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# Analysis of the Spatio - Temporal Dynamics of Soil Carbon and Nitrogen in a Tropical Bush - Fallow Chronosequence

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**Abstract:** ***The quantity of carbon (and nitrogen) that can be sequestered in soils is of particular interest to environmental scientists, ecologists, economists, and politicians amidst the changing climate, mainly driven by high levels of atmospheric carbondioxide. It seems logical, therefore, that bush fallows, which accounts for some of the largest land use in tropical environments, can maintain a reasonable store of carbon for long periods, thus the need to study and elucidate the soil nutrient status and interactions in such agro - ecosystems. Soil samples were collected in 2010 (Y1) and 2011 (Y2) from six different parts of the country separated by distance of at least 60 km. Each site is characterized by a different combination of geographic features and cultural setting of the local people. A total of 540 soil samples was taken from bush fallows one to 10 years old (denoted as 1Y, 2Y, 3Y, 4Y, 5Y, 6Y, 7Y, 8Y, 9Y and 10Y, respectively), at depths of 0cm, 2cm, 10cm and 20cm. The Elementor Vario EL and TruSpec CN analyzers were used to analyze the carbon and nitrogen content of the soils, in Y1 and Y2 sampling respectively, in accordance with published procedures. The relationship between C and N was consistent at all sampling depths, with very strong correlation ($r^2$ values >0.85) in all cases (Figure 2). The highest mean percentages at the 2cm depth in the Y1 samples was obtained from 5Y fallows for both C (5.35±3.15) and N (0.36±0.18), whist 9Y fallows accounted for the highest mean %C (5.48±0.94) and %N (0.44±0.02) in the Y2 samples. The largest, but negative change in %C occurred in fallow plots that were 5 - 6 years (mean =1.905±3.489), but reasonable increases also occurred on the 2 - 3 years (mean = 1.707±2.142) and 9 - 10 years (mean = 1.337±3.183) fallows, respectively (Figure 4). Mean %N change was highest for 2 - 3 years (0.140 ± 0.082) and 9 - 10 years (0.134 ± 0.197) fallows. The results from a one - way ANOVA (Table 3) indicate a strong significant difference in overall mean %C between the study sites in the Y1 samples ($F = 42.11$; $p < 0.001$) and a reasonable significant difference in the Y2 samples ($F = 3.09$; $p < 0.05$). In the case of %N, one - way ANOVA show very strong significant difference between sites in both Y1 samples ($F = 11.6$; $p < 0.001$) and Y2 samples ($F = 10.18$; $p < 0.001$), respectively. The general deduction from the nature of the graphs in Figure 3, especially at the 2 cm depth, is that C increased with 5 to 6 years of fallowing and declined by 7 to 8 years of fallowing and increased again towards 10 years of fallowing. Further research should throw light on the effect of location characteristics and management regimes on C and N dynamics in fallow soils.***

**Keywords:** Bush fallow, chronosequence, agroecosystem, ANOVA, pair - wise t test

## 1. Introduction

Soil carbon and nitrogen play vital roles in biogeochemical cycles, especially in maintaining the equilibrium that is required for efficient functional of all ecosystems [1] [2] [3] [4] [5]. The quantity of carbon (and nitrogen) that can be sequestered in soils is of particular interest to environmental scientists, ecologists, economists, and politicians alike [3], [6], as the globe experiences the phenomenon of a changing climate, mainly driven by high levels of green - house gases in the atmosphere, particularly carbondioxide. This has stimulated research on the potential of less known ecosystems like agricultural fallows to store carbon and cycle vital nutrient, if allowed to regenerate to secondary forest vegetation [7] [8] [9]. For example, it is estimated that forests in humid zones in Cameroon lose 220 tons of carbon upon conversion to agriculture, but most stable carbon pool was those contained in soil organic matter [10]. It seems logical, therefore, that bush fallows, which accounts for some of the largest land use in tropical environments, are capable of maintaining a reasonable store of carbon for long periods, thus the need to study and elucidate the soil nutrient status and interactions in such agro - ecosystems.

The replenishment of soil fertility to enhance crop yield is a vital feature of the bush fallow agriculture [11] [12]. wherein soil nutrient is allowed to accumulate over the course of time, resulting mainly from organic matter decomposition and the interactions of soil and/or plant macro - organisms and microorganisms. Conversely, soil carbon and nutrient content usually decline exponentially with long - term low - input cultivation after forest conversion to agriculture [13] [16]. The bush fallow system offers a form of agricultural soil management tool to guard against soil degradation and loss of fertility in the absence of technological inputs in traditional agriculture, especially in developing countries [5]. However, degradation of soil quality through distorted and reduced fallow practices and its effects on the local landscape - specific soil features [15]. tend to question the capacity of the bush fallow systems to sequester carbon and enhance soil condition. However, the varying pressure on land necessitated by irregular shortening or lengthening of bush fallow periods and other degradation - related activities, may rapidly break down the ecological system and have serious implications for soil nutrient availability and agricultural productivity [12] [16].

Agricultural activities primarily affect the topsoil, where much of the soil organic matter is contained. It is estimated that 64% of soil carbon has been found to occur in the top 50 cm [17] and there is a similar and isometric trend in soil carbon to nitrogen content in the topsoil [18] [19]. Invariably, published information on soil nutrient indicated greater variability in soil carbon and nutrient on the first 20 cm, wheremuch of the microbial activities occur [20], [21] [22]. Thus, this study focuses on the dynamics of carbon and


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nitrogen within the first 20cm depth of the soil. With an active 10 - year fallow period, wherein soil carbon and nutrient cycling are studied over a depth of 20cm, the variability within and between specific depths is very important in understanding the relationship between depths and fallow age.

This study has been designed to assess the relative spatial and temporal variation in carbon and nitrogen content in agricultural fallow system over a ten - year pseudo - chronosequence, through a depth of 0 to 20cm. The objectives are: (i) to understand how soil carbon and nitrogen changes with depth in fallow soils; (ii) to establish trends in fallow soil carbon and nitrogen over a defined ten - year chronosequence; (iii) to elucidate some aspects of the spatial dynamics of carbon and nitrogen in fallow soils. The results are expected to contribute to a wider understanding of nutrient dynamics in tropical fallow agricultural soils in relation to the temporal vegetation succession that is characterize by slash - and - burn agriculture in Sierra Leone, West Africa.

## 2. Methodology

### 2.1 Sampling locations and soil associations

The sampling locations were selected in six different parts of the country separated by distance of at least 60 km, in three different soil associations and in accordance with plant sampling sites selection (Figure 1; Table 1). Each site is characterized by a different combination of geographic features and cultural setting of the local people.

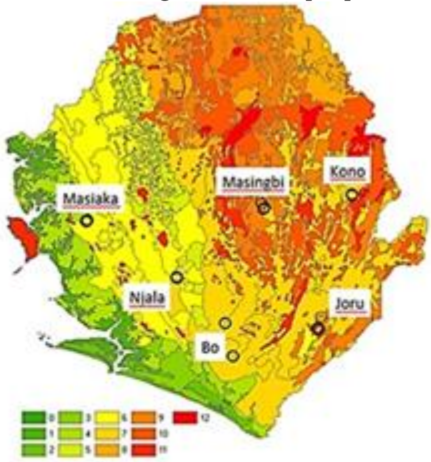


**Figure 1:** Soil map of Sierra Leone showing location of study sites. The number and colour indicate the different soil associations. FAO, 1979

**Table 1:** Edaphic characteristics of study sites. Data source: Birchall et al. (1979)

| Site & Soil Association | Soil depth | Texture | Soil pH (acidity) | Drainage |
|---|---|---|---|---|
| Masiaka (MA) (6) | Moderately shallow | Very gravelly clay to loam | Weak | Good |
| Masingbi (TD) (9 & 10) | Moderately shallow | Very gravelly loam to clay loam | Weak | Good |
| Kono (KD) (7) | Moderately shallow | Gravelly loam and sandy clay loam | Weak | Good |
| Njala (NA) (6) | Moderately deep to deep | Very gravelly loam to clays and sandy clays | Weak | Good |
| Bo - Pujehun (BD) (7) | Moderately deep to deep | Gravelly sandy clay loam to clay | Weak | Good |
| Joru (JA) (7, 9 & 10) | Moderately shallow to deep | Gravelly sandy to clay loams and stony | Strong to weak | Good |

***Sampling design and rationale***

Samples were collected from October to December, a period coinciding with the end of the rains to the start of the dry season and during which farming activities have generally subsided in the country. Sampling was done in two periods, temporally separated by a year's vegetation growth. The first set of samples was collected in 2010 (Year 1 – denoted as Y1) from all plots, aged one to 10 years and the second set was collected from the same plots one year later in 2011 (Year 2 – denoted as Y2), subsequently aged two to 10 years. The sampling procedure ensured that nutrient change over a 10 - year pseudo - chronosequence is obtained and that annual turn - over in nutrient level is also monitored. A total of 540 soil samples was taken from bush fallows one to 10 years old (denoted as 1Y, 2Y, 3Y, 4Y, 5Y, 6Y, 7Y, 8Y, 9Y and 10Y, respectively), from six sites, in the middle to southern section of the country at depths of 0cm, 2cm, 10cm and 20cm. For each selected chronological age of bush fallow, soils were collected from a plot area of between 0.5 ha (50 m x 100 m) and 1.0 ha (100 m x 100 m or equivalent).

In Year 1, a total of 360 soil samples were taken; 180 bulked sample (BS) and 180 non - bulked sample; homogeneity of soil samples was attained through known methods [23]. A homogenized sample of about 150g was taken in each case and stored in a black plastic bag for further laboratory treatment. In Year 2, sampling was focused on bulk samples alone because of the high correlation between bulk and non - homogenized samples in the preliminary analysis, observations consistent with published data [23]. During sampling care was taken to avoid any source of contamination, during collection drying, storage and analysis. For the purpose of this study, about 150 g of each soil sample was 2.0 mm sieved from which only 20 g of a well - mixed sampled was stored for analysis. The Elementor Vario EL and TruSpec CN analyzers were used to analyze the carbon and nitrogen content of the soils, in the first and second year of sampling respectively, in accordance with published procedures [24] [25]. There was a high degree of correlation between the results of the two analyzers, though the process involved were slightly different.

The data was analyzed with the aid of Excel *Analyze*it and R statistical software. As a general rule of thumb in standard statistics, all soil data weresubjected to a test homoscedasticity using the Kolmogorov - Smirnov algorithm [26] and were found to be normal to a greater or lesser extent. Simple regression was used to understand the relationship between carbon, nitrogen, bulk density and litterfall across all sites and between soil associations and fallow ages. ANOVA and pairwise t tests were used to assess the significance of carbon and nutrient content between the different sample locations, soil associations and


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fallow age.

## 3. Results

**Correlation of soil %C to %N at different depths and year of sampling**

The relationship between C and N was consistent at all sampling depths, with very strong correlation ($r^2$ values >0.85) in all cases (Figure 2). The correlation at the 0cm surface level was very strong ($r^2 = 0.9461$), whilst two diverging trends are observed in the strength of the correlation between Y1 and Y2 samples, at 2cm, 10cm and 20cm depths. Whereas the r - squared value increased with increasing depth in Y1, there was reversal of the trend in Y2. In fact, the disparity in the strength of the correlation between Y1 and Y2 samples widened with increasing depth, with differences in r - squared values of 0.009, 0.936, and 0.118 at 2cm, 10cm and 20cm depths, respectively, reflecting the observed trends in the content of the individual elements over the same depths. There was significant difference in %C ($F = 82.68$; $p < 0.001$) and %N ($F = 119.4$; $p < 0.001$) values, respectively, across all sampling depths.

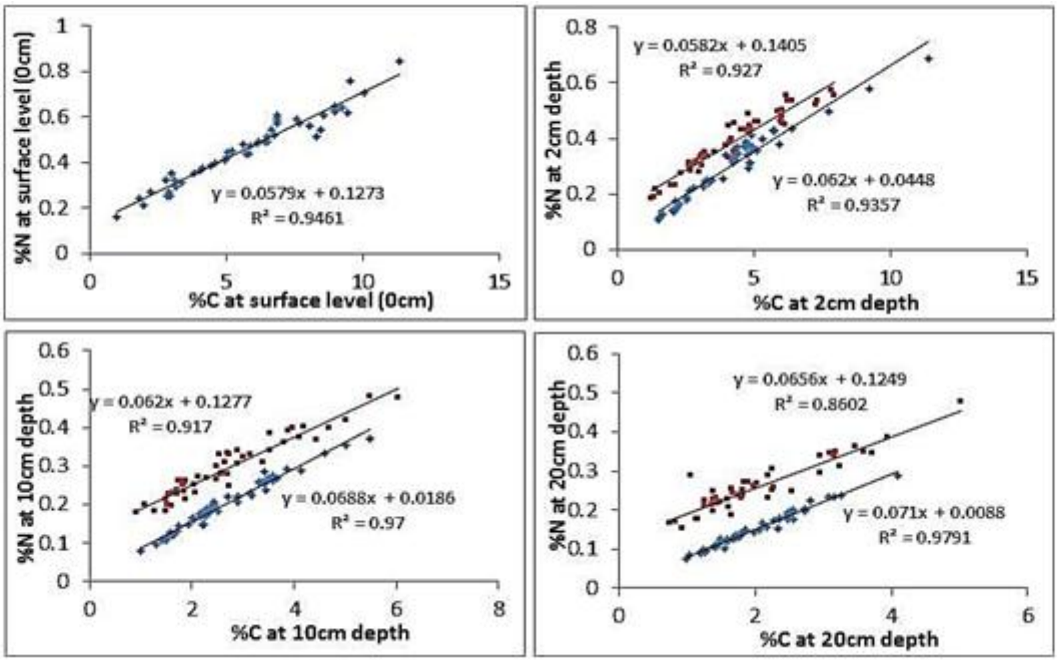


**Figure 2:** Correlation of %C to %N, comparing Y1 samples (blue plots) and Y2 samples (red plots) for each sampling depth. Note that samples were not taken at the surface (0cm) in the first year of sampling

**Changes in soil %C and %N with fallow age and depth of sampling**

Figure 3 shows trends in %C and %N at different depths across the chronosequence. The highest mean percentages at the 2cm depth in the Y1 samples was obtained from 5Y fallows for both C (5.35±3.15) and N (0.36±0.18), whist 9Y fallows accounted for the highest mean percentages for C (5.48±0.94) and N (0.44±0.02) in the Y2 samples. In the 10cm and 20cm depths, the highest mean %C and %N occurred in 5Y and 9Y years' fallows, in the Y1 samples, which is consistent with the observation at 2cm depth. The results only slightly differ in the Y2 samples, where 9Y fallows accounted for the highest mean %C and %N at all three sampling depths. Most sampled plots recorded increases in overall C and N levels between Y1 and Y2, but the levels in 1Y and 5Y years fallows declined. ANOVA tests indicate no significant increase in both %C and %N with fallow age, respectively.

The overall mean %C and mean %N across all depths were higher in Y2 samples compared to Y1 samples, except in 5Y fallows, where a decline was recorded (Figure 4). The highest mean change in %C came from 5Y fallows (3.44±2.39) in Y1 and from 9Y fallows (3.99±1.34) in Y2. Mean overall change in %N was highest for both 5Y (0.245±104) and 6Y (0.245±0.095) fallows in Y1 samples and highest in the 9Y fallows (0.361±0.07) in the Y2 samples.


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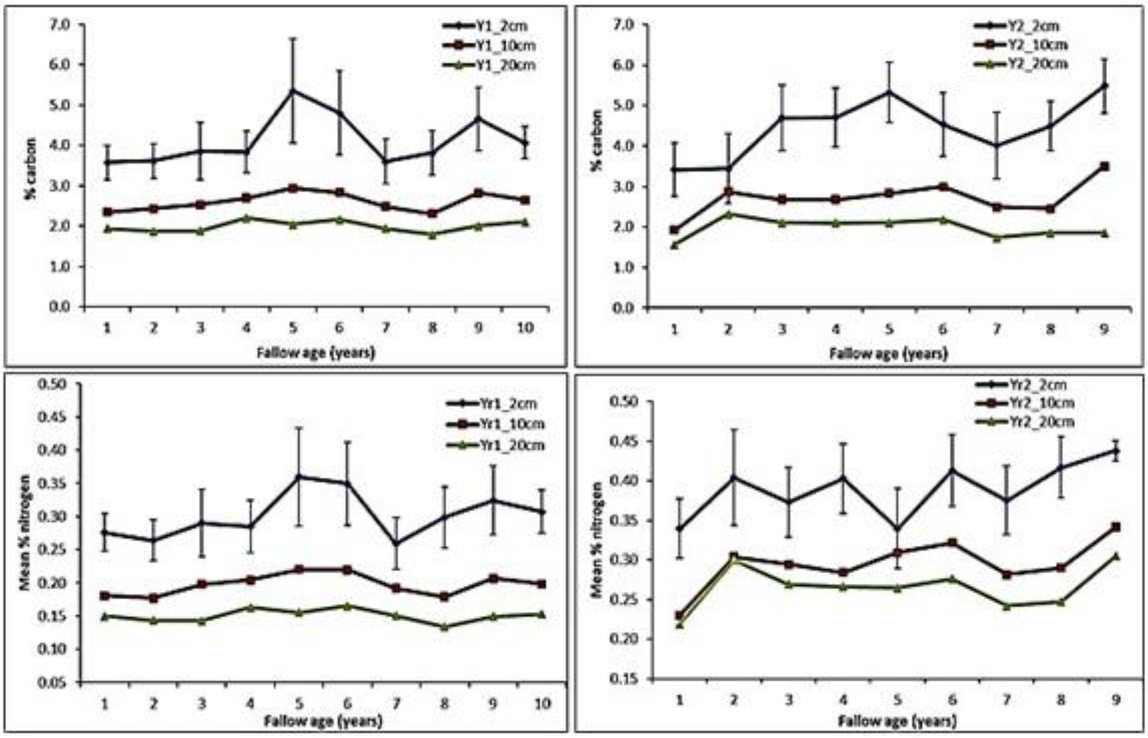


**Figure 3:** Trends in mean %C and mean %N at 2, 10 and 20 cm depth across all sites in (A) 2010 (Y1) and (B) 2011 (Y2). The plots represent the mean %C and %N across all study sites. The respective y - axes have been standardised for easy of comparison

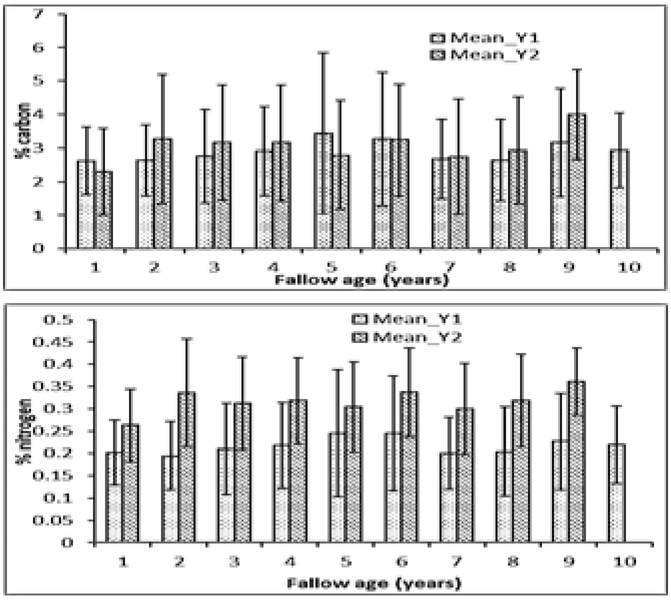


**Figure 4:** Comparison of the trends in overall mean±sd %C (top) and %N (bottom) along the 10 - year chronosequence, between Y1 and Y2 samples. The chart represents the mean %C per depth (2, 10 and 20 cm) across all study sites

**Relative change in %C and %N with fallow age between Y1 and Y2 samples**

Table 2 provide summaries of the statistics of the change that occurred in %C and %N between Y1 sampling) and Y2 based on data from 2cm sampling depth. The overall absolute increase in carbon content across all study sites is estimated at 16.73%. The largest, but negative change in %C occurred in fallow plots that were 5 - 6 years (mean =1.905±3.489), but reasonable increases also occurred on the 2 - 3 years (mean = 1.707±2.142) and 9 - 10 years (mean = 1.337±3.183) fallows, respectively (Figure 4). In all cases, there were individual plots that recorded declines in C, most of which were among the 5 - 6 years plots. The lowest decline occurred in fallows that were 1 - 2 years (mean = 0.165±1.015), and 6 - 7 years (mean =0.363±1.739). As observed in the 5 - 6 years plots, and 6 - 7 years fallows also experienced similar declines in %C even at the individual plots and in consequence, had the largest range (10.014 for 5 - 6 years and 5.326 for 6 - 7 years) of values of C in individual fallow plots between Y1 and Y2 samples.

The overall absolute increase in N at all depth across all plots and sites was 24.22%. Changes in %N content in the chronosequence showed similar trend as in %C, but with a relative decline only among the 5 - 6 years fallows (mean = 0.042 ± 0.215) (Figure 4; Table 2). Mean %N change was


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highest for 2 - 3 years (0.140 ± 0.082) and 9 - 10 years (0.134 ± 0.197) fallows. With the exception of fallows 2 - 3 years and 4 - 5 years, all others recorded declines in %C and %N at one or more of their individual plots, even among the 1 - 2 years plots. A pairwise t test comparing mean change between fallow age between Y1andY2 samples, show varying degrees of significance at plot age for both %C and %N, particularly comparing with 5 - 6 years plots and plots of other ages. However, most of the comparisons among plots of other ages show no significant differences.

**Table 2:** Summary statistics for change in % carbon per fallow age at 2cm depth from 2010 to 2011 across all sites assessed. A one - year fallow plot in Y1 becomes two years in Y2, respectively

| Fallow ages (years) | % Carbon | | | % Nitrogen | | |
|---|---|---|---|---|---|---|
| | Mean | SE | SD | Mean | SE | SD |
| 1 – 2 | - 0.165 | 0.414 | 1.015 | 0.064 | 0.025 | 0.061 |
| 2 – 3 | 1.707 | 0.874 | 2.142 | 0.140 | 0.034 | 0.082 |
| 3 – 4 | 0.839 | 0.556 | 1.363 | 0.083 | 0.051 | 0.125 |
| 4 – 5 | 0.880 | 0.327 | 0.801 | 0.118 | 0.016 | 0.038 |
| 5 – 6 | - 1.905 | 1.428 | 3.498 | - 0.042 | 0.088 | 0.215 |
| 6 – 7 | - 0.363 | 0.710 | 1.739 | 0.021 | 0.042 | 0.103 |
| 7 – 8 | 0.407 | 0.335 | 0.820 | 0.102 | 0.033 | 0.082 |
| 8 – 9 | 0.677 | 0.438 | 1.074 | 0.106 | 0.045 | 0.111 |
| 9 – 10 | 1.337 | 2.251 | 3.183 | 0.134 | 0.140 | 0.197 |

**Estimated absolute and relative change in soil C and N content in relation to study sites**

A comparison of the mean %C and %N at the different sites and soil depths sites is illustrated in Figure 5. Overall mean %C per study site for both sets of samples were highest in MA (12.23±3.96; 12.46±2.71) and lowest in BD (4.94±0.92; 6.34±4.56), respectively. Overall mean %N per site was also highest in MA (0.405±0.144; 0.448±0.112) and lowest in BD (0.154±0.040; 0.234±0.048) in the respective sample sets. The difference in %N between study sites and sampling time is relative more pronounced than that for %C, but the relative site distributions remained unchanged.

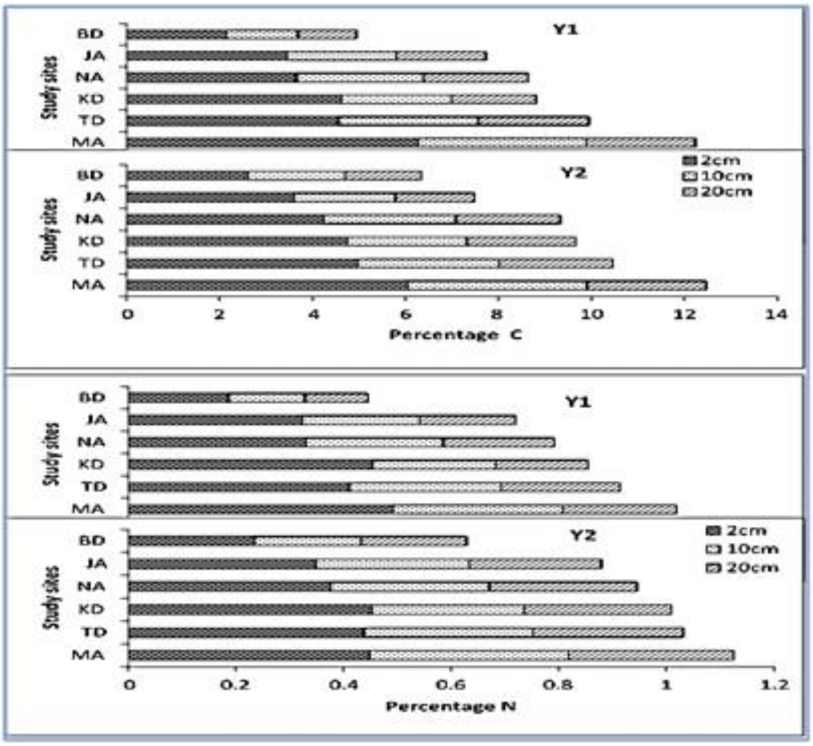


**Figure 5:** Relative distribution of C and N at different depths and at different study sites in the 2010 and 2011 samples. Sites have been arranged in descending order from lowest to highest total range in values among sample depths. Data from 0 cm has been excluded.


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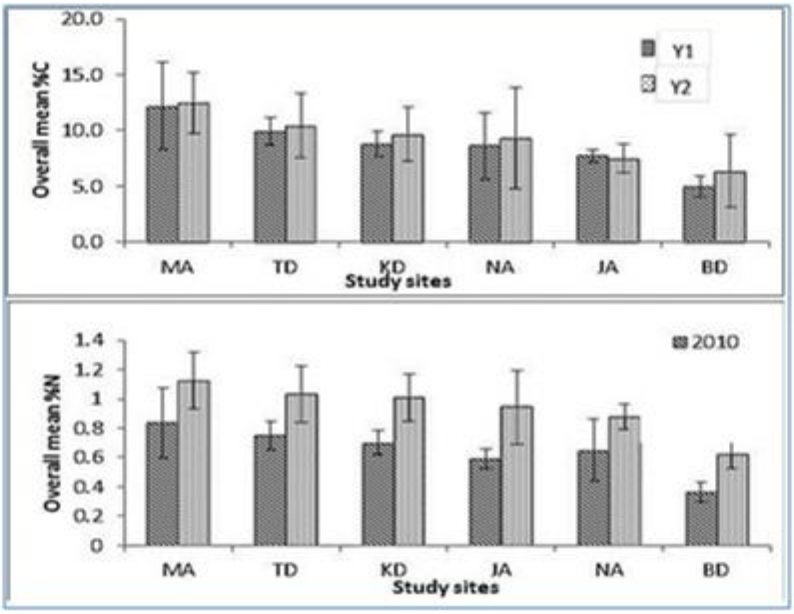


**Figure 6:** Comparison of overall mean %C and %N between sampling sites. Sites have been arranged in order of highest to lowest mean values

As depicted on the graph given in Figure 6, the overall mean change in %C per fallow age across all sites was 0.334±1.95, with the highest mean increase per fallow age (0.698±1.816%) accounted for by NA plots and the lowest (0.093±0.87%) occurring on KD fallows; MA was the only site where an overall decrease occurred ( - 0.194±3.868%). The overall mean change in %N was 0.076±0.12, with the highest mean from NA (0.115±0.093) and the lowest from MA (0.043±0.231). The highest range in absolute percentage change was recorded in MA plots; C change (range = 11.39) and N change (range = 0.356). The results from a one - way ANOVA (Table 3a) indicate a strong significant difference in overall mean %C between the study sites in the Y1 samples ($F = 42.11$; $p <0.001$) and a reasonable significant difference in the Y2 samples ($F = 3.09$; $p < 0.05$). In the case of %N, one - way ANOVA (Table 3b) show very strong significant difference between sites in both Y1 samples ($F = 11.6$; $p < 0.001$) and Y2 samples ($F = 10.18$; $p < 0.001$).

**Table 3:** Result of pairwise t test to compare mean %C, across all depts and between study sites. Order of significant differences at: a – p<0.001; b – p<0.01; c – p<0.05

| **Y1** | BD | JA | KD | MA | NA |
|---|---|---|---|---|---|
| JA | 0.0210$^{c}$ | - | | | |
| KD | <0.0001$^{a}$ | 0.0386$^{c}$ | - | | |
| MA | <0.0001$^{a}$ | 0.0001$^{a}$ | 0.0046$^{b}$ | - | |
| NA | 0.0081$^{b}$ | 0.7102 | 0.0864 | 0.0001$^{a}$ | - |
| TD | <0.0001$^{a}$ | 0.0487$^{c}$ | 0.9181 | 0.1887 | 0.1062 |
| **Y2** | | | | | |
| JA | 0.1938 | - | | | |
| KD | <0.0058$^{b}$ | 0.1302 | - | | |
| MA | <0.0001$^{a}$ | 0.0026$^{b}$ | 0.0891 | - | |
| NA | 0.0327$^{c}$ | 0.4017 | 0.4773 | 0.0191$^{c}$ | - |
| TD | 0.0034$^{b}$ | 0.0826 | 0.7767 | 0.1649 | 0.3321 |

**Table 3 (b):** Result of pairwise t test to compare mean %N across all depths and between study sites. Order of significant differences at: a – p<0.001; b – p<0.01; c – p<0.05

| **Y1** | BD | JA | KD | MA | NA |
|---|---|---|---|---|---|
| JA | 0.0011$^{c}$ | - | | | |
| KD | <0.0001$^{a}$ | 0.0996 | - | | |
| MA | <0.0001$^{a}$ | 0.0004$^{a}$ | 0.0429$^{c}$ | - | |
| NA | <0.0001$^{a}$ | 0.3738 | 0.4395 | 0.0061$^{b}$ | - |
| TD | <0.0001$^{a}$ | 0.0190$^{c}$ | 0.4612 | 0.1887 | 0.1341 |
| **Y2** | | | | | |
| JA | 0.0033$^{b}$ | - | | | |
| KD | <0.0001$^{a}$ | 0.0144$^{c}$ | - | | |
| MA | <0.0001$^{a}$ | 0.0223$^{c}$ | 0.9133 | - | |
| NA | <0.0005$^{a}$ | 0.5846 | 0.4395 | 0.0458$^{c}$ | - |
| TD | <0.0001$^{a}$ | 0.0396$^{c}$ | 0.7174 | 0.8056 | 0.1098 |

Sites - level to plot - level variations were observed in the analysis, some of which are highlighted thus: (i) relatively high levels of C and N in NA on 5Y, 7Y and 10Y fallows in 2011, and the higher levels of C and N for MA and KD on 3Y, 8Y and 9Y fallows; (ii) higher C and N content for TD on 5Y and 6Y fallows in 2011 samples; and (iii) most significantly the big drop in C and N between 2010 and 2011 samples in 5Y fallows.

## 4. Discussion

Studies on carbon and nutrient sequestration are gaining momentum in recent times because of their association with climate change and its attendant effect on vegetation and crop productivity. However, very little published information exists on the implications of the current practice on carbon and nutrient cycling in terms of its input and/or effects due to tillage (slashing and cultivation) in tropical Africa. Empirically, climate, vegetation and geomorphology are factors that have been identified to affect the soil and nutrient cycling, thus justifying the nature of the experimental design. This component of the study was meant to provide an empirical insight to the dynamics of carbon and nitrogen responses to a ten - year bush fallow


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system in Sierra Leone. The study was limited to a ten - year cycle because it constitutes the most active period of fallowing in Sierra Leone. Six study sites were chosen to ensure that the result is applicable to wider geographic coverage in the country, incorporating vegetation and soil variance in the sample collection. Each study site constituted ten original sampling plots aged one to 10 years of fallowing, which is considered a reasonable chronosequence that falls within the active bush fallow system in the country.

Spatio - temporal variations have been observed in several carbon and nutrient related studies, even within small spatial scales [10] [26] [28]. The high degree of correlation between %C and %N in fallow soils at all depths observed in this study has also been empirical demonstrated [7] [29]. The results from this study indicate significant difference in both C and N between fallow ages at 0cm ($F = 12.9$; $p<0.05$), in contrast to the results obtained respectively for 2cm, 10cm and 20 cm depths. Indeed, differences characterise biogeochemical processes at various depths in the soil [7] [28] [29], thus variations occur between surface level and below - ground carbon and that difference becomes more significant with disparity in depth. At the surface, C and N can be lost through erosion and exposure to direct sunlight because of openings created by disturbance events, which may have negative implications for farm productivity, livelihoods, nutrient storage, and sustainability [4] [30].

The general deduction from the nature of the graphs in Figure 3, especially at the 2 cm depth, is that C increased with 5 to 6 years of fallowing and declined by 7 to 8 years of fallowing and increased again towards 10 years of fallowing. The trend in N tend be consistent with that of C in the Y1 samples, but its values in Y2 samples show no particular trend. However, the general observation is that variability in %C and %N tend to dampen with increasing depth of sampling. These observations agree with empirical findings [10] - [26] that %C (implicitly %N) do not increase significantly with time since last cultivation, albeit with greater temporal scales and different socio - ecological settings.

The results of a pair - wise t test of the data summarised in Table 2, indicates that 5 - 6 years fallows were more significantly different from any other fallows, but more similar to 6 - 7 fallows and, younger fallows (1 - 4 years) were more similar to older fallows (7 - 10 years), in terms of C and N changes between Y1 and Y2 samples. This may partly explain the influence of factors such site level differences in edaphic, geomorphic and fallow management regimes on fallow soil C and N content, which is not within the scope of this paper. Soil samples came from six different locations with varying levels of edaphic and geomorphological features and so spatial variances are expected in C and N distribution in the chronosequence. There was greater combined variance in plot - level values for both substances in the 5Y fallows than any other fallow age.

In a study of an agroforestry system in Ghana, a significant increase in soil C was found, but no significant increase in soil N between 2 years and 15 years plot [28]. Invariably, most empirical data are based on larger temporal scales of up to 30 or more years of fallowing, in traditional farming systems; nonetheless, the trends in C and N observed in this study is generally inconsistent with published information. In the 10cm and 20cm depths, the highest mean percentages C and N soil content occurred in 5Y and 9Y years' fallows, in the Y1 samples, which is consistent with the observation at 2cm depth. The results only slightly differ in the Y2 samples, where 9Y fallows accounted for the highest mean %C and %N at all three sampling depths. Most sampled plots recorded increases in overall C and N levels between Year 1 and Year 2, but the levels in 1Y and 5Y years fallows declined.

The data showed a relatively high standard deviations in mean %C compared to mean %N reflecting a higher degree of variation in plot - level C compared to plot - level N across the chronosequence and at different study sites, which may explain their relative responses to fallowing, land use factors and geochemical processes, consistent with findings from previous studies [4] [6] [31]. MA, TD and, to a lesser extent KD, were mainly responsible the observed overall trends; but there were some degrees of consistency in the Y2 samples (Figure 6). The 5Y and 6Y fallows in MA were found to have much higher C (up to 11.4%) and N (up to 0.69%) levels than any other plots in the 2010 samples. There wasalso a greater combined variance in plot - level values for both substances in the 5Y fallows than any other fallow age. The rest of the sites show irregular trends in C and N, but a general feature is the high degree of correlation of the trends in C compared to N between Y1 and Y2 samples.

## 5. Conclusions

The study shows that both C and N contents in agricultural fallow soils were found to be influenced to a more or less extent by depth, age of following and site location. C: N ratio was very strong, across all depths but negatively influenced, apparently by location specific factors, which destabilise the C: N equilibrium in cultivated plots. There was no significant increase in C and N levels across the 10 - year chronosequence, but the general trends show a build - up of C and N from one to five years, a decline between six and eight years, followed by a recovery between eight and 10 years of fallowing. Soil depth had a significant positive influence on C and N content, but the trend was probably affected by locations differences. The results show a very tight correlation between C and N in tropical bush fallow soils, which obviously suggests that the soil samples are probably originating from sites with similar source. The study provides an initial understanding on carbon and nitrogen storage in soils under fallowing in a tropical low - income country, which may have implication for restoration and climate action [13] [32]. Further research should throw light on the effect of location characteristics and management regimes on C and N dynamics in fallow soils.

## 6. Acknowledgement

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