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# Spatial Distribution and Status of Biota Habitats in the Forest Reserves of Omo and Ago-Owu in Ogun State, Oluwa in Ondo State, and Ife and Shaha in Osun State, Southwestern Nigeria

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**ABSTRACT:** The biota comprises all living organisms (bacteria, fungi, plants, animals) that inhabit a given area. Therefore, the objective of this paper was to evaluate the spatial distribution and status of biota habitats in the forest reserves of Omo and Ago-Owu in Ogun State, Oluwa in Ondo State, and Ife and Shaha in Osun State of southwestern Nigeria using appropriate standard techniques. The field surveys were conducted in relation to a 5 km × 5 km grid of cells across the target region. Twenty-three transects 5 km in length were created, and walks of 2.5 km from the boundary to the center of the grid cell enabled observation and data collection in these forest complexes. Mammals were detected at very low rates, especially in the Osun reserves. From the 23 transects totaling 115 km, only 140 mammals were encountered. Most large mammals, particularly elephants, are relatively abundant across much of the western Omo Forest. Hunters' reports showed that chimpanzees are still present in southern Shasha and in Oluwa Forests. Our assessment revealed that except for the 4.6 km$^2$ Strict Natural Biosphere Reserve in Omo, all the remaining natural forests have been heavily damaged by many years of intensive logging. However, if protected and given time, these forests can still regenerate.

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The Omo, Oluwa, Shasha, Ife and Ago-Owu Forest reserves consist of the remaining few lowland rainforests in Nigeria (Adedeji and Adeofun, 2014). The 3,000 km$^2$ area now comprises clusters of contiguous forest vegetation that cut across three political administrative boundaries of southwestern Nigeria, namely, the eastern Ogun, western Ondo and southern Osun States (Fasona *et al*., 2022). Prior to the creation of the states in Nigeria, the Omo, Oluwa and Shasha Forest reserves, which occupied 1,325 km$^2$, 827 km$^2$ and 310 km$^2$, respectively, were all part of the Shasha Forest Reserve that was originally created in 1925 according to Olajiire-Ajayi *et al.* (2021) during the colonial era to safeguard water supplies and the production of timber (Kolade and Adejumo, 2019). Forests are hence of enormous biological importance once upon a time (Akpan-Ebe, 2017), but at present, they suffer enormous decimation and are currently

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threatened (Adeniyi, 2016; Nodza *et al*., 2024). The forest reserves were once subjected to sustained yield management but were abandoned after the discovery of petroleum in commercial quantities in the 1970s (Sakib and Nazmuz, 2021). Today, the area has transformed into a shadow of what they used to be about six decades ago. The Omo, Oluwa, Shasha, Ife, and Ago-Owu Forest reserves in southwestern Nigeria have been described as high-priority conservation areas (Jimoh *et al*., 2012). Accordingly, they were in need of height conservation and regeneration as of 2000 (Daramola *et al*., 2021). As these forest habitats continue to degrade in the face of large-scale perturbations and excessive exploratory activities by humans, great concern is expressed in many circles about developing effective conservation options for the remaining but threatened clusters of vegetation and its biological diversity (Capmourteres and Anand, 2016). This anxiety about the precarious status of the forest ecosystem in Nigeria may be one of the most critical aspects of sustainability deliberation. There is a need to intensify efforts in conservation programs, but more importantly, to complement such efforts with increased conservation audits (Sholler, 2019). This allusion is underscored by the recurrent failure of protected areas in many parts of the world (Wang *et al*., 2023). Ward *et al.* (2020) showed that while 40% of terrestrial plants are intact, only 9.7% of the earth's terrestrial protected areas can be considered structurally connected. Most of these protected areas, as they are today, have disintegrated.

Börner *et al.* (2020) and Afriyie *et al.* (2021) highlighted the scarcity of studies evaluating the success of protected areas, resulting in a lack of understanding regarding the reasons for their failures and the persistence of ineffective protection policies. They identified two main factors contributing to this deficiency: the high cost of long-term monitoring required for assessing conservation performance and inadequate coordination among various stakeholders involved in wildlife censuses. Without concerted action to address these issues, including enhanced monitoring efforts at both the individual and collaborative levels, the loss of numerous species and ecosystems over the coming decades is inevitable.

The extensive human-driven pressures on the lowland forests of southwestern Nigeria, including farming, logging, and oil extraction, underscore the urgency for intensified status assessments. Without intervention, the Omo-Shasha-Oluwa Forest complex faces imminent degradation due to unsustainable resource extraction and habitat loss, emphasizing the critical need for thorough periodic assessments and robust management plans to facilitate conservation efforts and ecosystem recovery. Through comprehensive investigations into the current ecosystem status and biological diversity, coupled with science-based management plans delineating contiguous areas, this study aimed to formulate effective conservation strategies for the region's remaining lowland forests. Therefore, the objective of this paper was to evaluate the spatial distribution and status of biota habitats in the forest reserves of Omo and Ago-Owu in Ogun State, Oluwa in Ondo State, and Ife and Shaha in Osun State in southwestern Nigeria.

## MATERIALS AND METHODS

*Study area:* The study area is geographically bounded by latitudes $4^0\,00'$ and $4°57'$ N and by longitudes $6°30'$ and $7°2'$ E, encompassing approximately 3066 $km^2$ of land area. The area was designated the Shasha Forest reserve in 1925 but was later split into the Omo, Oluwa Shasha, Ife, Ago-Owu, and Oshun Forest reserves. The Omo reserve alone covers approximately 1300 km2 and includes a 4.6 $km^2$ Strict Nature Reserve (Adedeji and Adeofun, 2014). The Omo Forest Reserve is highly conserved, with more than 200 species of tree, 125 species of bird and many mammal species, including forest elephant, chimpanzee and white-throated guenon monkeys, all of which are now seriously endangered (Ezeani *et al*., 2023; Ayanniyi *et al*., 2024). According to the NNMC (Ogunsesan *et al*., 2011), approximately 6.5 km2 of land area within the forest reserves has been converted to human enclaves inhabited by approximately 20,000 people. The terrain is undulating, and the maximum elevation 150 m above sea level is towards the west, while the lowest parts of the reserve are in the southern region where the Omo River joins the River Oni before flowing into the Lekki Peninsula on the Atlantic coast. The mean annual rainfall is approximately 2050 mm, and the mean monthly temperature is approximately 27°C. The natural vegetation, which was previously lowland tropical rainforest (moist evergreen type), has been reduced to secondary forest, thickets and varying degrees of fallow regrowth or annual and perennial crops, except in some parts of the forest reserves (Adedeji and Adeofun, 2014).

*Materials and Data used:* The instruments used for the study included computer notebooks, handheld GPS receivers (Garmin Map60-CSx), binoculars and hip chains. Additional field equipment included stealth infrared cameras, digital cameras, sleeping bags, backpacks and waterproof cases. A tailored data collection system was created using GPS receivers (Ogunsesan *et al*., 2011). The secondary data for the study included Landsat Thematic Mapper (TM) data obtained from the Global Land Cover Facility website.

Below is the annotated Landsat image depicting the forest reserves.

*Logistics for field survey:* Prior to the commencement of the field work, a geographic information system (GIS) was established to support the survey. To guide field operations and data collection, the satellite imagery was geo-referenced and subjected to supervised classification based on the information obtained from 'ground truthing' during the reconnaissance survey. Maps of the project area were produced from 'on-screen digitization' of scanned analogue maps of forest reserve boundaries and topographic map sheets. All geographic features, such as rivers and roads, were captured from scanned and georeferenced maps at a scale of 1:20,000. Information gathered from the field ground truthing exercise during the preliminary field work was utilized for database development of the maps produced.

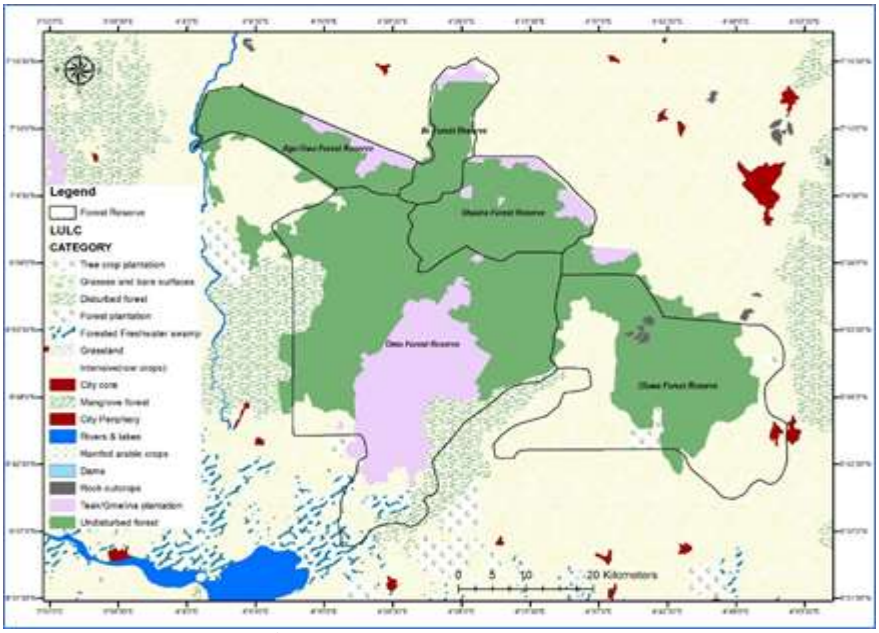


**Fig 1:** Location of the Omo-Oluwa-Shasha Forest complex in SW Nigeria
*Source: IFSERAR-FUNAAB Geospatial Laboratory, 2024*

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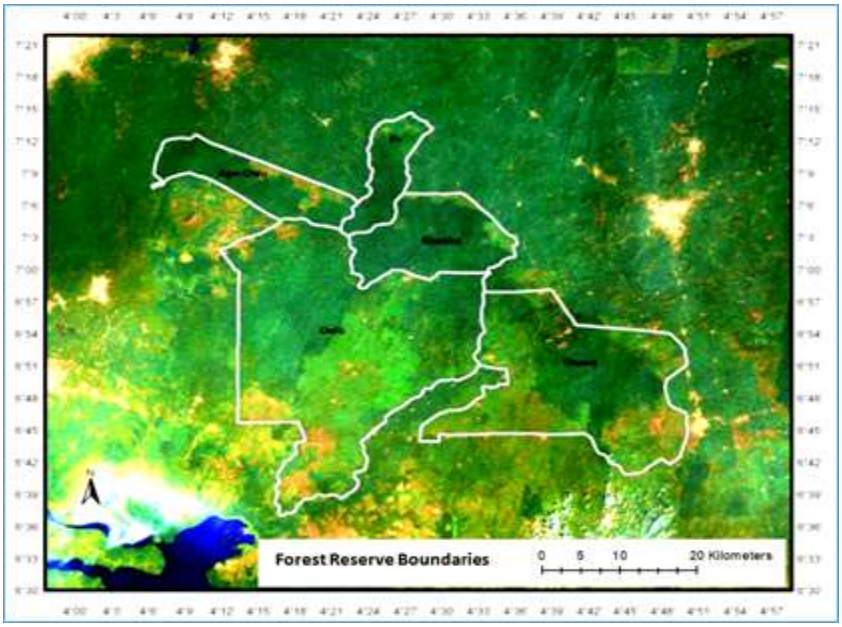


**Fig 2:** Landsat TM image of the Omo-Oluwa-Shasha Forest complex in SW Nigeria
*Source: IFSERAR-FUNAAB Geospatial Laboratory using Ogunsesan et al. 2011*

*Field transects and data collection methods:* A GIS was established to support the survey prior to the commencement of the field work. The satellite imagery was first geo-referenced in a geographic coordinate system (WGS, 1984) and subjected to supervised classification using the information obtained from the reconnaissance survey during 'ground truthing'. Maps of the project area were produced through 'on-screen digitization' of scanned paper maps of the forest reserve boundaries and topographic map sheets. All geographic features, such as rivers and roads, were captured from scanned and georeferenced maps at a scale of 1:20,000. The maps produced were used as a guide for field operations and data collection. Information gathered from the field ground truthing exercise during the preliminary field work was later utilized to update or develop the database of the maps produced. A grid of 5 km × 5 km was superimposed on the geo-referenced satellite image. The grid cells coincided with the area of interest in the study. The data were collected along a path of least resistance from the cell boundary towards the approximate centre of the grid cell, namely, old logging roads, trails, and through the forest undergrowth with light vegetation clearing. The grid and the coordinates of the center of each grid cell were uploaded to the GPS receivers and uploaded to the GPS; thus, identifying the area on land was quite easy. For each grid cell visited, the point centre quarter (PCQ) method of assessment was employed for data gathering. Each walk begins at the cell boundary, which is easily located with the aid of the 'go to' function of the hand-held GPS receiver and the hip chain. Distance travelled was measured with a hip chain. Figure 3 shows a Landsat image with annotations and a grid cell overlay.

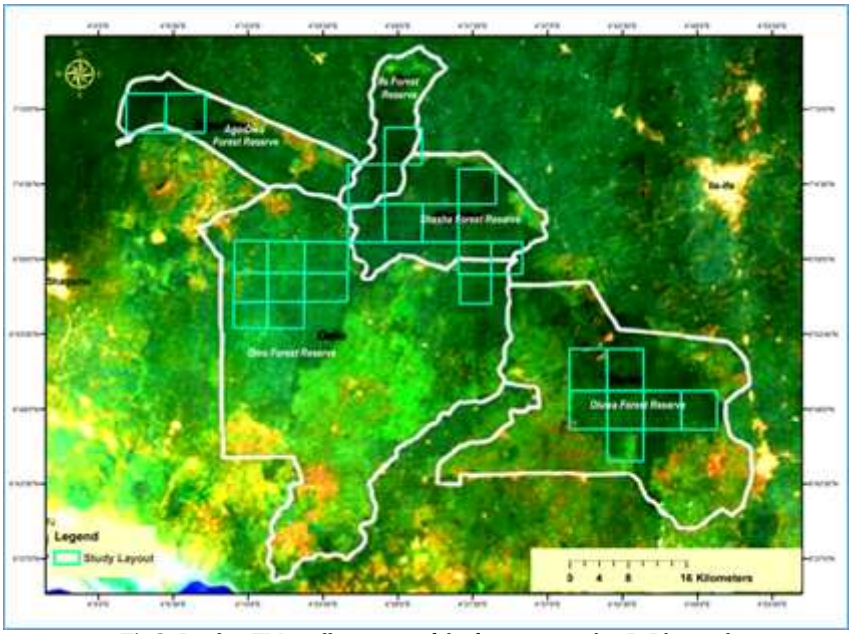


**Fig 3:** Landsat TM satellite image of the forest area with a 5×5 km grid
*Source: IFSERAR-FUNAAB Geospatial Laboratory, 2024 using Ogunsesan et al. (2011).*

The human activities and evidence of the presence of large mammals and birds were taken along with their respective GPS coordinates and documented as waypoints in the GIS. The land cover data were also recorded at 200-meter intervals. The vegetation data were collected, including assessments of undergrowth density. The large trees (with a stem diameter of at least 30 centimeters at breast height) were categorized as low, medium, or high density within 25 meters of each waypoint.

## RESULTS AND DISCUSSION

*Status of the habitat and wild animals:* Copious evidence of human dominance, such as footpaths, roads, logging, farming, hunting, and collection of non-wood forest products (NWFPs), abounds in every part of the forest reserve. The synoptic view of the forest reserves accessed through the satellite images provided evidence of several farmlands springing within the area. For instance, southern Shasha, which used to be predominantly forested, was heavily decimated by the time the satellite images were acquired.

*Distribution and status of natural forest:* In this paper, the term "natural forest" refers to those areas that have not been dominated by human presence, such as those already converted into tree plantations, farms or

settlements. The natural forest is the original vegetation of the area and might have been modified over the years by logging. The distribution of natural forests in the reserves is presented in Table 1.

**Table 1:** Areas of surveyed reserves and areas of natural forest in the Reserve

| | Reserve area ($km^2$) | Natural forest area ($km^2$) | Percent of reserve under natural forest |
|---|---|---|---|
| Omo | 1,325 | 381.2 | 28.8 |
| Oluwa | 827 | 347.9 | 42.1 |
| Shasha | 309 | 240.8 | 77.8 |
| Ago-Owu | 240 | 79.4 | 33.1 |
| Ife | 142 | 75.8 | 53.2 |

Interestingly, the area covered by natural forest is greatest in Shasha, with an area of approximately 187 $km^2$. This is encouraging compared with the area covered by natural vegetation in Omo and Oluwa. The most contiguous forest patches are more prominent in western Omo, Shasha and southern Ife. Although land cover analysis suggested that more than half of the Ago-Owu reserve is still forested, it is detached like Oluwa from the contiguous zone, as presented in the unsupervised classification on the ASTER image in the figure 4.

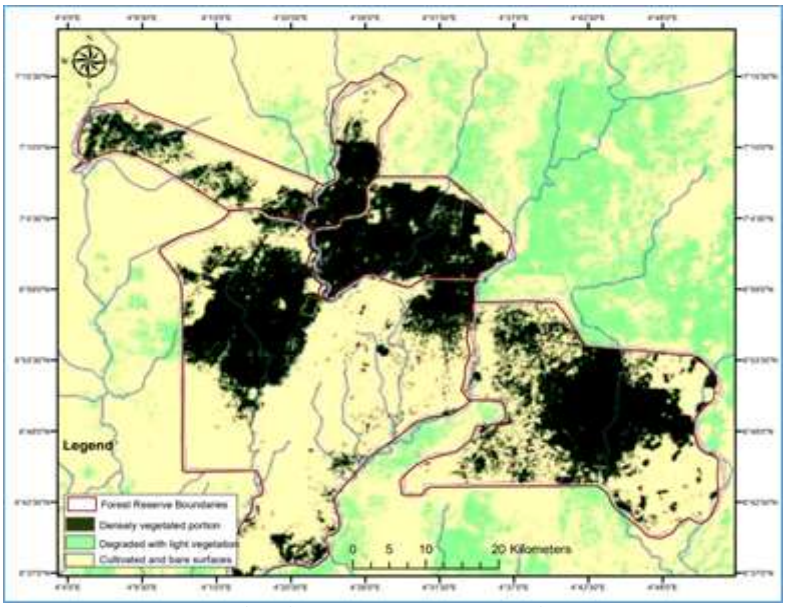


**Fig 4:** Map of the forest reserves showing high fragmentation.
*Source: IFSERAR-FUNAAB Geospatial laboratory, (2024) using Ogunsesan et al. (2011).*

The map in Figure 3 indicates that there is a gap of more than 10 km between the remaining area of continuous forest in Oluwa and the nearest forest area remaining in northeastern Omo. Ground surveys confirmed that much of the area depicted as densely forested on the image is actually a succession of teak and cocoa plantations, and only a few patches of natural forest remain. The forest has been grossly decimated by human activities, namely, logging, farming, enclave construction and poaching.

*Density of undergrowth:* A measure of human impact can be the estimate of tree density and undergrowth thickness at 200 m intervals on transects. The percent frequency of the density classes recorded is presented in Table 2.

**Table 2.** Percent undergrowth and tree density in western Omo

| | Shasha R. – Oni R. | | Oluwa F.R. |
|---|---|---|---|
| **Undergrowth** | | | |
| High | 47.0 | 66.7 | 46.6 |
| Medium | 40.5 | 23.0 | 38.8 |
| Low | 12.5 | 10.3 | 14.6 |
| **Tree Density** | | | |
| High | 32.7 | 27.6 | 19.4 |
| Medium | 42.9 | 36.8 | 52.4 |
| Low | 24.4 | 35.6 | 28.2 |

The densest undergrowth was found in the Shasha reserve (and adjacent areas). This confirms that Shasha is the most affected by uncontrolled logging. Overall,

western Omo appears to have been less damaged by logging than the other areas. However, with the highest logging scores recorded along the transects (Table 2), there is an indication that loggers are already shifting their focus to the western Omo because of its rich crop of timber-sized trees.

*Status of the Flora:* The forests of the area have been described as mixed moist, semievergreen rainforests in the Congolian subunit of the Guinea-Congolian Centre of Endemism (Amusa *et al*., 2021). The Guinea-Congolian zone is extremely rich in species and has high levels of endemism. This area is the richest in Africa for butterflies, a high proportion of which are endemic, with the highest richness of bird species and the richest mammal diversity (Mackinnon and Mackinnon 1986). Sanford (1969) observed 24 orchid species, 12 of which are characteristic of wet forest sites, while 3 were exclusive to Omo in his study of orchid species at 31 sites in Nigeria.

According to Isichei (1995), the most abundant climax forest species in the Strict Natural Reserve were *Diospyros dendo, Drypetes paxii, Rinorea dentata* and *Strombosia postulata*. The most frequent pioneer species was *Funtumia elastica*, while the common climbers were *Hippocratia pallens* and *Strychnos spp*. The herbs *Lankesteria thyrsoidea, Geophila afzelii* and *Cyanastrum cordifolium* were abundant.

The vegetation of the forest complex is classified as lowland rainforest, which typically contains many valuable timber trees, such as *Melicea excelsa, Cistanthera papaverifera, Cordia millenii, Diospyros inscupta, Erythrophylum ivorensis, Holoplea grandis, Irvingia gabonensis, Lophira procera, Lovoa* sp., *Mansonia altisima, Mitragyna ciliate, Piptadenia africana, Steculia rhinopetala, Terminalia superba, Triplochiton scleroxylon, Khaya ivorensis, Terminalia ivorensis, Antiaris africana, Guarea cedrela, Entandrophragma* spp. and *Afzelia Africana*

However, large areas of forest have been replaced with farmland (mostly cocoa). Much of the remaining forest in the reserve is secondary, overrun by the lianas (possibly a side effect of logging), except for scattered areas where a considerable number of large trees remain. The umbrella tree (*Musanga cercopioides*) is widespread and is symptomatic of heavily degraded forests. The entire area shows obvious signs of extensive logging, with an extensive network of roads allowing logging trucks to access the forest.

Timber tree species of significance present in forest reserves include *Afzelia africana, Mitragyna stipulosa, Cordia millemi, Alstonia congensis, and Brachystegia spp*. However, recent biodiversity surveys have revealed that these species are either threatened or endangered. A summary of the results of such a survey is shown in the table 3.

**Table 3:** Status of Plant Species in the Reserves

| S/No. | Plant Species | Status | | |
|---|---|---|---|---|
| | | Threatened | Endangered | Extinct |
| 1 | *Khaya Ivorensis* | | β | |
| 2 | *Sarcocephalus diderrichii* | β | | |
| 3 | *Terminalia superb* | β | | |
| 4 | *Irvingia gabonensis* | na | na | na |
| 5 | *Afzelia Africana* | β | | |
| 6 | *Mitragyna stipulosa* | β | | |
| 7 | *Cordia millenii* | β | | |
| 8 | *Alstonia congesis* | β | | |
| 9 | *Brachystegia spp* | β | | |

*Distribution and status of the wildlife: Mammals:* The table below presents records of mammals encountered along the transects in three zones of the forest, namely, the western Oluwa Forest Reserve, the Ife-Shasha-Northeastern Omo Forest Reserve, and the Oluwa Forest Reserve.

**Table 4:** Mammal records from transects

| All mammals | Western Omo | | | Shasha-Oni River | | | Oluwa F.R. | | |
|---|---|---|---|---|---|---|---|---|---|
| | *No.* | *No. per recce* | *No. per km* | *No.* | *No. per recce* | *No. per km* | *No.* | *No. per recce* | *No. per km* |
| | 105 | 11.7 | 2.33 | 10 | 1.67 | 0.33 | 33 | 4.71 | 0.94 |
| Elephants | 35 | 3.9 | 0.78 | - | - | - | - | - | - |
| Ungulates | 20 | 2.22 | 0.44 | 8 | 1.33 | 0.27 | 13 | 1.86 | 0.37 |
| Primates | 31 | 3.44 | 0.69 | 2 | 0.33 | 0.07 | 13 | 1.86 | 0.37 |

Records show that the mammalian class of wildlife is much more abundant in western Omo and Oluwa than in other forest areas. Mammal signs were more abundant in western Omo than in the other forest areas

and were much less abundant in the central survey area between the Shasha and Oni Rivers than in the other two areas. These differences are partly accounted for by the prevalence of elephant signs in western Omo and their absence elsewhere, but primates were also encountered much more often in western Omo than in the other areas, and primate evidence was very sparse in the Shasha-Oni zone.

*Elephants:* The African Forest Elephant (*Loxodonta africana cyclotis*) appears to be the widest range of wildlife in the reserve, as signs of its presence were observed from l0 metres of the camp to 16 km northwest, 7 km east and 6 km west of the Omo reserve. There are also obvious signs of elephant breeding, such as several footprints of a calf (Feleha, 2018). Elephant activities are predominant along riverbanks and in the farmlands of the locals where they have uprooted and destroyed crops. Figure 5 shows a map of the elephant roaming range in the forest reserve complex.

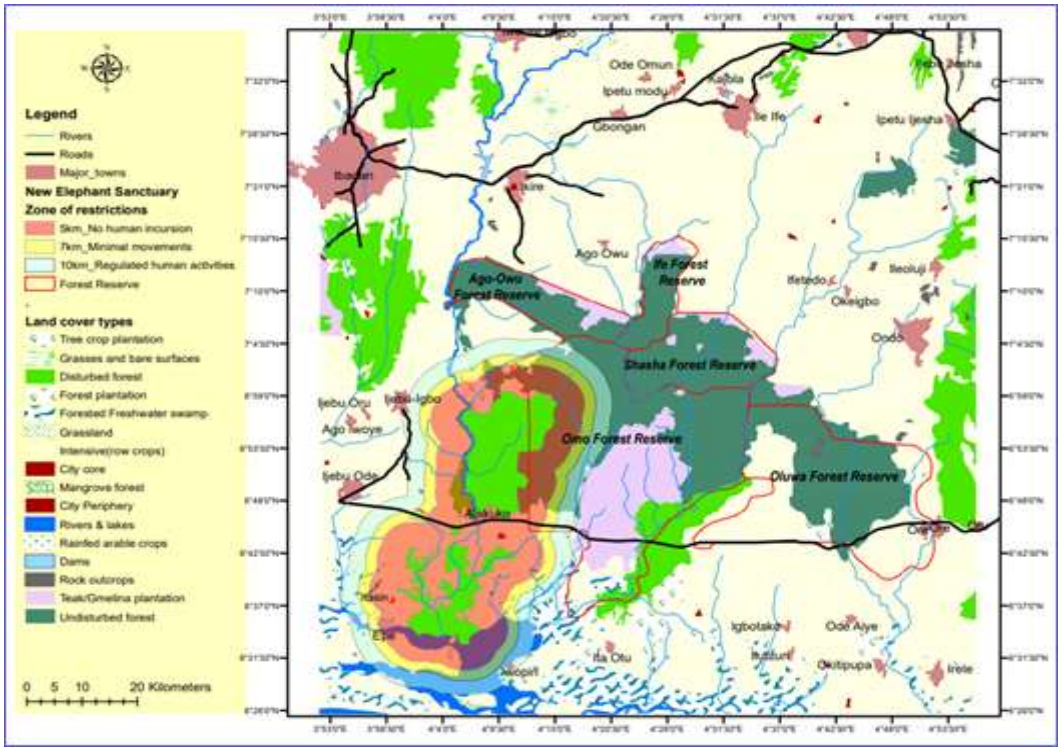


**Fig 5:** Map of the elephant roaming range in the forest reserve complex
*Source: IFSERAR-FUNAAB Geospatial Laboratory, (2024).*

*Primates:* Eight primate species were identified through direct and indirect methods in the forest. These species include the chimpanzee (*Pan troglodytes ellioti*), white throated monkey (*Cercopithecus erythrogaster*), putty nose monkey (*Cercopithecus nictitans*), Mona monkey (*Cercopithecus mona*), red capped mangabey (*Cercocebus torquatus*), Anubis baboon (*Papio anubis*), Potto (*Perodicticus potto*) and dwarf galago (*Galago seneganensis*) (Greengrass, 2009; Fotang *et al.,* 2021). Oluwa Forest appears to offer better potential than Omo Forest for the conservation of populations of primates in the proposed conservation area, with direct evidence of the presence of seven primate species (chimpanzee, white throated monkey, mona monkey, putty nosed monkey, red capped mangabey, pottos and galagos) and the possibility of one or two additional species (baboon and green monkey). With evidence of seven primate species (chimpanzee, white throated, mona, putty nosed guenons, red capped mangabey, potto and galago) and the possibility of one or two additional species (baboon and green monkey), the diversity of primates in the Omo and Oluwa forests is comparable to that in other conservation areas in the region, including Okomu National Park in Edo State. The presence of the endemic white throated guenon and the endangered Nigerian chimpanzee indicates that the forest is a relatively high conservation priority. Threats to primate populations are mainly from the conversion of forest to cocoa plantation arable farming, logging, and hunting.

*Carnivores and others:* The African Civet (*Civettictis civetta*), African Palm Civet (*Nandinia binotata*), African Wild Cat (*Felis Silvestris*) and *Genetta* sp. were identified as resident species in the Omo Forest Reserve (NFEG 1997, cited in Ishola, O. 1995), while the leopard (*Panthera pardus*) was reported as a formerly present species (Ikheme, 2007; Eniang *et al*., 2016). However, a considerable number of hunters in the northern Omo Forest Reserve still insist that leopards are still present in their locality but admit that they occur in very low numbers. Other mammals sighted in the area include the buffalo (*Syncems caffet*), bushbuck (*Tragelaphus scriptus*), and Maxwell duiker (*Cephalophus maxwelli*) tree hyrax (*Dendrohyrax dorsalis*) and the red river hog (*Votamochoerus porcus*) with small mammals such as the cane rat (*Thryonomys swinderianus*), squirrels (*Sciuridae*), brush-tailed porcupine (*Athemurus africanus*), cuisimanse (*Cressarchus obscurus*), pangolin (*Manis spp*.) marsh mongoose (*Atilax pakdinosus*) and bats (*Chiroptera*). Reptiles such as the monitor lizard {*Varanus* spp.), royal python (*Python sebae*) and black-necked cobra (*Serpentes* spp.) also exist. Many of these are directly observable along the trails around the Erin camp.

*Large birds:* large birds such as hornbills, raptors, guinea fowl and francolins are more readily sighted. The distribution of these birds across the survey zones is shown in Table 5.

**Table 5:** Large bird records from reconnaissance survey transects

| | Western Omo | | | Shasha - Oni River | | | Oluwa F.R. | | |
|---|---|---|---|---|---|---|---|---|---|
| | *No.* | *No. per encountered* | *No. per km* | *No.* | *No. per recce* | *No. per km* | *No.* | *No. per recce* | *No. per km* |
| All large birds | 23 | 2.6 | 0.51 | 14 | 2.33 | 0.47 | 21 | 3.0 | 0.60 |
| Large hornbills | 18 | 2.0 | 0.40 | 13 | 2.17 | 0.43 | 19 | 2.7 | 0.54 |

Large hornbills are most frequently sighted in forest reserves. There are four species, namely, black-and-white casqued hornbill (*Bycanistes subcylindricus*), white-thighed hornbill (*Bycanistes albotibialis*), black-casqued hornbill (*Ceratogymna atrata*) and yellow-casqued hornbill. The relative frequency of occurrence of large hornbills is 0.4-0.5 encounters/km. Even in many parts of West Africa, it is very rare to encounter any large hornbills at such a high frequency. This is an indication that the lowland rainforest of SW Nigeria still retains a significant amount of biodiversity and should be conserved.

*Other birds:* On the southern edge of the Ife Forest Reserve, where it adjoins the Shasha Forest, a colony of bristle-nosed barbets (*Gymnobucco peli*) was observed on a dead tree on farmland. This species was recently added to the Omo bird list and is rarely found in southwestern Nigeria.

*Conclusions:* This study provides significant information about biota habitat conditions in the remaining natural rainforest reserves of Southwest Nigeria, drawing attention to the significant pressures from human incursions, including logging and farming residences. The distribution and endangerment to animals were documented, providing baseline data that are crucial for conservation strategy. This study highlights the critical importance of effective conservation strategies using the integration of satellite remote sensing and GIS analysis with field survey techniques to offer creative strategies for evaluating habitats. This study will help us make wise decisions that will protect these ecosystems for coming generations by increasing the understanding of biota habitat protection. The use of remote sensing and GIS will improve the ability to properly manage the remaining forest reserves of southwestern Nigeria.

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