SURVEY OF GREENHOUSE GAS FLUXES FROM DIFFERENT VEGETATION, SEASONS AND LANDSCAPE UNITS IN SMALL SCALE FARMING SYSTEMS IN LOWER NYANDO-KENYA

BY

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DECLARATION

This thesis is my original work and has not been presented for a degree award in Maseno University or any other university.

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DEDICATION

To my parents Mr John Otiato and Mrs Dollyrose Otiato, son Tyron Calistus and daughters Tatyana Namulanda and Gift Nakhungu

ABSTRACT

Greenhouse gases (GHGs) emissions data from large-scale agricultural activities are available. In developing countries, e.g. Kenya, agriculture is dominated by smallholder farming, data on the assessment of possible contributions of smallholder agriculture to GHG emissions and GHG fluxes data from smallholder farming systems in the tropics is scarce. The study area is a 10 square km area also called the "Lower Nyando Block" in Western Kenya. The basin varies in landscapes (low lands, slopes and uplands) and climates (humid and sub-humid). The aim of the study was to assess the contribution of smallholder agricultural systems and seasonal variations in GHG fluxes within the block. The objectives were; to determine soil-atmosphere GHG fluxes under different land covers and crop types; establish effect of different landscape units on soil-atmosphere GHG fluxes and determine seasonal variations effect on soil-atmosphere GHG fluxes from smallholder farms in the lowland in Nyando Block. Study design was complete randomised design on 60 farms randomly selected within the landscape units. The farming activities include livestock keeping, fallows, woodlots and crop production. Farmers continued with their normal activities during data collection. GHG fluxes were estimated using static chamber method. Samples were analysed for CH_4, CO_2 and N_2O, then subjected to analysis of variance and paired T test. Grazing lands had lower ($p\leq0.05$) CH_4 uptake than fallow and crop areas with absorptions ranging between -0.15 to -0.85 mg C-CH_4 m^{-2} day^{-1}, but had higher emission of CO_2 than fallow and crop areas with emissions ranging between 3.13 to 1.20g C-$CO_2 m^{-2} day^{-1}$. No difference ($p\leq0.05$) was observed in N_2O emission in the various land covers having emissions between 0.29 to 0.05 µg N-N_2O $m^{-2} day^{-1}$. There was no difference ($p\leq0.05$) in GHG fluxes in the landscape units. CH_4 absorption increased ($p\leq0.05$) (-0.48 to -0.66 mg C-CH_4 $m^{-2} day^{-1}$), but CO_2 and N_2O emissions decreased ($p\leq0.05$) (2.2 to 1.54 g C-$CO_2 m^{-2} day^{-1}$ and 0.15 to 0.06 µg N-N_2O $m^{-2} day^{-1}$) from long to short rainy seasons respectively. The low emissions levels demonstrate that small scale farming systems in Nyando Block are not significant contributors to atmospheric GHGs. The activities were net absorbers of methane thereby mitigating climate change that could arise from GHG. However, grazing lands could have potential to be major emitters of CO_2 if animal keeping is intensified. It is recommended that the farmers continue with their farm practices and those in the lowland increase farm input to improve yields without adverse GHGs emissions.

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ANOVA	Analysis of variance
CCAFS	Climate change, agriculture and food security
GHG	Greenhouse gases
GWP	Global warming potential

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Climate change is the long term alteration in temperature, precipitation, wind and other elements of the earth's weather patterns (IPPC, 1996). It can be caused by natural processes such as fluctuations in the sun's intensity, complex motion of the earth round the sun, volcanic eruptions, and interactions between components of climate, among others. Some aspects causing current climate change are however not natural, as the magnitude and rates of the changes have been larger than usual. Greenhouse gas (GHG) emissions are one of the major factors that cause for climate change by causing an increase in atmospheric temperature. The solar radiation comes into the earth's atmosphere at shorter wavelengths that are able to penetrate the 'blanket' formed around the earth's atmosphere by the GHGs. When the radiation gets to the earth's surface at lower temperatures, the earth and the biosphere emit what is known as 'terrestrial radiation' (Kiehl and Trenberth, 1997). This radiation is at longer wavelength and is absorbed by the 'blanket' of GHG and subsequently reradiated back to the earth. Consequently heat is emitted back to the earth surface and is trapped leading to 'Greenhouse Effect' (Kiehl and Trenberth, 1997). Without global warming, estimates of the world's temperature would be 34^{o}C lower (IPPC, 1996), making it inhabitable. However, the magnitude of climate change is alarming (WMO, 2002). This notwithstanding, the increase in GHG concentration due to anthropogenic activities has caused a further temperature rise in the atmosphere to levels that can no longer be ignored. Global temperature is projected to increase $2\text{-}6^{o}$C (3.6-10.8 ^{o}F) during the 21st century (IPPC, 2007). Gases that are abundant in the atmosphere include nitrogen and oxygen. These are however not able to trap energy in the IR radiation spectrum and are therefore not GGHGs. The GHG include carbon (IV) oxide (CO_2), nitrous oxide (N_2O), and methane (CH_4), water vapour and ozone and CFCs, the primary ones being CO_2, N_2O, and CH_4. This is due to the molecule being polar as in N_2O or ability of these gases to have a dipole moment through vibrations of their molecules as in CH_4, CO_2 which allows these molecules to absorb infra-red radiation. CO_2 has a global warming potential (GWP) of 1 because it has the shortest atmospheric lifetime and lowest potential to absorb infrared radiation compared to other GHGs (Greenhouse gas working group, 2010). While CH_4 is a long-lived GHG with a contemporary GWP 21 times greater than $CO_{2.}$ N_2O is a long-lived, potent GHG with 310 times the GWP per molecule of CO_2 (U.S. Environmental Protection Agency, 2010). The GHG emissions are therefore a global issue that need to be understood and addressed urgently to help develop policies to mitigate climate change.

Nitrous oxide from agricultural land may arise from nitrification (oxidation of ammonia to form nitrates), denitrification (reduction of nitrates to nitrogen) and chemonitrification (chemical decomposition of nitrites). CO_2 from the soil may arise from methanotrophism process (a microbial process involving oxidation of methane to CO_2) or as a result of root respiration while methane may arise from the soil due to methanogenesis which occurs in anaerobic conditions.

Global warming has various negative effects such as melting of ice, change in hydrological cycle and rise in sea level, along with extreme weather conditions including frequent droughts, floods, heat waves, cold and long winters. A temperature rise of 3^{o}C could raise sea levels by about 80 cm, enough to flood huge areas of unprotected coastal land. Nearly a third of all human beings live within 60 km of a coastline. A rise in sea level of half a meter could have devastating effects on settlement patterns causing many people to migrate and many cities and ports to be submerged (Ngaira and Khaoma, 2007). The earth is tending towards warmer climates characterized by frequent prolonged droughts and heavy downpours such as 1968-1973 Sahelian drought and the devastating floods such as the 1997 - 1998 El Nino flood in equatorial East Africa, caused by the abnormal warming of the eastern pacific waters (Ngaira and Khaoma, 2007). Floods in Turkaka caused the displacement of 30000 people and death of one person, while in Garisa, 7250 people have been displaced and 3 dead in 2018 (The standard team, 2018). In Kenya also, 2.6 million people were acutely malnourished in 2017. Severe drought has dried up of the water resources in more than half of the 47 counties (Kenya: Humanitarian dashboard, 2017). In western Kenya, there have been frequent incidences of flooding in the Lake Victoria basin and longer than usual droughts. It is not known if these were caused by the general warming of the region.

Changes in climate also affect vegetation and agriculture. Some areas are no longer suitable for some crops while others become suitable for different crops (Kerstin, 2011). This impacts negatively on yield, quality, pests and diseases infestations (Kerstin, 2011) and may cause food insecurity. Anthropogenic activities such as changes in land use, deforestation, agriculture and urbanisation increase levels of GHG in the atmosphere. Agricultural practices especially fertilizer application, tillage and use of farm machinery increase levels of GHG. Agriculture accounts for 10-12% of the annual increase in anthropogenic greenhouse warming (Smith *et al*, 2007; IPPC, 2007). Most of this is due to CH_4 and N_2O emissions; which account for 50 and 70%, respectively, of anthropogenic emissions produced by agriculture (IPPC, 1994). Globally, agricultural emission of CH_4 and N_2O both increased by 17% from 1990 to 2005 (US-EPA, 2006). Greenhouse gas emissions from agriculture from many parts of the world have been quantified, (Lou *et al,* 2006; Li, 2007; Cerri *et al*, 2010; Fernandes *et al*, 2011). Most of the data were generated from large scale agricultural activities mostly in the developed subtropical world. For instance, in New York dairy farming, methane and nitrous oxide contributed 75% of total farm global warming potential (GWP) (Wightman, 2006). In Australia, agriculture was a major source of CH_4 (58.9%) and N_2O (85.9%) (The Australian Government, 2009). Despite the enormous research worldwide, there is very little information on GHG emission from agricultural activities in developing tropical countries such as Kenya.

Agriculture in Kenya is dominated by smallholder agriculture, even for the main commodity crops like tea (Buch-Hansen, 2012), sugarcane (Kenya Sugar Board, 2009) and coffee (Coffee Research Foundation, 2013). A number of studies have been done in Africa on GHG emissions, however, they were either in large scale or limited in scope due to the limited number of sites or period of sampling. Examples include: Hickman *et al*. (2015) in Kenya worked on large scale maize production between 1 Mar 2011–Jul 2011. Samples were collected daily to weekly and obtained emissions of N_2O: 0.1–0.3 kg ha^{-1} yr^{-1}. Sugihara *et al*, (2012) in Tanzania worked on maize plantation, with/without residue between 2 Mar 2007–June 2010 sampling 1–2 times per month and got emissions of CO_2: 0.9–4.0 $Mgha^{-1}$ yr^{-1}. Lompo *et al*, (2012) in Burkina Faso worked on large scale urban gardens between 2 Mar 2008–Mar 2009 sampled twice a day (“several” times per cropping period) obtained emissions of N_2O: 80.5–113.4 kg ha^{-1} yr^{-1}, CO_2: 22–36 $Mgha^{-1}$ yr^{-1}. Brümmer *et al*. (2008, 2009) in Burkina Faso worked on plantations of sorghum, cotton or peanut between 4 Jun–Sep 2005 and Apr–Sep 2006 sampled 1–3 times per week and obtained fluxes of N_2O: 0.19–0.67 kg ha^{-1} yr^{-1}, CO_2: 2.5–4.1$Mgha^{-1}$ yr^{-1}, CH_4 of -0.67 to -0.7 kg ha^{-1} yr^{-1}. Dick *et al*. (2008) in Mali worked on largescale farming of pearl millet with/without legume intercropping sampled monthly between 3 Jan 2004–Feb 2005 obtained emissions of N_2O: 0.9–1.5 kg ha^{-1} yr^{-1}. In addressing the problem of global warming, the role of agricultural emissions of GHG has been largely overlooked or insufficiently addressed, especially under small scale agricultural systems in the developing countries. The Lower Nyando Block can provide knowledge on the contribution of small scale farming under various conditions to GHG fluxes. The area has three landscape units with different altitudes, rainfall patterns, soils and temperatures which are the major causes of differences in agricultural practices (Onyango *et* *al*, 2012). It is not known if the small scale agricultural systems can be major contributors to GHG emissions.

Small scale farming has a number of characteristics. Crop residues and other growths on the farmlands are cleared by burning. Biomass burning is estimated to add 8 billion tonnes of GHGs per year in the atmosphere (IPPC, 1995). Similarly, most small scale farmers, in the absence of improved fertilizers, resort to compost manure or the farm yard manure. Use of organic manure is believed to have contributed to about 7% of CH_4 and N_2O combined (Smith *et al*, 2007). Ruminant animals produce methane as part of their natural digestive processes. Total methane emissions from domestic ruminant animals have been estimated to be between 60 and 100 million tonnes. In addition, animal wastes from anaerobic waste management systems are likely to yield on the order of 15 million tonnes globally (Smith *et al*, 2007). The contribution of agriculture to GHG emission by sector is shown in Figure 1.

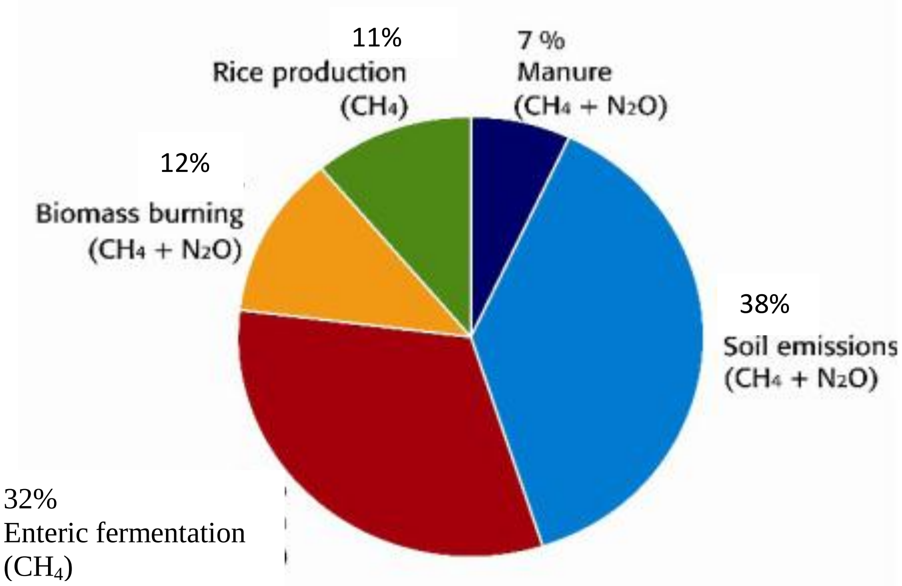


Figure 1: Main sources of global CH4 and N2O gas emissions in the agricultural sector in 2005 (Smith et al, 2007).

Although these figures were extrapolated at the global scale, most of the data were obtained from large scale farmers in developed countries (Smith *et al*, 2007). The contribution of small scale farming in tropical systems has been ignored. Due to the difficult economic conditions under which small scale farmers operate, estimations of GHG emissions from their agricultural practices is likely to vary from large scale farms in other climates.

Land configuration also influences soil – atmosphere GHG fluxes. There is a direct relationship between GHG fluxes and soil water content (Stres *et al*, 2008). The water content in the soil is determined by drainage properties of the soil. The drainage on the other hand is directly determined by the landscape configuration, both in terms of the slope and altitude. Often, the conditions of drainage may be related to the position of a soil on a slope. Consequently soils with very poor drainage lie at the bottom of the slopes whereas freely and excessively drained soils occur on the slope or at the crest, (Batjes and Bridges, 1992). Soils on the crest and slope will drain rapidly whereas those at the bottom of the slope receive water from upslope and will remain wet much longer. In such conditions, the period of saturated anaerobic conditions may be prolonged and lead to possibility of methane production (Batjes and Bridges, 1992). The Lower Nyando Block has soil configurations ranging from flat land at the top, steep slopes and flat land at the bottom. Such change in topography elicits differences in climatic conditions. The upland receives more rainfall distributed throughout the year. It also has fairly lower temperatures. The lowland receives scanty rainfall and floods due to runoff from the upland and slope. These differences may influence GHG fluxes.

Soil–atmosphere GHG fluxes vary with seasons. A season may be defined as a division of the year marked by changes in weather, ecology and hours of daylight (Khavrus and Shelevytsky, 2010). The GHG fluxes associated with agricultural activities have their genesis in the soil. The GHG emissions from the soils however are caused by two major factors namely heat (temperature) and moisture content, which change with seasons. In the Lower

Nyando Block, there are large variations in seasonal rainfall, air and soil temperatures. Indeed large variations in the basin occur between the upper part which receives relatively more rains that are more evenly distributed and cooler temperatures and the lower part of the basin that receives less rainfall that is poorly distributed and has higher temperatures and longer droughts (www.http.climate-data.org, 2012). It is not known if these variations in the Lower Nyando Block cause changes in GHG fluxes in the different parts of the Lower Nyando Block.

1.2. Statement of the Problem

The contribution of agriculture to global warming through release of GHG has been well documented in developed subtropical countries. However, data on contribution of small scale farming to GHG fluxes especially in tropical countries is scarce. Previous studies on the contribution of small scale agriculture to GHG is inconclusive since they were limited in scope, measuring emissions from a low number of sites for a short time period. They therefore did not give a good representation of small scale farming activities in the tropical regions. The Lower Nyando Block is one of the hot spots identified by CCAFS to have high mitigation potential and high vulnerability to food insecurity. The basin provides a range of topographical variability, varied climatic conditions including rainfall patterns, temperatures and soils. The difference in climatic conditions causes two planting seasons in the lowland and one in the upland and slope where there is production of different crops and livestock keeping. It is not known how the combination of seasons and crop management systems influence GHG fluxes in the different landscape units.

1.3. Justification

The quantification of GHG fluxes from various landscape units, vegetation and seasons would provide information on whether small scale farming systems are significant contributors to GHG emissions and how different factors within the Nyando Basin influence the GHG fluxes.

1.4. Aims and Objectives

1.4.1. Aim

The aim of the study was to assess the contribution of small scale agricultural systems in the Lower Nyando Block, West Kenya to GHG emissions under different land-covers, locations within the landscape and seasonal variations in the GHG fluxes.

1.4.2 Specific Objectives

The specific objectives of this work were:

i. To determine and compare soil-atmosphere greenhouse gas (GHG) fluxes from small scale farms in the Lower Nyando Block under fallow, grazing, woodlands and crop types,
ii. To establish the effect of the landscape unit (i.e. slope and altitude) on the soil-atmosphere GHG fluxes from small scale farms in the Lower Nyando Block, and
iii. To determine soil-atmosphere GHG fluxes in different seasons from small scale farms within the lowland in the Lower Nyando Block.

1.5. Research Hypothesis

1.5.1. Hypothesis (H_0)

i. Greenhouse gas (GHG) fluxes are not different in different land covers in the Lower Nyando Block.
ii. GHG fluxes do not vary in different landscape units in the Lower Nyando Block.
iii. GHG fluxes do not change with seasons in the lowlands in the Lower Nyando Block, western Kenya.

If the null hypotheses are not realized, the alternatives shall be accepted.

1.6 Significance of the study

This study helped to establish if small scale farming in Kenya contributes to global warming. This research, sought to quantify the contribution of small scale agriculture to GHG fluxes and establish the factors that influence the fluxes. Results helped in identification of agricultural practices and factors associated with high or low GHG emissions. Thus, this would contribute to data leading to the formulation of agricultural policies to mitigate climate change.

1.7 Limitation of the Study

i. Soil-atmosphere GHG emissions are highly variable in time (so-called hot moments). Therefore, there may have been a challenge to obtain reliable estimation of the GHG emissions. For example, missing hot moments (short-lasting pulse emissions) would result in underestimation of the total GHG emissions. On the other hand, detecting an emission pulse and extrapolating this value to periods between measurements may have led to overestimation of the fluxes.

ii. Soil-atmosphere GHG emissions are highly variable in space, with coefficients of variation over 100% within several meters (Arias-Navarro *et al,* 2013). In addition, complexity of the system in terms of patchy land covers and heterogeneous physiography contributes to sources of variability. Therefore, there may have been a challenge in accurately studying GHG emissions at the landscape level.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Climate change refers to a significant variation in either the mean state of the climate or in its variability, persisting for an extended period, typically decades or longer (WMO, 2002). This change may be due to natural internal processes or external forces, or due to persistent anthropogenic changes in the composition of the atmosphere or in land use. Part of the changes is caused by emissions of greenhouse gases. Greenhouse gases are trace gases with high global warming potential (GWP) and tend to cause greenhouse effect (IPPC, 2007). The GWP is due to their ability to trap and retain heat within the earth's atmosphere that causes a rise in global temperature. The additional rise in temperature caused by the extra GHG production is caused by anthropogenic activities and is what is often referred to as global warming. The primary GHGs are carbon (IV) oxide (CO_2), nitrous oxide (N_2O) (Paulino *et al*, 2010) and methane (CH_4). Agricultural activities release to the atmosphere significant amounts of CO_2, CH_4 and N_2O (Cole *et al*, 1997). Carbon (IV) oxide is released largely from microbial decay or burning of plant litter and soil organic matter (Smith, 2004).

$C + O_2 \longrightarrow CO_2$

CO_2 can also be produced from plant respiration by roots of plants as shown in the following equation.

$C_6H_{12}O_6 + 6\,O_2 \longrightarrow 6H_2O + 6\,CO_2 + ATP$

Also, through oxidation of methane by methanotrophs as shown in the following equation. This shows the pathway for the oxidation of methane and assimilation of formaldehyde. (Hanson and Hanson, 1996)

$CH_4 \longrightarrow CH_3OH \longrightarrow HCHO \longrightarrow HCOOH \longrightarrow CO_2$

Aerobic conditions of the soil are important for the oxidation of methane to CO_2 as shown in Figure 2.

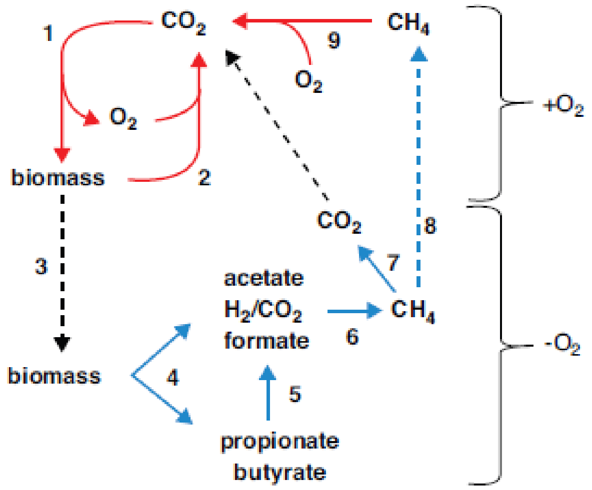


Figure 2: The global carbon cycle (Ferry, 2011).

Aerobic O_2-requiring conversions are shown in solid red arrows and anaerobic conversions in solid blue arrows. The brackets denote aerobic (+O_2) and anaerobic (-O_2) habitats. Black dotted arrows symbolize diffusion of substrates and products across the interface of zone (Ferry, 2011).

Nitrous oxide is generated by the microbial transformation of nitrogen in soils and manures, and is often enhanced where available nitrogen exceeds plant requirements, especially under wet conditions (Smith and Conen, 2004) allowing nitrification and denitrification processes. Nitrification process is shown in the following equation by Signor and Cerri (2013).

Nitritation: $2NH_4^+ + 3O_2 \rightarrow 2NO^{2-} + H_2O + 4H^+$ + energy;

Nitratation: $2NO^{2-} + O_2 \rightarrow 2NO^{3-}$ +energy

$$\begin{tikzcd}
NH_4^+ \arrow[r] & NO^{2-} \arrow[r] \arrow[d] & NO^{3-} \\
 & NO \arrow[r] & N_2O \arrow[r] & N_2
\end{tikzcd}$$

Figure 3 shows various steps followed in the formation of N_2O.

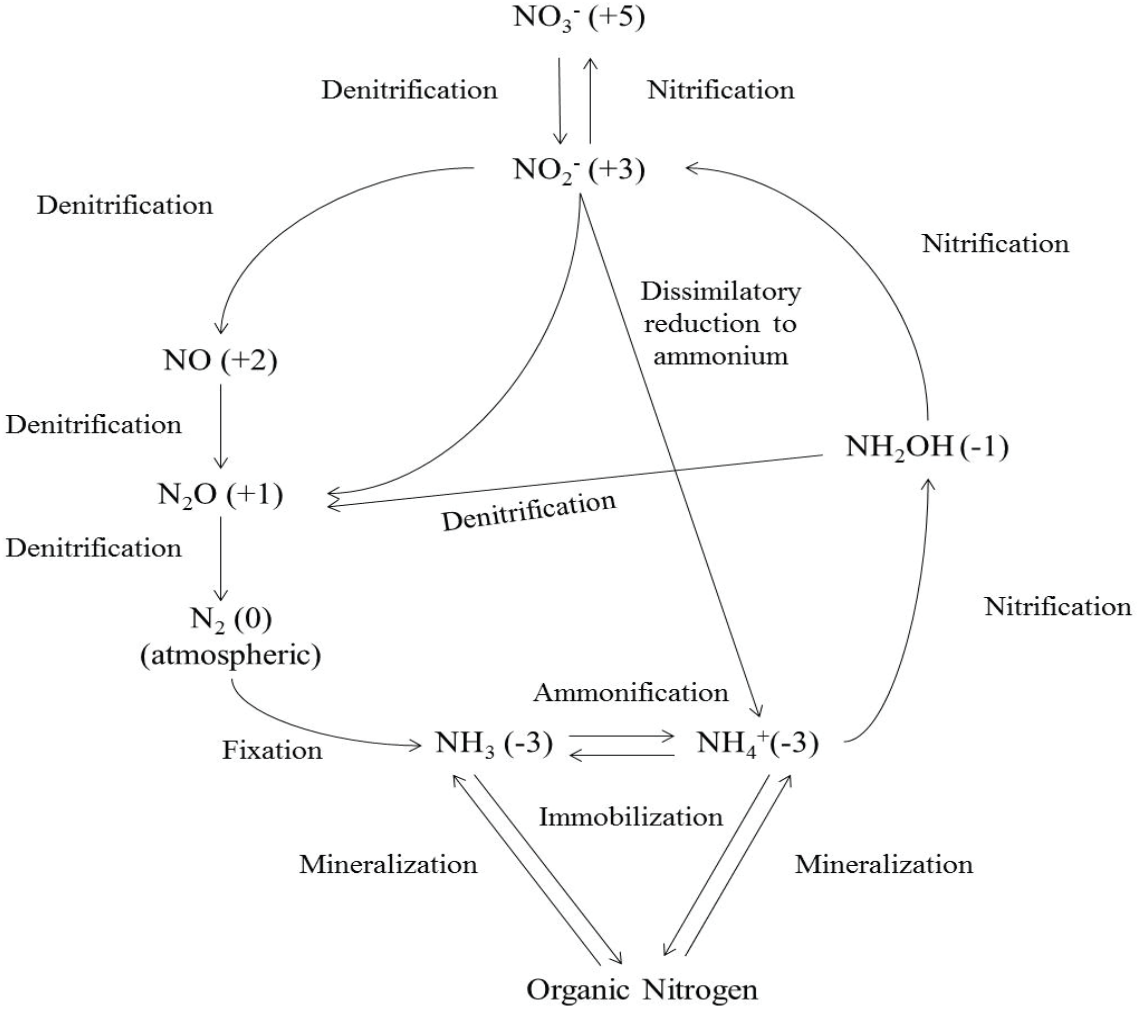


Figure 3: Nitrogen cycle and microbial formation of N_2O (Signor and Cerri 2013).

Presence of organic carbon and anaerobic condition favour the formation of N_2O.

Methane is produced when organic materials decompose under oxygen-deprived conditions, notably from fermentative digestion by ruminant livestock, stored manures and paddy rice grown under flooded conditions (Mosier *et al*, 1998).

Below are some of the reactions involved in the syntrophic metabolism of obligate proton-reducing acetogens and methanogens (Chynoweth, 1996).

- 1. Hydrogen

$4 H_2 + CO_2 \xrightarrow{} CH_4 + 2 H_2O$

- 2. Acetate

$CH_3COOH \xrightarrow{} CH_4 + CO_2$

- 3. Formate

$4 HCOOH \xrightarrow{} CH_4 + 3 CO_2 + 2 H_2O$

- 4. Methanol

$4 CH_3OH \xrightarrow{} 3 CH_4 + CO_2 + 2 H_2O$

- 5. Carbon monoxide

$4 CO + 2 H_2O \xrightarrow{} CH_4 + 3 H_2CO_3$

- 6. Trimethylamine

$4 (CH_3)_3N + 6 H_2O \xrightarrow{} 9 CH_4 + 3 CO_2 + 4 NH_3$

- 7. Dimethylamine

$2 (CH_3)2NH + 2 H_2O \xrightarrow{} 3 CH_4 + CO_2 + 2 NH_3$

- 8. Monomethylamine

$4 (CH_3)NH_2 + 2 H_2O \xrightarrow{} 3 CH_4 + CO_2 + 4 NH_3$

At the same time, soils may act as a weak sink for CH_4 due to the methanotrophic bacteria activity. Greenhouse gas fluxes in agricultural systems are complex and heterogeneous since agricultural practices vary from place to place and from culture to culture. The contribution of agriculture to GHG emissions in developed countries has been explored substantially. Studies have been conducted in Canada (Walker *et al*, 1997), Venezuela (Marquina *et al,* 2013). The Netherlands, Britain, Russia and China (Batjes and Bridges, 1992). These studies reported a direct relationship between agricultural activities and GHG emissions. This was particularly true for large scale agriculture which consumes large amounts of fertilizers and agrochemicals as well as extensive use of farm machineries (Smith *et al,* 2003). The relationship between agriculture and GHG emissions in third world countries, and particularly Africa, however remains blurred. Selected research has been carried out in Burkina Faso (Brummer *et al*, 2008), Sumatran Highlands in Indonesia (Verchot *et al*, 2006) and North Africa (Hickman *et al*, 2011) among others which also show that agricultural activities affect GHG fluxes. However, most of these researches were done among large scale farmers, with the contribution of small scale farming not being explored. Previous studies on the contribution of small scale agriculture to GHG in Africa were limited in scope, measuring emissions from a low number of sites (generally less than 10) for a short time period (i.e., less than 1 year) For example, Kimetu *et al*, (2007) in Kenya worked on maize plantation between 1 Mar–Jun 2000 (rainy season) and sampled 3 times per month. He obtained fluxes of N_2O: 31.2–295.2 μg m^{-2} day^{-1}. Mapanda *et al*, (2010) in Zimbabwe sampled in grassland/grazing, tree plantations and maize twice a month to once every 2 months between 12 Nov 2006–Mar 2007 (rainy season) obtained fluxes of N_2O: 24.0–112.8 μg m^{-2} day^{-1} CO_2: 540–1123.2 mg m^{-2} day^{-1} CH_4: -225.6 to 165.6 μg m^{-2} day^{-1}. Thomas, (2012) in Botswana worked on grazing field in 2 Feb, Apr, Jul, Nov 2010 (both rainy and dry season) and sampled 7 times per day on 12 separate days only and obtained emission of CO_2: 26.4–1010.4 mg m^{-2} day^{-1}. In most third world countries, agriculture is dominated by small scale farming. In Kenya agricultural activities are largely dominated by small scale farmers (Ministry of Agriculture – GoK, 2017), This is true even for the main industrial crops like tea (Buch-Hansen, 2012,), sugarcane (Kenya Sugar Board, 2009) and coffee (Coffee Research Foundation, 2013). Smallholder farming systems accounts for 67%, 85% and 75% of total land under tea, coffee and sugarcane respectively. Indeed even food crops production in Kenya is dominated by smallholder farmers. Approximately 80% of food in Kenya is produced by small scale farmers (Tamara, 2013). Information on the contribution of the small scale farmers planting different crops to GHG emission remains scanty and there is no information about small scale farming in the Lake Victoria basin where the Lower Nyando Block lies.

2.2 Land covers

Soil–atmosphere GHG fluxes are affected by a number of factors which usually interact with each other. A study establishing the effect of pastures (both grasslands and other pasture crops) on GHG emissions (Scheer *et al*, 2010) concluded that different crop/plant covers affected GHG fluxes. The findings indicated that although a small overall uptake of CH_4 was observed in this area, this could not offset the high emissions of N_2O and CO_2, (Scheer *et al*, 2010). Also the missions from specific crops varied greatly and the range within each crop was large (Mosier *et al*, 2004). Handling of crop residue may also affect GHG emission.

In sugarcane growing fields in tropical regions CH_4 and N_2O flux indicated that fertilizer placement and crop residue management impact GHGs emissions (Mosier *et al* 2004). In China, litter removal did not affect CH_4 uptake and did not also affect N_2O flux, (Liu *et al*, 2007). However, when manure was applied to crops it affected GHG emissions (Liu *et al*, 2007). The methane emissions increased with increasing temperature, but the increase in N_2O emission was much lower, (Rodhe *et al*, 2009). In Africa, combined emissions from paddocks, ranges, and pastures accounted for 74% of all agricultural N_2O emissions (Hickman *et al*, 2011). Emissions from on-farm manure management (including handling, storage, and application) accounted for an additional 3% (Hickman *et al*, 2011). In Burkina Faso, natural savannah emitted higher calculated cumulative annual N_2O emission than agricultural land (Brümmer *et al*, 2008). Gaseous losses during manure handling and storage not only represent a net loss of carbon and nutrients from the farm system, but also impact the overall greenhouse gas balance at farm scale through the emission of CO_2, CH_4 and N_2O (Steinfeld and Wassenaar, 2007). In Kenya, Tittonell *et al*, (2009), studied manure and mulches as the main land-covers. Manure handling increased GHG emissions, in both the developed and the developing countries land-cover of any form, particularly in agricultural practice, leads to increased N_2O and CO_2 fluxes.

The impact of land cover on CH_4 however remains mysterious as in some cases, land-cover and some crop types increased CH_4 emissions (Batjes and Bridges, 1992), while in some cases, land-cover presence and some crop types absorbed CH_4, (Scheer *et al*, 2010). N_2O fluxes from different plant types depend on availability of nitrate ions (NO_3^-) and aerobic conditions, (Fernandes *et al*, 2011). For instance, in Brazil, there were low N_2O fluxes in maize farms, and agricultural practices induced pulses of N_2O-N due to fertilisation. Variations of NO^{3-} N explained the N_2O-N emission under bean cultivation. The largest N_2O-N peaks occurred after nitrogen fertilizations in irrigated lands resulting in an increase of nitrogen availability under less aerobic soil environment. Also, slightly higher NO^{3-} availability and N_2O fluxes were observed during the senescence of bean and soybean and the post-harvest phase of cotton, which were related to nitrogen release from roots and nodules. (Fernandes *et al*, 2011). These studies indicate that various farming activities affect GHG emission. However, farming activities in large scale agriculture differ from those in small scale agriculture. Farmers in Nyando grow different crops such as tea, sugarcane, maize, and beans among others, which they do in small scale. It is however not known how much GHGs are emitted from these crops, being that they receive different treatments as compared to those grown in large scale in terms of farm input.

2.3 Landscape units

There is a direct relationship between land topography and levels of drainage (Stres *et al*, 2008). Soils with poor to very poor drainage usually lie at the bottom of the slopes whereas freely and excessively drained soils occur on the slope or at the crest. This causes production of N_2O in the bottom of the slope, and if the periods of saturated anaerobic conditions are prolonged, it would lead to possibility of methane production (Batjes and Bridges, 1992). These observations however differed from the findings of research done in South East Poland (Brzezińska *et al*, 2012). The middle slope had the highest emission of CH_4 followed by the top of the slope and the bottom of the slope had the least. Similarly, production of CO_2 was highest in the mid slope, followed by top and the bottom had the least. These results were corroborated a study in Canada (Peré and Bedard-Haughn, 2013) in which the mid and lower slope position had higher net CO_2 emissions than upper slope. The trend was not however consistent with results for the same area where very low net CH_4 and N_2O emissions were detected on most positions of the slope (Peré and Bedard-Haughn, 2013). The bottom of the slope receives water from upland and slopes which drain rapidly and therefore has anaerobic conditions which may lead to higher N_2O fluxes. If the condition is prolonged, it could lead to possible CH_4 production. The Lower Nyando Block has 3 landscape units, upland, slope and lowland. These areas have different rainfall patterns, temperatures and soil types leading to different agricultural activities (Onyango *et al*, 2012). The upland region has more rainfall that is better distributed leading to more intensive farming with greater amount of input in terms of manure and fertilizer application, yet in lower amounts than what is observed in large scale agricultural systems. Farmers there mostly keep dairy livestock which they keep in smaller numbers and feed on napier grass and grow crops like tea, sugarcane; bananas are grown that are not grown in the slopes and lower basin where crops like maize, sorghum, beans, woodlot, and grazing of a number of animals. It is however not known how small scale farming in the different sections of the basin affects GHG fluxes.

2.4 Seasons

Seasonal differences affect the temporal dynamics of the amount and activity of micro-organisms responsible for GHG production and consumption (Schindlbacher *et al*, 2004). During the dry season, microorganisms break down carbon bonds in dissolved organic compounds and in the process, electrons are transferred from organic carbon (electron donor) to electron acceptors (oxidising agent) in redox reaction. During the electron transfer process, ionized oxygen combines with dissociated carbon to form CO_2 in the microbial cells. The process leads to decomposition resulting to loss of soil carbon. N_2O emissions increases with increasing water filled pore space (WFPS) or decreasing water tension, respectively (Schindlbacher *et al*, 2004). When it rains the top soil becomes waterlogged and prevents the diffusion of oxygen (O_2) into the soil while at the same time, the microbes still use the remaining O_2 in the soil. Absence of O_2 activates denitrifiers in the soil which use (NO^{3-}) as an electron acceptor which receives electrons and is reduced to nitrite (NO^{2-}), and then NO then N_2O and finally N_2. N_2O may escape into the environment before further oxidation (Li, 2007). For instance, N_2O fluxes are extremely low in the dry soils prior to wetting. Slight net N_2O uptake may be observed occasionally during wet period (Yao *et al*, 2010).

Introduction of water to the dry soil results in a marked increase in N_2O emissions. As a result, the emissions are very high at the beginning of a wet season right after a dry season (Liu *et al*, 2007). These N_2O emission pulses may be induced by an accumulation of NH_4^+ and NO^{3-} during the dry season (Yue *et al*, 2003). The emissions increase with increase in soil moisture (Yao *et al*, 2010). There is therefore significant seasonal variation in N_2O fluxes, (Liu *et al*, 2007). If flooding occurs, for some time, oxidants become depleted and methanogens become activated. These use hydrogen as an electron acceptor to form $CH_{4,}$ (Li, 2007). In China, CH_4 uptakes were significantly higher in the dry season than in rainy season, (Liu *et al*, 2007). The seasonal variation was a major factor influencing CO_2 fluxes in volcanic soils (Paulino *et al*, 2010). In temperate countries, fluxes of CO_2 are higher, mainly before the beginning of winter and during spring, being at much lower values in the other seasons, (Paulino *et al*, 2010). Temperature also affects GHG emission in that methanogens activity increases as soil temperature rises gradually. Methanogens levels are high during rice growing season, and CH_4 emission also increase in the period (Yue *et al*, 2003). Increase in temperature increased N_2O in the soil profiles leading to an increase in N_2O emission (Yao *et al*, 2010). Water levels and temperature changes in different seasons are therefore important factors that affect GHG emissions. Lower Nyando Block has got landscape units which have different rainfall patterns and different temperatures that are expected to respond differently in terms of GHG emissions. The area lies in a tropical region as opposed to the majority of the studies which were done in the temperate and sub-tropical regions. It is however not known how temperature, rainfall and soils interact and affect GHG fluxes in this region, especially under small scale agricultural systems.

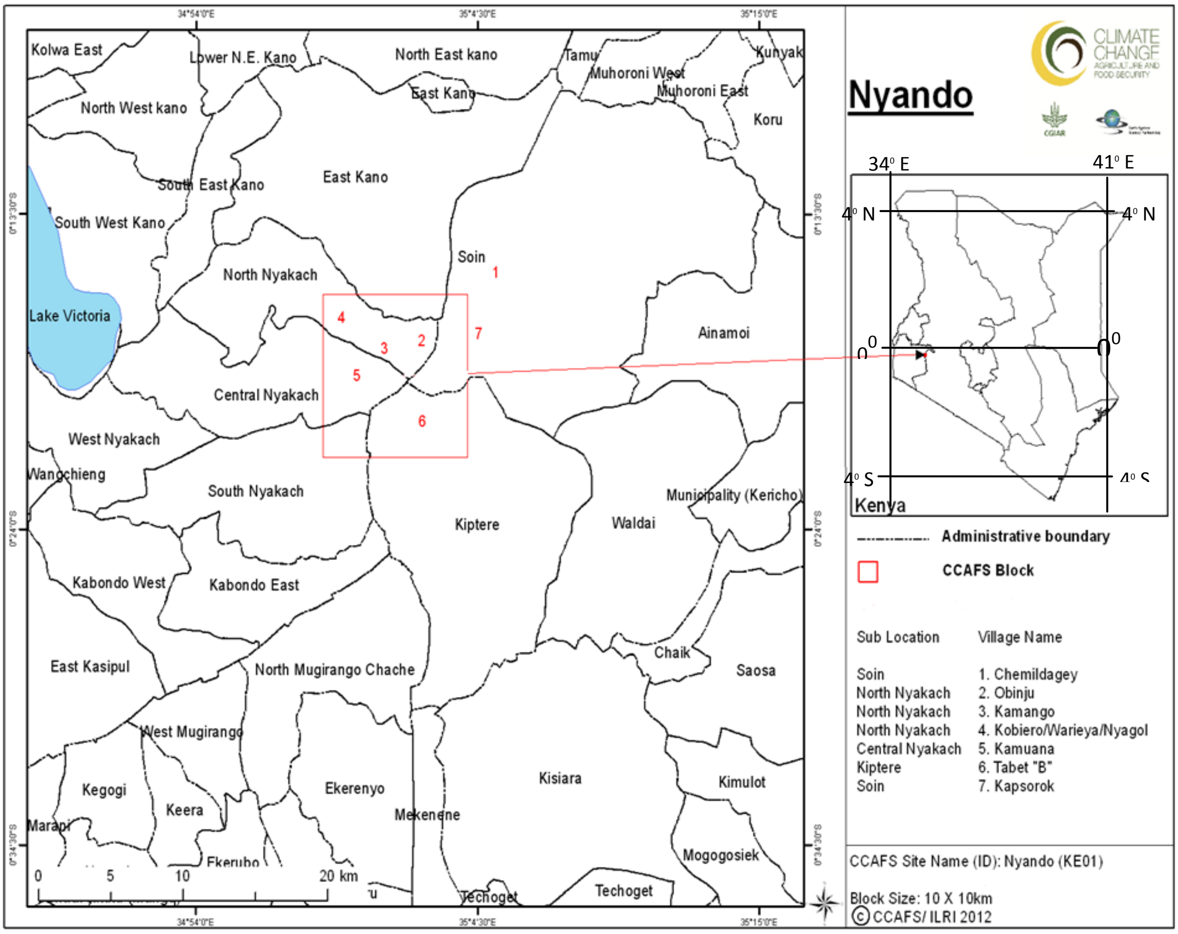
Small scale farming is usually characterised by lack of adequate farm inputs including low fertilizer applications (Ali-Olubandwa *et al*, 2011). Sometimes the small scale farming systems can be characterised by high inputs of manure. These differences may cause variations in GHG fluxes from the farms compared to results from developed countries under large scale agricultural systems. Farmers in the Lower Nyando Block are largely small scale farmers; rearing livestock whose droppings are used as manure and grow varied crops in different topographical regions. Farmers in the upper area of the Lower Nyando Block practice high inputs of inorganic fertilizer, mainly on tea, sugarcane and maize. They also have few animals that are fed within the farm on Napier grass. In the lower area of the Lower Nyando Block, these inputs are much lower and the farmers grow maize, sorghum, beans, and keep a number of animals (cattle, sheep and goats) which they graze in the fields according to the IMPACT Lite survey in the block (Onyango *et al*, 2012). It is not known if differences in agricultural inputs and crops have a direct impact on the GHG emissions within the area.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Site Description

The experimental site (Figure 2) was a 10 km square area in Western Kenya, (0^{o}13’30’’S - 0^{o}24’0’’S, 34^{o}54’0’’E – 35^{o}4’30’’E) known as the Lower Nyando Block. The altitude is between 1000 to 1500m above sea level. The area has two planting seasons in the lowland between April and July for the long rains and between August and November for the short rains. The Lower Nyando Block was identified by Climate Change, Agriculture and Food Security (CCAFS) as one of the “hot spots” (regions and system of high mitigation potential



and high vulnerability for food insecurity) (Onyango *et al*, 2012). The lowland field is in Kisumu County while the highland field is in Kericho County.

Figure 4: Location of the CCAFS benchmark Nyando site, Kenya (Source: Onyango et al, 2012).

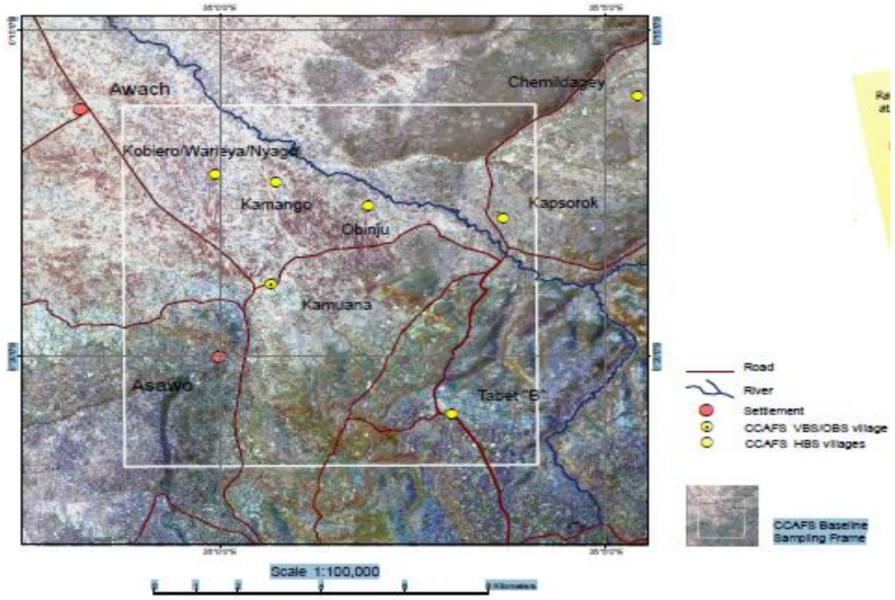


Figure 5: Location of the Lower Nyando Block, (Source: Sijmons et al, 2013)

3.2. Target Population

The target population was 60 small-scale landholder households) households identified in a study, IMPACT Lite survey in the block (Onya 2012). Most households are subsistence farmers producing crops and/or keeping livestock in small scale (Onyango *et al*, 2012).

3.3 Sample Selection

Convenient sampling based on an earlier household survey (Onyango *et al*, 2012) was used to identify different farms randomly based on the agro ecological zones (upland, slopes and lowlands) to set up the sampling fields and depended partly on logistical constraints (i.e., access). Up to 60 farms out of 200 farms selected at a confidence level of 95% and confidence interval of 10.5.

3.4. Sampling Design and Sampling

The sampling was based on landscape units and the study design was stratified completely randomized design where 60 spots were selected randomly for gas sampling. The farmers continued with their normal farm practices while research activities were being conducted. Land covers and crops included Maize, legume, cassava, woodlot/trees planted on the farm, banana, sugarcane, napier, sweet potato, sorghum, maize/sorghum, grazing and fallow.

The gases were collected using the static chamber method (Parkin and Venterea, 2010). Four bases/chambers approximately 2 meters apart were placed in each sampling area. Gas samples were taken from the chambers once a week. The pooling technique was employed for the four chambers whereby 15ml of gas was taken from each chamber to make a composite sample of 60ml. (Arias-Navarro *et al*, 2013). The samples were taken at intervals of 15 minutes starting from time zero to the 45th minute; that gives a total of four samples per sampling spot. In the pooling system, equal amounts of gas were taken from the four chambers to make an average sample rather than taking separate samples from the four chambers and analysing them separately then getting their average. In this study, no plants were included inside the chamber in the sampling except where there were weeds present in the farm or grasslands for grazing sites sampled. The sampling was done in the farms whereby the choice of crop was left to the farmer. Sampling was done once a week in each plot for eight months which covered the two rainy seasons. Vials of 10 ml volume were used to transport each sample to the laboratory. Out of the 60ml gas sample, 40 ml was used to flush the vial and 20 ml of gas was forced into the vial to create an overpressure.

3.5 Sample analysis

Air temperature and soil temperature (5 cm depth) were also measured at the time of gas sampling using a ProCheck handheld datalogger outfitted with a GS3 sensor (Decagon Devices). The sensor was pushed into the soil and reading recorded for soil temperature.

The gases were analysed using the gas chromatography, SRI 8610C gas chromatograph (2.74m Hayesep-D column) fitted with a ^{63}Ni-electron capture detector for N_2O and a flame ionization detector for CH_4 and CO_2 (after passing the CO_2 through a methanizer). The flow rate for the carrier gas (N_2/ was 20mLmin^{-1}. Oven column temperature of 60^{o}C, ECD cell of 350^{0}C and injection of 1ml of sample. Every fifth sample analysed on the gas chromatograph was a calibration gas (gases with known CO_2, CH_4 and N_2O concentrations in synthetic air) and the relation between the peak area from the calibration gas and its concentration was used to determine the CO_2, CH_4 and N_2O concentrations of the headspace samples.

Figure 6: A chamber used gas collect collection

Figure 7: Chambers in a sampling area.

3.6 Flux Calculation

Data was organised using Microsoft office Excel 2010 and the fluxes was calculated using the formula below (Butterbach-Bahl *et al*, 2011).

$$F = \frac{b * Mw * V_{Ch} * 60 * 10^{6}}{A_{Ch} * V_{m} * 10^{9}}$$

Where, F = flux rate (µg m^{-2} h^{-1})

b =slope of increase / decrease in concentration (ppb / min^{-1})

Mw = molecular weight of component (g mol^{-1})

V_{Ch} = chamber volume (m^{3})

A_{Ch} = chamber area (m^{2})

V_{m} = corrected standard gaseous molar volume(m^{3} mol^{-1})

V_{m} = (22.4*$10^{-3}$$m^{3}$$mol^{-1}$*(273.15+temp)/273.15*(air pressure/1013)

3.7 Data Analysis and Presentation

Inferential statistics was used as the mode of analysis. In particular, hypotheses one and two were tested through analysis of variance followed by Tukey honest significant difference (HSD) test for hypothesis one while hypothesis three was tested through paired T test for dependent samples. Completely randomized block design was used. The results obtained were presented through tables and figures.

3.7.1 Analysis of Variance

Analysis of variance was used to compare three or more means. It was used to test the claim that the means of three or more samples are equal (Bluman, 2007). This was suitable for testing hypothesis one as it could show different land covers, namely; fallow, grazing, woodlot and crops such as sorghum, maize-sorghum, sweet potatoes, napier, sugarcane, banana, cassava, legume, and maize from which variation in mean soil atmospheric GHG fluxes were being compared. The method was also suitable for testing hypothesis two since mean soil atmospheric GHG fluxes were being compared a cross three different landscapes, namely; lowland, slope and highland. In both cases, one way analysis of variance model was employed.

3.7.2 Paired T Test

T test was used in this case to separate seasonal (Bluman, 2007) soil atmospheric GHG fluxes. The hypothesis was: $H_0 : \mu_D = 0; H_1 : \mu_D \neq 0$ two tailed at 5% significance level, μ_D being the notation for the expected mean of the difference of matched pairs.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1.1 Variation in GHG fluxes in different land covers

The variations in GHG fluxes in different land covers are shown in Table 4.1 and Figures 4.1a, 4.1b and 4.1c.

Table 4.1: Skeleton of ANOVA output on GHG Fluxes in different land covers

		Sum of Squares	Df	Mean Square	F	Sig.
CH_4 concentration	Between land covers	12.442	11	1.131	2.574	0.004
	Within land covers	142.379	324	0.439		
	Total	154.821	335			
CO_2 concentration	Between land covers	87.109	11	7.919	8.028	0.000
	Within land covers	319.615	324	0.986		
	Total	406.723	335			
N_2O concentration	Between land covers	2.086	11	0.190	1.724	0.067
	Within land covers	35.739	325	0.110		
	Total	37.825	336			

There were significant ($p \leq 0.05$) differences in the absorption of CH_4; and emission of CO_2 in the land-covers. However, the difference in emission of N_2O in the land-covers was insignificant (Table 4.1). Despite CH_4 and CO_2 varying significantly, the actual levels between different types of land covers were small. Post-hoc comparison through Tukey HSD test indicated that the absorption of CH_4 (Figure 4.1a) for grazing (M=-0.15; SD=0.56) was lower than from fallow fields (M=-0.74; SD=0.59; p=0.041), sweet potatoes (M=-0.74; SD=0.74; p=0.034), bananas (M=-0.85; SD=0.68; p=0.012) and maize farms (M=-0.82; SD=0.62; p=0.007).

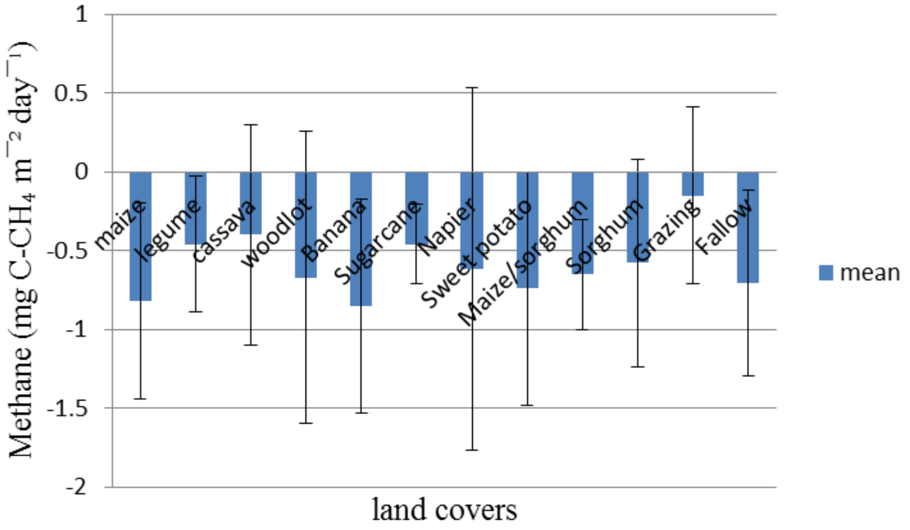


Figure 4.1a: Variations in CH_4 absorption in different land-covers.

Also, post-hoc comparison through Tukey HSD test indicated the mean CO_2 emission (Figure 4.1b) for grazing (M=3.12; SD=1.56) was significantly different from fallow (M=2.10; SD=0.69; p=0.003), sorghum (M=1.57; SD=1.28; p=0.000), maize-sorghum (M=1.86; SD=0.87; p=0.000), sweet potatoes (M=1.20; SD=0.46; p=0.000), napier (M=1.71; SD=0.87; p=0.000), sugarcane (M=1.54; SD=0.56; p=0.000), bananas (M=1.29; SD=0.42; p=0.000), woodlot (M=1.78; SD=1.36; p=0.000), cassava (M=1.70; SD=1.12; p=0.000), legume (M=1.23; SD=0.69; p=0.000), and maize (M=1.87; SD=0.84; p=0.000). Mean CO_2 emission in fallow land (M=2.10; SD=0.69) was higher than from sweet potatoes (M=1.20; SD=0.46; $p<0.034$) and legume (M=1.23; SD=0.69, p=0.033) but did not differ significantly from the rest of land covers.

All the land covers were methane sinks in this study as observed also by (Snyder *et al*, 2009). This is generally observed in non-flooded arable soils. However grazing areas showed lower uptake than fallow and crops land covers. This was not in conformity with Guardia *et al*, (2016), study in Spain where all land covers were CH_4 sinks, without significant differences between fallow (0.00125 mg C-CH_4 $m^{-2}h^{-1}$), legumes (-0.0017 mg C-CH_4 $m^{-2}h^{-1}$) and barley (-0.02625 mg C-CH_4 $m^{-2}h^{-1}$). Similar pattern had also been observed in the same area (Sanz-Cobena *et al*, 2014). In the Lower Nyando Block, mean CH_4 absorption ranged between -0.15 mg C-CH_4 m^{-2} day^{-1} in grazing fields to -0.85 mg C-CH_4 m^{-2} day^{-1} in banana fields. In sub-Saharan Africa, fluxes of methane in croplands ranged between -0.356 to 18.27 mg C-CH_4 m^{-2} d^{-1} (Kim *et al* 2016). In Germany Felessa *et al*, (1996), also found that urine areas were sinks of CH_4; however, dung patches were net emitters of CH_4. Dunfield and Knowles, (1995); Tate, (2015) have suggested an inhibitory effect of soil NH_4^+ on CH_4 uptake. The low levels of methane absorption under grazing land were attributed to patches of dung in these fields. Indeed due to the patching of dung distributions in the grazing lands there were no net emissions of methane as had been observed in other studies (Felessa *et al*, 1996; Dunfield and Knowles, 1995; Tate, 2015). Further, Low NH_4^+ contents in almost all of the cover crops except for grazing may explain the apparent lack of this inhibitory effect in the crops and a lot of it in the grazing leading to low CH_4 uptake. Similar observations had been made in a study on rice crop, (Banger *et al*, 2012). These results demonstrate that farming systems in the Lower Nyando Block do not contribute to emissions of methane.

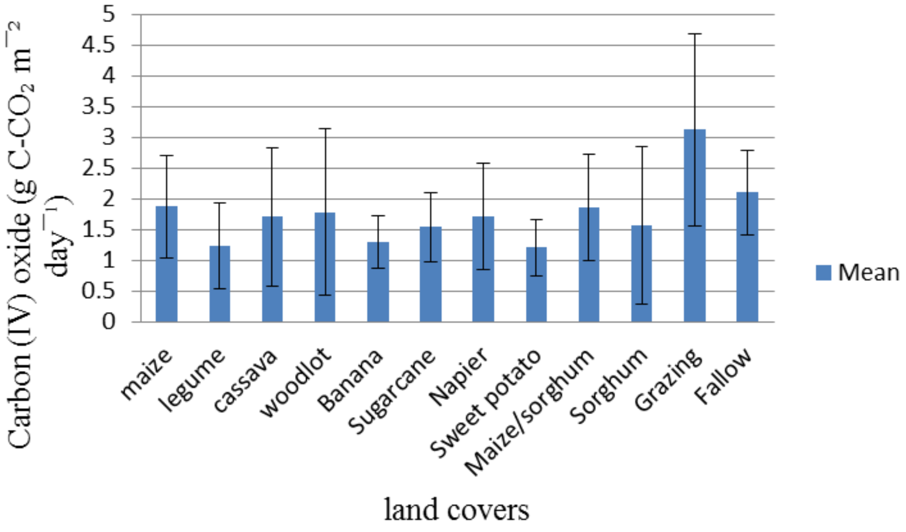


Figure 4.1b: Variations in CO_2 emission in different land-covers.

There was significant difference in CO_2 emission among the land covers. Grazing land had higher ($p \leq 0.05$) emission of CO_2 than fallow land and crops such as sorghum maize sweet potato, napier grass and legume crops (Table 4.1 and Figure 4.1b). In some other studies, there were no significant differences in CO_2 emissions from fallow, legumes and barley land covers (Guardia *et al,* 2016). But in another study (Sanz-Cobena, *et al,* 2014), presence of cover crops did not increase CO_2 emission, even though higher emissions were associated with barley (not legume) compared to fallow plots. Coffee plantations had CO_2 emission. Emissions of CO_2 from coffee plots were 20 to 80% higher than those in maize and napier grass. (Gonzalo *et al,* 2017). In the this study, mean CO_2 emissions ranged between 3.13g C-$CO_2m^{-2}day^{-1}$ in grazing fields to 1.20g C-CO_2 $m^{-2}day^{-1}$in sweet potato fields. This was probably as a consequence of higher root biomass and plant respiration rates in the grass than in the crops as observed in France (Oorts *et al,* 2007; Chirinda *et al,* 2010). The decomposition of cover crops residues and the growth of the grass rooting system in grazing fields resulted in an increase in CO_2 emissions (Oorts *et al,* 2007; Chirinda *et al,* 2010), Carbon accrual on optimally grazed lands is often greater than on ungrazed lands (Rice and

Owensby 2001; Liebig et al.2005). Although the pattern in response to emission of CO_2 under different land covers were similar to those observed elsewhere (Guardia *et al*, 2016; Sanz-Cobena *et al*, 2014; Oorts *et al*, 2007; Chirinda *et al*, 2010), the levels of CO_2 emission under different land covers in the Lower Nyando Block were very low even compared to studies on large scale agriculture in Sub Saharan Africa, in croplands, soil GHG emissions were also dominated by CO_2, ranging from 0.466 to 38.68 g C-CO_2 m^{-2} d^{-1}, from vegetable gardens ranged from 20.08 to 36.16 mg C-CO_2 $m^{-2}d^{-1}$ agroforestry were 10.59 g C-CO_2 m^{-2} d^{-1} (Kim *et al*, 2016). These results demonstrate that the land covers or farming systems in the Lower Nyando Block are not significantly contributing to CO_2 emission in the environment.

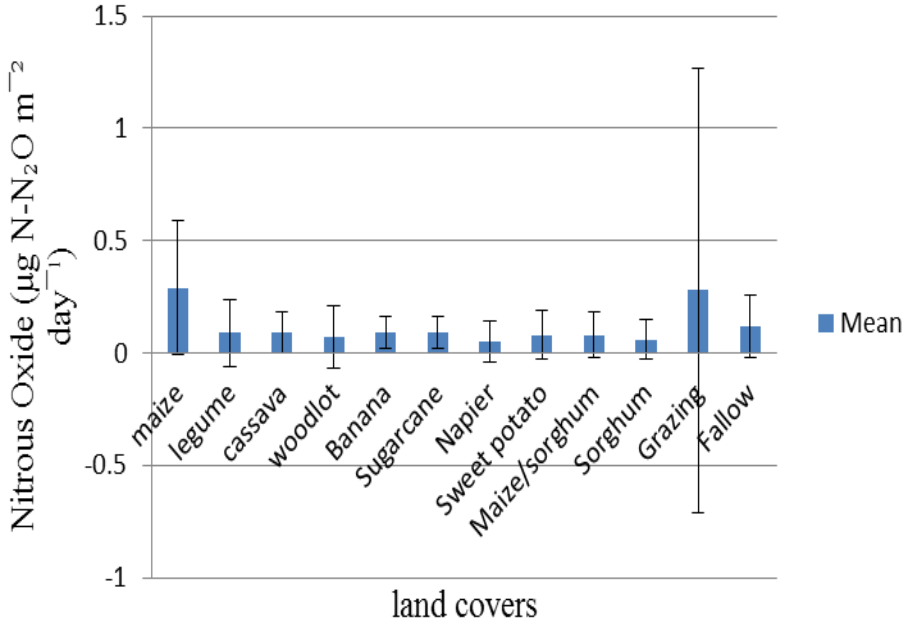


Figure 4.1c: Variations in N_2O emissions in different land-covers

There was however no significant difference in N_2O emissions in the various land covers (Figure 4.1 and Table 4.1). Urine areas are normally a significant source of N_2O, and urine patches had shown high N_2O emission with a maximum of 1250 and 25700µg N_2O m^{-2} h^{-1} (Sherlock and Gon, 1983 and Morgan and Barraclough, 1993) due to nitrification, denitrification and chemonitrification. The N_2O emissions from dung heaps are usually lower. For instance, the emissions were in a range of 1.0–13.4 mg N_2O–N kg^{-1} dry weight h^{-1} (Holst *et al*, 2007). In fact, N_2O emission from urine was higher than that from nitrogenous fertilizer as observed in Venezuela (Eichner, 1990) implying possible higher N_2O emission from grazing fields than crop covers. However, in some cases, intensive fertilizer application in largescale agricultural systems may cause a large production of N_2O, for instance in Sub Saharan Africa cropland produced 13698.663 to 30684931.51 µg N_2O m^{-2}d^{-1} while vegetable gardens produced 1466301367 to 486657534.25 µg N_2O m^{-2}d^{-1} (Kim *et al*, 2016).The lack of a significant difference between grazing and other land covers and low levels of N_2O emission at the Lower Nyando Block (0.29 µg N-N_2O m^{-2}day^{-1} in maize to 0.05 µg N-N_2O m^{-2}day^{-1} in napier grass) were attributed to the urine and dung patches in these fields since the animals were kept in small scale scale resulting to patchy distribution of dung and urine in the grazing fields. Indeed, cover crops increased N_2O losses compared to fallow land, especially in the case of legume compared to non-legume crops (Guardia *et al*, 2016; Basche *et al,* 2014; Sanz-Cobena *et al*, 2014). Legumes significantly affect N_2O emissions. This was contrary to what was observed at the Lower Nyando Block, which was attributed to the previous studies having been done in large scale farms where input in terms of fertilizer application were common. Indeed, the fertilizer was applied at a low rate in the Lower Nyando Block (< 25 kg N ha^{-1}). Application of synthetic fertilizers up to 70 kg N ha^{-1} at planting (Hickman *et al*, 2015), which is typical to small scale farming had no detectable effect on annual N_2O emissions. Emissions from other areas were high, up to 5.6 mg N_2O-Nm^{-2}day^{-1} from legume (Guardia *et al*, 2016) and 25700 µg N_2O-N m^{-2}h^{1-} from urine (Sherlock and Gon, 1983) indicating that Nitrous oxide emitted from small scale farming at the Lower Nyando block was low.

Farming in the Lower Nyando Block is done in small scale and is usually characterised by lack of adequate farm inputs including low fertilizer applications (Ali-Olubandwa *et al*, 2011). The inability to discern between fertilized and unfertilized plots suggests that the differences in soil fertility and primary productivity were too low to have a noticeable effect on the availability of substrate for microbial activity and the associated GHG emissions. All the fluxes were low at the Lower Nyando Block. The emissions were way below the EPA threshold of 6849315g CO_2 equivalent per day showing that small scale farming at the Lower Nyando Block is not a significant contributor to GHG emission and thus global warming.

4.1.2 Variation in GHG fluxes in different landscape units

The changes in GHG fluxes in different landscape units of the Lower Nyando Block are presented in Table 4.2 a and b and Figure 4.2

Table 4.2a: ANOVA output on GHG fluxes in different landscape units

		Sum of Squares	df	Mean Square	F	Sig. ($p \leq 0.05$)
CH_4 concentration	Between landscapes	0.060	2	0.030	0.884	0.419
	Within landscapes	1.809	53	0.034		
	Total	1.869	55			
CO_2 concentration	Between landscapes	0.783	2	0.391	1.367	0.263
	Within landscapes	15.745	55	0.286		
	Total	16.528	57			
N_2O concentration	Between landscapes	0.012	2	0.006	2.692	0.077
	Within landscapes	0.120	56	0.002		
	Total	0.132	58			

Table 4.2b: GHG fluxes in different landscape units

Gas	Landscape unit	Mean	S.D	P value
C-CH_4	lowland	-0.59	0.17	
	slope	-0.63	0.19	0.419
	upland	-0.67	0.19	
C-CO_2	lowland	1.51	0.37	
	slope	1.78	0.62	0.263
	upland	1.74	0.56	
N-N_2O	lowland	0.06	0.05	
	slope	0.07	0.05	0.077
	upland	0.09	0.04	

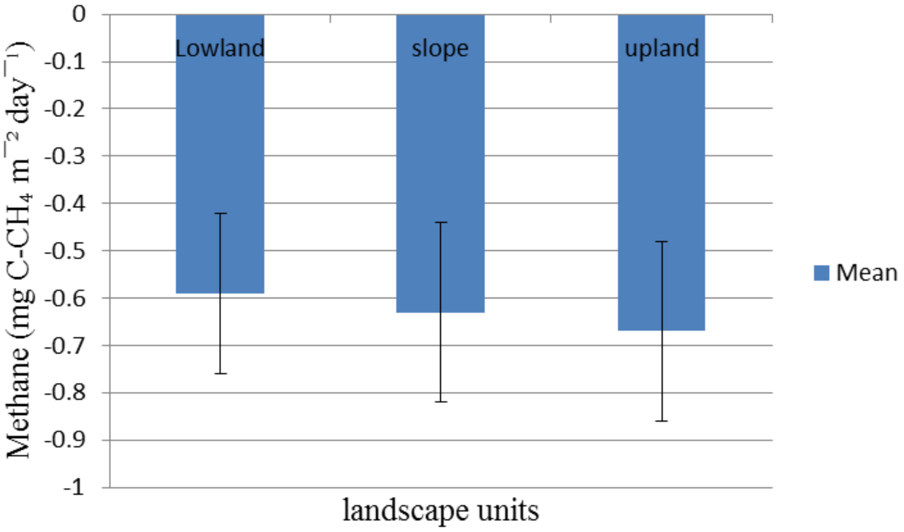


Figure 4.2a: Variations in mean concentration of CH_4 absorption in different landscape units in the Lower Nyando Block

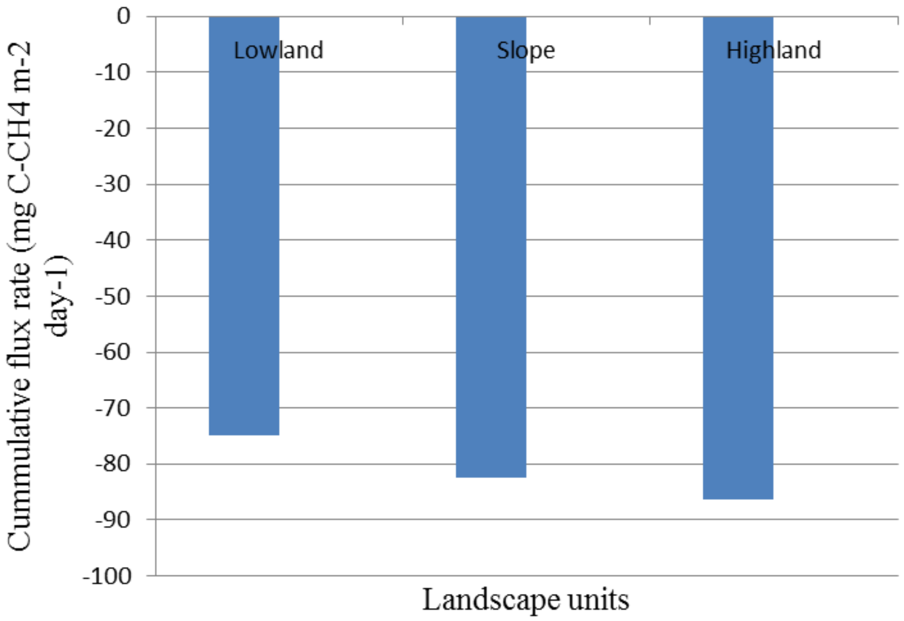


Figure 4.2b: Variations in cumulative CH_4 fluxes in different landscape units at the Lower Nyando Block

The GHG fluxes from the three landscapes were not significantly different (Table 4.2a and Table 4.2b). However methane absorption was -0.59, -0.63 and -0.67mg $C\text{-}CH_4$ $m^{-2}day^{-1}$ in the upland, slope and lowland respectively (Figure 4.2a and Figure 4.2b).

The order of variation was however different from the findings of research done in South East Poland (Brzezińska *et al*, 2012) where fluxes were 0.359 mg $C\text{-}CH_4$ $m^{-2}day^{-1}$ at the upland and -0.06 mg $C\text{-}CH_4$ $m^{-2}day^{-1}$ lowland. The slope had the highest emission of CH_4 followed by the upland and the lowland had the least. Although there were net emissions of methane in South East Poland (Brzezińska *et al*, 2012), at the Lower Nyando Block net absorption of methane was observed in all the landscapes. In Canada, the emissions were very low in all positions of the slope (Peré and Bedard-Haughn, 2013). Similar to our study, net absorptions were also observed in Zimbabwe (-7.2 and -31.2 mg $C\text{-}CH_4$ $m^{-2}day^{-1}$ in the upland and lowland respectively) (Nyamadzawo, 2015). These results show that the levels of methane fluxes vary with the environment. Studies in the temperate countries demonstrate net emissions (Brzezińska *et al*, 2012; Peré and Bedard-Haughn, 2013) while studies under tropical environment (Nyamadzawo, 2015) are showing net absorption of methane in different landscapes. Soils that lie at the lowlands usually have very poor drainage whereas soils that occur on the slope are usually excessively drained. At the upland, soils are fairly. Soils on the crest and slope drain rapidly whereas those at the lowland receive water from upslope and remain wet much longer. Under such conditions, anaerobic conditions are created causing the production of N_2O and if prolonged leads to production of CH_4 (Batjes and Bridges, 1992). However, in the lowland area of the Lower Nyando Block, the wetness and agricultural activities were not enough to cause an emission of methane; rather, there was only a decrease in the ability of the soils to be a better sink compared to the other landscape units. Indeed the study has demonstrated that landscapes in the Lower Nyando Block are not contributing to methane emissions, thereby not contributing to global warming.

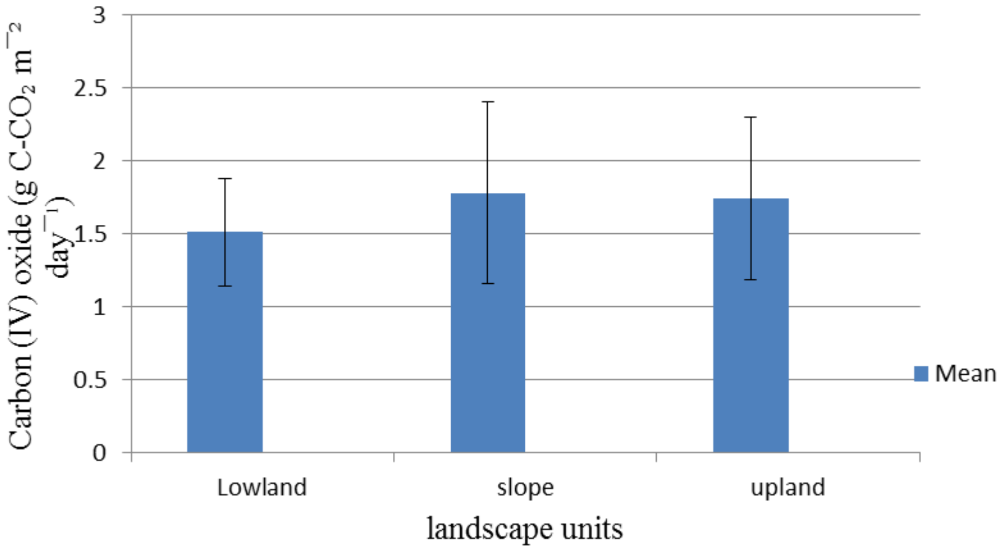


Figure 4.2c: Variations in mean concentration of CO_2 emissions in different landscape units in the Lower Nyando Block

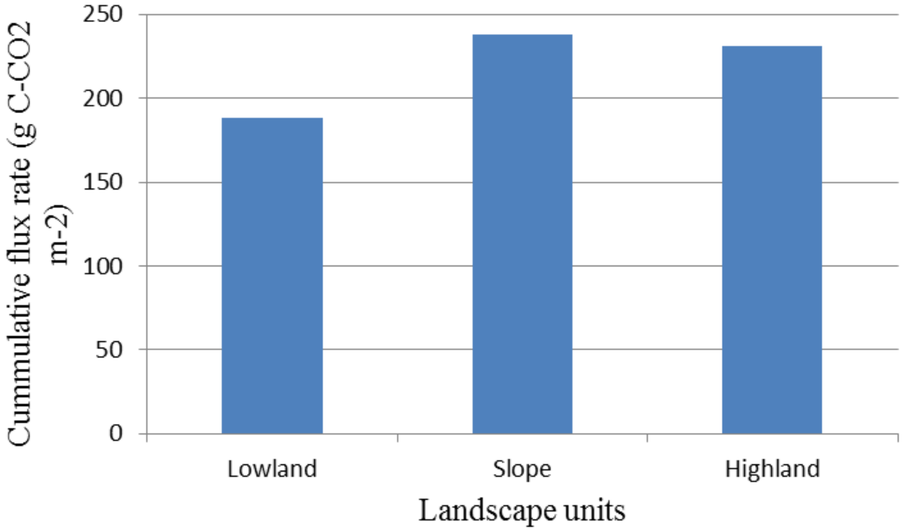


Figure 4.2d: Variations in cumulative CO_2 fluxes in different landscape units in the Lower Nyando Block

There was net CO_2 emission from all landscapes in the Lower Nyando Block. The levels were 1.51, 1.78 and 1.74 g $C\text{-}CO_2$ $m^{-2}day^{-1}$ in the upland, slope and lowland respectively (Figure 4.2c and 4.2d), The order of the pattern was similar to results from Poland where production of CO_2 was highest in the mid slope, however, it was followed by top and the bottom had the least (Brzezińska *et al*, 2012) and in Canada (Peré and Bedard-Haughn, 2013) where the mid and lower slope position had higher net CO_2 emissions than upper slope. However, these patterns varied with results from Zimbabwe where CO_2 emissions order was upland>slope>bottom (63.552, 21.504 and 14.16 g $C\text{-}CO_2$ $m^{-2}day^{-1}$) (Nyamadzawo, 2015). These variations in the order of emissions may to a large extent depend on anthropogenic activities in the area, the crops grown or land uses. Despite the differences in patterns, in Zimbabwe, emissions were low as in the Lower Nyando Block.These low emissions demonstrate the low contribution to global warming by the landscapes in the Lower Nyando Block.

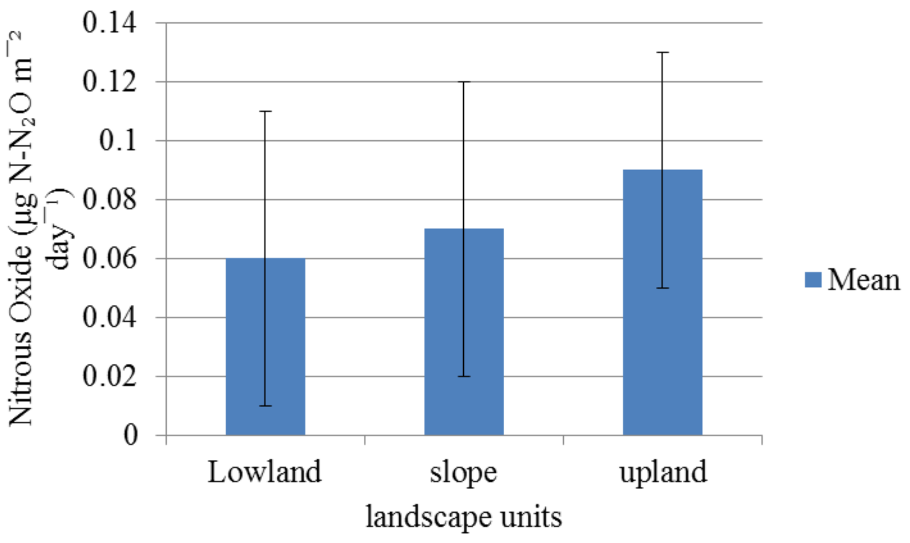


Figure 4.2e: Variations in mean concentration of N_2O emissions in different landscape units in the Lower Nyando Block.

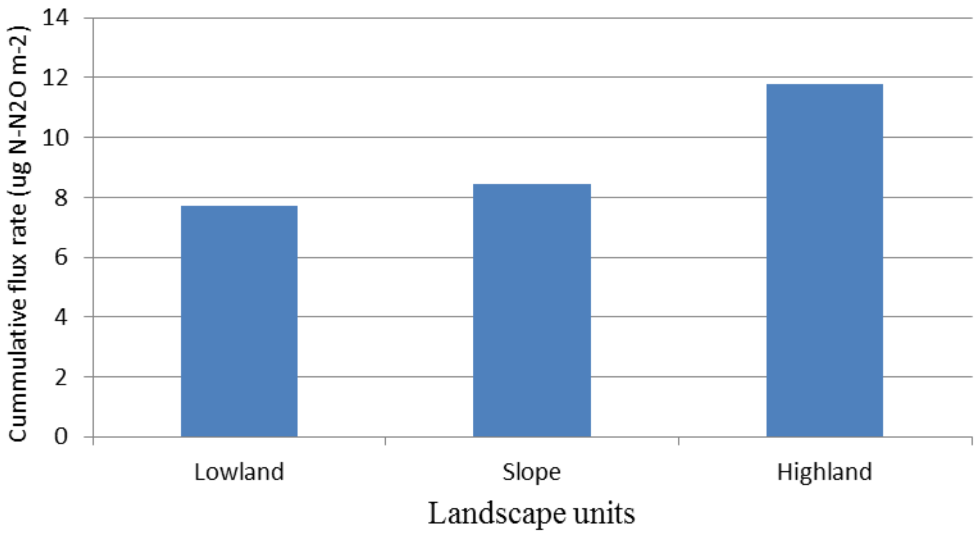


Figure 4.2f: Variations in cumulative N_2O fluxes in different landscape units in the Lower Nyando Block

N_2O was also emitted from the different landscapes in the Lower Nyando Block in the levels were 0.06, 0.07 and 0.09 µg N-N_2O $m^{-2}day^{-1}$ in the upland, slope and lowland respectively (Figure 4.2e and 4.2f). A different pattern was observed in Zimbabwe where N_2O emission was highest from, top followed by bottom and slope had the least (962.4, 132 and 93.7 µg N-N_2O $m^{-2}day^{-1}$) (Nyamadzawo, 2015). In Canada, like in the Lower Nyando Block, very low net CH_4 and N_2O emissions were detected along the terrain (Peré and Bedard-Haughn, 2013).

As is expected, due to levels of aeration and oxygen availability the better drained soils in the slope position had the highest CO_2 emission while the upland had the most N_2O emission. Despite these sequences, the emissions were generally low and the differences did not reach significant levels. The low emissions suggest that the Lower Nyando Block might not have had large enough differences in landscapes to cause significant variations in the GHG fluxes.

4.3 Variation in GHG fluxes in different seasons

The differences in GHG fluxes in different seasons in The Lower Nyando Block are presented in Table 4.3a and 4.3b and Figure 4.3.

Table 4.3a. Paired sample test on variation in GHG fluxes in different season

		Paired Differences					t	Df	Sig. (2 tailed) p≤1
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
CH_4	Pair S_1-S_2	-0.19	0.29	0.06	-0.30	-0.08	-3.46	27	0.002
CO_2	Pair S_1-S_2	0.66	0.82	0.16	0.35	0.98	4.28	27	0.000
N_2O	Pair S_1-S_2	0.09	0.09	0.02	0.05	0.12	4.88	27	0.000

Key: S_1= Long rains; S_2= Short rains

Table 4.3b. Paired sample test on variation in GHG fluxes in different seasons

Gas	Season	Mean	S.D	P value
C-CH_4	Long rains	-0.48	0.28	0.002
	Short rains	-0.66	0.36	
C-CO_2	Long rains	2.2	0.79	0.000
	Short rains	1.54	0.73	
N-N_2O	Long rains	0.15	0.11	0.000
	Short rains	0.06	0.06	

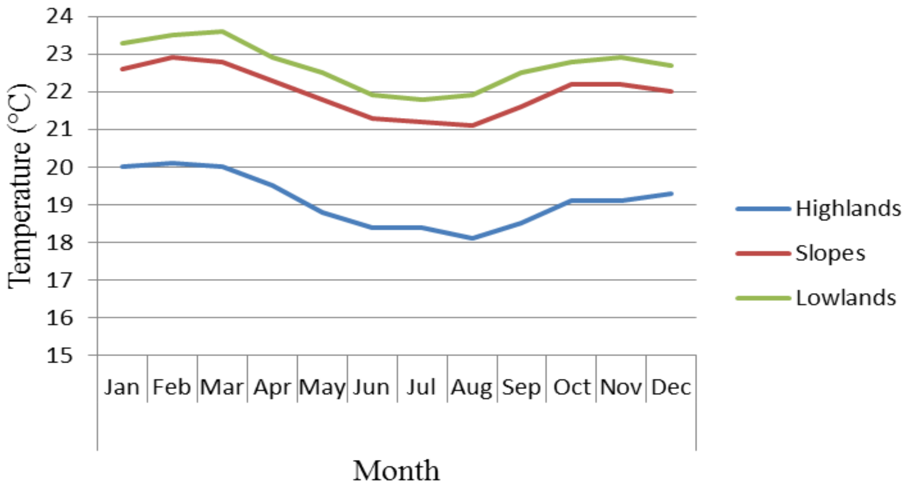


Figure 4.3a: Mean air temperatures in Nyando Basin, (°C)

Source: Climate-data.org (2012).

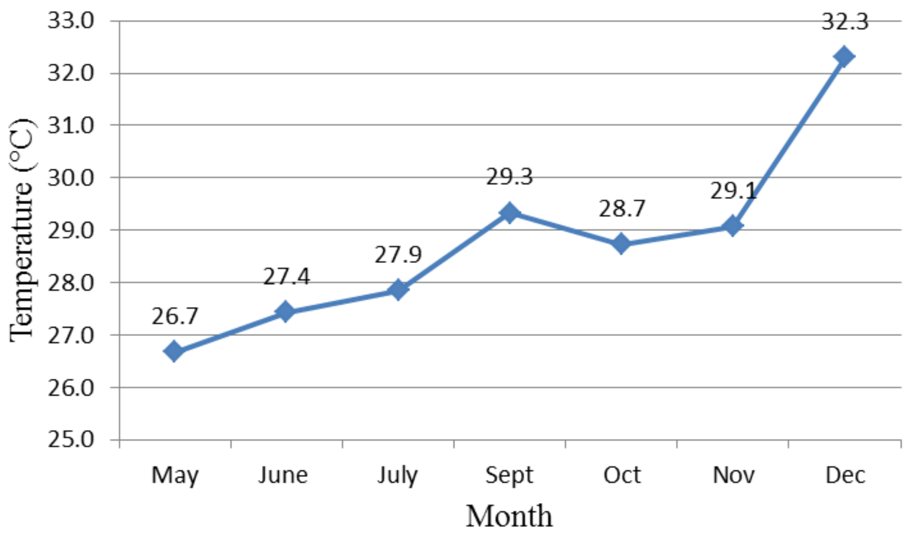


Figure 4.3b: Mean soil temperature in the lowland during the sampling period.

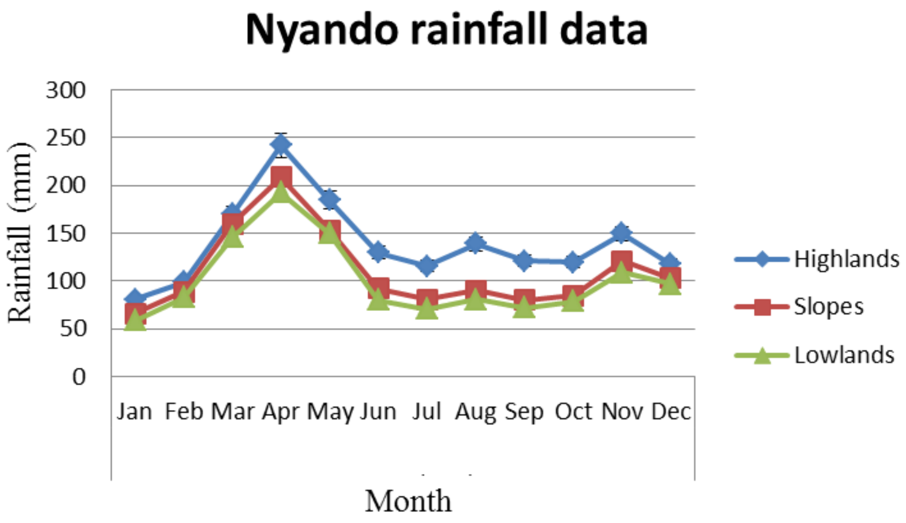


Figure 4.3c: Average rainfall at the Nyando Basin.

Source: Climate-data.org (2012).

Kenya is in the tropics where the atmospheric and soil temperatures do not vary by large margins. This is unlike in temperate countries where the temperatures range widely creating seasons such as winter, summer, spring and autumn. The changes in atmospheric and soil temperatures in Nyando Basin and the Lower Nyando Block are presented in Figures 4.3a and 4.3b. Nyando Basin also receives little rainfall (Figure 4.3c) (climate-data.org, 2012), (Figure 4.3d). Two rainy seasons are experienced in Kenya, that is, long rains (April-June) and short rains (October to December) (Ngetich *et al*, 1995). However this may vary from one area to another. Seasons in this study were considered depending on agricultural activities in the lowlands of the Lower Nyando Block. This is the long rains (May to August) and short rains (September to December) which indicate the main planting seasons.

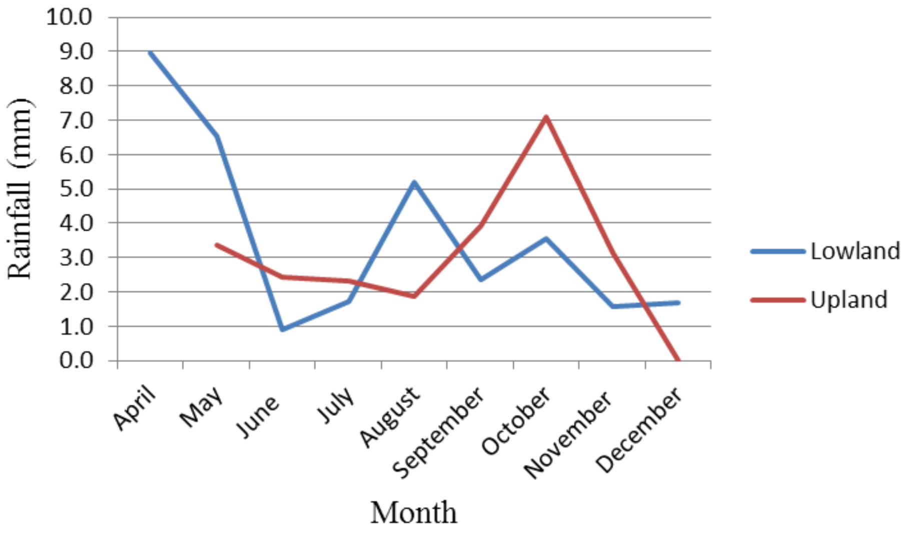


Figure 4.3d: Average rainfall during the sampling period.

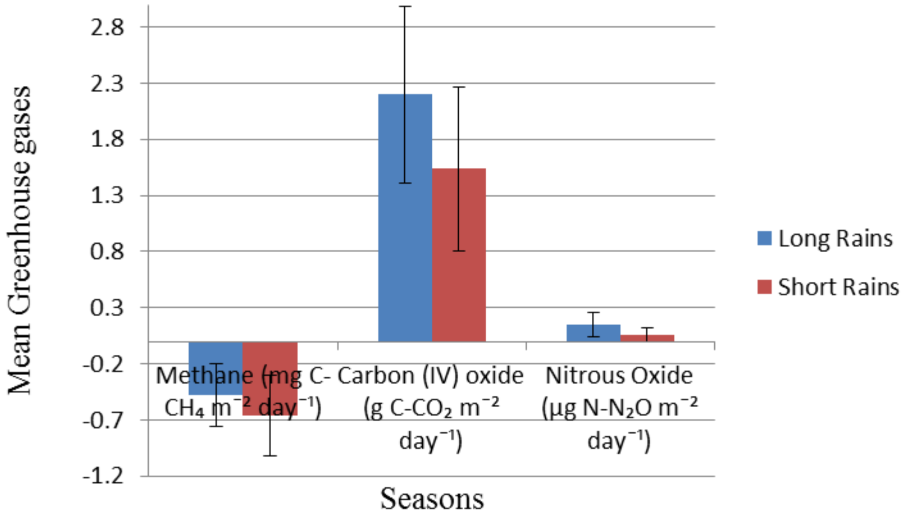


Figure 4.3: Variations in mean concentration of GHG fluxes in different seasons

Seasonal GHG were significantly ($p \leq 0.005$) different as shown in Table 4.3a and 4.3b and Figure 4.3. The lowlands in the Lower Nyando Block showed absorption of -0.48 and -0.66 mg C-CH_4 $m^{-2}day^{-1}$ in the long rains and short rains, respectively. Methane absorption was higher during the short rainy season than during the long rainy season. This was similar to a study in China, in an area with rainfall over 1000 mm and mean annual air temperature 21^0C. CH_4 absorptions were higher in the dry season (3.74 mg C-CH_4 $m^{-2}day^{-}$) than those in rainy seasons (3.024 mg C-CH_4 $m^{-2}day^{-}$), in fact, there were emissions in the wet season (Liu *et al,* 2007). Methanogens levels are high during paddy rice growing season which is generally wet, and CH_4 emission also increase in the period (Yue *et al,* 2003). Water logging during the long rains in the lowland in the Lower Nyando Block due to high rainfall during the period and rain water draining from the upland and slope was a major contributor to the lower in CH_4 absorption during the period. Temperatures also affect GHG emissions as methanogens activities increase as soil temperatures rise (Yue *et al*, 2003). However, in lower Nyando, the soil temperatures range of the top soil at approximately 10cm depth was not large with the highest temperature during the long rainy season being at 29^oC and during the short rains being at 32^oC (Figure 4.3b). This did not create much difference on CH_4 absorptions. Indeed, there are emissions of methane in wet periods (Liu *et al*, 2007, Yue *et al*, 2003) However, in both the seasons the soils under small scale farming in lower Nyando acted as a sink for CH_4 indicating that they are not a major contributor to global warming.

CO_2 emissions were higher ($p \leq 0.005$) in the long rainy season than in the short rainy season. The lowlands in the Lower Nyando Block showed emission of 2.2 and 1.54 g C-$CO_2m^{-2}day^{-1}$ in the short rains and long rains, respectively. A similar pattern was observed in China where CO_2 emissions were significantly higher in the rainy season (up to 20.856 g C-$CO_2m^{-2}day^{-1}$) than that in the dry season (up to 15.768 g C-$CO_2m^{-2}day^{-1}$) (Liu *et al*, 2007). In temperate countries, fluxes of CO_2 are higher, mainly before the beginning of winter and during spring, being at much lower values in the other seasons, (Paulino *et al*, 2010). In the tropics however, temperature difference are not large thus have minimal effect on emissions in small scale farming. In lower Nyando, like in other areas (Liu *et al*, 2007, Paulino *et al*, 2010), CO_2 emissions are higher in the wetter season than in the relatively drier season. This could be attributed to increase in number of methanotrophs which oxidise methane to $CO_{2.}$ However, emissions were quite low in both seasons on the Lower Nyando Block showing that the Lower Nyando Block is not a significant contributor to global warming.

Levels of N_2O emissions were higher ($p \leq 0.005$) during the long rains than the short rainy season. The lowlands in the Lower Nyando Block showed emissions of 0.15 and 0.06 µg N-N_2O $m^{-2}day^{-1}$ in the long rains and short rains, respectively. Seasonal differences affect the temporal dynamics of the amount and activities of microorganisms responsible for GHG production and consumption, (Schindlbacher *et al*, 2004). These have been shown to cause significant seasonal variation in N_2O fluxes, (Liu *et al*, 2007). In China, soils showed clear seasonal differences of N_2O fluxes. N_2O fluxes were higher in rainy season up to 17.6 µg N-N_2O $m^{-2}day^{-1}$ than in dry season, 7.056 µg N-N_2O $m^{-2}day^{-1}$ (Liu *et al*, 2007). Similar results were recorded in the Lower Nyando Block. The same pattern was observed in Inner Mongolia where N_2O fluxes are extremely low in the dry season and slight net N_2O absorption observed occasionally than during the wet (up to 367.2 µg N-N_2O $m^{-2}day^{-1}$) period (Yao *et al*, 2010). Introduction of water to the dry soil results in a marked increase in N_2O emissions, (Liu *et al*, 2007). These N_2O emission pulses may be induced by an accumulation of NH_4^+ and NO_3^- during the dry season (Yue *et al*, 2003). As a result, the emissions are very high at the beginning of a wet season right after a dry season (Liu *et al*, 2007). Increase in soil moisture causes rise in the emissions (Yao *et al*, 2010). Rise in temperatures increased N_2O in the soil profiles leading to increase in N_2O emission (Yao *et al*, 2010). Indeed N_2O emissions are generally higher in wetter seasons than in drier ones

(Liu *et al*, 2007, Yao *et al*, 2010, Liu *et al*, 2007, the Lower Nyando Block). This can be attributed to fairly high soil temperatures and the relatively high moisture content in the lowland in the Lower Nyando Block which were more suitable for soil biochemical processes, which may trigger N_2O emissions as was also observed elsewhere (Firestone and Davidson, 1989). Lack of adequate oxygen in the soil may have led to reduction of N_2O to nitrogen thus causing reduction of N_2O emission from long rains to short rains. However, the emissions were low in the Lower Nyando Block indicating that the basin is not a major contributor to global warming. These GHG fluxes are low compared to temperate regions (Liu *et al*, 2007, Yao *et al*, 2010). This implies that Lowlands in the Lower Nyando Block is not a significant contributor to GHG emissions and therefore global warming. Instead, the basin is in fact a sink for methane.

CHAPTER FIVE

5.0 SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of findings

There was significant ($p \leq 0.05$) difference in CH_4 uptake among land covers with grazing areas showing lower uptake than fallow land and cropland. Grazing lands had significantly ($p \leq 0.05$) higher emission of CO_2 than fallow and crop cover areas. However, no significant difference in N_2O emissions in the various land covers were observed.

All GHG emissions were low and there was no significant difference in mean soil-atmospheric GHG fluxes in the landscape units.

CH_4 absorption increased ($p \leq 0.05$) from long to short rains seasons, but CO_2 and N_2O emissions decreased ($p \leq 0.05$).

5.2 Conclusion

Variations occur in soil atmospheric GHG fluxes in different landcovers and crop types in the Lower Nyando Block. Grazing fields were the largest emitters of CO_2 and the least sinks for CH_4. However, N_2O emissions did not vary in the different land covers and were generally low. There were no variations in soil atmospheric GHG fluxes concentration in landscape units in the Lower Nyando Block, Kenya. Different landscape units did not ellicit different soil atmospheric GHG fluxes and as such had no influence on the same. Summarily, the levels of GHG were low in the different landscapes. Soil atmospheric GHG fluxes varied with seasons. The long rainy season had higher emission of CO_2 and N_2O and lower CH_4 absorption than the short rainy season. This study indicates that soil GHG fluxes from low-input, rain-fed agriculture in the Lower Nyando Block are lower than GHG fluxes from large scale tropical or subtropical agricultural systems with greater management intensities (e.g., China and Latin America). The small scale farming systems along the equator therefore do not seem to be significant contributors to GHG emissions and are therefore not contributing much to global warming through GHG emissions.

5.3 Recommendations

Small scale farmers in the Lower Nyando Block should maintain their production systems as the activities do not contribute to any significant GHG emissions.

Farmers in the lowland can intensify farming as this will not adversely affect GHG emissions.

Farmers in the Lower Nyando Block can continue with their farm practices in the different seasons as these do not have adverse GHGs emissions.

5.4 Suggestions for further study

Studies need to be carried out on large scale agricultural activities such as animals, tea, and rice production along the equator to establish if the noted low emissions are dependent on levels of agro economic inputs.

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APENDIX

1. Mean GHG Fluxes from different land covers in the Lower Nyando Block

	Methane (mg C-CH_4 m^{-2} day^{-1})		Carbon (IV) oxide (g C-CO_2 m^{-2} day^{-1})		Nitrous Oxide (µg N-N_2O m^{-2} day^{-1})	
Crops	mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Maize	-0.82	0.62	1.87	0.84	0.29	0.3
legume	-0.46	0.43	1.23	0.69	0.09	0.15
cassava	-0.4	0.7	1.7	1.12	0.09	0.09
woodlot	-0.67	0.93	1.78	1.36	0.07	0.14
Banana	-0.85	0.68	1.29	0.42	0.09	0.07
Sugarcane	-0.46	0.25	1.54	0.56	0.09	0.07
Napier	-0.62	1.15	1.71	0.87	0.05	0.09
Sweet potato	-0.74	0.74	1.2	0.46	0.08	0.11
Maize/sorghum	-0.65	0.35	1.86	0.87	0.08	0.1
Sorghum	-0.58	0.66	1.57	1.28	0.06	0.09
Grazing	-0.15	0.56	3.12	1.56	0.28	0.99
Fallow	-0.71	0.59	2.1	0.69	0.12	0.14

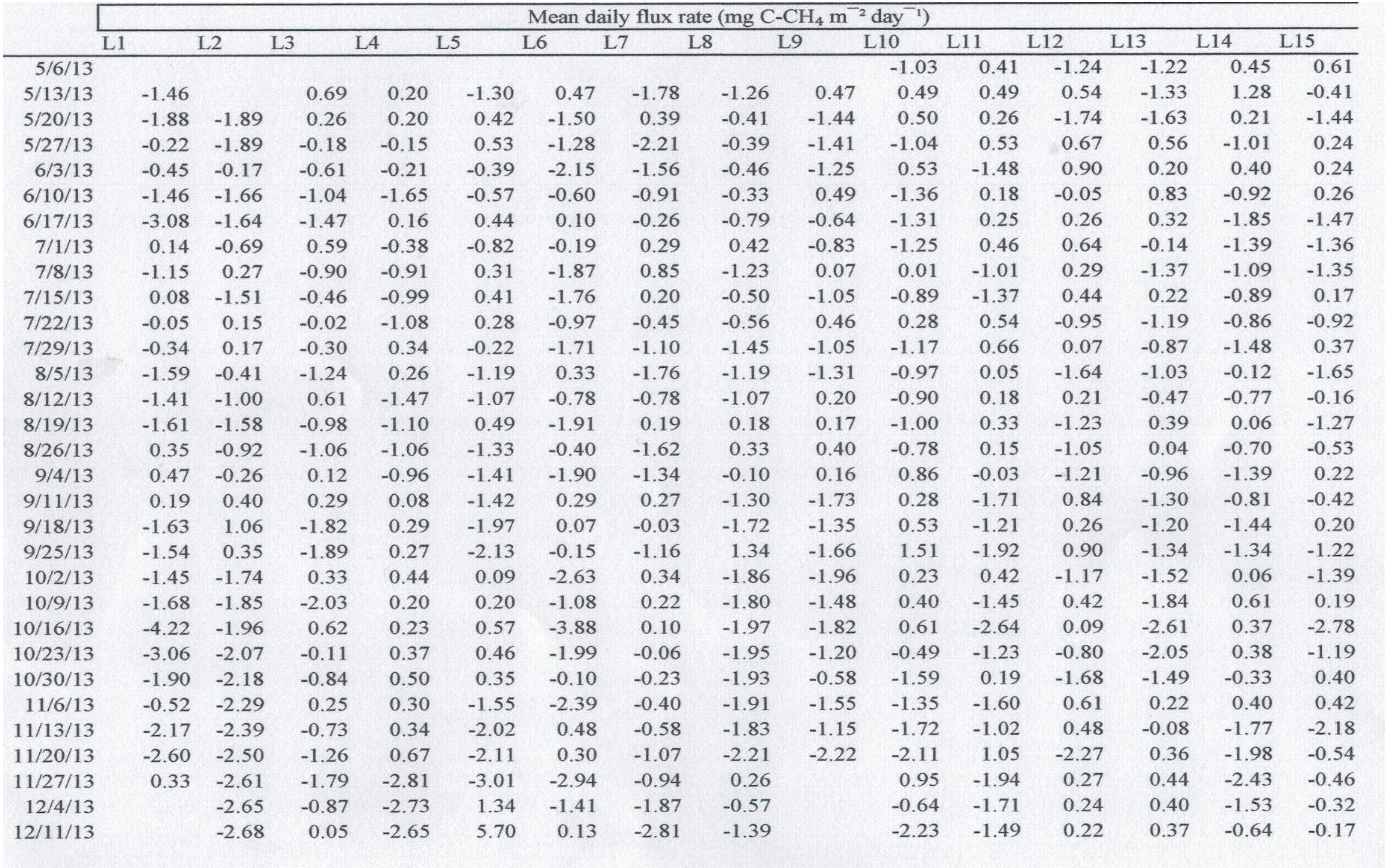
2. Mean GHG Fluxes from different landscape units in the Lower Nyando Block

	Methane (mg C-CH_4 m^{-2} day^{-1})		Carbon (IV) oxide (g C-CO_2 m^{-2} day^{-1})		Nitrous Oxide (µg N-N_2O m^{-2} day^{-1})	
Landscape units	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Lowland	-0.59	0.17	1.51	0.37	0.06	0.05
Slope	-0.63	0.19	1.78	0.62	0.07	0.05
Upland	-0.67	0.19	1.74	0.56	0.09	0.04

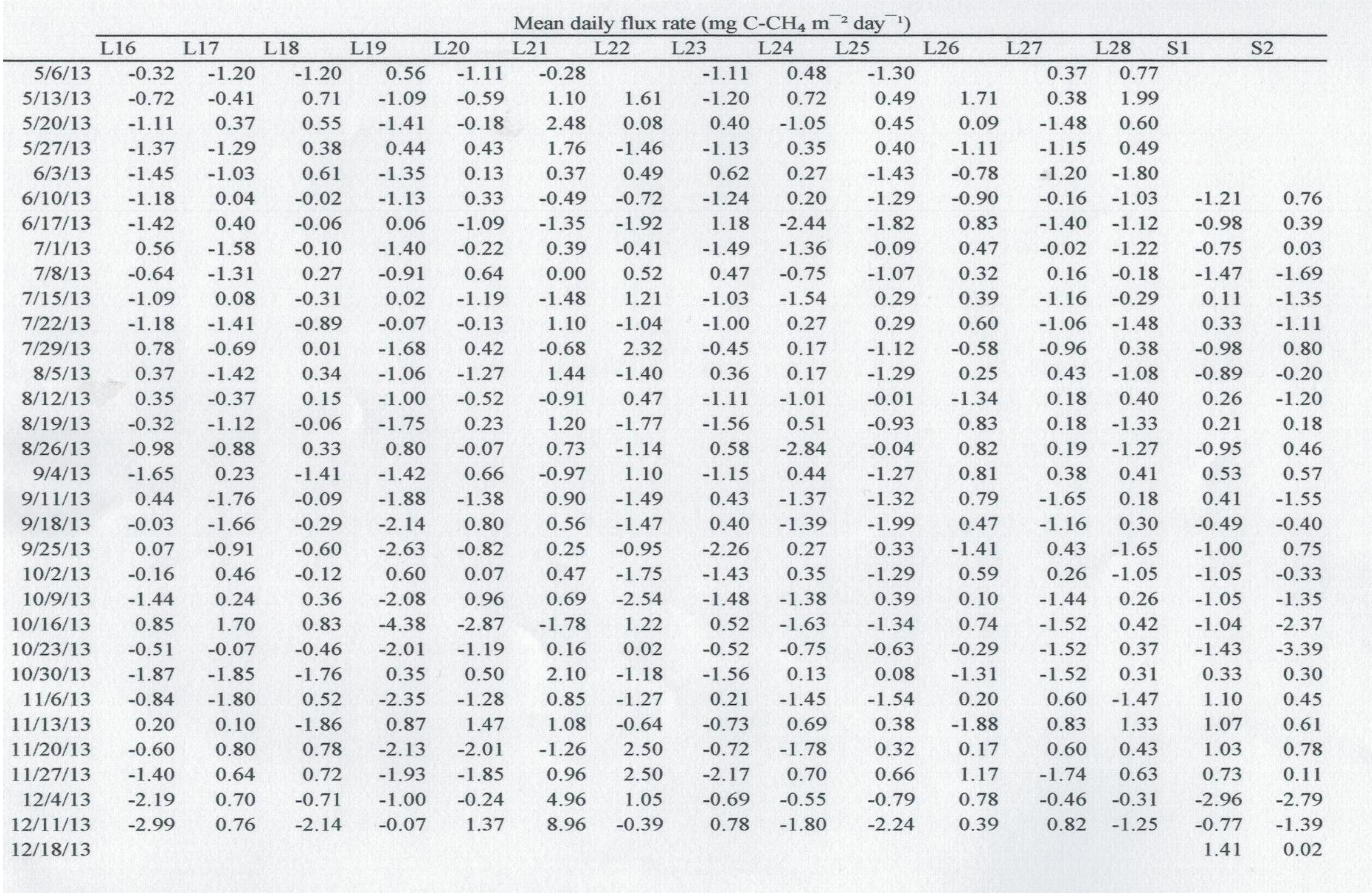
3. Mean GHG Fluxes from different planting seasons in the lowland in the Lower Nyando Block

	Methane (mg C-CH_4 m^{-2} day^{-1})		Carbon (IV) oxide (g C-CO_2 m^{-2} day^{-1})		Nitrous Oxide (µg N-N_2O m^{-2} day^{-1})	
Seasons	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Long Rains	-0.48	0.28	2.2	0.79	0.15	0.11
Short Rains	-0.66	0.36	1.54	0.73	0.06	0.06

APPENDIX 4: Raw data from Lower Nyando Block



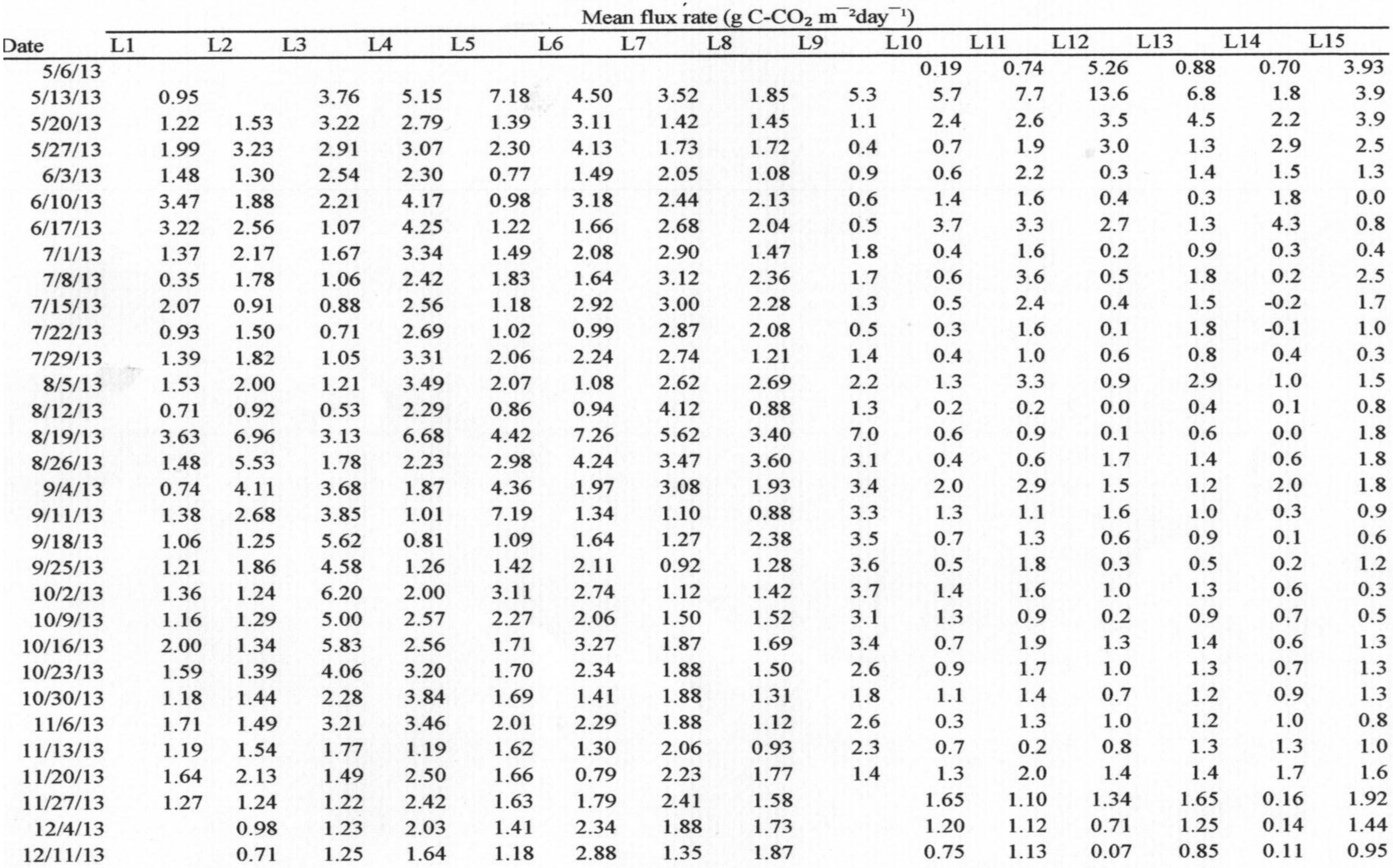
	Mean daily flux rate (mg C-CH_4 m^{-2} day^{-1})														
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15
5/6/13										-1.03	0.41	-1.24	-1.22	0.45	0.61
5/13/13	-1.46		0.69	0.20	-1.30	0.47	-1.78	-1.26	0.47	0.49	0.49	0.54	-1.33	1.28	-0.41
5/20/13	-1.88	-1.89	0.26	0.20	0.42	-1.50	0.39	-0.41	-1.44	0.50	0.26	-1.74	-1.63	0.21	-1.44
5/27/13	-0.22	-1.89	-0.18	-0.15	0.53	-1.28	-2.21	-0.39	-1.41	-1.04	0.53	0.67	0.56	-1.01	0.24
6/3/13	-0.45	-0.17	-0.61	-0.21	-0.39	-2.15	-1.56	-0.46	-1.25	0.53	-1.48	0.90	0.20	0.40	0.24
6/10/13	-1.46	-1.66	-1.04	-1.65	-0.57	-0.60	-0.91	-0.33	0.49	-1.36	0.18	-0.05	0.83	-0.92	0.26
6/17/13	-3.08	-1.64	-1.47	0.16	0.44	0.10	-0.26	-0.79	-0.64	-1.31	0.25	0.26	0.32	-1.85	-1.47
7/1/13	0.14	-0.69	0.59	-0.38	-0.82	-0.19	0.29	0.42	-0.83	-1.25	0.46	0.64	-0.14	-1.39	-1.36
7/8/13	-1.15	0.27	-0.90	-0.91	0.31	-1.87	0.85	-1.23	0.07	0.01	-1.01	0.29	-1.37	-1.09	-1.35
7/15/13	0.08	-1.51	-0.46	-0.99	0.41	-1.76	0.20	-0.50	-1.05	-0.89	-1.37	0.44	0.22	-0.89	0.17
7/22/13	-0.05	0.15	-0.02	-1.08	0.28	-0.97	-0.45	-0.56	0.46	0.28	0.54	-0.95	-1.19	-0.86	-0.92
7/29/13	-0.34	0.17	-0.30	0.34	-0.22	-1.71	-1.10	-1.45	-1.05	-1.17	0.66	0.07	-0.87	-1.48	0.37
8/5/13	-1.59	-0.41	-1.24	0.26	-1.19	0.33	-1.76	-1.19	-1.31	-0.97	0.05	-1.64	-1.03	-0.12	-1.65
8/12/13	-1.41	-1.00	0.61	-1.47	-1.07	-0.78	-0.78	-1.07	0.20	-0.90	0.18	0.21	-0.47	-0.77	-0.16
8/19/13	-1.61	-1.58	-0.98	-1.10	0.49	-1.91	0.19	0.18	0.17	-1.00	0.33	-1.23	0.39	0.06	-1.27
8/26/13	0.35	-0.92	-1.06	-1.06	-1.33	-0.40	-1.62	0.33	0.40	-0.78	0.15	-1.05	0.04	-0.70	-0.53
9/4/13	0.47	-0.26	0.12	-0.96	-1.41	-1.90	-1.34	-0.10	0.16	0.86	-0.03	-1.21	-0.96	-1.39	0.22
9/11/13	0.19	0.40	0.29	0.08	-1.42	0.29	0.27	-1.30	-1.73	0.28	-1.71	0.84	-1.30	-0.81	-0.42
9/18/13	-1.63	1.06	-1.82	0.29	-1.97	0.07	-0.03	-1.72	-1.35	0.53	-1.21	0.26	-1.20	-1.44	0.20
9/25/13	-1.54	0.35	-1.89	0.27	-2.13	-0.15	-1.16	1.34	-1.66	1.51	-1.92	0.90	-1.34	-1.34	-1.22
10/2/13	-1.45	-1.74	0.33	0.44	0.09	-2.63	0.34	-1.86	-1.96	0.23	0.42	-1.17	-1.52	0.06	-1.39
10/9/13	-1.68	-1.85	-2.03	0.20	0.20	-1.08	0.22	-1.80	-1.48	0.40	-1.45	0.42	-1.84	0.61	0.19
10/16/13	-4.22	-1.96	0.62	0.23	0.57	-3.88	0.10	-1.97	-1.82	0.61	-2.64	0.09	-2.61	0.37	-2.78
10/23/13	-3.06	-2.07	-0.11	0.37	0.46	-1.99	-0.06	-1.95	-1.20	-0.49	-1.23	-0.80	-2.05	0.38	-1.19
10/30/13	-1.90	-2.18	-0.84	0.50	0.35	-0.10	-0.23	-1.93	-0.58	-1.59	0.19	-1.68	-1.49	-0.33	0.40
11/6/13	-0.52	-2.29	0.25	0.30	-1.55	-2.39	-0.40	-1.91	-1.55	-1.35	-1.60	0.61	0.22	0.40	0.42
11/13/13	-2.17	-2.39	-0.73	0.34	-2.02	0.48	-0.58	-1.83	-1.15	-1.72	-1.02	0.48	-0.08	-1.77	-2.18
11/20/13	-2.60	-2.50	-1.26	0.67	-2.11	0.30	-1.07	-2.21	-2.22	-2.11	1.05	-2.27	0.36	-1.98	-0.54
11/27/13	0.33	-2.61	-1.79	-2.81	-3.01	-2.94	-0.94	0.26		0.95	-1.94	0.27	0.44	-2.43	-0.46
12/4/13		-2.65	-0.87	-2.73	1.34	-1.41	-1.87	-0.57		-0.64	-1.71	0.24	0.40	-1.53	-0.32
12/11/13		-2.68	0.05	-2.65	5.70	0.13	-2.81	-1.39		-2.23	-1.49	0.22	0.37	-0.64	-0.17



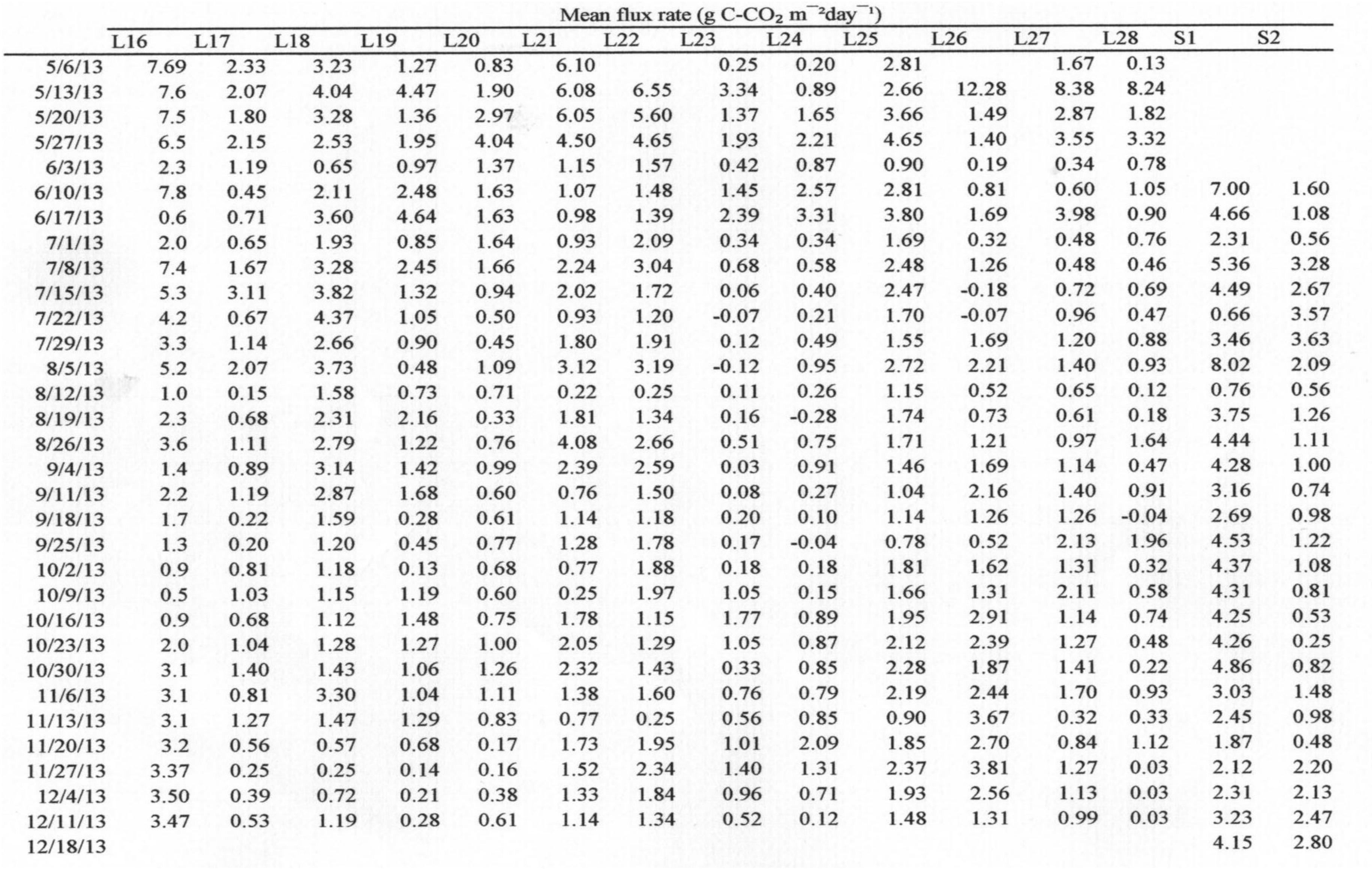
	Mean daily flux rate (mg C-CH$_4$ m^{-2} day^{-1})														
	L16	L17	L18	L19	L20	L21	L22	L23	L24	L25	L26	L27	L28	S1	S2
5/6/13	-0.32	-1.20	-1.20	0.56	-1.11	-0.28		-1.11	0.48	-1.30		0.37	0.77		
5/13/13	-0.72	-0.41	0.71	-1.09	-0.59	1.10	1.61	-1.20	0.72	0.49	1.71	0.38	1.99		
5/20/13	-1.11	0.37	0.55	-1.41	-0.18	2.48	0.08	0.40	-1.05	0.45	0.09	-1.48	0.60		
5/27/13	-1.37	-1.29	0.38	0.44	0.43	1.76	-1.46	-1.13	0.35	0.40	-1.11	-1.15	0.49		
6/3/13	-1.45	-1.03	0.61	-1.35	0.13	0.37	0.49	0.62	0.27	-1.43	-0.78	-1.20	-1.80		
6/10/13	-1.18	0.04	-0.02	-1.13	0.33	-0.49	-0.72	-1.24	0.20	-1.29	-0.90	-0.16	-1.03	-1.21	0.76
6/17/13	-1.42	0.40	-0.06	0.06	-1.09	-1.35	-1.92	1.18	-2.44	-1.82	0.83	-1.40	-1.12	-0.98	0.39
7/1/13	0.56	-1.58	-0.10	-1.40	-0.22	0.39	-0.41	-1.49	-1.36	-0.09	0.47	-0.02	-1.22	-0.75	0.03
7/8/13	-0.64	-1.31	0.27	-0.91	0.64	0.00	0.52	0.47	-0.75	-1.07	0.32	0.16	-0.18	-1.47	-1.69
7/15/13	-1.09	0.08	-0.31	0.02	-1.19	-1.48	1.21	-1.03	-1.54	0.29	0.39	-1.16	-0.29	0.11	-1.35
7/22/13	-1.18	-1.41	-0.89	-0.07	-0.13	1.10	-1.04	-1.00	0.27	0.29	0.60	-1.06	-1.48	0.33	-1.11
7/29/13	0.78	-0.69	0.01	-1.68	0.42	-0.68	2.32	-0.45	0.17	-1.12	-0.58	-0.96	0.38	-0.98	0.80
8/5/13	0.37	-1.42	0.34	-1.06	-1.27	1.44	-1.40	0.36	0.17	-1.29	0.25	0.43	-1.08	-0.89	-0.20
8/12/13	0.35	-0.37	0.15	-1.00	-0.52	-0.91	0.47	-1.11	-1.01	-0.01	-1.34	0.18	0.40	0.26	-1.20
8/19/13	-0.32	-1.12	-0.06	-1.75	0.23	1.20	-1.77	-1.56	0.51	-0.93	0.83	0.18	-1.33	0.21	0.18
8/26/13	-0.98	-0.88	0.33	0.80	-0.07	0.73	-1.14	0.58	-2.84	-0.04	0.82	0.19	-1.27	-0.95	0.46
9/4/13	-1.65	0.23	-1.41	-1.42	0.66	-0.97	1.10	-1.15	0.44	-1.27	0.81	0.38	0.41	0.53	0.57
9/11/13	0.44	-1.76	-0.09	-1.88	-1.38	0.90	-1.49	0.43	-1.37	-1.32	0.79	-1.65	0.18	0.41	-1.55
9/18/13	-0.03	-1.66	-0.29	-2.14	0.80	0.56	-1.47	0.40	-1.39	-1.99	0.47	-1.16	0.30	-0.49	-0.40
9/25/13	0.07	-0.91	-0.60	-2.63	-0.82	0.25	-0.95	-2.26	0.27	0.33	-1.41	0.43	-1.65	-1.00	0.75
10/2/13	-0.16	0.46	-0.12	0.60	0.07	0.47	-1.75	-1.43	0.35	-1.29	0.59	0.26	-1.05	-1.05	-0.33
10/9/13	-1.44	0.24	0.36	-2.08	0.96	0.69	-2.54	-1.48	-1.38	0.39	0.10	-1.44	0.26	-1.05	-1.35
10/16/13	0.85	1.70	0.83	-4.38	-2.87	-1.78	1.22	0.52	-1.63	-1.34	0.74	-1.52	0.42	-1.04	-2.37
10/23/13	-0.51	-0.07	-0.46	-2.01	-1.19	0.16	0.02	-0.52	-0.75	-0.63	-0.29	-1.52	0.37	-1.43	-3.39
10/30/13	-1.87	-1.85	-1.76	0.35	0.50	2.10	-1.18	-1.56	0.13	0.08	-1.31	-1.52	0.31	0.33	0.30
11/6/13	-0.84	-1.80	0.52	-2.35	-1.28	0.85	-1.27	0.21	-1.45	-1.54	0.20	0.60	-1.47	1.10	0.45
11/13/13	0.20	0.10	-1.86	0.87	1.47	1.08	-0.64	-0.73	0.69	0.38	-1.88	0.83	1.33	1.07	0.61
11/20/13	-0.60	0.80	0.78	-2.13	-2.01	-1.26	2.50	-0.72	-1.78	0.32	0.17	0.60	0.43	1.03	0.78
11/27/13	-1.40	0.64	0.72	-1.93	-1.85	0.96	2.50	-2.17	0.70	0.66	1.17	-1.74	0.63	0.73	0.11
12/4/13	-2.19	0.70	-0.71	-1.00	-0.24	4.96	1.05	-0.69	-0.55	-0.79	0.78	-0.46	-0.31	-2.96	-2.79
12/11/13	-2.99	0.76	-2.14	-0.07	1.37	8.96	-0.39	0.78	-1.80	-2.24	0.39	0.82	-1.25	-0.77	-1.39
12/18/13														1.41	0.02

	Mean daily flux rate (mg C-CH_4 m^{-2} day^{-1})															
	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	H1	H2
6/10/13	-1.43	-0.69	-0.04	0.26	0.01	0.05	0.38		-1.42	-0.99	-1.56	-1.13	-0.41	-1.48		
6/17/13	-1.13	-0.96	0.12	0.35	0.06	-0.68	-0.57		-0.49	-1.23	-1.20	-0.70	-0.31	-1.58		
7/1/13	-0.83	-1.22	0.28	0.44	0.11	-1.40	-1.53	0.12	0.45	-1.46	-0.84	-0.26	-0.22	-1.68		
7/8/13	-0.66	0.05	6.99	0.21	-1.46	0.36	0.34	-1.42	0.25	-1.69	-1.12	0.17	-0.29	-0.91		
7/15/13	0.42	-1.13	0.30	-1.46	0.19	-1.47	0.54	-1.54	-0.08	-0.93	-0.87	0.11	-0.76	-1.25		
7/22/13	-1.31	-0.81	0.46	-1.42	0.38	0.13	0.41	-1.24	-0.42	-0.57	-0.90	0.43	-0.02	-1.30		
7/29/13	-1.45	0.89	-1.11	0.39	-0.94	-0.73	0.28	-0.93	-0.75	-0.46	-0.28	0.41	0.32	-1.00		
8/5/13	0.67	0.49	0.16	-1.39	0.17	-0.26	0.25	-0.27	-1.08	0.38	0.33	0.68	-1.19	-0.85	0.17	
8/12/13	-1.20	-1.34	0.43	0.30	-1.22	0.21	-0.29	0.39	-1.41	0.25	-1.06	-1.15	-0.15	-1.15	-1.17	-0.98
8/19/13	0.14	0.17	-1.36	-0.10	-1.41	0.83	-1.18	-1.46	-1.19	-1.42	-0.97	-0.33	-0.11	0.15	-1.33	0.65
8/26/13	0.82	0.47	-1.05	-1.60	-0.56	0.63	-0.29	-1.17	-1.20	1.18	0.46	0.48	-1.40	-0.02	-1.09	-1.59
9/4/13	0.12	-1.67	-1.37	0.18	0.29	-1.19	0.67	-1.36	0.24	-1.53	-1.35	0.42	-1.48	-1.12	-1.30	0.20
9/11/13	-1.26	0.27	0.62	-0.12	-1.36	-1.48	0.80	-1.74	0.14	-1.23	0.51	0.24	-1.64	-1.21	-1.39	0.13
9/18/13	-1.58	0.34	0.41	0.27	-1.51	0.87	-1.66	-0.47	-1.42	0.29	-1.29	-1.49	0.33	0.95	-1.19	0.07
9/25/13	-0.95	-0.52	-1.72	0.36	-2.29	0.55	-1.78	0.65	-1.77	0.89	-1.92	0.37	0.76	-1.35	0.61	-1.71
10/2/13	-0.24	-1.37	-1.99	-1.68	-0.18	-1.77	-1.48	0.27	-1.28	0.82	-1.68	0.38	0.23	-0.62	0.30	-1.41
10/9/13	0.30	-0.62	-1.85	-1.99	-1.02	-0.98	-0.18	0.64	-0.79	-1.66	-1.44	0.39	0.11	0.36	1.19	-0.26
10/16/13	0.57	-0.87	-1.72	0.08	-1.86	-1.93	-1.33	0.47	-0.30	0.52	0.89	-1.56	-1.84	0.58	0.34	-1.81
10/23/13	0.98	0.89	0.48	0.60	0.21	-0.02	-1.46	-1.61	0.19	-2.44	-2.30	-1.62	-1.73	0.59	-1.50	-1.97
10/30/13	0.29	-2.14	-1.52	-1.79	0.42	-1.72	0.99	-1.68	-1.80	0.83	-1.32	-0.85	-1.65	0.56	-1.46	0.28
11/6/13	-2.32	-1.51	-1.50	0.56	-1.85	-1.76	0.62	0.37	-1.76	0.53	0.58	-0.79	-1.57	0.57	-1.45	0.53
11/13/13	-2.19	-0.29	-1.65	-0.69	-0.62	-0.39	0.53	-0.86	-2.19	0.60	-1.03	-1.18	-1.72	-0.60	-1.46	-1.66
11/20/13	-2.06	0.93	-1.80	-1.95	0.61	0.97	0.45	-2.09	-2.62	0.67	-2.64	-1.57	-1.87	-1.77	-1.85	0.54
11/27/13	-2.31	-2.59	-1.96	-0.90	0.45	0.51	-2.16	0.89	-2.71	-2.09	1.22	-2.30	-0.83	-2.36	-1.99	0.51
12/4/13	2.16	-2.01	1.08	0.15	3.77	0.53	-2.61	0.25	-2.51	-2.84	0.40	-2.53	-0.33	-2.95	-4.12	0.88
12/11/13	-0.12	-0.75	-0.47	-1.28	2.39	-0.94		-3.08	-2.31	-1.24	-0.42	-0.54		-0.69	-1.74	-1.08
12/18/13	-2.40	0.52	-2.02	-2.71	1.02	-2.41		1.27	-2.11	0.37	-1.24	1.44		1.58	0.65	-3.05

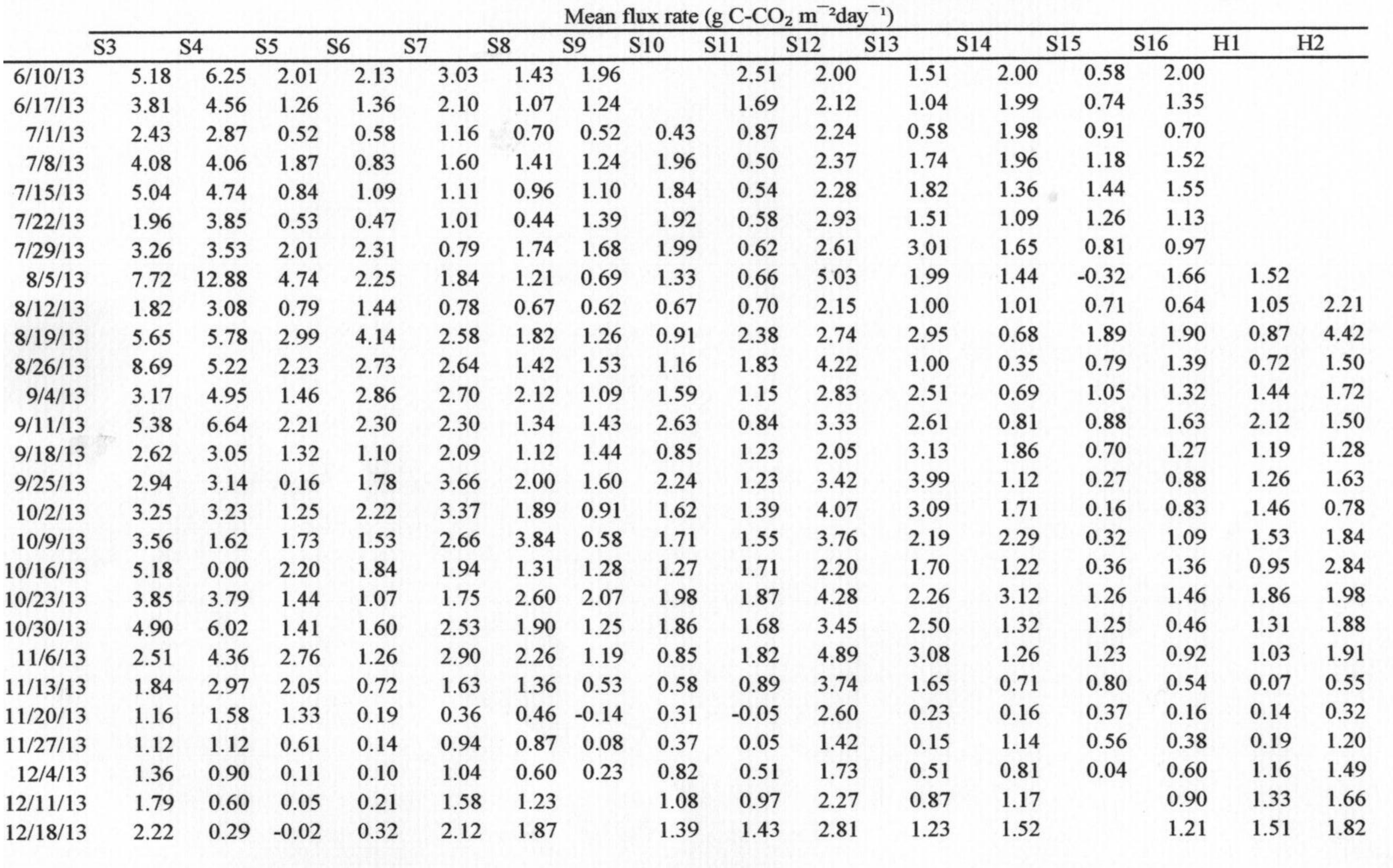
	Mean daily flux rate (mg C-CH_4 m^{-2} day^{-1})													
	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H16
7/29/13		-1.89								-0.82	0.51	0.06		
8/5/13	-1.52	-1.01	0.50			-1.13			0.30	0.30	-1.40	0.05	-1.24	-1.05
8/12/13	-1.64	-0.13	-0.83	-0.61	0.40	0.26	0.39	-1.34	0.59	0.40	-1.16	0.34	0.43	-1.57
8/19/13	0.34	-1.79	-1.05	-0.04	-0.04	-1.21	0.06	-1.49	0.49	-0.99	0.14	0.23	-1.31	-1.28
8/26/13	0.19	-1.66	0.49	0.53	-1.65	-0.18	-1.05	-1.72	0.23	-1.08	0.62	0.05	-1.51	-0.51
9/4/13	-1.73	-1.66	0.18	-0.91	0.40	0.29	-1.42	-2.16	0.56	0.24	-1.14	-1.39	0.08	0.25
9/11/13	-1.94	-1.54	0.45	0.34	-1.92	-1.25	0.65	-2.05	1.08	-0.02	-1.71	-0.46	0.82	-2.15
9/18/13	0.46	-0.15	-1.58	-0.98	0.33	0.45	0.32	-2.42	-1.95	-1.49	-1.38	0.47	-6.59	0.59
9/25/13	0.45	-0.01	-1.65	-1.39	0.12	-1.51	0.32	0.14	-1.69	0.47	-1.36	-1.71	0.83	0.67
10/2/13	-1.54	-2.23	0.45	0.55	-1.77	0.60	-1.69	-2.44	1.14	-1.18	0.47	-1.40	0.64	0.76
10/9/13	-1.69	-1.79	-1.98	-1.39	-2.02	-1.75	-0.62	0.38	0.54	0.00	-0.68	-1.80	0.22	0.84
10/16/13	0.49	-2.07	-0.76	-0.65	0.31	-2.00	0.73	0.45	-1.43	-1.48	-1.50	0.15	0.15	0.92
10/23/13	0.35	-0.26	0.46	-1.86	-1.41	0.61	-1.86	0.52	-1.91	0.64	-1.55	-2.30	1.02	1.00
10/30/13	-1.59	0.32	0.58	-1.58	0.00	-1.38	0.25	0.39	-0.96	0.30	-1.24	0.26	-1.91	-1.56
11/6/13	0.49	-1.88	0.62	-1.78	-1.49	-1.88	0.57	-2.37	0.32	-1.40	0.25	0.38	-1.81	0.59
11/13/13	0.77	-2.21	0.99	1.89	-2.27	0.68	-2.05	-3.06	0.66	-0.43	-1.74	0.29	1.04	-1.91
11/20/13	0.41	-3.26	0.34	-1.44	-1.20	-2.28	0.37	-2.27	0.68	-1.83	0.85	-2.32	0.91	1.00
11/27/13	0.50	-2.41	-2.05	0.53	-0.13	-1.48	1.26	-2.61	0.83	-1.72	1.08	0.51	-2.14	0.38
12/4/13	-3.74	0.19	0.30	-2.16	-2.57	-3.12	-0.26	-0.99	-1.82	1.44	-2.27	0.84	2.18	-2.94
12/11/13	-2.89	0.09	0.50	-2.02	-2.60	1.03	0.03	-2.83	0.77	0.99	-1.85	0.83	-0.31	-2.61
12/18/13	-2.05	-0.01	0.70	-1.88	-2.63		0.33			0.55	-1.43	0.81	-2.80	-2.28



Date	Mean flux rate (g C-CO_2 $m^{-2}day^{-1}$)														
	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15
5/6/13										0.19	0.74	5.26	0.88	0.70	3.93
5/13/13	0.95		3.76	5.15	7.18	4.50	3.52	1.85	5.3	5.7	7.7	13.6	6.8	1.8	3.9
5/20/13	1.22	1.53	3.22	2.79	1.39	3.11	1.42	1.45	1.1	2.4	2.6	3.5	4.5	2.2	3.9
5/27/13	1.99	3.23	2.91	3.07	2.30	4.13	1.73	1.72	0.4	0.7	1.9	3.0	1.3	2.9	2.5
6/3/13	1.48	1.30	2.54	2.30	0.77	1.49	2.05	1.08	0.9	0.6	2.2	0.3	1.4	1.5	1.3
6/10/13	3.47	1.88	2.21	4.17	0.98	3.18	2.44	2.13	0.6	1.4	1.6	0.4	0.3	1.8	0.0
6/17/13	3.22	2.56	1.07	4.25	1.22	1.66	2.68	2.04	0.5	3.7	3.3	2.7	1.3	4.3	0.8
7/1/13	1.37	2.17	1.67	3.34	1.49	2.08	2.90	1.47	1.8	0.4	1.6	0.2	0.9	0.3	0.4
7/8/13	0.35	1.78	1.06	2.42	1.83	1.64	3.12	2.36	1.7	0.6	3.6	0.5	1.8	0.2	2.5
7/15/13	2.07	0.91	0.88	2.56	1.18	2.92	3.00	2.28	1.3	0.5	2.4	0.4	1.5	-0.2	1.7
7/22/13	0.93	1.50	0.71	2.69	1.02	0.99	2.87	2.08	0.5	0.3	1.6	0.1	1.8	-0.1	1.0
7/29/13	1.39	1.82	1.05	3.31	2.06	2.24	2.74	1.21	1.4	0.4	1.0	0.6	0.8	0.4	0.3
8/5/13	1.53	2.00	1.21	3.49	2.07	1.08	2.62	2.69	2.2	1.3	3.3	0.9	2.9	1.0	1.5
8/12/13	0.71	0.92	0.53	2.29	0.86	0.94	4.12	0.88	1.3	0.2	0.2	0.0	0.4	0.1	0.8
8/19/13	3.63	6.96	3.13	6.68	4.42	7.26	5.62	3.40	7.0	0.6	0.9	0.1	0.6	0.0	1.8
8/26/13	1.48	5.53	1.78	2.23	2.98	4.24	3.47	3.60	3.1	0.4	0.6	1.7	1.4	0.6	1.8
9/4/13	0.74	4.11	3.68	1.87	4.36	1.97	3.08	1.93	3.4	2.0	2.9	1.5	1.2	2.0	1.8
9/11/13	1.38	2.68	3.85	1.01	7.19	1.34	1.10	0.88	3.3	1.3	1.1	1.6	1.0	0.3	0.9
9/18/13	1.06	1.25	5.62	0.81	1.09	1.64	1.27	2.38	3.5	0.7	1.3	0.6	0.9	0.1	0.6
9/25/13	1.21	1.86	4.58	1.26	1.42	2.11	0.92	1.28	3.6	0.5	1.8	0.3	0.5	0.2	1.2
10/2/13	1.36	1.24	6.20	2.00	3.11	2.74	1.12	1.42	3.7	1.4	1.6	1.0	1.3	0.6	0.3
10/9/13	1.16	1.29	5.00	2.57	2.27	2.06	1.50	1.52	3.1	1.3	0.9	0.2	0.9	0.7	0.5
10/16/13	2.00	1.34	5.83	2.56	1.71	3.27	1.87	1.69	3.4	0.7	1.9	1.3	1.4	0.6	1.3
10/23/13	1.59	1.39	4.06	3.20	1.70	2.34	1.88	1.50	2.6	0.9	1.7	1.0	1.3	0.7	1.3
10/30/13	1.18	1.44	2.28	3.84	1.69	1.41	1.88	1.31	1.8	1.1	1.4	0.7	1.2	0.9	1.3
11/6/13	1.71	1.49	3.21	3.46	2.01	2.29	1.88	1.12	2.6	0.3	1.3	1.0	1.2	1.0	0.8
11/13/13	1.19	1.54	1.77	1.19	1.62	1.30	2.06	0.93	2.3	0.7	0.2	0.8	1.3	1.3	1.0
11/20/13	1.64	2.13	1.49	2.50	1.66	0.79	2.23	1.77	1.4	1.3	2.0	1.4	1.4	1.7	1.6
11/27/13	1.27	1.24	1.22	2.42	1.63	1.79	2.41	1.58		1.65	1.10	1.34	1.65	0.16	1.92
12/4/13		0.98	1.23	2.03	1.41	2.34	1.88	1.73		1.20	1.12	0.71	1.25	0.14	1.44
12/11/13		0.71	1.25	1.64	1.18	2.88	1.35	1.87		0.75	1.13	0.07	0.85	0.11	0.95



	Mean flux rate (g C-CO_2 $m^{-2}day^{-1}$)														
	L16	L17	L18	L19	L20	L21	L22	L23	L24	L25	L26	L27	L28	S1	S2
5/6/13	7.69	2.33	3.23	1.27	0.83	6.10		0.25	0.20	2.81		1.67	0.13		
5/13/13	7.6	2.07	4.04	4.47	1.90	6.08	6.55	3.34	0.89	2.66	12.28	8.38	8.24		
5/20/13	7.5	1.80	3.28	1.36	2.97	6.05	5.60	1.37	1.65	3.66	1.49	2.87	1.82		
5/27/13	6.5	2.15	2.53	1.95	4.04	4.50	4.65	1.93	2.21	4.65	1.40	3.55	3.32		
6/3/13	2.3	1.19	0.65	0.97	1.37	1.15	1.57	0.42	0.87	0.90	0.19	0.34	0.78		
6/10/13	7.8	0.45	2.11	2.48	1.63	1.07	1.48	1.45	2.57	2.81	0.81	0.60	1.05	7.00	1.60
6/17/13	0.6	0.71	3.60	4.64	1.63	0.98	1.39	2.39	3.31	3.80	1.69	3.98	0.90	4.66	1.08
7/1/13	2.0	0.65	1.93	0.85	1.64	0.93	2.09	0.34	0.34	1.69	0.32	0.48	0.76	2.31	0.56
7/8/13	7.4	1.67	3.28	2.45	1.66	2.24	3.04	0.68	0.58	2.48	1.26	0.48	0.46	5.36	3.28
7/15/13	5.3	3.11	3.82	1.32	0.94	2.02	1.72	0.06	0.40	2.47	-0.18	0.72	0.69	4.49	2.67
7/22/13	4.2	0.67	4.37	1.05	0.50	0.93	1.20	-0.07	0.21	1.70	-0.07	0.96	0.47	0.66	3.57
7/29/13	3.3	1.14	2.66	0.90	0.45	1.80	1.91	0.12	0.49	1.55	1.69	1.20	0.88	3.46	3.63
8/5/13	5.2	2.07	3.73	0.48	1.09	3.12	3.19	-0.12	0.95	2.72	2.21	1.40	0.93	8.02	2.09
8/12/13	1.0	0.15	1.58	0.73	0.71	0.22	0.25	0.11	0.26	1.15	0.52	0.65	0.12	0.76	0.56
8/19/13	2.3	0.68	2.31	2.16	0.33	1.81	1.34	0.16	-0.28	1.74	0.73	0.61	0.18	3.75	1.26
8/26/13	3.6	1.11	2.79	1.22	0.76	4.08	2.66	0.51	0.75	1.71	1.21	0.97	1.64	4.44	1.11
9/4/13	1.4	0.89	3.14	1.42	0.99	2.39	2.59	0.03	0.91	1.46	1.69	1.14	0.47	4.28	1.00
9/11/13	2.2	1.19	2.87	1.68	0.60	0.76	1.50	0.08	0.27	1.04	2.16	1.40	0.91	3.16	0.74
9/18/13	1.7	0.22	1.59	0.28	0.61	1.14	1.18	0.20	0.10	1.14	1.26	1.26	-0.04	2.69	0.98
9/25/13	1.3	0.20	1.20	0.45	0.77	1.28	1.78	0.17	-0.04	0.78	0.52	2.13	1.96	4.53	1.22
10/2/13	0.9	0.81	1.18	0.13	0.68	0.77	1.88	0.18	0.18	1.81	1.62	1.31	0.32	4.37	1.08
10/9/13	0.5	1.03	1.15	1.19	0.60	0.25	1.97	1.05	0.15	1.66	1.31	2.11	0.58	4.31	0.81
10/16/13	0.9	0.68	1.12	1.48	0.75	1.78	1.15	1.77	0.89	1.95	2.91	1.14	0.74	4.25	0.53
10/23/13	2.0	1.04	1.28	1.27	1.00	2.05	1.29	1.05	0.87	2.12	2.39	1.27	0.48	4.26	0.25
10/30/13	3.1	1.40	1.43	1.06	1.26	2.32	1.43	0.33	0.85	2.28	1.87	1.41	0.22	4.86	0.82
11/6/13	3.1	0.81	3.30	1.04	1.11	1.38	1.60	0.76	0.79	2.19	2.44	1.70	0.93	3.03	1.48
11/13/13	3.1	1.27	1.47	1.29	0.83	0.77	0.25	0.56	0.85	0.90	3.67	0.32	0.33	2.45	0.98
11/20/13	3.2	0.56	0.57	0.68	0.17	1.73	1.95	1.01	2.09	1.85	2.70	0.84	1.12	1.87	0.48
11/27/13	3.37	0.25	0.25	0.14	0.16	1.52	2.34	1.40	1.31	2.37	3.81	1.27	0.03	2.12	2.20
12/4/13	3.50	0.39	0.72	0.21	0.38	1.33	1.84	0.96	0.71	1.93	2.56	1.13	0.03	2.31	2.13
12/11/13	3.47	0.53	1.19	0.28	0.61	1.14	1.34	0.52	0.12	1.48	1.31	0.99	0.03	3.23	2.47
12/18/13														4.15	2.80



	Mean flux rate (g C-CO$_2$ m^{-2}day^{-1})														
	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	H1	H2
6/10/13	5.18	6.25	2.01	2.13	3.03	1.43	1.96		2.51	2.00	1.51	2.00	0.58	2.00		
6/17/13	3.81	4.56	1.26	1.36	2.10	1.07	1.24		1.69	2.12	1.04	1.99	0.74	1.35		
7/1/13	2.43	2.87	0.52	0.58	1.16	0.70	0.52	0.43	0.87	2.24	0.58	1.98	0.91	0.70		
7/8/13	4.08	4.06	1.87	0.83	1.60	1.41	1.24	1.96	0.50	2.37	1.74	1.96	1.18	1.52		
7/15/13	5.04	4.74	0.84	1.09	1.11	0.96	1.10	1.84	0.54	2.28	1.82	1.36	1.44	1.55		
7/22/13	1.96	3.85	0.53	0.47	1.01	0.44	1.39	1.92	0.58	2.93	1.51	1.09	1.26	1.13		
7/29/13	3.26	3.53	2.01	2.31	0.79	1.74	1.68	1.99	0.62	2.61	3.01	1.65	0.81	0.97		
8/5/13	7.72	12.88	4.74	2.25	1.84	1.21	0.69	1.33	0.66	5.03	1.99	1.44	-0.32	1.66	1.52	
8/12/13	1.82	3.08	0.79	1.44	0.78	0.67	0.62	0.67	0.70	2.15	1.00	1.01	0.71	0.64	1.05	2.21
8/19/13	5.65	5.78	2.99	4.14	2.58	1.82	1.26	0.91	2.38	2.74	2.95	0.68	1.89	1.90	0.87	4.42
8/26/13	8.69	5.22	2.23	2.73	2.64	1.42	1.53	1.16	1.83	4.22	1.00	0.35	0.79	1.39	0.72	1.50
9/4/13	3.17	4.95	1.46	2.86	2.70	2.12	1.09	1.59	1.15	2.83	2.51	0.69	1.05	1.32	1.44	1.72
9/11/13	5.38	6.64	2.21	2.30	2.30	1.34	1.43	2.63	0.84	3.33	2.61	0.81	0.88	1.63	2.12	1.50
9/18/13	2.62	3.05	1.32	1.10	2.09	1.12	1.44	0.85	1.23	2.05	3.13	1.86	0.70	1.27	1.19	1.28
9/25/13	2.94	3.14	0.16	1.78	3.66	2.00	1.60	2.24	1.23	3.42	3.99	1.12	0.27	0.88	1.26	1.63
10/2/13	3.25	3.23	1.25	2.22	3.37	1.89	0.91	1.62	1.39	4.07	3.09	1.71	0.16	0.83	1.46	0.78
10/9/13	3.56	1.62	1.73	1.53	2.66	3.84	0.58	1.71	1.55	3.76	2.19	2.29	0.32	1.09	1.53	1.84
10/16/13	5.18	0.00	2.20	1.84	1.94	1.31	1.28	1.27	1.71	2.20	1.70	1.22	0.36	1.36	0.95	2.84
10/23/13	3.85	3.79	1.44	1.07	1.75	2.60	2.07	1.98	1.87	4.28	2.26	3.12	1.26	1.46	1.86	1.98
10/30/13	4.90	6.02	1.41	1.60	2.53	1.90	1.25	1.86	1.68	3.45	2.50	1.32	1.25	0.46	1.31	1.88
11/6/13	2.51	4.36	2.76	1.26	2.90	2.26	1.19	0.85	1.82	4.89	3.08	1.26	1.23	0.92	1.03	1.91
11/13/13	1.84	2.97	2.05	0.72	1.63	1.36	0.53	0.58	0.89	3.74	1.65	0.71	0.80	0.54	0.07	0.55
11/20/13	1.16	1.58	1.33	0.19	0.36	0.46	-0.14	0.31	-0.05	2.60	0.23	0.16	0.37	0.16	0.14	0.32
11/27/13	1.12	1.12	0.61	0.14	0.94	0.87	0.08	0.37	0.05	1.42	0.15	1.14	0.56	0.38	0.19	1.20
12/4/13	1.36	0.90	0.11	0.10	1.04	0.60	0.23	0.82	0.51	1.73	0.51	0.81	0.04	0.60	1.16	1.49
12/11/13	1.79	0.60	0.05	0.21	1.58	1.23		1.08	0.97	2.27	0.87	1.17		0.90	1.33	1.66
12/18/13	2.22	0.29	-0.02	0.32	2.12	1.87		1.39	1.43	2.81	1.23	1.52		1.21	1.51	1.82

	Mean flux rate (g C-CO_2 $m^{-2}day^{-1}$)													
	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H16
7/29/13		1.16								1.63	2.18	1.64		
8/5/13	4.15	1.11	2.46			0.93			4.47	0.89	3.71	1.11	1.45	0.63
8/12/13	1.83	1.07	1.00	0.71	0.63	0.75	1.10	0.79	2.33	0.33	0.87	0.20	5.09	0.52
8/19/13	1.52	2.35	4.61	2.87	2.56	3.52	5.80	2.60	2.03	2.70	4.90	2.10	8.37	2.41
8/26/13	2.27	1.72	2.59	1.19	2.06	2.93	3.21	1.75	1.59	1.15	3.21	1.26	7.44	2.07
9/4/13	3.00	1.51	1.75	2.09	1.64	2.27	2.58	1.17	1.72	1.20	1.82	1.34	3.33	1.74
9/11/13	2.07	1.80	2.49	2.02	1.78	2.36	1.43	1.20	2.84	1.20	3.06	0.99	3.30	0.79
9/18/13	3.43	1.47	2.22	1.73	2.19	2.54	3.24	1.96	2.46	1.30	1.18	0.64	3.89	0.96
9/25/13	2.82	2.04	2.35	1.76	2.55	2.11	4.08	1.48	2.11	0.88	0.66	0.26	3.27	0.99
10/2/13	2.75	1.18	1.74	2.00	1.74	1.80	4.31	0.88	0.59	1.35	2.20	1.17	5.53	1.01
10/9/13	1.40	1.94	1.37	3.22	1.90	1.57	3.99	1.56	2.32	1.63	1.96	1.72	4.38	1.04
10/16/13	1.71	1.59	1.57	1.80	1.08	2.48	3.90	1.20	1.87	2.03	1.51	1.58	1.67	1.07
10/23/13	1.99	1.22	1.77	1.41	1.42	2.71	3.50	0.84	1.62	1.44	1.70	1.48	2.36	1.09
10/30/13	1.69	1.58	1.79	1.77	1.80	3.48	4.24	1.50	2.49	1.89	2.21	1.70	5.36	1.06
11/6/13	1.32	1.28	0.82	1.17	0.77	2.81	1.74	0.97	0.98	1.95	1.82	0.56	2.81	0.49
11/13/13	0.65	0.53	0.37	0.87	0.14	1.60	1.02	-0.16	0.51	1.30	1.02	0.27	2.43	0.23
11/20/13	0.58	0.68	1.45	1.52	0.81	1.25	2.80	0.99	1.81	1.86	1.57	1.03	2.18	1.22
11/27/13	0.32	0.57	0.18	0.20	1.47	0.61	1.31	0.28	0.76	1.24	1.26	1.02	4.10	0.72
12/4/13	1.01	0.99	1.33	1.30	0.81	2.02	2.21	0.70	2.25	1.50	1.56	1.20	2.19	2.01
12/11/13	1.64	1.31	1.55	1.38	0.96	1.03	2.46	0.22	1.03	1.96	0.92	1.33	2.77	1.96
12/18/13	2.27	1.64	1.78	1.45	1.10		2.71			2.41	0.27	1.45	3.35	1.92

	Mean flux rate (μg N-N$_2$O m^{-2}day^{-1})														
Date	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12	L13	L14	L15
5/6/13										0.19	0.24	0.16	0.13	0.35	0.18
5/13/13	0.11		0.12	0.56	1.41	0.55	0.16	0.16	1.53	0.24	0.26	0.18	0.27	0.02	0.24
5/20/13	0.01	-0.06	0.09	0.21	0.48	0.17	0.21	0.19	0.15	0.12	0.07	0.06	0.15	0.32	0.31
5/27/13	0.09	0.08	0.05	0.01	0.36	0.17	0.08	-0.01	0.09	0.15	-0.03	0.01	0.01	0.10	0.19
6/3/13	0.11	0.12	0.01	0.10	0.21	0.13	0.06	0.07	-0.08	-0.25	0.09	-0.17	0.06	0.02	-0.08
6/10/13	0.21	-0.38	-0.02	0.11	-0.43	0.11	0.04	-0.10	0.05	0.10	0.37	-0.09	0.03	0.05	-0.07
6/17/13	-0.06	-0.04	-0.06	0.14	0.21	-0.17	0.02	0.17	-0.02	1.50	0.50	-0.09	0.08	4.04	-0.02
7/1/13	0.06	-0.07	0.10	0.10	0.43	0.08	0.09	-0.15	0.06	-0.04	0.14	-0.01	0.40	-0.03	0.05
7/8/13	-0.21	-0.09	-0.11	0.06	0.01	0.36	0.16	0.23	0.29	-0.20	0.18	0.04	0.15	0.13	0.29
7/15/13	0.13	0.13	-0.10	0.15	-0.09	-0.04	0.14	-0.18	0.14	0.09	0.18	-0.05	0.17	-0.19	-0.07
7/22/13	0.07	0.00	-0.09	0.24	0.08	0.03	0.12	0.02	0.01	0.16	-0.21	-0.04	1.73	-0.14	0.05
7/29/13	0.05	0.11	0.54	0.99	0.60	0.80	0.10	0.07	0.62	0.21	0.07	0.07	0.08	0.06	0.05
8/5/13	0.04	0.11	0.04	0.12	0.11	0.14	0.08	0.04	0.06	0.06	0.03	0.03	0.04	0.06	0.40
8/12/13	0.01	0.03	0.01	0.24	0.08	0.04	0.11	-0.09	0.09	0.01	0.02	-0.06	0.03	-0.01	0.01
8/19/13	0.17	0.17	0.44	0.89	0.93	0.95	0.14	0.10	0.71	0.11	0.00	-0.05	0.05	0.01	0.04
8/26/13	0.05	0.11	0.04	0.24	0.14	0.30	0.01	0.03	0.05	0.04	0.13	-0.08	0.16	0.08	0.06
9/4/13	0.02	0.05	0.11	0.11	0.35	0.01	0.17	0.10	0.09	0.53	0.25	0.00	0.18	0.14	0.07
9/11/13	0.07	0.00	0.24	0.07	0.07	-0.02	0.01	0.06	0.07	0.06	-0.05	0.06	0.06	0.02	0.04
9/18/13	-0.02	-0.06	0.03	0.03	0.42	0.01	0.01	0.02	0.02	0.13	0.01	-0.07	0.01	0.00	-0.05
9/25/13	0.01	-0.02	0.01	0.06	0.19	0.07	0.13	0.15	0.02	0.09	0.00	-0.02	0.02	0.02	0.00
10/2/13	0.04	-0.03	0.06	0.01	0.09	0.02	-0.05	0.03	0.01	0.00	0.03	-0.08	0.04	-0.01	0.01
10/9/13	-0.02	-0.01	0.07	0.04	0.28	0.05	-0.01	0.09	0.05	0.09	0.03	-0.05	0.00	0.03	0.05
10/16/13	0.01	0.01	0.08	0.01	0.15	0.05	0.03	0.03	0.02	0.12	0.08	0.03	0.04	0.01	0.13
10/23/13	0.00	0.02	0.04	-0.01	0.16	0.05	0.02	0.03	0.00	0.21	0.08	0.05	0.01	0.01	0.08
10/30/13	-0.01	0.04	-0.01	-0.03	0.18	0.05	0.01	0.03	-0.02	0.29	0.09	0.06	-0.03	0.02	0.04
11/6/13	0.00	0.05	0.07	-0.01	0.27	0.11	0.00	0.02	0.02	0.10	-0.07	-0.02	0.04	0.03	-0.03
11/13/13	0.00	0.07	0.05	0.20	0.12	0.04	0.00	0.02	0.02	0.04	-0.01	0.03	0.05	0.07	0.05
11/20/13	0.00	0.06	0.06	0.00	0.17	0.02	-0.01	0.02	0.04	0.12	0.02	-0.01	0.03	0.06	0.04
11/27/13	-0.03	-0.05	0.07	0.04	0.03	-0.01	-0.01	0.14		0.19	-0.06	0.00	0.13	-0.02	0.04
12/4/13		-0.06	0.09	0.02	0.21	-0.06	-0.03	0.12		0.12	-0.03	0.00	0.10	0.00	0.02
12/11/13		-0.07	0.10	0.01	0.39	-0.11	-0.05	0.11		0.04	-0.01	0.01	0.07	0.02	-0.01

	Mean flux rate (µg N-N_2O m^{-2}day^{-1})														
	L16	L17	L18	L19	L20	L21	L22	L23	L24	L25	L26	L27	L28	S1	S2
5/6/13	0.26	0.25	0.15	0.15	-0.07	5.47		-0.04	0.20	0.24		-0.11	0.04		
5/13/13	0.35	0.26	0.18	0.17	0.04	2.93	0.22	0.46	0.04	0.07	0.29	0.29	1.61		
5/20/13	0.44	0.26	0.02	0.12	0.14	0.40	0.05	-0.01	0.66	0.04	0.00	0.06	1.57		
5/27/13	0.07	0.56	-0.14	0.01	0.24	0.18	-0.11	-0.02	0.35	0.02	-0.16	0.20	0.56		
6/3/13	0.04	0.18	0.19	-0.08	-0.02	0.00	0.13	0.10	0.17	0.10	-0.04	0.14	0.06		
6/10/13	-0.13	-0.24	0.07	0.04	-0.05	-0.04	0.07	0.09	0.18	0.20	0.08	-0.12	0.02	0.09	0.67
6/17/13	-0.01	-0.07	0.02	-0.10	0.25	-0.08	0.01	0.61	0.44	0.45	0.17	0.44	-0.01	0.03	0.38
7/1/13	-0.12	0.18	-0.15	-0.07	0.17	0.16	0.38	0.06	-0.17	0.02	0.06	0.10	-0.05	-0.03	0.10
7/8/13	0.09	0.03	-0.08	-0.15	0.10	0.15	0.28	0.42	-0.01	0.08	0.13	-0.11	-0.10	0.16	0.18
7/15/13	0.17	-0.03	-0.07	-0.10	0.19	-0.20	0.02	0.11	0.17	-0.11	-0.12	0.21	-0.09	-0.15	0.20
7/22/13	-0.09	-0.12	-0.05	-0.13	0.36	0.09	0.15	-0.04	-0.23	0.08	0.14	0.17	-0.10	-0.09	0.02
7/29/13	0.02	0.06	0.04	0.00	0.13	0.12	0.19	0.08	0.06	0.17	0.10	0.13	0.15	0.21	1.64
8/5/13	0.08	0.02	0.07	-0.08	0.06	0.25	0.08	-0.02	0.07	0.11	0.07	0.09	0.01	0.06	0.98
8/12/13	-0.09	0.00	-0.02	0.00	0.10	0.07	0.00	0.03	0.00	0.01	0.03	0.03	-0.07	0.03	0.31
8/19/13	0.06	0.00	0.01	-0.01	0.15	0.09	0.01	0.02	-0.03	-0.01	0.03	-0.03	0.07	-0.06	0.08
8/26/13	0.20	0.03	0.00	-0.05	0.08	0.40	1.08	0.07	0.58	0.07	0.03	0.05	0.58	0.06	0.09
9/4/13	0.05	0.11	0.08	0.04	0.06	0.28	0.29	0.02	0.02	0.08	0.02	0.05	0.04	0.03	0.11
9/11/13	0.07	0.02	0.03	-0.08	0.11	0.06	0.05	-0.01	-0.01	0.01	0.01	0.03	0.05	0.08	0.09
9/18/13	0.07	-0.04	0.05	0.02	0.14	0.14	-0.02	0.04	0.01	0.01	0.00	0.03	0.01	0.04	0.28
9/25/13	0.07	0.09	-0.05	-0.03	0.03	-0.06	-0.22	-0.12	-0.03	0.00	-0.01	0.07	0.30	0.22	0.46
10/2/13	0.07	-0.07	-0.01	-0.02	0.05	-0.06	-0.09	0.05	-0.01	0.02	-0.04	0.01	-0.01	-0.03	0.14
10/9/13	0.07	-0.04	0.02	0.02	0.06	-0.07	0.05	0.09	-0.03	0.03	0.01	0.05	0.05	0.00	0.13
10/16/13	0.09	-0.04	0.05	0.02	0.04	0.14	0.13	-0.08	-0.01	0.00	0.00	0.03	0.07	0.02	0.12
10/23/13	0.07	-0.03	0.05	-0.01	0.05	0.19	0.29	0.03	0.03	0.03	0.00	0.06	0.08	-0.02	0.12
10/30/13	0.05	-0.02	0.05	-0.03	0.06	0.24	0.45	0.14	0.06	0.07	0.01	0.09	0.09	0.06	0.14
11/6/13	0.06	-0.03	0.02	0.04	0.03	0.17	0.15	0.15	-0.03	-0.02	-0.05	-0.01	0.13	-0.09	0.09
11/13/13	0.07	-0.10	-0.01	0.11	-0.03	0.29	0.16	0.05	-0.05	0.08	0.06	0.00	0.06	-0.03	0.08
11/20/13	0.05	0.01	0.06	0.11	0.03	0.12	0.52	0.08	0.03	0.01	0.04	0.01	0.14	0.02	0.07
11/27/13	0.02	0.02	0.04	0.02	0.01	0.37	0.35	0.38	0.00	0.08	0.19	0.00	0.26	0.05	0.11
12/4/13	0.00	0.01	0.03	-0.01	-0.01	0.23	0.20	0.21	0.01	0.04	0.06	0.00	0.15	0.00	0.01
12/11/13	0.00	0.00	0.03	-0.03	-0.04	0.08	0.05	0.04	0.02	0.00	-0.06	-0.01	0.04	0.01	0.03
12/18/13														0.03	0.06

	Mean flux rate (μg N-N_2O $m^{-2}day^{-1}$)															
	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	H1	H2
6/3/13																
6/10/13	0.06	0.14	0.17	0.10	-0.05	0.12	-0.32		0.26	-0.09	0.23	-0.16	0.31	0.09		
6/17/13	0.10	0.02	0.22	0.10	-0.21	0.07	-0.12		0.18	0.10	0.28	-0.11	0.16	0.05		
7/1/13	0.14	-0.10	0.27	0.11	-0.36	0.01	0.07	0.06	0.10	0.29	0.33	-0.06	0.02	0.01		
7/8/13	-0.15	0.02	-0.16	0.23	0.10	-0.09	-0.04	0.10	0.31	0.48	0.35	-0.02	-0.25	-0.12		
7/15/13	0.05	-0.26	0.08	0.06	-0.15	0.10	0.08	0.04	0.27	0.01	0.33	0.11	-0.17	0.05		
7/22/13	0.06	-0.12	0.08	0.21	-0.20	-0.10	0.28	0.26	0.22	-0.09	-0.06	0.15	0.09	0.09		
7/29/13	0.10	0.14	0.57	0.45	0.35	0.03	0.48	0.48	0.18	0.01	0.92	0.12	0.03	0.04		
8/5/13	0.06	0.06	0.12	0.00	0.09	0.06	0.06	0.36	0.14	0.12	0.16	0.02	-0.07	-0.16	0.19	
8/12/13	0.00	0.01	0.02	0.08	0.04	0.09	0.14	0.24	0.09	-0.02	0.20	0.02	-0.01	0.06	0.25	0.06
8/19/13	0.04	0.08	0.06	0.08	-0.01	0.00	0.08	0.06	-0.04	0.05	0.16	-0.05	-0.03	-0.04	0.09	-0.18
8/26/13	-0.12	0.04	-0.05	0.02	0.04	0.15	0.05	0.03	0.02	0.03	0.16	-0.12	-0.02	-0.05	0.05	0.13
9/4/13	0.14	0.02	-0.02	0.03	0.09	0.03	0.05	0.03	0.11	-0.02	0.35	-0.03	-0.04	-0.02	0.13	0.04
9/11/13	0.03	-0.04	0.09	-0.02	0.04	0.02	0.01	-0.01	0.07	-0.02	0.24	0.02	0.04	0.00	0.16	0.06
9/18/13	-0.05	0.09	0.01	-0.04	-0.02	-0.04	0.10	0.06	0.02	0.08	0.21	0.02	0.01	0.00	0.07	0.09
9/25/13	0.00	0.00	0.03	0.05	0.46	0.24	0.50	0.07	0.32	0.02	1.09	0.07	0.01	0.02	0.15	0.07
10/2/13	-0.02	-0.04	0.00	0.02	0.02	0.11	0.04	-0.03	0.26	-0.02	0.69	0.11	0.05	0.03	0.22	-0.13
10/9/13	-0.04	-0.02	0.02	0.11	0.08	0.11	0.36	0.05	0.20	0.13	0.30	0.14	0.01	0.05	0.10	0.05
10/16/13	0.03	0.00	0.04	0.04	0.13	0.01	0.10	-0.02	0.14	0.05	0.07	0.00	-0.05	0.02	0.07	0.15
10/23/13	-0.02	-0.08	-0.02	0.05	-0.05	-0.01	0.11	-0.08	0.08	-0.08	0.19	0.06	0.03	0.01	0.04	0.15
10/30/13	-0.02	0.11	0.01	0.01	0.02	-0.05	-0.01	0.00	0.09	0.06	0.17	0.06	0.13	0.08	0.07	0.15
11/6/13	0.14	0.08	0.01	-0.07	0.10	0.10	0.03	0.02	-0.01	0.08	0.41	0.01	0.23	0.03	0.04	0.14
11/13/13	0.04	0.05	0.02	-0.03	0.09	0.08	0.04	0.03	0.04	0.04	0.25	0.01	0.15	0.01	0.10	-0.03
11/20/13	-0.06	0.02	0.02	0.01	0.08	0.05	0.04	0.03	0.08	-0.01	0.09	0.01	0.08	0.00	0.09	0.05
11/27/13	0.04	0.03	0.03	-0.03	0.08	0.01	0.04	0.08	-0.07	0.09	0.12	0.00	0.01	0.02	0.08	0.04
12/4/13	-0.09	0.10	0.03	-0.07	-0.04	0.01	-0.02	-0.03	-0.03	-0.05	0.56	-0.04	0.03	0.03	0.07	-0.04
12/11/13	-0.04	0.10	0.03	-0.01	-0.01	0.01		0.04	0.01	0.03	1.00	-0.01		0.03	0.06	0.01
12/18/13	0.01	0.10	0.04	0.04	0.02	0.01		0.04	0.05	0.11	1.44	0.02		0.03	0.05	0.06

	Mean flux rate (μg $N\text{-}N_2O$ $m^{-2}day^{-1}$)													
	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13	H14	H15	H16
7/29/13		0.38								0.09	0.09	0.24		
8/5/13	0.06	0.33	0.12			0.05			0.09	-0.05	0.06	0.16	0.05	-0.08
8/12/13	0.25	0.27	0.11	0.10	0.04	0.10	0.10	0.04	0.15	0.04	-0.01	0.11	1.40	0.02
8/19/13	0.03	0.06	0.21	0.05	0.07	0.06	0.14	0.03	0.18	0.07	0.03	0.05	0.92	0.13
8/26/13	-0.01	0.05	0.10	-0.01	0.13	0.06	0.04	0.02	0.07	-0.01	-0.01	0.06	0.09	0.32
9/4/13	0.06	0.01	0.33	0.03	0.04	0.07	0.03	0.00	0.04	0.05	0.06	0.09	0.24	0.50
9/11/13	0.13	0.12	-0.08	0.11	0.10	0.09	0.02	-0.04	0.21	0.06	0.02	0.10	0.15	0.96
9/18/13	0.27	0.07	0.15	0.05	0.04	0.01	0.11	0.04	0.14	0.02	-0.03	0.10	0.14	0.27
9/25/13	0.18	0.06	-0.04	0.05	0.07	0.01	-0.02	-0.01	0.39	0.03	-0.04	-0.04	0.01	0.25
10/2/13	0.15	0.15	0.03	0.03	0.13	0.04	-0.07	0.04	0.06	0.01	0.06	0.18	0.09	0.23
10/9/13	0.27	0.05	0.03	-0.08	0.08	0.12	0.20	0.10	0.28	0.00	0.06	0.15	0.08	0.21
10/16/13	0.47	0.16	0.03	0.02	0.10	0.08	0.12	0.02	0.08	-0.03	0.05	0.12	0.00	0.19
10/23/13	0.32	-0.02	0.02	0.01	0.03	0.02	-0.03	-0.05	0.08	0.00	-0.03	0.13	0.02	0.18
10/30/13	0.32	0.10	0.05	0.04	0.14	0.10	0.08	0.00	0.20	0.04	0.06	0.02	0.19	0.33
11/6/13	0.03	-0.01	0.14	-0.01	0.14	0.04	0.08	0.02	-0.05	0.04	0.02	0.10	0.11	0.21
11/13/13	0.19	0.06	0.00	0.04	0.08	0.02	0.03	-0.02	0.05	0.03	0.07	0.06	0.11	0.02
11/20/13	0.02	0.16	0.04	0.03	0.06	0.15	0.07	-0.03	0.07	-0.01	0.09	0.01	0.27	0.06
11/27/13	0.06	0.03	0.05	-0.03	0.04	0.25	0.07	-0.05	0.04	-0.03	0.04	0.06	0.05	0.08
12/4/13	0.04	0.01	0.06	0.08	0.08	0.04	0.06	-0.04	-0.01	0.04	0.05	0.06	0.07	0.11
12/11/13	0.06	0.06	0.07	0.06	0.05	0.03	0.05	-0.01	-0.04	0.09	0.03	0.05	0.06	0.08
12/18/13	0.07	0.11	0.08	0.04	0.02		0.05			0.14	0.00	0.04	0.05	0.05