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Impact Assessment of Stand Forest Patches on Soil Characteristics of Ogbunike-Oyi Riparian Forest, Anambra State, Nigeria

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ABSTRACT

The increasing pace of forest fragmentation and the continuous displacement of buffer zones create overtures in the emerging landscape and carbon mitigation capacity. This study investigated 22 forest patches in Ogbunike-Oyi riparian forest across 4 classified vegetation patches - fine, fair-fine, coarse, and high-coarse grain landscapes. Augered soil samples in a randomized complete block experimental design were tested for physicochemical properties, subjected to descriptive statistics, ANOVA, and significant means separated with the Duncan Multiple Range Test at 5% level of significance. Results revealed a particle size distribution with sandy loam soil textural class that varied significantly ($p < 0.05$) across vegetation patches, with high clay (50.03%) > medium silt (24.62%) > low sand (8.33%) coefficients of variation. Organic carbon was medium (CV = 31.20%), and total nitrogen displayed high variability (CV = 81.31%), depicting uneven nitrogen distribution, viz-a-viz vegetation patch diversity. CEC varied widely, with a mean of 8.05 cmol/kg, showing adequate nutrient retention capacity for sustained forest health. Biochemically protected soil organic matter assessments across vegetation patches showed consistently low humic acid of 0.13 (CV = 1.87%) and fulvic acid variability with a mean of 0.06 (CV = 4.90%). The pH varied significantly ($p < 0.05$) in the coarse-grained landscape with the highest pH (6.53) neutral profile, as possible impacts of soil variability on vegetation by disturbances and forest litter qualities, highlighting the need for specialized target conservation, particularly with pioneer species, to foster a gregarious approach among patches.

Keywords: *Forest, Patches, Soil, Disturbances, Physicochemical, Biochemical properties*

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INTRODUCTION

Stand vegetation in riparian forests ecosystem uniquely manage water flux for biosynthesis and transpiration to reduce possible run-offs, leaching and erosion along riverbanks (Zaimes, 2006; Gurnell, 2014; Botero-Acosta, 2017) and thereby conferring transition zone status between the aquatic-terrestrial environments and characterizes a distinct edaphic and soil-related due to the mineral catches in the roots, leaves, and forest soils to dictate periodic flooding, high soil moisture, and nutrient deposits (Li, 2018). These zones support a wide spectrum of biodiversity, providing habitats for various flora and fauna species to thrive and render crucial specialized services, especially at the microclimatic level for humans.

The unique interactions between soil, water, and vegetation create buffer functions that assist aquatic and terrestrial environments to offer vital hydro-biological services in response to water filtration and flood regulation (Krzeminska *et al*, 2019), which shape biodiversity occurrence and stand vegetation structure (Botequim *et al*, 2021). However, the influence of several environmental factors, such as soil composition, moisture, nutrient availability, and flooding regimes (Nguyen *et al.,* 2022), plays a key role in the sustained functioning because soil properties, particularly texture, organic matter content, and pH, are directly related, which affect plants' growth distribution (Xiao *et al*, 2022). It is this complex mosaic of vegetation types that produce varying quantities and variegated litter to interact at upper soil horizons, generating rich components that attract the influx of human activities. Deforestation, agriculture, and selective urban occupation by fragmentation of the vegetation landscape lead to erosion and nutrient depletion. Mason *et al.* (2021) documented critical aspects of ecosystem transformation as crucial edaphic factors in the choice of anthropogenic exploitation of the riparian forest to the detriment of ecosystem functionality.

The litter yield component under varying anthropogenic pressure affects the role of organic matter in compensating forest stand losses by improving soil structure and fostering microbial activity, which contributes to the long-term sustainability of specialized forest ecosystems (Luo *et al*, 2021). Consequently, the contribution of riparian forests to maintaining ecological balance requires typical protection of occurring soil types to sustainably support a variety of plant species and fortify underlying soils (Tanaka & Green, 2023). The degradation of soil characteristics strongly influences the water table seasonal fluctuations and availability of moisture, which invariably affects nutrient cycling throughout the year. Therefore, the edaphic-vegetation relationship is particularly critical in the ability to function as a natural buffer zone, protecting the surrounding areas from soil erosion, nutrient loss, and maintaining water quality.

The vegetation composition of riparian forests often holds special interest in conservation of its respective endemic biodiversity species, which over time influence and enrich the edaphic quality (Njue *et al*, 2016) through abscission, litter, and decomposition rates. Clay-rich soils in lower-lying areas where significant riparian forests occur have been shown to retain more moisture and endemically favour a good number of IUCN Red List-threatened forest tree species compared to more available drier, sandy soils known to support tree species and some grass varieties (Green *et al.,* 2023). In fact, the species varieties and community churn out unique bioproducts that tend to define landscapes along riparian forest tracts. But anthropogenic activities, especially agricultural incursion and logging for timber and fuelwood, unabated, wrong a multiple land-use approach on riparian forest tracts, have reportedly led to soil degradation, increased salinity, and loss of biodiversity (Roberts *et al.,* 2022). These have been largely driven by soil fertility and moisture levels, often sought after during the dry seasons for all-year-round farming. Consequently, the loss of pioneer species in riparian forest tracts continues to redefine the landscape in forest ecosystems, beginning at the pedons and gradually obliteration of the contributing biodiversity. This is because the presence of stand pioneer species allows for the provision of food for frugivores and arboreal folivores while creating perches and other forest component structures to allow for seed dispersers (Lamb *et al*, 1997)

Therefore, human incursion into exploiting these readily available rich natural resources creates disturbances to shred habitat within the riparian forests and poses a multifaceted threat to endemic plant species and wildlife habitat, leading to broad ecological imbalance and the spread of invasive plant species (Aregai, 2019; Zaimes *et al*, 2019) since succession becomes impaired. Several hindrances to natural regeneration and forest succession due to severe threats to biological communities within forest ecosystems have been reported from the destruction of underlying ecosystem engineers (Ren *et al*, 2018; Derakhshan-Babaei *et al*, 2021). The need for an integrated approach that considers both the soil and vegetation aspects of riparian ecosystems in environmental planning (Zhou *et al.,* 2022), particularly where harnessed for tourism and other multiple land-use, has been suggested (Li *et al*, 2022; Wang *et al*, 2024). The objective of the study was therefore to investigate the relative intactness of the riparian forest vegetation on soil within the Ogbunike-Oyi riparian forest, with specific objectives of evaluating the physico-chemical properties of soil in fragmented patches with a view to extrapolating a more sustainable forest management.

MATERIALS AND METHODS

Description of forest study area

This study was conducted in a riparian forest tract at Ogbunike in Oyi Local Government Area, Anambra State, Nigeria as shown in **Figure 1**. The riparian forest falls within the South-eastern geopolitical zone of Nigeria. The forest is in a geographical location, situated approximately 6.2064’ N Latitude and 6.9138’ E Longitude.

The Ogbunike-Oyi riparian forest falls in the southern part of Anambra State, with typically higher rainfall compared to the northern areas that are relatively drier. The average annual rainfall is approximately 1500 - 2000 mm, with the wet season typically from April to March. Temperatures are relatively high throughout the year, with average monthly temperatures ranging from 25 - 30 °C.

The aspect of the riparian forest encompasses hills of varying heights and sizes, but interspersed with valleys and low-lying areas, providing special ecosystem services to endemic wildlife species. These hills and valleys contribute to the overall ruggedness of the terrain, creating a mosaic of microhabitats that support diverse flora and fauna communities, especially the arboreal folivores. The rivers, streams, and wetlands are integral components of the topography that shape hydrological processes while providing habitats for aquatic species.

These terrestrial bodies create zones with distinct vegetation patterns and serve as important corridors for wildlife movement around the Ogbunike Cave, which is a prominent feature. The cave system, with its underground streams and chambers, has been shown to influence local hydrology and provides unique habitats for specialized cave-dwelling species while acting as a tourism facility.

Delineation of forest patches

Four (4) different forest landscape patches were established in the riparian forest based on observable fragmentation in the stand composition per acre. These were Fine-grained (F) - where patches are short distances apart (0.25acre), Fair-fine grain (Ff) with stand patches further apart (0.75acre), but shorter than Coarse-grained (CG) with patches twice apart compared to the High-coarse grain (HC) vegetation where patches are 3 – 4 times apart. Approximately 22 forest patches of 0.25 acres each, comprising 2, 3, 7, and 10 of F, Ff, CG, and HC forest patches, respectively, were delineated and employed in the study as an influence index of anthropogenic activity.

The stream was used as a notable demarcation of the occurring riparian forest into two halves to obtain 60 and 40 % of the 22 forest patches per half. Then, 4 plots measuring 20 m x 20 m each were mapped per half within the occurring fine, fair-fine, coarse, and High-coarse-grained forest patches, respectively.

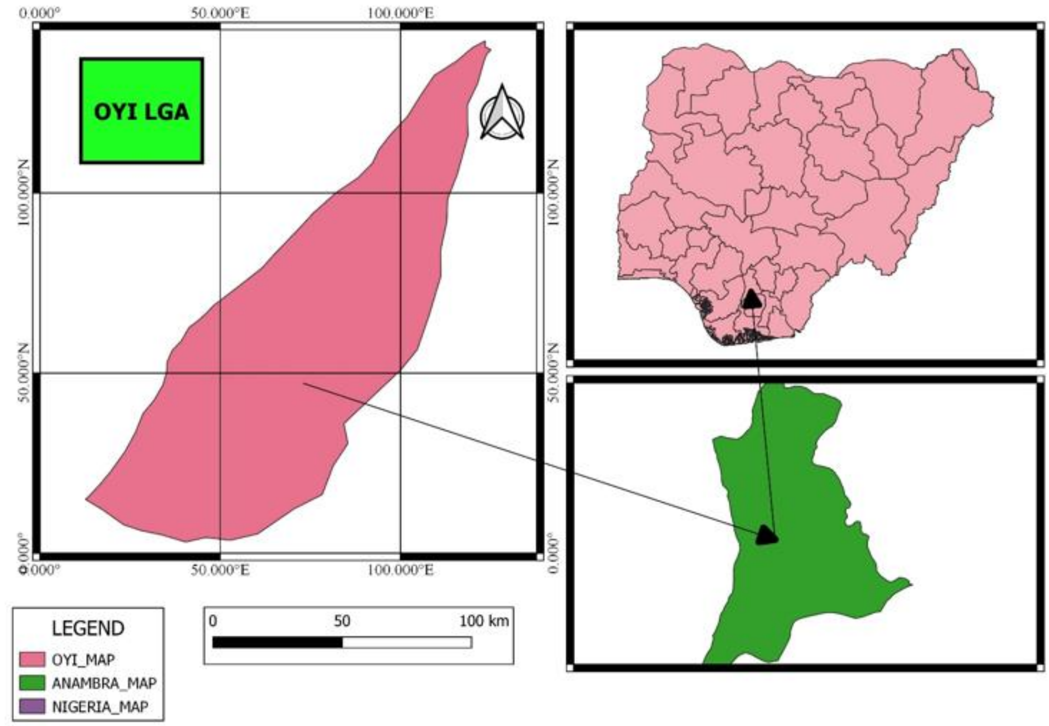

Figure 1. Map of the study area showing Ogbunike in the Oyi Local Government of Anambra State in Nigeria

Soil sampling technique

A transect line was diagonally established in each plot, and five (5) points along the line at 0, 5, 10, 15, and 20 m were marked out. Then, quadrants of 1m x 1m were constructed between 0-5, 5-10, and 10-15m, having one end of the quadrant only on the transect line at an angle of 45 degrees.

Each quadrant was further subdivided with a diagonal line to form two (2) similar triangles, and three (3) soil samples were collected at 20 cm depth with the aid of a soil auger from each quadrant in the four (4) plots of categorized forest patches. Eighteen (18) samples from each side of the stream, comprised of nine (9) samples from each plot, gave a total of 36 soil samples collected at a depth of 0-20cm for the study.

Furthermore, the tree species present in each plot was recorded, the root contents in each soil samples per location was determined, and the various root lengths as well as total root number per location were used as the vegetation extrapolation in the characterization.

Soil sample analysis

The collected soil samples were well labelled and taken to the laboratory for analysis of the following physicochemical properties of particle size distribution, pH, Soil density, Organic matter, Cation Exchange Capacity (CEC), porosity, and moisture content. Particle size Distribution using the hydrometer method as described by Gee and Or (2002), soil pH in water (1:2.5 W/v) by Thomas (1996). Soil organic carbon (SOC) by the wet digestion method (Nelson & Sommers, 1982), and Total Nitrogen (TN) by the Kjeldahl digestion method.

Exchangeable Basic Cations (calcium, magnesium, potassium, and sodium) according to Jackson (1962), Exchangeable acid cations: Hydrogen and Aluminum were estimated titrimetrically, Available phosphorus (Bray & Kurtz, 1945), and Cation Exchange Capacity (CEC) by the 1N ammonium acetate extraction method.

Oxalate was extracted with 10ml 0.2M acidified ammonium oxalate solution, and the extract was determined by AAS (Schwertmann, 1964); Pyrophosphate iron form was extracted with 0.1M sodium pyrophosphate solution according to Mckeaque (1967); and Dithionites were extracted with dithionite-citrate mixture buffered with sodium bicarbonate as described in Mehra and Jackson (1960).

Statistical analysis

Data collected were analyzed with descriptive statistics for measures of central tendency (mean, minimum, and maximum) and dispersion (skewness, kurtosis, standard deviation, coefficient of variability), and analysis of variance, while significant means were separated with Duncan Multiple Range Test at 5% level of probability.

RESULTS AND DISCUSSION

Descriptive statistics of the studied soil physical variables

Table 1 shows the descriptive statistics on soil particle size distribution. Sand content dominates the soil composition, with the mean value of 70.30% indicating a coarse-textured soil that supports rapid drainage with reduced water retention, which is one of the characteristics of riparian zones influenced by alluvial processes, where sand deposition is common due to sediment transport by water flows. The silt content had the least mean (12.02%), which may enhance soil fertility, but, when combined with high sand content with increased anthropogenic activities, could create a less cohesive structure. This may increase susceptibility to erosion in anthropogenically disturbed areas. This finding agrees with Heckward (2021) that disturbances in forest management create loss of soil matters that give birth to sheet erosion due to high percolation from reduced canopy cover.

Coefficient of variation (CV) by ranking, as applied by Shukla *et al.* (2004), ranged from low (<15%) through medium (15-35%) to high (>35%). The clay fraction had a high coefficient of variation (50.3%), which suggests more fluctuation in clay content across patches, with a likelihood of limiting water retention and nutrient storage, to influence vegetation patches, particularly during regeneration for forest restoration. This observation may encourage the application of inorganic fertilizer, where by chance adopted for agricultural practice and thereby leads to more acidic soil with reduced abundance of rhizobacteria for nitrogen efficient replenishment.

Table 1. Descriptive statistics of soil physical variables in disturbed forest

Variabless	Min	Max	Mean	Std. Deviation	Coefficient of Variation	Skewness	Kurtosis
Sand (%)	60.80	80.80	70.30	5.85	8.32	0.24ns	-0.54ns
Silt (%)	6.00	16.10	12.02	2.96	24.62	-0.40ns	-0.03ns
Clay (%)	5.20	29.20	16.03	8.02	50.03	0.17ns	-1.84*

Significant if the absolute value of skewness or kurtosis is ≥ 2X its standard error. The standard error of skewness is $(6/n)^{0.5,}$ while the standard error for kurtosis = $(24/n)^{0.5}$.*Significant; ns: Non-significant

Descriptive statistics for the studied soil chemical variables

The chemical properties are shown in **Table 2**. The coefficient of variation indicates a wide range of CV, with the highest by total nitrogen (TN) as the most variable, suggesting high diversity of nitrogen levels in the soil, probably due to the rich forest structure and interplay with varying decomposition factors instilled by the different forest grain types. This observation aligns with Ellwood *et al.* (2021) that variegated light and environmental components strongly facilitated the variation in decomposition as a result of differential C/N ratios. This is because forest loss and grain decline lead to a commensurate increase in acidity probably due to the decrease in the collective potential to reduce green gap from the lack of secondary pigmented chemicals in the stand.

Soil organic matter (SOM) showed a medium coefficient of variability (32.28%), probably due to the different forest grain types, and justifies the study as a check to further degradation of forest structure. The high variability may also have stemmed from the varieties of forest tree species with different litter yield rates and composition to redefine the quality of matter. This result aligns with Batjes (2014) that a shift in forest land use on a short-term basis could lead to significant alteration in the soil organic matter content, which may likely lead to a decline in bacterial enzymatic activity or population decline from resource competition, as reported in Liu *et al.* (2024).

The coefficient of variation for Phosphorus (P) was high (50.20%) and indicates the expected divergent microbial population as a result of the variable forest patches that are interspaced within the riparian forest. This variability confers a probable high transformative capacity to generate such from the fauna metabolism and phosphatic manures, particularly of avian excrement, between the fine and coarse vegetation patches (Benhmida *et al*., 2024; Pakalapati *et al*., 2024).

The calcium and potassium also displayed notable variability of 49.98% and 40.10 % respectively. The higher variability of calcium may not be unconnected with the dual source, moisture availability, and temperature differences among the forest stand patches. This finding agrees with Wu *et al.* (2021), who showed a significant relationship between calcim and several environmental variables in 27 urban forest patches (Sapunova *et al*., 2023; Khyade *et al*., 2024; Sowbaraniya *et al*., 2024).

Table 2. Descriptive statistics of soil chemical properties in the disturbed forest stand

Variables	Min	Max	Mean	Std Dev	Coefficient of Variation	Skewness	Kurtosis
SOC (%)	0.64	2.17	1.47	0.48	32.65	-0.35ns	-1.00ns
SOM (%)	1.10	3.74	2.54	0.82	32.28	-0.35ns	0.98ns
TEA (cmol/kg)	0.80	1.70	1.25	0.29	23.20	-0.25ns	-0.98ns
Al^{3+}(cmol/kg)	0.45	1.10	0.76	0.20	26.32	-0.00ns	-0.76ns
H^+ (cmol/kg)	0.20	0.70	0.47	0.15	31.92	0.10ns	-0.22ns
TN (%)	0.06	0.92	0.20	0.23	81.31	3.28*	11.10*
Ca^{2+} (cmol/kg)	2.00	8.00	4.03	2.02	5.01	0.95*	-0.20ns
Mg^{2+} (cmol/kg)	1.20	4.00	2.33	0.97	41.63	0.47ns	-1.21*
K^+ (cmol/kg)	0.11	0.42	0.25	0.10	10.25	-0.01ns	-1.38*
Na^+ (cmol/kg)	0.10	0.27	0.19	0.05	26.31	-0.35ns	-0.05ns
CEC (cmol/kg)	4.77	13.83	8.05	3.18	39.50	0.75ns	-0.70ns
BS (%)	76.05	88.40	83.34	3.98	4.78	-0.71ns	-0.43ns
P (mg/kg)	2.47	12.64	7.36	3.69	50.14	0.18ns	-0.16ns
pH $_{CaCl2)}$	3.57	5.45	4.39	0.58	13.21	0.01ns	-0.64ns

Significant if the absolute value of skewness or kurtosis is ≥ 2X its standard error. The standard error of skewness is $(6/n)^{0.5,}$ while the standard error for kurtosis = $(24/n)^{0.5}$.*Significant; ns: Non-significant

Descriptive statistics for the studied soil biochemical variables

The variables of oxalate, humic, and fulvic acid contents are shown in **Table 3**. The coefficient of variation of biochemical variables was low (<15%) as these ranged from 1.82 – 4.90% for the humic acids to fulvic acid, with mean values of 0.16 and 0.06, respectively. The humic acid with the least CV suggests relatively stable humus content across forest patches, probably due to the admissible litter qualities deposited on the top soil. The higher variability in oxalate may not be unconnected with the likely higher variation in decomposition pathways resulting from the grain differentials within as well as between stand forest patches, particularly with respect to non-hydrolysable soil organic carbon and the amorphous (inorganic) form of Fe. Pyrophosphate extractable is the organically-bound form of iron. Dithionite extractable is the total free oxides of iron.

Table 3. Descriptive statistics of soil biochemical properties in disturbed forest patches

Variables	Min	Max	Mean	Std Dev	Coefficient of Variation	Skewness	Kurtosis
Hmic acid	0.16	0.16	0.16	0.29	1.82	0.42ns	-1.53ns
Fulvic acid	0.05	0.06	0.06	0.29	4.90	-0.80*	-1.01ns
Oxalate (Fe_2O_3)	0.07	0.08	0.08	0.18	2.26	-0.57ns	-1.45ns
Dithionite (FeO_3)	0.03	0.03	0.03	0.08	2.83	0.57ns	-1.45ns
Pyrophosphate (Fe_2O_3)	0.06	0.06	0.06	0.16	2.72	-0.11ns	-0.62ns

Significant if the absolute value of skewness or kurtosis is ≥ 2X its standard error. The standard error of skewness is $(6/n)^{0.5,}$ while the standard error for kurtosis = $(24/n)^{0.5}$.*Significant; ns: Non-significant.

Assessment of land use impact on soil particle size distribution

Table 4 shows the effect of land-use impact on soil particle size distribution across four vegetation types. The particle size distribution shows that the soil of the zone was predominantly sandy loam with the highest sand content (74.80 ± 3.01%) recorded in the coarse vegetation type, followed by the fine and fair-fine types (69.47%), while the lowest was in the high-coarse type (67.47 ± 4.81 %). This shows that coarse vegetation patches are dominated by sandy soils, which support rapid drainage but potentially reduce water retention. Silt content was highest (15.37 ± 0.68 %) and was observed in fair-fine vegetation, which significantly differs from other vegetation types. This suggests finer soil textures in these areas, which are more cohesive and have higher fertility, offering better nutrient retention compared to the coarse or high-coarse patches.

The highest clay (18.53 ± 4.67%) in fine vegetation compared to the lowest (3.53 ± 6.77%) recorded in high-coarse vegetation indicates better water retention and nutrient storage suitable capable of vegetation. The result agrees with Roberts *et al.* (2022), which highlighted the detrimental effects of logging and agriculture on tropical riparian soil quality, often leading to sandier soils due to the substantial loss of root-soil intactness and decreased fertility from reduced rhizopheral interaction (Çakar *et al*., 2022).

The coarse vegetation had the highest sand content, which was significantly different ($p < 0.05$) from the others. To a large extent, particle size density can be significantly altered with variation in the vegetation graining pattern. This is as a result of the influence of biota and climate changes within the grain type, which can alter the appreciable temperature and microbial component and bring about breakage in the particle. The coarse vegetation type showed a significant difference in the sand content compared to other grains, probably due to the high unabated exposure to climatic and anthropogenic activities. Unfortunately, the high coarse differed significantly from the progeny coarse vegetation, accounting for a likelihood of apparent geomorphological difference that may have occurred over a period of time. This observation therefore suggests the need to halt and check the changes in particle size distribution occurring from the shift in pristine fine vegetation, because such could become the basis for sheet and then gully erosions.

Table 4. Soil particle size distribution of forest stand patches

Properties	Vegetation grain type			
	Fine	Fair-fine	Coarse	High-coarse
Sand (%)	69.47 ± 3.74^b	69.47 ± 1.33^b	74.80 ± 3.01^a	67.47 ± 4.81^c
Silt (%)	12.00 ± 1.16^b	15.37 ± 0.68^a	12.01 ± 1.15^b	8.70 ± 1.35^c
Clay (%)	18.53 ± 4.76^b	15.20 ± 2.00^c	9.87 ± 3.72^d	20.53 ± 6.77^a

Mean ± standard errors with the same superscripts on the same row are not significantly different ($p > 0.05$)

Assessment of disturbances on soil chemical variables

Table 5 shows the impact of land use on soil chemical properties between four vegetation/grain types (fine, fair-fine, coarse, and high-coarse), showing mean values and standard deviations for each variable by vegetation type. The pH was highest in coarse vegetation (6.53 ± 0.09), indicating a more neutral soil, while other vegetation types showed acidic ranges. This pH variability across vegetation types implicates land use impact and the potential implication of fragmented patches on soil chemistry, which may not be unconnected with the level of deforestation and stands left over to contribute to the nutrient status through the litter supply. This finding agrees with Yale *et al.* (2020), who reported a decrease on the pH scale for tropical soils along forest fringes due to a rapid progression in stand loss per annum.

Organic carbon and matter were not significantly different in the fine and fair-fine forest patches **(Table 5)**. This may be due to the productivity of stand vegetation compared to the coarse and high-coarse patches, which were also not significant ($p > 0.05$).

The pH_{H2O} was significantly different ($p < 0.05$) in all the patches, with coarse and fine grains having the highest and lowest, respectively. The pH_{CaCl2} showed no significant difference ($p > 0.05$) between the fair-fine and coarse-grain, as well as fine and high-coarse-grain vegetations. Total nitrogen showed no significant difference among the fine, coarse, and high-coarse probably due to the compensations presented by the aggregate age of stand patches and species uniformity. This finding is in line with Tu *et al.* (2022) that such ecological attributes contribute to the variation in N-availability, often related to the micro-climatic process within and between patchment forests (Jannath *et al*., 2024).

The CEC differed significantly, with fair fine having the highest, while the coarse vegetation was least. The fine patch was significantly different from all the other vegetation. These differences may not be unconnected with the varying capacities, conferred on the forest patches by anthropogenic activities, to pull water and mineral nutrients from the soil as well as the leftovers in the fallen leaves as litter on the forest floor (Adam, 2024; Garbarova *et al*., 2024; Nguyen Ha *et al*., 2024). This finding concurs with Chen *et al.* (2025) that a higher forest stand density impinges on the soil moisture content, which invariably leads to a decline in CEC due to high rates of evapotranspiration. But the compensation from floor litters assists in managing the loss, particularly before decomposition, even though acting as sponges afterwards for soil moisture retention and control. Furthermore, the range of nutrients and moisture contents may have played better roles under less canopy cover that allowed sunlight penetration in the fair-fine and coarse patches (Febriandika *et al*., 2023; Huyen *et al*., 2023; Keliddar *et al*., 2023; Terela *et al*., 2023; Zoubi *et al*., 2023). This finding corroborates Yang *et al.* (2024) that partitioning of forest soils can be initiated by the influence of canopy and the residual impact of nutrient differentials occasioned by rainfall and the throughfall often defined by the depth of crown cover.

The different vegetation grains play a key role in the carbon dynamics and conservation capacity of the riparian forests as habitats for biodiversity since the various grains provide different levels of habitat capacity for respective endemic species of wildlife. This finding agrees with Balasa *et al.* (2023) who reported that range areas with modified fine grains of a significant number of stands and canopies accounted for higher population density of arboreal frugivores and avian species that mostly colonized patches of coloured foliar and fruits habitats. This may not be unconnected with the characteristics of angiosperms that produce a wide variety of colours and aromas that attract a wide band of wildlife species. Consequently, these seeming oscillation in canopy depth and width form a robust habitat for reduced flight distance as well as height for the security of roosting birds from potential predators and enhanced conservation strategy.

The coarse grain landscape showed porous patches with highly absorbent solar radiation, which gives forest floors in riparian forests better than fine-grained vegetation. This gives birth to wider perching distances that could led to poor energy savings and reduced fat requirements to endanger endemic aboreal wildlife species. Coarse-grain vegetation creates severe opportunities for internal competition among ecosystem resource users and engineers, giving room for predation and attack of any available resource from both ends, which leads to species loss over time.

The presence of these types of vegetation grains in the study area therefore revealed a lot of anthropogenic influences on the earlier even grains and resulting in the middle types as an index of urgent need for intervention in the monitoring and restoration.

Table 5. Soil chemical properties of disturbed forest patches

Soil properties	Vegetation grain type			
	Fine	Fair-fine	Coarse	High-coarse
pH $_{(H2O)}$	4.37 ± 0.15^{cd}	5.80 ± 0.35^{b}	6.53 ± 0.09^{a}	4.67 ± 0.29^{c}
pH $_{(CaCl2)}$	4.40 ± 0.53^{b}	4.47 ± 0.18^{a}	4.77 ± 0.03^{a}	3.93 ± 0.34^{b}
OM (%)	2.94 ± 0.14^{a}	3.01 ± 0.12^{a}	1.44 ± 0.10^{b}	2.74 ± 0.32^{a}
OC (%)	1.70 ± 0.25^{a}	1.74 ± 0.20^{a}	0.83 ± 0.17^{b}	1.59 ± 0.55^{a}
TEA (cmol/kg)	1.18 ± 0.17^{a}	1.47 ± 0.15^{a}	0.93 ± 0.09^{ab}	1.43 ± 0.10^{a}
Al (cmol/kg)	0.72 ± 0.14^{a}	0.78 ± 0.14^{b}	0.63 ± 0.03^{b}	9.33 ± 0.09^{a}
H (cmol/kg)	0.47 ± 0.03^{a}	0.60 ± 0.11^{a}	0.30 ± 0.06^{b}	0.50 ± 0.06^{a}
TN (%)	0.15 ± 0.01^{c}	0.50 ± 0.01^{a}	0.07 ± 0.01^{a}	0.41 ± 0.25^{b}
Ca (cmol/kg)	3.93 ± 0.77^{b}	5.07 ± 1.27^{a}	2.40 ± 0.23^{c}	4.73 ± 1.75^{a}
Mg (cmol/kg)	2.33 ± 0.47^{b}	2.73 ± 0.47^{a}	1.33 ± 0.33^{c}	2.93 ± 0.71^{a}
K (cmol/kg)	0.28 ± 0.06^{a}	0.28 ± 0.08^{a}	0.20 ± 0.05^{b}	0.26 ± 0.07^{a}
Na (cmol/kg)	0.23 ± 0.03^{a}	0.21 ± 0.02^{a}	0.15 ± 0.02^{b}	0.17 ± 0.03^{b}
CEC (cmol/kg)	7.95 ± 1.30^{b}	9.76 ± 1.05^{a}	5.02 ± 0.24^{c}	9.49 ± 2.43^{a}
BS (%)	84.83 ± 1.67^{a}	84.26 ± 1.60^{a}	81.17 ± 2.24^{b}	83.08 ± 3.67^{a}
P (mg/kg)	9.36 ± 1.88^{a}	9.58 ± 1.18^{a}	2.77 ± 0.51^{c}	6.72 ± 2.48^{b}

Mean ± standard errors with the same superscripts on the same row are not significantly different ($p > 0.05$)

CONCLUSION

The study revealed the increasing fragmentation of the Ogbunike-Oyi riparian forest with palpable degradation of the ecosystem and decimation of the habitat for both ecological and environmental services. This underscores the necessity of regeneration with framework species to augment pioneer species, particularly in the coarse and high-coarse forest patches to allow for proximity, enhance ecological and maintain soil quality. Reduction of land use practices is crucial for soil resilience and support of biodiversity in the Ogbunike-Oyi riparian forest, with targeted conservation strategies focusing on sand-dominated and clay-enriched patches essential for ecosystem stability and prevention of soil degradation.

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REFERENCES

Adam, A. (2024). The impact of reward systems: Remuneration on job satisfaction within the hospitality industries in Ghana. *Journal of Organizational Behavior Research, 9*(1), 32–47. doi:10.51847/Zr4PHuhck0

Aregai, A., & Biedemariam, M. (2019). Human pressure and the abrupt changes on the natural environment: The case of Eritrean refugee settlements in the north western Tigray, Ethiopia. *Journal of Arid Environments, 166*, 37–42. doi:10.1016/j.jaridenv.2019.04.012

Balasa, N. K. B., Roquero, J. O., Lidasan, A. K., Casim, L. F., Agduma, A. R., & Tanalgo, K. C. (2023). Fruit color preference of frugivorous birds in an agroecosystem in Southcentral Mindanao, Philippines. *Birds, 4*(2), 190–201. doi:10.3390/birds4020016

Batjes, N. H. (2014). Projected changes in soil organic carbon stocks upon adoption of recommended soil and water conservation practices in the Upper Tana River Catchment, Kenya. *Land Degradation & Development.* doi:10.1002/ldr.2141

Benhmida, S., & Trabelsi, H. (2024). Fatty acid composition in bone fluid from knee osteoarthritis patients. *Journal of Biochemical Technology, 15*(2), 23–26. doi:10.51847/UNhuTqup51

Botequim, B., Bugalho, M. N., Rodrigues, A. R., Marques, S., Marto, M., & Borges, J. G. (2021). Combining tree species composition and understory coverage indicators with optimization techniques to address concerns with landscape-level biodiversity. *Land, 10*, 126. doi:10.3390/land10020126

Botero-Acosta, A., Chua, M. L., Guzman, J. A., Starks, P. J., & Moriasi, D. N. (2017). Riparian erosion vulnerability model based on environmental features. *Journal of Environmental Management, 203*, 592–602.

Bray, R. H., & Kurtz, L. T. (1945). Determination of total, organic, and available forms of phosphorus in soils. *Soil Science, 59*, 39–45.

Çakar, S., Özyer, K., & Azizoğlu, O. (2022). The mediating role of emotional labor in the impact of organizational climate on burnout. *Journal of Organizational Behavior Research, 7*(1), 1–13. doi:10.51847/oKRklsMVyv

Chen, H., Zhang, Z., & Yang, X. (2025). Effects of forest age and stand density on the growth, soil moisture content, and soil carbon content of *Populus simoni* plantations in the sandy area of western Liaoning, Northeast China. *Scientific Reports, 15*, 2499. doi:10.1038/s41598-025-86215-4

Derakhshan-Babaei, F., Nosrati, K., Mirghaed, F. A., & Egli, M. (2021). The interrelation between landform, land-use, erosion, and soil quality in the Kan catchment of the Tehran province, central Iran. *Catena, 204*, 105412.

Ellwood, T., Živković, L. A., Denissenko, P., Abiev, R. S., Rebrov, E. V., & Petkovska, M. (2021). Process intensification in photocatalytic decomposition of formic acid over a TiO_2 catalyst by forced periodic modulation of concentration, temperature, flowrate and light intensity. *Processes, 9*(11), 2046. doi:10.3390/pr9112046

Febriandika, N. R., Hakimi, F., Ashfahany, A. E., & Yayuli, Y. (2023). What drives Muslims' zakat compliance behavior in the profession? Evidence on Indonesia. *Journal of Organizational Behavior Research, 8*(1), 137–157. doi:10.51847/bEOitzpaPj

Garbarova, M., & Vartiak, L. (2024). Support of human entrepreneurial capital in creative industries. *Journal of Organizational Behavior Research, 9*(1), 1–14. doi:10.51847/jl6y7AimXu

Gee, G. W., & Or, D. (2002). Particle size analysis. In J. H. Dane & G. C. Topp (Eds.), *Methods of Soil Analysis, Part 4: Physical Methods* (Vol. 1, pp. 255–295). Soil Science Society of America.

Gurnell, A. (2014). Plants as river system engineers. *Earth Surface Processes and Landforms, 39*, 4–25.

Huyen, N. T., Nghi, P. H., Phuong, Đ. T. L., Trang, T. T. T., & Huyen, L. T. (2023). Public debt and prosperity nexus in Asian countries: Nonlinearity and threshold analysis. *Journal of Organizational Behavior Research, 8*(1), 74–91. doi:10.51847/tw5g65dco8

Jannath, A., Sivapragasam, S., Viswanathan, K., & Sundaram, R. (2024). Intentional replantation with simultaneous periapical surgery: A case report with one year of follow-up. *Annals of Dental Specialty, 12*(3), 23–27. doi:10.51847/JIs54FRstW

Keliddar, I., Dastoorpoor, M., Alaei, R., & Vahidnezhad, F. (2023). The relationship between leadership style and organizational health in educational hospitals. *Journal of Organizational Behavior Research, 8*(1), 92–104. doi:10.51847/HpAKksLryg

Khyade, V. B., Bajolge, R., & Yamanaka, S. (2024). Commercial enzymes for hydrolysates from BSF, *Hermetia illucens* L. *Journal of Biochemical Technology, 15*(2), 1–11. doi:10.51847/0nPMs1qQgU

Krzeminska, D., Kerkhof, T., Skaalsveen, K., & Stolte, J. (2019). Effect of riparian vegetation on stream bank stability in small agricultural catchments. *Catena, 172*, 87–96. doi:10.1016/j.catena.2018.08.014

Lamb, D., Parrotta, J., Keenan, R., & Tucker, N. (1997). Rejoining habitat remnants: Restoring degraded rainforest lands. In W. F. Laurance & R. O. Bierregaard (Eds.), *Tropical Forest Remnants*. University of Chicago Press.

Li, J. F., Tfwala, S. S., & Chen, S. C. (2018). Effects of vegetation density and arrangement on sediment budget in a sediment-laden flow. *Water, 10*, 1412.

Li, Y., Li, Yi, B., Fang, Q., & Wang, Z. Chen. (2022). Impacts of ecological programs on land use and ecosystem services since the 1980s: A case-study of a typical catchment on the Loess Plateau, China. *Land Degradation & Development, 33*(16), 3271–3282. doi:10.1002/ldr.4387

Liu, S. H. (2024). Effects of stand density on soil physicochemical properties and enzyme activities in *Robinia pseudoacacia* plantations in the Loess Hilly-Gully Region. *Research of Soil and Water Conservation.* doi:10.13869/j.cnki.rswc.2024.05.026

Luo, Y., Zhao, X., Li, Y., Liu, X., Wang, L., Wang, X., & Du, Z. (2021). Wind disturbance on litter production affects soil carbon accumulation in degraded sandy grasslands in semi-arid sandy grassland. *Ecological Engineering, 171*, 106373. doi:10.1016/j.ecoleng.2021.106373

Mason, D. L., Green, C. J., & Parker, A. (2021). Soil nutrient dynamics in tropical riparian forests. *Environmental Management, 41*(2), 221–237. doi:10.1038/s41467-021-12345

Mehra, O. P., & Jackson, M. L. (1960). Iron oxide removal from soils and clays by dithionite-citrate system buffered with sodium bicarbonate. *Clays and Clay Minerals, 5*, 317–327.

Nelson, D. W., & Sommers, L. E. (1982). Total carbon, organic carbon, and organic matter. In A. L. Page, R. H. Miller, & D. R. Keeney (Eds.), *Methods of Soil Analysis, Part 2* (pp. 539–579). American Society of Agronomy.

Nguyen Ha, M., Le Thanh, T., & Pham Thi Thanh, V. (2024). Factors affecting retail customers' satisfaction when using M-banking services: Case study at Sacombank – Hanoi Branch. *Journal of Organizational Behavior Research, 9*(1), 48–63. doi:10.51847/YrZHHIko2r

Nguyen, L. T., Zhou, F., & Wang, Y. (2022). Edaphic variability and its role in shaping riparian forest biodiversity. *Tropical Ecosystem Studies, 28*(7), 1123–1145. doi:10.1007/s00572-022-01234

Njue, N., Koech, E., Hitimana, J., & Sirmah, P. (2016). Influence of land use activities on riparian vegetation, soil, and water quality: An indicator of biodiversity loss, South West Mau Forest, Kenya. *Open Journal of Forestry, 6*, 373–385.

Pakalapati, A., Ranganadhareddy, A., & Kumar, N. N. P. (2024). From formation to detection: Understanding monoclonal antibody aggregation through analytical lenses. *Journal of Biochemical Technology, 15*(2), 27–32. doi:10.51847/MgvdN50FBW

Ren, B., Hu, Y., Chen, B., Zhang, Y., Thiele, J., Shi, R., & Bu, R. (2018). Soil pH and plant diversity shape soil bacterial community structure in the active layer across the latitudinal gradients in the continuous permafrost region of Northeastern China. *Scientific Reports, 8*(1), 5619.

Roberts, J. C., Phillips, E. L., & Zhou, L. (2022). Logging and agricultural impacts on riparian soil quality in tropical forests. *Land Use Policy, 19*(2), 351–365. doi:10.1016/j.landuse.2022.35123

Sapunova, D. A., Kachenkova, E. S., & Medvedev, I. N. (2023). The study of gender characteristics of arterial hypertension in the first and second stages. *Journal of Biochemical Technology, 14*(2), 24–31. doi:10.51847/S1aMjIftGe

Schwertmann, U. (1964). The differentiation of iron oxides in soils by photochemical extraction with acid ammonium oxalate. *Zeitschrift für Pflanzenernährung, Düngung, Bodenkunde, 105*, 194–202.

Shukla, M. K., Lal, R., & Ebinger, M. (2004). Principal component analysis for predicting biomass and corn yield under different land uses. *Soil Science, 169*, 215–224.

Sowbaraniya, S. M., & Syam, S. (2024). Genomic libraries – An overview and a narrative review. *Journal of Biochemical Technology, 15*(2), 18–22. doi:10.51847/73VjyOe9IQ

Tanaka, H., & Green, R. J. (2023). Hydrological and edaphic contributions of riparian forests to nutrient cycling. *Global Change Biology, 45*(3), 221–239. doi:10.1016/j.gcb.2023.00123

Terela, H., & Strilets, V. (2023). Supervision and control over compliance with labor law in Ukraine during martial law. *Journal of Organizational Behavior Research, 8*(1), 39–51. doi:10.51847/mEsB03yCM9

Thomas, G. W. (1996). Soil pH, soil acidity. In L. D. Sparks (Ed.), *Methods of soil analysis: Part 3, Chemical methods* (pp. 159–165). SSSA Book Series.

Tu, Y., Wang, A., & Zhu, F. (2022). Trajectories in nitrogen availability during forest secondary succession: Illustrated by foliar 15N. *Ecological Processes, 11*, 31. doi:10.1186/s13717-022-00374-0

Wang, C. X., Fu, X., Zhang, X., Wang, G., Zhang, Z., & Gong, Z. (2024). Modeling soil erosion dynamic processes along hillslopes with vegetation impact across different land uses on the Loess Plateau of China. *Catena, 243*, Article 108202. doi:10.1016/j.catena.2024.108202

Xiao, T., Wang, C., Yuan, X., Tao, L., Li, P., & Deng, W. (2022). Effects of different forest gap ages on soil physical properties and stoichiometric characteristics in *Cryptomeria japonica* plantations (L.f.) D. Don, 1839. *Forests, 13*, 1708. doi:10.3390/f13101708

Yang, J., Wang, A., Shen, L., Dai, G., Liu, Y., Zhang, Y., Fei, W., & Wu, J. (2024). The impact of canopy on nutrient fluxes through rainfall partitioning in a mixed broadleaf and coniferous forest. *Forests, 15*(4), 623. doi:10.3390/f15040623

Zaimes, G. N., Schultz, R. C., & Isenhart, T. M. (2006). Riparian land-uses and precipitation influences on stream bank erosion in central Iowa. *Journal of the American Water Resources Association, 42*, 83–97.

Zaimes, G. N., Tufekcioglu, M., & Schultz, R. C. (2019). Riparian land-use impacts on stream bank and gully erosion in agricultural watersheds: What we have learned. *Water, 11*, 1343. doi:10.3390/w11071343

Zoubi, M. K., Jaradat, H. A., Alqamaz, S., Lababneh, H., Kassawneh, F. Y., & Issa, M. M. (2023). The impact of the Covid-19 pandemic on interior design students' performance in Jordanian universities. *Journal of Organizational Behavior Research, 8*(1), 25–38. doi:10.51847/ZDkJp32geh