res.	1.4433
20.5	Forest	Control	359	Lignin res.	0.7246
20.5	Forest	Litter Addition	0	Lignin res.	3.3439
20.5	Forest	Litter Addition	14	Lignin res.	1.2593
20.5	Forest	Litter Addition	28	Lignin res.	3.2495
20.5	Forest	Litter Addition	56	Lignin res.	1.9301
20.5	Forest	Litter Addition	168	Lignin res.	0.6893
20.5	Forest	Litter Addition	359	Lignin res.	1.0744
20.5	Forest	Control	0	Phenol. Cell.	3.5577
20.5	Forest	Control	14	Phenol. Cell.	14.7286
20.5	Forest	Control	28	Phenol. Cell.	3.5679
20.5	Forest	Control	56	Phenol. Cell.	3.7782
20.5	Forest	Control	168	Phenol. Cell.	3.7271
20.5	Forest	Control	359	Phenol. Cell.	4.0902
20.5	Forest	Litter Addition	0	Phenol. Cell.	19.2662
20.5	Forest	Litter Addition	14	Phenol. Cell.	4.1980

20.5	Forest	Litter Addition	28	Phenol. Cell.	18.5753
20.5	Forest	Litter Addition	56	Phenol. Cell.	3.1948
20.5	Forest	Litter Addition	168	Phenol. Cell.	3.5197
20.5	Forest	Litter Addition	359	Phenol. Cell.	3.5630
20.5	Forest	Control	0	Poly. Alc. and Ether C-O	11.3300
20.5	Forest	Control	14	Poly. Alc. and Ether C-O	10.0470
20.5	Forest	Control	28	Poly. Alc. and Ether C-O	10.2003
20.5	Forest	Control	56	Poly. Alc. and Ether C-O	11.0705
20.5	Forest	Control	168	Poly. Alc. and Ether C-O	8.9871
20.5	Forest	Control	359	Poly. Alc. and Ether C-O	11.9382
20.5	Forest	Litter Addition	0	Poly. Alc. and Ether C-O	11.3277
20.5	Forest	Litter Addition	14	Poly. Alc. and Ether C-O	10.6687
20.5	Forest	Litter Addition	28	Poly. Alc. and Ether C-O	11.5142
20.5	Forest	Litter Addition	56	Poly. Alc. and Ether C-O	10.2732
20.5	Forest	Litter Addition	168	Poly. Alc. and Ether C-O	12.0702
20.5	Forest	Litter Addition	359	Poly. Alc. and Ether C-O	10.2172
20.5	Pasture	Control	0	Aliph. Alc. C-O	18.2585
20.5	Pasture	Control	14	Aliph. Alc. C-O	21.0382
20.5	Pasture	Control	28	Aliph. Alc. C-O	18.9492
20.5	Pasture	Control	56	Aliph. Alc. C-O	26.7250
20.5	Pasture	Control	168	Aliph. Alc. C-O	17.2084
20.5	Pasture	Control	359	Aliph. Alc. C-O	13.7340
20.5	Pasture	Litter Addition	0	Aliph. Alc. C-O	17.6545
20.5	Pasture	Litter Addition	14	Aliph. Alc. C-O	16.7225
20.5	Pasture	Litter Addition	28	Aliph. Alc. C-O	18.8415
20.5	Pasture	Litter Addition	56	Aliph. Alc. C-O	11.2361
20.5	Pasture	Litter Addition	168	Aliph. Alc. C-O	11.1833
20.5	Pasture	Litter Addition	359	Aliph. Alc. C-O	11.0070
20.5	Pasture	Control	0	Aliphat. C-H	12.2488
20.5	Pasture	Control	14	Aliphat. C-H	10.1647
20.5	Pasture	Control	28	Aliphat. C-H	15.1466
20.5	Pasture	Control	56	Aliphat. C-H	3.9165
20.5	Pasture	Control	168	Aliphat. C-H	17.9982
20.5	Pasture	Control	359	Aliphat. C-H	13.2239
20.5	Pasture	Litter Addition	0	Aliphat. C-H	14.7310
20.5	Pasture	Litter Addition	14	Aliphat. C-H	14.7017
20.5	Pasture	Litter Addition	28	Aliphat. C-H	14.5235
20.5	Pasture	Litter Addition	56	Aliphat. C-H	2.8168
20.5	Pasture	Litter Addition	168	Aliphat. C-H	2.1958
20.5	Pasture	Litter Addition	359	Aliphat. C-H	2.5668
20.5	Pasture	Control	0	Aro. Ester C--O	2.6146
20.5	Pasture	Control	14	Aro. Ester C--O	1.8804
20.5	Pasture	Control	28	Aro. Ester C--O	1.8483
20.5	Pasture	Control	56	Aro. Ester C--O	1.4045
20.5	Pasture	Control	168	Aro. Ester C--O	2.0672

20.5	Pasture	Control	359	Aro. Ester C--O	2.6518
20.5	Pasture	Litter Addition	0	Aro. Ester C--O	2.8926
20.5	Pasture	Litter Addition	14	Aro. Ester C--O	2.8023
20.5	Pasture	Litter Addition	28	Aro. Ester C--O	2.5528
20.5	Pasture	Litter Addition	56	Aro. Ester C--O	51.9913
20.5	Pasture	Litter Addition	168	Aro. Ester C--O	43.0967
20.5	Pasture	Litter Addition	359	Aro. Ester C--O	51.3351
20.5	Pasture	Control	0	Aromatic C-C	49.1772
20.5	Pasture	Control	14	Aromatic C-C	34.9326
20.5	Pasture	Control	28	Aromatic C-C	34.3236
20.5	Pasture	Control	56	Aromatic C-C	30.4181
20.5	Pasture	Control	168	Aromatic C-C	37.0803
20.5	Pasture	Control	359	Aromatic C-C	53.9962
20.5	Pasture	Litter Addition	0	Aromatic C-C	48.4701
20.5	Pasture	Litter Addition	14	Aromatic C-C	49.6318
20.5	Pasture	Litter Addition	28	Aromatic C-C	48.3387
20.5	Pasture	Litter Addition	56	Aromatic C-C	0.9991
20.5	Pasture	Litter Addition	168	Aromatic C-C	0.5687
20.5	Pasture	Litter Addition	359	Aromatic C-C	0.5701
20.5	Pasture	Control	0	Aromatic C-H	4.5103
20.5	Pasture	Control	14	Aromatic C-H	3.2213
20.5	Pasture	Control	28	Aromatic C-H	2.5404
20.5	Pasture	Control	56	Aromatic C-H	5.2006
20.5	Pasture	Control	168	Aromatic C-H	2.4040
20.5	Pasture	Control	359	Aromatic C-H	3.5647
20.5	Pasture	Litter Addition	0	Aromatic C-H	2.4071
20.5	Pasture	Litter Addition	14	Aromatic C-H	2.8323
20.5	Pasture	Litter Addition	28	Aromatic C-H	2.7208
20.5	Pasture	Litter Addition	56	Aromatic C-H	9.0251
20.5	Pasture	Litter Addition	168	Aromatic C-H	9.1914
20.5	Pasture	Litter Addition	359	Aromatic C-H	8.1546
20.5	Pasture	Control	0	Lignin res.	0.8209
20.5	Pasture	Control	14	Lignin res.	3.0327
20.5	Pasture	Control	28	Lignin res.	2.7975
20.5	Pasture	Control	56	Lignin res.	2.3843
20.5	Pasture	Control	168	Lignin res.	3.0677
20.5	Pasture	Control	359	Lignin res.	1.1557
20.5	Pasture	Litter Addition	0	Lignin res.	1.1711
20.5	Pasture	Litter Addition	14	Lignin res.	1.2221
20.5	Pasture	Litter Addition	28	Lignin res.	1.0473
20.5	Pasture	Litter Addition	56	Lignin res.	3.4899
20.5	Pasture	Litter Addition	168	Lignin res.	5.5256
20.5	Pasture	Litter Addition	359	Lignin res.	4.1185
20.5	Pasture	Control	0	Phenol. Cell.	3.8718
20.5	Pasture	Control	14	Phenol. Cell.	15.7176

20.5	Pasture	Control	28	Phenol. Cell.	14.8649
20.5	Pasture	Control	56	Phenol. Cell.	18.3509
20.5	Pasture	Control	168	Phenol. Cell.	11.8296
20.5	Pasture	Control	359	Phenol. Cell.	3.8488
20.5	Pasture	Litter Addition	0	Phenol. Cell.	3.1104
20.5	Pasture	Litter Addition	14	Phenol. Cell.	2.9647
20.5	Pasture	Litter Addition	28	Phenol. Cell.	3.2403
20.5	Pasture	Litter Addition	56	Phenol. Cell.	3.1093
20.5	Pasture	Litter Addition	168	Phenol. Cell.	5.4815
20.5	Pasture	Litter Addition	359	Phenol. Cell.	4.0627
20.5	Pasture	Control	0	Poly. Alc. and Ether C-O	8.4978
20.5	Pasture	Control	14	Poly. Alc. and Ether C-O	10.0126
20.5	Pasture	Control	28	Poly. Alc. and Ether C-O	9.5294
20.5	Pasture	Control	56	Poly. Alc. and Ether C-O	11.6001
20.5	Pasture	Control	168	Poly. Alc. and Ether C-O	8.3447
20.5	Pasture	Control	359	Poly. Alc. and Ether C-O	7.8250
20.5	Pasture	Litter Addition	0	Poly. Alc. and Ether C-O	9.5634
20.5	Pasture	Litter Addition	14	Poly. Alc. and Ether C-O	9.1225
20.5	Pasture	Litter Addition	28	Poly. Alc. and Ether C-O	8.7350
20.5	Pasture	Litter Addition	56	Poly. Alc. and Ether C-O	17.3324
20.5	Pasture	Litter Addition	168	Poly. Alc. and Ether C-O	22.7571
20.5	Pasture	Litter Addition	359	Poly. Alc. and Ether C-O	18.1853

Table IV: PLFA analysis data from the one-year incubation experiment. Grouped by microbial communities: actinobacteria, arbuscular mycorrhizal fungi (AMF), saprotrophic fungi (Fungi), Gram-positive bacteria (Gram+) and Gram-negative bacteria (Gram-).

Temperature (°C)	**Soil Type**	**Treatment**	**Time (Days)**	**Compound**	**nmol g^{-1}**	**Percentage (%)**
12.5	Forest	Control	0	Actinobacteria	26.5646	0.137
12.5	Forest	Control	14	Actinobacteria	44.5283	0.1401
12.5	Forest	Control	28	Actinobacteria	28.6966	0.1423
12.5	Forest	Control	56	Actinobacteria	14.2194	0.1346
12.5	Forest	Control	168	Actinobacteria	43.6913	0.1622
12.5	Forest	Control	359	Actinobacteria	23.6043	0.1344
12.5	Forest	Litter Addition	0	Actinobacteria	21.3792	0.1016
12.5	Forest	Litter Addition	14	Actinobacteria	27.5553	0.1256
12.5	Forest	Litter Addition	28	Actinobacteria	24.8478	0.1283
12.5	Forest	Litter Addition	56	Actinobacteria	27.5223	0.1423
12.5	Forest	Litter Addition	168	Actinobacteria	20.666	0.1154
12.5	Forest	Litter Addition	359	Actinobacteria	18.6915	0.1412
16.5	Forest	Control	0	Actinobacteria	52.9529	0.1517
16.5	Forest	Control	14	Actinobacteria	29.1596	0.1461
16.5	Forest	Control	28	Actinobacteria	24.1881	0.1456
16.5	Forest	Control	56	Actinobacteria	17.8574	0.1525
16.5	Forest	Control	168	Actinobacteria	28.7426	0.1567
16.5	Forest	Control	359	Actinobacteria	13.8945	0.1393

16.5	Forest	Litter Addition	0	Actinobacteria	26.5287	0.1056
16.5	Forest	Litter Addition	14	Actinobacteria	29.579	0.0875
16.5	Forest	Litter Addition	28	Actinobacteria	28.492	0.1208
16.5	Forest	Litter Addition	56	Actinobacteria	23.4817	0.1297
16.5	Forest	Litter Addition	168	Actinobacteria	37.8796	0.1311
16.5	Forest	Litter Addition	359	Actinobacteria	12.0306	0.1024
20.5	Forest	Control	0	Actinobacteria	16.8162	0.1393
20.5	Forest	Control	14	Actinobacteria	17.7344	0.128
20.5	Forest	Control	28	Actinobacteria	29.5491	0.1468
20.5	Forest	Control	56	Actinobacteria	34.4981	0.1707
20.5	Forest	Control	168	Actinobacteria	17.5716	0.1504
20.5	Forest	Control	359	Actinobacteria	13.3854	0.1283
20.5	Forest	Litter Addition	0	Actinobacteria	25.048	0.1242
20.5	Forest	Litter Addition	14	Actinobacteria	30.4878	0.121
20.5	Forest	Litter Addition	28	Actinobacteria	21.7564	0.1104
20.5	Forest	Litter Addition	56	Actinobacteria	20.6265	0.0989
20.5	Forest	Litter Addition	168	Actinobacteria	21.1579	0.1263
20.5	Forest	Litter Addition	359	Actinobacteria	12.4899	0.1365
12.5	Pasture	Control	0	Actinobacteria	30.5402	0.1307
12.5	Pasture	Control	14	Actinobacteria	34.0905	0.1443
12.5	Pasture	Control	28	Actinobacteria	41.5795	0.1568
12.5	Pasture	Control	56	Actinobacteria	35.1319	0.1502
12.5	Pasture	Control	168	Actinobacteria	35.5917	0.1453
12.5	Pasture	Control	359	Actinobacteria	25.4219	0.1748
12.5	Pasture	Litter Addition	0	Actinobacteria	38.9912	0.1112
12.5	Pasture	Litter Addition	14	Actinobacteria	40.3155	0.1239
12.5	Pasture	Litter Addition	28	Actinobacteria	37.3008	0.1497
12.5	Pasture	Litter Addition	56	Actinobacteria	20.4023	0.0778
12.5	Pasture	Litter Addition	168	Actinobacteria	22.3913	0.1055
12.5	Pasture	Litter Addition	359	Actinobacteria	20.8997	0.1246
16.5	Pasture	Control	0	Actinobacteria	26.4643	0.1319
16.5	Pasture	Control	14	Actinobacteria	38.6768	0.1369
16.5	Pasture	Control	28	Actinobacteria	47.9802	0.1527
16.5	Pasture	Control	56	Actinobacteria	28.1444	0.1402
16.5	Pasture	Control	168	Actinobacteria	18.1646	0.1508
16.5	Pasture	Control	359	Actinobacteria	26.5401	0.1706
16.5	Pasture	Litter Addition	0	Actinobacteria	50.3728	0.1273
16.5	Pasture	Litter Addition	14	Actinobacteria	37.82	0.1166
16.5	Pasture	Litter Addition	28	Actinobacteria	58.0759	0.1511
16.5	Pasture	Litter Addition	56	Actinobacteria	33.575	0.1442
16.5	Pasture	Litter Addition	168	Actinobacteria	32.6326	0.1125
16.5	Pasture	Litter Addition	359	Actinobacteria	35.0293	0.1104
20.5	Pasture	Control	0	Actinobacteria	26.374	0.1357
20.5	Pasture	Control	14	Actinobacteria	41.3182	0.1503
20.5	Pasture	Control	28	Actinobacteria	25.7588	0.15

20.5	Pasture	Control	56	Actinobacteria	25.7327	0.1547
20.5	Pasture	Control	168	Actinobacteria	20.7635	0.1424
20.5	Pasture	Control	359	Actinobacteria	26.2882	0.128
20.5	Pasture	Litter Addition	0	Actinobacteria	34.2456	0.1148
20.5	Pasture	Litter Addition	14	Actinobacteria	48.3572	0.1176
20.5	Pasture	Litter Addition	28	Actinobacteria	34.1979	0.1311
20.5	Pasture	Litter Addition	56	Actinobacteria	37.3496	0.1276
20.5	Pasture	Litter Addition	168	Actinobacteria	22.5763	0.0951
20.5	Pasture	Litter Addition	359	Actinobacteria	12.3043	0.1155
12.5	Forest	Control	0	AMF	8.0442	0.0415
12.5	Forest	Control	14	AMF	12.4339	0.0391
12.5	Forest	Control	28	AMF	4.3961	0.0218
12.5	Forest	Control	56	AMF	2.7216	0.0258
12.5	Forest	Control	168	AMF	6.3745	0.0237
12.5	Forest	Control	359	AMF	3.9257	0.0224
12.5	Forest	Litter Addition	0	AMF	6.7087	0.0319
12.5	Forest	Litter Addition	14	AMF	3.9771	0.0181
12.5	Forest	Litter Addition	28	AMF	3.0041	0.0155
12.5	Forest	Litter Addition	56	AMF	2.4705	0.0128
12.5	Forest	Litter Addition	168	AMF	3.8881	0.0217
12.5	Forest	Litter Addition	359	AMF	1.9623	0.0148
16.5	Forest	Control	0	AMF	14.6911	0.0421
16.5	Forest	Control	14	AMF	7.8182	0.0392
16.5	Forest	Control	28	AMF	3.1212	0.0188
16.5	Forest	Control	56	AMF	2.9819	0.0255
16.5	Forest	Control	168	AMF	2.5981	0.0142
16.5	Forest	Control	359	AMF	1.5783	0.0158
16.5	Forest	Litter Addition	0	AMF	8.1352	0.0324
16.5	Forest	Litter Addition	14	AMF	9.7698	0.0289
16.5	Forest	Litter Addition	28	AMF	5.4111	0.0229
16.5	Forest	Litter Addition	56	AMF	3.6017	0.0199
16.5	Forest	Litter Addition	168	AMF	5.6435	0.0195
16.5	Forest	Litter Addition	359	AMF	2.185	0.0186
20.5	Forest	Control	0	AMF	2.8924	0.024
20.5	Forest	Control	14	AMF	3.4129	0.0246
20.5	Forest	Control	28	AMF	3.2504	0.0161
20.5	Forest	Control	56	AMF	5.5228	0.0273
20.5	Forest	Control	168	AMF	0.8703	0.0074
20.5	Forest	Control	359	AMF	1.7049	0.0163
20.5	Forest	Litter Addition	0	AMF	5.1452	0.0255
20.5	Forest	Litter Addition	14	AMF	2.9478	0.0117
20.5	Forest	Litter Addition	28	AMF	3.8802	0.0197
20.5	Forest	Litter Addition	56	AMF	4.681	0.0224
20.5	Forest	Litter Addition	168	AMF	2.4808	0.0148
20.5	Forest	Litter Addition	359	AMF	0.9944	0.0109

12.5	Pasture	Control	0	AMF	9.996	0.0428
12.5	Pasture	Control	14	AMF	8.2951	0.0351
12.5	Pasture	Control	28	AMF	5.7211	0.0216
12.5	Pasture	Control	56	AMF	3.8559	0.0165
12.5	Pasture	Control	168	AMF	5.5477	0.0226
12.5	Pasture	Control	359	AMF	1.1043	0.0076
12.5	Pasture	Litter Addition	0	AMF	10.9781	0.0313
12.5	Pasture	Litter Addition	14	AMF	8.0915	0.0249
12.5	Pasture	Litter Addition	28	AMF	4.4193	0.0177
12.5	Pasture	Litter Addition	56	AMF	4.5215	0.0172
12.5	Pasture	Litter Addition	168	AMF	4.9611	0.0234
12.5	Pasture	Litter Addition	359	AMF	2.1831	0.013
16.5	Pasture	Control	0	AMF	8.6358	0.043
16.5	Pasture	Control	14	AMF	7.473	0.0265
16.5	Pasture	Control	28	AMF	3.7418	0.0119
16.5	Pasture	Control	56	AMF	4.0039	0.0199
16.5	Pasture	Control	168	AMF	1.1021	0.0091
16.5	Pasture	Control	359	AMF	1.2795	0.0082
16.5	Pasture	Litter Addition	0	AMF	11.2787	0.0285
16.5	Pasture	Litter Addition	14	AMF	8.4155	0.0259
16.5	Pasture	Litter Addition	28	AMF	5.7659	0.015
16.5	Pasture	Litter Addition	56	AMF	2.5396	0.0109
16.5	Pasture	Litter Addition	168	AMF	3.6885	0.0127
16.5	Pasture	Litter Addition	359	AMF	3.2383	0.0102
20.5	Pasture	Control	0	AMF	5.8508	0.0301
20.5	Pasture	Control	14	AMF	3.9942	0.0145
20.5	Pasture	Control	28	AMF	2.1682	0.0126
20.5	Pasture	Control	56	AMF	2.5542	0.0154
20.5	Pasture	Control	168	AMF	1.0146	0.007
20.5	Pasture	Control	359	AMF	3.0159	0.0147
20.5	Pasture	Litter Addition	0	AMF	8.5555	0.0287
20.5	Pasture	Litter Addition	14	AMF	8.5177	0.0207
20.5	Pasture	Litter Addition	28	AMF	3.8023	0.0146
20.5	Pasture	Litter Addition	56	AMF	4.7651	0.0163
20.5	Pasture	Litter Addition	168	AMF	4.2716	0.018
20.5	Pasture	Litter Addition	359	AMF	0.4709	0.0044
12.5	Forest	Control	0	Fungi	3.9391	0.0203
12.5	Forest	Control	14	Fungi	4.5036	0.0142
12.5	Forest	Control	28	Fungi	1.1943	0.0059
12.5	Forest	Control	56	Fungi	1.0379	0.0098
12.5	Forest	Control	168	Fungi	2.0491	0.0076
12.5	Forest	Control	359	Fungi	1.2123	0.0069
12.5	Forest	Litter Addition	0	Fungi	20.5692	0.0978
12.5	Forest	Litter Addition	14	Fungi	8.1898	0.0373
12.5	Forest	Litter Addition	28	Fungi	2.4953	0.0129

12.5	Forest	Litter Addition	56	Fungi	1.3564	0.007
12.5	Forest	Litter Addition	168	Fungi	7.0625	0.0394
12.5	Forest	Litter Addition	359	Fungi	3.0978	0.0234
16.5	Forest	Control	0	Fungi	5.4253	0.0155
16.5	Forest	Control	14	Fungi	2.9172	0.0146
16.5	Forest	Control	28	Fungi	1.0248	0.0062
16.5	Forest	Control	56	Fungi	1.3198	0.0113
16.5	Forest	Control	168	Fungi	0.9467	0.0052
16.5	Forest	Control	359	Fungi	1.1858	0.0119
16.5	Forest	Litter Addition	0	Fungi	25.6212	0.1019
16.5	Forest	Litter Addition	14	Fungi	27.3386	0.0809
16.5	Forest	Litter Addition	28	Fungi	8.2506	0.035
16.5	Forest	Litter Addition	56	Fungi	4.1228	0.0228
16.5	Forest	Litter Addition	168	Fungi	9.2935	0.0322
16.5	Forest	Litter Addition	359	Fungi	2.9211	0.0249
20.5	Forest	Control	0	Fungi	0.7855	0.0065
20.5	Forest	Control	14	Fungi	0.9191	0.0066
20.5	Forest	Control	28	Fungi	1.3312	0.0066
20.5	Forest	Control	56	Fungi	2.125	0.0105
20.5	Forest	Control	168	Fungi	0.6267	0.0054
20.5	Forest	Control	359	Fungi	1.2009	0.0115
20.5	Forest	Litter Addition	0	Fungi	9.6808	0.048
20.5	Forest	Litter Addition	14	Fungi	2.4891	0.0099
20.5	Forest	Litter Addition	28	Fungi	4.0149	0.0204
20.5	Forest	Litter Addition	56	Fungi	7.9749	0.0382
20.5	Forest	Litter Addition	168	Fungi	0.6932	0.0041
20.5	Forest	Litter Addition	359	Fungi	1.9758	0.0216
12.5	Pasture	Control	0	Fungi	3.1031	0.0133
12.5	Pasture	Control	14	Fungi	1.96	0.0083
12.5	Pasture	Control	28	Fungi	0.9461	0.0036
12.5	Pasture	Control	56	Fungi	0.9942	0.0043
12.5	Pasture	Control	168	Fungi	1.7061	0.007
12.5	Pasture	Control	359	Fungi	0.9903	0.0068
12.5	Pasture	Litter Addition	0	Fungi	21.0655	0.0601
12.5	Pasture	Litter Addition	14	Fungi	11.8372	0.0364
12.5	Pasture	Litter Addition	28	Fungi	3.7549	0.0151
12.5	Pasture	Litter Addition	56	Fungi	2.8732	0.011
12.5	Pasture	Litter Addition	168	Fungi	5.3572	0.0252
12.5	Pasture	Litter Addition	359	Fungi	2.2622	0.0135
16.5	Pasture	Control	0	Fungi	3.7012	0.0184
16.5	Pasture	Control	14	Fungi	2.246	0.008
16.5	Pasture	Control	28	Fungi	1.7864	0.0057
16.5	Pasture	Control	56	Fungi	1.254	0.0062
16.5	Pasture	Control	168	Fungi	0.5644	0.0047
16.5	Pasture	Control	359	Fungi	1.0825	0.007

16.5	Pasture	Litter Addition	0	Fungi	39.5662	0.1
16.5	Pasture	Litter Addition	14	Fungi	9.0128	0.0278
16.5	Pasture	Litter Addition	28	Fungi	3.0612	0.008
16.5	Pasture	Litter Addition	56	Fungi	1.5636	0.0067
16.5	Pasture	Litter Addition	168	Fungi	2.5872	0.0089
16.5	Pasture	Litter Addition	359	Fungi	2.7571	0.0087
20.5	Pasture	Control	0	Fungi	1.6473	0.0085
20.5	Pasture	Control	14	Fungi	1.375	0.005
20.5	Pasture	Control	28	Fungi	0.8761	0.0051
20.5	Pasture	Control	56	Fungi	1.261	0.0076
20.5	Pasture	Control	168	Fungi	0.8442	0.0058
20.5	Pasture	Control	359	Fungi	1.8522	0.009
20.5	Pasture	Litter Addition	0	Fungi	15.3012	0.0513
20.5	Pasture	Litter Addition	14	Fungi	9.0807	0.0221
20.5	Pasture	Litter Addition	28	Fungi	2.2632	0.0087
20.5	Pasture	Litter Addition	56	Fungi	3.4304	0.0117
20.5	Pasture	Litter Addition	168	Fungi	6.1984	0.0261
20.5	Pasture	Litter Addition	359	Fungi	0.8171	0.0077
12.5	Forest	Control	0	Gram-	74.9805	0.3867
12.5	Forest	Control	14	Gram-	115.5295	0.3636
12.5	Forest	Control	28	Gram-	57.7611	0.2864
12.5	Forest	Control	56	Gram-	31.637	0.2996
12.5	Forest	Control	168	Gram-	77.2167	0.2867
12.5	Forest	Control	359	Gram-	53.4592	0.3045
12.5	Forest	Litter Addition	0	Gram-	74.2334	0.3529
12.5	Forest	Litter Addition	14	Gram-	56.2857	0.2566
12.5	Forest	Litter Addition	28	Gram-	54.1719	0.2798
12.5	Forest	Litter Addition	56	Gram-	55.5614	0.2873
12.5	Forest	Litter Addition	168	Gram-	60.1141	0.3355
12.5	Forest	Litter Addition	359	Gram-	30.0306	0.2268
16.5	Forest	Control	0	Gram-	128.1475	0.3671
16.5	Forest	Control	14	Gram-	67.392	0.3378
16.5	Forest	Control	28	Gram-	45.3996	0.2732
16.5	Forest	Control	56	Gram-	32.7424	0.2796
16.5	Forest	Control	168	Gram-	47.2875	0.2579
16.5	Forest	Control	359	Gram-	28.4197	0.2849
16.5	Forest	Litter Addition	0	Gram-	88.9522	0.3539
16.5	Forest	Litter Addition	14	Gram-	119.7759	0.3544
16.5	Forest	Litter Addition	28	Gram-	75.6624	0.3207
16.5	Forest	Litter Addition	56	Gram-	59.261	0.3272
16.5	Forest	Litter Addition	168	Gram-	91.3456	0.3161
16.5	Forest	Litter Addition	359	Gram-	32.9612	0.2806
20.5	Forest	Control	0	Gram-	31.1646	0.2582
20.5	Forest	Control	14	Gram-	37.8243	0.2731
20.5	Forest	Control	28	Gram-	49.6224	0.2465

20.5	Forest	Control	56	Gram-	63.5532	0.3145
20.5	Forest	Control	168	Gram-	26.7758	0.2292
20.5	Forest	Control	359	Gram-	31.0802	0.298
20.5	Forest	Litter Addition	0	Gram-	64.9783	0.3221
20.5	Forest	Litter Addition	14	Gram-	67.0697	0.2662
20.5	Forest	Litter Addition	28	Gram-	64.2457	0.3261
20.5	Forest	Litter Addition	56	Gram-	75.2594	0.3607
20.5	Forest	Litter Addition	168	Gram-	52.2798	0.312
20.5	Forest	Litter Addition	359	Gram-	21.3763	0.2336
12.5	Pasture	Control	0	Gram-	90.3591	0.3867
12.5	Pasture	Control	14	Gram-	77.1798	0.3268
12.5	Pasture	Control	28	Gram-	62.5937	0.236
12.5	Pasture	Control	56	Gram-	58.7654	0.2513
12.5	Pasture	Control	168	Gram-	71.6086	0.2923
12.5	Pasture	Control	359	Gram-	28.2667	0.1944
12.5	Pasture	Litter Addition	0	Gram-	125.8655	0.3591
12.5	Pasture	Litter Addition	14	Gram-	103.7183	0.3188
12.5	Pasture	Litter Addition	28	Gram-	57.5143	0.2309
12.5	Pasture	Litter Addition	56	Gram-	78.0668	0.2977
12.5	Pasture	Litter Addition	168	Gram-	71.2911	0.336
12.5	Pasture	Litter Addition	359	Gram-	36.9742	0.2204
16.5	Pasture	Control	0	Gram-	78.9839	0.3936
16.5	Pasture	Control	14	Gram-	84.6925	0.2998
16.5	Pasture	Control	28	Gram-	73.9867	0.2355
16.5	Pasture	Control	56	Gram-	54.6724	0.2723
16.5	Pasture	Control	168	Gram-	27.4821	0.2281
16.5	Pasture	Control	359	Gram-	31.4404	0.2021
16.5	Pasture	Litter Addition	0	Gram-	130.7575	0.3304
16.5	Pasture	Litter Addition	14	Gram-	116.9442	0.3605
16.5	Pasture	Litter Addition	28	Gram-	104.9299	0.273
16.5	Pasture	Litter Addition	56	Gram-	63.4831	0.2726
16.5	Pasture	Litter Addition	168	Gram-	80.51	0.2776
16.5	Pasture	Litter Addition	359	Gram-	55.9259	0.1762
20.5	Pasture	Control	0	Gram-	64.785	0.3333
20.5	Pasture	Control	14	Gram-	62.3395	0.2268
20.5	Pasture	Control	28	Gram-	44.0058	0.2563
20.5	Pasture	Control	56	Gram-	41.9747	0.2524
20.5	Pasture	Control	168	Gram-	37.9603	0.2603
20.5	Pasture	Control	359	Gram-	57.0941	0.2781
20.5	Pasture	Litter Addition	0	Gram-	101.6365	0.3408
20.5	Pasture	Litter Addition	14	Gram-	131.5284	0.3199
20.5	Pasture	Litter Addition	28	Gram-	75.9358	0.2911
20.5	Pasture	Litter Addition	56	Gram-	91.4093	0.3124
20.5	Pasture	Litter Addition	168	Gram-	80.8022	0.3403
20.5	Pasture	Litter Addition	359	Gram-	19.5605	0.1836

12.5	Forest	Control	0	Gram+	80.3465	0.4144
12.5	Forest	Control	14	Gram+	140.7792	0.443
12.5	Forest	Control	28	Gram+	109.6291	0.5436
12.5	Forest	Control	56	Gram+	55.9875	0.5302
12.5	Forest	Control	168	Gram+	140.0248	0.5198
12.5	Forest	Control	359	Gram+	93.365	0.5318
12.5	Forest	Litter Addition	0	Gram+	87.4869	0.4159
12.5	Forest	Litter Addition	14	Gram+	123.3084	0.5622
12.5	Forest	Litter Addition	28	Gram+	109.1024	0.5635
12.5	Forest	Litter Addition	56	Gram+	106.5016	0.5506
12.5	Forest	Litter Addition	168	Gram+	87.4205	0.488
12.5	Forest	Litter Addition	359	Gram+	78.6293	0.5938
16.5	Forest	Control	0	Gram+	147.8752	0.4236
16.5	Forest	Control	14	Gram+	92.2431	0.4623
16.5	Forest	Control	28	Gram+	92.4465	0.5563
16.5	Forest	Control	56	Gram+	62.2023	0.5312
16.5	Forest	Control	168	Gram+	103.794	0.566
16.5	Forest	Control	359	Gram+	54.6654	0.5481
16.5	Forest	Litter Addition	0	Gram+	102.0983	0.4062
16.5	Forest	Litter Addition	14	Gram+	151.5406	0.4483
16.5	Forest	Litter Addition	28	Gram+	118.1418	0.5007
16.5	Forest	Litter Addition	56	Gram+	90.6368	0.5005
16.5	Forest	Litter Addition	168	Gram+	144.7691	0.5011
16.5	Forest	Litter Addition	359	Gram+	67.3555	0.5735
20.5	Forest	Control	0	Gram+	69.0497	0.572
20.5	Forest	Control	14	Gram+	78.6103	0.5676
20.5	Forest	Control	28	Gram+	117.5559	0.584
20.5	Forest	Control	56	Gram+	96.3879	0.477
20.5	Forest	Control	168	Gram+	71.0007	0.6076
20.5	Forest	Control	359	Gram+	56.9419	0.5459
20.5	Forest	Litter Addition	0	Gram+	96.8758	0.4802
20.5	Forest	Litter Addition	14	Gram+	148.968	0.5912
20.5	Forest	Litter Addition	28	Gram+	103.0982	0.5234
20.5	Forest	Litter Addition	56	Gram+	100.1023	0.4798
20.5	Forest	Litter Addition	168	Gram+	90.9576	0.5428
20.5	Forest	Litter Addition	359	Gram+	54.6698	0.5974
12.5	Pasture	Control	0	Gram+	99.6822	0.4266
12.5	Pasture	Control	14	Gram+	114.6781	0.4855
12.5	Pasture	Control	28	Gram+	154.3709	0.5821
12.5	Pasture	Control	56	Gram+	135.0759	0.5777
12.5	Pasture	Control	168	Gram+	130.5622	0.5329
12.5	Pasture	Control	359	Gram+	89.6579	0.6165
12.5	Pasture	Litter Addition	0	Gram+	153.6039	0.4382
12.5	Pasture	Litter Addition	14	Gram+	161.3672	0.496
12.5	Pasture	Litter Addition	28	Gram+	146.101	0.5865

12.5	Pasture	Litter Addition	56	Gram+	156.4061	0.5964
12.5	Pasture	Litter Addition	168	Gram+	108.1781	0.5098
12.5	Pasture	Litter Addition	359	Gram+	105.4035	0.6284
16.5	Pasture	Control	0	Gram+	82.8659	0.413
16.5	Pasture	Control	14	Gram+	149.3939	0.5289
16.5	Pasture	Control	28	Gram+	186.7099	0.5942
16.5	Pasture	Control	56	Gram+	112.7059	0.5613
16.5	Pasture	Control	168	Gram+	73.1705	0.6073
16.5	Pasture	Control	359	Gram+	95.2554	0.6122
16.5	Pasture	Litter Addition	0	Gram+	163.7726	0.4138
16.5	Pasture	Litter Addition	14	Gram+	152.2324	0.4692
16.5	Pasture	Litter Addition	28	Gram+	212.5186	0.5529
16.5	Pasture	Litter Addition	56	Gram+	131.7039	0.5656
16.5	Pasture	Litter Addition	168	Gram+	170.5626	0.5882
16.5	Pasture	Litter Addition	359	Gram+	220.3758	0.6945
20.5	Pasture	Control	0	Gram+	95.698	0.4924
20.5	Pasture	Control	14	Gram+	165.8828	0.6034
20.5	Pasture	Control	28	Gram+	98.8904	0.576
20.5	Pasture	Control	56	Gram+	94.7635	0.5699
20.5	Pasture	Control	168	Gram+	85.2734	0.5846
20.5	Pasture	Control	359	Gram+	117.0582	0.5702
20.5	Pasture	Litter Addition	0	Gram+	138.4795	0.4644
20.5	Pasture	Litter Addition	14	Gram+	213.6366	0.5196
20.5	Pasture	Litter Addition	28	Gram+	144.6163	0.5545
20.5	Pasture	Litter Addition	56	Gram+	155.6906	0.532
20.5	Pasture	Litter Addition	168	Gram+	123.625	0.5206
20.5	Pasture	Litter Addition	359	Gram+	73.3608	0.6887

Personal Declaration

I hereby declare that the submitted thesis is the result of my own, independent work. All external sources are explicitly acknowledged in the thesis.

Lutzenberg AR, 30. April 2024

Place, Date Signature