Scientific Research Publishing

Natural Resources, 2026, 17(9), 257-279
https://www.scirp.org/journal/nr
ISSN Online: 2158-7086
ISSN Print: 2158-706X

Anthropogenic Impact on Chimpanzees (*Pan troglodytes troglodytes*) Habitat Use: Case Study: Douala-Edea National Park, Littoral-Cameroon

Sime Tchuenche Winny Laeticia[1], Mvo Denis Chuo[1*], Jean Pascal Koh Dimbot[1], Dief Danael Gatchou Koukeu[2], Theodore B. Mayaka[1]

[1]Research Unit of Applied Biology and Ecology, Faculty of Science, University of Dschang, Dschang, Cameroon
[2]Research Unit of Applied Botany Faculty of Science, University of Dschang, Dschang, Cameroon
Email: *mvo235@yahoo.com

How to cite this paper: Winny Laeticia, S.T., Chuo, M.D., Dimbot, J.P.K., Koukeu, D.D.G. and Mayaka, T.B. (2026) Anthropogenic Impact on Chimpanzees (*Pan troglodytes troglodytes*) Habitat Use: Case Study: Douala-Edea National Park, Littoral-Cameroon. *Natural Resources*, **17**, 257-279.
https://doi.org/10.4236/nr.2026.179015

Received: June 30, 2026
Accepted: September 20, 2026
Published: September 23, 2026

Abstract

Anthropogenic activities increasingly threaten the ecological integrity of tropical forests and the survival of great apes. Understanding how these pressures influence chimpanzee (*Pan troglodytes troglodytes*) habitat use is therefore essential for effective conservation planning in coastal Cameroon. This study investigates the impact of human disturbance on chimpanzee habitat use in the Douala-Edéa National Park (DENP). Field surveys were conducted using reconnaissance-transects, during which chimpanzee signs (nests, feeding traces, vocalizations) and anthropogenic indicators (snares, farms, logging, settlements) were systematically recorded and georeferenced. Habitat types were classified according to vegetation structure and canopy cover. Data analysis involved calculating encounter rates of chimpanzee and anthropogenic signs in Microsoft Excel (2013), while Kendall's rank correlation in R (version 4.1.0) was used to assess the relationship between chimpanzee presence indices and altitude gradients. Georeferenced maps were produced using QGIS (version 3.20) and Landsat 8 - 9 OLI/TIRS imagery. Results indicate that chimpanzee signs were more frequent in undisturbed forest patches (liana and primary forests) characterized by high canopy cover and greater food availability. Hunting pressure and habitat fragmentation emerged as the most critical threats, reducing access to key feeding and nesting sites. Although the sample size was relatively small, the findings suggest that human activity intensity negatively influences chimpanzee habitat use. This study provides baseline evidence to inform adaptive management strategies aimed at mitigating anthropogenic impacts, thereby supporting the long-term persistence of chimpanzee populations and the ecosystem services they sustain in Douala-Edéa National Park.

Keywords

Chimpanzees, Anthropogenic Impact, Habitat Preferences, Douala-Edéa National Park, Poaching Pressure, Community-Based Conservation

1. Introduction

Despite the United Nations' Millennium Goal to reduce biodiversity decline by 2010 [1], most indicators of biodiversity status continue to show a decrease, while pressures on habitats have increased [2]. These processes are primarily driven by human poverty and population growth, which together lead to excessive dependence on nature, thereby threatening wildlife [3]. The rapid growth of the human population and the rising per capita energy demand have led to intensified energy development and changes in land use [4]. These transformations mainly affect previously intact ecosystems that shelter endangered species [5]. Human infrastructure, particularly those related to resource extraction and energy development, poses a major threat to animal populations [6]-[7].

Human activities such as deforestation, agricultural expansion, and hunting are the leading drivers of biodiversity loss worldwide [8]. Large mammals, including chimpanzees, have lost over half of their distribution in tropical regions between 1992 and 2015 due to habitat conversion and hunting pressure [9]. Globally, chimpanzees balance resource use with risks in human-dominated landscapes, often foraging near villages when wild fruits are scarce [10]. This habitat loss, caused by deforestation and land conversion, is one of the main drivers of species decline, particularly among primates [11]-[12]. Although some species manage to adapt and survive in landscapes modified by human activities, their long-term viability and adaptability may be compromised due to chronic stress [4]. The habitat quality of the chimpanzee, including the availability of plant-based food and nesting species is crucial for ensuring the long-term survival of this endangered species [10]. Globally, this species is classified as Endangered by the International Union for Conservation of Nature [13] as a result of their significant population declined, primarily due to the loss of their preferred habitats [14].

Across West and Central Africa, chimpanzees inhabit forest-agricultural mosaics, relying on cultivated crops when wild fruits decline [9]. In Guinea (Bissau), chimpanzees prefer mature forests but forage near fields, facing risks of human encounters and vehicle collisions [10]. Human population growth and agricultural expansion increase fragmentation, forcing primates to adapt or face decline. The loss of preferred habitats, which serve as the chimpanzee's main refuge, is particularly critical in tropical regions, where forests are often converted into agricultural lands or exploited for timber [15]. Chimpanzees play a key role in the functioning of forest ecosystems, notably as seed dispersers, thereby promoting forest regeneration [16]. However, African chimpanzee populations are under significant pressure due to the combined effects of rapid urbanization, resource extraction, and subsistence hunting. Central Africa, home to the Central African chimpanzee, has experienced a dramatic loss of forest cover, estimated at over 30% between 2001 and 2018 [17].

In Cameroon, studies in Mount Cameroon National Park show chimpanzees use montane, sub-montane, and lowland forests, but nesting and activity patterns are influenced by vegetation diversity and human disturbance [18]. In North-West Cameroon, chimpanzees select tall primary trees at high elevations to avoid hunters, showing how human activity shapes nesting behavior [19]. Nationally, threats include illegal logging, poaching, and agricultural expansion, which degrade habitats and reduce population viability [20]. The main causes of habitat degradation include slash-and-burn agriculture, commercial logging, and infrastructure development [2]. The country is a biodiversity hotspot, but conservation efforts struggle to align with rapid population growth and economic needs [21]. Despite laws protecting chimpanzees, such as Law No. 94/01 governing forests, wildlife, and fisheries, the enforcement of these regulations remains insufficient, particularly in rural areas (Republic of Cameroon, 1994).

The Douala-Edéa National Park, located in the Littoral region of Cameroon, exemplifies the conservation challenges in a local context [22]. Established in 1932 and officially designated as a National Park in 2018, this site is an area of exceptional ecological richness [23], hosting numerous endemic species, including the chimpanzee [24]. However, recent surveys reveal illegal logging and hunting as dominant anthropogenic activities, alongside habitat degradation and bushmeat trade [25] [26]. Ecosystem services such as fisheries, mangroves, and timber are heavily exploited, creating pressure on wildlife populations, including chimpanzees [27]. Local communities depend on bush-meat and forest products for income, intensifying unsustainable exploitation and threatening species persistence [28].

Anthropogenic pressures increasingly affect chimpanzee habitat use in the study area. Although chimpanzees are among the most ecologically flexible primates, their survival now depends heavily on how they adapt to human disturbances within fragmented habitats. Numerous studies across Central Africa have examined chimpanzee habitat use and population trends [19] [29] [30], but most have focused on relatively undisturbed forest systems. In contrast, coastal ecosystems such as the Douala-Edéa National Park remain poorly studied, particularly with respect to how human activities—including logging, farming, and settlement expansion—shape chimpanzee habitat selection and distribution. Previous research has established general patterns of chimpanzee abundance and distribution [31], yet little is known about how these patterns manifest under varying levels of human disturbance in Cameroon's coastal forests. This gap limits effective management planning in areas where wildlife and human land use overlap. Local dynamics, combined with broader national and global pressures, highlight the urgent need for a deeper understanding of chimpanzee habitat use in such contexts.

The study aimed to assess the relationship between anthropogenic activity intensity and chimpanzee habitat use within the Douala-Edéa National Park. Specifically, it sought to identify which habitat types are most affected by human disturbance and how these impacts influence chimpanzee presence and distribution. It was hypothesized that chimpanzee signs (e.g., nests, vocalizations) would be less frequent in habitats with higher levels of anthropogenic disturbance, reflecting avoidance behavior and reduced habitat suitability in heavily impacted areas. By addressing this gap, the study provides empirical evidence to guide conservation strategies and adaptive management of endangered chimpanzees in coastal Cameroon.

2. Materials and Methods

2.1. Presentation of the Study Area

The Douala-Eéa National Park, formerly known as the Douala-Edéa Wildlife Reserve, is a protected area in Cameroon. It is located in the Littoral region, within the Sanaga Maritime department. Covering an area of approximately 2630 km^2, it stretches along the Atlantic coast south of Douala for about 35 km to the Dipombé River. It is geographically located at 3˚30'00"N, 9˚49'60"E. Tissongo Lake, a lagoon connected to the southern bank of the Sanaga River by a five-kilometer tidal channel, is included in the reserve. This area of state public land, designated for wildlife conservation, encompasses the localities of Mouanko, Edéa, Dizangué, and the Manoka Islands. The park is bordered to the north by the southern suburbs of Douala, to the south by Kribi, and to the west by the Atlantic Ocean [32], as shown in **Figure 1**.

2.2. Data Collection Techniques

Field surveys were conducted between March and June 2024, corresponding to the early rainy season in Littoral Cameroon. Prior to selecting the technique for identifying habitat structures and evaluating the impact of human activities on chimpanzee habitat use, a reconnaissance survey was carried out with the assistance of local hunters identified by village chiefs. This preliminary survey provided information on potential chimpanzee locations within the park. Coordinates of these sites were recorded on data sheets and later imported into Quantum GIS (QGIS). Using a digital map of Douala-Edéa National Park obtained from the Protected Planet database, recce-transect positions were systematically established.

A grid system of 2 km was created across the study zone. Within each grid, a 1 km recce-transect was positioned, spaced 1 km apart, ensuring coverage of different vegetation types (**Figure 2**). Each transect was defined by a starting point (A) and an ending point (B), with a line drawn between them to cut across multiple habitat types. In total, 31 recce-transects were established, representing the diversity of ecosystems within the sampling zone. Coordinates of transects (points A, B, and the transect line) were uploaded into a Garmin 64 GPS to facilitate navigation during fieldwork.

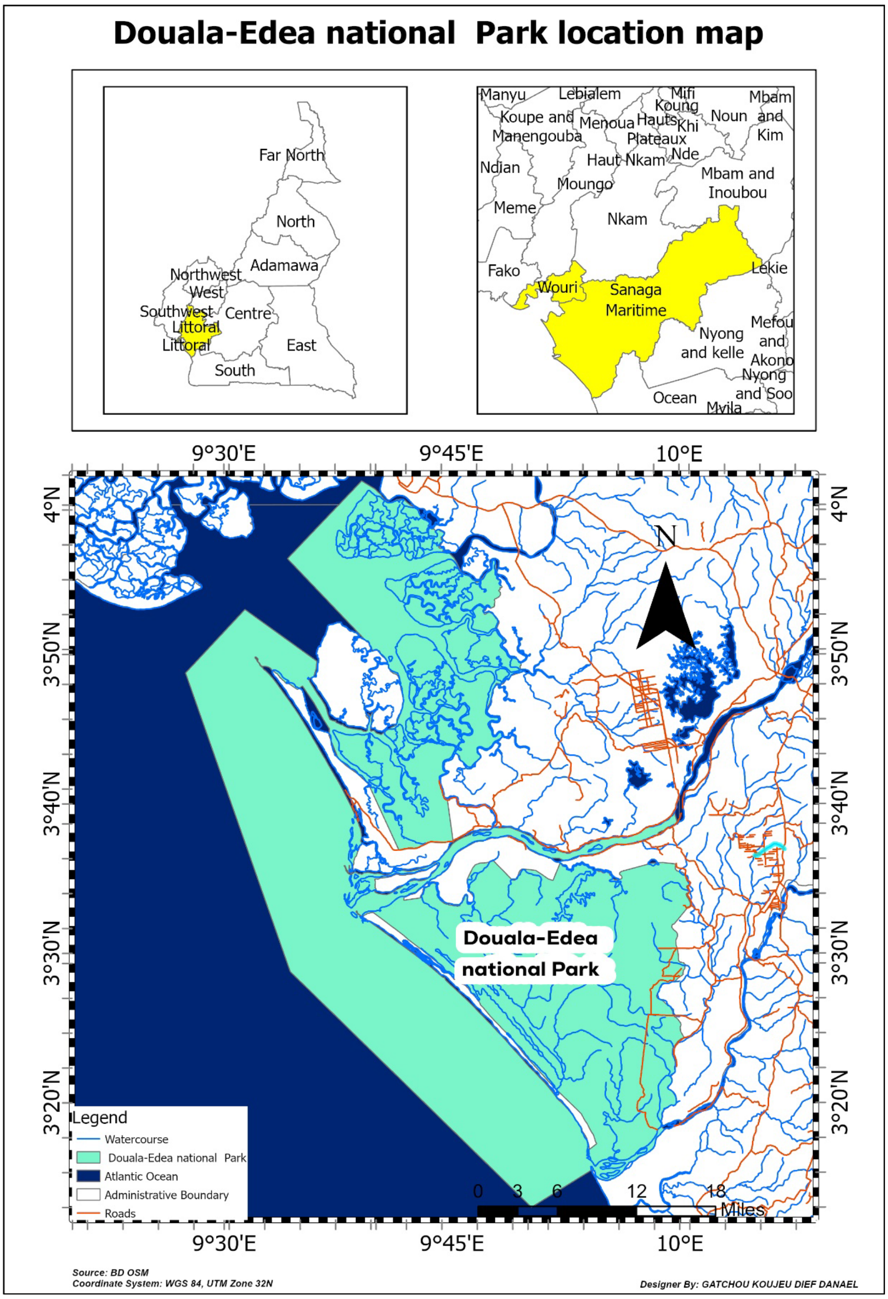

Figure 1. Location map of Douala-Edéa national park.

Detection probability was not formally estimated; however, observer consistency, standardized sign identification, and GPS recording minimized bias. GPS track logs were activated during transect walks to avoid double counting signs, considering that multiple signs could originate from the same individuals.

During the main survey, all 31 recce-transects were systematically traversed once. While transects were designed as straight lines, in practice they were followed opportunistically—using hunter and animal trails where available, or cutting through vegetation with machetes when necessary. This approach ensured coverage of different vegetation types and reduced the risk of double counting.

Data collection began at point A and continued toward point B.

Chimpanzee presence signs included both direct sightings and indirect evidence such as vocalizations, feeding traces (fruit remains, nut-cracking sites), nests (fresh, recent, old, degraded), dung (fresh, recent, old, very old), and tracks. Anthropogenic signs recorded included snares, farms, logging activity, and settlements. All signs were documented opportunistically along transects. The total sampling effort amounted to 31 kilometers, corresponding to the 31 recce-transects surveyed during the rainy season (**Figure 2**).

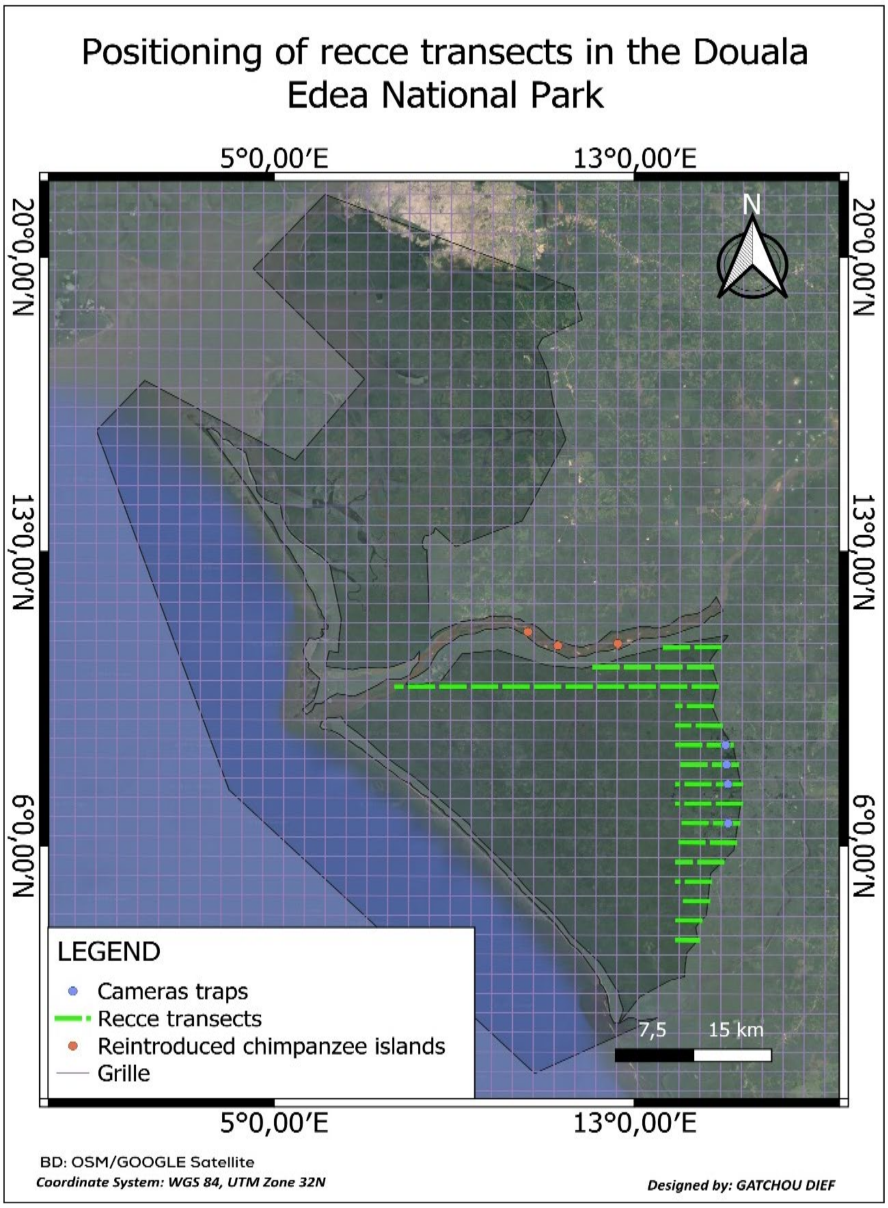

Figure 2. Map showing the data collection zone in the Douala-Edéa National Park.

In the field, each observation—whether a chimpanzee presence sign or an anthropogenic indicator—was systematically assigned to a habitat class and canopy category. Habitat types were classified according to vegetation structure and land use. For example, primary forest was defined as undisturbed, mature forest with a closed canopy; secondary forest as regenerating areas with mixed successional vegetation; farm-forest mosaics as zones where agricultural plots were interspersed with remnant forest patches; and liana forest as areas dominated by vines.

Canopy cover was visually estimated by trained observers within a 20-meter radius of each observation point. Categories included: Closed canopy (>70% cover), Semi-open canopy (40% - 70% cover) and Open canopy (<40% cover). Each observation was georeferenced using GPS coordinates and immediately assigned to the appropriate habitat class based on the dominant vegetation type at the location. This systematic approach ensured consistency across survey teams and minimized observer bias. However, not all quadrates were sampled during field inventory as shown in **Figure 3**.

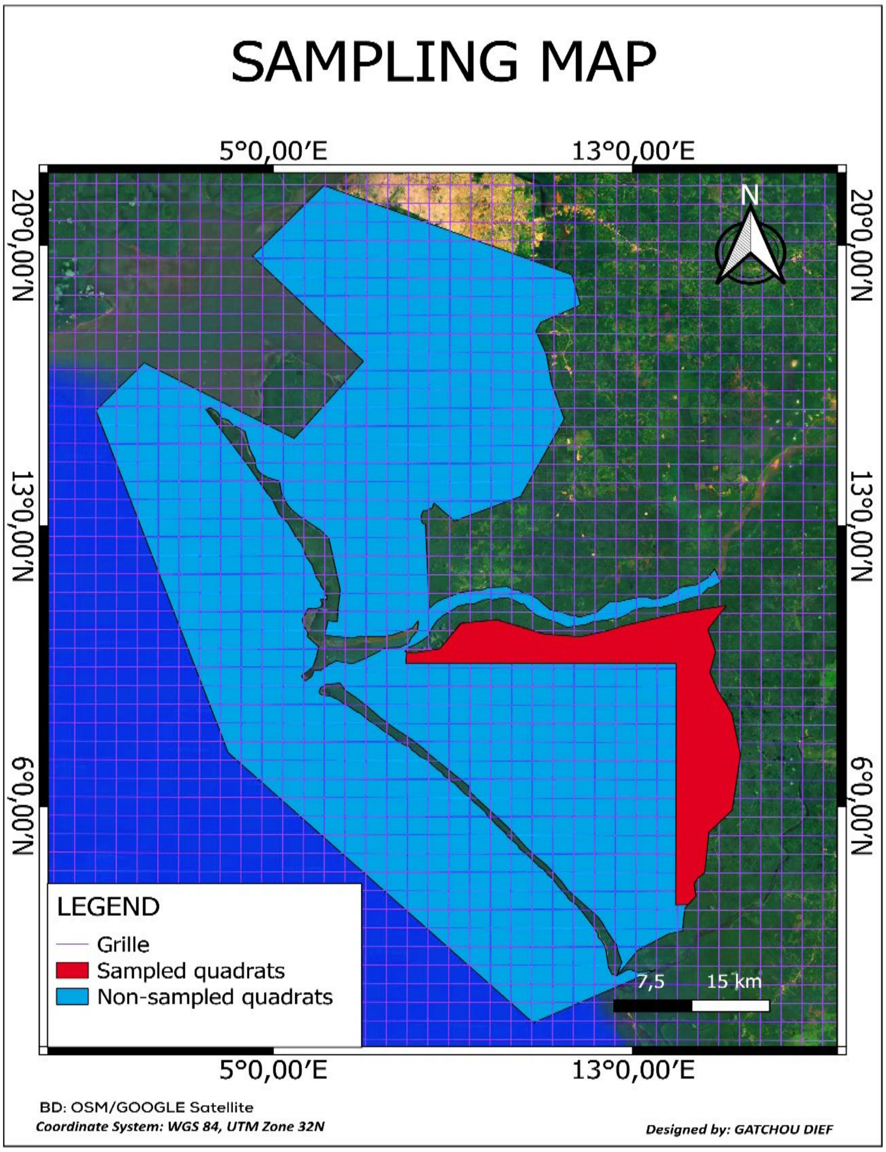

Figure 3. Map showing the sampled and non-sampled quadrats.

Two teams of four people were formed. The principal investigator, equipped with a Garmin 64 GPS (for recording coordinates and following transect lines) and a Xperia XZ3 phone camera (for photographic documentation), was responsible for observing chimpanzee signs and anthropogenic signs and recording data on standardized sheets. An assistant carried a 12 × 42 binocular (for distant observations) and a compass (for orientation), and assisted in identifying signs. A local guide carried a machete to clear difficult paths and helped identify chimpanzee traces. A porter transported materials and food supplies and also contributed to animal identification. Chimpanzee signs were recorded through both direct and indirect observations, including nests, droppings, vocalizations, food remains, tools, and footprints. Signs of anthropogenic activities such as traps, tree stumps, cultivated fields, fishing nets, hunter camps, charcoal production sites, and other tools—were also documented along transects. Surveys were conducted during peak activity hours, between 6:00 - 10:00 am and 3:00 - 5:00 pm and each recce-transects was walked for approximately one hour.

2.3. Data Analysis

Data analysis began with decoding the information recorded on field data sheets and GPS devices into a computer. Field data were first entered into Microsoft Excel 2013 and subsequently imported into R software (version 4.1.0) [33] for statistical analyses. Results were generated in the form of figures, curves, frequencies, and percentages.

Encounter rates (signs per kilometer) were calculated as the number of biological or anthropogenic indices divided by the total survey distance (31 km), representing the sampling effort. Statistical significance was set at a 5% probability threshold for all analyses.

Kendall's rank correlation test was applied to assess the relationship between chimpanzee presence indices and altitude gradients. Kendall's tau was selected because it is a non-parametric test suitable for ordinal data and small sample sizes, allowing robust assessment of monotonic relationships.

Habitat use analysis was based on the relative frequency of chimpanzee signs per habitat type, standardized by survey effort. The relationship between chimpanzee signs (dependent variable: occurrence, presence/absence, or counts) and anthropogenic signs (independent variable: intensity, measured as the number of human activity indicators per sampling unit) was assessed descriptively.

For cartographic outputs, coordinates of biological and anthropogenic indices recorded with a Garmin 64 GPS were exported into QGIS 3.20. This facilitated the production of maps, including the study area map, sampling map, spatial distribution of chimpanzee indices, and anthropogenic activity maps. To determine chimpanzee habitat types, Landsat 8 - 9 OLI/TIRS satellite imagery (November 2021) was downloaded from the USGS Earth Explorer (https://earthexplorer.usgs.gov/). The imagery was processed in ENVI 4.5 using an unsupervised classification strategy, grouping land use into three classes. Outputs from the classification were later integrated in QGIS to generate the final land cover map.

3. Results

3.1. Habitat Structures and Compositions Influencing Chimpanzee Habitat Preferences

This section presents the habitat structures and compositions preferred by chimpanzees, including encounter rates of biological signs, canopy cover, slope, and the different habitat types observed.

3.1.1. Encounter Rates of Chimpanzee Biological Signs

During the surveys, a variety of biological signs of chimpanzees were identified, including nests, feces, vocalizations, tools, footprints, and food remains. The percentages and encounter rates of these signs were estimated. Table 1 summarizes the encounter rates of chimpanzee biological signs recorded in the study area. The results show that nests were the most frequently observed indicator, with an encounter rate of 0.87 signs/km (n = 27). In contrast, tools (0.06 sign/km; n = 2) and vocalizations (0.06 sign/km; n = 2) were the least represented.

Table 1. Encounter rates of chimpanzee biological signs.

Biological Indices	Frequency	Percentage(%)	ERC (sign/km)
Nest	27	58	0.87
Droppings	3	6	0.09
Vocalisation	2	4	0.06
Leftover food	8	17	0.25
Tools	2	4	0.06
Footprint	5	11	0.16
Total	47	100%	1.52

Legend: ERC: Encounter Rate of Chimpanzee, sign/km: sign per kilometer.

3.1.2. Encounter Rates of Nests Based on Age

The nests encountered during the survey were categorized into four age classes: fresh nests, recent nests, old nests, and degraded nests. Table 2 presents the encounter rates of these nest types. The results indicate that degraded nests were the most frequently observed, with an encounter rate of 0.38 sign/km (n = 12), whereas fresh nests were the least observed, with an encounter rate of 0.06 sign/km (n = 2) in the study area.

Table 2. Encounter rates of nests based on age in the study area.

Type of nests	Age of nests	Nomber found	(%)	TDC	ERC sign/km
Tree nests	Fresh nests	2	7	31	0.06
	Recent nests	8	30	31	0.25
	Old nests	5	19	31	0.16
	Degraded nests	12	44	31	0.38
Total	/	27	100%	/	0.87

Legend: ERC: Encounter Rate of Chimpanzee, (%): Percentage, TDC: Total Distance Cover.

3.1.3. Types of Habitats and Altitudes Identified in the Study Area

The chimpanzee signs recorded during the surveys made it possible to distinguish between different habitat types and the altitudes preferred by chimpanzees. Table 3 presents the percentage of observations across habitat types and the average estimated altitudes in the study area. Results show that liana forests (0.32 sign/km) and primary forests (0.25 sign/km) had the highest encounter rates of chimpanzee signs, with average altitudes of 42 m and 54 m, respectively. However, leftover food (8 indices) and footprint (indices) were not included in this table since they could not be specifically be distinguish from other primates sharing the same habitats.

Table 3. Average altitudes and chimpanzee encounter rates by habitat type.

Habitat types	NOH	PH (%)	AA (m)	NCSI	PCS (%)	ERC/31 sign/km
Liana forest	7	16	42	10	29	0.32
Primary forest	9	20	54	8	23	0.25
Secondary forest	7	16	39	2	6	0.06
Woody forest	5	11	33	5	15	0.16
Swamp forest	2	5	15	2	6	0.06
Raphia swamp	2	4	28	2	6	0.06
Farms	6	13	24	0	0	0
River	2	4	12	2	6	0.06
Stream	4	9	12	3	9	0.09
Ravine	1	2	9	0	0	0
Total	45	100%	/	34	100%	1.06

Legend: Number of Observations per Habitat (NOH), Percentage of Habitats (PH), Average Altitudes (AA), Number of Chimpanzee Signs Identified (NCSI), Percentage of Chimpanzee Signs (PCS), and Encounter Rate of Chimpanzee (ERC).

Statistical analysis revealed a significant association between the altitudinal gradient and the probability of encountering chimpanzee presence signs. The number of presence signs increased with altitude **(**Kendall's tau = 0.51, p = 0.04**)**, as illustrated in Figure 4**.**

3.1.4. Vegetation Cover in the Study Area

The frequencies of different canopy types were determined based on biological and anthropogenic signs recorded in each habitat type. Table 4 presents the percentages of canopy types by habitat. Results indicate that closed canopies were most common in liana forests (20%) and primary forests (12%). Sparse canopies occurred across nearly all habitats, but their percentages were very low in rivers (2%), swamps (5%), farms (5%), and secondary forests (5%). In contrast, open canopies were most prevalent in farms (21%), secondary forests (19%), and rivers (16%), while they were less frequent in primary forests and completely absent in liana forests (0%).

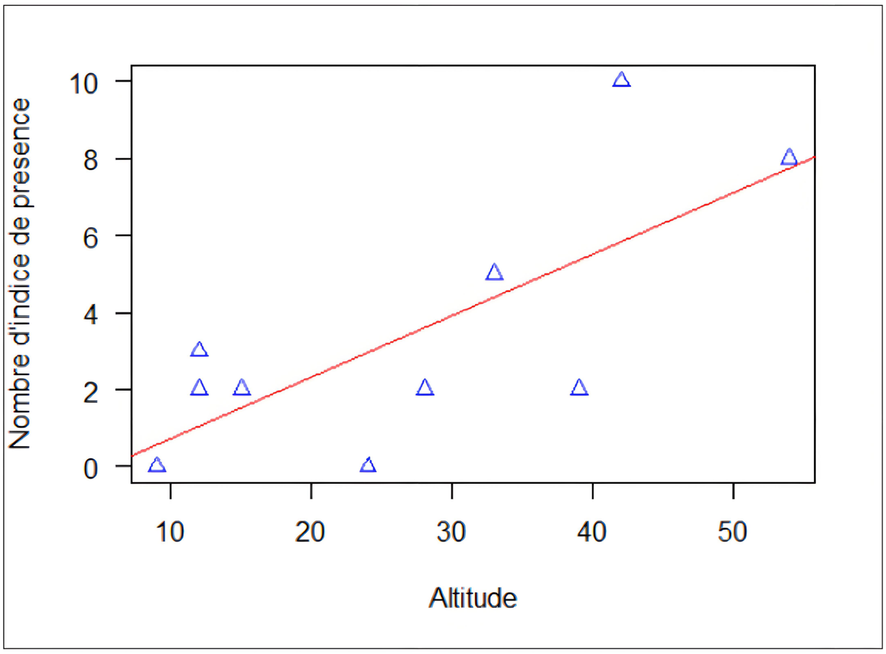

Figure 4. Significant association between the altitudinal gradient and the probability of encountering chimpanzee presence signs.

Table 4. Distribution of canopy types by habitat.

Habitat Types	FCC	(%)	FSC	(%)	FOC	(%)
Liana Forest	8	20	8	14	0	0
Primary Forest	12	30	7	12	2	2
Secondary Forest	0	0	3	5	15	19
Woody Forest	8	20	7	12	3	4
Swamp Forest	5	12	12	21	6	7
Raphia swamp	2	5	6	10	6	8
Farms	2	5	5	9	17	21
River	0	0	1	2	13	16
Stream	1	3	3	5	10	13
Ravine	2	5	6	10	8	10
Total	40	100%	58	100%	80	100%

Legend: FCC: Frequency of Closed Canopies, (%): Percentage, FSC: Frequency of Sparse Canopies, FOC: Frequency of Open Canopies.

3.1.5. Spatial Distribution of Chimpanzee Signs in the Study Area

The coordinates of chimpanzee signs were imported into QGIS to produce a spatial distribution map (**Figure 5**). This map illustrates the distribution of chimpanzee presence across the study area. Using compass orientation, it was observed that the northern, northwestern, and southern sectors of the sampled area showed no evidence of chimpanzee presence. In contrast, the northeastern and southeastern sectors contained only a few observations. The eastern sector, together with several islands where chimpanzees have been reintroduced, recorded the highest concentration of signs, indicating localized habitat use and preference.

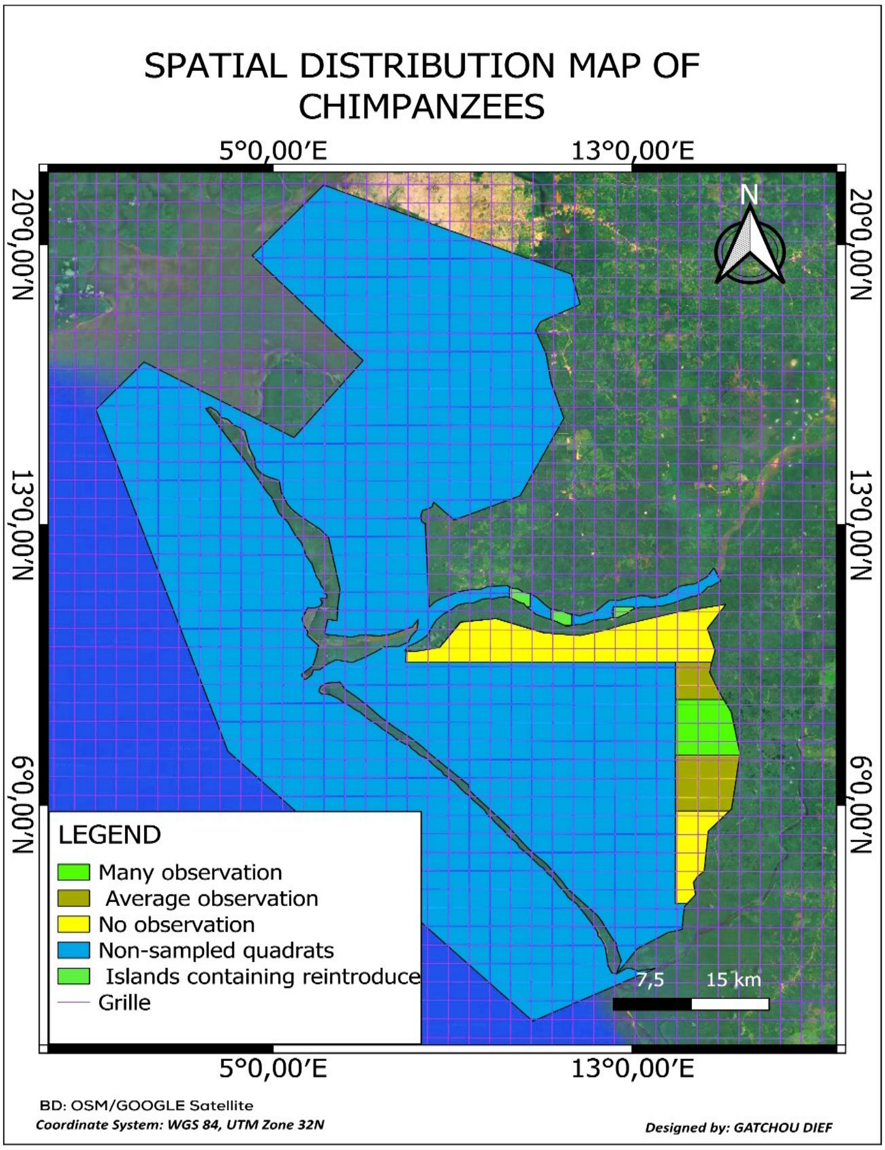

Figure 5. Map of spatial distribution of chimpanzee in Douala-Edéa national park.

3.1.6. Representation of Vegetation Cover and Land Use Map

A vegetation cover and land use map was developed to identify potential locations of chimpanzee-preferred habitats within the study area (**Figure 6**). This map was generated using Landsat 8 - 9 OLI/TIRS satellite imagery (November 2021) to classify land cover and land use. The results indicate that the study area is predominantly composed of primary forest, which surrounds the liana forests—the habitats most strongly preferred by chimpanzees. These areas represent the most critical zones for targeted conservation efforts, as they provide essential ecological conditions for chimpanzee survival and habitat use.

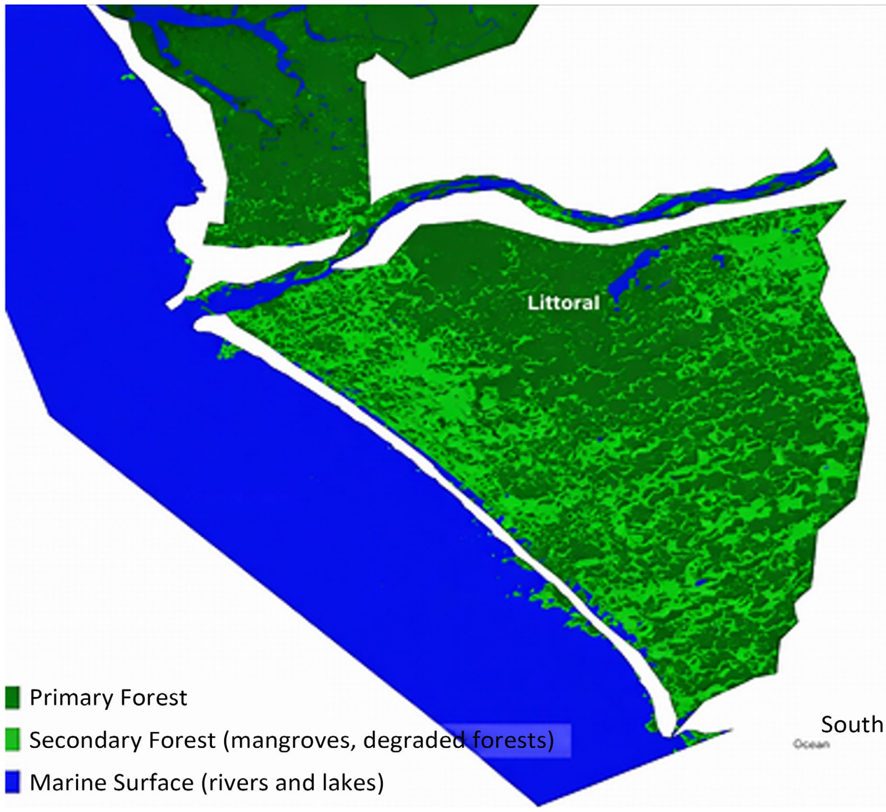

Figure 6. Vegetation cover and land use map of Douala-Edéa national park.

3.2. Impact of Human Activities on the Preferred Habitats of Chimpanzees

3.2.1. Encounter Rates of Anthropogenic Signs

Within study area, several anthropogenic signs were recorded, including illegal hunting (poaching), deforestation, and agricultural expansion (Table 5). The data indicate that hunting was the most prevalent activity, with an encounter rate of 3.7 sign/km (N = 115). This was followed by deforestation, which had an encounter rate of 2.06 sign/km (N = 64). The least observed activity was the use of fishing net, with an encounter rate of 0.06 signs/km (N = 2).

Table 5. Encounter rates of anthropogenic signs in the study area.

AA	Index type	Frequency	(%)	TRA/sign/km
Hunting	Catridge case	27	10	0.87
	Traps	82	30	2.64
	Hunting Huts	6	2	0.19
Culture	Farms	17	6	0.54
	Tree trunk	40	14	1.29
Deforestation	Wood color camp	5	2	0.16
	Chainsaw noise	14	5	0.45
	Charcoal production camp	5	2	0.16

Continued

Fishing net	Net	2	1	0.06
Cutting trace	Cutting trace	56	20	1.80
Human track	Human tracks	18	6	0.58
Tools	Tools	6	2	0.19
Total		278	100%	8.35

Legend: AA: Anthropogenic Activities, TRA: Encounter Rate of Anthropogenic Signs, %: Percentage.

3.2.2. Habitat Types Based on the Number of Encountered Anthropogenic Signs

The anthropogenic activities recorded during the surveys allowed for differentiation among the various habitat types. **Table 6** shows that the highest encounter rate of anthropogenic activities occurred in secondary forests (3.29 sign/km; N = 102), followed by wooded forests (0.93 sign/km; N = 29) and fields (0.90 sign/km; N = 28). In contrast, encounter rates were very low in primary forests (0.32 sign/km; N = 10) and ravines (0.16 sign/km; N = 5).

Table 6. Habitat types based on anthropogenic activity signs.

Habitat types	NOH	PH	AS	PAS (%)	ERAS/31 sign/km
Liana forest	7	16	20	7	0.64
Primary forest	9	20	10	4	0.32
Secondary forest	7	16	102	39	3.29
Woody forest	5	11	29	11	0.93
Swamp forest	2	5	10	4	0.32
Raphia swamp	2	4	31	12	1
Farms	6	13	28	11	0.90
River	2	4	15	6	0.48
Stream	4	9	10	4	0.32
Ravine	1	2	5	2	0.16
Total	45	100%	258	100%	8.36

Legend: Number of Observations per Habitat (NOH), Percentage of Habitats (PH), Anthropogenic Signs (AS), Percentage of Anthropogenic Signs (PAS), Encounter Rate of Anthropogenic Signs (ERAS) signs/km.

3.2.3. Spatial Distribution of Anthropogenic Activities

The coordinates of anthropogenic signs were imported into QGIS to generate a spatial distribution map (**Figure 7**). This map illustrates the extent and location of human activities within the study area. Compass orientation revealed that the northern, northwestern, and southern sectors of the sampled area exhibited the highest levels of anthropogenic activity. The northeastern and southeastern sectors showed moderate levels, while the eastern sector recorded low levels of activity.

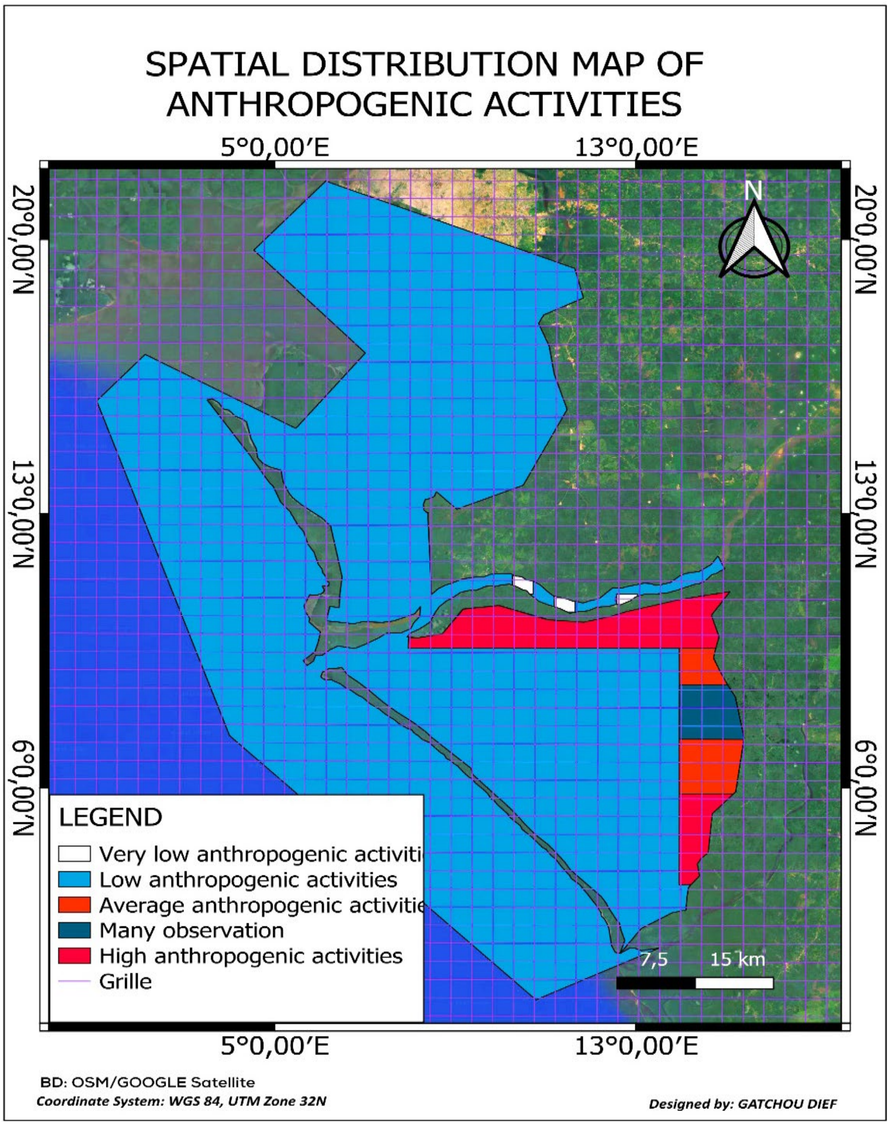

Figure 7. Map of spatial distribution of anthropogenic activities in douala-edéa national park.

3.2.4. Influence of Anthropogenic Activities on Chimpanzee Signs Based on Their Preferred Habitats

During the ecological surveys, six types of chimpanzee presence signs were identified: food remains, vocalizations, footprints, tools, dropping and nests. The number of these presence signs (encounter rates) varied across habitat types. The highest encounter rates were recorded in the liana forest (N = 10) and primary forest (N = 8). In contrast, the lowest rates were observed in riparian zones, swamp forests, secondary forests, and raffia forests, while no presence signs were recorded in ravines. The greater number of presence signs in liana and primary forests may be attributed to the lower intensity of anthropogenic activities in these habitats, as illustrated in **Figure 8**. Conversely, the secondary forest, which exhibited the highest encounter rate of anthropogenic activities, showed relatively low numbers of chimpanzee presence signs (**Figure 8**).

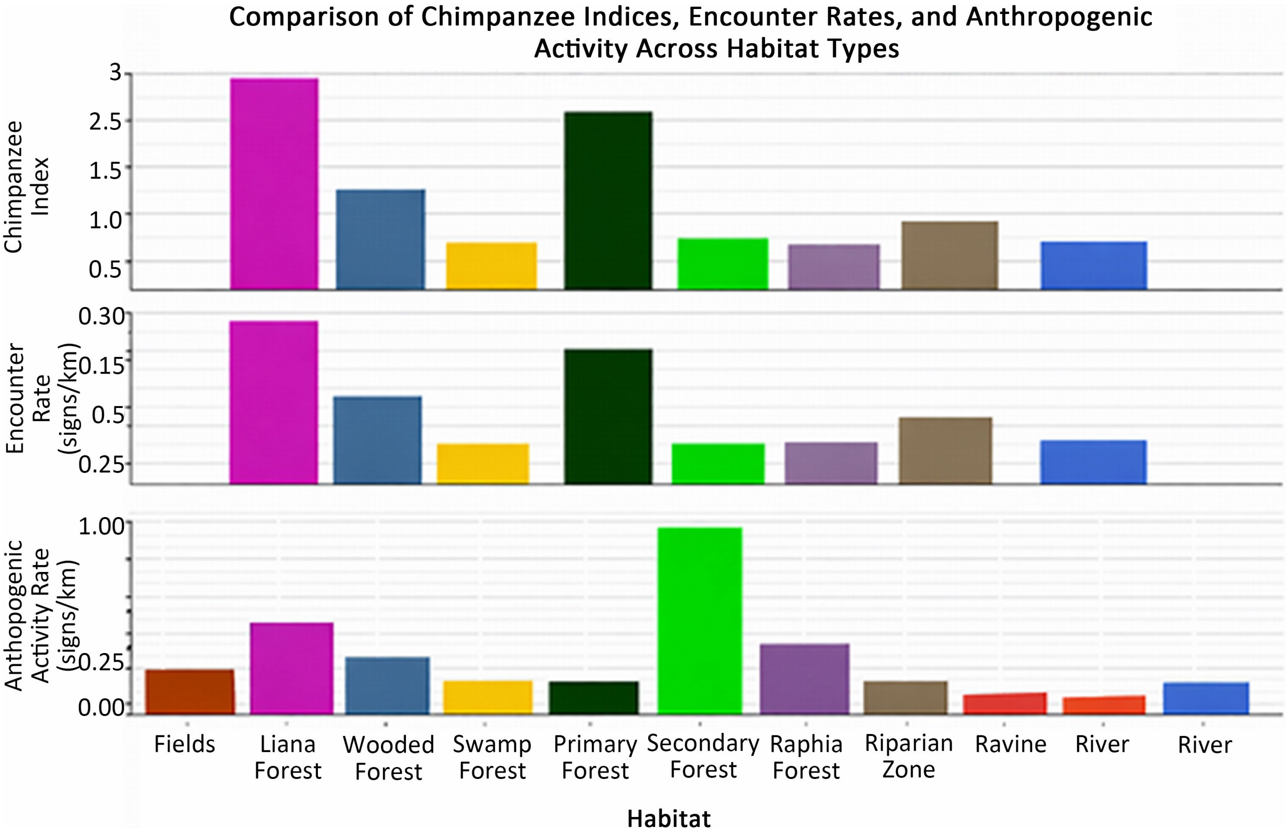

Figure 8. Influence of anthropogenic activities on chimpanzee signs across habitat types.

4. Discussion

4.1. Habitat Structures and Preferences

Chimpanzee presence in Douala-Edéa National Park was highest in liana and primary forests, this because these forests may provide abundant fruiting trees, nesting opportunities, and structural cover, which together make them attractive habitats. For instance, findings by [19] in their studies in Kimbi Fungom National Park and the Kom-Wum Reserve, shows that the presence of chimpanzee signs were highest in primary and liana forests with minimal anthropogenic activities. This finding is consistent with studies in Mount Cameroon National Park, where canopy density and vegetation diversity were identified as key drivers of chimpanzee nesting ecology [18]. Similarly, research in Mbam-Djerem National Park found that nest abundance was strongly associated with dense canopy and higher altitudes [34]. The abundance of various tree species preferred by chimpanzees for nest construction plays a crucial role in their survival in the study area. A notable study by [35] in Kalinzu National Park, Uganda, examined the selection of trees for nest construction, showing that chimpanzees favor certain tree species due to their availability, branch structure (providing stability), and habitat positioning. Conversely, a study by [36] in Gabon found that while chimpanzees have preferences, they adapt to available resources when their habitat is disturbed. These habitat compositions and structures demonstrate that the study area provides favorable conditions for the preferred habitats of chimpanzees.

The significant positive correlation between altitude and chimpanzee presence signs (Kendall's tau = 0.51, $p = 0.040$) suggests that higher altitude areas coincide with reduced human disturbance, which likely explains the greater frequency of chimpanzee signs there. Comparable results have been reported in other Central African forests, where chimpanzees select habitats that balance food availability and safety from human activity [9]. This highlights the importance of preserving habitats at higher altitudes to minimize human disturbances and promote chimpanzee presence. Additionally, chimpanzee nests were often found near watercourses and in areas with fruiting trees, facilitating their access to water and food. These observations are consistent with the findings of [10].

During the surveys, various biological signs were identified. Nests (0.87 signs/km) were the most represented indices, which aligns with the findings of [29], where nests were the most frequently observed signs. In areas of the study site where chimpanzee signs were found, the species preferred higher altitudes and dense canopies. This preference allows them to evade predators and shelter themselves from diverse climatic conditions, during different seasons. This observation aligns with the findings of [37] in Guinea, where chimpanzees were noted to prefer dense-canopy forests and areas with moderate altitudes for reasons of safety, access to food resources, and avoidance of anthropogenic pressure.

4.2. Vegetation Cover and Canopy Types

Closed canopies were most common in liana and primary forests, which corresponded with higher chimpanzee encounter rates. Sparse and open canopies, more frequent in farms and secondary forests, were associated with lower chimpanzee presence. This pattern reflects broader ecological findings that canopy closure provides protection and microclimatic stability, both critical for chimpanzee nesting and foraging [18].

4.3. Anthropogenic Impacts

Human activities were widespread, with hunting (3.7 signs/km) and deforestation (2.06 signs/km) being the most prevalent. This aligns with research conducted in Cameroon and Equatorial Guinea by [38], which indicates that poaching remains the primary threat to chimpanzees, particularly in the peripheral areas of national parks. These pressures mirror broader patterns across Cameroon, where bushmeat hunting and agricultural expansion are the primary drivers of chimpanzee decline [39] [40]. Likewise, deforestation for agricultural expansion, charcoal production, logging, canoe-making, and fish smoking also contributes to the destruction of chimpanzee-preferred habitats in the study area. [19] reported similar anthropogenic activities disrupting chimpanzee habitats in Kimbi Fungom National Park and the Kom-Wum Reserve. Secondary forests, which had the highest rate of anthropogenic activities, showed very low chimpanzee presence, highlighting the direct negative impact of human disturbance. This finding is consistent with [41] in Sierra Leone, where chimpanzees avoid swampy and heavily degraded secondary forest areas due to human proximity and infrastructure (e.g., roads, industrial camps). Secondary forests, despite their high level of anthropogenic activity, had very few chimpanzee presence signs, likely due to the presence of fruit trees such as mangoes, bananas, and oil palms.

Spatial analysis revealed that chimpanzee signs were concentrated in the eastern sector and islands, areas with lower anthropogenic activity. In contrast, the northern, northwestern, and southern sectors showed high human activity and no chimpanzee presence. This spatial separation underscores the importance of intact forest refuges for chimpanzee survival, as also noted in studies of community attitudes toward primate conservation in Douala-Edéa [25].

4.4. Conservation Implications

This study faced certain constraints, including limited temporal coverage, reliance on indirect signs rather than direct observations, potential observer bias in habitat classification, and the absence of long-term monitoring that would strengthen projections for strategic conservation across the entire park. Nevertheless, the findings demonstrate that the overlap between preferred habitats (liana and primary forests) and areas of reduced human activity should be prioritized for conservation.

Effective strategies must integrate habitat protection, anti-poaching enforcement, and community-based conservation initiatives. Such approaches are particularly critical given that local populations remain heavily dependent on forest resources and often reluctant to abandon hunting practices [42] [43]. Strengthening these measures will not only support the long-term persistence of chimpanzee populations but also safeguard the broader ecological integrity of Douala-Edéa National Park.

5. Conclusions

This study demonstrates that chimpanzee distribution and habitat use in Douala-Edéa National Park are strongly influenced by habitat quality, vegetation cover, and altitude, while being negatively impacted by anthropogenic activities. The highest encounter rates of chimpanzee signs were recorded in liana and primary forests, which provide dense canopy cover, fruiting trees, and suitable nesting sites. The significant positive correlation between altitude and chimpanzee presence further highlights the importance of ecological gradients in shaping habitat preferences.

Conversely, secondary forests and agricultural fields, which exhibited the highest levels of human disturbance through hunting, deforestation, and farming, showed very low chimpanzee presence. This spatial overlap between anthropogenic pressures and reduced biological signs underscores the urgent need for targeted conservation measures.

The mapping of vegetation cover and land use revealed that primary forests surrounding liana forests represent the most critical habitats for chimpanzees in the park. These areas should therefore be prioritized for conservation interventions, including anti-poaching patrols, habitat protection, and restoration programs. Moreover, the absence of anthropogenic activities on the islands, where reintroduced chimpanzees were observed, suggests that isolated refuges may serve as important safe havens for sustaining populations.

Effective conservation in Douala-Edéa will require a community-based approach, as local populations remain heavily dependent on forest resources. Integrating environmental education, alternative livelihoods, and participatory management can help reduce hunting pressure and foster coexistence.

In conclusion, the findings highlight that the survival of chimpanzees in Douala-Edéa National Park depends on the protection of intact forest habitats and the mitigation of human pressures. Strengthening conservation strategies in these priority areas will not only safeguard chimpanzees but also preserve the broader ecological integrity of the park.

Recommendations

Based on the results of this study, the following recommendations are proposed to strengthen chimpanzee conservation in Douala-Edéa National Park:

- Prioritize liana and primary forests: These habitats recorded the highest encounter rates of chimpanzee signs and should be designated as core conservation zones. Strict protection measures, including habitat monitoring and restoration, are essential.
- Strengthen anti-poaching enforcement: Hunting was identified as the most prevalent anthropogenic activity. Increasing patrol frequency, improving ranger capacity, and applying stricter penalties can reduce poaching pressure.
- Implement community-based conservation: Local populations rely heavily on forest resources. Conservation strategies must integrate environmental education, alternative livelihoods (e.g., agroforestry, ecotourism), and participatory management to reduce dependence on hunting and logging.
- Promote habitat restoration in secondary forests: Secondary forests showed the highest levels of anthropogenic activity and lowest chimpanzee presence. Reforestation and enrichment planting can improve habitat quality and connectivity.

Perspectives

The findings of this study provide important insights into the ecological requirements and conservation challenges of chimpanzees in Douala-Edéa National Park. Moving forward, several perspectives emerge:

- Long-term ecological monitoring: Continued use of GIS, remote sensing, and camera traps will be essential to track changes in chimpanzee distribution, vegetation cover, and human activity.
- Community engagement and co-management: Since local populations rely

heavily on forest resources, conservation success will depend on participatory approaches that integrate environmental education, alternative livelihoods, and benefit-sharing mechanisms.

- Habitat restoration and connectivity: Secondary forests and degraded areas should be prioritized for reforestation and enrichment planting to improve habitat quality and maintain ecological corridors between chimpanzee populations.

Acknowledgements

Many thanks to the Research Unit of Applied Biology and Ecology, Department of Animal Biology, Faculty of Science, University of Dschang, to the Ministry of Scientific Research and Innovation, to the Ministries of Forestry and Wildlife Cameroon, and Douala Edea National Park Conservator and staff for granting us permission to carry out this study. Our gratitude to the Papaye France Association for accepting and collaborating to meet the objectives of the study. Great thanks to Mr. Anyong Armstrong and his wife Mrs Clodia Forchibe Aghah for their invaluable field materials support. We acknowledge with due consideration the devotedness of Mr. Mine, Chief Nzoke and all the elders from the different villages during ecological data collections.

Author Contributions

Mvo Denis Chuo: Conceptualization; methodology; data collection and analysis; writing a grant proposal; preparing the original and final draft. Sime Tchuenche Winny Laeticia: Conceptualization; methodology; data collection; project administration; writing and editing the draft. Jean Pascal Koh Dimbot: Data analysis and editing the final draft. Dief Danael: production of maps. Theodore B. Mayaka: Supervision; contributed critically to the drafts. All authors gave their final approval for publication.

Funding

Although this study did not receive direct financial support, we sincerely thank the Project Manager of the Large Mammals Status Project (DENP) for granting us the opportunity to participate in data collection. Their project, supported by the Mohamed bin Zayed Species Conservation Fund and Idea Wild**,** provided invaluable assistance. We remain deeply grateful for their continued guidance, encouragement, and commitment to advancing conservation research.

Data Availability

The datasets generated and analyzed for the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

[1] Butchart, S.H.M., Walpole, M., Collen, B., van Strien, A., Scharlemann, J.P.W., Almond, R.E.A., *et al.* (2010) Global Biodiversity: Indicators of Recent Declines. *Science*, **328**, 1164-1168. https://doi.org/10.1126/science.1187512

[2] Hovick, T.J., Elmore, R.D., Dahlgren, D.K., Fuhlendorf, S.D. and Engle, D.M. (2014) Evidence of Negative Effects of Anthropogenic Structures on Wildlife: A Review of Grouse Survival and Behaviour. *Journal of Applied Ecology*, **51**, 1680-1689. https://doi.org/10.1111/1365-2664.12331

[3] Maijo, S.P., Piel, A.K. and Treydte, A.C. (2020) Perturbations anthropiques et utilisation de l'habitat des chimpanzés (*Pan troglodytes*) dans l'écosystème de Masito-Ugalla, Tanzanie. *Journal de Mammalogie*, **101**, 1660-1669.

[4] Carlitz, E.H.D., Miller, R., Kirschbaum, C., Gao, W., Hänni, D.C. and van Schaik, C.P. (2016) Measuring Hair Cortisol Concentrations to Assess the Effect of Anthropogenic Impacts on Wild Chimpanzees (*Pan troglodytes*). *PLOS ONE*, **11**, e0151870. https://doi.org/10.1371/journal.pone.0151870

[5] Lior, N. (2008) Energy Resources and Use: The Present Situation and Possible Paths to the Future. *Energy*, **33**, 842-857. https://doi.org/10.1016/j.energy.2007.09.009

[6] De Lucas, M., Janss, G.F.E., Whitfield, D.P. and Ferrer, M. (2008) Collision Fatality of Raptors in Wind Farms Does Not Depend on Raptor Abundance. *Journal of Applied Ecology*, **45**, 1695-1703. https://doi.org/10.1111/j.1365-2664.2008.01549.x

[7] Miller, T.A., Brooks, R.P., Lanzone, M., Brandes, D., Cooper, J., O'Malley, K., *et al.* (2014) Assessing Risk to Birds from Industrial Wind Energy Development via Paired Resource Selection Models. *Conservation Biology*, **28**, 745-755. https://doi.org/10.1111/cobi.12227

[8] Rands, M.R.W., Adams, W.M., Bennun, L., Butchart, S.H.M., Clements, A., Coomes, D., *et al.* (2010) Biodiversity Conservation: Challenges beyond 2010. *Science*, **329**, 1298-1303. https://doi.org/10.1126/science.1189138

[9] Bersacola, E., Hill, C.M. and Hockings, K.J. (2021) Chimpanzees Balance Resources and Risk in an Anthropogenic Landscape of Fear. *Scientific Reports*, **11**, Article No. 4569. https://doi.org/10.1038/s41598-021-83852-3

[10] Bryson-Morrison, N., Tzanopoulos, J., Matsuzawa, T. and Humle, T. (2017) Activity and Habitat Use of Chimpanzees (*Pan troglodytes* Verus) in the Anthropogenic Landscape of Bossou, Guinea, West Africa. *International Journal of Primatology*, **38**, 282-302. https://doi.org/10.1007/s10764-016-9947-4

[11] Chapman, C.A. and Chapman, L.J. (2000) Constraints on Group Size in Red Colobus and Red-Tailed Guenons: Examining the Generality of the Ecological Constraints Model. *International Journal of Primatology*, **21**, 565-585. https://doi.org/10.1023/a:1005557002854

[12] Estrada, A. (2013) Socioeconomic Contexts of Primate Conservation: Population, Poverty, Global Economic Demands, and Sustainable Land Use. *American Journal of Primatology*, **75**, 30-45. https://doi.org/10.1002/ajp.22080

[13] IUCN (2021) The IUCN Red List of Threatened Species. Version 2021-3. International Union for Conservation of Nature. https://www.iucnredlist.org

[14] Kühl, H.S., Boesch, C., Kulik, L., Haas, F., Arandjelovic, M., Dieguez, P., *et al.* (2019) Human Impact Erodes Chimpanzee Behavioral Diversity. *Science*, **363**, 1453-1455. https://doi.org/10.1126/science.aau4532

[15] Tweheyo, M., Lye, K.A. and Weladji, R.B. (2004) Chimpanzee Diet and Habitat Selection in the Budongo Forest Reserve, Uganda. *Forest Ecology and Management*,

188, 267-278. https://doi.org/10.1016/j.foreco.2003.07.028

[16] Morgan, D., Sanz, C. and Onononga, J.R. (2018) Impacts of Forest Fragmentation on Chimpanzees in Central Africa. *Journal of Wildlife Research*, **45**, 227-240.

[17] Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., *et al.* (2020) Global Forest Change (2001-2018): Data Derived from Satellite Observations. *Science*, **368**, 1-8.

[18] Kinge, R.L., Kamah, P.B., Longonje, S.N., Ndive, S.N., Ettagbor, H.E. and Makongo, N.J. (2026) Habitat Utilization of Chimpanzees in Mount Cameroon National Park, West Coast Cluster. *GPH International Journal of Applied Science*, **9**, 45-62.

[19] Chuo, M.D., Angwafo, T.E., Chefor, F. and Fru, B.S. (2017) Estimation of Chimpanzee's (Pan Troglodytes Ellioti) Abundance in the Kimbifungum National Park and Kom-Wum Forest Reserve, NW, Cameroon. *Journal of Biodiversity Management & Forestry*, **6**, 20-30. https://doi.org/10.4172/2327-4417.1000185

[20] Chuo, M.D. and Tsi, A.E. (2017) Chimpanzee in Ethno-Primatological Practices and It Implications for Biodiversity Conservation: Kimbi-Fungom National Park and Kom-Wum Forest Reserve, Cameroon. *American Journal of Agriculture and Forestry*, **5**, 157-165. https://doi.org/10.11648/j.ajaf.20170505.14

[21] Ministère des Forêts et de la Faune (MINFOF) (2014) Plan de gestion de la faune au Cameroun. MINFOF.

[22] Angoni, H., Mbolo, M., Bernard, A. and Youmbi, E. (2018) Ecological Study of the Vegetation of the Douala-Edéa Wildlife Reserve in Cameroon. *International Journal of Development Research*, **5**, 1-10.

[23] MINFOF (2018) Décret N°2018/606 portant création du Parc National de Douala-Edéa.

[24] Chuo, M.D., Berquèle, N.T. and Mayaka, T.B. (2026) Impact of Anthropogenic Activities on Herbivorous Mammal Diversity in the Douala-Edéa National Park, Littoral Region, Cameroon. *Annals of Ecology and Environmental Science*, **8**, 54-68. https://doi.org/10.22259/2637-5338.0801005

[25] Chuo, M.D., Tsopgni, B.N. and Mayaka, T.B. (2026) Determinants of Local Attitudes and Knowledge toward Herbivorous Mammal Conservation in Coastal Cameroon: A Case Study of the Douala-Edéa National Park. *International Journal of Rural Development, Environment and Health Research*, **9**, 1-15.

[26] Fonkwo, S.N. (2023) Financial Values of Bushmeat and Effects of Anthropogenic Activities in Douala-Edéa National Park. *European Journal of Wildlife Research*, **69**, 1-12. https://doi.org/10.1007/s10344-023-01672-4

[27] Angoni, H., Mebenga, N.R.L., Ajonina, G., *et al.* (2026) Ecosystem Services and Degradation Factors in Douala-Edéa Reserve. *International Journal of Biodiversity and Conservation*, **18**, 145-162.

[28] Chuo, M.D., Ariel Laslande, T.T. and Mayaka, T.B. (2026) Knowledge and Attitudes of Local Populations toward the Conservation of Diurnal Primates: A Case Study of the Douala-Edéa National Park, Cameroon. *International Journal of Forest, Animal and Fisheries Research*, **10**, 1-19. https://doi.org/10.22161/ijfaf.10.2.1

[29] Njukang, A.P., Angwafor, T.E., Akwanjoh, S.R. and Lebga, A.K. (2019) Effects of Anthropogenic Activities on Chimpanzee Nest Location in the Tofala Hill Wildlife Sanctuary, South West Region, Cameroon. *International Journal of Forest, Animal and Fisheries Research*, **3**, 1-9. https://doi.org/10.22161/ijfaf.3.6.1

[30] Tsi, E.A. and Chuo, M.V. (2016) Contributions of Indigenous Knowledge of Gorilla (*Gorilla gorilla diehi*), Chimpanzee (*Pan troglodytes ellioti*) and Buffalo (*Syncerus

caffer) Conservation, in Waindow, North West Cameroon. *Annual Research & Review in Biology*, **11**, 1-14. https://doi.org/10.9734/arrb/2016/28428

[31] Angwafo, T.E., Yannick, K.N. and Chuo, M.D. (2019) Impact of Hunting on Primates and Their Conservation in the Mont Kupe Region, South-West and Littoral Cameroon. *International Journal of Forest, Animal and Fisheries Research*, **3**, 18-50. https://doi.org/10.22161/ijfaf.3.6.4

[32] MINFOF (2018) Plan d'aménagement du Parc National de Douala-Edéa. Ministère des Forêts et de la Faune, Cameroun.

[33] R Core Team (2021) R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org

[34] Kamgang, S.A., Bobo, K.S., Maisels, F., Ambahe, R.D.D., Ambassa Ongono, D.E., Gonder, M.K., *et al.* (2018) The Relationship between the Abundance of the Nigeria-Cameroon Chimpanzee (*Pan troglodytes ellioti*) and Its Habitat: A Conservation Concern in Mbam-Djerem National Park, Cameroon. *BMC Ecology*, **18**, Article No. 40. https://doi.org/10.1186/s12898-018-0199-3

[35] Furuichi, T., Hashimoto, C. and Tashiro, Y. (2001) Fruit Availability and Habitat Use by Chimpanzees in the Kalinzu Forest, Uganda: Examination of Fallback Foods. *International Journal of Primatology*, **22**, 929-945. https://doi.org/10.1023/A:1012009520350

[36] Koops, K., Humle, T., Sterck, E.H.M. and Matsuzawa, T. (2007) Ground-Nesting by the Chimpanzees of the Nimba Mountains, Guinea: Environmentally or Socially Determined? *American Journal of Primatology*, **69**, 407-419. https://doi.org/10.1002/ajp.20358

[37] Morgan, D. and Sanz, C. (2006) Chimpanzee Feeding Ecology and Comparisons with Sympatric Gorillas in the Goualougo Triangle, Republic of Congo. In: Hohmann, G., Robbins, M.M. and Boesch, C., *Feeding Ecology in Apes and Other Primates*, Cambridge University Press, 97-122.

[38] Carvalho, J.S., Graham, B., Bocksberger, G., Maisels, F., Williamson, E.A., Wich, S., *et al.* (2021) Predicting Range Shifts of African Apes under Global Change Scenarios. *Diversity and Distributions*, **27**, 1663-1679. https://doi.org/10.1111/ddi.13358

[39] Young, L. (2025) Why Are Chimpanzees Losing Their Habitat? The Institute for Environmental Research and Education. https://iere.org

[40] Gale, J. (2025) What Is the Biggest Threat to Chimpanzees? Institute for Environmental Research and Education. https://iere.org

[41] Vanthomme, H., Kolowski, J. and Alonso, A. (2021) Distribution of Chimpanzees and Human Activities in the Forest-Savanna Mosaic of Gabon: Implications for Conservation. *African Journal of Ecology*, **59**, 345-358.

[42] Chuo, M.D. and Dallya, L.T.M. (2026) Local Communities' Interactions with Wildlife in the Ebo Forest Reserve, Littoral Region, Cameroon. *Annals of Ecology and Environmental Science*, **8**, 1-15. https://doi.org/10.22259/2637-5338.0802001

[43] Chuo, M.D. and Dallya, L.T.M. (2026) Field Assessment of Human-Wildlife Interactions within Cameroon's Ebo Forest Reserve. *International Journal of Forest, Animal and Fisheries Research*, **11**, 6-20. https://doi.org/10.22161/ijfaf.10.3.2