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# REMOTE SENSING-GIS SUPPORTED LAND COVER ANALYSIS OF GASHAKA-GUMTI NATIONAL PARK, NIGERIA

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*Abstract*

*This paper, using remotely acquired data and field survey analyzed land cover types, classified (supervised) and observed mean tree species distribution between the two sectors of the Gashaka-Gumti National Park (GGNP). Landsat Enhanced Thematic Mapped (ETM), 1999 imagery; Two scenes P186R054 and P186R055 were analyzed using Integrated Land and Water Information System (ILWIS) soft ware version3.2a for the land cover types and classification. Using GPS, sample units coordinates and altitude were determined and species distribution per 625m² of unit area were surveyed in the field while, soil types and characteristics were restricted to published documents and field checks. Percentages of cover types and mean species distribution per unit area as well as significance variation in mean species distributions between the two sectors were calculated using student t- test. Result of the data analysis revealed based on set criteria seven land cover classes, which further computed into their percent (%) surface cover. Result of the of the cover types indicated Wood/grass lands constituted 52.42%, gallery forest 20.84% lowland forest 8.46%, montane grass land 9.05% montane forest 5.25%, water bodies/streams 0.62%, rock outcrop 1.80% and bare surfaces 1.54%. The observed mean distribution of tree species per sample unit show means of 41, 48, 46 densities and 9, 10, 9 diversities for the northern, southern sectors and the entire park respectively. Soil type, altitude, nearness to water channels and slope gradient are noted among the determinant factors in observed cover types and distribution pattern.*

Key Words: Biodiversity, Gashaka-Gumti, Land cover, Remote Sensing-GIS, Species distribution

## Introduction

Remotely sensed data has been found to provide effective environmental data at all levels (local, regional, national and global), but limited applications of these data have been made with respect to nature conservation in Nigeria, and in particular Gashaka-Gumti National Park. Use of remotely acquired data for nature conservation studies has the ability to accurately identify and localize the habitat of specific species (Jan de Leeuw and Albright 1999). Biodiversity assessment enabled marking out environmental activity priorities: protection, conservation, restoration, reconstruction and exhibition of plant communities and/or land cover types.

It is generally recognized that the conservation of biodiversity at level of ecosystems, landscapes, species population, individuals and genes is essential to sustain and maintain an integrated healthy and high vitality ecosystems, thereby safeguarding their productive functions (GFA, 2005; Signeid, *et al*., 2000). Naturally, ecosystems (biodiversity) provide goods and services essential to human livelihoods and aspirations, and enable societies to adopt to changing needs and circumstances. The functions and processes characterizing biodiversity or natural ecosystems, supplying humanity with array of services upon which society depends, falls into four (4) classes: 1) Production functions e.g. production of renewable resources such as water, energy resources, raw materials; ii) Regulation functions: regulation of global climate, chemical composition of atmosphere, the oceans, runoff, and recharge of water-catchments and ground water,; iii) Carrier function e.g. provision of space and materials for construction of human habitation, space for cultivation; iv) Information function e.g. provision of services such as aesthetic information (tourism/recreation), religious, historic information (heritage value), scientific and educational information (Lobo, 2001; Ehrlich and Erlich, 1992). Despite the significance of biodiversity, depletion of fauna and flora resources have been occurring on a continuing pace, consequently, many ecosystem services are already faltering (BDCP, 2001).

The goal of conserving biodiversity is to ensure that variability and variation will continue to be present and can dynamically develop and evolve both through natural processes and through direct and indirect intervention and influence of humans (Ericksons *et al.*, 1993). For instance, contemporary research findings and observations both have shown variability in climate over the last years, and this should concern conservationists (Takumine, 2002; ScienceDaily, 2006). At large scales of 10 $km^2$ and above, macroclimate have been seen as a crucial element in the distribution patterns of many organisms (Tokumine, 2002) and that the rate of genetic adaptation is unlikely to match the speed of climate change. This change is already believed to have had an impact or is predicted to cause major changes on many natural systems /biodiversity for which new conservation paradigms must be established ((IPCC, 2001; Peterson *et al.,* 2003). These new paradigms need predictions of potential future change on which to base current conservation strategy. Therefore, the study of land cover types of the vast and diverse landscape of Gashaka-Gumti National Park, using remotely sensed data, GIS and field survey would provide base line information for understanding present conditions and monitoring future trends particularly as it relate to climate variability and likely human interference.

## Environmental setting

The park covers an extensive 6,660$km^2$ land area and falls within land mass of Adamawa and Taraba states of Nigeria. Lying between latitude 6° 55′ to 8° 05′ north and longitude 11° 11 to 12° 13′, in the east the park share boundary with the Republic of Cameroon to the east, to the south and west is the Gashaka LGA of Taraba state while to the north is Toungo LGA of Adamawa state see (Figure 1). Elevation varies from 240 m to 2,400 m above sea level and is characterized by vast plains, floodplains and isolated hills in the northern sector and the southern sector is dominated by undulating relatively high lands, high mountains, and riparian plains (see Figure 2). The lower drier northern sector records mean annual rainfall of 1,500 mm while, the higher wetter southern sector receives mean annual of 2,033mm. Temperatures are on the range of mean annual minimum of 20°C to mean annual maximum of 31.7°C.Numerous streams of varying order of magnitudes proliferate the landscape of the study area. Perennial ones include River (Mayo) Kam the largest in the park, Mayo Yim, Mayo Ngetti and Mayo Gam-Gam.

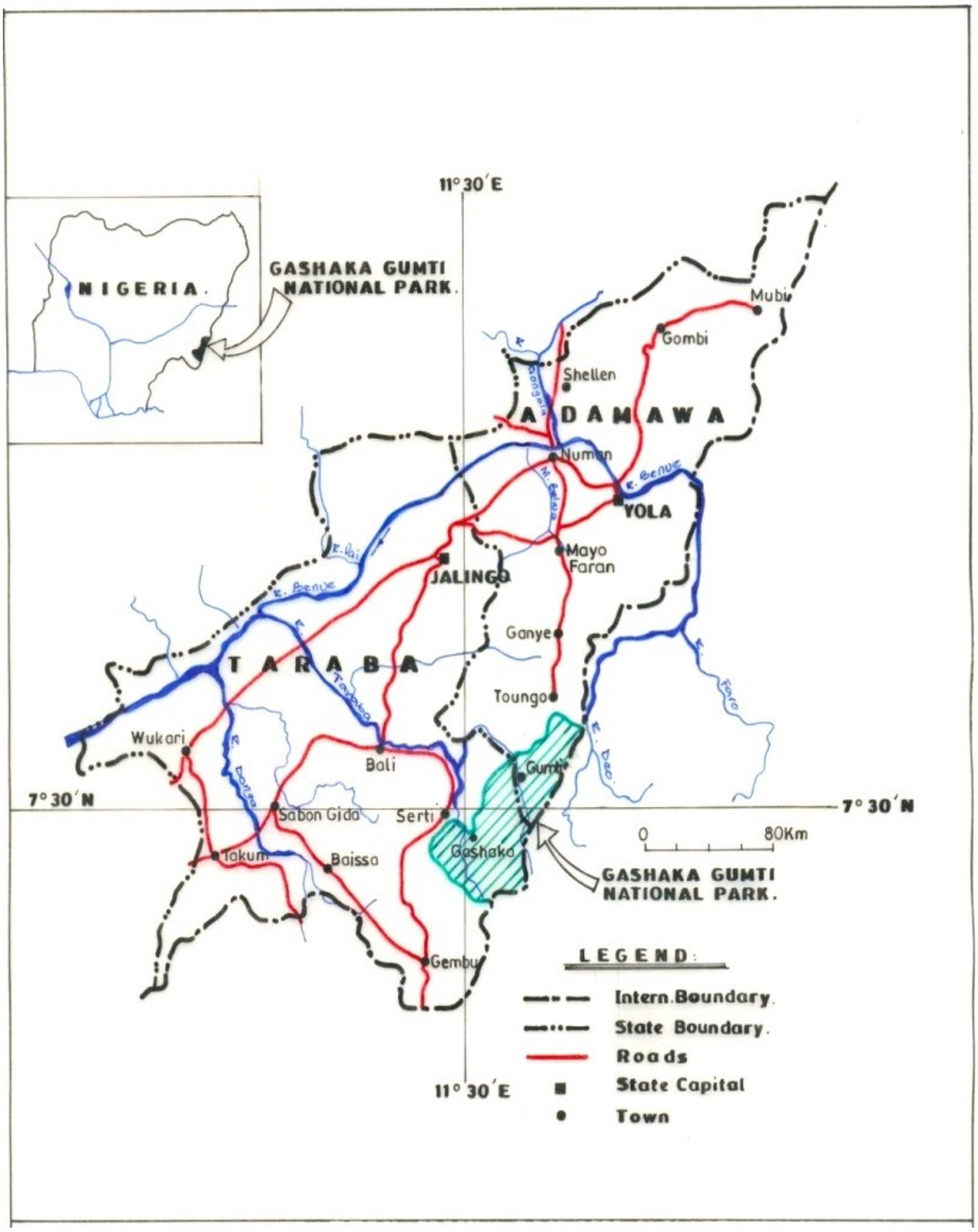


**Fig. 1.0:** Location of the study area. **Source:** Dunn and Ejebare (1999)

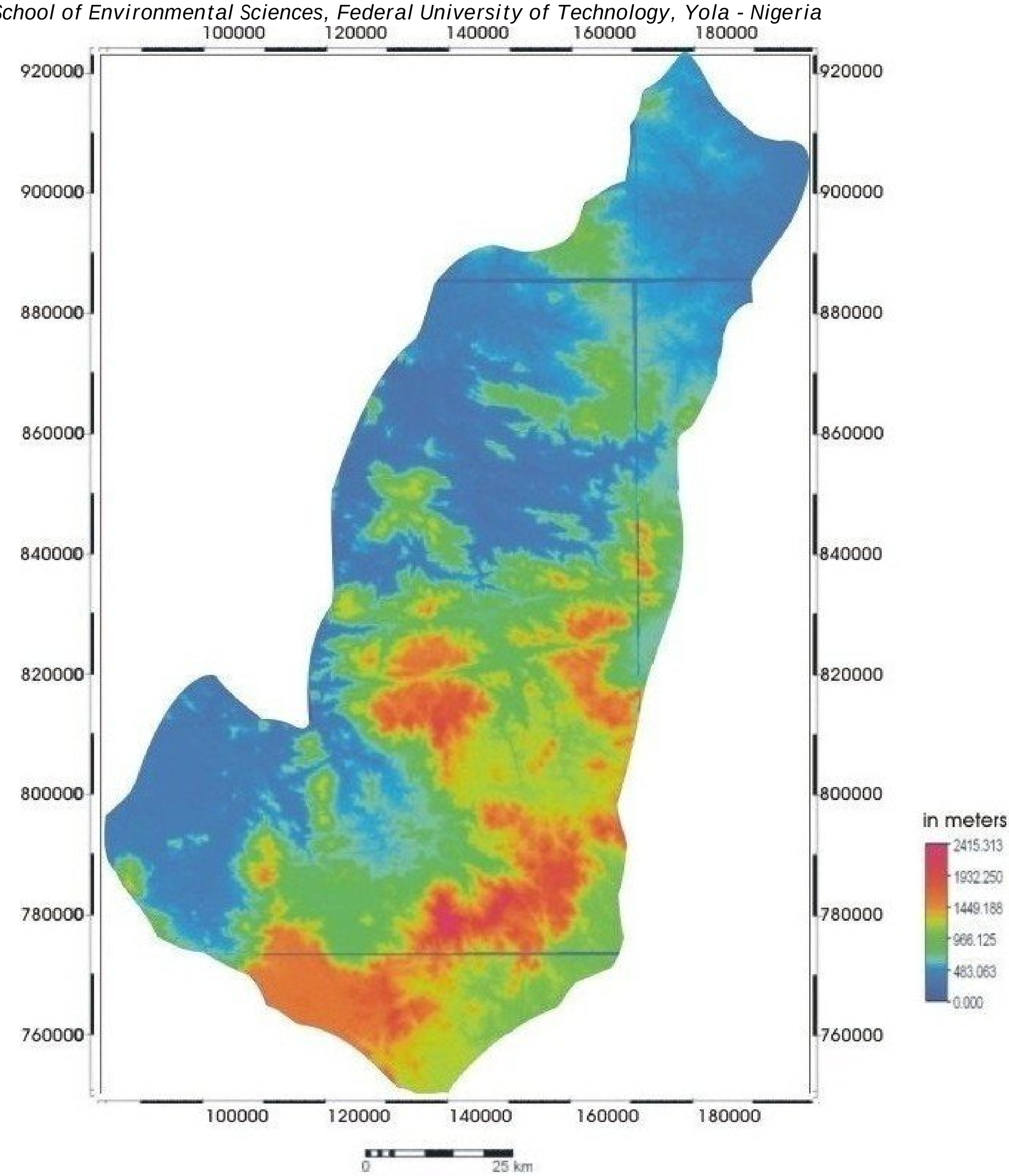


**Fig. 2.0:** Relief -Digital Elevation Model (DEM) of the Gashaka-Gumti National Park **Source:** Mubi, 2008

The soils of the area comprised of Leptesols, mainly on the undulating high plains of the southwestern and central parts of the southern sector. Also in the south, Ferrisols tend to occupy the upper slopes where they occurred along side Acrisols and Leptisols and are associated with altitude of 1400m and above. In the northern sector except for a relatively large area lying between Gumti and Toungo covered with Leptisols Luvisols soil covered the entire plains of the area and support medium to high vegetation cover of trees and grasses (see Fig. 3 and 4).

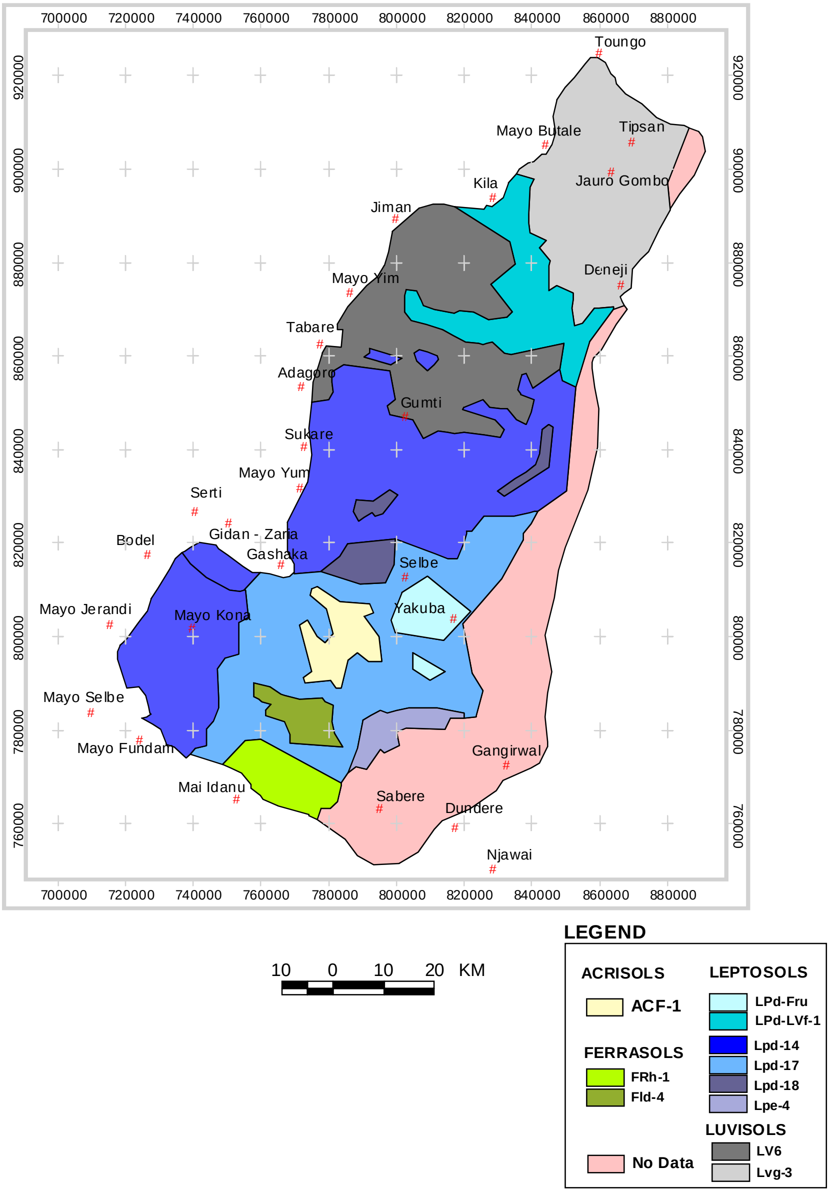


**Figure 3.0:** Soil classes of the Gashaka-Gumti National Park
**Source:** FAO 2(005) Global Soil Regions.

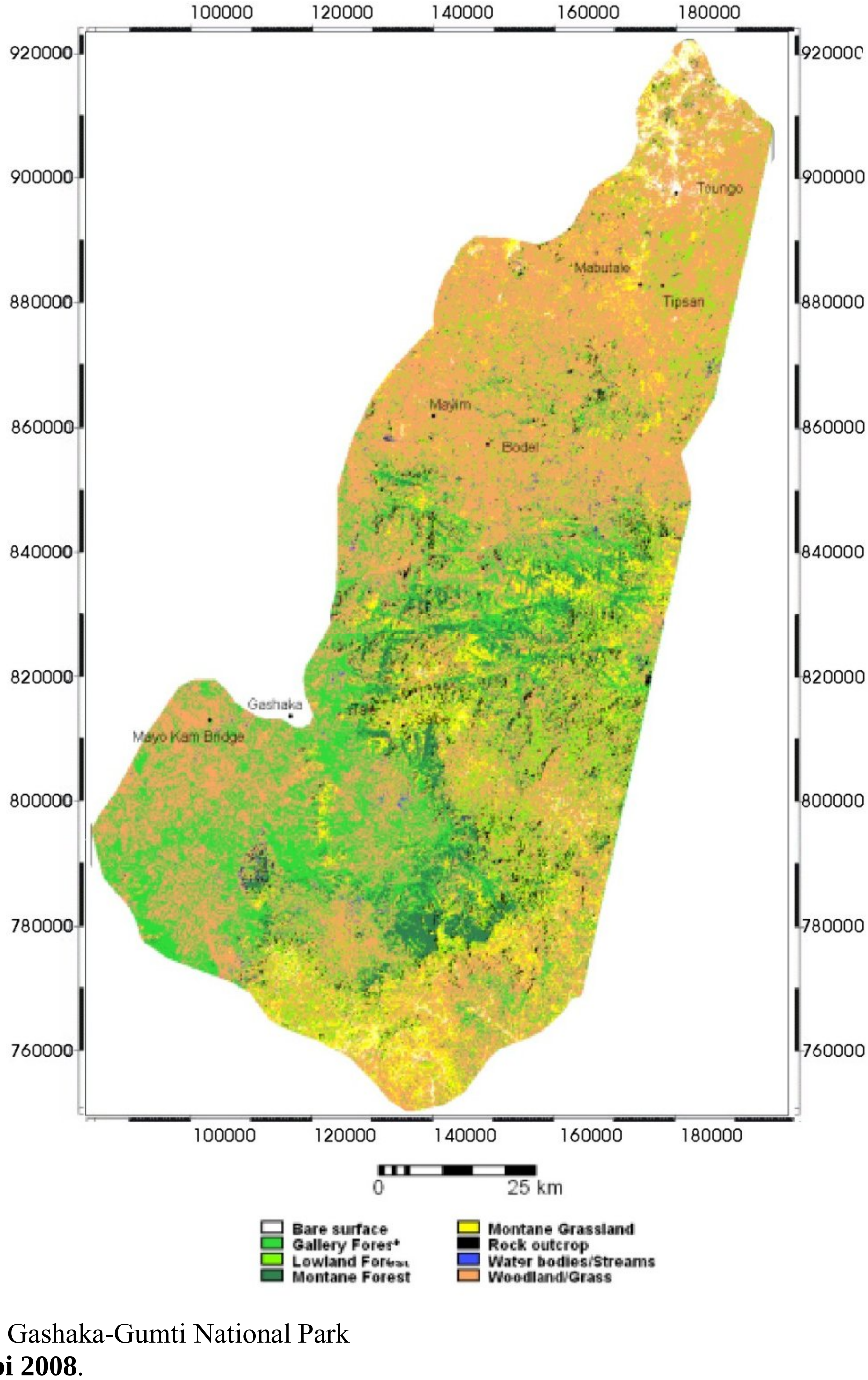


**Figure 4.0:** V Gashaka-Gumti National Park
**Source: Mubi 2008**.

## Materials and Methods

A combination of remotely acquired data, field investigation, GIS and statistical tools were used in data collection and analysis. Landsat ETM, 1999 imageries; Two scenes, P186R054 and P186R055, covering the study area were imported to ILWIS, overlaid and glued to form a scene. The boundary of the study area therefore, superimposed on the satellite imagery, after certifying that the boundary fitted into the imagery, as could be seen from the situation of the coordinates, a subset of the imagery was processed in accordance with the shape of the boundary, and the others were discarded.

A supervised classification of the vegetation into classes was then carried out. Classification is the process of sorting pixels into finite number of individual classes or categories of data, based on their data file values. If a pixel satisfies a certain set of criteria, then the pixel is assigned to the class that corresponds to those criteria. The first part of the classification process was to train the computer, to recognize patterns in the data. Training is the process of designing the criteria by which these patterns are recognized. The training of the data was guided using the data on the location of the different vegetation types obtained in the field during reconnaissance survey/ground truthing.

Total of 39 and 64 quadrants were delineated 625m$^2$ in the field in northern and southern sectors of the park respectively for data training. Data training sites selection were randomly picked based on variation on relief, vegetation types, density and diversity across the park. The southern sector is more diverse in terms of landscape features and vegetation types than the northern sector hence, selection of more samples from that sector. The Minimum Distance method of classification was adopted for the cover classification. It was based on Euclidean Distance towards class mean. The method has an advantage over other methods (e.g. Maximum Likelihood, Minimum Muhalanobis Distance) for areas that have several classes that are difficult to delineate (Matinfar *et al*., 2007). In the case of Gashaka-Gumti National Park, the montane, gallery and lowland forests have similar signatures hence, the choice of the method. The result of the training was a set of signatures, which were criteria for a set of proposed classes: Bare Surfaces, Gallery Forest, Montane Forest, Montane Grassland, Water bodies/stream, Rock outcrop and Wood/Grass lands (see Fig. 4.0).

## Results and Discussion

### Land cover types

Figure 4.0 depicting the vegetation types reveal that montane forests are restricted to the central, southern and towards the eastern part of the Park, where highest elevations over of 1,600m exists (see Figs. 2.0 and 4.0). The lowland and gallery forests characterized the foot slopes of the mountains and the riparian landscapes (Plates 1.1 and 1.2). They are widely distributed (particularly the gallery forests) throughout the Park and are found within an altitude range of 240m to about 1’300m above mean sea level. In-between the montane forests and the lowland gallery forest on the well-drained slopes lay the montane grasslands (Plate 1.3) on heights of about 900m to 1, 600m. Wood/grass lands favored well drained and relatively flat surfaces thus, its concentration in the northern sector and, on well drained undulating surfaces away from the riparian zone in the southern sector (plate 1.4). The percentage cover of the wood/grasslands is higher in the north and appears to be uniformly distributed there. In the south, the wood/grassland vegetation is dominant in the west and extends eastwards to the interior in this sector. Water bodies particularly stream/rivers are widely distributed throughout the park but capturing these features from 30m resolution image during processing was not possible as most of these streams are under thick canopies of the lowland and gallery forests.

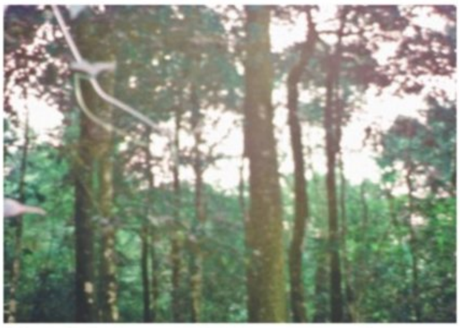

**Plate1.1:** Low land forest around Kwano southern sector - GGNP

**Plate 1.2:** Gallery forest along river Kam, a reach between the Hippo Pool and the Bridge

**Plate1.3:** Montane grassland at Selbe area, southern sector - GGNP

**Plate1.4:** Savanna Woodland/Grass in the southern sector -GGNP

Calculation of cover percentages of the different vegetation types revealed that wood/grasslands the dominant cover type represents 52.42% of the total cover; gallery forests 20.84%, montane forest 5.25%, montane grasslands 9.05%, lowland forests 8.46%, water bodies and streams 0.62% while rock outcrop and bare surface represent 1.80% and 1.54% of the surface cover respectively (see Fig. 5.0).

The domination of wood/grasslands over other cover types could primarily be attributed to factors such as the entire northern sector is flat, well-drained and receives low amount of rainfall which last for few months compared to the southern sector hence, conditions that favored wood/grasslands growth. The presence of numerous networks of streams of varying order of magnitudes, the high elevations in the central, southern and eastern areas of the Park coupled with the high amount of rain received over a period of seven (7) months are some of the supporting factors for the gallery, lowland and montane forests in areas where they exists in the Park. These types of cover ranked 2nd, $4^{th}$ and $5^{th}$ in terms of the area they occupied in the park. Montane grasslands which showed affinity for upper slopes are sandwiched between the montane and gallery/lowland forests, and constitute 3rd order in terms of aerial coverage. Rock outcrop and bare surfaces which dotted the different cover types occupied very small areas hence came 6th and 7th in area coverage respectively. While water bodies/streams though widely distributed throughout the park is eight in term of cover percentage as revealed from the analysis.

| | npix | npixpct | pctnotund | Area | AREAKM2 |
|---|---|---|---|---|---|
| Bare surface | 161321 | 0.71 | 1.54 | 131032982.2 | 131.03 |
| Gallery Forest | 2188379 | 9.60 | 20.84 | 1777510842.7 | 1777.51 |
| Lowland Forest | 887791 | 3.89 | 8.46 | 721108239.7 | 721.11 |
| Montane Forest | 551557 | 2.42 | 5.25 | 448002173.2 | 448.00 |
| Montane Grasslai | 950470 | 4.17 | 9.05 | 772019257.5 | 772.02 |
| Rock outcrop | 189238 | 0.83 | 1.80 | 153708565.5 | 153.71 |
| Water bodies/St: | 65576 | 0.29 | 0.62 | 53264106.0 | 53.26 |
| Woodland/Grass | 5504327 | 24.15 | 52.43 | 4470889605.7 | 4470.89 |
| Min | 65576 | 0.29 | 0.62 | 53264106.0 | 53.26 |
| Max | 5504327 | 24.15 | 52.43 | 4470889605.7 | 4470.89 |
| Avg | 1312332 | 5.76 | 12.50 | 1065941971.6 | 1065.94 |
| StD | 1827207 | 8.02 | 17.40 | 1484149115.2 | 1484.15 |
| Sum | 10498659 | 46.06 | 99.99 | 8527535772.8 | 8527.53 |

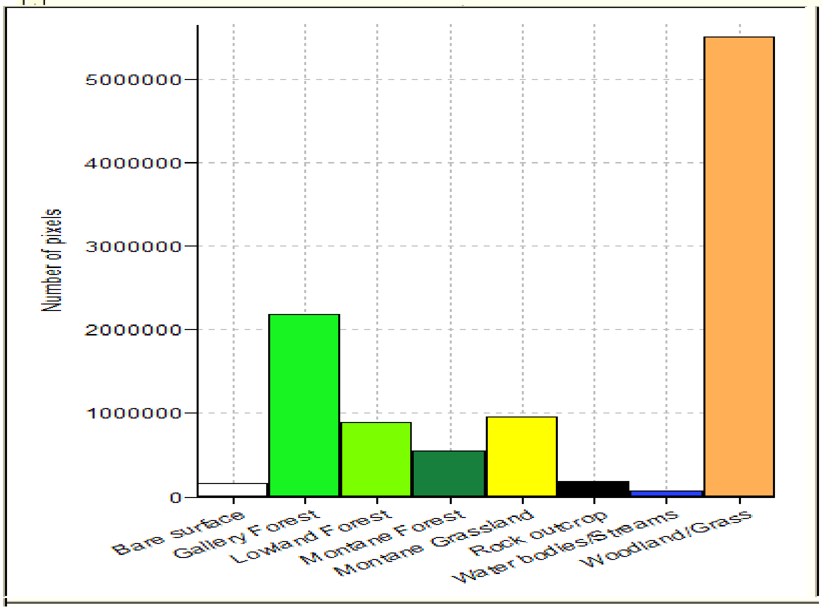


**Fig 5.0:** Area/ percentage of land cover types in the Gashaka-Gumti National Park
**Source:** Mubi, 2008

Mean species density and diversity distribution between sectors of the park

Investigation of species density and diversity distribution across and between the two sectors of the park show variation in the distribution pattern. The sampled northern sector has a mean altitude of 442m and mean species density/diversity of 41 and 9/625m$^2$, while the southern sector has a mean altitude of 594m and species mean density/diversity of 48 and 10/625m$^2$. Whereas, the mean value for the entire Park is 537m for altitude and 45 and 9/625m$^2$ species for density/diversity respectively (see Table 1 and Figs 6.1, 6.2 6.3).

Table 1: Species density and diversity distribution within and across the park

| S/N | Location No. of Sample Points | North (37) | South (64) | Entire Park (103) |
|---|---|---|---|---|
| (a) | Altitude (m) | | | |
| | Mean | 442 | 594 | 537 |
| | Range | 399 | 1,604 | 1,604 |
| | Standard Deviation | 112.38 | 442.84 | 362.41 |
| | Covariance (%) | 25 | 75 | 68 |
| | Standard error | 17.995 | 55.355 | 35.709 |
| (b) | Species Density/625m$^2$ | | | |
| | Mean | 41 | 48 | 46 |
| | Range | 109 | 117 | 119 |
| | Standard Deviation | 22.68 | 25.60 | 24.67 |
| | Covariance (%) | 55 | 53 | 54 |
| | Standard error | 3.633 | 3.200 | 0.492 |
| (c) | Species Diversity/625m$^2$ | | | |
| | Mean | 9 | 10 | 9 |
| | Range | 16 | 19 | 19 |
| | Standard Deviation | 3.54 | 3.93 | 3.77 |
| | Covariance (%) | 39 | 42 | 40 |
| | Standard error | 0.568 | 0.492 | 0.372 |

Source: Mubi, 2008

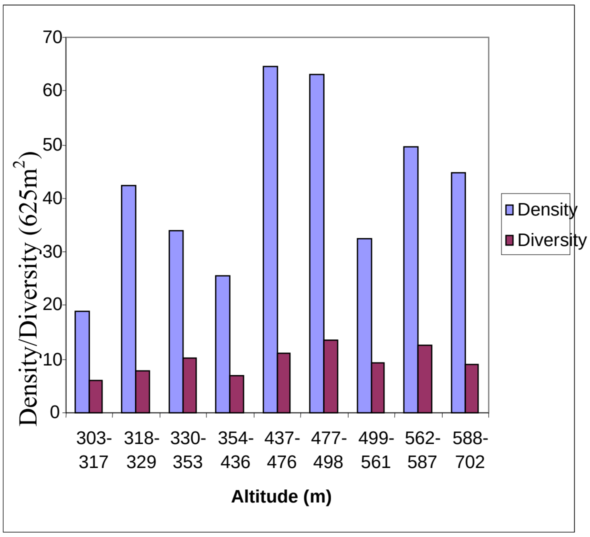


**Fig. 6.1** Mean species density/diversity distribution pattern with altitude for the northern sector.
**Source:** Mubi, 2008

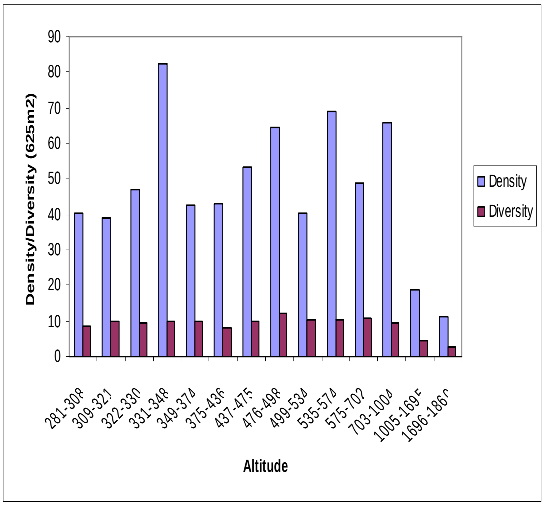


**Figure 6.2:** Mean species density/diversity distribution pattern with altitude for the southern sector. **Source:** Mubi, 2008

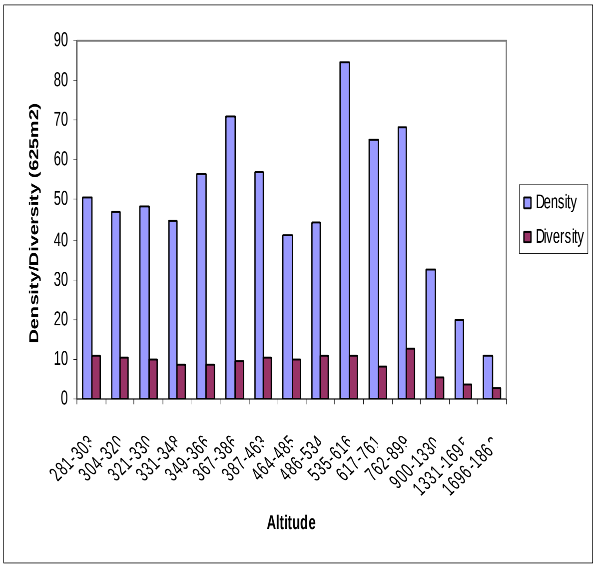


**Figure 6.3**: Mean species density/diversity distribution pattern with altitude for the entire park **Source:** Mubi, 2008

The observed patterns in the species mean density between and within the Park could be attributed to the variation in the characteristics of variables (relief altitude and gradient in particular, soil and hydrology) which determine species and their density and diversity distribution patterns.

Comparison of mean species distribution per unit of land between the southern and the northern sectors using Student t – test at 0.095 test level, revealed values of 10.16 for density which is significant and 0.035 for diversity which is not significant. What this results show is that, the general distribution of species per individual unit ($625m^2$) varied significantly between the two sectors in the case of density. But in the case of diversity there is no significant variation in the mean distribution between the two sectors. This however is attributable to the fact that the diverse composition measured per sampled unit is found to be determined by other factors such as soil, and altitude rather than species density.

Furthermore, criteria for a particular species to be counted as being abundant is worked based on their means, frequency and density distribution per unit ($625m^2$). The means are classified into quartiles and that specie is said to be abundant if either it's mean frequency or mean diversity fall into the first upper quartile. *Terminalea glaucoscens, Burkia africana, Hymoneacardia acida Psedocidria koschel* and *Danialia oliveri* are the most frequently distributed tree species in the northern sector. In the southern sector *Nauclea latifolia, Corossopteryx februfuga, Annona senegalensis* and *Uapaka togoensis* constituted the main tree species (see Table 2).

**Table 2:** The abundant species in the sample units (103) of the northern/southern sectors and the entire Park

| Northern Sector 39 | | | Southern Sector 64 | | | Entire Park 103 | | |
|---|---|---|---|---|---|---|---|---|
| SPPT | FSU ($625m^2$) | SMDU ($625m^2$) | SPPT | FSU ($625m^2$) | SMDU ($625m^2$) | SPPT | FSU ($625m^2$) | SMDU ($625m^2$) |
| *Uapaka togoensis* | 13 | 7.92 | *Uapaka togoensis* | 32 | 15.68 | *Uapaka togoensis* | 45 | 13.44 |
| *Monetis kestingii* | 3 | 35.0 | * *Diospyros spp* | 21 | 15.85 | * *Diospyros spp* | 24 | 12.74 |
| *Terminalia glaucoscens* | 26 | 4.69 | *Hymenocardia acida* | 25 | 7.12 | *Hymenocardia acida* | 38 | 7.05 |
| *Hymonecardia acida* | 13 | 6.92 | *Crossopteryx februfuga* | 24 | 6.37 | *Crossopteryx februfuga* | 42 | 5.21 |
| *Isoberlinia tomentosa* | 8 | 9.62 | *Annona senegalensis* | 28 | 4.69 | *Annona senegalensis* | 41 | 4.85 |
| *Burkia Africana* | 12 | 6.33 | *Nauclea latifolia* | 24 | 3.08 | *Terminalia glaucoscens* | 40 | 7.07 |
| *Psedocidiria koschyel* | 9 | 8.33 | * *Vitex doniana* | 29 | 1.93 | *Piliostigma thonningii* | 37 | 3.75 |
| *Danielia oliveri* | 9 | 7.22 | | | | | | |

•SPPT – Species type •FSU – Frequency of species per unit •SMDU – Species mean density per unit *Mainly riparian species. Source: Mubi, 2008

## Conclusion

The vast area of Gashaka-Gumti National Park host diverse and dense population of flora species, variedly distributed across the park landscape units. Significant variation existes in the area of species density distribution compared to no significant variation in species diversity distribution as it relate to density per unit area. Spatial difference in elevations, numerous streams of different order of magnitudes and different soil groups combined to provide unique habitats for the observed densities and diversities. For better understanding, protection, monitoring and conservation of landscape/species relatedness there is need for detailed analysis of soil properties of the park and practical application of remote sensing and GIS tool, so as to present the park resources in both historical and geographical context.

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