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Master Thesis

CO_2-Exchange and Enzyme Activities of Climate Change Simulation Treatment Plots in Subarctic Tundra Heath

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Abstract

Arctic ecosystems are exposed to stronger warming than the rest of the world and shrub vegetation is expanding in the tundra, which may alter soil organic matter (SOM) decomposition, while increasing litter input to the soil. These changes raise the question about possible climate change feedbacks: E.g. Will enhanced plant growth increase the carbon sink capacity, or will faster SOM turnover increase the CO2 emissions from the large belowground carbon stocks? The study site, located in a subarctic tundra heath in northern Sweden, has been manipulated for 6 years with warming (**W**) or addition of following substrates: Leaf litter from local *Betula* (**B**) or *Salix* (**S**) species or fungal fruitbodies (**F**), with a C:N ratio of 45, 22 and 11 respectively. Carbon fluxes on ecosystem level, respiration (ER), photosynthesis (GEP) and net exchange (NEE) and Net Differential Vegetation Index (NDVI) were measured 14 times during the snow free period. All fluxes and NDVI were enhanced by B, S and F treatment in correlation with the nitrogen content of the substrate. Warming increased fluxes and NDVI stronger than litter addition but less than the fungi treatment. We conclude that increasing litter input will enhance activity and growth in dependence of its quality, but warming is the main control agent for change in tundra ecosystems. Impact of W and F treatments were statistically significant (α=0.05), except for NEE. Still, NEE changed with the same treatment pattern as ER, GEP and NDVI and strengthens our implications about the carbon sink function of the ecosystem. Abiotic soil properties and extracellular enzyme activities from soils collected during mid-summer were not affected after 6 years of treatment. Activity of carbon and nitrogen cycling enzymes were higher in 5-10 cm depth than in surface soil, in contrast to phosphatase. This suggests different nutrient demands of tundra soil at different depths and potential higher decomposition of SOM below the top 5cm of soil.

CO_2-flux, Enzyme activity, subarctic tundra, climate warming, litter addition

Abstract in German

Arktische Ökosysteme erwärmen sich stärker als der Rest der Welt und in der Tundra ist bereits Verstrauchung zu erkennen, was den Streueintrag erhöht und den Abbau organischer Bodensubstanz (OBS) verändern kann. Das könnte Rückkopplungs-Effekte auf den Klimawandel verursachen, z.B. begünstigte Kohlenstoff-Speicherung durch erhöhtes Pflanzenwachstum oder aber erhöhte CO2-Emissionen durch den verstärkten Abbau im Boden gespeicherter OBS. Untersuchungsflächen, in einer subarktischen Tundra in Nordschweden, wurden 6 Jahre lang mit Erwärmung (**W**) oder Zugabe folgender Substrate behandelt: Laub lokaler Birken (*B. pubescens* ssp *tortuosa*, **B**) und Weiden (*S. myrsinifolia*, **S**) sowie Pilz-Fruchtkörpern (**F**) mit einem jeweiligen C:N Verhältnis von 45, 22 bzw. 11. Die CO2-Flüsse, Atmung (ER), Photosynthese (GEP) und Nettoaustausch (NEE), und der Normierte Differenzierte Vegetationsindex (NDVI) wurden 14-mal während der schneefreien Periode gemessen. Alle CO2-Flüsse, sowie der NDVI wurden durch B-, S- und F-Behandlungen in Korrelation mit dem Stickstoffgehalt des Substrats erhöht. Erwärmung erhöhte CO2-Austausch und NDVI stärker als Laub- aber weniger als Pilz-Zugabe. Daraus schließen wir, dass der zunehmende Streueintrag die Aktivität in Abhängigkeit von der Streuqualität steigern wird, wobei Erwärmung der kontrollierende Faktor für Tundra-Ökosysteme bleibt. Der Einfluss von W- und F-Manipulation war für alle Messgrößen statistisch signifikant ($\alpha = 0,05$), außer für NEE. Jedoch wies NEE ähnliche Trends auf wie ER, GEP und NDVI und zeigte erhöhte CO2 Aufnahme des Ökosystems. Bodenparameter und extrazelluläre Enzymaktivitäten aus einer Probenentnahme im Sommer waren nach 6 Jahren Manipulation nicht verändert. Die Aktivität aller hydrolytischer Enzyme, mit Ausnahme der Phosphatase, waren in 5-10 cm Tiefe höher als in 0-5 cm. Dies deutet auf andere Nährstoffumsätze in verschiedenen Bodentiefen der Tundra und potentiell stärkerem Abbau von OBS unterhalb von 5 cm Bodentiefe hin.

CO_2-Austausch, Enzymaktivität, subarktische Tundra, Klimaerwärmung, Streu-Zugabe

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Contents

1 Introduction

Climate change causes temperatures to rise and will alter ecosystems globally but will be especially pronounced in northern high latitudes (IPCC 2014). Arctic regions north of 67.5°N are estimated to face a more than 2 times stronger warming on a yearly average than global mean (IPCC 2013). Although strongly amplified warming can be accounted mainly to increased warming in winter, most climate simulations also result in above average temperature changes during summer in Scandinavia (Kjellström et al. 2018).

Arctic ecosystems belong to the least productive on the globe, but large amounts of carbon have accumulated in its soils, as respiration in the past was more inhibited than primary production (Shaver and Jonasson 2001). The combination of both large carbon stocks in arctic ecosystems and extraordinary exposure to warming and its resulting direct and indirect effects on ecosystems induces high concern about a possible positive climate change feedback and net carbon release to the atmosphere. However, enhanced carbon uptake through enhanced primary production due to climate change has been reported for the past as well (McGuire et al. 2009). Apart from faster respiration and photosynthesis through higher temperatures itself, carbon flux dynamics can be influenced by several changes in the ecosystem, such as prolonged growing season, vegetation shifts and subsequent changes in substrate inputs to ecosystems, altered biogeochemical cycles in soils, changes in precipitation patterns or herbivory pressure (Larsen et al. 2014).

1.1 Carbon fluxes in changing ecosystems

It is widely recognised, that respiration reacts more sensitive to warming than photosynthesis (Davidson and Janssens 2006), and this can be confirmed by experimental warming in field studies in the tundra (Biasi et al. 2008; Welker et al. 1999). Consequently, potential stronger carbon loss with higher temperatures than increasing carbon uptake through primary production may be expected. This however is maybe only true for labile fractions of SOM, and falls short regarding other environmental chemical constraints to decomposition, which could be further affected by climate change (Davidson and Janssens 2006). Also, primary production from ecosystems can be enhanced by increased temperatures at least for some plants or ecotypes and thus increase living plant biomass and counteract potential carbon losses from respiration of soils (Campioli et al. 2013; Welker et al. 2004).

Vegetation changes in arctic ecosystems have been reported over earlier warming periods (Larsen et al. 2014). Perennial shrub vegetation is expanding as result of climate change in tundra ecosystems (Hallinger and Wilmking 2011; Tape et al. 2006), such as on our study site close to Abisko in Sweden. Plant biomass is therefore likely to increase, and assimilated carbon will remain longer in the system with woody shrub vegetation, compared to graminoid or moss dominated tundra types (Campioli et al. 2009a).

Higher temperatures will further likely prolong the growing season as summarized by Linderholm (2006), again allowing plants to gain more biomass. However, changes in growing season length should be observed with caution, because local climate variabilities and other factors, such as changes in snow depths, could result in shortened growth seasons as well. Declining snow depths and shorter duration of ice cover on Lake Torneträsk (Callaghan et al. 2010) would also suggest lengthening of growing season at our research site in subarctic Sweden close to Abisko.

Apart from to the harsh climate, nitrogen is supposed to be the main limiting factor in tundra for both SOM decomposition (Mack et al. 2004) and plant growth (Jonasson et al. 1999). Thus available nitrogen can possibly amplify carbon release or uptake from the ecosystem (Weintraub and Schimel 2005a). In principle the main input of nitrogen to the ecosystem is through fixation by moss associated cyano-bacteria and is likely increasing with warming (Rousk and Michelsen 2017). But shrub expansion will also increase litter input and is a possible source of nutrients to the top layer of the soil and affect both respiration and photosynthetic production of the ecosystem.

Additional plant litter input also holds the potential for building up carbon stocks in soils. Cornelissen et al (2007) point out, that expanding deciduous shrubs could have a positive or negative feedback dependent on whether easier decomposed higher quality litter of forbs and graminoids, or more recalcitrant mosses will be replaced. The quality of the litter therefore seems to be of importance for carbon fluxes. Increased plant growth due to warming could possibly reduce nitrogen content of plant biomass, because of a dilution effect, thus also of the litter, although this is very species dependent and likely to be offset by increased nitrogen availability due to release from decomposed SOM in the long term (Turunen et al. 2009).

Decomposition of SOM could be also enhanced by additional labile carbon input, an effect named as priming, as litter input and root exudates could be increased, as result of higher plant productivity (Kuzyakov 2002). This would be confirmed by Hartley et al (2012) who observed bigger carbon stocks in soils of low productive tundra compared to the more productive mountain birch forests in the same region. In contrast a direct priming effect after labile carbon addition in tundra soils could not be observed by Lynch et al (2018) but microbial communities of shrub vegetation could reduce respiration of fresh carbon inputs compared to graminoid dominated soils. Rousk et al (2016) reported rather selective mining for nutrients in SOM, but reduced overall decomposition of SOM in response to carbon input, giving potential of carbon accumulation in soils as result of shrub growth.

Considering the seasonal development of the ecosystem during growth season, it is not an easy task to make general conclusions of responses to climate change. Leaf Area Index (LAI) can be correlated to Normalized Difference Vegetation Index (NDVI) and changes along the short growing season of tundra ecosystems also differ for dominant species (Juutinen et al. 2017). LAI increases early after snow melt, especially for deciduous shrubs (Campioli et al. 2009b), while secondary growth and also leaf productivity of evergreen plants remains high through the whole growing season (Campioli et al. 2009a). Variation in nitrogen content of produced plant tissue at different times could change nitrogen demand during the season. Input of fresh nutrient rich litter occurs mainly in autumn, at a point of low nitrogen demand by plants. Nutrients, however, appear to be solubilized and accumulated during autumn and winter and are most available for assimilation into biomass by microbes and plants during snow melt, while depletion and hence competition is highest in mid-summer (Weintraub and Schimel 2005b). Temperature conditions, soil moisture and solar radiation are changing permanently according to actual weather conditions throughout the growing season and can readily affect the carbon flux dynamics at any point of time.

1.2 Changes of potential enzymatic activities

Soil microorganisms play a crucial role in the decomposition of complex organic molecules for the purpose of cycling and provision of nutrients for assimilation into new biomass. To a large extent this is conducted by extracellular enzymes, mainly released by microorganisms, which decompose specific substrates in a kinetic cascade, controlled by environmental factors such as substrate, enzyme and product concentration, sorption and diffusion processes in soil, water potential, pH or temperature (Sinsabaugh and Follstad Shah 2012). Because of the comparably easy and reliable assessment methods of potential enzyme activities and their importance in organic matter metabolism, enzymes can be used as a valuable indicator for biological activity and biochemical processes in ecosystems (Nanniperi 2002). The resource allocation theory that enzymes are expressed as a response to nutrient limitation and resource demands for microbial growth (Sinsabaugh and Moorhead 1994) and can be confirmed by a recent comprehensive meta-analysis of 132 studies on natural ecosystems undergoing N or P addition treatments, among others (Xiao et al. 2018). According to Sinsabaugh and Follstad Shah (2012) this is most apparent for phosphorus cycling enzymes, though in principle also reported for enzymes associated with catabolism of nitrogen rich compounds, which are often simultaneously also a relevant source of carbon. Anyway, to draw clear conclusions on the effect of the complicated interactions of C and N limitation on SOM decomposition in tundra is difficult. Low N availability is expected to limit decomposition of SOM, and N addition showed amplification of decomposition and associated extracellular enzymes (Koyama et al. 2013; Sistla et al. 2012). But theoretically, enhanced catabolization of organic carbon could also occur under nitrogen limitation and be reduced by N addition (Schimel and Weintraub 2003). This could also explain the observation of Melle et al. (2015), where nitrogen addition in arctic tundra soils did not increase carbon mineralization or growth of microbial biomass, although Melle et al. rather concluded carbon limitation in his study.

Temperature affects the in-situ degradation through enzymes in many ways. Increasing temperature generally fastens up the turnover rate of any biological process, as well as makes substrates and enzymes more soluble in soil water and enhance turnover in that way (Wallenstein et al. 2011). But also the production rate of exoenzymes is likely to increase with temperatures, and shift resources allocation of microbes towards enzyme production, thus increasing potential enzyme activity (Wallenstein et al. 2011). The meta analysis by Brzostek et al (2012) observed a global trend for increased proteolytic enzyme activities after experimental warming, especially in organic soils and in soils of higher northern latitudes. In the study of Sistla and Schimel (2013), increased enzyme activity was observed strongly in winter, but very weakly during the warmest month and if present only in mineral horizons. For Jing et al (2014) an increase of potential enzyme activity in response to warming treatment was not detectable. These results depict clearly that still uncertainties exist in which way extracellular enzyme expression is affected by enhanced temperatures.

As resource availabilities and demands moisture and temperature conditions change through the season it is of no surprise, that enzyme activities change permanently in dependence of environmental conditions and dominant vegetation. In tussock tundra potential enzyme activities peaked right before and shortly after snowmelt, while remained generally low with a slight increase along the growth period for shrub dominated tundra (Wallenstein et al. 2009). Similar peaks of hydrolytic enzymes during spring thaw were observed by Sistla and Schimel (2013) and could be explained by high nutrient availability after winter and increased nutrient demand during mid-summer for all tundra types, but also increased competition through the whole season by tundra typical shrub vegetation (*Betula nana*) which is very efficient in N uptake (Weintraub and Schimel 2005b).

1.3 Aim of the Study

It is evident, that climate change will alter ecosystems globally, but especially in higher northern latitudes. If the large carbon stocks are affected by those changes, a feedback on CO_2 concentrations in the atmosphere and thus on global warming is likely. Although the scientific community is aware of that threat, the mechanisms causing either an increase or loss of biomass are only partly understood and possibly also unequal among different ecosystem types in the northern regions. It is further also difficult to extrapolate from single ecosystem processes to overall changes in the ecosystem. Therefore, analysis of carbon fluxes for different biomes on ecosystem level could help assessing possible feedback mechanisms.

The subarctic region around Abisko is undergoing typical changes of climate change, with rising temperatures, prolonged growth season and expansion of shrub vegetation in tundra areas. The experiment located in a mesic tundra heath close to the treeline of birch forest is exposed to 4 different treatments to resemble possible effects on the changing ecosystem.

Input of litter material and its quality appears to be of importance to decomposition processes in soil and nutrient availability to plants. Two treatments should reveal the effect of additional litter input of expanding shrubs (Birch and Willow) with two contrasting qualities, with Birch litter having a twice as high C:N ratio than Willow litter. A third treatment with substrate addition (fungal fruitbodies) was not considered to resemble increased fungal growth in tundra, rather than offering another but high-quality substrate with easily available nitrogen for an additional comparison to more recalcitrant shrub litter.

The warming treatment should give insights on changes in the carbon balance under elevated temperature conditions, probably the most obvious and direct effect of climate change.

Environmental parameters are changing either along with the growth season or from day to day dependent on actual weather conditions. Measurement of CO_2 fluxes therefore have been conducted from beginning of the growing season after snow melt until the end when first frost occurred and plants shed their leaves. A total number of 14 measurement rounds could disclose whether possible treatment effects on carbon flux dynamics are different at different time points in the season, under special environmental conditions or over all throughout the growth period after several years of treatment application.

Enzymes are an easy measurable indicator for resource demand and soil microbial activities in manipulated ecosystems and play a crucial role in decomposition of SOM. As a huge proportion of the measurable carbon exchange between the environment and the atmosphere are controlled by photosynthesis and respiration of plants and therefore possibly mask treatment effects on soil respiration, an assessment of potential enzymatic activity should indicate whether treatments have also impact on organic matter decomposition in the soil. Although enzymatic activities change along with the season and environmental conditions as well, only one soil sampling for enzymatic activity assessment was conducted to reduce impact on treatment plots to a minimum extent and to allow relatively unaffected future research on these manipulation plots. The sampling was scheduled towards the end of the most active growth season in mid-summer, when nutrients are probably limited. Direct effects of fresh additional carbon inputs through litter are therefore unlikely and extracellular enzymes will hopefully give a clearer picture on enzyme activity in general due to alterations of the ecosystem after 6 years of manipulation.

1.4 Hypotheses

Based on above reported knowledge of past experiments and theories, I hypothesise that:

- Substrate addition will have a positive impact on Gross Ecosystem Production as well as Ecosystem Respiration. Effects will be relatively stronger with increasing N content of the substrate: Fungi > *Salix* > *Betula.*
- Warming will enhance Ecosystem Respiration to a stronger degree than photosynthesis, reducing Net Primary Production and thereby ecosystem uptake of carbon during the growing season.
- Additional available substrate enhances enzymatic activity in the top layers of soils. Relative to substrate quality, potential activity will be higher for nitrogen cycling enzymes for lower quality litter addition (*Betula*) and higher for phosphorus and carbon cycling enzymes for addition of N rich substrates (*Salix* and fungi fruitbody).
- Warmed plots will slightly enhance the potential activity of carbon cycling enzymes.

2 Methods

2.1 Site description

The experiment is located about 200 kilometers north of the Arctic Circle close to the scientific research station in Abisko, Sweden, which also records long term weather data. The annual precipitation is around 300mm and mean temperatures about 0.5 °C. The experiment is adjacent to the Birch forest tree line but contains solely tundra vegetation, mainly dwarf shrubs and mosses with some graminoids and forbs. Common ericoid dwarf shrubs are, *Vaccinium uliginosum*, *Empetrum hermaphroditum*, *Rhododendron lapponicum* and *Andromeda polifolia*, common non erocoid dwarf shrubs are *Betula nana*, *Salix myrsinites*, and *Dryas octopetala*. Typical moss vegetation contains *Dicranum* spp., *Tomentyphnum nitens* and *Hylocomium splend*ens (Rousk et al. 2016; Rousk and Michelsen 2017). The organic soil layer is 8-15cm deep with a pH of 6.7 ±0.03 (Rousk et al. 2016), and the bedrock material is a base-rich schist. There is no permafrost in the field site.

Figure 1: Field site in subarctic tundra adjacent to mountain birch forest treeline in autumn. (Photo: Balduin Landl)

2.2 Experiment setup

To simulate effects of global warming, 5 treatments have been established. The treatments are control (referred to as "**C**"), litter addition of birch leaves (*Betula pubescens* ssp. *tortuosa*; referred to as "Betula" or "**B**"), litter addition of willow leaves (*Salix myrsinifolia*; referred to as "Salix" or "**S**"), fungal fruitbody addition (mainly *Leccinum scabrum* referred to as "Fungi" or "**F**") and warming treatment (referred to as "**W**" conducted by open top chambers.

The treatments where applied to 1x1m plots on the tundra vegetation in a randomized block design with 6 replicates. First Betula, Salix and Fungi applications have been conducted annually in autumn with 90g dw m^{-2} yr^{-1} of litter and 90g dw m-2 yr^{-1} fresh weight of fungi since 2011. The C:N ratio of the added substrate was 45 ± 4.1 for Betula, 22 ± 1.3 for Salix (mean ± se, n = 3) and for the Fungi 11.25. Fungi is expected to reduce nitrogen limitation in the ecosystem. Treatment application in 2017 was conducted on 30th of August.

The warming is established with open top chambers (OTC) which side walls are assembled as a hexagonal frustum of 35cm height and a diameter of 150cm at bottom and 85cm at top with 3mm thick transparent acrylic glass. The OTCs are in place throughout the whole year since May 2012 and led to an annual temperature increase of the soil surface of 0.7°C and 1.8°C during the snow free period. All measurements and samplings in 2017 have been conducted in the 6th year of treatment.

At each plot a 33 x 33 cm squared metal frame is permanently installed to allow closure of the manipulated ecosystem for gas flux measurements. The metal frame can be filled with water to seal the gap between CO_2 flux chamber and frame and prohibit gas exchange.

Figure 2: Warming treatment plot with OTC and 33 x 33 cm metal frame for CO_2 flux measurements. (Photo: Anne Schäfer)

2.3 CO_2 flux measurements

CO2 fluxes of each climate change manipulation plot have been measured 14 times during the snow free period between 24th of May and 19th of September. The average measurement interval was 9 days but not fully consistent due to weather limitations. One whole set of measurements (all 30 manipulation plots) required 2 consecutive working days of similar environmental conditions which was tried to be assured at its best. All 5 different treatment plots per block were measured in one series to achieve best comparability of the treatments. The measurements of the blocks were conducted in ascending order for the first three measurements (24 May, 2 Jun, 16 Jun) and since then randomized for the following 11 measurements (28 Jun - 19 Sep). The net ecosystem CO_2 exchange (NEE) was measured by placing a cubic transparent acrylic glass chamber of 33cm side length on the installed metal frames and sealed with water for minimum 3 and maximum 7 minutes depending on environmental conditions. The change in CO2 concentration in the closed system was recorded by an infra-red gas analyser EGM 4 (PP Systems, Amesbury, USA) connected to the chamber every 1.6 seconds. Additionally, temperature, relative humidity, atmospheric pressure and photosynthetically active radiation (PAR) were recorded by the EGM-4 probe in the chamber. Soil moisture (3 places), soil temperature at 2cm and 5cm were measured manually in the manipulation plots, but outside the chamber frame to avoid disturbance of the plot area used for carbon flux measurements. Normalized Differential Vegetation Index was measured disturbance free with a hand-held device of the area within the chamber frame (3 replicates).

After a NEE measurement of each plot a subsequent ecosystem respiration (ER) measurement was conducted by shortly removing and replacing the chamber but covered with a cardboard box and a black cloth, to prohibit photosynthesis.

The CO2 concentration changes were used to calculate the CO2-flux (µmol CO_2 h^{-1} m^{-2}) of NEE and ER under given conditions with MS Excel using following formula,

$$CO_2\ flux = \frac{slope * volume * pressure}{area * temp * R} * 360$$

with slope (µmol mol^{-1} s^{-1}) as the concentration change in the chamber, volume (m^3) as the volume of the chamber, pressure (Pa) as the pressure in the chamber, area (m^2) as the ground area of the measured plot, Temp (K) the temperature in the chamber and the universal gas constant R (8.31446 kg m^2 s^{-2} K^{-1} mol^{-1}).

Gross ecosystem production (GEP) was calculated from NEE-flux and ER-flux with following formula

$$ER - GEP = NEE$$

Figure 3: Transparent gas flux measurement chamber for NEE measurement on metal frame connected to EGM-4 and laptop in early spring (Foto: Anders Michelsen)

2.4 Soil sampling

Soil samples were collected once on August the 3rd in 2017. Two cores per plot were taken with a 37mm diameter auger and divided in 5cm sections. In the research station lab in Abisko, soils were weighted for estimation of bulk density. Soil cores of same depth and plot have

been homogenized and roots picked out manually. Sieving the samples was not possible due to the high organic matter content and high water content at time of sampling. Root biomass of fine roots <1mm and coarse roots >1mm were determined separately. 5g fresh soil per sample were used for determining gravimetric water content, by weighing after 48h drying in oven at 60°C. 3g subsamples were frozen and transported to Vienna for later potential enzyme activity analysis. The rest of the soil samples were transported to Copenhagen for analysis of carbon and nitrogen content.

2.5 Enzyme activity assessment

Potential enzyme activity in 0-5cm and 5-10cm depth of each plot was assessed in the laboratory of the Institute of Soil Science at University of Natural Resources and Life Sciences Vienna (BOKU). Fluorometric assays were conducted following the standard protocol used by BOKU for extracellular enzyme activities assay after (German et al. 2011; Sinsabaugh et al. 1999) for following enzymes: β-glucosidase (BG), β-Xylosidase (BX), β-N-Acetylglucosaminidase (NAG), Acid Phosphatase (AP), β-D-Cellubiosidase (CB) using Methylumbelliferyl (MUF) linked Substrates and for Leucine Aminopeptidase (LAP) using Leucine-Aminomethylcoumarin (AMC) as substrate.

1 gram of soil was suspended in 100ml sodium acetate buffer (50mM) at environmental pH 6,7 (Rousk and Michelsen 2017) and homogenised with ultrasonicator for 40 seconds. Stock solutions with the respective substrates for each enzyme where prepared to guarantee excess availability for extracellular enzymes. Substrates and soil suspension were pipetted together with 4 replicates for each sample on microtiter plates, together with a few representative quenched MUF and AMC standards and standards in pure buffer solution, as well as buffer control, substrate control. The microtiter plates were incubated for 120min at 20°C and fluorescence of the metabolized substrate measured on a fluorescence spectrophotometer (Perkin Elmer EnSpire Plate Reader) with an extinction wavelength 365nm and Emission wavelength 450nm and 30 flashes. Potential enzyme activity was calculated with slightly adapted formulas of German et al. (2011) as follows.

$$Activity\ (\text{nmol g}^{-1}\ \text{h}^{-1}) = \frac{Net\ fluorescence * Buffer\ volume(\text{mL})}{Emission\ coefficient * Homogenate\ volume\ [\text{mL}] * Time[\text{h}] * Soil\ mass[\text{g}]}$$

$$\text{Net fluorescence} = \left(\frac{Assay\ -\ Homogenate\ control}{Quench\ coefficient}\right) - \text{Substrate control}$$

$$Emission\ coefficient\ [\text{fluorescence}\ nmol^{-1}] = \frac{Standardcurve\ slope(buffer)\left[\frac{Fluorescence}{nmol\ mL^{-1}}\right]}{Assay\ volume[\text{mL}]}$$

$$Quench\ coefficient = \frac{Standarccurve\ slope\ (\text{homogenate})}{Standardcurve\ slope\ (\text{buffer})}$$

Activity of oxidative enzymes, Phenoloxidase and Peroxidase were assessed by using L-3,4-dihydroxyphenylalanin (DOPA). Soil suspension or sodium acetate buffer for blanks have been pipetted with DOPA in 2ml-Eppis, mixed for 20s on a Vortexer and centrifuged at 5000 rpm for 5 min. 3 replicates of each sample and blank where transferred on two transparent microtiter plates respectively, one with additional 10µL of 0.3% H2O2 to enable additional Peroxidase activity in reaction wells. Absorption was measured with the Perkin Elmer EnSpire Plate Reader, first right after pipetting and again after 20h incubation at 20°C at at 450 nm wavelength. Calculation of oxidative enzyme activity is based on (2011).

$$Activity(\mu\text{mol } g^{-1}h^{-1}) = \frac{Net\ absorbance * Buffervolume[mL]}{Extinctioncoefficient * HomogenateVolume[mL] * Time[h] * Soilmass[g]}$$

$$Net\ absorbance\ = Assay_{\ t_{20}} - \ Blank\ control_{\ t_{20}}\ - \ Assay_{\ t_0} - \ Blank\ control_{\ t_0}$$

$$Extinctioncoefficient\ = 0.445[\text{absorbance}/\mu\text{mol}]$$

Phenoloxidase activity could be assessed and calculated in this way, while Peroxidase activity could be assessed separately but together with Phenoloxidase in the same wells with added Hydrogen Peroxide. Hence, Peroxidase activity hat to be calculated by substraction of Phenoloxidase activity from activities of both oxidative enzymes together.

$$Activity_{Peroxidase}\ = \ Activity_{Phenolox.+Perox.} - \ Activity_{Phenoloxidase}$$

2.6 Statistical analysis

Statistical analysis of treatment and additional measured variables impact on NEE, GEP, ER, enzyme activities and soil parameters was conducted with Rstudio statistic software.

Effect of treatment on CO_2 fluxes was modelled with generalized linear mixed effect models, for different seasons (spring: 24 May - 17 Jun, summer: 28 Jul - 27 Aug, autumn: 4 Sep - 20 Sep) and whole season where applicable. At least 2 measurements in autumn (4/5 Sep and 11/12 Sep) were influenced by application of litter and fungi treatments a few days earlier and therefore only warming and control plots were modelled for autumn season. The two influenced measurement rounds starting 4 and 11 September were further excluded for the whole season models. Effect of block was included in the model if it expressed a likely impact on the flux ($p < 0.2$). Plot ID was included as random effect to account for repeated measures on the same plots throughout the whole season. Validity of models were assessed visually, with normal Q-Q plots and observed vs fitted residual plots. Log transformation of fluxes was conducted if necessary to meet model assumptions.

For soil parameters and enzymatic activities, 2- or 3-way ANOVAs have been conducted, with treatment, block (if $p < 0.2$) and if applicable depth as factors. Soil variables where tested for each depth layer in 5cm intervals down to 20 cm depth. Soil cores of only 8 plots reached a depth below 20 cm, therefore only summary statistics, but no statistical analysis was performed for soil depth 20-25 cm. Enzymatic activity assays were only conducted for top soil layers in 0-5cm and 5-10cm depth. MANOVA was conducted for functional grouped enzymes to assess treatment effects of several enzymes in combination. Multivariate normality was tested with Shapiro-Wilk-Test as well as visually with Q-Q plots. For grouped enzymes which appeared to show interesting results for MANOVA analysis Linear Discriminant Analysis (LDA) was conducted as follow up analysis, to assess graphically patterns of treatment influence on ecoenzyme expression.

3 Results

3.1 Soil Characteristics

3.1.1 Characteristics of the soil profile

The depth of the soil at the field site showed high variability for individual plots. Depths from the 60 soil cores taken beginning of August 2017 ranged from only 8cm to 25cm, depending upon presence of stones and the depth of the bedrock. There was no permafrost at the site. Soil depths were distributed randomly among the site, as a spatial influence of the soil depth could not be observed by ANOVA. The first 5 cm or 10cm of the profile contained a large amount of weakly decomposed organic material, as for example mosses. The upper layers were penetrated with fine roots (<1mm) and coarse roots (≥1mm) more than the soils in deeper layers which were still rich in organic matter but consisted more of dark, well decomposed organic material. Carbon content was almost 40% in top 5cm and declined with depth to slightly above 30% for the deeper layers. Nitrogen content is lowest in the top layer of the soil but remains steady at approximately 2% for the rest of the profile below 5cm. The C to N ratio therefore declines from 28 to 16 from top to 15cm depth but from that point remains steady further down in the profile. Also, gravimetric water content of sampled soil declined continuously with depth. Bulk soil densities of those high organic soil cores were generally low but increased with depth from 0.05 g cm^{-3} at the top to 0.22 g cm^{-3} at the bottom. Biomass of both fine roots (<1mm) and coarse roots (≥1mm) is highest in the top layers and declines continuously with depth. While coarse root biomass is bigger in the first 10cm, at depth 10-15cm coarse root biomass almost equals fine root biomass and is even lower in the deep soil layers. Two-way ANOVAs do not indicate any effect of treatment on any of the described soil parameters, 6 years after first application, in each 5cm layer of the soil. Statistical tests, integrating all soil layers within 0-10cm or 0-20cm with treatment, block and depth as factors result in significant influence of depth only, but no significant effect of treatment. An exception to this is soil nitrogen content if modelled over the whole profile depth of 0-20cm.

Table 1: Soil characteristics in various depths, (mean ± se; 0-5cm n=30, 5-10cm n=30, 10-15cm n= 29, 15-20cm n=23, 20-25cm n=8)

	0 - 5 cm	5 - 10 cm	10 - 15 cm	15 - 20 cm	20 - 25 cm
Bulk soil density (g cm^{-1})	0.05 (0.01)	0.10 (0.01)	0.14 (0.01)	0.20 (0.03)	0.22 (0.03)
Water content (g H_2O g $Soil^{-1}$)	386.1 (23.1)	370.6 (27.5)	341.1 (23.7)	283.7 (16.7)	264.9 (25.4)
Carbon content (%)	39.98 (0.22)	36.98 (0.65)	33.86 (0.78)	31.84 (0.95)	31.94 (1.69)
Nitrogen content (%)	1.46 (0.04)	1.97 (0.06)	2.11 (0.06)	1.99 (0.07)	2.0 (0.13)
C:N ratio	27.70 (0.72)	19.51 (0.60)	16.24 (0.43)	16.12 (0.41)	16.21 (0.76)
Fine root biomass (g dm^{-1})	4.74 (0.32)	2.93 (0.14)	1.47 (0.12)	0.90 (0.11)	0.90 (0.26)
Coarse root biomass (g dm^{-1})	7.65 (0.67)	4.52 (0.60)	1.75 (0.38)	0.32 (0.12)	0.10 (0.08)

A general linear mixed effect model returns a tendency towards an effect of treatment on nitrogen content ($p= 0.052$), lower in control plots than in the B treatment ($\alpha=0.05$) and in the F treatment ($\alpha=0.1$). The higher nitrogen levels in plots with treatment are more pronounced in lower depths of 10-20cm (Figure 4).

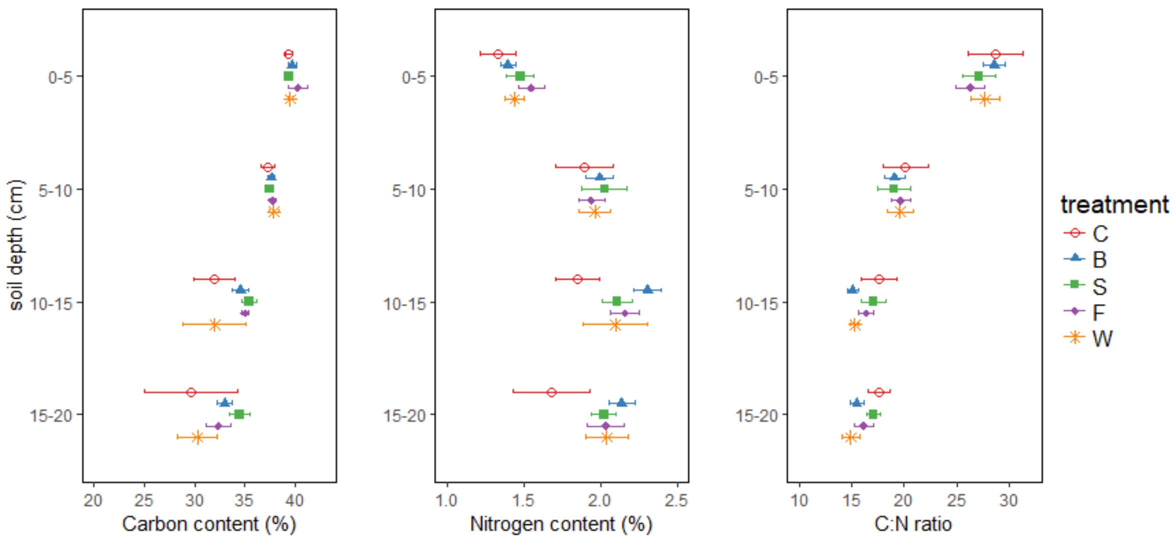

Figure 4: Carbon content, Nitrogen content and C:N ratio of soil in various depths (mean ± se, 6 ≥ n ≥ 5, but $n_{C.15\text{-}20}$ = 4, $n_{S.15\text{-}20}$ = 3)

3.1.2 Soil temperature and moisture during flux measurements throughout the season

The soil water content in the top 6 cm changed throughout the growing season between 19.9 ± 1.5 vol % (mean ± SE, n=30) on July 28 and 97.5 ± 3.1 vol % (mean ± SE, n=30) on July 15 where the site was partly flooded after heavy rainfalls. Partly flooding of the site resulted to few erroneous moisture measurements of more than 100% volumetric water content. A soil moisture gradient was present from East to West side of the site with a significant higher soil water content on the 3 blocks on the East side from spring until summer (25 May – 15 August, $p<0.001$) which changed in the comparable dry period later in the season (26 Aug – 19 Sep, $p<0.001$) where water content was higher in the West. Soil moisture showed a very weak response to treatment over the whole season if the moisture gradient was included as East/West factor variable in a linear model ($p=0.072$). Tukey pairwise comparison resulted in higher moisture content of *Salix* compared to *Betula* litter treatment only on $\alpha=0.1$ level.

Soil temperatures fluctuated over the whole growing season according to weather conditions. Based on soil temperature measurements during each flux measurement, no treatment effect was observed during the time periods spring, summer and autumn or at single measurement days, except on 11 September ($p=0.016$) with open top chambers (warming) being warmer than B and S treatment (1.4 and 1.1°C respectively). However, soil temperature was significantly enhanced by warming over the whole season, if PAR (measured in transparent chamber) and daytime, as a surrogate for change in ambient temperature, is included in the generalized linear mixed effect model. Temperature was enhanced by 1.1 °C in 2 cm depth ($p=0.014$) and by 0.9 °C in 5 cm depth ($p=0.018$).

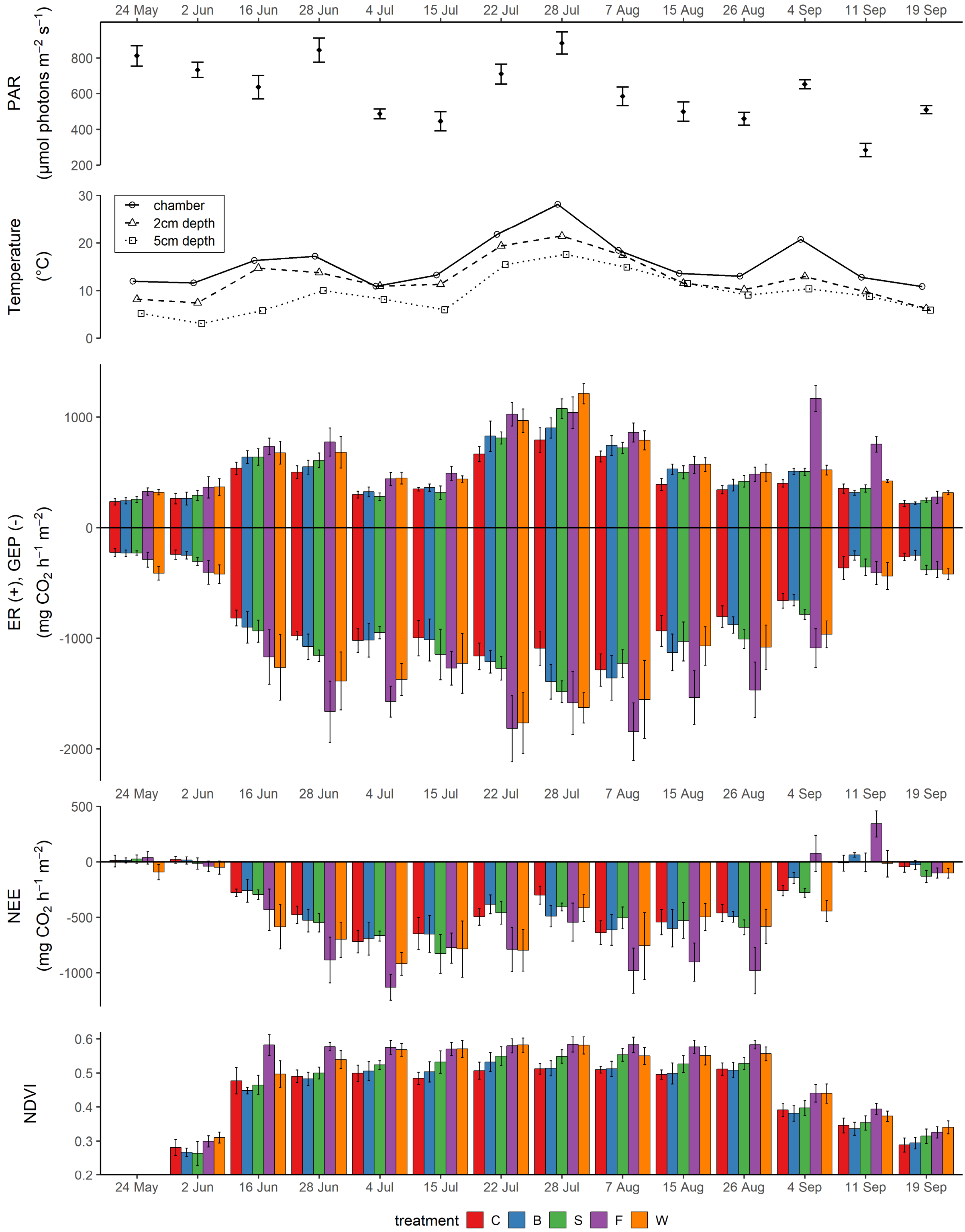

Figure 5: Seasonal development of: CO_2-fluxes: Ecosystem Respiration = positive values, Gross Ecosystem Photosynthesis = negative values, Net Ecosystem Exchange (positive values = CO_2 release, negative values = CO_2 uptake by ecosystem), for different treatments (mean ± SE, n=6) and additional Variables: PAR in Chamber (transparent) during flux measurements (mean ± SE, n=30); Mean temperature in Chamber (dark), 2cm and 5cm soil depth during flux measurements (mean, n=30); Normalized Differential Vegetation Index for different treatments (mean ± SE, n=6), NDVI data for 24 May is missing, note that scale does not start with 0.

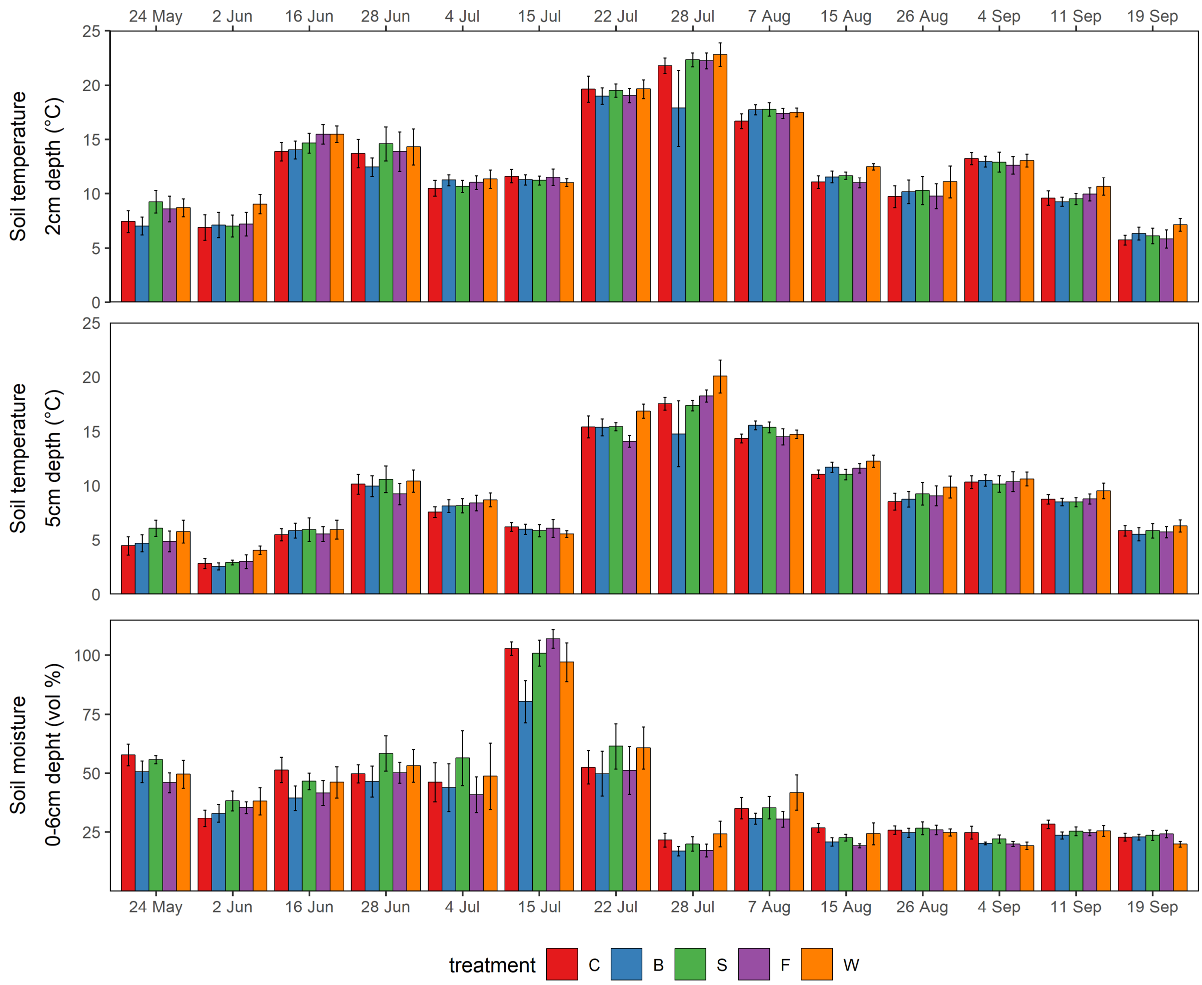

Figure 6: Seasonal development of: Soil temperature during flux measurements in 2cm and 5cm depth for different treatments (mean ± SE, n=6); Soil moisture on flux measurement days for different treatments (mean ± SE, n=6)

3.2 CO_2 fluxes

3.2.1 Ecosystem Respiration (ER)

Ecosystem respiration is significantly influenced by treatments throughout the whole growing season (Table 2, Figure 7). F and W treatment plots show higher activity compared to control plots similar in spring, summer and over the whole season. Measurements on 4 and 11 September were not included in the whole season model because of obvious strongly enhanced respiration due to fresh litter and fungal fruit body application on B, S and F treatment plots. Only W treatment was compared to control in autumn season and showed a significant enhancement of respiration.

Table 2: Treatment effects on Ecosystem Respiration compared to control: p-values for Dunnett's test for generalized mixed effect models estimated marginal means. For autumn, B, S and F treatment excluded from model and for whole season, measurements on 4 and 11 of September excluded, due to influence of treatment application. Significant treatment effects in bold, indicated by: $^{+}$ p ≤ 0.1, * p ≤ 0.05, ** p ≤ 0.01.

	B	S	F	W
Spring (24 May - 16 Jun)	0.668	0.248	**0.001 ****	**0.002 ****
Summer (28 Jun - 26 Aug)	0.397	0.307	**0.002 ****	**0.004 ****
Autumn (4 Sep - 19 Sep)	-	-	**-**	**0.007 ****
Whole Season (24 May - 19 Sep)	0.400	0.236	**0.001 ****	**0.001 ****

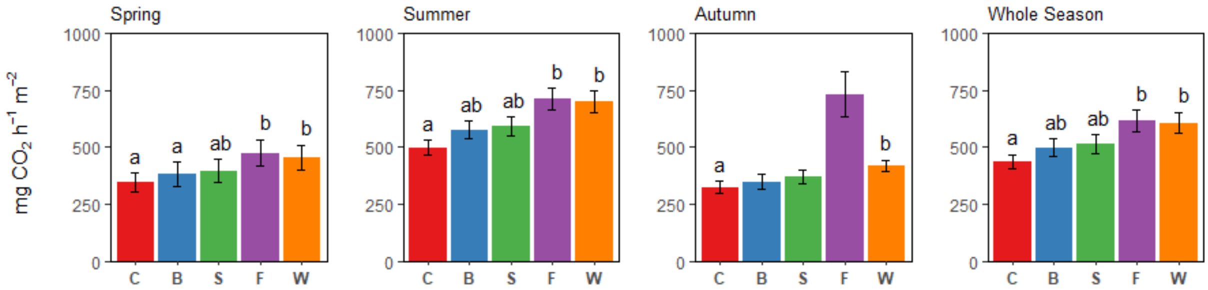

Figure 7: ER of different treatments at different seasons, mean ± SE (mg CO_2 h^{-1} m^{-2}). Spring: 24 May, 2 and 16 Jun. Summer: 28 Jun - 26 Aug (8 measurement rounds). Autumn: 4, 11 and 19 Sep (B, S and F treatment excluded from model due to treatment application impact). Whole season: 24 May - 19 Sep, (12 measurements, 4 and 11 Sep excluded due to treatment application impact). Letters indicate significant differences between treatments after Tukey pairwise comparison of estimated marginal means (α=0.05).

3.2.2 Gross Ecosystem Photosynthesis (GEP)

Early in the season warmed plots showed increased activity compared to the control plots. Photosynthesis remained rather high over the whole season, but shows now significant difference to other treatments, but to the *Betula* addition treatment during autumn. Although photosynthesis activity of F treatment plots dropped slightly below the W treatment in spring, F and W are clearly most productive treatments during the whole season and the only treatments with a significant treatment effect compared to controls. Litter addition treatment plots B and S showed no significant treatment effect but the trend for intermediate productivity between the lower C and higher F and W plots is visible. (Table 3, Figure 8)

Table 3: Treatment effects on Gross Ecosystem Photosynthesis compared to control: p-values for Dunnett's test for generalized mixed effect models estimated marginal means. Significant treatment effects indicated by: $^{+}$ p ≤ 0.1, * p ≤ 0.05, ** p ≤ 0.01

	B	S	F	W
Spring (24 May - 16 Jun)	0.985	0.721	0.206	**0.018 ***
Summer (28 Jun - 26 Aug)	0.902	0.769	**0.016 ***	**0.067 $^{+}$**
Autumn (4 Sep - 19 Sep)	0.630	0.899	**0.034 ***	0.167
Whole Season (24 May - 19 Sep)	0.999	0.803	**0.024 ***	**0.066 $^{+}$**

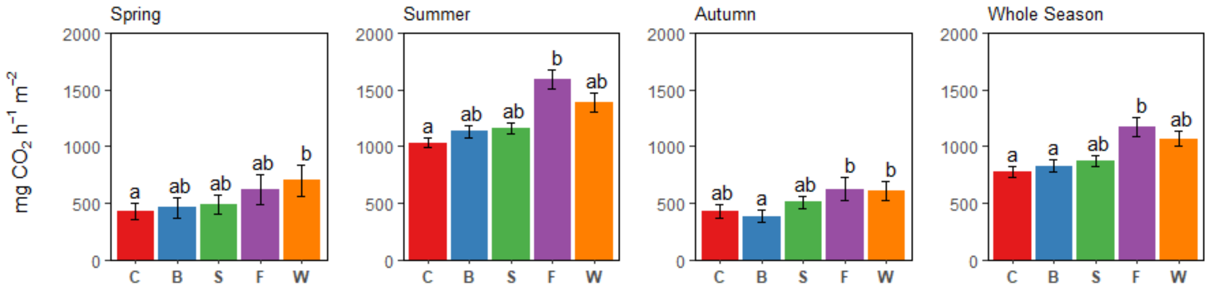

Figure 8: GEP of different treatments at different seasons, mean ± SE (mg CO_2 h^{-1} m^{-2}). Spring: 24 May, 2 and 16 Jun. Summer: 28 Jun - 26 Aug (8 measurement rounds). Autumn: 4, 11 and 19 Sep. Whole season: 24 May - 19 Sep (14 measurements rounds). Letters indicate significant differences between treatments after Tukey pairwise comparison of estimated marginal means (α=0.05).

3.2.3 Net Ecosystem Exchange (NEE)

No significant treatment effect could be observed by the models, although enhanced carbon uptake from W and F plots can be observed visually over the whole season (Figure 9). Covariates as Photosynthesis Active Radiation, temperature in chamber during measurement and soil temperature improved the model fit but did not influence treatment response. Spatial effects from block was not included, except in the model for spring, as it showed no effect on NEE ($p>0.2$). During the first two measurement rounds (24 May and 2 June) NEE was very close to zero but slightly positive for warming (Figure 5), but strong CO_2 uptake un 16 June turned the ecosystem into a net carbon sink already in spring. Also, the autumn season remains a net carbon sink until the the last measurement day, although on the second last measurement round 11 September respiration equaled primary production for C, S and W treatment plots and was a source of carbon for B and F plots. It must be recognised, that NEE of B, S and F treatment plots is influenced by enhanced respiration at least on 4 and 11 September due to substrate application shortly before and were therefore not analysed in the model.

Table 4: Treatment effects on Net Ecosystem Exchange compared to control: p-values for Dunnett's test for generalized mixed effect models estimated marginal means. For autumn, B, S and F treatment excluded from model and for whole season, measurements on 4 and 11 of September excluded, due to influence of treatment application. Significant treatment effects in bold, indicated by: $^{+}p \leq 0.1$, $^{*}p \leq 0.05$, $^{**}p \leq 0.01$.

	B	S	F	W
Spring (24 May - 16 Jun)	0.987	0.967	0.764	0.555
Summer (28 Jun - 26 Aug)	0.996	0.950	**0.063^{+}**	0.288
Autumn (4 Sep - 19 Sep)	-	-	-	0.525
Whole Season (24 May - 19 Sep)	0.982	0.963	0.103	0.216

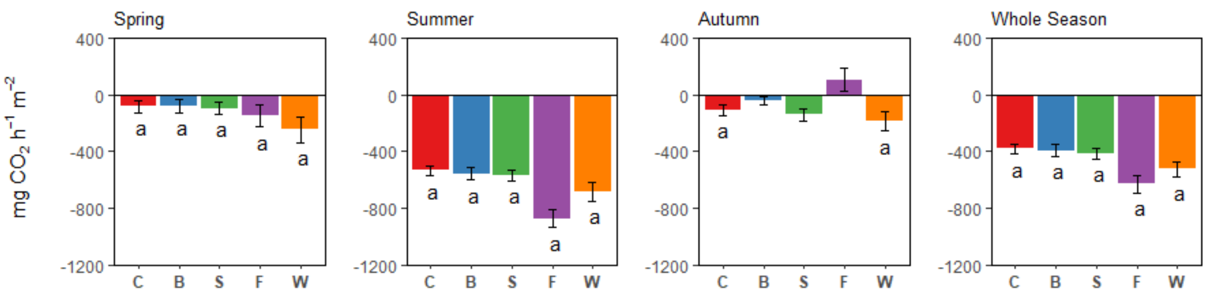

Figure 9: NEE of different treatments at different seasons, mean ± SE (mg CO_2 h^{-1} m^{-2}). Spring: 24 May, 2 and 16 Jun. Summer: 28 Jun - 26 Aug (8 measurement rounds). Autumn: 4, 11 and 19 Sep (B, S and F treatment excluded from model due to treatment application impact). Whole season: 24 May - 19 Sep (12 measurements, 4 and 11 Sep excluded due to treatment application impact). Letters indicate significant differences between treatments after Tukey pairwise comparison of estimated marginal means (α=0.05).

3.3 Normalized Differential Vegetation Index (NDVI)

In the early season the F treatment plots appear to have a higher NDVI with a significant difference to the generally low NDVI of the *Betula* treatment. During summer also the NDVI of the warming plots was significantly higher than the control. In the autumn when leaf senescence started, a difference in NDVI cannot be confirmed by the statistical models anymore on α=0.05 level, although the patterns of higher and lower NDVIs did not change on visual impression.

Table 5: Treatment effects on Normalized Differential Vegetation Index compared to control: p-values for Dunnett's test for generalized mixed effect models estimated marginal means. For autumn, B, S and F treatment excluded from model and for whole season, measurements on 4 and 11 of September excluded, due to influence of treatment application. Significant treatment effects in bold, indicated by: + p ≤ 0.1, * p ≤ 0.05, ** p ≤ 0.01.

	B	S	F	W
Spring	0.819	0.992	**0.098**	0.646
Summer	0.970	0.365	**0.003**	**0.020**
Autumn	0.977	0.844	**0.093**	0.195
Whole Season	0.999	0.474	**0.003**	**0.027**

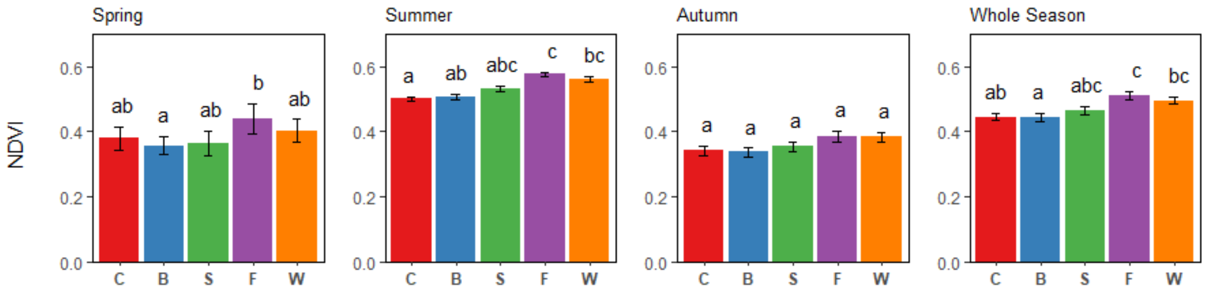

Figure 10: NDVI of different treatments at different seasons, mean ± SE (mg CO_2 h^{-1} m^{-2}). Spring: 2 and 16 Jun. Summer: 28 Jun - 26 Aug (8 measurement rounds). Autumn: 4, 11 and 19 Sep. Whole season: 24 May - 19 Sep (14 measurement rounds). Letters indicate significant differences between treatments after Tukey pairwise comparison of estimated marginal means (α=0.05).

3.4 Potential Enzyme Activity

β-Xylosidase and β-C-Cellubiosidase activity is very low close to the limit of detection. But since they express a very similar pattern, which appears to be not random variation, results are still considered as trustworthy. Potential activity of β-Glucosidase β-N-Acetylglucosaminidase Acid Phosphatase and Leucine-Aminopeptidase were higher in general (Figure 12). The potential enzyme activity of all six enzymes changed significantly with depth. All measured enzymes activities were higher in 5-10 cm depth compared to the top 5 cm layer, except for Phosphatase which was more active close to the surface. The control plots appeared to be lower in activity compared to any other treatment for most of the enzymes in the top 5 cm of the soil. This pattern seemed not to be repeated in 5-10 cm depth where especially activity of warmed plots usually was equal to or below control plots. Treatments where substrate has been added (B, S and F) enzyme activities appeared to be still slightly higher also in 5-10 cm, with the exception of NAG in which the control plots showed the highest activity.

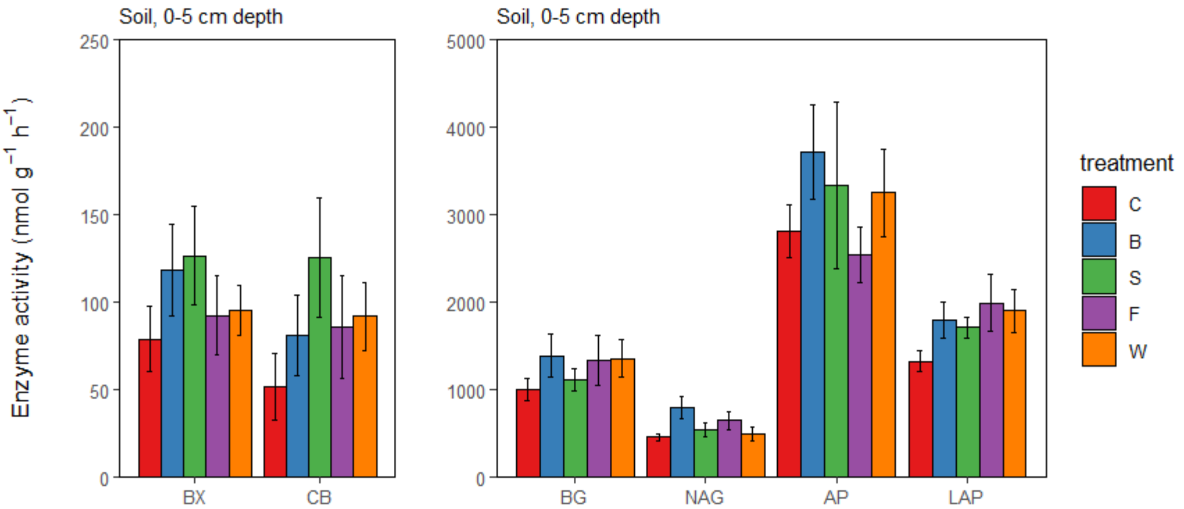

Figure 11: Potential activity of enzymes in 0-5cm depth. Note different scale for BX and CB (left) and BG, NAG, AP and LAP (right), (mean±SE, n=6)

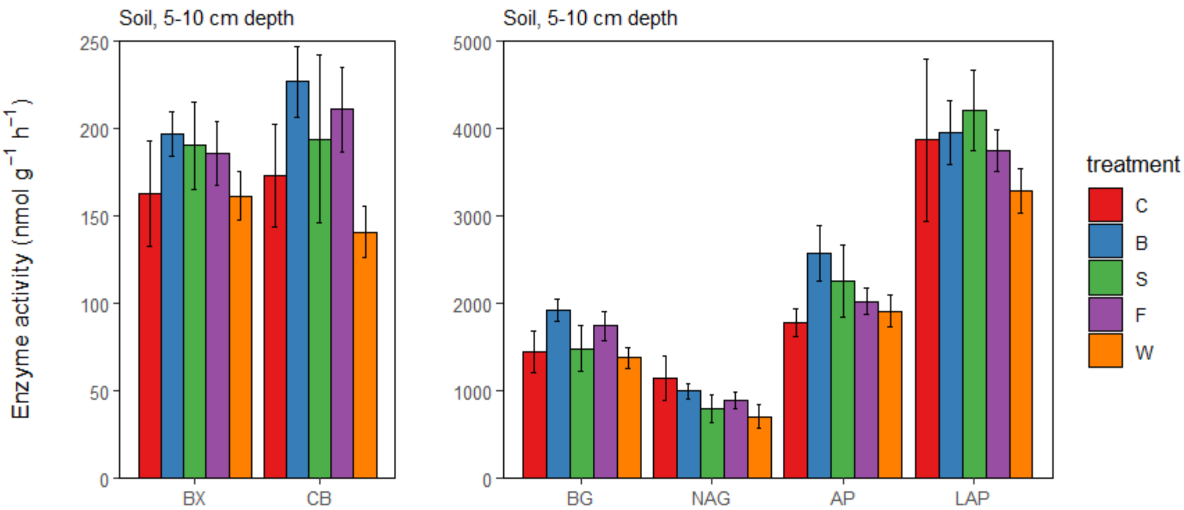

Figure 12: Potential activity of enzymes in 5-10 cm depth. Note different scale for BX and CB (left) and BG, NAG, AP and LAP (right), (mean±SE, n=6)

Statistically testing the potential enzyme activity with two- and three-way ANOVAS revealed no significant effect of 6 years of treatment application on enzyme activity. NAG in 0-5cm depth is the only enzyme which showed a tendency towards an effect (Table 6). A pairwise comparison after Tukey could not reveal any differences between treatments.

Table 6: Two-way ANOVA results on potential enzyme activity effects of treatments and block in several depths of soil (0-5cm and 5-10cm), 3 way ANOVA results including depth as variable and error term for plot ID to account for measurements in two depths on same plot on top 10 cm of soil.

	0 – 5 cm		5 - 10 cm		0 – 10 cm		
Enzyme	Treatment	Block	Treatment	Block	Treatment	Block	Depth
BX	0.596	-	0.605	0.147	0.277	-	**<0.001 *****
CB	0.396	-	0.300	-	0.221	-	**<0.001 *****
BG	0.397	**0.012 ***	0.248	-	0.152	**0.084 ⁺**	**0.006 ****
NAG	**0.051 ⁺**	**0.072 ⁺**	0.338	-	0.285	-	**<0.001 *****
AP	0.447	**0.020 ***	0.274	-	0.168	**0.022 ***	**<0.001 *****
LAP	0.256	-	0.741	0.190	0.842	-	**<0.001 *****

To analyse the effect of treatment on several enzymes in combination, several different statistical methods have been conducted. Enzymes where grouped as follows: All enzymes together, C-cycling enzymes (BX, CB, BG), N-cycling enzymes (NAG, LAP), Nutrient-cycling enzymes (NAG, AP, LAP), and enzymes with relatively high activity (BG, NAG, AP, LAP) compared to BX and CB. Summing up several enzymes activities per plot does not make any treatment effects visible for any of the grouped enzymes and two different depths. MANOVA analyses were conducted to investigate potential treatment effects over several enzymes together. Tendencies for treatment effect on nutrient cycling enzymes are visible. Enzyme activity data were log transformed for all enzymes, but for C-cycling enzymes at depth 5-10cm. The model assumption of multivariate normal distribution of dependent variables, observed with Shapiro-Wilk test and visually with normal QQ-plots, were still often not met. Block had impact on all MANOVA models and was therefore included in the models.

Table 7: p-values for MANOVA analysis for treatment effect on several grouped Enzymes; p-value for Shapiro-Wilk-Test (multivariate normality given if p≥0.05); visual interpretation of Q-Q plot for multi variate normality.

	0 – 5 cm			5 - 10 cm		
Enzyme cluster	Treatment effect	Shapiro-Wilk Test	Visual model check	Treatment effect	Shapiro-Wilk Test	Visual model check
All Enzymes	0.219	0.0001	poor	0.167	0.001	poor
C-cycling Enzymes (BX, CB, BG)	0.376	0.133	OK	0.225	0.127	poor
N-cycling Enzymes (NAG, LAP)	0.165	0.077	poor	0.141	0.005	poor
N,P-cycling Enzymes (NAG, AP, LAP)	**0.094** $^{+}$	0.0001	OK	**0.087** $^{+}$	0.011	OK
High activity Enzymes (BG, NAG, AP, LAP)	0.221	0.0001	poor	0.103	0.001	OK

Expressing the enzyme activities per g soil carbon, instead of soil, does not affect the results of the tests to a relevant degree, as soil carbon content is very similar among all plots. Variance of nitrogen content and C:N ratio is higher, hence test results change to some degree if activities are divided by the C:N ratio or calculated as activities per g Nitrogen. ANOVAs on transformed potential enzyme activities do not indicate treatment effects (data not shown). MANOVA results however indicate a treatment effect on potential activities relative to C:N ratio on some enzyme clusters. Examples therefore would be enzymes with higher activity BG, NAG, AP and LAP divided by C:N ratio in depth 5-10 cm (p=0.064) or nutrient cycling enzymes NAG, AP and LAP divided by C:N ratio in 5-10cm depth (p=0.042). In both cases the Shapiro-Wilk-test and visual interpretation of residual plots and Q-Q plots suggest multivariate normality.

A Linear Discriminant Analysis have been further conducted complementary to the MANOVA models, to check in which way the treatments possibly change the activity of grouped enzymes. On the new calculated linear discriminant axes on the biplot a clear grouping of the individual treatments is not visible, indicating that treatment effects are not visible after 6 years of treatment yet.

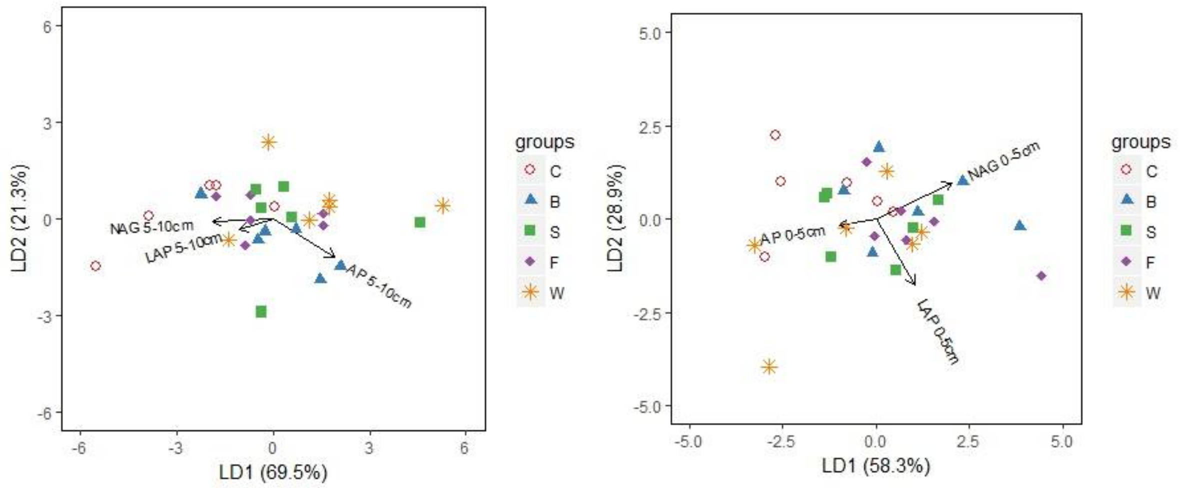

Figure 13: Biplot of Linear Discriminant Analysis for nitrogen and phosphor cycling enzymes (NAG, AP, LAP) at two different depths (0-5cm, 5-10cm). Each datapoint depicts one experimental plot with a specific treatment. Direction and length of vectors indicate influence of the potential activity of the respective enzyme on the position of each plot on the 2 plotted new calculated linear discriminant axes.

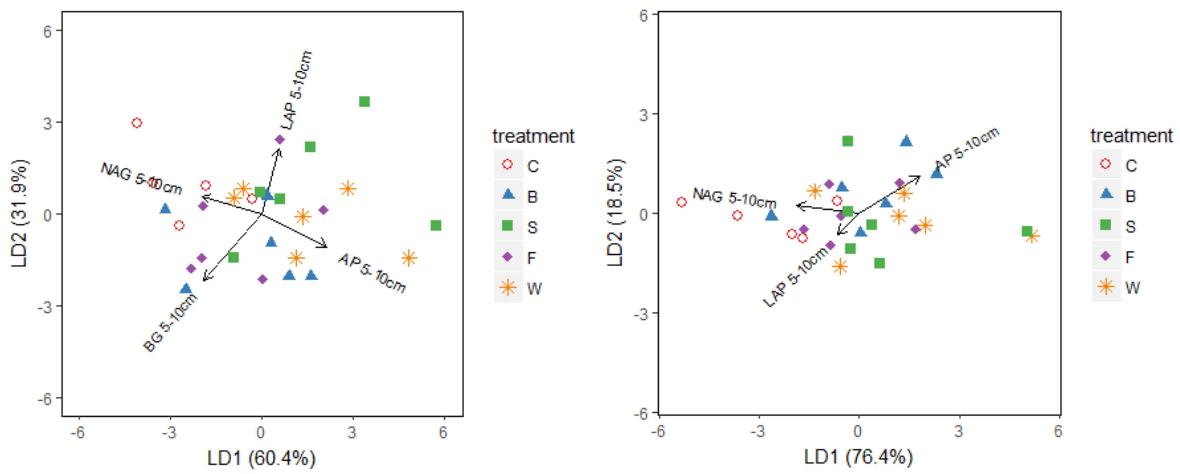

Figure 14: Biplot of Linear Discriminant Analysis for potential enzyme activity relative to C:N ratio. enzymes with high activity (BG, NAG, AP, LAP) in 5-10cm depth and nutrient cycling enzymes (NAG, AP, LAP) at 5-10cm depth. Each datapoint depicts one experimental plot with a specific treatment. Direction and length of vectors indicate influence of the potential activity divided by C:N ratio of the respective enzyme on the position of each plot on the 2 plotted new calculated linear discriminant axes.

3.4.1 Oxidative Enzymes

Peroxidase activities were in the negative range in 0-5cm soil depth. Both, Peroxidase and Phenoloxidase expressed very high variations within each treatment. Results of the oxidative enzymes were therefore considered as untrustworthy, probably due to methodological problems, and henceforth not considered any further. See supplementary graphs in the Appendix (S.Figure 1)

4 Discussion

4.1 Soil properties

4.1.1 Soil samples

The decline in carbon content with depth is common due to higher mixing with mineral substrate from the bottom and can be seen also in another experiment nearby, in a more wet heath type (Phillips et al. 2018). Interestingly at this site the carbon stocks differed with treatment and significant losses of carbon pools were observed in warmed plots after 16 years of treatment, which was not the case after only 7 years of treatments (Rinnan et al. 2008) and is apparently also not detectable at our site after 6 years of treatments. As losses through enhanced respiration of organic carbon or through lateral waterflow of dissolved organic carbon (Pedersen et al. 2017; Phillips et al. 2018) is taking place over longer time spans, the possibility of changing carbon stocks according to treatments at our field site can of course be not excluded, although relevant carbon losses at our dryer site through lateral waterflow are less likely.

A relative lower total nitrogen content in the soil close to the surface relative to deeper layers was also observed in other studies close by (Phillips et al. 2018; Rinnan et al. 2008) and can be probably accounted to the enhanced decomposition and nutrient uptake in this more active layer with higher root density. The resulting high C:N ratio fits well to the selective mineralization of N rich compounds of SOM observed by Rousk et al. (2016) with higher availability of labile carbon, which should be the case in the upper soil due to root exudates and litter input.

Difficult to answer is the observed higher total nitrogen levels of all treatment plots compared to control plots (Figure 4). A possible source of nitrogen is of course the substrate added with treatments B, S and F, and in fact the nitrogen content of the top 5 cm of the soils apparently increases slightly, in accordance with the nitrogen content of the added substrate. Enhanced nitrogen content in the top soil of warming treatment plots could possibly be explained by enhanced N_2 fixation, observed in previous studies in this region (Lett and Michelsen 2014; Rousk and Michelsen 2017). Another possibility is of course, that enhanced plant growth in warming treatment relocated nitrogen to the top layer, by uptake from deeper soils and partially return of N in aboveground biomass again with litter fall. These changes in total N in the top layer of the soil do follow a treatment pattern, but are anyhow not statistically significant and the explanations are rather insufficient for the varying nitrogen contents between treatments in deeper plots, where lower nitrogen of control plots is most obvious. In these deeper layers however, not only the nitrogen content but also carbon content of control plots appears to be much lower and both are subject to much higher variation than the treatment plots. As we sampled the soils all the way down to the mineral bedrock, it is possible that considerably high amounts of mineral soil substrate were mixed with the rather high organic soil samples at the bottom end of the soil cores, although we carefully removed the grey sandy and silty mineral material. The soil depths were between 10 and 25 cm, thus influenced single samples at different depths. Testing treatment effect on nitrogen content was only significant if modelled over the whole profile depth of 20 cm and further very sensitive to removal of single datapoints with remarkably low SOM content. Although we observed no significant differences between treatment plots for soil depth, I assume that by chance control plots were more mixed with mineral bedrock than treatment plots, for which treatments cannot be accountable. Therefore, the visibly lower nitrogen contents of control and its confirmation by statistical tests should not be overrated especially in deeper soil layers. Still, the nitrogen content, hence also C:N ratios of the top 5 cm fits very well within the treatment response pattern also of carbon fluxes and NDVI measurements (see discussion of CO_2 fluxes)

In contrast to our samples, the soil samples of the same plots 3 years earlier observed significant higher amounts of carbon and nitrogen in the organic horizon of the litter addition treatments (Rousk et al. 2016; fungi treatment plots not reported). Three possible explanations could have led to this discrepancy between visible treatment effects after 3 years, but not after 6 years of plot manipulations. In the earlier study, a higher number of 6 soil cores were sampled per plot and maybe achieve a higher representativeness of the soil properties in contrast to the 2 soil core sampling we conducted 3 years later, in order to reduce destructive impact on the experiment. Rousk et al. (2016) further reported the differences for samples of the whole organic horizon which was reported to be 8-15 cm in depth, and did not strictly dissect the soil cores into 5cm sections, regardless of the soil profile depth, as we did. A third explanation could be, that the additional carbon and nitrogen observed by Rousk was derived from the additional added litter itself, and to a lesser extent from increased litter fall of enhanced plant growth of the warmed plots, which showed a slightly and less significant increase in organic carbon and nitrogen stocks in the earlier study as well. However, it does still not sufficiently explain why this effect was not observable after 3 more years of treatment.

The biomass of fine and coarse root as well as the decline with depth is well in line with the results from the wetter subarctic tundra site of Rinnan et al. (2008) and Phillips et al. (2018). However, Rinnan et al. observed a significant enhancement of fine roots in the top 5 cm of warmed plots what is not the case in our study although warming has been applied in a similar time span.

4.1.2 Soil properties throughout the growth season

Although we observed a soil water gradient from East to West it is unlikely it had a relevant impact on our experiment. Blocks at different positions contained all treatments, therefore each treatment should have been influenced in similar way by different moisture conditions. Still the two litter addition treatments slightly differed with higher moisture for *Salix* addition treatment plots to *Betula* addition treatment plots on a low significance level ($\alpha = 0.1$). As other experiments often observed a negative impact of litter addition to soil moisture (Lett and Michelsen 2014; Pedersen et al. 2017) it is surprising that the only visible changes in soil moisture of our experiment occurred between two litter treatments and not in comparison to C, F and W treatments. This moisture difference is anyway not explainable by differences in litter properties and therefore considered as neglectable, especially as soil moisture apparently had no detectable effect on CO_2 fluxes.

The range of observed soil warming of about 1 °C was slightly lower than during the growing season in 2014, where soil temperatures were enhanced by 1.8 °C in W treatment plots (Rousk and Michelsen 2017). As the soil temperature is of course influenced by incoming solar radiation it is possible that enhanced plant growth in warmed plots caused relatively more shading compared to control and reduced in that way the warming effect on soil with continuing experiment duration. Warming with open top chambers, built in tent form, in the experiment nearby however resulted in similarly low temperature enhancement as in our field manipulations (Pedersen et al. 2017; Ravn et al. 2017).

4.2 CO_2 exchange of ecosystem

4.2.1 Effects of environmental parameters on CO_2 fluxes

Figure 5 reveals clearly, that CO2 fluxes in both ways, uptake and release from the ecosystem, are very dependent on environmental parameters, which appears to be not true for soil moisture in the upper soil layer. For example, neither ER nor GEP appeared to change in any relation to big variations in volumetric water content during the 4 measurements in July. Similarily, also Pedersen et al (2017) observed no correlation of water content to ER in a similar manipulation experiment close to Abisko as well. Other environmental parameters (PAR, temperature in soil and in measurement chamber and NDVI) correlate well with fluxes. Radiation from the sun is clearly the main driver for temperature in 2 cm and 5 cm soil depth as well as in the measurement chamber, indicated very well by the fact that those parameters change along the whole growing season very much in parallel, except for the first two measurement rounds very early in spring and on the last measurement round in autumn. Likewise, ecosystem respiration obviously rises and falls along with temperature, which confirms the long known temperature sensitivity of respiration processes in ecosystems (Davidson and Janssens 2006) which was also the case in other local experiments (Larsen et al. 2007; Pedersen et al. 2017). In accordance with that, respiration rates were lowest at dates when also temperatures were lowest, in early spring, on 4 and 15 July and late September, but relatively independent from plant development stage.

NDVI shows a simple pattern of quick increase in spring, remained very stable over the summer season, and NDVI declined continuously in September. (2010) reported not very strong and also plant community dependent but significant relationships of manually assessed NDVI on plot scale in various subarctic tundra ecosystems to LAI and plant biomass and even GEP and NEE carbon fluxes. Community dependence of plant development through the season in subarctic tundra and possible continuous plant growth throughout the snow-free season was reported by Campioli et al (2009b) and indicates that plant growth in tundra can continue until autumn. However, since NDVI increased quickly to a stable level in spring, it can be assumed that plant foliage was developed to a large extent already at the beginning of summer.

4.2.2 CO_2 fluxes during growth period

Photosynthesis takes place in green plant tissue, therefore it is little surprising, that GEP was high and relatively stable in contrast to ER during summer at high NDVI values, although showing relevant fluctuations along with temperature and PAR. Since PAR and temperature in chamber or soil correlate apparently well for most of the season, it is not possible to assess whether one of those or both factors are governing photosynthesis. Although opinions and experimental observations of ER and GEP sensitivity to temperature are not unambiguous, it is likely that temperature affects respiration to a larger extent than primary production, especially on the short term (Davidson and Janssens 2006; Luo 2007), as for example temperature fluctuation during season. In accordance with that stands our observation on changes of NEE at different time points. Carbon uptake of the ecosystem is of course highly dependent on proper developed green plant tissue, but additionally fluctuates with temperature as it impacts ER and GEP. Highest carbon uptake occurred on relatively cold days of low respiration but during summer season, when productive plant tissue was fully developed, specifically during first half of July. Furthermore, lowest carbon uptake in summer season occurred on the 2 hottest measurement days right after cold days in the second half of July, because of strongly enhanced respiration and despite the similar NDVI and higher GEP compared to the beginning of July. On cold days in spring and autumn, at times of low NDVI values, photosynthesis was impeded and the ecosystem functioned only as a very weak or no carbon sink.

4.2.3 Treatment effects on CO_2 fluxes and NDVI

Although not statistically significant for single measurement rounds, a reoccurring pattern of treatment effects appears to be present for most of the CO2 flux measurements as well as for NDVI, especially during summer, but also to a relevant degree in spring and autumn season. This is a general visible enhancement of plant growth (NDVI) and for activity of ecosystem (CO_2 fluxes), in relation to quality of additional substrate added on plots. Changes to NDVI and CO_2 fluxes by *Betula* litter addition compared to control are almost not recognisable and range from a slight decrease to increase of fluxes and NDVI. Thus, we assume that *Betula* litter, the substrate addition treatment with highest C:N ratio, has very little to no effect on the ecosystem. Fluxes and NDVI of *Salix* litter addition plots, a substrate of better quality, is slightly higher in most of the single measurements of carbon fluxes and NDVI. Fungal fruitbody addition, the substrate with lowest C:N ratio resulted in the biggest increase of CO_2 fluxes and NDVI in all measurements compared to the two other treatments with substrate input. However, these responses are significant only for the F treatment, but for F in many cases of the seasonal grouped measurements.

Also, NDVI and CO_2 fluxes of warmed plots are enhanced to a very similar degree but on average usually a bit lower than the F treatment plots, thus have also a relative fixed position in the response pattern somewhere between F and S treatment, with a significant enhancement compared to control for ER over the whole season, for GEP in spring and for NDVI in summer.

Statistically insignificant, but apparently the same pattern is also visible for the top 5cm of the soil total N content and C:N ratio (Figure 4). While it appears logic, that N content changes with quality of substrate added continuously, the reasons for potentially enhanced N content in topsoil of warming treatment plots remains more difficult to explain.

However, similar patterns have been also observed in similar manipulation experiments in close proximity and similar vegetation. In mesic tundra enhancement of GEP and ER through fertilization (comparable to fungi addition treatment) was stronger as for warming treatment after 10 and 11 years of warming (Illeris et al. 2004). Although, the same site after 23 years of treatment, warming enhanced ER slightly more than fertilization (Ravn et al. 2017). A close by wet tundra heath shows same pattern of weak enhancement for *Betula* litter addition and a stronger enhancement through warming for ecosystem and soil respiration (Ravn et al. 2017) and similarly for ER and in early season also for GEP in the study of Pedersen et al (2017). These results from the wet tundra field site could be further linked to enhanced losses of soil carbon and nitrogen stocks, more by warming than litter addition (Phillips et al. 2018) and significantly increased NDVI for the litter and warming treatment, although on the same magnitude (Rinnan et al. 2008). An incubation experiment with soil samples of the region showed same pattern for increased respiration rates by litter addition and stronger increase through 2° warming (Jonasson et al. 2004). Zamin and Grogan (2012) reported increased plant growth of *Betula glandulosa* in a similar response pattern to warming, low and high nitrogen fertilization, although phosphorus fertilization showed an even stronger response in their study. However, it should be noted, that this patterns in other studies were visible only for some assessed response variables, maybe even only for parts of the season, and only sometimes statistically significant and in other studies at subarctic tundra field sites around Abisko those patterns were not observable (Christensen et al. 1997). Net carbon exchange fluxes of the ecosystems anyway showed various responses, to warming, fertilization or litter addition, with increasing or decreasing uptake or even release of carbon from ecosystem and further, effects of combined treatments were not coherent (Christensen et al. 1997; Illeris et al. 2004; Pedersen et al. 2017; Tiiva et al. 2008; Zamin and Grogan 2012). Therefore, general conclusions of same effects of climate warming and increasing litter input over global tundra ecosystems should be taken carefully.

The reoccurring pattern of effect magnitude for all 3 different substrates, gives clear indication of the importance of litter quality on the activity effect on ecosystems. If we assume nitrogen limitation, as it is common in tundra (Jonasson et al. 1999; Mack et al. 2004; Sistla et al. 2012), this pattern is further easily explainable by the different nitrogen inputs of the respective substrates. *Betula* litter with a C:N ratio of 45 is even lower in quality than the soil with C:N ratio of 28 in top 5 cm, which further declines with depth, hence probably not improving nitrogen availability at all. The litter of *Salix* has a C:N ratio of 22, thus is of slightly higher quality than top soil. The very high nitrogen content of fungi with a C:N ratio of 11 obviously functions as a boost for plant growth and respiration. Not only the total amount of nitrogen inputs which differ by a magnitude of 4, also the C:N ratio of litter input is an important factor for N turnover rates in the soil and in this way higher quality litter can feedback to a higher nutrient availability and plant growth and carbon loss from soil on the long term (Buckeridge et al. 2010). Therefore, development of the species composition in a warming tundra, for example which shrub species will profit most with shrub expansion, can be of relevance to carbon and nitrogen cycling and hence the risk to carbon losses to atmosphere.

The warming treatment of course interacts in a different way with the ecosystem than the substrate addition treatments, but still shows a similar response. Remarkably the effect of warming on CO_2 fluxes is observable already earlier in the season compared to substrate addition plots, being the only treatment, which is a carbon sink in May already. Thus, a lengthening of the growing season due to warmer temperatures could result in more carbon accumulation in new plant biomass to a small extent, even though enhanced NEE carbon uptake is not significant.

At least during summer period, NDVI of warmed plots is significantly higher than in control. Photosynthetic capacity is correlated with nitrogen content of plant leaves (Chapin et al. 2011), hence nitrogen uptake by plants is of importance for production green plant tissue which impacts NDVI and potentially enhances carbon fluxes. For this reason, chlorophyll and Nitrogen content of plants have been related to enhanced plant growth and been of interest in previous tundra ecosystem field studies. Semenchuk et al. (2015) reported enhanced growth and nitrogen accumulation in *Salix polaris* leaves, due to higher nitrogen availability of winter warmed soils and at a similar subarctic tundra heath as our site, enhanced nitrogen content and biomass was observed after few years of summer warming at least for dominant evergreen shrub (*Cassiope tetragona*) (Michelsen et al. 1996). I therefore conclude that plants in warmed plots were able to accumulate more nitrogen and invest in leaf production, resulting in higher NDVI for this treatment, even stronger as for litter treatments. Several explanations for the enhanced N uptake by plants and increase in NDVI are possible.

Nitrogen fixation by cyano bacteria associated with tundra mosses is considered as an important pathway of N input to arctic ecosystems. At the same field site of our study, N-fixation was enhanced by warming (Rousk and Michelsen 2017) as well as in a close by wet tundra heath (Lett and Michelsen 2014). However, the amount of enhanced N fixation during growth season under warmed conditions was modelled to be only 60 mg N m^{-2} (Rousk and Michelsen 2017), thus only of a few percent of N input by either substrate addition and unlikely to exceed N availability at litter treatment plots.

Enhanced NDVI could be further explained by an increase of biomass or a change in plant community composition in favour of species allocating more nutrients. A shift towards deciduous shrubs and graminoids and increased biomass production thereof on the cost of lichens and mosses after warming, similarly as for fertilization, has been reported in previous studies (Chapin et al. 1995; Walker et al. 2006). Nitrogen uptake by deciduous shrubs was observed to be much more efficient compared to evergreen shrubs under high nitrogen availability in the soil and vice versa at sites with low availability (Vankoughnett and Grogan 2014). At our field site, Rousk and Michelsen (2017) observed twice as much plant cover of the dominant sedge *Carex vaginata*, and increased litter compared to control plots after 4 years of treatment already. If nutrient availability increased with warming, we would expect the vegetation to shift towards deciduous shrubs and graminoids and increased plant growth, thus resulting in higher NDVI values. Higher mineralization rates of SOM and associated nutrient release due to warming has been reported in numerous studies as summarized by Hobbie et al (2002) although other environmental factors than temperature are also of importance for nutrient mineralization and availability. Results from subarctic tundra soil incubated together with grass seedlings and Betula litter addition and warming as treatment suggest that mobilization of nitrogen and uptake by plants is facilitated by warming, though not by Betula litter addition (Jonasson et al. 2004) which could explain the stronger response in NDVI and carbon fluxes due to reduced N limitation in warmed plots also in our study.

In summary it can be claimed, that effect of additional leaf litter input of expanding shrub vegetation has less consequences for the ecosystem than warming, despite the fact, that the ecosystem is obviously nutrient limited. Litter quality and nutrient availability is of importance for the activity and magnitude of carbon fluxes, but warming apparently offsets limitation of changing substrate quality to a bigger extent. Strong fertilization by enhanced fungi fruitbody appearance in future is not a realistic future scenario. The tundra experiences a vegetation change at the moment which alters litter composition which we were simulating by the two litter addition treatments. However, additional organic matter thus nutrient input will not be derived from external sources but recycled nutrients from its own soil beneath, returned through plant litter. Considering that and comparing the carbon fluxes and NDVI responses of the litter treatments to temperature enhancement, it is clear that temperature as accelerator for plant growth and organic matter turnover rates is of higher relevance on short terms than additional litter input.

The increase of ER is statistically significant for F and W treatment for every different subdivision of the season, spring, summer and autumn. Effects of F and W treatment on GEP are significant only partly for the seasonal subdivisions and only for F treatment over the whole season. This can probably be accounted to the observation that more environmental parameters than temperature have a main influence on photosynthesis. However, the magnitude to which treatment effects on GEP is bigger than for ER, which results in a higher net carbon uptake of the ecosystem compared to control plots. NEE is controlled by GEP and ER and therefore affected in complicated ways by several environmental parameters. This results in higher variation between plots for NEE and consequently, changes in NEE lack statistical evidence. But apparently the same treatment effect pattern occurs for NEE than it does for the other fluxes. Looking at subdivisions of the seasons the treatment effect pattern of NEE appears to be more or less identical to GEP. I therefore conclude that despite the lack of significant statistical evidence, the visual observation of enhanced carbon uptake in treatment plots is not random, but high nutrient input or warming strengthens the carbon sink function of tundra ecosystems during summer season and daytime in this experiment. This is maybe in contrast to observations in close by ecosystems (Christensen et al. 1997; Pedersen et al. 2017) where warming usually decreased net carbon uptake. Results from litter addition showed little effect on carbon uptake rates (Pedersen et al. 2017) and fertilization enhanced carbon uptake (Christensen et al. 1997). Although, at the same manipulation experiment as in Christensen et al. (1997) no changes of NEE by treatments were observed a couple of years later by Illeris et al. (2004). This reflects maybe again the difficulty to assess the net carbon exchange. Anyway, there is a potential that although respiration and therefore potential carbon losses are the most evident effects of climate change, changes in plant community and increasing ecosystem production is able to offset those losses. Furthermore, it has to be noted, we measured CO_2 fluxes only during the day and under absence of rain, for the protection of instruments. Changing environmental conditions, such as light influx and temperature, change carbon flux dynamics on a diurnal circle and even vary between different years (Tenhunen et al. 1995) and temperature sensitivity of carbon fluxes changes strongly during the day and night cycle, making it not possible properly estimate carbon balances over seasons without diurnal measurements (Fouché et al. 2017). Illeris et al. (2004) observed that carbon uptake during day can be easily lost again at night, regardless of treatment. Diurnal CO_2 flux measurements, would therefore be necessary to estimate how much of the increased carbon uptake during day remains in the system on the long term.

4.3 Enzymes

Because of the strong indication of the importance of nutrient inputs on the ecosystem and hence also for carbon fluxes, it is very surprising that the treatment response pattern of fluxes is not visibly related to any patterns of potential enzyme activities in the soil. Statistical evidence for treatment effects hardly exists. This in fact fits the observation of no or low effects of treatments on soil properties, such as carbon and nitrogen content or root biomass. The weak response to treatments make it further very difficult to assess whether methodological problems led to high variation within treatments, or whether treatment effects on soil conditions and enzyme production was very low just at sampling time in the middle of the active summer season.

4.3.1 Activities at different depths

Surprisingly potential extracellular enzyme activity was higher in 5-10 cm depth than in the top layer of the soil. In general it is assumed, that hydrolytic enzymes decline with depth as organic material becomes less present as reported for forest ecosystems (Baldrian and Štursová 2011), but also observed in tundra ecosystems (Jing et al. 2014; Koyama et al. 2013). Also the potential enzyme activities in similar vegetation (Phillips et al. 2018) either remained similar or slightly declined with depth. Although enzymes are produced to make more nutrients available, production thereof is nutrient intensive itself (Allison and Vitousek 2005). It might be possible, that the depleted nitrogen content of the first 5 cm in the soil and possible nutrient limitation are the reason for low enzyme production. This appears rather unlikely, since if nitrogen limitation was the reason for lower activity in our experiment, we could expect an increase in most hydrolytic enzymes with enhanced nitrogen availability (Sistla et al. 2012). An effect of treatments which have higher nitrogen inputs should be visible, thus for *Salix* litter addition plots and especially in the fungi addition treatment plots. This was not the case, at least at time of sampling. In addition, phosphatase activity behaves contrary to all other hydrolytic enzymes and exhibits a much higher activity in the top 5 cm of the soil than in the soil layer underneath, and for that reason production is probably not nitrogen limited.

According to the resource allocation theory (Sinsabaugh and Moorhead 1994) we should assume, that demand for phosphorus is relatively higher than for nitrogen and carbon in the top 5 cm compared to soil in 5-10 cm depth. As the total nitrogen concentration increases with depth, it appears rather confusing that nitrogen cycling enzymes have relative higher and phosphorus relative lower potential activity in deeper soils. The results in this way suggests, that phosphorus is even more limiting in the topsoil, while more available in 5-10 cm. This can be explained only with making simplifications and assumptions over parameters we did not assess. Possibly total nitrogen content or the C:N ratio is an unsuitable approximation of nitrogen availability. For example, ammonium concentrations and N mineralization rates in soils at our field site assessed by Rousk et al. (2016) appear to be unrelated to total nitrogen content. Another explanation could be that microbial community, hence also the microbial nutrient demand and associated extracellular enzyme production change significantly within these first 10 cm of the soil profile. For example the Fungi:Bacteria ratio, as well as microbial community response to treatment apparently differed between 0-5 cm and 5-10cm at a similar experiment site (Rinnan et al. 2007). The opposite depth response of phosphatase activity could maybe also be enhanced in top 5 cm by phosphatase release from plant roots. Plants can for example influence their phosphorus ability with release of high amounts of phosphatases to the environment (Wu et al. 2013). For instance, the tussock tundra plant *Eriophorum vaginatum* (not present at our site) was reported to increase phosphatase release late in the season, when litter input makes organic bound phosphorus relatively abundant, even though plant phosphorus demand is highest in spring (Moorhead et al. 1993). However, phosphate release from phosphatases associated with *Eriophorum vaginatum* root tips, doubled the plants demand but accounted for few percent of total phosphorus release in soil only. Weintraub and Schimel (2005b) observed peaks of available phosphates during mid-summer growth season in graminoid dominated tundra, as well as gradually increasing phosphate concentrations in shrub tundra in the second half of the growing season and set it in relation to increased phosphatases released from roots earlier in season, as already than suggested by Moorhead. It is possible that also in our experiment, phosphatase release in middle of the growing season adds to the relatively high phosphatase activity in top 5 cm of soil, which is most densely rooted zone. Anyway, all those theories on opposite activity changes with depth effect for phosphatase compared to N and C cycling enzymes are highly speculative without additional information on total phosphorus, available forms of nitrogen and phosphorus or microbial biomass and community structure at different depths, which have unfortunately not been assessed by us or previous studies in at the site.

The general enhancement of all other enzyme activities than phosphatase in 5-10 cm indicates an enhanced turnover of organic matter underneath the top 5cm of the soil. This contradicts maybe the observations at the most similar field experiment very close to our location, where microbial biomass and all forms of soluble nutrients were decreased, as well as root biomass in 5-10 cm depth (Rinnan et al. 2007), which speaks against enhanced activity. In the study of Phillips et al. (2018) enzyme activities were not enhanced with depth in a similar way as in our experiment. However, carbon losses through warming were a result of C-stock depletion and enhanced soil respiration in 5-10 cm depth, while microbial biomass, nitrogen and phosphorus remained fairly similar in both depths. Although the strongest treatment effects would be expected on the top of the soils, this could maybe be an indication for the high relevance of deeper soils, and their impact on ecosystem functions and alteration of carbon stocks on the long term. At least in our ecosystem, possible climate change feedbacks, positive or negative, would probably be stronger from soils below 5cm depth.

4.3.2 Effect of time during season on enzyme activities

The timepoint of soil sampling might have a very relevant effect on potential enzyme activities in the soil (Sistla and Schimel 2013; Wallenstein et al. 2009). Our samples were taken early in August in the middle of the main growing season. Nutrient availabilities in tundra soils can change rapidly within days and available nitrogen is very much depleted during summer and controlled by uptake activities rather than by source availabilities (Weintraub and Schimel 2005b). In that way, treatments which rather increase nutrient input, as we have in the substrate addition treatments of *Betula, Salix* and *Fungi* and indirectly also in the warming treatment, may not change the deficiency of nitrogen supply during summer, as additional nutrients are utilized immediately. Also Sistla and Schimel (2013) observed no difference of hydrolytic enzyme activities between control and warmed plots, in the organic soil horizon, after 22 years of treatment during summer season, when nutrient availabilities and microbial biomass were lowest, but treatment differences were significant during early winter and spring thaw. Additional substrate resources or warming allows for enhanced plant and microbial growth, thus also carbon fluxes, but will not overcome nutrient limitation during the most active time of the year. Hence production of extracellular enzymes to encounter nutrient demand would be a necessary strategy of plants and microbes among all treatments, probably masking treatment effects at certain times of the season, probably explaining why treatment effects are clearly visible on a plant level but appear to not affect enzyme activities in soils at certain times of sampling, as in the beginning of August.

The only potential enzyme activity which showed statistical relevant difference by treatment compared to control is β-N-Acetylglucosaminidase in 0-5 cm soil depth (Table 6), an enzyme associated with nitrogen cycling. The enhanced activity of the *Betula* litter treatment was observed in the same way by Phillips et al. (2018). The same litter was used in this experiment and is low in its nitrogen content, but at the same time adds considerable high amounts of phosphorus (Michelsen, unpublished). Inorganic phosphorus was reported to increase at this wetter tundra site in the top 5 cm of soil (Rinnan et al. 2008), while this could not be observed by Phillips et al. (2018) several years later. If phosphorus is co-limiting the ecosystem, an increase in nitrogen cycling enzymes would fit well with the nutrient allocation theory (Sinsabaugh and Moorhead 1994) if phosphorus availability is enhanced by *Betula* litter addition. In any way, the enhancement of NAG remains the only indication for a treatment effect on potential enzyme activities, and our hypothesis of changing patterns of enzyme activities with changing quality of added substrates cannot be confirmed.

5 Conclusion

As I hypothesised, the results of this study clearly indicate that type of available substrate and nutrient input through litter plays an important role for the activity and carbon turnover of the tundra ecosystem. Plant growth responds to different substrate additions and in correlation to its nutrient content. However, if considered, that changing ecosystems will naturally not be subject to very high nutrient additions, as in the Fungi treatment, temperature remains the key driver for changing the ecosystem on intermediate terms. The activity and plant growth apparently responded with higher activity to warming. NDVI, as well as all carbon fluxes (ER, GEP and NEE) were increased to a larger extent than the two litter addition treatments, though usually to a lower extent than fungi addition treatment. In any way, if warming enhances plant growth, it will result in more litter input in future. The relatively low response of litter addition may not be underestimated on the long term (beside lacking statistical evidence), as the response pattern of different substrates was similar among all assessed fluxes and NDVI at any season. In that way, a cascading effect as suggested by Buckeridge et al. (2010) and Hartley et al. (2012) of enhanced activity, induced by warming, and amplified by accelerated nutrient cycling, plant uptake and return through litterfall, is likely to interactively change tundra ecosystems; here the C/N ratio of litter will play an important role and may control the pace at which this cascade is running. However, our experiment does not indicate increased carbon losses from ecosystem through climate change. All treatments increased carbon uptake to a stronger degree than carbon release through respiration. This contradicts our expectation for the warming treatment, as respiration is supposed to be more temperature sensitive than photosynthesis. Warming during past 6 years shifted the ecosystem to a state which supported plant growth and consequently increased its photosynthesis ability and CO_2 uptake during the day. Increasing plant growth of all treatment plots therefore suggests a potential carbon accumulation in the ecosystem. To estimate the magnitude of potential carbon accumulation, however, would require additional measurements during the whole diurnal circle, as photosynthesis and respiration may be differently affected by lower light conditions and temperatures at night. Furthermore, better estimates for actual plant biomass than NDVI would help to assess whether increased plant growth offsets possible carbon losses from soil.

After 6 years of treatment application, no significant effects on abiotic soil properties as well as potential enzymatic activities were detected. Abiotic soil conditions respond probably slower to treatments and climate change than plant growth and assessment of those is methodological more complicated than for in situ methods of carbon fluxes and NDVI measurements. Soil sampling for enzyme activity assessment was conducted during a time when nutrient availability was probably lowest, and deficiency might have affected all treatments in a similar way, masking possible treatment effects. Additional potential enzyme activity assessments at different times of the growing season could reveal whether treatments do affect enzyme production at certain times of the season. Our hypotheses about enzyme activity response to treatments cannot be confirmed by our single time point assessment. Surprisingly, nutrient demands appear to change significantly with depth, and the top layer of the soil was lower in enzyme activities than 5 cm beneath, except for phosphatase. This would suggest, that phosphate is relatively more limiting in the top soil compared to the soil below. Higher carbon and nitrogen cycling enzyme activities in 5-10 cm depth suggest, that SOM decomposition and therefore potential carbon loss from soil through climate change effects is of bigger relevance below the top soil layer. This is similar as observed by Phillips et al. (2018) after 16 years of same treatments, despite the fact that the first centimetres of soil are generally considered as the most active layer. Also at our field site changes of carbon and nitrogen stocks in soil could become visible after additional years of continuing treatments, an should be subject to future research.

6 Library

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7 List of Tables

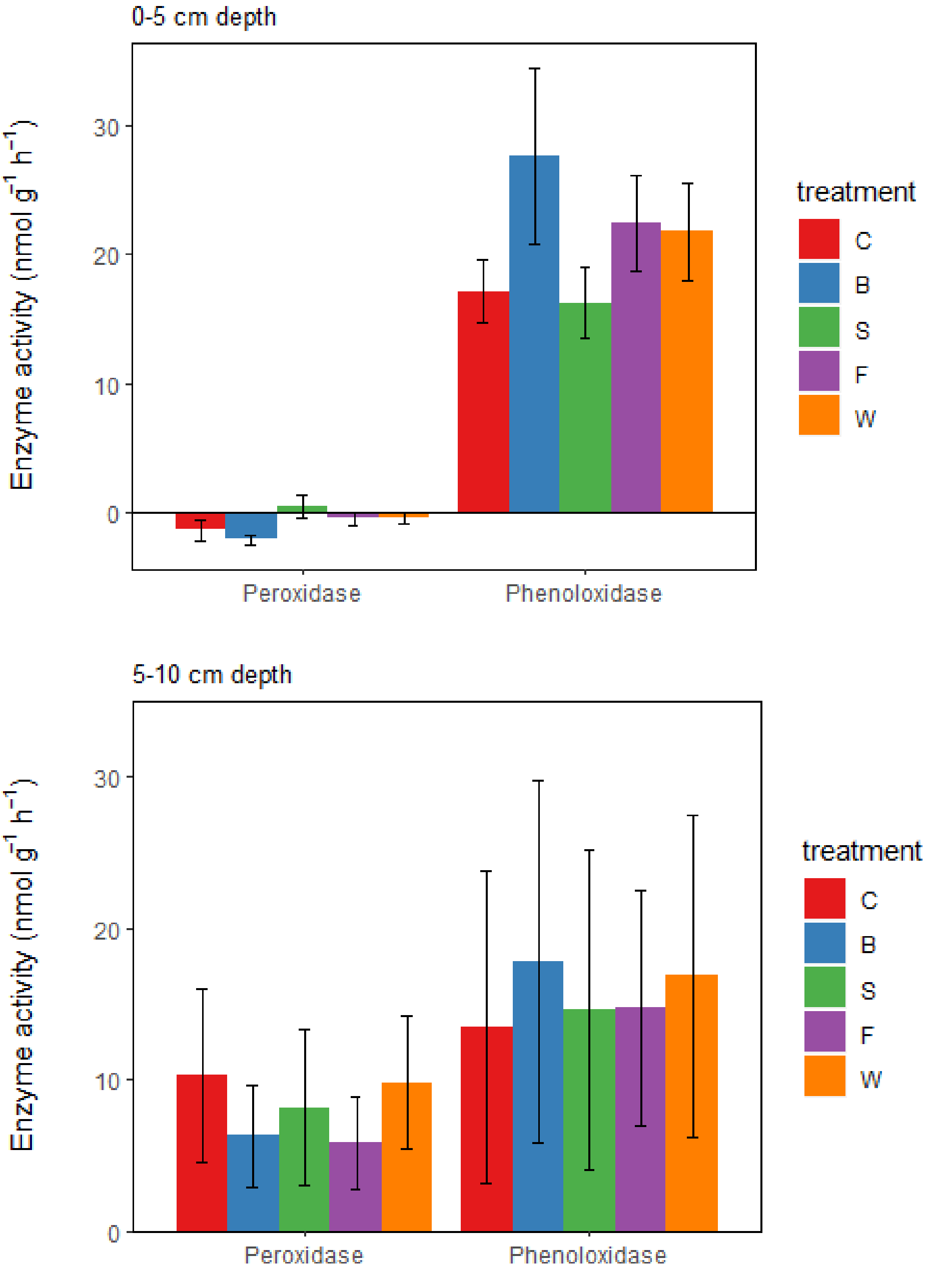
8 List of Figures

9 List of Acronyms

C	Control (no treatment)
B	Betula pubescens ssp. Tortuosa Litter addition treatment
S	Salix myrsinifolia litter addition treatment
F	Fungal fruitbody addition treatment
W	Warming treatment with open top chambers
OTC	Open top chambers for warming treatment
ER	Ecosystem Respiration
GEP	Gross Ecosystem Photosynthesis
NEE	Net Ecosystem Exchange
NDVI	Net Differential Vegetation Index
BX	β-Xylosidase
CB	β-D-Cellubiosidase
BG	β-glucosidase
NAG	β-N-Acetylglucosaminidase
AP	Acid Phosphatase
LAP	Leucine Aminopeptidase
SOM	Soil Organic Matter

10 Appendix

10.1 Oxidative Enzymes



S.Figure 1: Oxidative enzymes: Peroxidase and Phenoloxidase in 0-5cm (top) and 5-10cm (bottom) soil depth

10.2 Experimental plots

Plot			Metal frame base area	Chamber + Base volume
Nr.	Treatment	Block	m^2	m^3
1	W	1	0.1190	0.0401
2	C	1	0.1190	0.0383
3	P	1	0.1190	0.0413
4	F	1	0.0961	0.0427
5	B	1	0.1190	0.0395
6	W	2	0.1190	0.0425
7	P	2	0.1190	0.0383
8	B	2	0.1190	0.0419
9	C	2	0.1190	0.0419
10	F	2	0.0961	0.0412
11	C	3	0.1190	0.0401
12	B	3	0.1190	0.0401
13	W	3	0.1190	0.0407
14	P	3	0.1190	0.0359
15	F	3	0.0961	0.0436
16	B	4	0.1190	0.0449
17	C	4	0.1190	0.0425
18	F	4	0.0961	0.0403
19	P	4	0.1190	0.0383
20	W	4	0.0961	0.0431
21	B	5	0.0961	0.0422
22	P	5	0.0961	0.0422
23	W	5	0.0961	0.0412
24	F	5	0.0961	0.0427
25	C	5	0.0961	0.0431
26	W	6	0.0961	0.0436
27	B	6	0.0961	0.0427
28	P	6	0.0961	0.0431
29	C	6	0.0961	0.0436
30	F	6	0.0961	0.0422

S.Table 1: Experimental design and plot attributes; Dimensions of metal frame bases and measurement chamber for flux measurements.

10.3 Data of soil properties

Plot	Soil layer	Depth core1	Depth core2	Water content	Dry weight	Bulk-soil	Coarse roots	Fine roots	Nitrogen content	Carbon content	C:N ratio
Nr.	cm	cm	cm	g H_2O g soil^{-1}	g	g cm^{-1}	g dm^{-1}	g dm^{-1}	%	%	
1	0-5	13	13	385.4	3.63	0.0337	11.8	2.9	1.5	40.4	26.1
2	0-5	23	25	557.9	3.70	0.0344	9.0	1.7	1.2	40.5	33.2
3	0-5	20	22	594.4	4.22	0.0392	4.6	6.1	1.3	40.0	30.4
4	0-5	24	23	488.2	4.78	0.0445	3.0	4.4	1.4	39.8	29.4
5	0-5	17	22	293.7	5.64	0.0524	8.1	4.2	1.3	39.7	31.1
6	0-5	12	24	354.5	4.39	0.0408	7.3	4.5	1.4	39.2	27.8
7	0-5	23	24	338.6	3.23	0.0300	5.9	2.9	1.3	38.9	29.1
8	0-5	17	20	488.2	2.71	0.0252	9.6	5.0	1.5	39.4	25.8
9	0-5	10	10	254.6	8.04	0.0748	10.8	3.3	1.9	39.1	20.4
10	0-5	16	17	532.9	2.76	0.0257	20.1	3.1	1.5	39.3	26.8
11	0-5	17	19	693.7	4.53	0.0421	2.1	6.9	1.0	38.5	37.8
12	0-5	15	17	575.7	5.39	0.0501	8.7	4.1	1.3	39.0	29.6
13	0-5	15	20	455.6	4.33	0.0403	8.5	4.8	1.3	39.5	31.3
14	0-5	11	14	474.7	6.04	0.0562	8.0	5.8	1.7	39.2	22.9
15	0-5	17	18	338.6	3.73	0.0347			1.5	39.7	26.3
16	0-5	19	20	296.8	9.96	0.0926	5.8	5.7	1.6	38.9	25.1
17	0-5	12	15	313.2	4.90	0.0456	1.4	1.7	1.3	38.9	30.6
18	0-5	8	21	275.9	10.20	0.0949	10.3	4.2	1.8	37.7	20.9
19	0-5	10	13	237.8	7.25	0.0674	10.7	5.4	1.6	39.1	23.8
20	0-5	15	17	242.5	8.56	0.0796	8.3	5.3	1.6	38.8	24.2
21	0-5	14	14	380.8	5.04	0.0469	10.6	6.1	1.4	41.4	29.0
22	0-5	14	13	437.6	3.85	0.0358	6.3	6.9	1.2	39.3	32.3
23	0-5	14	17	509.8	3.84	0.0357	5.4	8.2	1.6	39.2	24.8
24	0-5	17	21	443.5	5.83	0.0542	7.1	3.8	1.3	40.2	29.9
25	0-5	18	20	267.6	6.53	0.0607	9.8	6.6	1.5	39.0	26.9
26	0-5	17	17	300.0	4.16	0.0387	5.8	2.8	1.2	39.9	32.0
27	0-5	17	19	278.8	5.45	0.0507	4.5	4.7	1.3	39.9	31.0
28	0-5	15	20	252.1	6.99	0.0650	3.8	4.1	1.6	39.8	24.3
29	0-5	15	16	222.6	6.94	0.0645	6.3	8.2	1.7	39.8	23.4
30	0-5	8	17	296.8	4.46	0.0415	8.1	4.1	1.8	45.0	24.7

S.Table 2: Soil properties for 0-5 cm.

Plot	Soil layer	Depth core1	Depth core2	Water content	Dry weight	Bulk-soil	Coarse roots	Fine roots	Nitrogen content	Carbon content	C:N ratio
Nr.	cm	cm	cm	g H_2O g soil^{-1}	g	g cm^{-1}	g dm^{-1}	g dm^{-1}	%	%	
1	5-10	13	13	380.8	10.04	0.0934	10.3	3.2	2.1	37.8	18.3
2	5-10	23	25	584.9	5.31	0.0493	6.6	2.8	1.3	38.4	28.5
3	5-10	20	22	541.0	5.11	0.0475	4.7	4.3	1.5	37.8	25.3
4	5-10	24	23	495.2	5.72	0.0532	8.1	3.6	1.6	38.1	23.8
5	5-10	17	22	323.7	7.57	0.0704	6.6	2.6	1.7	38.4	22.8
6	5-10	12	24	323.7	10.09	0.0939	0.8	2.2	2.0	38.8	19.6
7	5-10	23	24	624.6	4.81	0.0448	0.0	2.6	1.7	37.6	22.0
8	5-10	17	20	247.2	11.55	0.1074	8.3	3.3	2.3	37.6	16.6
9	5-10	10	10	145.1	42.52	0.3954	0.0	2.0	1.1	18.7	17.4
10	5-10	16	17	262.3	9.42	0.0876	10.0	2.6	2.0	37.4	18.5
11	5-10	17	19	861.5	5.19	0.0483	5.0		1.6	38.5	24.6
12	5-10	15	17	549.4	7.57	0.0704	4.2	2.2	1.8	37.7	20.8
13	5-10	15	20	443.5	5.73	0.0533	5.4	3.3	1.7	39.3	22.6
14	5-10	11	14	455.6	9.71	0.0903	3.8	2.6	2.5	37.0	15.0
15	5-10	17	18	281.7	8.09	0.0752			2.1	39.2	18.8
16	5-10	19	20	254.6	9.35	0.0869	1.2	0.8	2.1	36.4	17.1
17	5-10	12	15	287.6	11.32	0.1053	4.7	2.4	2.3	38.1	16.3
18	5-10	8	21	287.6	11.19	0.1301	5.3	3.6	2.2	37.4	17.2
19	5-10	10	13	267.6	18.30	0.1702	2.0	2.7	2.2	38.1	17.5
20	5-10	15	17	270.4	16.03	0.1491	1.1	3.7	2.0	37.3	18.4
21	5-10	14	14	385.4	10.67	0.0993	3.4	2.9	2.0	38.2	19.4
22	5-10	14	13	410.2	9.73	0.0905	2.4	4.6	2.1	38.0	18.2
23	5-10	14	17	437.6	10.64	0.0989	4.3	3.1	2.3	36.2	15.5
24	5-10	17	21	420.8	9.66	0.0899	0.0	3.8	1.9	37.6	19.6
25	5-10	18	20	303.2	9.93	0.0924	3.3	2.9	2.2	35.0	16.0
26	5-10	17	17	247.2	6.67	0.0621	6.3	2.7	1.6	37.8	23.3
27	5-10	17	19	267.6	6.81	0.0633	2.3	3.4	2.1	37.4	17.9
28	5-10	15	20	273.1	14.20	0.1320	3.4	2.2	2.2	36.1	16.2
29	5-10	15	16	247.2	11.22	0.1043	13.1	3.1	2.0	36.7	17.9
30	5-10	8	17	237.8	8.80	0.1023	4.3	3.0	1.8	37.0	20.1

S.Table 3: Soil properties for 5-10 cm.

Plot	Soil layer	Depth core1	Depth core2	Water content	Dry weight	Bulk-soil	Coarse roots	Fine roots	Nitrogen content	Carbon content	C:N ratio
Nr.	cm	cm	cm	g H_2O g soil^{-1}	g	g cm^{-1}	g dm^{-1}	g dm^{-1}	%	%	
1	10-15	13	13	371.7	10.39	0.1611	0.2	0.9	2.4	34.6	14.4
2	10-15	23	25	461.8	7.01	0.0652	5.6	2.8	1.5	36.6	24.2
3	10-15	20	22	468.2	6.76	0.0629	4.9	2.9	1.8	37.2	20.5
4	10-15	24	23	733.3	6.37	0.0592	0.3	2.1	2.1	33.9	16.5
5	10-15	17	22	346.4	12.70	0.1181	3.0	1.2	2.2	35.8	16.5
6	10-15	12	24	293.7	9.74	0.1294	4.1	2.6	2.3	35.0	15.5
7	10-15	23	24	371.7	11.58	0.1077	0.6	1.9	1.8	37.2	20.7
8	10-15	17	20	316.7	16.06	0.1494	2.7	1.2	2.3	34.9	15.4
10	10-15	16	17	287.6	18.56	0.1726	1.2	0.7	2.1	35.0	16.8
11	10-15	17	19	706.5	7.69	0.0715	2.5	1.3	2.2	34.7	15.7
12	10-15	15	17	290.6	18.30	0.1702	0.3	1.0	2.1	30.6	14.6
13	10-15	15	20	400.0	10.46	0.0973		0.9	2.3	34.6	15.0
14	10-15	11	14	410.2	6.15	0.1144	0.3	1.4	2.2	35.9	16.4
15	10-15	17	18	313.2	14.83	0.1379	5.9	2.0	2.4	36.3	15.3
16	10-15	19	20	296.8	18.70	0.1739	0.3	1.1	2.3	36.2	15.5
17	10-15	12	15	184.1	18.72	0.2487	0.5	1.2	1.8	30.2	16.9
18	10-15	8	21	300.0	4.96	0.0923	2.3	2.2	2.1	35.4	17.1
19	10-15	10	13	309.8	5.07	0.1572	0.6	1.5	2.3	35.6	15.3
20	10-15	15	17	275.9	8.99	0.0836	0.2	0.7	2.1	35.7	17.0
21	10-15	14	14	346.4	13.86	0.1611	2.9	1.0	2.2	35.3	15.8
22	10-15	14	13	323.7	11.91	0.1582	1.0	1.1	2.2	33.8	15.2
23	10-15	14	17	148.8	32.98	0.3408	1.4	0.2	1.1	16.2	15.1
24	10-15	17	21	380.8	13.70	0.1274	0.5	1.6	2.5	34.4	13.7
25	10-15	18	20	197.6	23.89	0.2222	0.0	0.7	1.6	24.9	15.7
26	10-15	17	17	273.1	12.46	0.1159	6.7	2.2	2.4	35.8	14.7
27	10-15	17	19	284.6	17.45	0.1623	0.0	1.6	2.7	34.5	12.7
28	10-15	15	20	270.4	19.01	0.1768	0.8	1.4	2.3	32.8	14.3
29	10-15	15	16	262.3	18.39	0.1711	0.2	1.8	2.2	33.3	15.4
30	10-15	8	17	265.0	6.45	0.1200	0.0	1.4	1.9	35.2	18.9

S.Table 4: Soil properties for 10-15 cm.

Plot	Soil layer	Depth core1	Depth core2	Water content	Dry weight	Bulk-soil	Coarse roots	Fine roots	Nitrogen content	Carbon content	C:N ratio
Nr.	cm	cm	cm	g H_2O g soil^{-1}	g	g cm^{-1}	g dm^{-1}	g dm^{-1}	%	%	
2	15-20	23	25	385.4	7.55	0.0702	1.0	1.8	1.7	35.2	20.6
3	15-20	20	22	415.5	9.93	0.0924	1.1	0.8	2.2	34.6	16.0
4	15-20	24	23	212.5	28.27	0.2629	0.0	1.0	1.9	27.2	14.0
5	15-20	17	22	303.2	11.54	0.1533	1.4	1.0	2.3	34.4	14.8
6	15-20	12	24	270.4	10.51	0.1956	0.4	1.9	2.2	32.8	14.7
7	15-20	23	24	293.7	15.28	0.1422	0.0	0.9	2.0	36.3	18.1
8	15-20	17	20	249.7	14.49	0.1925	0.0	0.2	2.0	30.8	15.1
10	15-20	16	17	214.5	8.61	0.2668	0.4	0.2	1.5	30.6	19.8
11	15-20	17	19	327.4	7.60	0.1178	0.0	0.7	2.1	34.0	16.4
12	15-20	15	17	358.7	2.17	0.1010	1.9	0.6	2.1	31.4	14.7
13	15-20	15	20	474.7	6.17	0.1148	0.0	0.9	2.0	26.2	13.2
15	15-20	17	18	287.6	10.72	0.1994	0.0	0.9	2.4	33.4	14.1
16	15-20	19	20	237.8	22.55	0.2330	1.0	0.7	1.9	33.8	18.0
18	15-20	8	21	303.2	8.04	0.1495	0.0	1.7	2.1	35.1	16.5
20	15-20	15	17	247.2	4.69	0.2183	0.0	0.0	1.8	33.6	18.4
23	15-20	14	17	208.6	6.88	0.3198	0.0	0.7	1.7	24.6	14.4
24	15-20	17	21	300.0	13.02	0.1730	0.1	0.5	2.3	34.2	15.1
25	15-20	18	20	71.8	60.03	0.6978	0.0	0.5	1.0	15.8	16.3
26	15-20	17	17	273.1	5.75	0.1337	0.0	0.7	2.4	34.1	13.9
27	15-20	17	19	281.7	13.64	0.2115	0.0	1.7	2.3	34.6	15.0
28	15-20	15	20	240.1	10.77	0.2002	0.0	0.9	1.9	32.6	17.2
29	15-20	15	16	297.7	1.72	0.1599	0.0	1.1	2.0	33.5	17.2
30	15-20	8	17	270.4	4.77	0.2219	0.0	1.3	2.0	33.7	17.3

S.Table 5: Soil properties for 15-20 cm.

Plot	Soil layer	Depth core1	Depth core2	Water content	Dry weight	Bulk-soil	Coarse roots	Fine roots	Nitrogen content	Carbon content	C:N ratio
Nr.	cm	cm	cm	g H_2O g soil^{-1}	g	g cm^{-1}	g dm^{-1}	g dm^{-1}	%	%	
2	20-25	23	25	367.3	6.85	0.0797	0.0	0.4	2.2	34.8	15.5
3	20-25	20	22	327.4	3.52	0.1638	0.2	0.9	2.3	34.1	14.8
4	20-25	24	23	208.6	17.58	0.2336	0.0	0.6	2.1	28.9	13.8
5	20-25	17	22	287.6	3.62	0.1685	0.0	0.8	2.0	34.0	17.3
6	20-25	12	24	133.6	16.20	0.3767	0.0	0.6	1.2	21.3	17.5
7	20-25	23	24	267.6	14.52	0.1929	0.7	1.2	1.7	35.5	20.5
18	20-25	8	21	284.6	3.57	0.3324	0.0	2.5	2.3	34.8	15.3
24	20-25	17	21	242.5	2.58	0.2397	0.0	0.1	2.1	32.1	15.0

S.Table 6: Soil properties for 20-25 cm.

10.4 Data of CO_2-flux measurement and environmental parameters

Plot	Measurement Time		Measurem. type	Chamber temp.	Soil moisture	Soil temp 2cm	Soil temp 5cm	PAR	Chamber pressure	Flux slope	CO_2 flux (mg CO_2 m^2 h^{-1})		
	hour	min	NEE / ER	°C	vol %	°C	°C	mbar	ppm s^{-1}	ppm s^{-1}	NEE	ER	GEP
1	12	15	NEE	14.0	25.4	5.9	3.2	1227	943	-0.0822	-184		432
2	12	35	NEE	14.8	60.0	8.4	6.6	1084	943	-0.1025	-209		397
3	12	56	NEE	15.1	61.9	8.3	8.0	1020	943	-0.0248	-54		244
4	13	14	NEE	13.1	58.4	7.3	5.1	1296	943	-0.0099	-26		420
5	13	35	NEE	18.3	58.8	6.6	3.1	1179	943	-0.0327	-68		259
1	12	25	ER	14.8	25.4	5.9	3.2	0	943	0.1116		249	
2	12	44	ER	13.8	60.0	8.4	6.6	20	943	0.0916		188	
3	13	5	ER	12.1	61.9	8.3	8.0	3	943	0.0872		191	
4	13	24	ER	15.0	58.4	7.3	5.1	0	943	0.1510		394	
5	13	44	ER	16.4	58.8	6.6	3.1	27	944	0.0915		191	
6	14	2	NEE	15.1	59.5	8.8	7.6	537	944	-0.0438	-100		478
7	14	18	NEE	15.8	53.0	7.4	7.2	1152	944	-0.0275	-56		309
8	14	38	NEE	14.4	42.8	4.5	3.0	677	945	0.0098	22		123
9	14	57	NEE	12.5	44.6	6.0	3.9	774	945	-0.0072	-17		190
10	15	19	NEE	11.5	48.9	4.9	1.7	908	945	0.0294	80		130
6	14	8	ER	15.2	59.5	8.8	7.6	0	944	0.1649		377	
7	14	28	ER	14.9	53.0	7.4	7.2	0	945	0.1239		253	
8	14	47	ER	13.5	42.8	4.5	3.0	0	945	0.0647		145	
9	15	7	ER	10.7	44.6	6.0	3.9	0	945	0.0722		173	
10	15	30	ER	11.8	48.9	4.9	1.7	0	945	0.0773		209	
11	15	44	NEE	13.4	72.9	8.4	5.3	926	945	-0.0221	-48		249
12	16	6	NEE	14.5	62.8	9.4	6.2	926	945	0.0193	41		189
13	16	29	NEE	14.1	66.9	10.1	9.1	988	945	-0.0771	-163		450
14	16	52	NEE	13.8	59.3	9.7	7.9	389	946	-0.0341	-64		228
15	17	15	NEE	9.0	54.3	11.0	8.8	329	946	0.0274	75		200
11	15	55	ER	12.9	72.9	8.4	5.3	0	945	0.0920		201	
12	16	17	ER	14.1	62.8	9.4	6.2	0	945	0.1086		229	
13	16	41	ER	16.0	66.9	10.1	9.1	26	946	0.1369		287	
14	17	4	ER	10.6	59.3	9.7	7.9	0	946	0.0874		165	
15	17	26	ER	8.0	54.3	11.0	8.8	0	946	0.0999		275	
16	12	43	NEE	17.6	35.2	8.3	3.5	1335	947	0.0387	93		221
17	13	2	NEE	18.5	67.1	4.5	1.8	904	946	0.0759	172		197
18	13	24	NEE	17.6	32.0	12.9	5.3	1246	946	0.0356	92		334
19	13	34	NEE	19.8	54.4	13.8	4.5	1019	946	0.0757	157		173
20	13	57	NEE	18.4	45.6	10.9	5.3	825	946	0.0511	142		259
16	12	33	ER	16.8	35.2	8.3	3.5	11	947	0.1306		314	
17	12	54	ER	18.8	67.1	4.5	1.8	18	947	0.1627		369	
18	13	15	ER	17.1	32.0	12.9	5.3	0	946	0.1637		426	
19	13	43	ER	19.6	54.4	13.8	4.5	1	946	0.1590		330	
20	14	11	ER	16.3	45.6	10.9	5.3	8	946	0.1433		401	
21	14	25	NEE	15.0	58.3	4.9	7.9	690	946	-0.0032	-9		331
22	14	44	NEE	13.0	50.8	9.6	5.0	555	946	0.0270	75		221
23	15	5	NEE	13.1	45.6	9.8	6.9	631	946	-0.1168	-316		629
24	15	31	NEE	12.7	46.4	8.1	5.1	509	946	-0.0819	-211		523
25	15	51	NEE	10.9	53.8	11.4	6.8	513	946	0.0385	110		164
21	14	35	ER	13.9	58.3	4.9	7.9	2	946	0.1168		322	
22	14	54	ER	12.2	50.8	9.6	5.0	17	946	0.1067		296	
23	15	19	ER	13.4	45.6	9.8	6.9	0	946	0.1162		314	
24	15	41	ER	11.4	46.4	8.1	5.1	0	946	0.1204		312	
25	16	0	ER	10.5	53.8	11.4	6.8	0	946	0.0957		273	
26	16	9	NEE	11.2	54.0	6.7	2.5	495	946	0.0199	57		229
27	16	29	NEE	14.9	45.3	8.4	4.5	1010	946	-0.0036	-10		268
28	16	49	NEE	13.7	54.4	6.7	3.9	458	946	0.0337	95		206
29	17	7	NEE	11.7	47.5	5.9	2.3	370	947	0.0155	43		162
30	17	29	NEE	10.0	35.8	7.4	3.2	388	947	0.0760	208		130
26	16	19	ER	12.2	54.0	6.7	2.5	17	946	0.0998		286	
27	16	38	ER	15.9	45.3	8.4	4.5	1	946	0.0964		258	
28	16	59	ER	12.5	54.4	6.7	3.9	0	947	0.1062		301	
29	17	17	ER	10.7	47.5	5.9	2.3	0	947	0.0733		205	
30	17	41	ER	9.1	35.8	7.4	3.2	0	947	0.1231		337	

S.Table 7: CO_2-flux measurements and environmental parameters on 24 and 25 May

Plot	Measurement Time		Measurem. type	Chamber temp.	Soil moisture	Soil temp 2cm	Soil temp 5cm	PAR	Chamber pressure	Flux slope	CO_2 flux		
											mg CO2 m^2 h^{-1}		
	hour	min	NEE / ER	°C	vol %	°C	°C	µ mol m^2 s^{-1}	mbar	ppm s^{-1}	NEE	ER	GEP
1	11	1	NEE	12.3	37.2	5.2	2.6	572	955	-0.0525	-119		324
2	11	16	NEE	11.1	25.9	4.5	1.9	533	955	-0.0456	-95		266
3	11	32	NEE	9.7	26.7	5.5	2.6	539	955	-0.0184	-41		201
4	11	51	NEE	9.0	35.8	5.1	2.0	588	955	-0.0386	-104		295
5	12	8	NEE	9.6	26.7	3.2	1.2	665	955	-0.0443	-96		273
1	11	9	ER	11.8	37.2	5.2	2.6	0	955	0.0896		204	
2	11	24	ER	10.0	25.9	4.5	1.9	0	955	0.0811		170	
3	11	41	ER	9.2	26.7	5.5	2.6	0	955	0.0717		160	
4	11	59	ER	9.1	35.8	5.1	2.0	0	955	0.0706		191	
5	12	17	ER	10.0	26.7	3.2	1.2	0	956	0.0818		177	
6	12	27	NEE	10.6	31.1	8.1	3.2	713	955	-0.0651	-153		420
7	12	45	NEE	11.9	35.1	6.0	2.5	753	955	-0.0280	-59		334
8	13	2	NEE	11.7	51.4	6.8	2.4	850	956	-0.0140	-32		251
9	13	19	NEE	11.2	21.0	5.8	2.7	546	956	0.0341	82		180
10	13	37	NEE	9.3	35.9	6.6	1.8	494	956	0.0086	24		236
6	12	36	ER	11.2	31.1	8.1	3.2	18	955	0.1138		267	
7	12	54	ER	11.6	35.1	6.0	2.5	0	956	0.1318		276	
8	13	11	ER	11.6	51.4	6.8	2.4	0	956	0.0962		220	
9	13	28	ER	9.9	21.0	5.8	2.7	0	956	0.1079		262	
10	13	46	ER	10.2	35.9	6.6	1.8	0	956	0.0940		259	
11	13	55	NEE	11.0	35.6	5.9	2.1	629	956	-0.0258	-57		256
12	14	12	NEE	13.1	30.0	6.1	2.4	690	956	0.0014	3		198
13	14	30	NEE	13.3	20.7	11.1	4.5	542	956	-0.0182	-39		292
14	14	47	NEE	11.8	35.4	7.3	3.6	536	956	-0.0490	-93		281
15	15	4	NEE	10.7	35.3	5.2	2.2	694	956	-0.0474	-131		321
11	14	3	ER	12.0	35.6	5.9	2.1	19	956	0.0895		199	
12	14	20	ER	12.4	30.0	6.1	2.4	0	956	0.0936		201	
13	14	38	ER	12.3	20.7	11.1	4.5	7	956	0.1178		253	
14	14	56	ER	10.7	35.4	7.3	3.6	0	956	0.0987		188	
15	15	14	ER	10.5	35.3	5.2	2.2	0	956	0.0690		190	
16	15	23	NEE	9.8	27.2	5.9	2.7	430	956	0.0204	51		159
17	15	43	NEE	9.2	35.7	5.2	1.9	427	956	0.0175	41		166
18	16	4	NEE	9.8	31.0	5.3	2.2	677	956	-0.0205	-55		312
19	16	22	NEE	10.2	51.1	4.6	2.2	466	956	-0.0008	-2		319
20	16	42	NEE	12.0	39.6	10.5	4.2	890	956	0.0206	59		206
16	15	35	ER	9.7	27.2	5.9	2.7	0	956	0.0841		209	
17	15	54	ER	8.3	35.7	5.2	1.9	0	956	0.0875		208	
18	16	13	ER	9.9	31.0	5.3	2.2	17	956	0.0954		257	
19	16	32	ER	10.4	51.1	4.6	2.2	0	956	0.1464		317	
20	16	52	ER	13.2	39.6	10.5	4.2	0	956	0.0930		266	
21	12	43	NEE	25.5	34.2	11.0	2.9	1251	937	0.0037	10		213
22	13	2	NEE	20.1	50.7	7.1	3.1	860	937	-0.0445	-119		458
23	13	21	NEE	17.0	63.4	9.0	4.5	683	937	-0.0865	-228		782
24	13	42	NEE	19.6	46.3	9.9	4.1	1146	937	-0.0598	-149		930
25	14	3	NEE	20.4	43.3	12.4	4.7	1013	936	0.0304	83		170
21	12	53	ER	21.6	34.2	11.0	2.9	5	937	0.0839		223	
22	13	12	ER	18.1	50.7	7.1	3.1	0	937	0.1260		339	
23	13	32	ER	18.1	63.4	9.0	4.5	0	937	0.2106		554	
24	13	53	ER	20.9	46.3	9.9	4.1	0	936	0.3145		780	
25	14	13	ER	19.0	43.3	12.4	4.7	0	936	0.0921		252	
26	14	23	NEE	20.1	36.9	10.3	5.1	1104	936	0.0609	168		487
27	14	43	NEE	23.6	28.0	9.7	3.6	1243	935	0.0560	144		402
28	15	0	NEE	22.9	30.9	11.6	3.4	739	935	0.0815	220		242
29	15	17	NEE	20.9	23.3	7.6	3.6	670	935	0.0217	58		427
30	15	36	NEE	20.3	28.2	11.1	5.6	1034	935	0.0643	168		334
26	14	34	ER	21.3	36.9	10.3	5.1	0	936	0.2382		655	
27	14	52	ER	23.1	28.0	9.7	3.6	0	935	0.2119		546	
28	15	10	ER	21.2	30.9	11.6	3.4	0	935	0.1701		462	
29	15	26	ER	19.9	23.3	7.6	3.6	0	935	0.1817		485	
30	15	48	ER	20.7	28.2	11.1	5.6	0	935	0.1927		501	

S.Table 8: CO_2-flux measurements and environmental parameters on 2 and 5 Jun

Plot	Measurement Time		Measurem. type	Chamber temp.	Soil moisture	Soil temp 2cm	Soil temp 5cm	PAR	Chamber pressure	Flux slope	CO_2 flux		
											mg CO2 m^2 h^{-1}		
	hour	min	NEE / ER	°C	vol %	°C	°C	µ mol m^2 s^{-1}	mbar	ppm s^{-1}	NEE	ER	GEP
1	11	49	NEE	17.5	30.8	13.6	3.2	517	945	-0.2512	-556		948
2	12	9	NEE	17.1	34.8	15.0	7.3	447	945	-0.1709	-347		706
3	12	28	NEE	16.0	57.4	13.2	5.8	442	945	-0.1246	-269		646
4	12	46	NEE	15.9	61.7	17.2	5.5	657	945	-0.2190	-572		1198
5	13	5	NEE	16.5	52.1	12.1	4.2	793	945	-0.2897	-607		1188
1	11	59	ER	17.1	30.8	13.6	3.2	0	945	0.1774		393	
2	12	18	ER	16.3	34.8	15.0	7.3	0	945	0.1767		359	
3	12	37	ER	15.3	57.4	13.2	5.8	0	945	0.1738		376	
4	12	55	ER	15.7	61.7	17.2	5.5	0	945	0.2400		627	
5	13	15	ER	17.8	52.1	12.1	4.2	0	945	0.2784		581	
6	13	25	NEE	18.4	42.0	16.8	6.9	531	945	-0.1546	-350		953
7	13	43	NEE	19.3	34.8	13.6	4.5	621	945	-0.2217	-446		1100
8	14	10	NEE	19.6	29.9	14.1	4.4	481	945	-0.0628	-138		699
9	14	28	NEE	18.7	43.8	13.4	3.5	510	945	-0.0755	-176		565
10	14	48	NEE	16.7	36.3	16.9	4.3	524	945	-0.0845	-225		750
6	13	35	ER	18.4	42.0	16.8	6.9	0	945	0.2660		603	
7	14	2	ER	19.6	34.8	13.6	4.5	0	945	0.3251		654	
8	14	19	ER	19.0	29.9	14.1	4.4	0	945	0.2550		561	
9	14	39	ER	17.2	43.8	13.4	3.5	0	945	0.1665		389	
10	14	57	ER	16.7	36.3	16.9	4.3	0	945	0.1969		525	
11	15	7	NEE	16.4	71.4	12.5	5.4	469	945	-0.1050	-227		727
12	15	27	NEE	14.3	54.0	13.8	5.8	246	945	0.0352	74		403
13	15	46	NEE	12.7	46.8	13.0	5.3	246	945	-0.0098	-21		484
14	16	8	NEE	12.6	54.4	18.9	11.1	275	945	-0.0817	-153		625
15	16	27	NEE	12.7	40.2	17.8	8.5	243	945	0.0053	14		760
11	15	17	ER	15.1	71.4	12.5	5.4	0	945	0.2310		501	
12	15	37	ER	13.1	54.0	13.8	5.8	0	945	0.2250		477	
13	15	56	ER	12.4	46.8	13.0	5.3	0	945	0.2178		463	
14	16	17	ER	12.5	54.4	18.9	11.1	0	945	0.2520		472	
15	16	37	ER	12.4	40.2	17.8	8.5	0	945	0.2862		775	
16	12	2	NEE	29.3	21.0	17.5	8.4	1549	947	-0.2181	-504		1371
17	12	21	NEE	25.7	60.8	10.7	4.4	946	947	-0.1641	-364		1036
18	12	40	NEE	24.5	42.1	12.9	4.0	1113	947	-0.2626	-667		1572
19	12	58	NEE	23.3	41.9	12.8	3.5	1418	947	-0.1367	-280		936
20	13	16	NEE	23.4	27.9	15.7	4.9	905	947	-0.5306	-1450		2530
16	12	11	ER	27.8	21.0	17.5	8.4	0	947	0.3738		867	
17	12	31	ER	23.9	60.8	10.7	4.4	0	947	0.3014		672	
18	12	50	ER	22.7	42.1	12.9	4.0	0	947	0.3543		905	
19	13	7	ER	23.1	41.9	12.8	3.5	0	947	0.3193		655	
20	13	25	ER	24.4	27.9	15.7	4.9	0	947	0.3968		1080	
21	13	36	NEE	25.1	41.8	14.7	7.3	797	947	-0.0879	-233		949
22	13	54	NEE	24.4	42.0	14.5	5.5	1359	947	-0.1433	-382		1220
23	14	23	NEE	23.1	60.5	17.8	9.5	640	947	-0.3043	-795		1660
24	14	41	NEE	21.9	47.1	12.9	6.3	967	947	-0.4613	-1154		2139
25	14	58	NEE	20.3	50.5	15.3	6.3	448	947	-0.1279	-353		957
21	13	46	ER	23.5	41.8	14.7	7.3	0	947	0.2679		715	
22	14	15	ER	23.6	42.0	14.5	5.5	0	947	0.3142		839	
23	14	32	ER	22.0	60.5	17.8	9.5	0	947	0.3296		864	
24	14	50	ER	21.0	47.1	12.9	6.3	0	947	0.3928		985	
25	15	9	ER	19.1	50.5	15.3	6.3	0	947	0.2181		605	
26	15	18	NEE	18.5	68.6	16.0	5.9	483	947	-0.1229	-345		1006
27	15	36	NEE	17.8	37.6	12.1	5.1	389	947	-0.0580	-154		793
28	15	54	NEE	16.4	48.8	15.0	5.3	380	947	-0.0868	-243		1079
29	16	10	NEE	15.6	46.3	16.4	6.0	355	947	-0.0765	-210		899
30	16	27	NEE	14.9	22.5	15.1	4.8	324	947	0.0059	16		581
26	15	28	ER	18.1	68.6	16.0	5.9	0	947	0.2349		661	
27	15	45	ER	17.0	37.6	12.1	5.1	0	947	0.2393		639	
28	16	2	ER	15.9	48.8	15.0	5.3	0	947	0.2982		836	
29	16	19	ER	15.1	46.3	16.4	6.0	0	947	0.2508		689	
30	16	36	ER	14.6	22.5	15.1	4.8	0	947	0.2218		597	

S.Table 9: CO_2-flux measurements and environmental parameters on 16 and 17 Jun

Plot	Measurement Time		Measurem. type	Chamber temp.	Soil moisture	Soil temp 2cm	Soil temp 5cm	PAR	Chamber pressure	Flux slope	CO_2 flux		
											mg CO2 m^2 h^{-1}		
	hour	min	NEE / ER	°C	vol %	°C	°C	µ mol m^2 s^{-1}	mbar	ppm s^{-1}	NEE	ER	GEP
1	15	40	NEE	15.0	41.1	10.2	7.0	449	947	-0.2553	-571		960
2	16	2	NEE	14.5	56.8	11.4	9.6	400	947	-0.2060	-422		854
3	16	22	NEE	18.6	47.0	12.7	8.9	774	947	-0.3233	-694		1245
4	16	39	NEE	20.8	51.8	8.9	6.5	721	947	-0.1929	-496		1133
5	16	57	NEE	20.6	41.2	11.6	8.6	1065	947	-0.4115	-852		1507
1	15	51	ER	14.6	41.1	10.2	7.0	0	947	0.1739		389	
2	16	12	ER	16.4	56.8	11.4	9.6	0	947	0.2118		432	
3	16	31	ER	20.1	47.0	12.7	8.9	0	947	0.2579		551	
4	16	40	ER	20.2	51.8	8.9	6.5	0	947	0.2469		636	
5	17	6	ER	22.2	41.2	11.6	8.6	0	947	0.3180		655	
6	12	35	NEE	15.4	37.9	13.6	11.6	280	952	-0.0543	-125		703
7	12	51	NEE	15.6	34.3	13.3	12.4	631	952	-0.2494	-512		1078
8	13	8	NEE	16.5	28.5	12.1	10.8	333	952	-0.0604	-135		699
9	13	31	NEE	20.3	37.7	13.4	9.3	1317	952	-0.0906	-211		899
10	13	47	NEE	24.3	36.3	19.5	11.6	1362	952	-0.2305	-603		1144
6	12	43	ER	14.9	37.9	13.6	11.6	0	952	0.2501		578	
7	13	0	ER	16.3	34.3	13.3	12.4	0	952	0.2761		566	
8	13	15	ER	16.2	28.5	12.1	10.8	0	952	0.2520		564	
9	13	38	ER	22.3	37.7	13.4	9.3	0	952	0.2973		688	
10	13	56	ER	25.4	36.3	19.5	11.6	0	952	0.2075		541	
11	14	5	NEE	25.0	58.3	19.0	12.2	1289	952	-0.2628	-555		1065
12	14	23	NEE	24.5	69.3	12.5	11.4	1337	952	-0.2783	-571		1271
13	14	43	NEE	26.7	40.2	18.7	13.8	1333	951	-0.2651	-540		1337
14	15	5	NEE	28.1	88.5	18.2	13.4	1157	951	-0.1965	-351		1232
15	15	23	NEE	27.5	54.8	16.8	11.2	1322	951	-0.4310	-1115		2442
11	14	15	ER	24.0	58.3	19.0	12.2	0	952	0.2411		511	
12	14	31	ER	25.9	69.3	12.5	11.4	0	951	0.3427		700	
13	14	55	ER	27.7	40.2	18.7	13.8	0	951	0.3927		797	
14	15	13	ER	27.0	88.5	18.2	13.4	0	951	0.4917		881	
15	15	32	ER	26.9	54.8	16.8	11.2	0	951	0.5122		1327	
16	15	44	NEE	26.9	35.4	16.5	13.4	966	952	-0.1537	-359		1019
17	16	3	NEE	26.2	58.2	15.6	13.1	1164	951	-0.1573	-349		992
18	16	22	NEE	25.1	38.3	16.9	10.4	1154	951	-0.2553	-650		1535
19	16	40	NEE	24.7	55.0	20.4	13.8	1136	951	-0.1507	-309		1035
20	16	57	NEE	24.1	66.5	20.0	11.9	886	952	-0.4320	-1184		2526
16	15	55	ER	26.0	35.4	16.5	13.4	0	952	0.2812		660	
17	16	12	ER	24.9	58.2	15.6	13.1	0	951	0.2877		642	
18	16	32	ER	24.8	38.3	16.9	10.4	0	952	0.3471		885	
19	16	48	ER	23.4	55.0	20.4	13.8	0	952	0.3524		726	
20	17	6	ER	26.1	66.5	20.0	11.9	0	952	0.4932		1342	
21	11	50	NEE	12.6	42.1	10.9	7.3	657	947	-0.2119	-587		936
22	12	13	NEE	13.4	63.2	12.5	8.1	525	947	-0.2115	-585		1024
23	12	49	NEE	15.9	79.5	11.8	9.7	534	947	-0.4121	-1104		1624
24	13	10	NEE	16.6	55.9	11.7	9.5	1303	947	-0.7115	-1812		2580
25	13	31	NEE	17.1	40.0	12.8	9.6	508	947	-0.2705	-755		1075
21	12	2	ER	13.0	42.1	10.9	7.3	0	947	0.1259		348	
22	12	24	ER	13.6	63.2	12.5	8.1	0	947	0.1592		440	
23	13	0	ER	16.5	79.5	11.8	9.7	0	947	0.1947		520	
24	13	20	ER	18.7	55.9	11.7	9.5	0	947	0.3036		768	
25	13	39	ER	15.9	40.0	12.8	9.6	0	947	0.1143		320	
26	13	59	NEE	14.9	53.0	11.6	8.4	722	947	-0.2428	-691		1159
27	14	21	NEE	15.0	62.1	11.2	8.1	460	947	-0.2477	-665		1022
28	14	41	NEE	14.2	61.4	10.5	6.8	540	947	-0.2966	-836		1325
29	14	59	NEE	13.3	47.2	10.1	6.9	439	947	-0.2084	-576		981
30	15	18	NEE	14.5	63.6	9.5	6.1	560	947	-0.2397	-645		1135
26	14	11	ER	15.6	53.0	11.6	8.4	0	947	0.1650		468	
27	14	30	ER	14.5	62.1	11.2	8.1	0	947	0.1326		357	
28	14	49	ER	13.7	61.4	10.5	6.8	0	947	0.1730		489	
29	15	7	ER	13.3	47.2	10.1	6.9	0	947	0.1464		405	
30	15	27	ER	15.1	63.6	9.5	6.1	0	947	0.1825		490	

S.Table 10: CO_2-flux measurements and environmental parameters on 28 and 29 Jun

Plot	Measurement Time		Measurem. type	Chamber temp.	Soil moisture	Soil temp 2cm	Soil temp 5cm	PAR	Chamber pressure	Flux slope	CO_2 flux		
											mg CO2 m^2 h^{-1}		
	hour	min	NEE / ER	°C	vol %	°C	°C	µ mol m^2 s^{-1}	mbar	ppm s^{-1}	NEE	ER	GEP
1	12	31	NEE	11.1	51.8	9.3	6.8	504	949	-0.3852	-875		1218
2	12	49	NEE	11.2	48.0	10.7	6.5	486	949	-0.3381	-703		946
3	13	4	NEE	11.1	69.6	8.7	7.6	501	949	-0.4003	-884		1175
4	13	21	NEE	10.8	47.3	10.5	7.9	654	949	-0.3153	-841		1174
5	13	37	NEE	12.4	48.1	11.1	9.1	737	949	-0.5862	-1251		1597
1	12	40	ER	11.3	51.8	9.3	6.8	0	949	0.1514		343	
2	12	56	ER	11.1	48.0	10.7	6.5	0	949	0.1171		243	
3	13	12	ER	10.7	69.6	8.7	7.6	0	949	0.1318		291	
4	13	29	ER	11.9	47.3	10.5	7.9	0	949	0.1253		333	
5	13	46	ER	13.1	48.1	11.1	9.1	0	949	0.1627		346	
6	11	4	NEE	9.5	23.5	11.4	7.6	421	949	-0.2864	-672		1102
7	11	23	NEE	10.2	32.5	9.3	7.0	442	949	-0.3045	-635		835
8	11	39	NEE	10.6	30.5	9.1	6.2	323	949	-0.1458	-332		581
9	11	55	NEE	10.5	71.3	9.1	6.2	471	949	-0.1452	-349		668
10	12	11	NEE	11.2	29.8	8.4	6.3	601	949	-0.3298	-900		1202
6	11	13	ER	10.0	23.5	11.4	7.6	0	949	0.1833		430	
7	11	31	ER	10.6	32.5	9.3	7.0	0	949	0.0956		199	
8	11	47	ER	10.4	30.5	9.1	6.2	0	949	0.1097		250	
9	12	3	ER	10.9	71.3	9.1	6.2	0	949	0.1331		319	
10	12	19	ER	11.2	29.8	8.4	6.3	0	949	0.1107		302	
11	13	56	NEE	12.2	69.3	10.2	7.3	349	949	-0.2520	-554		848
12	14	13	NEE	12.6	76.9	12.6	7.9	589	949	-0.4675	-997		1286
13	14	31	NEE	12.2	83.8	14.9	9.8	451	949	-0.3363	-718		1062
14	14	52	NEE	11.9	97.0	11.6	9.1	369	949	-0.3763	-709		965
15	15	10	NEE	11.2	44.4	11.1	9.4	479	949	-0.5488	-1497		1940
11	14	5	ER	12.4	69.3	10.2	7.3	0	949	0.1339		294	
12	14	22	ER	12.9	76.9	12.6	7.9	0	949	0.1357		289	
13	14	41	ER	12.5	83.8	14.9	9.8	0	949	0.1614		344	
14	15	0	ER	11.4	97.0	11.6	9.1	0	949	0.1360		257	
15	15	22	ER	10.7	44.4	11.1	9.4	0	949	0.1622		443	
16	11	59	NEE	10.8	17.9	10.8	7.6	366	946	-0.1761	-432		942
17	12	21	NEE	11.6	24.3	8.4	7.6	531	946	-0.3380	-785		1200
18	12	42	NEE	12.0	24.0	11.0	7.2	357	946	-0.4185	-1108		1476
19	13	3	NEE	11.5	27.8	10.7	6.6	379	946	-0.2850	-608		881
20	13	20	NEE	11.2	16.7	9.7	7.9	385	946	-0.4816	-1371		1940
16	12	10	ER	10.9	17.9	10.8	7.6	0	946	0.2073		509	
17	12	32	ER	11.8	24.3	8.4	7.6	0	946	0.1787		415	
18	12	51	ER	11.7	24.0	11.0	7.2	0	946	0.1387		368	
19	13	11	ER	11.3	27.8	10.7	6.6	0	946	0.1278		273	
20	13	31	ER	12.1	16.7	9.7	7.9	0	946	0.2005		569	
21	15	14	NEE	13.2	68.1	12.6	10.4	302	946	-0.1531	-423		762
22	15	54	NEE	10.9	75.3	11.9	10.9	356	946	-0.2138	-596		822
23	16	10	NEE	10.5	95.2	12.5	10.9	317	946	-0.3215	-876		1234
24	16	28	NEE	11.0	73.2	12.1	11.2	388	947	-0.5633	-1463		1959
25	16	46	NEE	11.7	29.5	13.5	9.5	769	947	-0.3803	-1081		1401
21	15	23	ER	12.3	68.1	12.6	10.4	0	946	0.1223		339	
22	16	2	ER	10.7	75.3	11.9	10.9	0	946	0.0812		226	
23	16	20	ER	10.7	95.2	12.5	10.9	0	946	0.1314		358	
24	16	37	ER	10.9	73.2	12.1	11.2	0	947	0.1908		496	
25	16	54	ER	12.0	29.5	13.5	9.5	0	947	0.1125		320	
26	13	45	NEE	14.8	20.9	10.2	9.1	927	946	-0.3580	-1018		1659
27	14	2	NEE	15.6	21.5	11.3	7.5	649	946	-0.2701	-723		938
28	14	18	NEE	13.8	35.7	11.7	7.7	422	946	-0.2063	-582		1014
29	14	36	NEE	12.0	34.4	11.0	8.2	514	946	-0.3062	-850		1053
30	14	55	NEE	13.2	26.6	13.1	8.4	578	946	-0.3666	-990		1680
26	13	54	ER	15.7	20.9	10.2	9.1	0	946	0.2264		641	
27	14	10	ER	14.5	21.5	11.3	7.5	0	946	0.0800		215	
28	14	27	ER	12.7	35.7	11.7	7.7	0	946	0.1528		433	
29	14	45	ER	12.5	34.4	11.0	8.2	0	946	0.0735		204	
30	15	3	ER	13.6	26.6	13.1	8.4	0	946	0.2558		690	

S.Table 11: CO_2-flux measurements and environmental parameters on 4 and 5 Jul.

Plot	Measurement Time		Measurem. type	Chamber temp.	Soil moisture	Soil temp 2cm	Soil temp 5cm	PAR	Chamber pressure	Flux slope	CO_2 flux		
											mg CO2 m^2 h^{-1}		
	hour	min	NEE / ER	°C	vol %	°C	°C	µ mol m^2 s^{-1}	mbar	ppm s^{-1}	NEE	ER	GEP
1	12	37	NEE	18.3	92.2	10.8	5.7	387	942	-0.2952	-649		1114
2	12	53	NEE	18.1	107.3	14.6	7.8	442	942	-0.3833	-772		1101
3	13	9	NEE	17.6	119.1	11.0	5.4	484	942	-0.4445	-952		1355
4	13	24	NEE	17.4	107.2	13.2	8.0	448	942	-0.2193	-567		892
5	13	41	NEE	17.0	64.2	12.3	6.9	322	941	-0.3234	-673		1149
1	12	46	ER	18.2	92.2	10.8	5.7	0	942	0.2114		465	
2	13	0	ER	17.7	107.3	14.6	7.8	0	941	0.1632		329	
3	13	16	ER	17.3	119.1	11.0	5.4	0	942	0.1883		403	
4	13	31	ER	17.3	107.2	13.2	8.0	0	941	0.1254		324	
5	13	49	ER	16.6	64.2	12.3	6.9	0	941	0.2279		475	
6	15	36	NEE	14.3	116.9	10.4	5.4	318	946	-0.2788	-642		1110
7	15	55	NEE	11.5	98.5	12.2	6.6	324	946	-0.3593	-744		1048
8	16	12	NEE	10.9	84.5	10.5	5.0	325	947	-0.1737	-394		675
9	16	29	NEE	10.4	100.6	10.1	5.3	311	947	-0.1627	-390		736
10	16	45	NEE	10.6	114.1	8.1	2.9	505	947	-0.3257	-889		1340
6	15	44	ER	12.7	116.9	10.4	5.4	0	946	0.2023		468	
7	16	3	ER	11.1	98.5	12.2	6.6	0	946	0.1467		304	
8	16	20	ER	10.6	84.5	10.5	5.0	0	947	0.1238		281	
9	16	37	ER	10.3	100.6	10.1	5.3	0	947	0.1440		346	
10	16	53	ER	12.4	114.1	8.1	2.9	0	947	0.1664		451	
11	13	58	NEE	16.0	110.7	11.4	6.6	257	941	-0.2074	-446		801
12	14	12	NEE	15.5	102.8	12.2	7.3	226	941	-0.2109	-442		764
13	14	27	NEE	15.1	103.5	10.7	5.9	225	941	-0.1941	-407		718
14	14	43	NEE	14.7	114.4	11.8	7.2	258	941	-0.3080	-570		734
15	15	1	NEE	14.2	104.0	13.0	8.3	241	941	-0.2309	-618		1397
11	14	5	ER	15.6	110.7	11.4	6.6	0	941	0.1646		355	
12	14	19	ER	15.2	102.8	12.2	7.3	0	941	0.1541		323	
13	14	36	ER	14.9	103.5	10.7	5.9	0	941	0.1483		311	
14	14	52	ER	14.4	114.4	11.8	7.2	0	941	0.0887		164	
15	15	9	ER	14.2	104.0	13.0	8.3	0	941	0.2908		779	
16	13	51	NEE	14.4	44.8	10.9	5.3	765	945	-0.4132	-1001		1431
17	14	18	NEE	12.9	91.1	10.9	6.3	484	945	-0.4088	-945		1308
18	14	37	NEE	13.2	114.3	11.5	5.9	895	946	-0.5358	-1413		1899
19	14	54	NEE	14.6	96.8	10.7	4.3	522	946	-0.4599	-971		1195
20	15	12	NEE	13.5	61.7	10.0	4.7	1020	946	-0.7247	-2046		2532
16	13	59	ER	14.4	44.8	10.9	5.3	0	945	0.1772		430	
17	14	27	ER	12.1	91.1	10.9	6.3	0	945	0.1565		363	
18	14	46	ER	15.7	114.3	11.5	5.9	0	945	0.1862		486	
19	15	2	ER	13.1	96.8	10.7	4.3	0	946	0.1058		224	
20	15	21	ER	14.2	61.7	10.0	4.7	0	946	0.1725		486	
21	15	18	NEE	14.2	90.1	12.4	6.7	222	941	-0.0553	-151		433
22	15	34	NEE	13.8	88.6	12.1	7.3	185	942	-0.0831	-228		465
23	15	49	NEE	13.7	113.8	12.0	6.8	202	941	-0.1874	-503		995
24	16	4	NEE	13.7	113.2	11.0	6.5	190	942	-0.2062	-528		936
25	16	20	NEE	13.6	99.9	11.6	6.1	167	942	-0.0691	-194		483
21	15	25	ER	14.0	90.1	12.4	6.7	0	941	0.1025		281	
22	15	41	ER	13.6	88.6	12.1	7.3	0	942	0.0862		237	
23	15	56	ER	13.6	113.8	12.0	6.8	0	941	0.1834		492	
24	16	12	ER	13.6	113.2	11.0	6.5	0	942	0.1595		408	
25	16	28	ER	13.3	99.9	11.6	6.1	0	942	0.1027		289	
26	12	34	NEE	11.1	93.7	12.1	4.8	330	945	-0.1656	-476		884
27	12	50	NEE	11.9	95.6	9.4	4.7	1212	946	-0.4595	-1246		1630
28	13	5	NEE	16.8	86.9	9.5	4.4	1208	945	-0.5413	-1509		2072
29	13	20	NEE	16.0	106.5	11.1	5.1	549	946	-0.4159	-1138		1545
30	13	35	NEE	13.9	88.2	12.4	4.8	355	945	-0.2423	-652		1147
26	12	43	ER	11.2	93.7	12.1	4.8	0	945	0.1418		408	
27	12	58	ER	15.2	95.6	9.4	4.7	0	945	0.1435		384	
28	13	13	ER	16.8	86.9	9.5	4.4	0	945	0.2019		563	
29	13	27	ER	15.0	106.5	11.1	5.1	0	946	0.1485		408	
30	13	42	ER	12.9	88.2	12.4	4.8	0	946	0.1830		494	

S.Table 12: CO_2-flux measurements and environmental parameters on 15 and 16 Jul

Plot	Measurement Time		Measurem. type	Chamber temp.	Soil moisture	Soil temp 2cm	Soil temp 5cm	PAR	Chamber pressure	Flux slope	CO_2 flux		
											mg CO2 m^2 h^{-1}		
	hour	min	NEE / ER	°C	vol %	°C	°C	µ mol m^2 s^{-1}	mbar	ppm s^{-1}	NEE	ER	GEP
1	15	5	NEE	23.7	71.9	19.4	17.4	769	957	-0.3487	-765		1387
2	15	21	NEE	23.7	56.6	24.3	19.3	456	957	-0.2977	-598		1193
3	15	37	NEE	22.7	87.1	20.1	14.8	521	958	-0.3707	-793		1608
4	15	52	NEE	22.5	77.0	18.5	14.7	407	958	-0.0942	-244		987
5	16	6	NEE	20.6	52.3	17.0	14.0	363	958	-0.2764	-579		1022
1	15	13	ER	24.6	71.9	19.4	17.4	0	957	0.2848		623	
2	15	28	ER	22.7	56.6	24.3	19.3	0	958	0.2947		595	
3	15	45	ER	23.1	87.1	20.1	14.8	0	958	0.3812		815	
4	15	59	ER	21.4	77.0	18.5	14.7	0	958	0.2862		743	
5	16	12	ER	20.0	52.3	17.0	14.0	0	958	0.2115		444	
6	16	23	NEE	19.5	55.5	17.4	17.6	321	958	-0.1554	-356		1237
7	16	37	NEE	19.3	43.0	16.7	15.5	360	958	-0.2146	-438		1103
8	16	51	NEE	18.8	31.2	17.4	15.5	389	958	-0.1076	-240		867
9	17	5	NEE	18.8	54.0	16.2	11.9	381	958	-0.1336	-315		687
10	17	20	NEE	20.2	40.6	18.2	12.7	425	958	-0.2190	-585		1466
6	16	29	ER	19.4	55.5	17.4	17.6	0	958	0.3849		881	
7	16	44	ER	19.0	43.0	16.7	15.5	0	958	0.3255		665	
8	16	58	ER	18.8	31.2	17.4	15.5	0	958	0.2810		627	
9	17	12	ER	19.0	54.0	16.2	11.9	0	958	0.1581		372	
10	17	27	ER	22.8	40.6	18.2	12.7	0	958	0.3333		882	
11	12	45	NEE	25.2	80.7	19.8	14.2	1067	960	-0.2833	-603		1442
12	12	59	NEE	28.1	88.4	17.6	12.9	1059	959	-0.3177	-649		1324
13	13	13	NEE	27.7	71.7	21.7	18.1	866	959	-0.3321	-680		1532
14	13	29	NEE	27.4	76.9	19.8	15.0	878	960	-0.3819	-690		1470
15	13	43	NEE	26.4	58.9	19.7	16.2	808	959	-0.3922	-1027		2360
11	12	52	ER	26.9	80.7	19.8	14.2	0	959	0.3972		840	
12	13	6	ER	27.5	88.4	17.6	12.9	0	959	0.3292		674	
13	13	20	ER	28.0	71.7	21.7	18.1	0	959	0.4170		853	
14	13	36	ER	27.0	76.9	19.8	15.0	0	959	0.4318		781	
15	13	51	ER	25.1	58.9	19.7	16.2	0	959	0.5072		1333	
16	13	59	NEE	25.5	29.2	21.3	18.5	1076	959	-0.0976	-231		1575
17	14	13	NEE	24.0	32.1	17.9	15.5	653	959	-0.1218	-275		1055
18	14	27	NEE	23.7	26.1	21.9	14.5	604	960	-0.2686	-693		1689
19	14	43	NEE	25.6	45.4	21.0	14.4	769	959	-0.2131	-439		1238
20	14	58	NEE	26.3	27.3	18.5	15.8	1048	959	-0.6090	-1668		3069
16	14	6	ER	24.9	29.2	21.3	18.5	0	959	0.5663		1344	
17	14	20	ER	23.5	32.1	17.9	15.5	0	959	0.3450		780	
18	14	35	ER	24.2	26.1	21.9	14.5	0	960	0.3866		996	
19	14	50	ER	25.5	45.4	21.0	14.4	0	959	0.3874		798	
20	15	6	ER	28.5	27.3	18.5	15.8	0	959	0.5148		1401	
21	12	37	NEE	30.1	62.9	20.5	15.9	944	958	-0.1717	-454		1210
22	12	51	NEE	28.8	83.2	20.6	16.0	303	958	-0.0539	-143		888
23	13	6	NEE	27.0	89.2	22.8	18.1	890	957	-0.3183	-830		1919
24	13	21	NEE	28.4	80.1	17.3	12.9	1425	957	-0.6657	-1647		2999
25	13	36	NEE	28.4	54.1	21.8	16.4	1212	957	-0.2714	-737		1496
21	12	44	ER	29.8	62.9	20.5	15.9	0	958	0.2860		756	
22	12	58	ER	26.7	83.2	20.6	16.0	0	958	0.2790		745	
23	13	14	ER	27.4	89.2	22.8	18.1	0	957	0.4183		1089	
24	13	29	ER	28.0	80.1	17.3	12.9	0	957	0.5463		1353	
25	13	43	ER	28.0	54.1	21.8	16.4	0	957	0.2791		759	
26	13	51	NEE	28.7	48.0	18.0	14.1	1098	957	-0.1815	-498		1450
27	14	6	NEE	30.4	34.2	20.0	15.4	619	957	-0.0566	-146		1265
28	14	20	NEE	27.2	32.3	18.8	16.9	436	958	-0.0946	-258		1316
29	14	34	NEE	23.8	36.9	17.7	15.2	442	958	-0.1642	-443		1097
30	14	49	NEE	24.5	24.0	18.5	13.5	687	958	-0.2098	-552		1395
26	13	58	ER	30.6	48.0	18.0	14.1	0	957	0.3493		952	
27	14	13	ER	28.9	34.2	20.0	15.4	0	958	0.4320		1120	
28	14	27	ER	25.0	32.3	18.8	16.9	0	958	0.3848		1058	
29	14	41	ER	23.3	36.9	17.7	15.2	0	958	0.2419		654	
30	14	55	ER	24.2	24.0	18.5	13.5	0	957	0.3205		843	

S.Table 13: CO_2-flux measurements and environmental parameters on 22 and 23 Jul

Plot	Measurement Time		Measurem. type	Chamber temp.	Soil moisture	Soil temp 2cm	Soil temp 5cm	PAR	Chamber pressure	Flux slope	CO_2 flux		
											mg CO2 m^2 h^{-1}		
	hour	min	NEE / ER	°C	vol %	°C	°C	µ mol m^2 s^{-1}	mbar	ppm s^{-1}	NEE	ER	GEP
1	13	13	NEE	31.7	48.0	19.9	15.1	838	940	-0.2758	-579		1471
2	13	28	NEE	31.8	25.4	21.6	18.7	1237	940	-0.2969	-570		1610
3	13	43	NEE	31.9	29.3	20.2	16.1	1064	940	-0.1695	-345		1422
4	14	0	NEE	31.8	28.8	19.8	16.7	641	939	-0.2297	-565		1473
5	14	16	NEE	30.9	21.1	19.7	17.7	1287	939	-0.4796	-951		2055
1	13	20	ER	31.4	48.0	19.9	15.1	0	940	0.4251		892	
2	13	35	ER	32.0	25.4	21.6	18.7	0	940	0.5422		1040	
3	13	53	ER	31.9	29.3	20.2	16.1	0	939	0.5292		1077	
4	14	8	ER	31.1	28.8	19.8	16.7	0	939	0.3684		908	
5	14	23	ER	31.0	21.1	19.7	17.7	0	939	0.5567		1104	
6	15	21	NEE	34.5	16.9	24.6	23.4	470	942	-0.0995	-213		1539
7	15	35	NEE	35.8	18.9	21.5	17.5	1123	942	-0.2115	-402		1840
8	15	50	NEE	35.9	14.5	21.8	17.5	1060	942	-0.1407	-292		1117
9	16	4	NEE	33.5	30.4	23.7	15.3	642	942	-0.0918	-202		690
10	16	17	NEE	32.4	18.4	21.7	17.7	454	942	0.0290	73		892
6	15	28	ER	34.7	16.9	24.6	23.4	3	942	0.6201		1326	
7	15	42	ER	35.4	18.9	21.5	17.5	1	942	0.7566		1439	
8	15	57	ER	34.4	14.5	21.8	17.5	0	942	0.3962		825	
9	16	10	ER	32.8	30.4	23.7	15.3	0	942	0.2204		487	
10	16	25	ER	30.7	18.4	21.7	17.7	0	942	0.3810		966	
11	15	1	NEE	34.9	27.1	23.8	18.9	1033	942	-0.1554	-314		1341
12	14	47	NEE	34.9	23.6	22.1	19.3	935	942	-0.2387	-469		1439
13	14	33	NEE	34.7	20.3	26.7	25.1	918	942	-0.0466	-92		1367
14	14	17	NEE	35.9	26.9	24.8	19.2	1211	942	-0.2423	-418		1401
15	14	2	NEE	36.4	13.8	23.1	19.3	1361	942	-0.3328	-828		2207
11	15	8	ER	34.6	27.1	23.8	18.9	0	942	0.5075		1027	
12	14	55	ER	35.3	23.6	22.1	19.3	1	942	0.4950		971	
13	14	40	ER	34.8	20.3	26.7	25.1	0	942	0.6492		1275	
14	14	24	ER	35.6	26.9	24.8	19.2	4	942	0.5694		983	
15	14	10	ER	35.9	13.8	23.1	19.3	2	942	0.5535		1379	
16	17	35	NEE	22.6	11.7	0.4	-0.4	264	942	-0.1869	-439		934
17	17	19	NEE	24.1	18.7	19.4	16.7	282	942	-0.0056	-12		721
18	17	5	NEE	26.0	9.4	21.0	18.9	331	942	-0.0927	-233		1035
19	16	50	NEE	26.9	11.9	22.0	18.0	487	942	-0.1742	-351		1127
20	16	34	NEE	28.9	17.1	20.0	17.7	346	942	-0.2920	-779		1845
16	17	42	ER	22.5	11.7	0.4	-0.4	18	942	0.2105		495	
17	17	28	ER	23.1	18.7	19.4	16.7	18	942	0.3188		709	
18	17	11	ER	24.8	9.4	21.0	18.9	18	942	0.3178		802	
19	16	57	ER	26.6	11.9	22.0	18.0	0	942	0.3846		776	
20	16	43	ER	27.5	17.1	20.0	17.7	0	942	0.3977		1066	
21	12	48	NEE	34.8	18.7	21.5	17.2	629	943	-0.1518	-389		1323
22	13	2	NEE	34.2	21.7	22.7	17.3	1131	942	-0.1358	-348		1446
23	13	16	NEE	34.1	30.4	22.4	20.8	1049	942	-0.2625	-658		2209
24	13	31	NEE	35.5	18.0	23.0	20.0	1201	942	-0.4720	-1123		2661
25	13	46	NEE	35.8	15.7	22.0	18.6	1222	942	-0.0902	-235		1256
21	12	55	ER	34.3	18.7	21.5	17.2	0	942	0.3646		935	
22	13	9	ER	33.9	21.7	22.7	17.3	0	942	0.4279		1098	
23	13	24	ER	34.7	30.4	22.4	20.8	0	942	0.6203		1551	
24	13	39	ER	35.5	18.0	23.0	20.0	2	942	0.6469		1538	
25	13	53	ER	35.9	15.7	22.0	18.6	3	942	0.3916		1021	
26	14	32	NEE	31.4	11.9	23.3	18.2	1038	939	-0.0636	-170		1326
27	14	48	NEE	34.0	11.8	21.7	17.3	1200	939	-0.1573	-393		1469
28	15	3	NEE	34.4	10.9	22.9	16.1	1118	939	-0.2191	-572		1651
29	15	18	NEE	33.6	11.7	20.3	17.0	914	939	-0.1811	-464		928
30	15	33	NEE	31.6	14.3	24.9	16.8	995	939	-0.2350	-592		1230
26	14	39	ER	32.3	11.9	23.3	18.2	0	939	0.4350		1157	
27	14	56	ER	34.1	11.8	21.7	17.3	0	939	0.4306		1076	
28	15	11	ER	33.9	10.9	22.9	16.1	0	939	0.4122		1078	
29	15	26	ER	31.2	11.7	20.3	17.0	0	939	0.1798		464	
30	15	40	ER	32.3	14.3	24.9	16.8	0	939	0.2540		638	

S.Table 14: CO_2-flux measurements and environmental parameters on 28 and 29 Jul

Plot	Measurement Time		Measurem. type	Chamber temp.	Soil moisture	Soil temp 2cm	Soil temp 5cm	PAR	Chamber pressure	Flux slope	CO_2 flux		
											mg CO2 m^2 h^{-1}		
	hour	min	NEE / ER	°C	vol %	°C	°C	µ mol m^2 s^{-1}	mbar	ppm s^{-1}	NEE	ER	GEP
1	14	25	NEE	21.7	75.2	16.2	14.4	716	947	-0.3344	-730		1286
2	14	37	NEE	21.4	37.4	18.7	15.8	1124	947	-0.4784	-958		1567
3	14	50	NEE	21.6	54.6	17.0	15.0	725	947	-0.4281	-909		1589
4	15	3	NEE	21.2	42.0	17.4	15.2	626	947	-0.4351	-1117		2055
5	15	15	NEE	22.4	31.8	17.7	16.9	932	947	-0.5435	-1118		1893
1	14	31	ER	21.2	75.2	16.2	14.4	0	947	0.2538		555	
2	14	43	ER	21.1	37.4	18.7	15.8	0	947	0.3038		609	
3	14	57	ER	20.8	54.6	17.0	15.0	0	947	0.3192		680	
4	15	9	ER	21.5	42.0	17.4	15.2	0	947	0.3654		938	
5	15	22	ER	22.8	31.8	17.7	16.9	0	947	0.3770		774	
6	12	19	NEE	23.5	29.7	17.9	14.1	720	946	-0.2779	-620		1404
7	12	31	NEE	21.5	28.6	15.1	13.5	544	946	-0.2357	-472		1193
8	12	43	NEE	22.4	31.6	17.6	14.5	820	946	-0.2489	-542		1257
9	12	55	NEE	20.3	52.2	15.4	13.0	431	946	-0.1661	-385		872
10	13	7	NEE	20.4	37.3	16.1	11.3	669	946	-0.2815	-742		1429
6	12	25	ER	22.5	29.7	17.9	14.1	0	946	0.3508		785	
7	12	37	ER	21.7	28.6	15.1	13.5	0	946	0.3610		721	
8	12	49	ER	21.1	31.6	17.6	14.5	0	946	0.3270		715	
9	13	1	ER	20.0	52.2	15.4	13.0	0	946	0.2101		487	
10	13	14	ER	20.9	37.3	16.1	11.3	0	946	0.2615		688	
11	18	35	NEE	15.0	43.0	15.1	14.1	251	948	-0.1146	-249		800
12	18	23	NEE	15.3	39.3	16.6	15.5	228	948	-0.1422	-300		821
13	18	11	NEE	16.0	40.3	17.7	15.3	177	948	-0.0424	-89		649
14	17	59	NEE	17.6	25.7	18.3	17.0	196	948	-0.1079	-199		702
15	17	46	NEE	19.3	21.9	16.9	16.2	306	947	-0.4631	-1226		1852
11	18	41	ER	14.7	43.0	15.1	14.1	0	948	0.2532		551	
12	18	28	ER	15.0	39.3	16.6	15.5	0	948	0.2465		521	
13	18	17	ER	15.4	40.3	17.7	15.3	0	948	0.2652		559	
14	18	5	ER	16.7	25.7	18.3	17.0	0	948	0.2718		503	
15	17	53	ER	18.7	21.9	16.9	16.2	0	947	0.2356		625	
16	15	29	NEE	23.7	27.0	17.1	14.4	849	947	-0.3661	-861		2010
17	15	41	NEE	23.7	29.5	16.1	14.2	791	947	-0.3263	-728		1499
18	16	1	NEE	24.4	32.1	18.3	14.8	718	947	-0.2861	-727		1685
19	16	14	NEE	23.8	44.3	19.4	15.1	618	947	-0.2480	-508		1329
20	16	26	NEE	23.1	31.0	17.1	13.3	322	947	-0.7618	-2083		3006
16	15	35	ER	23.4	27.0	17.1	14.4	0	947	0.4881		1149	
17	15	47	ER	23.7	29.5	16.1	14.2	0	947	0.3457		771	
18	16	7	ER	24.1	32.1	18.3	14.8	0	947	0.3769		959	
19	16	20	ER	22.6	44.3	19.4	15.1	0	947	0.3995		821	
20	16	33	ER	23.6	31.0	17.1	13.3	0	947	0.3380		923	
21	14	12	NEE	22.5	32.8	17.5	15.9	326	947	-0.0750	-201		911
22	14	0	NEE	24.5	33.9	18.5	16.2	615	947	-0.2217	-590		1405
23	13	48	NEE	24.0	48.1	19.1	15.7	343	946	-0.3779	-984		2073
24	13	34	NEE	25.0	27.1	19.1	15.9	1133	946	-0.7109	-1758		2944
25	13	23	NEE	22.2	24.9	18.9	14.0	1112	946	-0.2894	-793		1581
21	14	17	ER	21.8	32.8	17.5	15.9	0	947	0.2645		710	
22	14	6	ER	23.7	33.9	18.5	16.2	0	947	0.3056		815	
23	13	54	ER	24.6	48.1	19.1	15.7	0	946	0.4194		1090	
24	13	41	ER	24.5	27.1	19.1	15.9	0	946	0.4789		1186	
25	13	29	ER	23.8	24.9	18.9	14.0	0	946	0.2890		788	
26	17	32	NEE	19.9	26.5	16.9	15.6	394	947	-0.0201	-56		884
27	17	20	NEE	20.4	21.5	19.9	16.1	675	947	-0.2504	-660		1253
28	17	5	NEE	20.2	24.7	18.3	15.4	320	947	-0.1274	-352		1143
29	16	52	NEE	21.6	23.6	15.9	15.0	528	947	-0.2672	-718		1388
30	16	40	NEE	23.6	21.7	16.5	13.7	337	947	-0.1260	-329		1094
26	17	39	ER	19.3	26.5	16.9	15.6	0	947	0.2956		828	
27	17	26	ER	20.5	21.5	19.9	16.1	0	947	0.2248		593	
28	17	11	ER	19.2	24.7	18.3	15.4	0	947	0.2855		791	
29	16	58	ER	20.9	23.6	15.9	15.0	0	947	0.2488		670	
30	16	46	ER	22.1	21.7	16.5	13.7	0	947	0.2921		766	

S.Table 15: CO_2-flux measurements and environmental parameters on 7 Aug.

Plot	Measurement Time		Measurem. type	Chamber temp.	Soil moisture	Soil temp 2cm	Soil temp 5cm	PAR	Chamber pressure	Flux slope	CO_2 flux		
											mg CO2 m^2 h^{-1}		
	hour	min	NEE / ER	°C	vol %	°C	°C	µ mol m^2 s^{-1}	mbar	ppm s^{-1}	NEE	ER	GEP
1	16	11	NEE	13.8	45.5	11.7	10.5	429	955	-0.1848	-418		807
2	16	23	NEE	13.4	30.0	11.9	11.7	280	954	-0.1602	-332		748
3	16	35	NEE	12.7	20.8	11.6	10.6	165	955	-0.0527	-116		742
4	16	48	NEE	13.3	19.6	11.8	12.2	470	955	-0.2320	-617		1054
5	17	0	NEE	14.9	21.3	12.1	12.4	410	954	-0.4338	-923		1381
1	16	17	ER	13.6	45.5	11.7	10.5	0	955	0.1718		389	
2	16	29	ER	13.3	30.0	11.9	11.7	0	955	0.2001		415	
3	16	42	ER	12.3	20.8	11.6	10.6	0	955	0.2828		625	
4	16	54	ER	13.3	19.6	11.8	12.2	0	955	0.1641		436	
5	17	7	ER	16.3	21.3	12.1	12.4	0	954	0.2167		459	
6	17	14	NEE	17.1	20.7	12.7	13.1	206	954	-0.2124	-488		1039
7	17	26	NEE	19.3	17.2	11.7	11.3	318	954	-0.2724	-554		983
8	17	38	NEE	20.0	16.8	12.7	12.7	306	954	-0.2160	-478		997
9	17	50	NEE	18.3	29.9	11.2	10.6	477	954	-0.1500	-353		571
10	18	9	NEE	18.3	21.1	11.1	11.8	637	955	-0.2230	-597		
6	17	20	ER	18.1	20.7	12.7	13.1	0	954	0.2402		550	
7	17	32	ER	19.2	17.2	11.7	11.3	0	954	0.2112		429	
8	17	44	ER	18.4	16.8	12.7	12.7	0	954	0.2333		519	
9	17	56	ER	18.3	29.9	11.2	10.6	0	955	0.0929		218	
10	-	-	ER		21.1	11.1	11.8		-	-	-	-	-
11	11	51	NEE	14.0	30.7	9.3	10.3	338	954	-0.2475	-544		774
12	12	3	NEE	13.3	20.9	10.3	11.0	423	954	-0.0495	-106		599
13	12	15	NEE	13.3	17.6	12.7	12.8	407	954	-0.2397	-513		1007
14	12	27	NEE	13.4	25.3	11.1	9.9	381	954	-0.3035	-572		858
15	12	39	NEE	12.7	16.3	9.2	10.4	407	954	-0.5879	-1603		2128
11	11	57	ER	13.6	30.7	9.3	10.3	0	954	0.1049		231	
12	12	9	ER	13.4	20.9	10.3	11.0	0	954	0.2306		493	
13	12	21	ER	13.5	17.6	12.7	12.8	0	954	0.2315		495	
14	12	33	ER	13.0	25.3	11.1	9.9	0	954	0.1515		286	
15	12	52	ER	12.5	16.3	9.2	10.4	0	954	0.1921		524	
16	12	59	NEE	13.8	17.8	9.7	9.8	989	954	-0.5015	-1229		1662
17	13	11	NEE	14.6	19.2	9.6	10.3	1166	954	-0.4404	-1021		1499
18	13	25	NEE	18.2	17.7	10.5	10.8	1087	954	-0.3675	-960		1608
19	13	37	NEE	19.3	27.4	12.1	9.9	967	954	-0.3796	-795		1219
20	13	50	NEE	16.0	14.7	12.3	11.8	292	954	-0.3294	-930		1728
16	13	5	ER	13.5	17.8	9.7	9.8	0	954	0.1765		433	
17	13	17	ER	15.5	19.2	9.6	10.3	0	954	0.2068		478	
18	13	31	ER	18.5	17.7	10.5	10.8	0	954	0.2480		648	
19	13	43	ER	17.5	27.4	12.1	9.9	0	954	0.2013		424	
20	13	57	ER	15.5	14.7	12.3	11.8	0	954	0.2822		798	
21	15	58	NEE	13.4	28.6	11.3	11.6	273	955	-0.0953	-266		777
22	15	46	NEE	14.2	21.5	13.0	13.0	318	955	-0.0172	-48		588
23	15	32	NEE	13.7	28.1	13.7	14.1	347	955	-0.2271	-618		1326
24	15	19	NEE	13.8	18.4	12.6	13.3	521	955	-0.4444	-1152		1982
25	15	7	NEE	14.2	27.3	13.3	12.7	320	955	-0.1118	-318		817
21	16	4	ER	13.3	28.6	11.3	11.6	0	955	0.1832		511	
22	15	52	ER	13.7	21.5	13.0	13.0	0	955	0.1940		540	
23	15	38	ER	14.1	28.1	13.7	14.1	0	955	0.2605		708	
24	15	25	ER	13.8	18.4	12.6	13.3	0	955	0.3200		830	
25	15	13	ER	13.5	27.3	13.3	12.7	0	955	0.1752		499	
26	14	54	NEE	15.7	18.7	11.9	11.0	222	954	-0.0069	-20		505
27	14	42	NEE	17.2	19.3	13.2	12.5	709	954	-0.2232	-599		1345
28	14	30	NEE	16.6	23.3	10.5	11.4	1241	954	-0.3880	-1093		1780
29	14	18	NEE	13.0	22.9	11.1	10.6	545	954	-0.2472	-690		1190
30	14	6	NEE	13.8	21.6	10.8	11.0	336	954	-0.1846	-502		900
26	15	0	ER	15.0	18.7	11.9	11.0	0	954	0.1695		486	
27	14	48	ER	16.8	19.3	13.2	12.5	0	954	0.2773		746	
28	14	36	ER	17.7	23.3	10.5	11.4	0	954	0.2449		687	
29	14	24	ER	14.5	22.9	11.1	10.6	0	954	0.1802		500	
30	14	13	ER	13.1	21.6	10.8	11.0	0	954	0.1462		398	

S.Table 16: CO_2-flux measurements and environmental parameters on 15 Aug

Plot	Measurement Time		Measurem. type	Chamber temp.	Soil moisture	Soil temp 2cm	Soil temp 5cm	PAR	Chamber pressure	Flux slope	CO_2 flux		
											mg CO2 m^2 h^{-1}		
	hour	min	NEE / ER	°C	vol %	°C	°C	µ mol m^2 s^{-1}	mbar	ppm s^{-1}	NEE	ER	GEP
1	16	29	NEE	9.7	27.0	8.0	7.8	136	949	-0.0182	-42		285
2	16	14	NEE	10.5	24.0	9.0	8.2	164	949	-0.0839	-175		445
3	15	59	NEE	11.5	22.7	8.5	8.0	271	949	-0.1777	-392		718
4	15	43	NEE	12.3	21.5	8.8	8.3	570	949	-0.4782	-1269		1636
5	15	28	NEE	12.6	32.5	9.5	8.4	295	949	-0.2697	-575		977
1	16	37	ER	9.2	27.0	8.0	7.8	0	949	0.1065		243	
2	16	22	ER	9.9	24.0	9.0	8.2	0	949	0.1290		270	
3	16	6	ER	10.9	22.7	8.5	8.0	0	949	0.1479		327	
4	15	51	ER	11.9	21.5	8.8	8.3	0	949	0.1380		367	
5	15	36	ER	12.1	32.5	9.5	8.4	0	949	0.1882		402	
6	15	19	NEE	18.2	27.1	15.3	11.9	210	951	-0.1895	-432		1065
7	15	35	NEE	19.1	28.1	12.2	10.9	700	951	-0.2770	-562		1044
8	15	51	NEE	19.3	20.1	12.4	10.6	617	951	-0.1667	-369		848
9	16	7	NEE	18.8	32.9	11.0	8.9	535	951	-0.1201	-281		615
10	16	23	NEE	18.5	29.7	10.3	9.7	577	951	-0.1765	-470		974
6	15	27	ER	18.6	27.1	15.3	11.9	0	951	0.2775		632	
7	15	43	ER	19.0	28.1	12.2	10.9	0	951	0.2379		483	
8	15	59	ER	18.6	20.1	12.4	10.6	0	951	0.2164		480	
9	16	15	ER	18.4	32.9	11.0	8.9	0	951	0.1423		333	
10	16	31	ER	18.1	29.7	10.3	9.7	0	951	0.1886		504	
11	12	41	NEE	18.1	21.3	11.4	9.8	626	952	-0.3061	-661		1064
12	12	57	NEE	17.5	21.9	10.9	9.4	601	952	-0.3076	-647		1123
13	13	12	NEE	16.9	19.1	15.2	12.8	497	952	-0.2579	-543		1017
14	13	28	NEE	17.2	20.4	13.6	12.0	542	952	-0.3146	-584		1013
15	13	45	NEE	17.1	21.3	11.2	10.3	707	952	-0.6295	-1687		2286
11	12	49	ER	17.4	21.3	11.4	9.8	0	952	0.1860		403	
12	13	5	ER	17.3	21.9	10.9	9.4	0	952	0.2261		476	
13	13	20	ER	16.9	19.1	15.2	12.8	0	952	0.2249		474	
14	13	37	ER	16.8	20.4	13.6	12.0	0	952	0.2310		429	
15	13	52	ER	17.2	21.3	11.2	10.3	0	952	0.2235		599	
16	12	41	NEE	8.2	27.6	6.5	6.4	351	948	-0.2278	-566		907
17	12	56	NEE	8.5	26.2	6.9	6.3	329	948	-0.2262	-533		780
18	13	12	NEE	8.8	31.2	6.5	6.5	302	948	-0.2320	-623		950
19	13	28	NEE	8.8	38.1	6.7	6.4	290	948	-0.2288	-494		818
20	13	43	NEE	8.8	28.8	6.9	6.8	283	949	-0.4025	-1159		1555
16	12	49	ER	8.2	27.6	6.5	6.4	0	948	0.1373		341	
17	13	4	ER	8.6	26.2	6.9	6.3	0	948	0.1050		247	
18	13	20	ER	8.8	31.2	6.5	6.5	0	948	0.1221		328	
19	13	36	ER	8.7	38.1	6.7	6.4	0	949	0.1502		325	
20	13	51	ER	9.0	28.8	6.9	6.8	0	949	0.1377		396	
21	15	2	NEE	19.3	20.8	13.6	10.4	706	951	-0.1414	-384		843
22	14	47	NEE	19.2	22.0	13.6	11.5	749	951	-0.2309	-628		1261
23	14	31	NEE	18.2	23.8	11.9	11.3	453	951	-0.3182	-849		1630
24	14	16	NEE	19.0	21.2	14.3	12.5	595	951	-0.5231	-1328		2052
25	13	59	NEE	18.2	22.3	12.9	11.2	893	952	-0.1916	-535		1024
21	15	10	ER	18.3	20.8	13.6	10.4	0	951	0.1678		458	
22	14	54	ER	19.2	22.0	13.6	11.5	0	951	0.2325		633	
23	14	39	ER	18.9	23.8	11.9	11.3	0	951	0.2933		781	
24	14	23	ER	18.2	21.2	14.3	12.5	9	951	0.2844		724	
25	14	8	ER	19.0	22.3	12.9	11.2	18	951	0.1754		489	
26	15	12	NEE	10.8	22.5	9.2	8.5	417	949	-0.1623	-469		926
27	14	44	NEE	10.6	24.9	8.1	7.2	277	949	-0.1543	-422		567
28	14	29	NEE	10.3	27.9	7.2	6.6	489	949	-0.3062	-877		1188
29	14	14	NEE	9.8	27.8	7.1	6.7	326	949	-0.2069	-580		890
30	13	59	NEE	9.1	29.7	7.5	7.0	291	949	-0.1899	-522		889
26	15	19	ER	12.7	22.5	9.2	8.5	0	949	0.1590		456	
27	14	52	ER	10.5	24.9	8.1	7.2	0	949	0.0532		145	
28	14	36	ER	10.7	27.9	7.2	6.6	0	949	0.1090		312	
29	14	21	ER	10.1	27.8	7.1	6.7	0	949	0.1106		310	
30	14	6	ER	9.7	29.7	7.5	7.0	0	949	0.1340		368	

S.Table 17: CO_2-flux measurements and environmental parameters on 26 and 27 Aug.

Plot	Measurement Time		Measurem. type	Chamber temp.	Soil moisture	Soil temp 2cm	Soil temp 5cm	PAR	Chamber pressure	Flux slope	CO_2 flux		
											mg CO2 m^2 h^{-1}		
	hour	min	NEE / ER	°C	vol %	°C	°C	μ mol m^2 s^{-1}	mbar	ppm s^{-1}	NEE	ER	GEP
1	12	3	NEE	23.8	23.4	11.3	8.4	698	962	-0.1695	-373		755
2	12	16	NEE	24.4	21.1	12.1	9.8	774	962	-0.1959	-395		789
3	12	29	NEE	23.7	18.5	11.5	9.2	819	962	-0.1873	-401		931
4	12	43	NEE	23.2	21.4	11.1	8.3	771	962	0.0207	54		1383
5	12	56	NEE	23.6	19.8	13.3	10.9	854	962	-0.1637	-341		884
1	12	10	ER	23.8	23.4	11.3	8.4	0	962	0.1734		382	
2	12	23	ER	23.4	21.1	12.1	9.8	0	962	0.1954		395	
3	12	37	ER	22.6	18.5	11.5	9.2	0	962	0.2462		529	
4	12	49	ER	22.9	21.4	11.1	8.3	0	962	0.5539		1437	
5	13	3	ER	23.2	19.8	13.3	10.9	0	962	0.2606		543	
6	13	10	NEE	23.7	17.7	11.8	10.0	790	962	-0.2099	-476		923
7	13	24	NEE	24.8	21.6	10.8	8.1	805	962	-0.1362	-274		821
8	13	36	NEE	25.0	21.6	11.1	8.2	757	962	-0.0821	-180		669
9	13	49	NEE	24.7	36.4	13.7	8.1	738	962	-0.0552	-128		418
10	14	3	NEE	24.5	21.6	10.2	7.5	729	962	0.2479	655		730
6	13	17	ER	23.8	17.7	11.8	10.0	0	962	0.1975		447	
7	13	30	ER	24.5	21.6	10.8	8.1	0	962	0.2714		547	
8	13	43	ER	24.5	21.6	11.1	8.2	0	962	0.2224		489	
9	13	56	ER	24.2	36.4	13.7	8.1	0	962	0.1247		290	
10	14	10	ER	24.3	21.6	10.2	7.5	0	962	0.5238		1385	
11	14	18	NEE	24.8	22.4	14.1	11.1	725	962	-0.1879	-401		862
12	14	31	NEE	25.4	17.6	13.9	11.5	695	961	-0.0626	-129		645
13	14	44	NEE	25.5	16.2	15.0	13.0	723	961	-0.1437	-297		807
14	15	4	NEE	26.9	19.9	16.9	13.2	560	961	-0.0853	-155		662
15	15	17	NEE	26.9	17.5	12.5	10.4	696	961	-0.0237	-62		1480
11	14	25	ER	24.8	22.4	14.1	11.1	0	961	0.2158		461	
12	14	37	ER	24.9	17.6	13.9	11.5	0	961	0.2492		516	
13	14	52	ER	25.6	16.2	15.0	13.0	0	961	0.2469		510	
14	15	11	ER	26.6	19.9	16.9	13.2	0	961	0.2799		508	
15	15	24	ER	26.0	17.5	12.5	10.4	0	961	0.5399		1418	
16	15	30	NEE	26.0	20.5	13.5	11.3	581	961	0.0094	22		572
17	15	43	NEE	25.1	28.6	12.7	9.7	590	961	-0.0945	-213		715
18	15	55	NEE	24.4	21.6	12.5	11.2	561	961	0.0600	155		627
19	16	8	NEE	24.3	24.7	12.6	10.2	541	961	-0.0923	-192		788
20	16	22	NEE	24.3	24.5	13.1	11.3	545	961	-0.3041	-841		1532
16	15	37	ER	25.0	20.5	13.5	11.3	0	961	0.2500		594	
17	15	49	ER	24.2	28.6	12.7	9.7	0	961	0.2222		502	
18	16	2	ER	23.8	21.6	12.5	11.2	0	961	0.3026		782	
19	16	15	ER	23.5	24.7	12.6	10.2	0	961	0.2868		596	
20	16	29	ER	24.2	24.5	13.1	11.3	0	961	0.2501		691	
21	12	41	NEE	24.8	20.1	11.9	9.8	651	958	-0.0556	-149		536
22	12	54	NEE	26.6	18.4	14.0	11.3	791	958	-0.1054	-282		655
23	13	7	NEE	26.0	15.8	14.5	10.9	498	958	-0.1961	-513		1016
24	13	28	NEE	26.9	15.6	15.6	13.8	570	958	-0.2308	-574		1556
25	13	41	NEE	27.7	19.8	15.3	11.0	734	958	-0.0699	-190		601
21	12	47	ER	25.4	20.1	11.9	9.8	0	958	0.1441		387	
22	13	1	ER	26.0	18.4	14.0	11.3	0	958	0.1395		374	
23	13	21	ER	26.5	15.8	14.5	10.9	0	958	0.1924		503	
24	13	35	ER	27.5	15.6	15.6	13.8	0	958	0.3954		982	
25	13	48	ER	28.0	19.8	15.3	11.0	0	958	0.1508		410	
26	13	56	NEE	27.3	17.5	12.7	10.0	363	958	-0.0580	-160		744
27	14	13	NEE	27.2	21.2	14.1	11.1	687	958	-0.0360	-94		614
28	14	32	NEE	26.4	28.9	11.7	8.8	515	957	-0.1361	-372		843
29	15	32	NEE	20.2	19.6	11.6	12.2	338	957	-0.0849	-232		568
30	15	5	NEE	23.8	21.7	13.9	10.9	450	957	0.0904	238		748
26	14	3	ER	27.0	17.5	12.7	10.0	0	957	0.2116		584	
27	14	19	ER	27.3	21.2	14.1	11.1	0	957	0.1997		520	
28	14	44	ER	24.4	28.9	11.7	8.8	0	957	0.1713		471	
29	15	45	ER	18.0	19.6	11.6	12.2	0	957	0.1226		337	
30	15	12	ER	23.7	21.7	13.9	10.9	0	957	0.3744		986	

S.Table 18: CO_2-flux measurements and environmental parameters on 4 and 5 Sep.

Plot	Measurement Time		Measurem. type	Chamber temp.	Soil moisture	Soil temp 2cm	Soil temp 5cm	PAR	Chamber pressure	Flux slope	CO_2 flux		
											mg CO2 m^2 h^{-1}		
	hour	min	NEE / ER	°C	vol %	°C	°C	µ mol m^2 s^{-1}	mbar	ppm s^{-1}	NEE	ER	GEP
1	13	49	NEE	15.4	33.4	9.4	8.6	220	931	0.0647	142		320
2	14	7	NEE	13.2	25.0	11.1	9.9	181	932	0.0442	90		328
3	14	27	NEE	12.1	19.3	10.1	9.5	151	932	0.1408	304		189
4	14	41	NEE	11.6	27.6	10.7	10.1	190	932	0.2252	588		269
5	14	53	NEE	11.5	27.6	9.8	9.0	231	932	-0.0021	-4		410
1	13	55	ER	14.6	33.4	9.4	8.6	0	932	0.2098		462	
2	14	20	ER	12.6	25.0	11.1	9.9	27	932	0.2053		417	
3	14	34	ER	11.7	19.3	10.1	9.5	7	932	0.2279		493	
4	14	47	ER	11.5	27.6	10.7	10.1	2	932	0.3281		858	
5	15	1	ER	11.4	27.6	9.8	9.0	0	932	0.1931		406	
6	15	11	NEE	11.5	28.4	11.6	11.2	164	933	0.0289	66		344
7	15	25	NEE	11.5	31.5	9.6	8.6	206	933	0.0305	62		306
8	15	38	NEE	11.8	26.3	9.6	8.9	210	933	0.0282	63		274
9	15	51	NEE	12.0	35.4	9.9	8.7	186	933	-0.0008	-2		229
10	16	5	NEE	12.4	28.3	10.0	8.8	199	933	0.2120	566		268
6	15	18	ER	11.4	28.4	11.6	11.2	0	933	0.1788		410	
7	15	32	ER	11.6	31.5	9.6	8.6	0	933	0.1805		369	
8	15	44	ER	11.9	26.3	9.6	8.9	0	933	0.1511		336	
9	15	59	ER	12.1	35.4	9.9	8.7	0	933	0.0966		227	
10	16	13	ER	12.1	28.3	10.0	8.8	24	933	0.3119		834	
11	11	9	NEE	9.5	26.6	7.6	7.8	84	934	0.0626	137		160
12	11	23	NEE	9.7	18.2	7.8	7.4	89	934	0.0538	114		147
13	11	37	NEE	9.9	17.0	8.5	7.9	95	934	0.1061	225		152
14	11	50	NEE	10.1	21.3	8.1	7.9	93	934	0.0704	131		142
15	12	5	NEE	10.3	22.5	8.1	7.8	116	934	0.1950	525		125
11	11	15	ER	9.7	26.6	7.6	7.8	0	934	0.1362		297	
12	11	30	ER	9.8	18.2	7.8	7.4	0	934	0.1233		261	
13	11	44	ER	10.0	17.0	8.5	7.9	0	934	0.1781		377	
14	11	58	ER	10.2	21.3	8.1	7.9	0	934	0.1468		274	
15	12	12	ER	10.5	22.5	8.1	7.8	0	934	0.2416		650	
16	12	20	NEE	10.7	20.3	8.2	7.7	128	934	0.0473	115		161
17	12	26	NEE	10.9	24.2	7.7	7.3	132	934	0.0461	106		243
18	13	3	NEE	11.8	25.5	8.2	7.4	224	934	0.0738	193		364
19	13	18	NEE	12.4	25.1	8.0	6.9	232	934	-0.0653	-137		423
20	13	33	NEE	12.4	23.8	9.1	7.6	187	934	0.0043	12		405
16	12	32	ER	10.9	20.3	8.2	7.7	0	934	0.1136		275	
17	12	57	ER	11.4	24.2	7.7	7.3	0	934	0.1522		349	
18	13	11	ER	12.3	25.5	8.2	7.4	0	934	0.2133		557	
19	13	26	ER	12.3	25.1	8.0	6.9	0	934	0.1363		286	
20	13	41	ER	12.2	23.8	9.1	7.6	0	934	0.1489		417	
21	13	36	NEE	17.5	23.4	10.0	9.6	270	931	0.0323	86		200
22	13	23	NEE	19.6	27.5	11.2	9.6	674	931	-0.0412	-110		452
23	13	8	NEE	16.7	23.1	13.8	11.8	363	931	-0.2293	-602		1008
24	12	55	NEE	15.8	21.5	11.7	10.1	399	931	-0.0598	-150		775
25	12	42	NEE	16.4	26.3	11.4	10.0	588	931	-0.0206	-57		373
21	13	42	ER	16.5	23.4	10.0	9.6	18	931	0.1065		286	
22	13	29	ER	18.9	27.5	11.2	9.6	19	931	0.1282		342	
23	13	14	ER	17.8	23.1	13.8	11.8	18	931	0.1552		406	
24	13	1	ER	15.6	21.5	11.7	10.1	0	931	0.2487		625	
25	12	48	ER	16.1	26.3	11.4	10.0	0	931	0.1149		316	
26	12	28	NEE	16.4	26.5	11.6	9.9	303	931	0.0197	55		394
27	12	9	NEE	20.3	25.2	10.1	8.3	654	931	0.0038	10		321
28	11	54	NEE	20.1	26.8	10.0	8.4	752	930	-0.1002	-272		632
29	11	42	NEE	20.0	31.6	9.8	8.7	804	931	-0.1292	-343		854
30	11	24	NEE	19.9	22.4	10.9	8.4	407	930	0.1315	341		657
26	12	35	ER	16.1	26.5	11.6	9.9	0	931	0.1612		449	
27	12	15	ER	18.9	25.2	10.1	8.3	0	931	0.1272		331	
28	12	2	ER	20.5	26.8	10.0	8.4	0	930	0.1328		360	
29	11	48	ER	19.5	31.6	9.8	8.7	1	930	0.1921		511	
30	11	36	ER	19.3	22.4	10.9	8.4	0	931	0.3840		999	

S.Table 19: CO_2-flux measurements and environmental parameters on 11 and 12 Sep.

Plot	Measurement Time		Measurem. type	Chamber temp.	Soil moisture	Soil temp 2cm	Soil temp 5cm	PAR	Chamber pressure	Flux slope	CO_2 flux		
											mg CO2 m^2 h^{-1}		
	hour	min	NEE / ER	°C	vol %	°C	°C	µ mol m^2 s^{-1}	mbar	ppm s^{-1}	NEE	ER	GEP
1	16	19	NEE	10.1	22.0	8.0	7.1	274	963	0.0085	20		232
2	16	2	NEE	9.5	18.3	6.9	7.7	307	963	-0.0307	-65		223
3	15	44	NEE	9.2	16.6	6.7	7.9	334	963	0.0253	57		272
4	15	17	NEE	9.6	19.2	5.9	6.0	424	962	-0.0804	-218		478
5	15	0	NEE	10.1	23.2	8.4	7.8	458	962	-0.0300	-65		329
1	16	24	ER	10.1	22.0	8.0	7.1	0	963	0.1087		251	
2	16	11	ER	9.2	18.3	6.9	7.7	0	963	0.0741		157	
3	15	53	ER	8.9	16.6	6.7	7.9	0	963	0.1459		329	
4	15	35	ER	8.5	19.2	5.9	6.0	0	963	0.0952		260	
5	15	9	ER	9.6	23.2	8.4	7.8	0	962	0.1206		263	
6	12	42	NEE	13.5	22.4	4.8	3.9	588	957	-0.0395	-92		433
7	12	25	NEE	13.2	24.4	3.8	3.6	639	957	-0.0806	-168		383
8	12	2	NEE	13.4	26.5	4.4	3.8	575	957	-0.0159	-36		269
9	11	42	NEE	12.5	29.9	3.9	4.1	506	957	-0.0450	-108		230
10	11	23	NEE	13.1	30.7	2.0	3.5	248	956	-0.0240	-66		164
6	12	51	ER	12.6	22.4	4.8	3.9	0	957	0.1455		341	
7	12	34	ER	13.4	24.4	3.8	3.6	0	957	0.1033		215	
8	12	16	ER	12.5	26.5	4.4	3.8	0	957	0.1023		233	
9	11	53	ER	12.9	29.9	3.9	4.1	0	957	0.0507		122	
10	11	33	ER	12.0	30.7	2.0	3.5	0	956	0.0358		98	
11	11	48	NEE	13.3	22.6	6.0	5.6	254	962	-0.0906	-201		395
12	12	6	NEE	13.5	18.5	7.5	6.6	607	962	-0.0066	-14		198
13	12	24	NEE	14.7	16.1	9.0	7.9	470	962	-0.1153	-248		521
14	12	41	NEE	16.1	19.9	8.9	7.1	616	962	-0.1035	-195		426
15	12	59	NEE	16.1	23.8	7.9	7.2	632	962	-0.0106	-29		515
11	11	58	ER	12.8	22.6	6.0	5.6	0	962	0.0870		193	
12	12	15	ER	13.6	18.5	7.5	6.6	0	962	0.0852		183	
13	12	33	ER	15.7	16.1	9.0	7.9	0	962	0.1279		273	
14	12	50	ER	15.8	19.9	8.9	7.1	0	962	0.1227		231	
15	13	11	ER	16.9	23.8	7.9	7.2	0	962	0.1792		486	
16	13	15	NEE	13.3	19.9	5.2	4.3	602	957	-0.0538	-133		365
17	13	32	NEE	12.1	21.2	5.4	5.4	556	957	0.0262	61		213
18	13	49	NEE	11.4	25.4	5.8	5.3	544	957	-0.0245	-66		368
19	14	6	NEE	11.8	28.9	5.0	4.5	709	957	-0.1546	-333		558
20	14	23	NEE	12.8	22.7	7.6	6.3	588	957	-0.0057	-16		362
16	13	24	ER	12.2	19.9	5.2	4.3	0	957	0.0938		232	
17	13	41	ER	11.3	21.2	5.4	5.4	0	957	0.1168		275	
18	13	58	ER	11.1	25.4	5.8	5.3	0	957	0.1124		302	
19	14	15	ER	12.2	28.9	5.0	4.5	0	957	0.1044		225	
20	14	33	ER	13.3	22.7	7.6	6.3	0	957	0.1208		345	
21	14	42	NEE	13.9	24.5	6.1	5.3	558	957	-0.0274	-76		280
22	14	59	NEE	13.0	22.3	5.6	5.9	537	958	-0.0205	-57		279
23	15	18	NEE	12.4	16.8	6.5	5.8	626	958	-0.0788	-216		543
24	15	38	NEE	13.4	21.3	7.1	6.4	509	958	-0.0971	-253		572
25	15	57	NEE	13.1	23.5	5.5	6.0	408	958	0.0390	112		189
21	14	51	ER	13.0	24.5	6.1	5.3	0	957	0.0727		203	
22	15	8	ER	12.4	22.3	5.6	5.9	0	958	0.0790		222	
23	15	27	ER	13.3	16.8	6.5	5.8	0	958	0.1196		327	
24	15	48	ER	12.5	21.3	7.1	6.4	0	958	0.1221		319	
25	16	5	ER	12.2	23.5	5.5	6.0	0	958	0.1047		301	
26	13	20	NEE	16.5	19.0	7.0	6.8	490	962	-0.0218	-63		421
27	13	37	NEE	15.4	24.3	6.4	5.4	613	962	0.0543	148		61
28	13	55	NEE	14.1	29.0	6.7	6.1	568	962	-0.0350	-100		373
29	14	23	NEE	12.4	20.9	6.7	6.3	537	962	-0.0269	-76		338
30	14	40	NEE	11.2	24.2	6.4	6.0	527	962	0.0091	25		160
26	13	28	ER	15.7	19.0	7.0	6.8	0	962	0.1245		359	
27	13	47	ER	14.1	24.3	6.4	5.4	0	962	0.0765		209	
28	14	14	ER	12.2	29.0	6.7	6.1	0	962	0.0944		272	
29	14	31	ER	11.3	20.9	6.7	6.3	0	962	0.0928		263	
30	14	49	ER	10.3	24.2	6.4	6.0	0	962	0.0666		185	

S.Table 20: CO_2-flux measurements and environmental parameters on 19 and 20 Sep.

10.5 Data of enzyme activities

Plot	Soil depth	Soil mass*	water content	dry weight	Enzyme	Activity
Nr.	cm	(g)	(g water g^{-1} soil)	(g)		(nmol g^{-1} soil h^{-1})
1	0-5	0.994	385	0.204764	BX	121.25
2	0-5	0.985	558	0.14972	BX	41.75
3	0-5	0.978	594	0.140832	BX	93.16
4	0-5	0.999	488	0.16983	BX	102.99
5	0-5	0.964	294	0.244856	BX	130.63
6	0-5	0.975	355	0.2145	BX	76.78
7	0-5	0.962	339	0.219336	BX	123.32
8	0-5	0.991	488	0.16847	BX	181.8
9	0-5	0.968	255	0.272976	BX	100.04
10	0-5	0.965	533	0.15247	BX	179.27
11	0-5	0.963	694	0.121338	BX	48.56
12	0-5	0.963	576	0.142524	BX	81.3
13	0-5	1.011	456	0.18198	BX	101.59
14	0-5	0.978	475	0.170172	BX	75.42
15	0-5	0.951	339	0.216828	BX	124.12
16	0-5	0.995	297	0.25074	BX	203.73
17	0-5	0.995	313	0.24079	BX	27.06
18	0-5	0.946	276	0.251636	BX	34.06
19	0-5	0.94	238	0.27824	BX	165.12
20	0-5	0.975	242	0.2847	BX	143.86
21	0-5	0.959	381	0.199472	BX	69.35
22	0-5	0.943	438	0.175398	BX	57.49
23	0-5	0.994	510	0.163016	BX	86.77
24	0-5	0.947	443	0.174248	BX	41.08
25	0-5	0.951	268	0.258672	BX	135.52
26	0-5	0.94	300	0.235	BX	44.23
27	0-5	0.963	279	0.254232	BX	43.18
28	0-5	1.036	252	0.294224	BX	245.28
29	0-5	0.936	223	0.29016	BX	121.23
30	0-5	0.945	297	0.23814	BX	74.42
1	0-5	0.994	385	0.204764	CB	169.85
2	0-5	0.985	558	0.14972	CB	24.56
3	0-5	0.978	594	0.140832	CB	81.47
4	0-5	0.999	488	0.16983	CB	36.4
5	0-5	0.964	294	0.244856	CB	69.74
6	0-5	0.975	355	0.2145	CB	75.91
7	0-5	0.962	339	0.219336	CB	56.81
8	0-5	0.991	488	0.16847	CB	52.73
9	0-5	0.968	255	0.272976	CB	63.42
10	0-5	0.965	533	0.15247	CB	222.87
11	0-5	0.963	694	0.121338	CB	30.08
12	0-5	0.963	576	0.142524	CB	82.26
13	0-5	1.011	456	0.18198	CB	66.76
14	0-5	0.978	475	0.170172	CB	248.43
15	0-5	0.951	339	0.216828	CB	94.41
16	0-5	0.995	297	0.25074	CB	177.33
17	0-5	0.995	313	0.24079	CB	9.35
18	0-5	0.946	276	0.251636	CB	52.83
19	0-5	0.94	238	0.27824	CB	105.81
20	0-5	0.975	242	0.2847	CB	103.66
21	0-5	0.959	381	0.199472	CB	98.43
22	0-5	0.943	438	0.175398	CB	50.24
23	0-5	0.994	510	0.163016	CB	107.14
24	0-5	0.947	443	0.174248	CB	30.26
25	0-5	0.951	268	0.258672	CB	140.23
26	0-5	0.94	300	0.235	CB	29.86
27	0-5	0.963	279	0.254232	CB	7.95
28	0-5	1.036	252	0.294224	CB	210.68
29	0-5	0.936	223	0.29016	CB	42.49
30	0-5	0.945	297	0.23814	CB	78.98

S.Table 21: Data used for enzyme activity calculation: 0-5cm, BX and CB. * mass of soil suspended in 100ml Buffer for Enzyme Assay.

Plot	Soil depth	Soil mass*	water content	dry weight	Enzyme	Activity
Nr.	cm	(g)	(g water g^{-1} soil)	(g)		(nmol g^{-1} soil h^{-1})
1	0-5	0.994	385	0.204764	BG	2259.6
2	0-5	0.985	558	0.14972	BG	1103.74
3	0-5	0.978	594	0.140832	BG	1202.57
4	0-5	0.999	488	0.16983	BG	1230.26
5	0-5	0.964	294	0.244856	BG	1344.16
6	0-5	0.975	355	0.2145	BG	1304.93
7	0-5	0.962	339	0.219336	BG	1347.14
8	0-5	0.991	488	0.16847	BG	2329.22
9	0-5	0.968	255	0.272976	BG	1330.74
10	0-5	0.965	533	0.15247	BG	2616.4
11	0-5	0.963	694	0.121338	BG	1337.93
12	0-5	0.963	576	0.142524	BG	1556.67
13	0-5	1.011	456	0.18198	BG	1572.49
14	0-5	0.978	475	0.170172	BG	1041.35
15	0-5	0.951	339	0.216828	BG	1611.58
16	0-5	0.995	297	0.25074	BG	1267.41
17	0-5	0.995	313	0.24079	BG	573.33
18	0-5	0.946	276	0.251636	BG	913.61
19	0-5	0.94	238	0.27824	BG	1445
20	0-5	0.975	242	0.2847	BG	869.96
21	0-5	0.959	381	0.199472	BG	1372.44
22	0-5	0.943	438	0.175398	BG	589.45
23	0-5	0.994	510	0.163016	BG	1331.86
24	0-5	0.947	443	0.174248	BG	593.21
25	0-5	0.951	268	0.258672	BG	891.29
26	0-5	0.94	300	0.235	BG	808.19
27	0-5	0.963	279	0.254232	BG	482.88
28	0-5	1.036	252	0.294224	BG	1073.9
29	0-5	0.936	223	0.29016	BG	778.8
30	0-5	0.945	297	0.23814	BG	1081.09
1	0-5	0.994	385	0.204764	NAG	712.05
2	0-5	0.985	558	0.14972	NAG	414.83
3	0-5	0.978	594	0.140832	NAG	439.74
4	0-5	0.999	488	0.16983	NAG	512.93
5	0-5	0.964	294	0.244856	NAG	715.33
6	0-5	0.975	355	0.2145	NAG	517.99
7	0-5	0.962	339	0.219336	NAG	811.46
8	0-5	0.991	488	0.16847	NAG	1173.87
9	0-5	0.968	255	0.272976	NAG	435.8
10	0-5	0.965	533	0.15247	NAG	1122.1
11	0-5	0.963	694	0.121338	NAG	487.54
12	0-5	0.963	576	0.142524	NAG	444.76
13	0-5	1.011	456	0.18198	NAG	400.84
14	0-5	0.978	475	0.170172	NAG	301.65
15	0-5	0.951	339	0.216828	NAG	658.57
16	0-5	0.995	297	0.25074	NAG	1175.75
17	0-5	0.995	313	0.24079	NAG	299.61
18	0-5	0.946	276	0.251636	NAG	552.01
19	0-5	0.94	238	0.27824	NAG	697.72
20	0-5	0.975	242	0.2847	NAG	775.19
21	0-5	0.959	381	0.199472	NAG	816.81
22	0-5	0.943	438	0.175398	NAG	539.02
23	0-5	0.994	510	0.163016	NAG	288.77
24	0-5	0.947	443	0.174248	NAG	437.9
25	0-5	0.951	268	0.258672	NAG	588.02
26	0-5	0.94	300	0.235	NAG	289.15
27	0-5	0.963	279	0.254232	NAG	474.1
28	0-5	1.036	252	0.294224	NAG	482.05
29	0-5	0.936	223	0.29016	NAG	540.65
30	0-5	0.945	297	0.23814	NAG	612.98

S.Table 22: Data used for enzyme activity calculation: 0-5cm, BG and NAG. * mass of soil suspended in 100ml Buffer for Enzyme Assay.

Plot	Soil depth	Soil mass *	water content	dry weight	Enzyme	Activity
Nr.	cm	(g)	(g Water g^{-1} Soil)	(g)		(nmol g^{-1} soil h^{-1})
1	0-5	0.994	385	0.204764	AP	3582.08
2	0-5	0.985	558	0.14972	AP	2576.78
3	0-5	0.978	594	0.140832	AP	1200.27
4	0-5	0.999	488	0.16983	AP	1779.87
5	0-5	0.964	294	0.244856	AP	3411
6	0-5	0.975	355	0.2145	AP	1998.76
7	0-5	0.962	339	0.219336	AP	3373.74
8	0-5	0.991	488	0.16847	AP	4002.58
9	0-5	0.968	255	0.272976	AP	3628.45
10	0-5	0.965	533	0.15247	AP	3822.86
11	0-5	0.963	694	0.121338	AP	1927.69
12	0-5	0.963	576	0.142524	AP	2238.65
13	0-5	1.011	456	0.18198	AP	1989.38
14	0-5	0.978	475	0.170172	AP	1407.16
15	0-5	0.951	339	0.216828	AP	2430.82
16	0-5	0.995	297	0.25074	AP	5645.23
17	0-5	0.995	313	0.24079	AP	2826.43
18	0-5	0.946	276	0.251636	AP	2286.53
19	0-5	0.94	238	0.27824	AP	7462.58
20	0-5	0.975	242	0.2847	AP	4406.48
21	0-5	0.959	381	0.199472	AP	4597.87
22	0-5	0.943	438	0.175398	AP	4229.06
23	0-5	0.994	510	0.163016	AP	4834.46
24	0-5	0.947	443	0.174248	AP	1897.29
25	0-5	0.951	268	0.258672	AP	3704.43
26	0-5	0.94	300	0.235	AP	2708.19
27	0-5	0.963	279	0.254232	AP	2425.09
28	0-5	1.036	252	0.294224	AP	2337.88
29	0-5	0.936	223	0.29016	AP	2209.85
30	0-5	0.945	297	0.23814	AP	3077.88
1	0-5	0.994	385	0.204764	LAP	2066.22
2	0-5	0.985	558	0.14972	LAP	844.05
3	0-5	0.978	594	0.140832	LAP	1715.56
4	0-5	0.999	488	0.16983	LAP	1605.19
5	0-5	0.964	294	0.244856	LAP	1200.7
6	0-5	0.975	355	0.2145	LAP	1988.32
7	0-5	0.962	339	0.219336	LAP	1808.06
8	0-5	0.991	488	0.16847	LAP	2587.93
9	0-5	0.968	255	0.272976	LAP	1133.17
10	0-5	0.965	533	0.15247	LAP	3498.95
11	0-5	0.963	694	0.121338	LAP	1464.54
12	0-5	0.963	576	0.142524	LAP	1916.29
13	0-5	1.011	456	0.18198	LAP	1561.04
14	0-5	0.978	475	0.170172	LAP	1670.51
15	0-5	0.951	339	0.216828	LAP	1914.05
16	0-5	0.995	297	0.25074	LAP	1872.01
17	0-5	0.995	313	0.24079	LAP	1548.91
18	0-5	0.946	276	0.251636	LAP	1187.99
19	0-5	0.94	238	0.27824	LAP	1485.77
20	0-5	0.975	242	0.2847	LAP	1426.02
21	0-5	0.959	381	0.199472	LAP	1912.04
22	0-5	0.943	438	0.175398	LAP	1395.24
23	0-5	0.994	510	0.163016	LAP	2954.14
24	0-5	0.947	443	0.174248	LAP	1732.81
25	0-5	0.951	268	0.258672	LAP	1347.9
26	0-5	0.94	300	0.235	LAP	1418.24
27	0-5	0.963	279	0.254232	LAP	1312.31
28	0-5	1.036	252	0.294224	LAP	2228.45
29	0-5	0.936	223	0.29016	LAP	1636.37
30	0-5	0.945	297	0.23814	LAP	2035.38

S.Table 23: Data used for enzyme activity calculation: 0-5cm, AP and LAP. *Mass of soil suspended in 100ml Buffer for Enzyme Assay.

Plot	Soil depth	Soil mass *	water content	dry weight	Enzyme	Activity
Nr.	cm	(g)	(g Water g^{-1} Soil)	(g)		(nmol g^{-1} soil h^{-1})
1	5-10	0.975	380.7692308	0.2028	BX	197.4120545
2	5-10	0.979	584.9315068	0.142934	BX	156.1856371
3	5-10	0.966	541.025641	0.150696	BX	215.3466822
4	5-10	0.963	495.2380952	0.161784	BX	142.5204891
5	5-10	0.975	323.7288136	0.2301	BX	180.86574
6	5-10	0.96	323.7288136	0.22656	BX	154.5477979
7	5-10	0.992	624.6376812	0.136896	BX	302.671098
8	5-10	0.951	247.2222222	0.273888	BX	189.161659
9	5-10	0.967	145.0980392	0.394536	BX	57.10068579
10	5-10	0.961	262.3188406	0.265236	BX	171.2372561
11	5-10	1.003	861.5384615	0.104312	BX	278.2590428
12	5-10	0.96	549.3506494	0.14784	BX	235.5443528
13	5-10	0.995	443.4782609	0.18308	BX	190.4283146
14	5-10	1.049	455.5555556	0.18882	BX	177.9510408
15	5-10	0.995	281.6793893	0.26069	BX	273.6204403
16	5-10	0.98	254.6099291	0.27636	BX	166.2669126
17	5-10	0.98	287.5968992	0.25284	BX	161.9342837
18	5-10	0.96	287.5968992	0.24768	BX	180.7557393
19	5-10	0.99	267.6470588	0.26928	BX	145.405091
20	5-10	0.96	270.3703704	0.2592	BX	124.1274732
21	5-10	1.02	385.4368932	0.21012	BX	237.241324
22	5-10	0.97	410.2040816	0.19012	BX	139.9119321
23	5-10	1.08	437.6344086	0.20088	BX	183.7058077
24	5-10	1.01	420.8333333	0.19392	BX	182.2162701
25	5-10	0.96	303.2258065	0.23808	BX	198.8322544
26	5-10	0.95	247.2222222	0.2736	BX	119.3559021
27	5-10	0.96	267.6470588	0.26112	BX	173.6113526
28	5-10	0.94	273.1343284	0.25192	BX	161.7470411
29	5-10	1.05	247.2222222	0.3024	BX	126.9233372
30	5-10	0.95	237.8378378	0.2812	BX	164.9095593
1	5-10	0.975	380.7692308	0.2028	CB	102.3334057
2	5-10	0.979	584.9315068	0.142934	CB	188.2476513
3	5-10	0.966	541.025641	0.150696	CB	243.770545
4	5-10	0.963	495.2380952	0.161784	CB	211.2180001
5	5-10	0.975	323.7288136	0.2301	CB	210.6047915
6	5-10	0.96	323.7288136	0.22656	CB	181.255075
7	5-10	0.992	624.6376812	0.136896	CB	399.2860925
8	5-10	0.951	247.2222222	0.273888	CB	317.2657752
9	5-10	0.967	145.0980392	0.394536	CB	43.52491727
10	5-10	0.961	262.3188406	0.265236	CB	180.0244213
11	5-10	1.003	861.5384615	0.104312	CB	255.4746467
12	5-10	0.96	549.3506494	0.14784	CB	201.4290009
13	5-10	0.995	443.4782609	0.18308	CB	105.0467656
14	5-10	1.049	455.5555556	0.18882	CB	161.3135808
15	5-10	0.995	281.6793893	0.26069	CB	328.5565478
16	5-10	0.98	254.6099291	0.27636	CB	182.6524102
17	5-10	0.98	287.5968992	0.25284	CB	172.3794154
18	5-10	0.96	287.5968992	0.24768	CB	186.6113927
19	5-10	0.99	267.6470588	0.26928	CB	148.7458099
20	5-10	0.96	270.3703704	0.2592	CB	124.0260215
21	5-10	1.02	385.4368932	0.21012	CB	250.0662317
22	5-10	0.97	410.2040816	0.19012	CB	54.37497249
23	5-10	1.08	437.6344086	0.20088	CB	184.0035574
24	5-10	1.01	420.8333333	0.19392	CB	174.4051246
25	5-10	0.96	303.2258065	0.23808	CB	216.0818015
26	5-10	0.95	247.2222222	0.2736	CB	150.0628437
27	5-10	0.96	267.6470588	0.26112	CB	199.540386
28	5-10	0.94	273.1343284	0.25192	CB	157.1712379
29	5-10	1.05	247.2222222	0.3024	CB	162.0405257
30	5-10	0.95	237.8378378	0.2812	CB	185.8073246

S.Table 24: Data used for enzyme activity calculation: 5-10cm, BX and CB. *Mass of soil suspended in 100ml Buffer for Enzyme Assay.

Plot	Soil depth	Soil mass *	water content	dry weight	Enzyme	Activity
Nr.	cm	(g)	(g Water g^{-1} Soil)	(g)		(nmol g^{-1} soil h^{-1})
1	5-10	0.975	380.7692308	0.2028	BG	1442.542187
2	5-10	0.979	584.9315068	0.142934	BG	1360.022226
3	5-10	0.966	541.025641	0.150696	BG	1688.938716
4	5-10	0.963	495.2380952	0.161784	BG	1249.354714
5	5-10	0.975	323.7288136	0.2301	BG	1638.642168
6	5-10	0.96	323.7288136	0.22656	BG	1512.138729
7	5-10	0.992	624.6376812	0.136896	BG	2620.358504
8	5-10	0.951	247.2222222	0.273888	BG	1946.328021
9	5-10	0.967	145.0980392	0.394536	BG	413.2808702
10	5-10	0.961	262.3188406	0.265236	BG	1463.823347
11	5-10	1.003	861.5384615	0.104312	BG	2121.224486
12	5-10	0.96	549.3506494	0.14784	BG	2001.877938
13	5-10	0.995	443.4782609	0.18308	BG	1535.750824
14	5-10	1.049	455.5555556	0.18882	BG	1300.55251
15	5-10	0.995	281.6793893	0.26069	BG	2212.010083
16	5-10	0.98	254.6099291	0.27636	BG	1752.243471
17	5-10	0.98	287.5968992	0.25284	BG	1659.719631
18	5-10	0.96	287.5968992	0.24768	BG	1574.780215
19	5-10	0.99	267.6470588	0.26928	BG	921.9271149
20	5-10	0.96	270.3703704	0.2592	BG	813.8543612
21	5-10	1.02	385.4368932	0.21012	BG	2484.571126
22	5-10	0.97	410.2040816	0.19012	BG	899.6210154
23	5-10	1.08	437.6344086	0.20088	BG	1673.401544
24	5-10	1.01	420.8333333	0.19392	BG	2280.339247
25	5-10	0.96	303.2258065	0.23808	BG	1780.161335
26	5-10	0.95	247.2222222	0.2736	BG	1305.6813
27	5-10	0.96	267.6470588	0.26112	BG	1745.110733
28	5-10	0.94	273.1343284	0.25192	BG	1474.210311
29	5-10	1.05	247.2222222	0.3024	BG	1383.73412
30	5-10	0.95	237.8378378	0.2812	BG	1700.085972
1	5-10	0.975	380.7692308	0.2028	NAG	1317.343314
2	5-10	0.979	584.9315068	0.142934	NAG	755.7166553
3	5-10	0.966	541.025641	0.150696	NAG	612.8784322
4	5-10	0.963	495.2380952	0.161784	NAG	670.9534748
5	5-10	0.975	323.7288136	0.2301	NAG	1103.849294
6	5-10	0.96	323.7288136	0.22656	NAG	706.9176845
7	5-10	0.992	624.6376812	0.136896	NAG	1487.511073
8	5-10	0.951	247.2222222	0.273888	NAG	905.6575964
9	5-10	0.967	145.0980392	0.394536	NAG	385.7334188
10	5-10	0.961	262.3188406	0.265236	NAG	607.0574715
11	5-10	1.003	861.5384615	0.104312	NAG	1997.00363
12	5-10	0.96	549.3506494	0.14784	NAG	732.1054466
13	5-10	0.995	443.4782609	0.18308	NAG	292.0802825
14	5-10	1.049	455.5555556	0.18882	NAG	409.7775511
15	5-10	0.995	281.6793893	0.26069	NAG	968.870052
16	5-10	0.98	254.6099291	0.27636	NAG	1249.150114
17	5-10	0.98	287.5968992	0.25284	NAG	1733.662938
18	5-10	0.96	287.5968992	0.24768	NAG	1067.7927
19	5-10	0.99	267.6470588	0.26928	NAG	976.6675793
20	5-10	0.96	270.3703704	0.2592	NAG	775.9001044
21	5-10	1.02	385.4368932	0.21012	NAG	1140.382702
22	5-10	0.97	410.2040816	0.19012	NAG	571.5029618
23	5-10	1.08	437.6344086	0.20088	NAG	656.3329989
24	5-10	1.01	420.8333333	0.19392	NAG	1229.012985
25	5-10	0.96	303.2258065	0.23808	NAG	992.2603695
26	5-10	0.95	247.2222222	0.2736	NAG	523.0939723
27	5-10	0.96	267.6470588	0.26112	NAG	858.3705749
28	5-10	0.94	273.1343284	0.25192	NAG	756.1321428
29	5-10	1.05	247.2222222	0.3024	NAG	1030.040754
30	5-10	0.95	237.8378378	0.2812	NAG	820.4980561

S.Table 25: Data used for enzyme activity calculation: 5-10cm, BG and NAG. *Mass of soil suspended in 100ml Buffer for Enzyme Assay.

Plot	Soil depth	Soil mass *	water content	dry weight	Enzyme	Activity
Nr.	cm	(g)	(g Water g^{-1} Soil)	(g)		(nmol g^{-1} soil h^{-1})
1	5-10	0.975	380.7692308	0.2028	AP	2413.292658
2	5-10	0.979	584.9315068	0.142934	AP	1837.637156
3	5-10	0.966	541.025641	0.150696	AP	1925.097583
4	5-10	0.963	495.2380952	0.161784	AP	1568.942661
5	5-10	0.975	323.7288136	0.2301	AP	1621.082292
6	5-10	0.96	323.7288136	0.22656	AP	2106.425892
7	5-10	0.992	624.6376812	0.136896	AP	4278.280093
8	5-10	0.951	247.2222222	0.273888	AP	3250.859077
9	5-10	0.967	145.0980392	0.394536	AP	1425.468116
10	5-10	0.961	262.3188406	0.265236	AP	1986.811305
11	5-10	1.003	861.5384615	0.104312	AP	2474.98153
12	5-10	0.96	549.3506494	0.14784	AP	2102.821593
13	5-10	0.995	443.4782609	0.18308	AP	1961.035659
14	5-10	1.049	455.5555556	0.18882	AP	2306.248953
15	5-10	0.995	281.6793893	0.26069	AP	2044.327222
16	5-10	0.98	254.6099291	0.27636	AP	3704.605891
17	5-10	0.98	287.5968992	0.25284	AP	1903.161253
18	5-10	0.96	287.5968992	0.24768	AP	1686.530106
19	5-10	0.99	267.6470588	0.26928	AP	1930.633021
20	5-10	0.96	270.3703704	0.2592	AP	1969.082876
21	5-10	1.02	385.4368932	0.21012	AP	2472.441099
22	5-10	0.97	410.2040816	0.19012	AP	1523.655139
23	5-10	1.08	437.6344086	0.20088	AP	1979.410779
24	5-10	1.01	420.8333333	0.19392	AP	2540.118975
25	5-10	0.96	303.2258065	0.23808	AP	1532.281268
26	5-10	0.95	247.2222222	0.2736	AP	1077.533944
27	5-10	0.96	267.6470588	0.26112	AP	2302.257524
28	5-10	0.94	273.1343284	0.25192	AP	1589.394077
29	5-10	1.05	247.2222222	0.3024	AP	1535.359032
30	5-10	0.95	237.8378378	0.2812	AP	2327.203326
1	5-10	0.975	380.7692308	0.2028	LAP	3849.260103
2	5-10	0.979	584.9315068	0.142934	LAP	3791.11262
3	5-10	0.966	541.025641	0.150696	LAP	4969.854509
4	5-10	0.963	495.2380952	0.161784	LAP	4616.337777
5	5-10	0.975	323.7288136	0.2301	LAP	3440.309682
6	5-10	0.96	323.7288136	0.22656	LAP	3784.077594
7	5-10	0.992	624.6376812	0.136896	LAP	6111.334655
8	5-10	0.951	247.2222222	0.273888	LAP	3796.291142
9	5-10	0.967	145.0980392	0.394536	LAP	1294.497227
10	5-10	0.961	262.3188406	0.265236	LAP	3838.602484
11	5-10	1.003	861.5384615	0.104312	LAP	8111.695615
12	5-10	0.96	549.3506494	0.14784	LAP	5741.329904
13	5-10	0.995	443.4782609	0.18308	LAP	3772.590796
14	5-10	1.049	455.5555556	0.18882	LAP	3538.771329
15	5-10	0.995	281.6793893	0.26069	LAP	3830.377917
16	5-10	0.98	254.6099291	0.27636	LAP	3383.60864
17	5-10	0.98	287.5968992	0.25284	LAP	3644.790226
18	5-10	0.96	287.5968992	0.24768	LAP	3298.471
19	5-10	0.99	267.6470588	0.26928	LAP	3030.388456
20	5-10	0.96	270.3703704	0.2592	LAP	2274.099269
21	5-10	1.02	385.4368932	0.21012	LAP	3775.750261
22	5-10	0.97	410.2040816	0.19012	LAP	4047.341571
23	5-10	1.08	437.6344086	0.20088	LAP	3089.048096
24	5-10	1.01	420.8333333	0.19392	LAP	3945.697572
25	5-10	0.96	303.2258065	0.23808	LAP	3187.139248
26	5-10	0.95	247.2222222	0.2736	LAP	2973.927539
27	5-10	0.96	267.6470588	0.26112	LAP	3633.390355
28	5-10	0.94	273.1343284	0.25192	LAP	3556.66619
29	5-10	1.05	247.2222222	0.3024	LAP	3207.877706
30	5-10	0.95	237.8378378	0.2812	LAP	2959.450275

S.Table 26: Data used for enzyme activity calculation: 5-10cm, AP and LAP. *Mass of soil suspended in 100ml Buffer for Enzyme Assay.