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Effects of Boreal Forest Fertilization on Soil Carbon and Ectomycorrhizal Fungi

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Management of Natural Resources

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Abstract

Boreal forests represent a large fraction of the global carbon (C) stock. Increasing attention is given to utilizing these forests in the battle against climate changed driven by increased atmospheric CO_2. Part of this solution is fertilizing boreal forests in order to increase C accumulation, as proposed by the Norwegian Environment Agency in the document “Klimakur 2030” (Søgaard et al., 2020). It is widely accepted that fertilization increase aboveground biomass production, but less is known about the effects is has on carbon storage in soil. Much of the accumulated C in boreal forests is stored in soil, where it persists many orders of magnitude longer than above ground. One of the pathways that leads C from CO_2 in the air to deep underground is through root associations between plants ectomycorrhizal (EM) fungi. These associations depend on a mutual benefit for both plant and fungus. There are indications that fertilization, and especially addition of nitrogen may disrupt this pathway, and consequently lessen the beneficial effect of fertilization. In this study fertilizer was added to sample plots in a forest in central Norway are part of a long term fertilization experiment started in 2013. Soil samples were taken on fertilized plots and nearby control plots at three dates during the growing season of 2019. The aim of the study was to identify if fertilization affects soil C and N as well as production and stocks of fungal biomass in the topmost organic soil, including litter, as well as the mineral soil directly beneath it. C and N content in organic topsoil was higher in fertilized plots than control plots on all sampling dates. Results show a similar increase in C, N and fungal biomass during the growing season in the upper organic soil layer for fertilized and control plots. The amount of total fungal biomass in the mineral rich lower soil layer was less in the fertilized plots at the end of the growing season. This can indicate production of newly formed mycelium or faster decomposition. The available literature shows contrasting effects of fertilization, and further study is required to fully understand the consequences for EM fungi and soil C stocks.

Sammendrag

Boreal skog utgjør en stor andel av det globale karbonlageret. Utnyttelse av denne skogen i kampen mot klimaendringer som følge av økt atmosfærisk CO_2 er i vinden som aldri før. Miljødirektoratet tar dette for seg i rapporten «Klimakur 2030», der de blant annet foreslår å øke skogens opptak av CO_2 ved å gjødsle den. Det er allment akseptert at gjødsling øker biomasseproduksjonen i treverket over bakken, men man vet mindre om effekten det har under jorda. En stor andel av karbonlageret i boreale skoger ligger i jorda, og karbonet her blir værende mye lenger enn det over bakken. En av måtene karbonet fra CO_2 ender opp dypt under bakken er via koblinger mellom planterøtter og en type sopp som kalles mykorrizasopp. Funksjonen av disse koplingene er bundet til et gjensidig avhengighetsforhold. Studier antyder at gjødsling kan forstyrre dette forholdet, spesielt gjelder dette tilførsel av nitrogen. Kort sagt kan det føre til at trærne ikke lenger vil sende like mye karbon ned under jorda, slik at fordelen man får ved å gjødsle blir mindre, og i verste fall kan snu til å bli negativt for langsiktig karbonlagring. Denne studien er en del av er skogsgjødslingforsøk som startet i 2003, og det ble tatt jordprøver av det organiske topplaget i tillegg til mineraljorden under, både av gjødslede prøveflater og nærliggende kontrollflater ved tre anledninger i løpet av vekstsesongen i 2019. Målet med studien var å undersøke om gjødsling påvirker mengden karbon, nitrogen og produksjon og lagring av soppbiomasse i jorda. Resultatene viser at mengden karbon, nitrogen og soppbiomasse øker i det øverste organiske jordlaget i løpet av vekstsesongen både for gjødslete flater og kontrollflater. Verdiene var også høyere ved den første prøvetakingen som ble gjort før gjødsling, dette viser en varig effekt av gjødslingsforsøket som startet i 2013. Det var også mindre soppbiomasse i den dypere mineraljorden ved enden av vekstsesongen. Dette kan bety lavere tilvekst av soppmycel, eller raskere nedbrytning. Det er motstridene resultater i litteraturen som omhandler effekten av skoggjødsling, og det er nødvendig med videre studier for å fullt ut forstå virkningene på mykorrizasopp og karbonlageret i jorda.

Introduction

A large proportion of the terrestrial carbon (C) storage is found in the soils of the coniferous forests that circumvent the globe in the boreal regions on the northern hemisphere (Bartlett et al., 2020). The cold climate with short growing seasons allows for higher net production than decomposition, leading to accumulation of organic matter (Bartlett et al., 2020). One important factor in this accumulation is the symbiotic relationship between trees and ectomycorrhizal fungi (EM fungi)(Maaroufi et al., 2015). Briefly, the rhizomes of trees are connected to fungal hyphae in such a way that nutrients can be exchanged. Plants and EM fungi take advantage of this by exchanging C and N. Plant growth in the boreal region is mainly limited by access to nitrogen (N)(LeBauer & Treseder, 2008), which is supplied by the fungi, while fungi are limited by C provided by the tree. One effect of this is that carbon is allocated from aboveground as sugars or cellulose fibers to the fungi below ground. EM fungi are made up of different compounds than plants, especially melanized cell walls, which are more resistant to decomposition than plant matter (Clemmensen et al., 2015). All these factors in combination makes boreal forest soils a stable long-term C sink.

It is suggested that the amount of biomass from EM fungi will increase when carbon dioxide levels in the atmosphere increases because of increased allocation of C from trees. This could provide a negative feedback on the anthropogenic CO_2 emissions, mitigating some of the effect (Treseder & Allen, 2000). There are concerns however that this effect could be negated by increased N due to human impacts. There are two main ways that human activities influence N availability. The first is the indirect N deposition from industry and agriculture that leaches into ground water and waterways that lead to forests, as well as evaporating and then ending up as precipitation over forests. N deposition has steadily increased, especially in areas with high industrial and agricultural activities(Maskell et al., 2010), but effects are also shown to be long ranging, even to a global scale(Phoenix et al., 2006). In contrast to this steady and gradual indirect increase, N is also added directly as fertilizer to increase forest growth (Haugland et al., 2014). Forest fertilization is a relatively new activity, and not yet prevalent in Norwegian forestry, however, Sweden has a longer history of fertilizing forests to increase profitability (Lindkvist et al., 2011). The proposed method by the Norwegian Environment Agency is fertilizing forests plot as a one-time addition about ten years prior to harvest, increasing growth by an estimated 0,15 m^{-2} year (Haugland et al., 2014). In this study I aim to look at the short-term effect a one-time addition of compound fertilizer has on soil dynamics throughout the season, and particularly how fungal growth is affected. The study will also assess the effects of fertilization prior to 2019.

To test if fertilization has different effects on saprotrophic (SAP) and EM fungi I measured fungal biomass at different soil depths, one consisting of the upper layer that consists of mostly organic material, including litter, and secondly the mineral layer directly beneath that is made up of mostly inorganic compounds. To explore the presence of fungal tissue in detail, ergosterol was used as a proxy for fungal biomass. Ergosterol is a lipid that is only found in the cell walls of fungi. It exists in two different forms, as free ergosterol in newly formed fungal tissue and in a bound form in older tissue closer to senescence (Clemmensen et al., 2013). Dahlman et al (2002) describes how to extract and measure both the amount of free ergosterol and the total amount (the sum of free and bound ergosterol). Enabling identification of newly formed fungal biomass is useful to understand if fertilization affects fungal growth, because an increase might not be detectable using only total fungal biomass. Measurements of total ergosterol, representing both new and old fungal biomass can be used to get a broader picture of the long-term conditions for fungi, and how recalcitrant the tissue is in the soil (Clemmensen et al., 2013). Another component of fungal cell walls, chitin, persist longer in soil after senescence, and is even better for estimation of long term EM fungal-driven C storage (Clemmensen et al., 2013), but was not included in this study.

Different functional groups of fungi can be found at different depths in the soil according to their preferred sources of C and N (Chen et al., 2019). EM fungi can be divided into two functional groups according to their use of older or newer organic material. Hydrophobic EM fungi are adapted to growing long, exploratory hyphae in search of N, and is found deeper in the soil than hydrophilic EM fungi and SAP fungi(Lilleskov et al., 2011). If a change in fungal biomass is found in the lower soil level, this would be an indication that the hydrophilic EM fungi were affected by the fertilization. If this response contrasts to the findings in the topsoil, it would further be an indication that either EM fungi as a group, or hydrophobic EM fungi, are differently affected than SAP fungi. On basis of literature and previous studies at the site I hypothesize firstly (1) that soil C and N will be higher in fertilized plots, and (2) that C and N will be positively affected in fertilized plots throughout the season. I also hypothesize that (3) EM fungi will respond negatively to fertilization, and (4) that community structure will be different in fertilized and control plots.

Materials and methods

Description of the study site

The study was done in a Norway spruce forest near Kittilbu in Gausdal municipality in Oppland county in Norway at an elevation of about 800m. This location is the site of a fertilization experiment that started in 2003 when yearly additions of 15 kg ha $^{-1}$ of fertilizer was added to 15x15 m (225m^2) plots (Nybakken et al., 2018). The forest constitutes of Norway spruce (*Picea abies*) of various stand age ranging from 50-200 years old. The field layer consist largely of bilberry (*Vaccinum myrtilum*), røsslyng (*Calluna vulgaris)*, lingonberry(*Vaccinum vitis-idaea)*, and juniper(*Juniperus communis*). The ground cover is dominated by mostly bryophytes such as red-stemmed feathermoss (*Pleurozium schreberi)* and glittering woodmoss (*Hylocomium splendens)*as well as wavy hair-grass (*Deschampsia flexuosa)*. The whole area is sloped decreasing in altitude from NE to SW. The plots are organized pairwise in fertilized and control plots approximately along the 800 m NW to SE cross section of the forest, starting with pair 1 in the northwestern side. To avoid the possibility of nutrients leaching from the fertilized plots to the control plots, fertilized plots were placed at lower altitude than the control plots. More detailed information about the study area and its vegetation are given by Gauslaa et al.(2008), Bach et al.(2009), and Davey et al(2017)

Sampling design

Soil samples were obtained at three dates between the spring and fall of 2019. The first samples were collected on June 11th immediately followed by fertilization of the previously fertilized plots. Soil samples were also collected at the approximate middle of the growing season on July 18th, and lastly on October 5th at the end of the season. A compound fertilizer containing 24,6% N, 2% P, 6% K and trace elements of micronutrients (YaraMila 25-2-6 full-fertilizer) was distributed evenly over the plot by hand. The amount of fertilizer used was the same as the previous experiment, 15 kg ha^{-1} or 3,375 kg per plot.

Samples were taken using a steel cylinder with an inner diameter of 5,8 cm. Five samples were collected from each plot, one sample from each corner about 2 m from the corner marking, and one in the center of the plot. Average sample depths were 6,5 cm for the topsoil and 4,5 cm of mineral soil (see appendix). The goal was to collect samples that included both the organic topsoil layer and the lower mineral soil layer. On some locations it was not possible to obtain mineral soil within a reasonable distance from the planned sample location 2 m from a corner or in the center. In these instances, mineral soil was not included in the sample. In most of these locations there was a thick layer of peat that went deeper than we could reach with our equipment, and the samples were cut off at 25 cm depth. After collection the samples were placed in plastic bags and temporarily stored at room temperature for <24 hours, and then stored at -18^{o}C.

Figure 1. An example of how the samples were split into two layers. (Photo: Karsten Nordal Hauken, 2019)

To be able to freeze-dry the samples within a reasonable time, all samples were split between the organic topsoil layer and the mineral soil layer (Figure 1), and then into quarters lengthwise. The quarter sub-samples from each main sample were then placed in paper bags and freeze dried for 48 hours and replaced in freezer for storage. All samples were weighed before and after splitting and freeze drying.

Large stones in the mineral soil samples were removed by sifting the sample through a 2mm mesh sieve, removing any stones that remained, while replacing large organic fragments in the sample. Organic and mineral samples were then crushed to a fine powder using a ball mill (MM 400, Retsch, Haag, Germany).

To improve the comparability of each sample and minimize variation due to stochasticity, the five samples from each plot were mixed together in equal amounts before analysis.

5 grams of material was mixed to get enough material for the various analyses. There were 5 sub-samples in most plots, however for some plots there were 2-4 mineral samples because of excessive depth of the topsoil layer. In these cases, the amount taken from each sub-sample was increased to get 5 grams in total. Leftover material was replaced in freezer for possible future study on spatial variation within sample plots.

The process resulted in two samples per plot per date, one containing soil from the organic top layer and one from the mineral layer, 120 samples in total. These were then used for C, N, pH and ergosterol analysis.

C and N analysis

Carbon and nitrogen content in the samples were measured using Elementar vario MICRO cube elemental analyzer (Elementar Analysensysteme GmbH, Hanau, Germany). I used 5-7 mg of soil from the organic layer and 10-12 mg from the mineral layer. I then estimated the volumetric contents of C and N based on an average of the volume of the original samples.

Fungal biomass

To estimate fungal biomass, the amount of the sterol molecule ergosterol that is found in fungal tissues was used as a proxy using methods described by Davey et al (2009).

Free ergosterol was measured using an adapted version of the method described in Dahlman et al.(2002). 200mg of powdered and mixed soil were added to 1ml of MeOH in 10ml glass vials, vortexed, then shaken in darkness for 30 minutes and vortexed again. The sample were then centrifuged for 15 minutes at 4000rpm, and the supernatant were transferred to 1.5ml centrifuge tubes which were centrifuged for 4 minutes at 16400rpm.

The exctraction of total ergosterol is also described in Dahlman et al (2002). 200mg of soil were mixed with 7ml 3M KOH in MeOH in 10ml glass tubes and vortexed. The samples were then incubated for 90 minutes at 70 ºC in an ultrasonic bath, vortexed and centrifuged for 15 min at 4000rpm. The contents were then transferred to 20ml glass tubes with 2ml of distilled water. Ergosterol was extracted by adding 5ml of hexane, then vortexed for 1 min. After phase-separation the hexane phase were transferred to 7 ml plastic tubes and put in a vacuum vaporizer till dryness.

This step was done twice to ensure evaporation of all the hexane. When completely dry, the contents were re-dissolved in 0.5ml MeOH in and ultrasonic bath. The re-dissolved ergosterol in MeOH was poured over to 1.5ml centrifuge tubes and centrifuged for 4 minutes at 16400rpm.

The extract from both free and total ergosterol was analyzed using an 1200 Series HPL (Agilent technologies, Waldbronn, Germany) according to Davey et al (2009). Ergosterol was identified and separated on a reversed phase ODS ultrasphere column, 250 cm x 4,6mm, particle size 5 μm using MeOH as the mobile phase flowing at 1,5 mL / min, analyzing for 12 minutes. Ergosterol was detected at 280 nm, and the amount was calculated based on retention time, online UV-spectra and co-chromatography of commercial standard ergosterol.

pH

For measuring pH 3 ml of powdered soil sample were added to 15 ml glasses with 7 ml of distilled water. The glasses were then shaken on a vortex and left in room temperature for approximately 24 hours. The glasses were then shaken again and pH was measured with a WTW pH720 Inolab digital pH meter using a WTW GH SenTix electrode (WTW GmbH, Weilheim, Germany).

Statistical analyses

Linear mixed model tests were performed using the package lme4 (Bates et al., 2020). Response variables were C, N, CN, pH, total ergosterol and free ergosterol. One data point from total ergosterol was omitted from analysis because of a probable error in sample preparation giving a non-sensical result. Fixed variables were sampling date, depth (organic vs mineral soil?) and treatment (fertilized vs control). Plot was used as random factor. To test for normality a Shapiro-Wilk test of normality (Royston, 1982) was performed on the residuals of each model. Samples were tested according to pairwise comparisons using the package emmeans (Lenth et al 2020). ANOVA was used to find p and f values. The significance level was set to $p<0.05$. Standard errors and means were calculated using Microsoft Excel. Statistical analyses were done using R studio version 1.2.5033 (RStudio, Inc.).

Results

Carbon

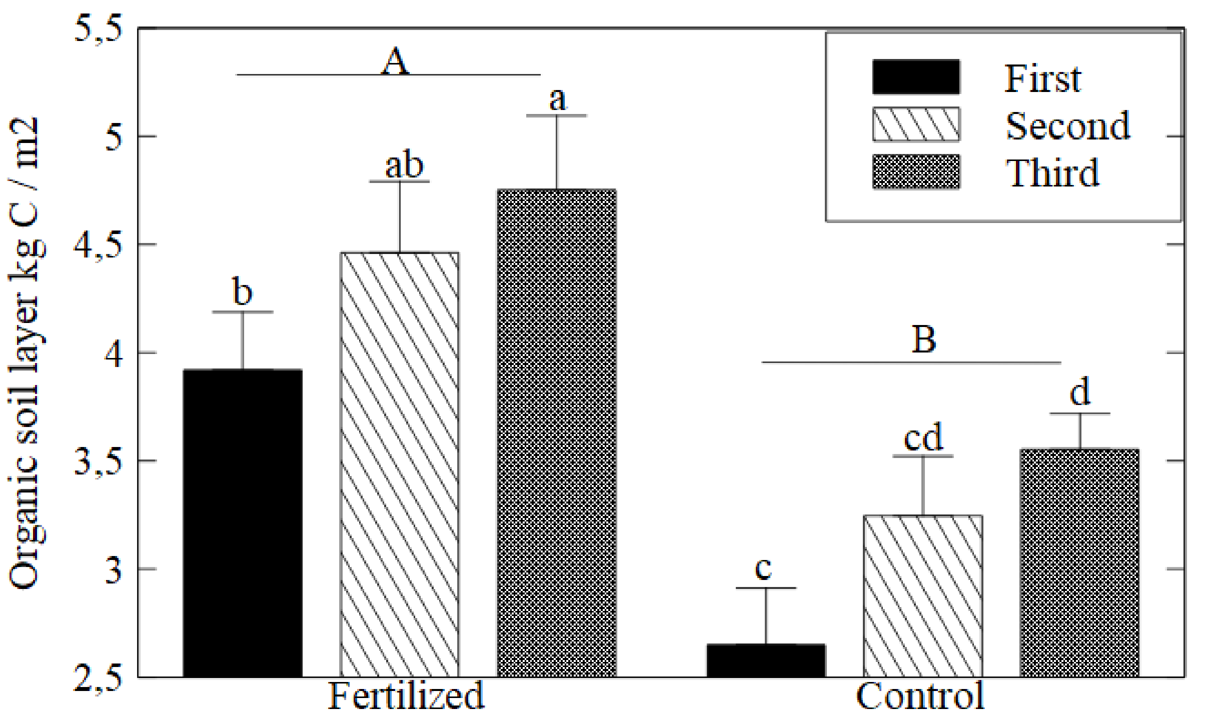

Figure 2. Average amount of C in samples from the organic topsoil layer. Different letters above bars indicate significant differences

C concentration in the organic topsoil layer were significantly higher than the mineral soil layer for all sample dates ($p<0,001$). The amount of C in the organic topsoil layer increased throughout the season for both fertilized and control ($p=0,001$)(figure 2). C content in the organic topsoil layer was significantly higher ($p<0,001$) in fertilized plots than control plots, with 4,38 kg m^2 on average for fertilized plots and 3,15 kg m^2 for control plots. In the mineral soil the result was opposite, with 0,4 kg m^2 less C in fertilized plots ($p=0,04$)

Nitrogen

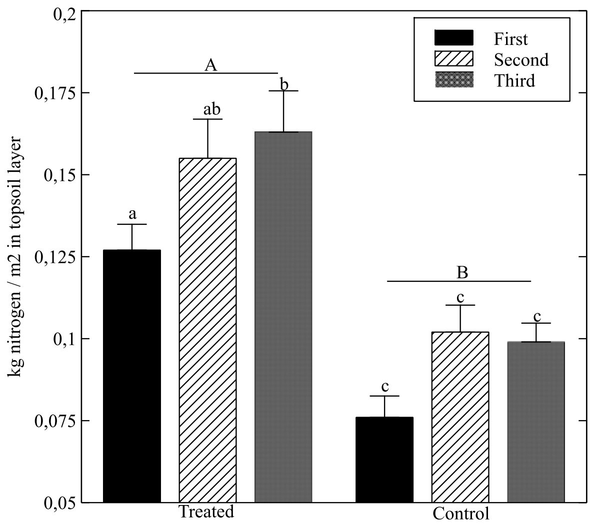

Figure 3 Amount of N in topsoil layer, letters above bars indicate significant differences between samplings within groups.

N concentrations in the fertilized plots were significantly higher than in the unfertilized plots on sampling dates in the organic topsoil layer ($p<0.001$). Amount of N increased in fertilized plots between the first and third sampling ($p=0,02$) (figure 3). When fertilized and control were tested as pooled, the increase was significant both between the first and second ($p=0,02$), and first and third sampling ($p=0,005$). There was no significant difference in N concentration between the unfertilized organic samples and both treatments in the mineral soil layer. See appendix for detailed results from all statistical analyses.

pH

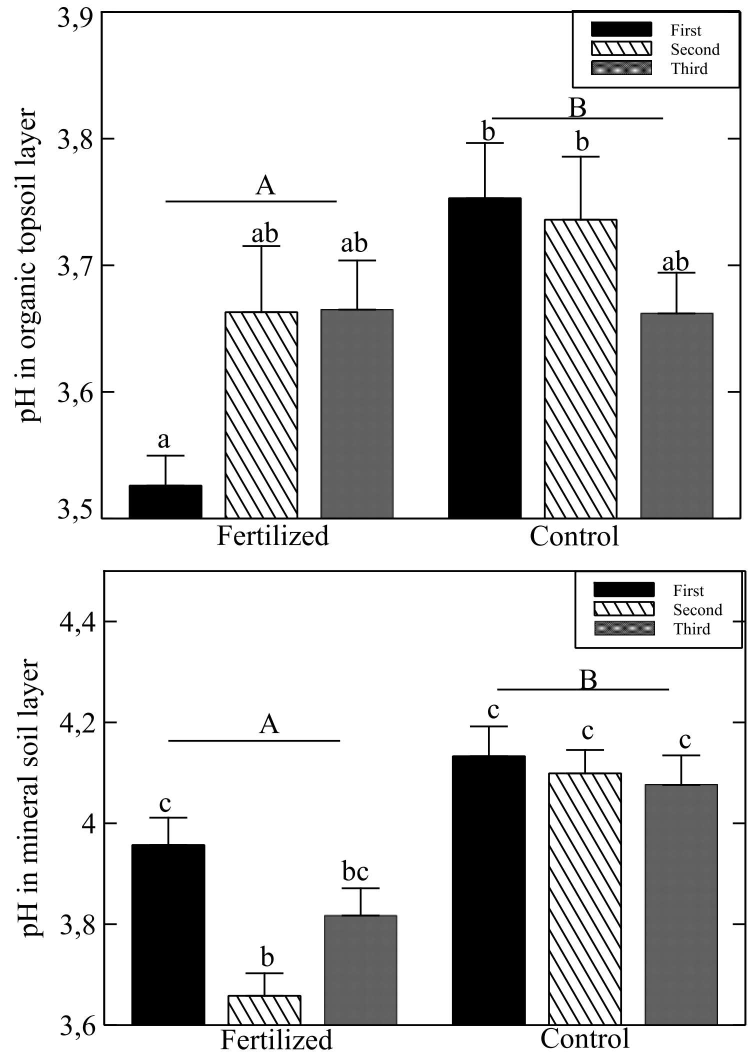

Figure 4. Average pH for all samplings. Different letters above bars indicate significant differences within groups.

All the significant differences in pH were driven by differences in the topsoil. The pH changed significantly between the first and second sampling (p=0,003)(figure 4). This was due to an increase in pH in the mineral soil layer(p<0,001) (figure 4). The organic soil layer was more acidic than the mineral soil layer, the difference is mostly explained by a very low pH from the first sampling date in the organic soil layer and the consistently high pH in the mineral soil in the control plots (figure 4)

Ergosterol

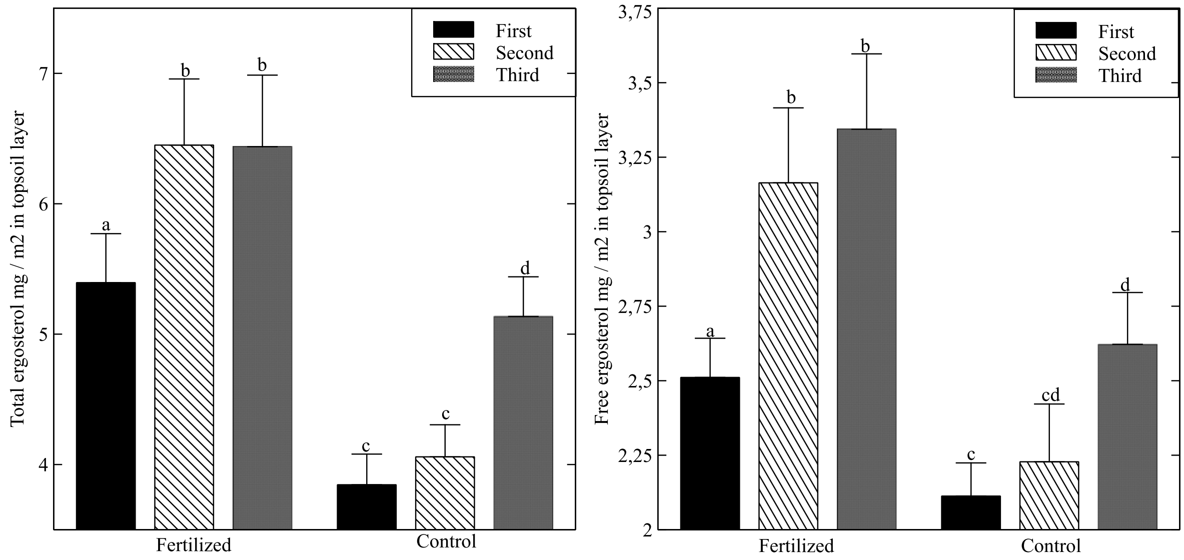

Figure 5 Total and free ergosterol in topsoil. Letters above bars indicate significant differences between sampling dates within groups.

Amount of total ergosterol was higher than free ergosterol, which is to be expected as the total includes both free and bound ergosterol. Both free and bound ergosterol was more abundant in topsoil than mineral soil (p<0,001) (see appendix 1). Both responded positively to fertilization in the topsoil.

Total ergosterol

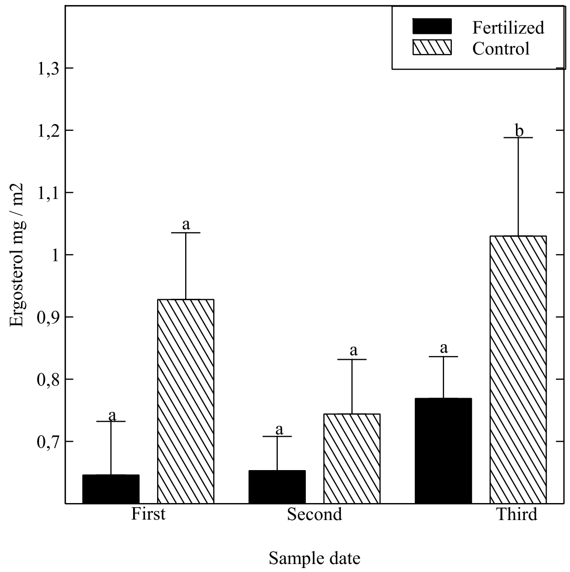

Figure 6 Total ergosterol in mineral soil. Different letters above bars indicate significant differences. Comparisons were done between fertilized and control for each sample date. The difference was significant on the third sampling (p=0,027)

Total ergosterol in topsoil were higher in the fertilized plots for all sampling dates (p=0,017, 0,003, 0,044)(Table 1). In the organic topsoil layer there was a significant increase in total ergosterol after fertilization in the fertilized plots (p=0,031) (Figure 5), while the increase in unfertilized plots did not occur until between the second and third sampling (p=0,027) (Figure 5). The only significant response in the mineral soil layer was found on the third sampling, where amount of total ergosterol was lower in fertilized plots (Figure 6).

Free ergosterol

The pattern in free ergosterol was similar to the total ergosterol. Amounts were higher in topsoil than mineral soil. There was an increase in free ergosterol in topsoil, and the increase happened earlier in the fertilized plots than the control plots. No significant changes were found in the mineral soil layer. See figure 1 and appendix 1 for detailed results from the statistical analyses.

Table 1. Linear mixed model test for effects of treatment (fertilized or control), sample (organic topsoil or mineral soil layer) and date (first, second and third sampling) as random factor on amount of C, N, C/N ratio, free ergosterol, total ergosterol and soil pH. Bold letters indicate significant values.

	Treatment	Sample	Date	Treatment:sample	Treatment:date	Sample:date	Treatment:sample:date
C	**9,07(0,003)**	**185,93(<0,001)**	**4,34(0,02)**	**35,12(<0,001)**	0,10(0,908)	4,60(0,123)	0,05(0,95)
N	**20,59(<0,001)**	**48,70(<0,001)**	1,46(0,238)	**35,73(<0,001)**	0,07(0,928)	**6,98(0,001)**	0,36(0,701)
C/N	**39,40(<0,001)**	**1167,77(<0,001)**	**4,95(0,009)**	**3,45(0,066)**	1,44(0,242)	1,66(0,196)	0,12(0,891)
Free ergosterol	**13,25(0,004)**	**739,40(<0,001)**	**6,47(0,002**	**22,65(<0,001)**	1,35(0,264)	**5,20(0,007)**	0,57(0,567)
Total ergosterol	**20,91(<0,001)**	**689,70(<0,001)**	**4,74(0,011)**	**33,56(<0,001)**	1,30(0,278)	**3,45(0,036)**	0,67(0,513)
pH	**54,23(<0,001)**	**118,64(<0,001)**	1,41(0,249)	**13,21(<0,001)**	1,98(0,143)	**6,08(0,003)**	**5,61(0,005)**

Discussion

Ergosterol

The third and fourth hypotheses that EM fungi would decrease and that fungal community would change due to fertilization is weakly supported by the data. The fungal biomass in the topsoil layer responded positively to fertilization, while the only response in the mineral soil was a negative response for total ergosterol on the last sampling. This may indicate changes in the community structure between SAP and hydrophobic and hydrophilic EM fungi, see Chen et al. (2019) and Lilleskov et al. (2011). The data does however not give wide support to this theory because the results from the first sampling did not show any difference in ratio between free or total ergosterol compared to the second and third sampling or between treatments, as would have been expected if the results were lasting. The results indicate that the effect of fertilization takes longer to reach this deep (Lilleskov et al., 2011). In contrast to my hypothesis, the lack of difference between fertilized and control plots on the first sampling, indicate that the negative impact on EM fungi are short term, as suggested by Treseder & Allen (2000). A lasting change in proportions of EM and SAP fungi in the organic topsoil layer could not be detected by the methods used in this study. An eventual decrease in EM fungal biomass due to less C-allocation below ground might be compensated for by increased saprotrophic mass as a result increased N availability (Chen et al., 2019). This effect is expected to be prevalent in the organic layer of the soil which contains more of the SAP fungi. There are methods for distinguishing between EM and SAP fungi. One is by measuring ergosterol in soil before and after incubating the sample for several months, with the assumption that EM fungi dies when no longer in contact with root-supplied C (Bååth et al., 2004), it could also be done by analyzing for differences in phospholipid fatty acid composition (Högberg et al., 2003), DNA-barcoding (Clemmensen et al., 2013), or by using mesh bags or other methods to prevent ingrowth of roots, excluding EM fungi (Hendricks et al., 2006). Contrasting results from studies on the effects on increased N on EM and ECM fungi make it clear that there are several factors that play together to determine the response, such as fungal species and access to phosphorus (Treseder & Allen, 2000).

C and N

There was more N and C in topsoil in the fertilized plots from already on the first sampling date, supporting first hypothesis. There was no relative increase compared to the control plots during the growing season contrasting to my second hypothesis. This indicates a long term effect from the previous fertilizations in the project, with yearly additions starting in 2003 (Nybakken et al., 2018). The data could not confirm any additional effect of the fertilization done in 2019, perhaps indicating that increased fertilizing above a certain threshold does not increase production, but more likely that the effects are seen on longer time scales than a single season. The higher C and N content in the organic topsoil were in accordance with the expected variation. The top layer receives high inputs of C and N from litterfall as well as roots. The uppermost part of the mineral soil, which is what was included in this study, are also penetrated by P. abies roots, but to a lower degree than the topsoil, and a large fraction of the C and N from litter is consumed before it can be deposited lower in the soil profile (Berger et al., 2002). Total amount of soil C in P. abies forests are reported in several studies from less than 7 to more than 12 kg / m^2 (Berger et al., 2002; Nilsen & Strand, 2008) in conventionally cultivated forests, and as high as 20 kg / m2 in >200 year old Norway spruce forests (Kyrkjeeide et al., 2020). These estimates includes the whole soil profile down to 50 cm or more (see e.g. Berger et al. (2002)). The samples in this study only penetrated about 11 cm and are therefore difficult to compare directly. Comparing with the proportion of C in the upper 10 cm in Berger et al. (Berger et al., 2002), my results show relatively high C contents, this is also expected as the forest has a varied tree age up to 200 years.

pH

The pH in the organic soil layer were significantly lower in the fertilized plots. This is likely due to the prior fertilization of the plots which has created a denser canopy that allows for less litter from shrubs and grass and more from the spruce trees that leads to more acidic soil (Berger et al., 2002). After treatment the pH in the fertilized plots increased and were not different from the control plots, likely due mostly to the pH of the added fertilizer. The pH in the mineral soil did not differ between fertilized and control plots before fertilization, after fertilization the pH lowered in the fertilized plots, interestingly opposite to the organic layer. Lower pH in mineral soil was correlated with increased SOM by Tamminen and Derome in 2005 where mineral samples were taken down to 30cm below the organic layer, which is much deeper than in my study(Tamminen & Derome, 2005). Furthermore, I did not find such a correlation between pH and C, and other explanations seems more likely. When looking at the pH data (appendix X), the pH in the mineral soil samples had little variation, and many seemingly non-sensical readings. The equipment and method might not have been suited to measure this low of a difference in pH, and I believe that a more accurate method is needed to justify further investigation into this.

Difference between humus and mineral soil layer

While the results for C and N were as expected in the humus layer, the same pattern was not found in the mineral soil layer. This can partly be explained by the vastly lower amounts of C and N in these samples, meaning that they were more sensitive to random interference(Muukkonen et al., 2009). It could also be expected to see a time-lag for the effects of fertilization reaches deeper soil levels (source: long term fertilization boreal forest spruce carbon nitrogen).

Consequences for soil C after fertilization

The overall results from this study are in accordance with other studies on increased N availability, such as Maaroufi et al. (2015) and Mäkipää (1995).

The concentrations of ergosterol in the mineral soil samples could indicate that there may be less mycelium in the fertilized plots, but the variances were too large to show significance. Further study that can compensate for the uncertainty is required to confirm any such difference, and the consequences this may have on long-term C storage.

Conclusion

Fertilization of boreal forests increases C storage and fungal biomass in the upper organic soil profile. Results from this and other studies indicate that mycorrhizal fungi might be negatively affected by fertilization, but it is unclear how persistent this effect is, and if it can influence C storage. More knowledge about the long-term effects on plant-fungal relationships and fungal community structure is needed when boreal forest fertilization becomes more widespread.

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Appendix 1 – statistical analyses

Carbon:

ANOVA

```
Type III Analysis of Variance Table with Satterthwaite's method
                       Sum Sq Mean Sq NumDF  DenDF  F value    Pr(>F)    
treatment               5.129   5.129     1 98.998   9.0671  0.003303 ** 
sample                105.188 105.188     1 98.998 185.9341 < 2.2e-16 ***
date                    4.905   2.453     2 98.998   4.3353  0.015673 *  
treatment:sample       19.870  19.870     1 98.998  35.1226 4.521e-08 ***
treatment:date          0.109   0.055     2 98.998   0.0967  0.907959    
sample:date             5.200   2.600     2 98.998   4.5957  0.012342 *  
treatment:sample:date   0.054   0.027     2 98.998   0.0482  0.953011    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Contrasts sample|date

```
sample = M:
 treatment emmean    SE df lower.CL upper.CL
 A           1.69 0.195 22     1.29     2.10
 B           2.09 0.195 22     1.69     2.50

sample = O:
 treatment emmean    SE df lower.CL upper.CL
 A           4.38 0.195 22     3.97     4.78
 B           3.15 0.195 22     2.74     3.56

Results are averaged over the levels of: date 
Degrees-of-freedom method: satterthwaite 
Confidence level used: 0.95 

$contrasts
sample = M:
 contrast estimate    SE df t.ratio p.value
 A - B       -0.40 0.194 99 -2.061  0.0419 

sample = O:
 contrast estimate    SE df t.ratio p.value
 A - B        1.23 0.194 99  6.320  <.0001 

Results are averaged over the levels of: date 
Degrees-of-freedom method: satterthwaite 
```

Contrasts date|sample

```
sample = M:
 date   emmean    SE   df lower.CL upper.CL
 first    1.99 0.218 32.5     1.55     2.44
 second   1.62 0.218 32.5     1.17     2.06
 third    2.06 0.218 32.5     1.62     2.51

sample = O:
 date   emmean    SE   df lower.CL upper.CL
 first    3.28 0.218 32.5     2.84     3.73
 second   3.85 0.218 32.5     3.41     4.30
 third    4.15 0.218 32.5     3.71     4.60

Results are averaged over the levels of: treatment 
Degrees-of-freedom method: satterthwaite 
```

```
Confidence level used: 0.95

$contrasts
sample = M:
 contrast       estimate    SE df t.ratio p.value
 first - second    0.378 0.238 99  1.589  0.2550
 first - third    -0.069 0.238 99 -0.290  0.9547
 second - third   -0.447 0.238 99 -1.879  0.1500

sample = O:
 contrast       estimate    SE df t.ratio p.value
 first - second   -0.570 0.238 99 -2.396  0.0480
 first - third    -0.869 0.238 99 -3.651  0.0012
 second - third   -0.298 0.238 99 -1.255  0.4240

Results are averaged over the levels of: treatment
Degrees-of-freedom method: satterthwaite
P value adjustment: tukey method for comparing a family of 3 estimates

Contrasts date|treatment|sample
sample = M:
 date   emmean    SE   df lower.CL upper.CL
 first    1.99 0.218 32.5     1.55     2.44
 second   1.62 0.218 32.5     1.17     2.06
 third    2.06 0.218 32.5     1.62     2.51

sample = O:
 date   emmean    SE   df lower.CL upper.CL
 first    3.28 0.218 32.5     2.84     3.73
 second   3.85 0.218 32.5     3.41     4.30
 third    4.15 0.218 32.5     3.71     4.60

Results are averaged over the levels of: treatment
Degrees-of-freedom method: satterthwaite
Confidence level used: 0.95

$contrasts
sample = M:
 contrast       estimate    SE df t.ratio p.value
 first - second    0.378 0.238 99  1.589  0.2550
 first - third    -0.069 0.238 99 -0.290  0.9547
 second - third   -0.447 0.238 99 -1.879  0.1500

sample = O:
 contrast       estimate    SE df t.ratio p.value
 first - second   -0.570 0.238 99 -2.396  0.0480
 first - third    -0.869 0.238 99 -3.651  0.0012
 second - third   -0.298 0.238 99 -1.255  0.4240

Results are averaged over the levels of: treatment
Degrees-of-freedom method: satterthwaite
P value adjustment: tukey method for comparing a family of 3 estimates

$emmeans
treatment = A, sample = M:
 date   emmean    SE df lower.CL upper.CL
 first    1.82 0.276 63    1.272     2.37
 second   1.46 0.276 63    0.907     2.01
 third    1.79 0.276 63    1.242     2.34

treatment = B, sample = M:
 date   emmean    SE df lower.CL upper.CL
 first    2.17 0.276 63    1.615     2.72
 second   1.77 0.276 63    1.224     2.33
```

```
 third    2.33 0.276 63    1.783     2.88

treatment = A, sample = O:
 date   emmean    SE df lower.CL upper.CL
 first    3.92 0.276 63    3.368     4.47
 second   4.46 0.276 63    3.911     5.01
 third    4.75 0.276 63    4.201     5.30

treatment = B, sample = O:
 date   emmean    SE df lower.CL upper.CL
 first    2.65 0.276 63    2.099     3.20
 second   3.25 0.276 63    2.696     3.80
 third    3.55 0.276 63    3.003     4.10

Degrees-of-freedom method: satterthwaite
Confidence level used: 0.95

$contrasts
treatment = A, sample = M:
 contrast       estimate    SE df t.ratio p.value
 first - second    0.365 0.336 99  1.085  0.5255
 first - third     0.030 0.336 99  0.089  0.9956
 second - third   -0.335 0.336 99 -0.996  0.5812

treatment = B, sample = M:
 contrast       estimate    SE df t.ratio p.value
 first - second    0.391 0.336 99  1.162  0.4784
 first - third    -0.168 0.336 99 -0.499  0.8717
 second - third   -0.559 0.336 99 -1.662  0.2250

treatment = A, sample = O:
 contrast       estimate    SE df t.ratio p.value
 first - second   -0.543 0.336 99 -1.614  0.2444
 first - third    -0.833 0.336 99 -2.476  0.0394
 second - third   -0.290 0.336 99 -0.862  0.6653

treatment = B, sample = O:
 contrast       estimate    SE df t.ratio p.value
 first - second   -0.597 0.336 99 -1.775  0.1834
 first - third    -0.904 0.336 99 -2.688  0.0228
 second - third   -0.307 0.336 99 -0.913  0.6336

Degrees-of-freedom method: satterthwaite
P value adjustment: tukey method for comparing a family of 3 estimates
```

Nitrogen:

ANOVA

```
Type III Analysis of Variance Table with Satterthwaite's method
                        Sum Sq  Mean Sq NumDF DenDF F value    Pr(>F)    
treatment             0.017521 0.017521     1    99 20.5893 1.602e-05 ***
sample                0.041441 0.041441     1    99 48.6985 3.431e-10 ***
date                  0.002480 0.001240     2    99  1.4572  0.237847    
treatment:sample      0.030401 0.030401     1    99 35.7250 3.600e-08 ***
treatment:date        0.000127 0.000063     2    99  0.0744  0.928329    
sample:date           0.011887 0.005943     2    99  6.9842  0.001454 ** 
treatment:sample:date 0.000607 0.000303     2    99  0.3565  0.701048    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Contrasts sample|date

```
sample = M:
```

```
 treatment emmean      SE   df lower.CL upper.CL
 A         0.0793 0.00714 25.4   0.0646    0.094
 B         0.0870 0.00714 25.4   0.0723    0.102

sample = O:
 treatment emmean      SE   df lower.CL upper.CL
 A         0.1483 0.00714 25.4   0.1336    0.163
 B         0.0923 0.00714 25.4   0.0776    0.107

Results are averaged over the levels of: date
Degrees-of-freedom method: satterthwaite
Confidence level used: 0.95

$contrasts
sample = M:
 contrast estimate      SE df t.ratio p.value
 A - B    -0.00767 0.00753 99 -1.018  0.3112

sample = O:
 contrast estimate      SE df t.ratio p.value
 A - B     0.05600 0.00753 99  7.435  <.0001

Results are averaged over the levels of: date
Degrees-of-freedom method: satterthwaite

Contrasts date|sample

sample = M:
 date   emmean      SE   df lower.CL upper.CL
 first  0.0920 0.00807 38.4   0.0757   0.1083
 second 0.0730 0.00807 38.4   0.0567   0.0893
 third  0.0845 0.00807 38.4   0.0682   0.1008

sample = O:
 date   emmean      SE   df lower.CL upper.CL
 first  0.1015 0.00807 38.4   0.0852   0.1178
 second 0.1285 0.00807 38.4   0.1122   0.1448
 third  0.1310 0.00807 38.4   0.1147   0.1473

Results are averaged over the levels of: treatment
Degrees-of-freedom method: satterthwaite
Confidence level used: 0.95

$contrasts
sample = M:
 contrast       estimate      SE df t.ratio p.value
 first - second   0.0190 0.00922 99  2.060  0.1036
 first - third    0.0075 0.00922 99  0.813  0.6959
 second - third  -0.0115 0.00922 99 -1.247  0.4288

sample = O:
 contrast       estimate      SE df t.ratio p.value
 first - second  -0.0270 0.00922 99 -2.927  0.0117
 first - third   -0.0295 0.00922 99 -3.198  0.0052
 second - third  -0.0025 0.00922 99 -0.271  0.9603

Results are averaged over the levels of: treatment
Degrees-of-freedom method: satterthwaite
P value adjustment: tukey method for comparing a family of 3 estimates

Contrasts date|treatment|sample
treatment = A, sample = M:
 date   emmean     SE   df lower.CL upper.CL
 first   0.091 0.0104 72.8   0.0703   0.1117
```

```
 second  0.068 0.0104 72.8   0.0473   0.0887
 third   0.079 0.0104 72.8   0.0583   0.0997

treatment = B, sample = M:
 date   emmean     SE   df lower.CL upper.CL
 first   0.093 0.0104 72.8   0.0723   0.1137
 second  0.078 0.0104 72.8   0.0573   0.0987
 third   0.090 0.0104 72.8   0.0693   0.1107

treatment = A, sample = O:
 date   emmean     SE   df lower.CL upper.CL
 first   0.127 0.0104 72.8   0.1063   0.1477
 second  0.155 0.0104 72.8   0.1343   0.1757
 third   0.163 0.0104 72.8   0.1423   0.1837

treatment = B, sample = O:
 date   emmean     SE   df lower.CL upper.CL
 first   0.076 0.0104 72.8   0.0553   0.0967
 second  0.102 0.0104 72.8   0.0813   0.1227
 third   0.099 0.0104 72.8   0.0783   0.1197

Degrees-of-freedom method: satterthwaite
Confidence level used: 0.95

$contrasts
treatment = A, sample = M:
 contrast       estimate    SE df t.ratio p.value
 first - second    0.023 0.013 99  1.763  0.1874
 first - third     0.012 0.013 99  0.920  0.6291
 second - third   -0.011 0.013 99 -0.843  0.6772

treatment = B, sample = M:
 contrast       estimate    SE df t.ratio p.value
 first - second    0.015 0.013 99  1.150  0.4860
 first - third     0.003 0.013 99  0.230  0.9713
 second - third   -0.012 0.013 99 -0.920  0.6291

treatment = A, sample = O:
 contrast       estimate    SE df t.ratio p.value
 first - second   -0.028 0.013 99 -2.146  0.0858
 first - third    -0.036 0.013 99 -2.760  0.0188
 second - third   -0.008 0.013 99 -0.613  0.8132

treatment = B, sample = O:
 contrast       estimate    SE df t.ratio p.value
 first - second   -0.026 0.013 99 -1.993  0.1193
 first - third    -0.023 0.013 99 -1.763  0.1874
 second - third    0.003 0.013 99  0.230  0.9713

Degrees-of-freedom method: satterthwaite
P value adjustment: tukey method for comparing a family of 3 estimates
```

Free ergosterol:

ANOVA

```
Type III Analysis of Variance Table with Satterthwaite's method
                       Sum Sq Mean Sq NumDF DenDF  F value    Pr(>F)
treatment               2.646   2.646     1    99  13.2457 0.0004364 ***
sample                147.719 147.719     1    99 739.3971 < 2.2e-16 ***
date                    2.586   1.293     2    99   6.4712 0.0022842 **
treatment:sample        4.524   4.524     1    99  22.6450 6.649e-06 ***
treatment:date          0.540   0.270     2    99   1.3512 0.2636672
sample:date             2.078   1.039     2    99   5.2015 0.0071120 **
```

```
treatment:sample:date   0.228   0.114     2    99   0.5705 0.5670625
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Contrasts sample|date

date = first:
 sample emmean    SE   df lower.CL upper.CL
 M       0.452 0.109 65.7    0.233    0.670
 O       2.312 0.109 65.7    2.093    2.531

date = second:
 sample emmean    SE   df lower.CL upper.CL
 M       0.385 0.109 65.7    0.166    0.603
 O       2.696 0.109 65.7    2.477    2.915

date = third:
 sample emmean    SE   df lower.CL upper.CL
 M       0.498 0.109 65.7    0.279    0.717
 O       2.983 0.109 65.7    2.764    3.202

Results are averaged over the levels of: treatment
Degrees-of-freedom method: satterthwaite
Confidence level used: 0.95

$contrasts
date = first:
 contrast estimate    SE df t.ratio p.value
 M - O       -1.86 0.141 99 -13.163 <.0001

date = second:
 contrast estimate    SE df t.ratio p.value
 M - O       -2.31 0.141 99 -16.354 <.0001

date = third:
 contrast estimate    SE df t.ratio p.value
 M - O       -2.48 0.141 99 -17.581 <.0001

Results are averaged over the levels of: treatment
Degrees-of-freedom method: satterthwaite

Contrasts date|treatment|sample


treatment = A, sample = M:
 date   emmean    SE   df lower.CL upper.CL
 first   0.373 0.148 99.1   0.0789    0.667
 second  0.362 0.148 99.1   0.0679    0.656
 third   0.462 0.148 99.1   0.1679    0.756

treatment = B, sample = M:
 date   emmean    SE   df lower.CL upper.CL
 first   0.530 0.148 99.1   0.2359    0.824
 second  0.407 0.148 99.1   0.1129    0.701
 third   0.534 0.148 99.1   0.2399    0.828

treatment = A, sample = O:
 date   emmean    SE   df lower.CL upper.CL
 first   2.511 0.148 99.1   2.2169    2.805
 second  3.164 0.148 99.1   2.8699    3.458
 third   3.344 0.148 99.1   3.0499    3.638

treatment = B, sample = O:
 date   emmean    SE   df lower.CL upper.CL
```

```
 first   2.113 0.148 99.1   1.8189    2.407
 second  2.228 0.148 99.1   1.9339    2.522
 third   2.622 0.148 99.1   2.3279    2.916

Degrees-of-freedom method: satterthwaite
Confidence level used: 0.95

$contrasts
treatment = A, sample = M:
 contrast       estimate  SE df t.ratio p.value
 first - second    0.011 0.2 99  0.055  0.9983
 first - third    -0.089 0.2 99 -0.445  0.8966
 second - third   -0.100 0.2 99 -0.500  0.8713

treatment = B, sample = M:
 contrast       estimate  SE df t.ratio p.value
 first - second    0.123 0.2 99  0.615  0.8121
 first - third    -0.004 0.2 99 -0.020  0.9998
 second - third   -0.127 0.2 99 -0.635  0.8010

treatment = A, sample = O:
 contrast       estimate  SE df t.ratio p.value
 first - second   -0.653 0.2 99 -3.267  0.0042
 first - third    -0.833 0.2 99 -4.167  0.0002
 second - third   -0.180 0.2 99 -0.900  0.6413

treatment = B, sample = O:
 contrast       estimate  SE df t.ratio p.value
 first - second   -0.115 0.2 99 -0.575  0.8336
 first - third    -0.509 0.2 99 -2.546  0.0330
 second - third   -0.394 0.2 99 -1.971  0.1248

Degrees-of-freedom method: satterthwaite
P value adjustment: tukey method for comparing a family of 3 estimates
```

Total ergosterol:

ANOVA

```
Type III Analysis of Variance Table with Satterthwaite's method
                      Sum Sq Mean Sq NumDF  DenDF  F value    Pr(>F)
treatment              17.67   17.67     1 98.084  20.9113 1.406e-05 ***
sample                582.66  582.66     1 98.084 689.6975 < 2.2e-16 ***
date                    8.00    4.00     2 98.083   4.7368   0.01087 *
treatment:sample       28.35   28.35     1 98.084  33.5624 8.353e-08 ***
treatment:date          2.19    1.10     2 98.083   1.2976   0.27784
sample:date             5.83    2.91     2 98.083   3.4492   0.03567 *
treatment:sample:date   1.14    0.57     2 98.083   0.6727   0.51267
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Contrasts sample|date

```
date = first:
 sample emmean    SE   df lower.CL upper.CL
 M       0.787 0.218 75.5    0.352     1.22
 O       4.620 0.218 75.5    4.185     5.06

date = second:
 sample emmean    SE   df lower.CL upper.CL
 M       0.699 0.218 75.5    0.263     1.13
 O       5.255 0.218 75.5    4.819     5.69

date = third:
```

```
 sample emmean    SE   df lower.CL upper.CL
 M       0.891 0.224 78.1    0.445     1.34
 O       5.787 0.218 75.5    5.352     6.22

Results are averaged over the levels of: treatment 
Degrees-of-freedom method: satterthwaite 
Confidence level used: 0.95 

$contrasts
date = first:
 contrast estimate    SE   df t.ratio p.value
 M - O       -3.83 0.291 98.0 -13.187 <.0001

date = second:
 contrast estimate    SE   df t.ratio p.value
 M - O       -4.56 0.291 98.0 -15.675 <.0001

date = third:
 contrast estimate    SE   df t.ratio p.value
 M - O       -4.90 0.295 98.3 -16.605 <.0001

Results are averaged over the levels of: treatment 
Degrees-of-freedom method: satterthwaite 

Contrasts date|sample

sample = M:
 date   emmean    SE   df lower.CL upper.CL
 first   0.787 0.218 75.5    0.352     1.22
 second  0.699 0.218 75.5    0.263     1.13
 third   0.891 0.224 78.1    0.445     1.34

sample = O:
 date   emmean    SE   df lower.CL upper.CL
 first   4.620 0.218 75.5    4.185     5.06
 second  5.255 0.218 75.5    4.819     5.69
 third   5.787 0.218 75.5    5.352     6.22

Results are averaged over the levels of: treatment 
Degrees-of-freedom method: satterthwaite 
Confidence level used: 0.95 

$contrasts
sample = M:
 contrast       estimate    SE   df t.ratio p.value
 first - second   0.0885 0.291 98.0  0.304  0.9502
 first - third   -0.1042 0.295 98.3 -0.353  0.9335
 second - third  -0.1927 0.295 98.3 -0.654  0.7908

sample = O:
 contrast       estimate    SE   df t.ratio p.value
 first - second  -0.6345 0.291 98.0 -2.183  0.0791
 first - third   -1.1667 0.291 98.0 -4.014  0.0003
 second - third  -0.5322 0.291 98.0 -1.831  0.1649

Results are averaged over the levels of: treatment 
Degrees-of-freedom method: satterthwaite 
P value adjustment: tukey method for comparing a family of 3 estimates 

Contrasts treatment|sample|date

date = first, sample = M:
 treatment emmean    SE  df lower.CL upper.CL
 A          0.646 0.452 108  -0.2492     1.54
```

```
 B          0.928 0.452 108   0.0328     1.82

date = second, sample = M:
 treatment emmean    SE  df lower.CL upper.CL
 A          0.653 0.452 108  -0.2422     1.55
 B          0.744 0.452 108  -0.1512     1.64

date = third, sample = M:
 treatment emmean    SE  df lower.CL upper.CL
 A          0.769 0.452 108  -0.1262     1.66
 B          2.204 0.452 108   1.3088     3.10

date = first, sample = O:
 treatment emmean    SE  df lower.CL upper.CL
 A          5.395 0.452 108   4.4998     6.29
 B          3.845 0.452 108   2.9498     4.74

date = second, sample = O:
 treatment emmean    SE  df lower.CL upper.CL
 A          6.450 0.452 108   5.5548     7.35
 B          4.059 0.452 108   3.1638     4.95

date = third, sample = O:
 treatment emmean    SE  df lower.CL upper.CL
 A          6.438 0.452 108   5.5428     7.33
 B          5.135 0.452 108   4.2402     6.03

Degrees-of-freedom method: satterthwaite
Confidence level used: 0.95

$contrasts
date = first, sample = M:
 contrast estimate    SE  df t.ratio p.value
 A - B      -0.282 0.639 108 -0.442  0.6597

date = second, sample = M:
 contrast estimate    SE  df t.ratio p.value
 A - B      -0.091 0.639 108 -0.142  0.8870

date = third, sample = M:
 contrast estimate    SE  df t.ratio p.value
 A - B      -1.435 0.639 108 -2.247  0.0267

date = first, sample = O:
 contrast estimate    SE  df t.ratio p.value
 A - B       1.550 0.639 108  2.427  0.0169

date = second, sample = O:
 contrast estimate    SE  df t.ratio p.value
 A - B       2.391 0.639 108  3.744  0.0003

date = third, sample = O:
 contrast estimate    SE  df t.ratio p.value
 A - B       1.303 0.639 108  2.040  0.0438

Degrees-of-freedom method: satterthwaite


Contrasts date|treatment|sample

treatment = A, sample = M:
 date   emmean    SE  df lower.CL upper.CL
 first   0.646 0.300 103   0.0512     1.24
 second  0.653 0.300 103   0.0582     1.25
```

```
 third   0.769 0.300 103   0.1742     1.36

treatment = B, sample = M:
 date   emmean    SE  df lower.CL upper.CL
 first   0.928 0.300 103   0.3332     1.52
 second  0.744 0.300 103   0.1492     1.34
 third   1.013 0.316 104   0.3873     1.64

treatment = A, sample = O:
 date   emmean    SE  df lower.CL upper.CL
 first   5.395 0.300 103   4.8002     5.99
 second  6.450 0.300 103   5.8552     7.04
 third   6.438 0.300 103   5.8432     7.03

treatment = B, sample = O:
 date   emmean    SE  df lower.CL upper.CL
 first   3.845 0.300 103   3.2502     4.44
 second  4.059 0.300 103   3.4642     4.65
 third   5.135 0.300 103   4.5406     5.73

Degrees-of-freedom method: satterthwaite
Confidence level used: 0.95

$contrasts
treatment = A, sample = M:
 contrast       estimate    SE   df t.ratio p.value
 first - second  -0.0070 0.411 98.0 -0.017  0.9998
 first - third   -0.1230 0.411 98.0 -0.299  0.9519
 second - third  -0.1160 0.411 98.0 -0.282  0.9571

treatment = B, sample = M:
 contrast       estimate    SE   df t.ratio p.value
 first - second   0.1840 0.411 98.0  0.448  0.8956
 first - third   -0.0853 0.423 98.5 -0.202  0.9778
 second - third  -0.2693 0.423 98.5 -0.637  0.8000

treatment = A, sample = O:
 contrast       estimate    SE   df t.ratio p.value
 first - second  -1.0550 0.411 98.0 -2.567  0.0314
 first - third   -1.0430 0.411 98.0 -2.537  0.0338
 second - third   0.0120 0.411 98.0  0.029  0.9995

treatment = B, sample = O:
 contrast       estimate    SE   df t.ratio p.value
 first - second  -0.2140 0.411 98.0 -0.521  0.8615
 first - third   -1.2903 0.411 98.0 -3.139  0.0063
 second - third  -1.0763 0.411 98.0 -2.619  0.0274

Degrees-of-freedom method: satterthwaite
P value adjustment: tukey method for comparing a family of 3 estimates
```

pH

ANOVA

```
Type III Analysis of Variance Table with Satterthwaite's method
                      Sum Sq Mean Sq NumDF DenDF  F value    Pr(>F)    
treatment            1.14661 1.14661     1    99  54.2271 5.381e-11 ***
sample               2.50852 2.50852     1    99 118.6369 < 2.2e-16 ***
date                 0.05972 0.02986     2    99   1.4122 0.2484647    
treatment:sample     0.27937 0.27937     1    99  13.2123 0.0004433 ***
treatment:date       0.08374 0.04187     2    99   1.9803 0.1434581    
sample:date          0.25708 0.12854     2    99   6.0792 0.0032346 ** 
treatment:sample:date 0.23731 0.11865    2    99   5.6115 0.0049144 ** 
```

```
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Contrasts sample|date

date = first:
 sample emmean     SE   df lower.CL upper.CL
 M        4.04 0.0381 47.6     3.97     4.12
 O        3.64 0.0381 47.6     3.56     3.72

date = second:
 sample emmean     SE   df lower.CL upper.CL
 M        3.88 0.0381 47.6     3.80     3.96
 O        3.70 0.0381 47.6     3.62     3.78

date = third:
 sample emmean     SE   df lower.CL upper.CL
 M        3.95 0.0381 47.6     3.87     4.02
 O        3.66 0.0381 47.6     3.59     3.74

Results are averaged over the levels of: treatment
Degrees-of-freedom method: satterthwaite
Confidence level used: 0.95

$contrasts
date = first:
 contrast estimate    SE df t.ratio p.value
 M - O       0.406 0.046 99 8.818   <.0001

date = second:
 contrast estimate    SE df t.ratio p.value
 M - O       0.179 0.046 99 3.893   0.0002

date = third:
 contrast estimate    SE df t.ratio p.value
 M - O       0.283 0.046 99 6.154   <.0001

Results are averaged over the levels of: treatment
Degrees-of-freedom method: satterthwaite


Contrasts treatment|sample|date

sample = M, date = first:
 treatment emmean     SE   df lower.CL upper.CL
 A           3.96 0.0501 84.7     3.86     4.06
 B           4.13 0.0501 84.7     4.03     4.23

sample = O, date = first:
 treatment emmean     SE   df lower.CL upper.CL
 A           3.53 0.0501 84.7     3.43     3.63
 B           3.75 0.0501 84.7     3.65     3.85

sample = M, date = second:
 treatment emmean     SE   df lower.CL upper.CL
 A           3.66 0.0501 84.7     3.56     3.76
 B           4.10 0.0501 84.7     4.00     4.20

sample = O, date = second:
 treatment emmean     SE   df lower.CL upper.CL
 A           3.66 0.0501 84.7     3.56     3.76
 B           3.74 0.0501 84.7     3.64     3.84

sample = M, date = third:
```

```
 treatment emmean     SE   df lower.CL upper.CL
 A           3.82 0.0501 84.7     3.72     3.92
 B           4.08 0.0501 84.7     3.98     4.18

sample = O, date = third:
 treatment emmean     SE   df lower.CL upper.CL
 A           3.66 0.0501 84.7     3.57     3.76
 B           3.66 0.0501 84.7     3.56     3.76

Degrees-of-freedom method: satterthwaite
Confidence level used: 0.95

$contrasts
sample = M, date = first:
 contrast estimate    SE df t.ratio p.value
 A - B      -0.176 0.065 99 -2.706  0.0080

sample = O, date = first:
 contrast estimate    SE df t.ratio p.value
 A - B      -0.227 0.065 99 -3.491  0.0007

sample = M, date = second:
 contrast estimate    SE df t.ratio p.value
 A - B      -0.441 0.065 99 -6.781  <.0001

sample = O, date = second:
 contrast estimate    SE df t.ratio p.value
 A - B      -0.073 0.065 99 -1.123  0.2643

sample = M, date = third:
 contrast estimate    SE df t.ratio p.value
 A - B      -0.259 0.065 99 -3.983  0.0001

sample = O, date = third:
 contrast estimate    SE df t.ratio p.value
 A - B       0.003 0.065 99  0.046  0.9633

Degrees-of-freedom method: satterthwaite
Contrasts date|treatment|sample

treatment = A, sample = M:
 date   emmean     SE   df lower.CL upper.CL
 first    3.96 0.0501 84.7     3.86     4.06
 second   3.66 0.0501 84.7     3.56     3.76
 third    3.82 0.0501 84.7     3.72     3.92

treatment = B, sample = M:
 date   emmean     SE   df lower.CL upper.CL
 first    4.13 0.0501 84.7     4.03     4.23
 second   4.10 0.0501 84.7     4.00     4.20
 third    4.08 0.0501 84.7     3.98     4.18

treatment = A, sample = O:
 date   emmean     SE   df lower.CL upper.CL
 first    3.53 0.0501 84.7     3.43     3.63
 second   3.66 0.0501 84.7     3.56     3.76
 third    3.66 0.0501 84.7     3.57     3.76

treatment = B, sample = O:
 date   emmean     SE   df lower.CL upper.CL
 first    3.75 0.0501 84.7     3.65     3.85
 second   3.74 0.0501 84.7     3.64     3.84
 third    3.66 0.0501 84.7     3.56     3.76
```

```
Degrees-of-freedom method: satterthwaite
Confidence level used: 0.95

$contrasts
treatment = A, sample = M:
 contrast       estimate    SE df t.ratio p.value
 first - second    0.299 0.065 99  4.598  <.0001
 first - third     0.140 0.065 99  2.153  0.0846
 second - third   -0.159 0.065 99 -2.445  0.0426

treatment = B, sample = M:
 contrast       estimate    SE df t.ratio p.value
 first - second    0.034 0.065 99  0.523  0.8604
 first - third     0.057 0.065 99  0.877  0.6563
 second - third    0.023 0.065 99  0.354  0.9334

treatment = A, sample = O:
 contrast       estimate    SE df t.ratio p.value
 first - second   -0.137 0.065 99 -2.107  0.0936
 first - third    -0.139 0.065 99 -2.137  0.0875
 second - third   -0.002 0.065 99 -0.031  0.9995

treatment = B, sample = O:
 contrast       estimate    SE df t.ratio p.value
 first - second    0.017 0.065 99  0.261  0.9630
 first - third     0.091 0.065 99  1.399  0.3452
 second - third    0.074 0.065 99  1.138  0.4932

Degrees-of-freedom method: satterthwaite
P value adjustment: tukey method for comparing a family of 3 estimates
```

CN

ANOVA

```
Type III Analysis of Variance Table with Satterthwaite's method
                      Sum Sq Mean Sq NumDF DenDF  F value    Pr(>F)    
treatment             367.30  367.30     1    99  39.3924 9.216e-09 ***
sample               2470.70 2470.70     1    99 264.9769 < 2.2e-16 ***
date                   89.27   44.63     2    99   4.7868   0.01037 *  
treatment:sample       32.20   32.20     1    99   3.4537   0.06608 .  
treatment:date         26.77   13.38     2    99   1.4355   0.24291    
sample:date            30.88   15.44     2    99   1.6561   0.19612    
treatment:sample:date   2.16    1.08     2    99   0.1159   0.89065    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Contrasts treatment|date

date = first:
 treatment emmean    SE   df lower.CL upper.CL
 A           26.0 0.806 46.4     24.4     27.6
 B           29.4 0.806 46.4     27.8     31.0

date = second:
 treatment emmean    SE   df lower.CL upper.CL
 A           25.0 0.806 46.4     23.4     26.6
 B           27.4 0.806 46.4     25.8     29.0

date = third:
 treatment emmean    SE   df lower.CL upper.CL
 A           25.9 0.806 46.4     24.3     27.5
 B           30.6 0.806 46.4     28.9     32.2
```

```
Results are averaged over the levels of: sample
Degrees-of-freedom method: satterthwaite
Confidence level used: 0.95

$contrasts
date = first:
 contrast estimate    SE df t.ratio p.value
 A - B       -3.43 0.966 99 -3.557  0.0006

date = second:
 contrast estimate    SE df t.ratio p.value
 A - B       -2.38 0.966 99 -2.460  0.0156

date = third:
 contrast estimate    SE df t.ratio p.value
 A - B       -4.69 0.966 99 -4.854  <.0001

Results are averaged over the levels of: sample
Degrees-of-freedom method: satterthwaite

Contrasts date|treatment

sample = M:
 date   emmean    SE   df lower.CL upper.CL
 first    22.5 0.806 46.4     20.8     24.1
 second   22.0 0.806 46.4     20.3     23.6
 third    24.1 0.806 46.4     22.5     25.7

sample = O:
 date   emmean    SE   df lower.CL upper.CL
 first    33.0 0.806 46.4     31.3     34.6
 second   30.4 0.806 46.4     28.8     32.0
 third    32.3 0.806 46.4     30.7     34.0

Results are averaged over the levels of: treatment
Degrees-of-freedom method: satterthwaite
Confidence level used: 0.95

$contrasts
sample = M:
 contrast       estimate    SE df t.ratio p.value
 first - second    0.502 0.966 99  0.519  0.8621
 first - third    -1.639 0.966 99 -1.697  0.2113
 second - third   -2.141 0.966 99 -2.217  0.0733

sample = O:
 contrast       estimate    SE df t.ratio p.value
 first - second    2.536 0.966 99  2.626  0.0268
 first - third     0.614 0.966 99  0.636  0.8005
 second - third   -1.922 0.966 99 -1.990  0.1200

Results are averaged over the levels of: treatment
Degrees-of-freedom method: satterthwaite
P value adjustment: tukey method for comparing a family of 3 estimates

Contrasts date|treatment|sample

treatment = A, sample = M:
 date   emmean   SE   df lower.CL upper.CL
 first    21.1 1.06 83.2     19.0     23.2
 second   21.4 1.06 83.2     19.3     23.5
 third    22.4 1.06 83.2     20.3     24.5
```

```
treatment = B, sample = M:
 date   emmean   SE   df lower.CL upper.CL
 first    23.8 1.06 83.2     21.7     25.9
 second   22.5 1.06 83.2     20.4     24.6
 third    25.8 1.06 83.2     23.7     27.9

treatment = A, sample = O:
 date   emmean   SE   df lower.CL upper.CL
 first    30.9 1.06 83.2     28.8     33.0
 second   28.6 1.06 83.2     26.5     30.7
 third    29.4 1.06 83.2     27.3     31.5

treatment = B, sample = O:
 date   emmean   SE   df lower.CL upper.CL
 first    35.0 1.06 83.2     32.9     37.1
 second   32.2 1.06 83.2     30.1     34.3
 third    35.3 1.06 83.2     33.2     37.4

Degrees-of-freedom method: satterthwaite
Confidence level used: 0.95

$contrasts
treatment = A, sample = M:
 contrast       estimate   SE df t.ratio p.value
 first - second   -0.312 1.37 99 -0.228  0.9717
 first - third    -1.299 1.37 99 -0.951  0.6092
 second - third   -0.988 1.37 99 -0.723  0.7503

treatment = B, sample = M:
 contrast       estimate   SE df t.ratio p.value
 first - second    1.315 1.37 99  0.963  0.6021
 first - third    -1.979 1.37 99 -1.449  0.3200
 second - third   -3.294 1.37 99 -2.412  0.0462

treatment = A, sample = O:
 contrast       estimate   SE df t.ratio p.value
 first - second    2.290 1.37 99  1.677  0.2192
 first - third     1.526 1.37 99  1.118  0.5055
 second - third   -0.763 1.37 99 -0.559  0.8420

treatment = B, sample = O:
 contrast       estimate   SE df t.ratio p.value
 first - second    2.782 1.37 99  2.038  0.1086
 first - third    -0.298 1.37 99 -0.218  0.9742
 second - third   -3.080 1.37 99 -2.255  0.0671

Degrees-of-freedom method: satterthwaite
P value adjustment: tukey method for comparing a family of 3 estimates
```

Tests of normality

```
> shapiro.test((all$Carea))

        Shapiro-Wilk normality test

data:  (all$Carea)
W = 0.93789, p-value = 3.093e-05

> shapiro.test(all$Narea)

        Shapiro-Wilk normality test

data:  all$Narea
```

```
W = 0.93601, p-value = 2.327e-05

> shapiro.test(all$Fearea)

        Shapiro-Wilk normality test

data:  all$Fearea
W = 0.87246, p-value = 9.682e-09

> shapiro.test(alledit$Earea)

        Shapiro-Wilk normality test

data:  alledit$Earea
W = 0.87069, p-value = 9.01e-09

> shapiro.test(all$CN)

        Shapiro-Wilk normality test

data:  all$CN
W = 0.98016, p-value = 0.07365

> shapiro.test(all$pH)

        Shapiro-Wilk normality test

data:  all$pH
W = 0.95738, p-value = 0.0007834
```

Appendix 2, pH

Treatment	Layer	ID	pH	date
T	O	1	3,46	first
T	O	2	3,54	first
T	O	3	3,46	first
T	O	4	3,61	first
T	O	5	3,62	first
T	O	6	3,47	first
T	O	7	3,58	first
T	O	8	3,57	first
T	O	9	3,57	first
T	O	10	3,38	first
T	O	11	3,64	second
T	O	12	3,51	second
T	O	13	3,66	second
T	O	14	3,92	second
T	O	15	4,02	second
T	O	16	3,59	second
T	O	17	3,62	second
T	O	18	3,6	second
T	O	19	3,61	second
T	O	20	3,46	second
T	O	21	3,72	third
T	O	22	3,55	third
T	O	23	3,62	third
T	O	24	3,9	third
T	O	25	3,84	third
T	O	26	3,49	third
T	O	27	3,67	third
T	O	28	3,65	third
T	O	29	3,54	third
T	O	30	3,67	third
C	O	31	3,73	first
C	O	32	3,92	first
C	O	33	3,57	first
C	O	34	3,63	first
C	O	35	3,88	first
C	O	36	3,65	first
C	O	37	3,88	first
C	O	38	3,68	first
C	O	39	3,97	first
C	O	40	3,62	first

C	O	41	3,56	second
C	O	42	3,99	second
C	O	43	3,69	second
C	O	44	3,62	second
C	O	45	3,8	second
C	O	46	3,51	second
C	O	47	3,94	second
C	O	48	3,65	second
C	O	49	3,91	second
C	O	50	3,69	second
C	O	51	3,56	third
C	O	52	3,69	third
C	O	53	3,62	third
C	O	54	3,68	third
C	O	55	3,67	third
C	O	56	3,67	third
C	O	57	3,85	third
C	O	58	3,55	third
C	O	59	3,81	third
C	O	60	3,52	third
T	M	61	4,29	first
T	M	62	4	first
T	M	63	4,07	first
T	M	64	4,07	first
T	M	65	3,98	first
T	M	66	3,67	first
T	M	67	3,98	first
T	M	68	3,75	first
T	M	69	3,78	first
T	M	70	4,01	first
T	M	71	3,72	second
T	M	72	3,83	second
T	M	73	3,8	second
T	M	74	3,85	second
T	M	75	3,66	second
T	M	76	3,54	second
T	M	77	3,44	second
T	M	78	3,72	second
T	M	79	3,52	second
T	M	80	3,5	second
T	M	81	3,84	third
T	M	82	3,92	third
T	M	83	3,81	third
T	M	84	3,7	third
T	M	85	4,14	third

T	M	86	3,55	third
T	M	87	3,62	third
T	M	88	3,8	third
T	M	89	3,75	third
C	M	90	4,04	third
C	M	91	4,07	first
C	M	92	4,21	first
C	M	93	3,98	first
C	M	94	3,93	first
C	M	95	4,23	first
C	M	96	4,17	first
C	M	97	4,59	first
C	M	98	3,92	first
C	M	99	4,05	first
C	M	100	4,18	first
C	M	101	3,9	second
C	M	102	4,19	second
C	M	103	4,18	second
C	M	104	4,16	second
C	M	105	3,86	second
C	M	106	3,97	second
C	M	107	4,35	second
C	M	108	4,02	second
C	M	109	4,17	second
C	M	110	4,19	second
C	M	111	4,17	third
C	M	112	3,97	third
C	M	113	4,18	third
C	M	114	4,02	third
C	M	115	4,3	third
C	M	116	3,82	third
C	M	117	4,4	third
C	M	118	3,79	third
C	M	119	4,11	third
C	M	120	4	third

appendix 3

ID	treatment	sample	volume	sample.wet.mass	sample.dry.mass	sub.sample.wet.mass
T1-5	A	O	198,156	85,9	22,61	21,85
T2-5	A	O	171,7352	125,45	42,97	29,05
T3-5	A	O	184,9456	76,6	22,49	18,05
T4-5	A	O	118,8936	34,5	11,29	10,7
T5-5	A	O	145,3144	57,7	16,03	22,5
T6-5	A	O	158,5248	69,15	20,81	20,9
T7-5	A	O	264,2079	72,35	20,19	22,25
T8-5	A	O	343,4703	124,6	24,32	39,2
T9-5	A	O	211,3664	64,25	18,58	18,5
T10-5	A	O	0	153,45	38,38	39,1
T11-5	A	O	290,6287	122,4	26,05	34,2
T12-5	A	O	145,3144	106,45	26,54	28,8
T13-5	A	O	105,6832	35,4	17,55	9,4
T14-5	A	O	79,26238	34,9	17,1	10,9
T15-5	A	O	158,5248	52,8	36,07	11,8
T16-5	A	O	211,3664	72,5	34,61	20,8
T17-5	A	O	158,5248	53,6	28,2	16,1
T18-5	A	O	224,5768	122,5	56,11	36,2
T19-5	A	O	171,7352	47,9	25,18	15,6
T20-5	A	O	171,7352	95,8	35,13	25,2
T21-5	A	O	290,6287	348,7	90,9	98,7
T22-5	A	O	198,156	230,1	47,81	68,3
T23-5	A	O	171,7352	83,7	24,67	24,8
T24-5	A	O	105,6832	89,7	23,88	27,5
T25-5	A	O	132,104	48,5	16,51	15,8
T26-5	A	O	171,7352	129,4	31,64	33,7
T27-5	A	O	198,156	90,4	22,58	24,3
T28-5	A	O	92,47278	144,2	44,43	36,9
T29-5	A	O	105,6832	84,1	28,23	22,4
T30-5	A	O	184,9456	71	20,44	22,2
C1-5	B	O	356,6807	26,2	6,89	6,55
C2-5	B	O	435,9431	174,3	46,49	50,05
C3-5	B	O	92,47278	72,25	21,16	18,1
C4-5	B	O	105,6832	41,4	11,04	11,25
C5-5	B	O	145,3144	45,5	9,73	13,8
C6-5	B	O	171,7352	44,9	12,83	14,8
C7-5	B	O	105,6832	92,25	27,75	23,2
C8-5	B	O	132,104	97,7	21,18	23,25
C9-5	B	O	92,47278	45,25	13,14	11,95
C10-5	B	O	52,84159	87,35	29,77	22,3
C11-5	B	O	105,6832	45,65	18,13	14,4
C12-5	B	O	501,9951	278,4	54,03	81
C13-5	B	O	66,05199	16,2	7,95	5,5
C14-5	B	O	184,9456	48,3	21,74	10,8
C15-5	B	O	92,47278	75,2	22,1	18
C16-5	B	O	132,104	58,8	15,5	20,1
C17-5	B	O	92,47278	36,5	17,41	10,8
C18-5	B	O	317,0495	227,1	54	69,1

C19-5	B	O	171,7352	65,1	33,76	15,6
C20-5	B	O	132,104	76,6	26,06	22,9
C21-5	B	O	132,104	141,3	32,17	42,6
C22-5	B	O	92,47278	82	21,35	25,5
C23-5	B	O	198,156	119,7	32,35	33,3
C24-5	B	O	145,3144	88,1	22,67	22
C25-5	B	O	184,9456	127,6	30,14	33,4
C26-5	B	O	343,4703	78	22,25	22,3
C27-5	B	O	211,3664	52,9	10,74	13,4
C28-5	B	O	105,6832	73,4	16,26	20,9
C29-5	B	O	0	115,2	37,52	27,2
C30-5	B	O	211,3664	129,8	30,26	32
T1-5	A	M	118,8936	128,3	96,66	47,3
T2-5	A	M	79,3	85,55	57,11	35,05
T3-5	A	M	26,42079	52,95	37,58	15,85
T4-5	A	M	92,47278	132,45	102,87	30,45
T5-5	A	M	118,8936	139,8	105,78	45
T6-5	A	M	92,47278	118	94,62	37,7
T7-5	A	M	132,104	97,8	64,87	30
T8-5	A	M	52,84159	48	21,31	19,15
T9-5	A	M	118,8936	153,65	111,79	37,4
T10-5	A	M	0	129,05	96,53	29,25
T11-5	A	M	52,84159	64,7	65,71	21,2
T12-5	A	M	66,1	40	20,01	14,35
T13-5	A	M	66,05199	71,55	57,86	22,95
T14-5	A	M	52,84159	68,8	49,55	19,8
T15-5	A	M	26,42079	23,6	20,81	8,3
T16-5	A	M	105,6832	72,6	51,11	20,1
T17-5	A	M	105,6832	28	19,57	10,5
T18-5	A	M	145,3144	15,9	10,86	5,9
T19-5	A	M	39,63119	25,4	19,4	7,2
T20-5	A	M	132,104	163,8	109,67	38,1
T21-5	A	M	237,7871			
T22-5	A	M	237,8	96,6	51,65	25,4
T23-5	A	M	105,6832	126,4	91	33,1
T24-5	A	M	132,104	110,4	75,86	35,7
T25-5	A	M	303,8391	344,1	191,1	104,6
T26-5	A	M	158,5248	99,4	46,83	24,6
T27-5	A	M	171,7352	125,3	93,63	36
T28-5	A	M	171,7352	95,7	50,28	29,1
T29-5	A	M	132,104	70	46,03	22,6
T30-5	A	M	13,2104			
C1-5	B	M	66,05199	183,55	124,77	55,4
C2-5	B	M	39,63119	30,95	10,96	12
C3-5	B	M	105,6832	62,45	40,73	17,25
C4-5	B	M	92,47278	30,1	18,11	12,55
C5-5	B	M	105,6832	168,95	105,87	46,6
C6-5	B	M	26,42079	69,7	44,58	17,2
C7-5	B	M	184,9456	104,2	80,95	29,35
C8-5	B	M	105,6832	76,9	27,16	18,35

C9-5	B	M	211,3664	229,6	181,44	56,35
C10-5	B	M	198,156	51,65	37,83	10,05
C11-5	B	M	118,8936	109,2	37,16	31,3
C12-5	B	M	0		0	
C13-5	B	M	184,9456	300,3	253,15	82,8
C14-5	B	M	26,42079		0	
C15-5	B	M	118,8936	38,1	24,07	10,1
C16-5	B	M	158,5248	155,5	78,72	56,3
C17-5	B	M	198,156	166	129,54	41,3
C18-5	B	M	290,6287	118,3	71,85	40,7
C19-5	B	M	52,84159			
C20-5	B	M	105,6832	119,5	88,6	33,3
C21-5	B	M	237,7871	188,9	108,93	47,5
C22-5	B	M	52,84159			
C23-5	B	M	145,3144	114,1	79,34	30
C24-5	B	M	158,5248	85,4	65,04	32,3
C25-5	B	M	158,5248	42	19,08	13,1
C26-5	B	M	0			
C27-5	B	M	184,9456	215,1	131,25	54,9
C28-5	B	M	118,8936	87,5	50	25,2
C29-5	B	M	330,2599	185,4	187,26	45,9
C30-5	B	M	184,9456	101	55,22	27,4

sub.sample.dry.mass	sub.sample.water.	avg.volume	avg.sample.dry.mass	avg.sub.sample.dry.mass
5,75	73,68	148	31,49171383	8,2441
9,95	65,75	187,6	23,58895883	6,45
5,3	70,64	163,8	17,20374645	4,87
3,5	67,29	124,2	18,25510258	5,53
6,25	72,22	184,9	18,63676764	5,92
6,29	69,9	235,1	29,72894521	10,072
6,21	72,09	233,8	24,75489362	7,578
7,65	80,48	244,4	24,67920396	7,256
5,35	71,08	174,4	16,17769201	4,276
9,78	74,99	145,3	30,02972291	8,8
7,28	78,71	191,6	23,36283798	6,588
7,18	75,07	199,5	29,24493823	8,14
4,66	50,43	134,7	18,33379328	4,598
5,34	51,01	136,1	19,93283966	5,772
8,06	31,69	183,6	29,00996744	7,694
9,93	52,26	244,4	38,96611412	11,816
8,47	47,39	179,7	25,07331915	6,904
16,58	54,2	338,2	36,43029882	10,426
8,2	47,44	184,9	27,5284042	8,336
9,24	63,33	239,1	36,51742508	9,584
25,73	73,93	269,5	40,4613497	11,788
14,19	79,22	278,7	36,28770529	10,63
7,31	70,52	157,2	20,60172687	5,86
7,32	73,38	158,5	18,64942466	6,052
5,38	65,95	179,7	22,67041907	6,538
8,24	75,55	245,7	39,47023607	11,118
6,07	75,02	166,5	31,01369884	8,082
11,37	69,19	198,2	39,61796069	10,76
7,52	66,43	129,5	24,23328161	6,444
6,39	71,22	171,7	39,67294851	10,852
1,72	73,69	198,2	10,2916448	2,82464
13,35	73,33	229,9	30,6787911	8,65
5,3	70,72	116,3	12,35080636	3,58
3	73,33	177	16,42546678	5,35
2,95	78,62	145,3	13,45797073	4,25
4,23	71,42	215,3	15,01354802	4,504
6,98	69,91	184,9	15,45638758	4,276
5,04	78,32	155,9	16,16810165	4,564
3,47	70,96	145,3	16,4212753	4,406
7,6	65,92	153,2	19,45466334	5,834
5,72	60,28	133,4	15,96380669	5,088
15,72	80,59	285,3	25,60628448	7,144
2,7	50,91	97,8	16,17583219	4,364
4,86	55	211,4	22,59159636	6,102
5,29	70,61	166,5	20,50110474	5,63
5,3	73,63	179,7	25,07629986	7,772
5,15	52,31	167,8	17,32342816	4,988
16,43	76,22	306,5	32,94781969	9,118

8,09	48,14	229,9	31,77042703	8,734
7,79	65,98	113,6	17,05216538	4,854
9,7	77,23	154,6	24,77086309	7,238
6,64	73,96	249,7	33,80740822	9,922
9	72,97	161,2	20,21086283	5,712
5,66	74,27	196,8	19,25008665	5,424
7,89	76,38	215,3	24,38919344	7,108
6,36	71,48	258,9	25,55757837	6,59
2,72	79,7	158,5	17,80429083	4,944
4,63	77,85	132,1	24,54163249	6,972
8,86	67,43	66,1	27,54540709	7,076
7,46	76,69	121,5	23,65508361	6,636
35,63	24,66	121,5	120,541155	39,80642
23,4	33,24	184,9	65,86174415	18,6
11,25	29,02	95,1	112,2058411	35,02
23,65	22,33	87,2	53,79168197	15,35
34,05	24,33	66,1	57,71755077	16,45
30,23	19,81	109	92,48	25,695
19,9	33,67	96,4	91,70870616	27,462
8,5	55,61	99,1	81,07029229	20,866
27,21	27,25	118,9	92,81708269	25,674
21,88	25,2	74	60,8430739	16,266
21,53	-1,56	77,9	86,80511522	22,864
7,18	49,97	54,2	40,81960204	12,47
18,56	19,13	71,3	70,3077192	19,72
14,26	27,98	75,3	85,93720592	20,808
7,32	11,81	46,2	48,66921288	14,122
14,15	29,6	34,7	29,76755266	9,7775
7,34	30,1	84,5	78,43991345	21,202
4,03	31,69	48,4	44,27601974	12,9
5,5	23,61	55,5	49,50579842	13,774
25,51	33,04	51,5	50,24905407	13,254
		87,2	100,8171442	27,7225
13,58	46,54	104,4	91,30343899	23,418
23,83	28,01	91,2	105,9771188	26,43
24,53	31,29	68,7	81,03691483	20,632
58,09	44,46	121,5	128,0512982	35,485
11,59	52,89	31,7	51,57683805	14,01
26,9	25,28	140	63,15200207	17,166
15,29	47,46	142,7	48,73370803	12,492
14,86	34,25	108,3	64,44630196	17,0625
		129,5	69,4623116	15,8267
37,66	32,02	124,2	73,77089486	23,67014
4,25	64,58	140	63,44314001	16,55
11,25	34,78	97,8	44,03812812	12,38
7,55	39,84	81,9	59,20604127	18,15
29,2	37,34	108,3	83,41617794	23,818
11	36,05	75,3	61,30813499	18,702
22,8	22,32	166,5	145,2599409	40,506
6,48	64,69	108,3	53,30745504	15,158

44,53	20,98	100,4	102,2845044	26,186
7,36	26,77	60,8	67,76347577	18,408
10,65	65,97	85,9	83,7087781	24,062
		76	65,93464142	16,72
69,8	15,7	113,6	117,4359258	31,112
		72,7	70,17580796	19,3025
6,38	36,83	76,6	62,96390146	19,378
28,5	49,38	82,6	69,50396679	20,48
32,23	21,96	122,9	115,4783898	30,662
24,72	39,26	68,7	69,55040614	20,545
		50,2	54,52208732	14,485
24,69	25,86	71,3	74,23453469	19,004
27,39	42,34	170,4	163,4622105	39,276
		99,1	87,26806546	23,7575
20,86	30,47	118,9	132,4395239	36,754
24,6	23,84	56,8	53,58958574	16,626
5,95	54,58	107	77,69435939	20,964
		60,8	57,53344072	13,8775
33,5	38,98	190,2	125,6735646	30,838
14,4	42,86	113,6	30,72835482	8,89
46,36	-1	214	100,1973043	25,5
14,98	45,33	150,6	90,48628311	24,456

C.in.sample(g)	Cmass%	mg C/cm3	C.kg/m2	Tot.C.OM	N.in.sample(g)	Nmass%	mg N/cm3
13,35414943	42,40528	90,23074	5,05	7,59	0,400517915	1,27182	2,706202
10,99562989	46,61346	58,6121	4,16	6,61	0,359035748	1,52205	1,913837
8,205892873	47,69829	50,09703	3,11	5,27	0,270979651	1,57512	1,654332
7,881290041	43,17308	63,45644	2,98	3,84	0,280851102	1,53848	2,261281
8,538176043	45,81361	46,17726	3,23	4,39	0,249482954	1,33866	1,349286
13,36506352	44,9564	56,84842	5,06	6,98	0,400876989	1,34844	1,705134
11,19255878	45,21352	47,87236	4,24	5,47	0,383829577	1,55052	1,6417
10,45595433	42,36747	42,78214	3,96	6,45	0,378396363	1,53326	1,548267
6,895060138	42,62079	39,5359	2,61	4,47	0,227573211	1,40671	1,304892
12,64671751	42,114	87,03866	4,79	6,37	0,392815802	1,30809	2,703481
10,08878834	43,18306	52,65547	3,82	6,08	0,348272162	1,49071	1,817704
12,38893083	42,36265	62,0999	4,69	6,30	0,41023922	1,40277	2,056337
7,558153948	41,22526	56,11102	2,86	4,04	0,269426093	1,46956	2,000194
8,250523254	41,39161	60,62104	3,12	4,87	0,292867233	1,46927	2,151853
12,04873298	41,53308	65,62491	4,56	5,91	0,408001984	1,40642	2,222233
16,36769675	42,00495	66,97094	6,20	7,03	0,598644204	1,53632	2,449444
10,68657457	42,6213	59,46897	4,04	5,72	0,380685697	1,51829	2,118451
14,50868709	39,82588	42,89973	5,49	6,95	0,487645051	1,33857	1,441884
10,86280189	39,46034	58,7496	4,11	5,29	0,392728473	1,42663	2,124005
15,13597241	41,44863	63,30394	5,73	7,01	0,530809987	1,45358	2,220033
14,62730391	36,1513	54,27571	5,54	8,01	0,511682321	1,26462	1,898636
14,384929	39,64133	51,61438	5,44	7,86	0,47226634	1,30145	1,694533
8,790060517	42,66662	55,91642	3,33	4,79	0,292212834	1,41839	1,85886
8,274096992	44,3665	52,2025	3,13	4,66	0,284640574	1,52627	1,79584
9,756280591	43,03529	54,29205	3,69	5,51	0,30451587	1,34323	1,694579
16,6600472	42,20914	67,80646	6,31	8,52	0,565434814	1,43256	2,301322
14,38572592	46,38507	86,40076	5,44	6,47	0,51222225	1,6516	3,07641
14,24888085	35,96571	71,89143	5,39	7,09	0,579333439	1,4623	2,922974
9,859926148	40,68754	76,13843	3,73	5,25	0,336515465	1,38865	2,598575
14,58170494	36,75478	84,92548	5,52	7,28	0,452573127	1,14076	2,635837
4,629365022	44,98178	23,35704	1,75	3,69	0,135000651	1,31175	0,681133
12,85829127	41,91264	55,92993	4,87	8,59	0,341497895	1,11314	1,485419
5,53201633	44,79073	47,56678	2,09	3,02	0,177351404	1,43595	1,524948
7,046543317	42,90011	39,81098	2,67	4,40	0,176815222	1,07647	0,998956
5,342249145	39,6958	36,76703	2,02	4,21	0,17789284	1,32184	1,224314
6,522954225	43,44712	30,29705	2,47	4,25	0,151989653	1,01235	0,705944
6,487322537	41,97179	35,08557	2,46	5,05	0,19535792	1,26393	1,05656
7,03656479	43,52128	45,13512	2,66	5,53	0,192794911	1,19244	1,236658
6,196431938	37,73417	42,64578	2,35	4,12	0,213092321	1,29766	1,466568
8,347188671	42,90585	54,48557	3,16	5,28	0,23610374	1,21361	1,541147
6,334708283	39,68169	47,48657	2,40	4,21	0,203594409	1,27535	1,526195
10,55193245	41,20837	36,98539	3,99	5,76	0,339352406	1,32527	1,189458
5,691859629	35,18743	58,19897	2,15	4,58	0,208451479	1,28866	2,131406
9,475611335	41,94308	44,82314	3,59	4,82	0,261274071	1,15651	1,235923
8,014129906	39,09121	48,13291	3,03	5,40	0,231828543	1,13081	1,392364
8,777730572	35,00409	48,84658	3,32	5,02	0,24385197	0,97244	1,356995
6,7118583	38,7444	39,99916	2,54	4,32	0,21055934	1,21546	1,254823
12,92043477	39,21484	42,15476	4,89	7,23	0,391532121	1,18834	1,277429

11,10206771	34,94466	48,29086	4,20	5,21	0,375034006	1,18045	1,631292
6,229580612	36,53249	54,83786	2,36	3,66	0,198234833	1,16252	1,745025
8,38718635	33,85908	54,25088	3,17	6,09	0,274830249	1,10949	1,777686
11,71530484	34,65307	46,91752	4,43	10,65	0,372902474	1,10302	1,493402
8,111943065	40,13655	50,32223	3,07	5,04	0,233366749	1,15466	1,447685
7,566852936	39,30815	38,44946	2,86	3,94	0,221121895	1,14868	1,123587
9,711352456	39,81826	45,10614	3,68	5,85	0,275980796	1,13157	1,281843
10,67857218	41,78241	41,24593	4,04	6,90	0,265159876	1,0375	1,024179
7,683838743	43,15723	48,47848	2,91	5,15	0,223880055	1,25745	1,412492
10,24822251	41,75852	77,57928	3,88	4,67	0,276861519	1,12813	2,095848
10,79863696	39,20304	163,3682	4,09	5,89	0,322771571	1,17178	4,88308
8,998398536	38,04002	74,06089	3,41	4,70	0,214852028	0,90827	1,768329
6,693385147	5,55278	55,08959	2,53		0,445773245	0,36981	3,668916
6,458791216	9,80659	34,93127	2,44		0,287460169	0,43646	1,554679
5,716461222	5,09462	60,11	2,16		0,305525285	0,27229	3,212674
2,254113537	4,19045	25,84993	0,85		0,09182778	0,17071	1,053071
3,050563026	5,28533	46,15073	1,15		0,129194966	0,22384	1,954538
5,086418496	5,50002	46,66439	1,93		0,237294432	0,25659	2,177013
3,261519255	3,55639	33,83319	1,23		0,154290727	0,16824	1,600526
6,584902063	8,12246	66,44704	2,49		0,329842591	0,40686	3,328381
4,91499867	5,29536	41,33725	1,86		0,212161288	0,22858	1,784367
4,192945679	6,89141	56,66143	1,59		0,203294963	0,33413	2,747229
5,984214436	6,89385	76,81918	2,26		0,302611312	0,34861	3,884612
4,247724526	10,40609	78,3713	1,61		0,238908967	0,58528	4,407915
3,127554519	4,44838	43,86472	1,18		0,133605759	0,19003	1,873854
4,605314709	5,35893	61,15956	1,74		0,190832159	0,22206	2,534292
3,573770568	7,34298	77,35434	1,35		0,141544672	0,29083	3,063737
2,201721311	7,39638	63,45018	0,83		0,10929157	0,36715	3,149613
4,438757822	5,6588	52,52968	1,68		0,205175282	0,26157	2,42811
3,846612043	8,6878	79,47546	1,46		0,183501964	0,41445	3,791363
3,109860196	6,28181	56,03352	1,18		0,154542251	0,31217	2,784545
3,395444156	6,75723	65,93095	1,29		0,164927445	0,32822	3,202475
6,540905417	6,48789	75,01038	2,48		0,277095921	0,27485	3,177706
6,370733977	6,97754	61,02236	2,41		0,329568893	0,36096	3,15679
3,853116085	3,6358	42,24908	1,46		0,175466316	0,16557	1,923973
4,033069488	4,97683	58,70552	1,53		0,168127287	0,20747	2,447268
4,807673186	3,75449	39,56933	1,82		0,22093971	0,17254	1,818434
5,852650752	11,34744	184,6262	2,22		0,246697174	0,47831	7,782245
2,719287318	4,30594	19,42348	1,03		0,125811419	0,19922	0,898653
4,484724355	9,20251	31,42764	1,70		0,247786538	0,50845	1,736416
4,006819932	6,2173	36,99741	1,52		0,156707628	0,24316	1,446977
4,654134641	6,70023	35,93926	1,76		0,193716495	0,27888	1,49588
5,118165669	6,93792	41,20906	1,94		0,195404346	0,26488	1,573304
9,836148295	15,50388	70,2582	3,72		0,510254142	0,80427	3,644672
2,447577508	5,55786	25,02635	0,93		0,10981788	0,24937	1,122882
4,573601561	7,72489	55,84373	1,73		0,195865426	0,33082	2,391519
5,784987015	6,93509	53,41632	2,19		0,261201078	0,31313	2,411829
4,700102338	7,66636	62,41836	1,78		0,162055793	0,26433	2,152135
6,854104837	4,71851	41,16579	2,59		0,405899853	0,27943	2,437837
7,584382135	14,22762	70,03123	2,87		0,252885236	0,47439	2,335044

4,700494628	4,59551	46,81768	1,78	0,197848917	0,19343	1,970607
5,614901931	8,28603	92,35036	2,13	0,219567214	0,32402	3,611303
4,777854298	5,70771	55,62112	1,81	0,214076829	0,25574	2,492163
4,664889067	7,07502	61,38012	1,77	0,194592907	0,29513	2,560433
6,418026012	5,46513	56,49671	2,43	0,321069821	0,2734	2,826319
3,264999641	4,6526	44,91059	1,24	0,131242796	0,18702	1,805265
6,25084206	9,92766	81,60368	2,37	0,271047003	0,43048	3,538473
4,48934462	6,45912	54,35042	1,70	0,169457621	0,24381	2,051545
4,700374639	4,07035	38,24552	1,78	0,24613064	0,21314	2,00269
6,185256719	8,8932	90,03285	2,34	0,253205209	0,36406	3,685665
2,66701878	4,89163	53,12786	1,01	0,140607011	0,25789	2,800936
3,433473428	4,62517	48,15531	1,30	0,155261529	0,20915	2,177581
7,715792299	4,72023	45,28047	2,92	0,318963811	0,19513	1,871853
16,41809895	18,81341	165,672	6,21	0,494958287	0,56717	4,994534
5,207733983	3,93216	43,79928	1,97	0,237079992	0,17901	1,993944
2,851721575	5,32141	50,20637	1,08	0,119617314	0,22321	2,105939
5,741543234	7,38991	53,65928	2,17	0,272707201	0,351	2,548665
7,553156945	13,12829	124,2296	2,86	0,186661495	0,32444	3,07009
5,919111786	4,70991	31,12046	2,24	0,329591491	0,26226	1,732868
2,095286621	6,81874	18,44442	0,79	0,083415192	0,27146	0,734289
4,753450294	4,74409	22,21238	1,80	0,200083997	0,19969	0,934972
3,423883321	3,78387	22,73495	1,30	0,128074285	0,14154	0,850427

N.kg/m2	Tot N OM	E in sample(µg)	E in sample(µg/g	µg E/cm3	E mg/m2	tot E OM
0,15	0,32	12,88313475	0,4091	0,087048208	4,88	5,54
0,14	0,24	12,87596874	0,5458	0,068635228	4,87	5,55
0,10	0,22	14,74174559	0,8569	0,089998447	5,58	6,30
0,11	0,14	10,23894373	0,5609	0,08243916	3,88	4,14
0,09	0,14	12,53490477	0,6726	0,067792887	4,74	5,08
0,15	0,24	17,71518487	0,5959	0,075351701	6,71	7,42
0,15	0,20	21,90512557	0,8849	0,093691726	8,29	8,80
0,14	0,27	13,71768181	0,5558	0,056127994	5,19	6,03
0,09	0,17	13,75933961	0,8505	0,078895296	5,21	6,49
0,15	0,23	12,1464263	0,4045	0,083595501	4,60	5,06
0,13	0,25	14,94485627	0,6397	0,078000294	5,66	6,67
0,16	0,25	13,20118681	0,4514	0,066171362	5,00	5,56
0,10	0,15	14,13337826	0,7709	0,104924857	5,35	5,87
0,11	0,18	10,4319142	0,5234	0,076648892	3,95	4,58
0,15	0,21	24,536572	0,8458	0,13364146	9,29	10,03
0,23	0,27	22,02583282	0,5653	0,090122066	8,34	8,70
0,14	0,22	13,72776843	0,5475	0,076392701	5,20	5,93
0,18	0,25	18,6212427	0,5111	0,055059854	7,05	7,86
0,15	0,21	18,15001886	0,6593	0,09816127	6,87	7,45
0,20	0,26	20,57753322	0,5635	0,086062456	7,79	8,33
0,19	0,30	13,4005397	0,3312	0,049723709	5,07	5,78
0,18	0,30	19,26605076	0,5309	0,069128277	7,29	8,18
0,11	0,18	15,26228508	0,7408	0,097088327	5,78	6,70
0,11	0,17	10,09788032	0,5415	0,063709024	3,82	4,68
0,12	0,20	17,69181163	0,7804	0,098451929	6,70	7,36
0,21	0,31	22,51928289	0,5705	0,091653573	8,52	9,76
0,19	0,24	26,43746085	0,8524	0,158783549	10,01	10,82
0,22	0,31	15,65804197	0,3952	0,079001221	5,93	6,38
0,13	0,19	17,14586949	0,7075	0,132400537	6,49	7,09
0,17	0,24	12,60036551	0,3176	0,073385938	4,77	5,31
0,05	0,13	9,584502695	0,9313	0,048357733	3,63	4,45
0,13	0,32	11,03879754	0,3598	0,048015648	4,18	5,52
0,07	0,11	8,188138925	0,6630	0,070405322	3,10	3,72
0,07	0,14	10,92394893	0,6651	0,061717226	4,13	4,77
0,07	0,17	7,805126511	0,5800	0,053717319	2,95	3,71
0,06	0,12	8,645903456	0,5759	0,040157471	3,27	4,25
0,07	0,23	10,79556989	0,6985	0,058385992	4,09	4,90
0,07	0,17	10,03332844	0,6206	0,064357463	3,80	5,52
0,08	0,16	9,495199125	0,5782	0,065348927	3,59	4,18
0,09	0,17	15,08642683	0,7755	0,098475371	5,71	6,72
0,08	0,16	8,49055124	0,5319	0,063647311	3,21	3,80
0,13	0,20	9,726579312	0,3799	0,034092462	3,68	5,16
0,08	0,20	7,533783362	0,4657	0,07703255	2,85	3,48
0,10	0,15	13,22573404	0,5854	0,062562602	5,01	5,65
0,09	0,19	9,827767725	0,4794	0,059025632	3,72	4,45
0,09	0,16	9,352360081	0,3730	0,052044297	3,54	4,28
0,08	0,17	11,12590303	0,6422	0,066304547	4,21	5,04
0,15	0,24	14,25077961	0,4325	0,046495203	5,39	6,20

0,14	0,20	12,84958993	0,4045	0,055892083	4,86	5,22
0,08	0,13	10,88710989	0,6385	0,095837235	4,12	4,77
0,10	0,22	12,13866493	0,4900	0,078516591	4,59	5,88
0,14	0,33	9,993577612	0,2956	0,040022337	3,78	5,77
0,09	0,18	13,25925422	0,6560	0,082253438	5,02	5,02
0,08	0,13	11,41569149	0,5930	0,058006562	4,32	4,86
0,10	0,21	12,48053742	0,5117	0,057968125	4,72	5,79
0,10	0,17	16,05366437	0,6281	0,062007201	6,08	7,62
0,08	0,21	13,74983737	0,7723	0,086749763	5,20	6,01
0,10	0,14	12,60284704	0,5135	0,095403838	4,77	5,22
0,12	0,20	1,952871119	0,0709	0,029544192	0,74	1,70
0,08	0,13	14,44977644	0,6109	0,118928201	5,47	6,11
0,17		1,752546058	0,0145	0,014424247	0,66	
0,11		1,776568502	0,0270	0,009608267	0,67	
0,12		1,895517736	0,0169	0,019931837	0,72	
0,03		0,710038867	0,0132	0,008142648	0,27	
0,05		0,892597324	0,0155	0,013503742	0,34	
0,09		1,889874012	0,0204	0,017338294	0,72	
0,06		1,333107867	0,0145	0,01382892	0,50	
0,12		2,207596522	0,0272	0,022276453	0,84	
0,08		3,389035143	0,0365	0,028503239	1,28	
0,08		1,212485012	0,0199	0,016384933	0,46	
0,11		2,690865783	0,0310	0,034542565	1,02	
0,09		1,482309925	0,0363	0,027348892	0,56	
0,05		1,37512186	0,0196	0,019286422	0,52	
0,07		1,680771047	0,0196	0,022320997	0,64	
0,05		1,975162901	0,0406	0,042752444	0,75	
0,04		0,964944808	0,0324	0,027808208	0,37	
0,08		1,935211068	0,0247	0,022901906	0,73	
0,07		2,156866237	0,0487	0,044563352	0,82	
0,06		1,543284828	0,0312	0,027806934	0,58	
0,06		1,418879724	0,0282	0,027551063	0,54	
0,10		1,859047751	0,0184	0,021319355	0,70	
0,12		2,357730365	0,0258	0,022583624	0,89	
0,07		2,443588799	0,0231	0,026793737	0,92	
0,06		2,268153772	0,0280	0,033015339	0,86	
0,08		1,762532186	0,0138	0,014506438	0,67	
0,09		3,256357383	0,0631	0,102724208	1,23	
0,05		2,16184407	0,0342	0,015441743	0,82	
0,09		1,20422971	0,0247	0,008438891	0,46	
0,06		1,585411707	0,0246	0,014639074	0,60	
0,07		1,418457805	0,0204	0,010953342	0,54	
0,07		2,167834996	0,0294	0,017454388	0,82	
0,19		3,549900679	0,0560	0,025356433	1,34	
0,04		1,633275504	0,0371	0,016700159	0,62	
0,07		1,685354626	0,0285	0,020578201	0,64	
0,10		2,003203927	0,0240	0,018496804	0,76	
0,06		2,570232429	0,0419	0,034133233	0,97	
0,15		2,153014146	0,0148	0,012931016	0,81	
0,10		4,555994274	0,0855	0,042068276	1,72	

0,07	1,557462241	0,0152	0,015512572	0,59
0,08	2,672997117	0,0394	0,043963768	1,01
0,08	1,537882886	0,0184	0,017903177	0,58
0,07	3,901734233	0,0592	0,051338608	1,48
0,12	1,664815033	0,0142	0,014655062	0,63
0,05	1,697614737	0,0242	0,023350959	0,64
0,10	1,924915203	0,0306	0,025129441	0,73
0,06	1,946363587	0,0280	0,023563724	0,74
0,09	2,185148867	0,0189	0,017779893	0,83
0,10	2,135313401	0,0307	0,031081709	0,81
0,05	0,933602721	0,0171	0,018597664	0,35
0,06	1,7205227	0,0232	0,024130753	0,65
0,12	3,390620003	0,0207	0,019898005	1,28
0,19	5,258877078	0,0603	0,053066368	1,99
0,09				
0,05	1,420850752	0,0265	0,025014978	0,54
0,10	2,804240765	0,0361	0,026207858	1,06
0,07	4,078720096	0,0709	0,067084212	1,54
0,12	2,126972136	0,0169	0,011182819	0,81
0,03	1,192796271	0,0388	0,010499967	0,45
0,08	2,543796015	0,0254	0,011886897	0,96
0,05	1,694059245	0,0187	0,011248733	0,64

FE in sample(µg)	FE in sample(µg/g)	µg FE/cm3	FE mg/m2	tot FE OM	pH	CN	ID_new
6,980536661	0,2217	0,047166	2,64	3,10	3,46	33,3423	1
6,513059575	0,2761	0,034718	2,47	2,74	3,54	30,6254	2
7,264752608	0,4223	0,044351	2,75	3,11	3,46	30,2823	3
4,771057062	0,2614	0,038414	1,81	1,94	3,61	28,0622	4
5,882539784	0,3156	0,031815	2,23	2,43	3,62	34,2234	5
7,004080737	0,2356	0,029792	2,65	3,09	3,47	33,3396	6
9,169272177	0,3704	0,039218	3,47	3,85	3,58	29,1603	7
5,897597839	0,2390	0,024131	2,23	2,69	3,57	27,6323	8
6,851850283	0,4235	0,039288	2,59	3,32	3,57	30,2982	9
5,997583063	0,1997	0,041277	2,27	2,55	3,38	32,1951	10
7,612721367	0,3258	0,039732	2,88	3,43	3,64	28,9681	11
5,589746836	0,1911	0,028019	2,12	2,44	3,51	30,1993	12
6,247040994	0,3407	0,046377	2,36	2,67	3,66	28,0527	13
4,717786318	0,2367	0,034664	1,79	2,15	3,92	28,1715	14
10,51079999	0,3623	0,057248	3,98	4,38	4,02	29,531	15
9,188732519	0,2358	0,037597	3,48	3,66	3,59	27,3413	16
8,510735839	0,3394	0,047361	3,22	3,65	3,62	28,0719	17
9,888273109	0,2714	0,029238	3,74	4,17	3,6	29,7526	18
10,5350684	0,3827	0,056977	3,99	4,33	3,61	27,6599	19
10,77079175	0,2949	0,045047	4,08	4,36	3,46	28,5149	20
6,648190446	0,1643	0,024669	2,52	2,92	3,72	28,5866	21
10,02502702	0,2763	0,035971	3,79	4,38	3,55	30,4593	22
7,815410028	0,3794	0,049716	2,96	3,49	3,62	30,0809	23
5,728382999	0,3072	0,036141	2,17	2,68	3,9	29,0687	24
8,921068395	0,3935	0,049644	3,38	3,89	3,84	32,0387	25
10,75699552	0,2725	0,043781	4,07	4,77	3,49	29,4642	26
13,50490888	0,4354	0,081111	5,11	5,53	3,67	28,0849	27
8,354888434	0,2109	0,042154	3,16	3,42	3,65	24,5953	28
9,161206737	0,3780	0,070743	3,47	3,84	3,54	29,3	29
7,427012277	0,1872	0,043256	2,81	3,13	3,67	32,2196	30
4,871307238	0,4733	0,024578	1,84	2,32	3,73	34,2915	31
6,001438813	0,1956	0,026105	2,27	3,04	3,92	37,6528	32
5,107429062	0,4135	0,043916	1,93	2,30	3,57	31,1924	33
6,104408561	0,3716	0,034488	2,31	2,69	3,63	39,8527	34
4,432735431	0,3294	0,030507	1,68	2,12	3,88	30,0306	35
5,13237768	0,3418	0,023838	1,94	2,56	3,65	42,9173	36
5,997842442	0,3880	0,032438	2,27	2,74	3,88	33,2075	37
5,192444794	0,3212	0,033306	1,97	2,78	3,68	36,4976	38
5,109301803	0,3111	0,035164	1,93	2,35	3,97	29,0787	39
7,899958253	0,4061	0,051566	2,99	3,55	3,62	35,354	40
4,787065638	0,2999	0,035885	1,81	2,13	3,56	31,1145	41
5,494140765	0,2146	0,019257	2,08	2,73	3,99	31,0942	42
4,347594822	0,2688	0,044454	1,65	2,05	3,69	27,3055	43
6,642754447	0,2940	0,031423	2,51	2,86	3,62	36,2669	44
4,481421822	0,2186	0,026915	1,70	2,08	3,8	34,5693	45
4,455083741	0,1777	0,024792	1,69	2,18	3,51	35,996	46
5,594832155	0,3230	0,033342	2,12	2,56	3,94	31,8764	47
7,65154673	0,2322	0,024964	2,90	3,34	3,65	32,9997	48

9,72172229	0,3060	0,042287	3,68	3,90	3,91	29,6028	49
5,665393911	0,3322	0,049871	2,14	2,51	3,69	31,4253	50
5,844558874	0,2359	0,037804	2,21	2,93	3,56	30,5178	51
4,812909321	0,1424	0,019275	1,82	2,60	3,69	31,4165	52
6,755689367	0,3343	0,041909	2,56	3,04	3,62	34,7604	53
5,678595077	0,2950	0,028855	2,15	2,45	3,68	34,2204	54
6,395996149	0,2622	0,029707	2,42	2,98	3,67	35,1886	55
8,438542222	0,3302	0,032594	3,19	4,08	3,67	40,2723	56
7,211159718	0,4050	0,045496	2,73	3,17	3,85	34,3211	57
6,619406068	0,2697	0,050109	2,51	2,74	3,55	37,0156	58
10,250798	0,3721	0,15508	3,88	4,49	3,81	33,456	59
7,273051323	0,3075	0,059861	2,75	3,07	3,52	41,882	60
1,218870809	0,0101	0,010032	0,46		4,29	15,015	61
0,737981352	0,0112	0,003991	0,28		4	22,4684	62
0,944683516	0,0084	0,009934	0,36		4,07	18,7104	63
0,364395125	0,0068	0,004179	0,14		4,04	24,5474	64
0,527482714	0,0091	0,00798	0,20		3,98	23,612	65
1,167549836	0,0126	0,010711	0,44		3,67	21,4347	66
1,001203891	0,0109	0,010386	0,38		3,98	21,1384	67
1,202585122	0,0148	0,012135	0,46		3,75	19,964	68
1,933036153	0,0208	0,016258	0,73		3,78	23,1663	69
0,738590299	0,0121	0,009981	0,28		4,01	20,6247	70
1,442640788	0,0166	0,018519	0,55		3,72	19,7752	71
0,866421641	0,0212	0,015986	0,33		3,83	17,7797	72
0,814726962	0,0116	0,011427	0,31		3,8	23,4088	73
0,970184479	0,0113	0,012884	0,37		3,85	24,1323	74
1,059752356	0,0218	0,022938	0,40		3,66	25,2484	75
0,484112603	0,0163	0,013951	0,18		3,54	20,1456	76
1,137525666	0,0145	0,013462	0,43		3,44	21,6343	77
1,139826615	0,0257	0,02355	0,43		3,72	20,9621	78
0,895561264	0,0181	0,016136	0,34		3,52	20,1233	79
0,737635582	0,0147	0,014323	0,28		3,5	20,5877	80
1,06890719	0,0106	0,012258	0,40		3,84	23,605	81
1,554697459	0,0170	0,014892	0,59		3,92	19,3303	82
1,397266987	0,0132	0,015321	0,53		3,81	21,9596	83
1,361648766	0,0168	0,01982	0,52		3,7	23,9881	84
1,362401458	0,0106	0,011213	0,52		4,14	21,7598	85
1,834308073	0,0356	0,057865	0,69		3,55	23,7241	86
1,112575052	0,0176	0,007947	0,42		3,62	21,6143	87
0,682752213	0,0140	0,004785	0,26		3,8	18,0992	88
0,976821063	0,0152	0,00902	0,37		3,75	25,5683	89
0,843128863	0,0121	0,006511	0,32		4,04	24,0252	90
1,256463727	0,0170	0,010116	0,48		4,07	26,1928	91
2,040762893	0,0322	0,014577	0,77		4,21	19,2769	92
0,976199282	0,0222	0,009982	0,37		3,98	22,2877	93
1,011349783	0,0171	0,012349	0,38		3,93	23,3509	94
1,162700149	0,0139	0,010736	0,44		4,23	22,1478	95
1,628153086	0,0266	0,021622	0,62		4,17	29,0032	96
1,228449028	0,0085	0,007378	0,46		4,59	16,8859	97
2,141860195	0,0402	0,019777	0,81		3,92	29,9913	98

1,089121126	0,0106	0,010848	0,41	4,05	23,758	99
1,46915236	0,0217	0,024164	0,56	4,18	25,5725	100
0,832637475	0,0099	0,009693	0,32	3,9	22,3181	101
1,725254659	0,0262	0,022701	0,65	4,19	23,9726	102
1,063042379	0,0091	0,009358	0,40	4,18	19,9898	103
0,918071297	0,0131	0,012628	0,35	4,16	24,8772	104
1,005208754	0,0160	0,013123	0,38	3,86	23,062	105
1,31305996	0,0189	0,015897	0,50	3,97	26,4929	106
1,162063411	0,0101	0,009455	0,44	4,35	19,0975	107
1,177987684	0,0169	0,017147	0,45	4,02	24,4279	108
0,593776224	0,0109	0,011828	0,22	4,17	18,9679	109
0,961285539	0,0129	0,013482	0,36	4,19	22,1143	110
1,905407786	0,0117	0,011182	0,72	4,17	24,1903	111
2,061284639	0,0236	0,0208	0,78	3,97	33,1708	112
1,273312866	0,0096	0,010709	0,48	4,18	21,9665	113
0,796425405	0,0149	0,014022	0,30	4,02	23,8407	114
1,480648092	0,0191	0,013838	0,56	4,3	21,0539	115
2,352139046	0,0409	0,038686	0,89	3,82	40,4643	116
1,158634878	0,0092	0,006092	0,44	4,4	17,9588	117
0,627800658	0,0204	0,005526	0,24	3,79	25,1186	118
1,603809667	0,0160	0,007494	0,61	4,11	23,757	119
0,841637042	0,0093	0,005589	0,32	4	26,7345	120

ID_old	plot	date	pp	pair
1	1	first	prior	1
5	3	first	prior	2
9	5	first	prior	3
13	7	first	prior	4
17	9	first	prior	5
21	11	first	prior	6
25	13	first	prior	7
29	15	first	prior	8
33	17	first	prior	9
37	19	first	prior	10
41	1	second	post	1
45	3	second	post	2
49	5	second	post	3
53	7	second	post	4
57	9	second	post	5
61	11	second	post	6
65	13	second	post	7
69	15	second	post	8
73	17	second	post	9
77	19	second	post	10
81	1	third	post	1
85	3	third	post	2
89	5	third	post	3
93	7	third	post	4
97	9	third	post	5
101	11	third	post	6
105	13	third	post	7
109	15	third	post	8
113	17	third	post	9
117	19	third	post	10
3	2	first	prior	1
7	4	first	prior	2
11	6	first	prior	3
15	8	first	prior	4
19	10	first	prior	5
23	12	first	prior	6
27	14	first	prior	7
31	16	first	prior	8
35	18	first	prior	9
39	20	first	prior	10
43	2	second	post	1
47	4	second	post	2
51	6	second	post	3
55	8	second	post	4
59	10	second	post	5
63	12	second	post	6
67	14	second	post	7
71	16	second	post	8

75	18	second	post	9
79	20	second	post	10
83	2	third	post	1
87	4	third	post	2
91	6	third	post	3
95	8	third	post	4
99	10	third	post	5
103	12	third	post	6
107	14	third	post	7
111	16	third	post	8
115	18	third	post	9
119	20	third	post	10
2	1	first	prior	1
6	3	first	prior	2
10	5	first	prior	3
14	7	first	prior	4
18	9	first	prior	5
22	11	first	prior	6
26	13	first	prior	7
30	15	first	prior	8
34	17	first	prior	9
38	19	first	prior	10
42	1	second	post	1
46	3	second	post	2
50	5	second	post	3
54	7	second	post	4
58	9	second	post	5
62	11	second	post	6
66	13	second	post	7
70	15	second	post	8
74	17	second	post	9
78	19	second	post	10
82	1	third	post	1
86	3	third	post	2
90	5	third	post	3
94	7	third	post	4
98	9	third	post	5
102	11	third	post	6
106	13	third	post	7
110	15	third	post	8
114	17	third	post	9
118	19	third	post	10
4	2	first	prior	1
8	4	first	prior	2
12	6	first	prior	3
16	8	first	prior	4
20	10	first	prior	5
24	12	first	prior	6
28	14	first	prior	7
32	16	first	prior	8

36	18	first	prior	9
40	20	first	prior	10
44	2	second	post	1
48	4	second	post	2
52	6	second	post	3
56	8	second	post	4
60	10	second	post	5
64	12	second	post	6
68	14	second	post	7
72	16	second	post	8
76	18	second	post	9
80	20	second	post	10
84	2	third	post	1
88	4	third	post	2
92	6	third	post	3
96	8	third	post	4
100	10	third	post	5
104	12	third	post	6
108	14	third	post	7
112	16	third	post	8
116	18	third	post	9
120	20	third	post	10

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