Land Transformation of Tropical Forest Conservation Sites in Nigeria: Case Study of Gashaka-Gumti National Park from 1987–2014.

ABSTRACT:

The study utilized Landsat imageries of 1987 (Landsat Thematic Mapper (TM)), 2000 (Landsat Enhanced Thematic Mapper plus (ETM+)) and 2014 (Landsat Operational Land Imager (OLI)) to examine land transformation in the Gashaka Gumti National Park. The analysis indicated that dense forest which occupied 367,500 hectares at 62.2% of the total area of the park in 1987 have been converted into farmland and built-up area. Thus, the dense forest have reduced to 343, 300 hectares by year 2000 and 107, 600 hectares in 2014 respectively. The result shows that the riparian forest decreased from 21,300 hectares in 1987 at 3.6% to16, 000 hectares in 2000 at 2.7% and further to11, 000 hectares (1.8%) by 2014. Savannah vegetation found to be concentrated in the northern part of the study area and occupied a total area of 81,260 hectares at 13% in 1987, reduced to 62,100 hectares at 10.5% in 2000 and increased to 183,800 hectares at 31.1% of the total area in 2014. Built-up area occupied total area of 4,476 hectares at 7.5% in 1987. The built up increased to 11,070 hectares at 1.81% in 2000 but decreased to10.930 hectares at1.85% in 2014 as a result of the news that the insurgents were shifting their base towards the park to hide from security forces and some of the people living within the area became afraid and deserted their houses and resettled in the nearby towns and villages that are outside the park

Keywords: Land Transformation, Gashaka Gumti National Park, Landsat images.

INTRODUCTION

Land is defined as the earth's surface, including both land and water, and the natural resources in their original states. Land use involves both the manner in which the biophysical attributes of the land are manipulated, and the intent underlying that manipulation – the purpose for which the land is used [1]. The consequences of forest fragmentation include habitat loss for some plant and animal species, habitat creation for others, decreased connectivity of the remaining vegetation, decreased patch size, increased distance between patches, and an increased in edge at the expense of interior habitat [2]

Uncontrolled human activities have led to significant modification of the natural biodiversity in the world over the years. Consequentially, land use and land covers are changed abruptly without adequate consideration for future developments. There is continuous deterioration from the rich biodiversity. The effects of land use on the environment ranges from minor land cover changes and soil modification to severe desertification, deforestation, erosion, and river encroachment problems.

According to FAO [3], fragmentation of forest may also be as a result of natural occurrences or human induced activities, which vary in terms of the extent, severity, quality, origin and

39 frequency. The natural induced process can be through fire, storm, drought, pest and disease
40 among others, and the human induced   activities could be unsustainable logging, excessive fuel
41 wood collection, shifting cultivation, unsustainable hunting, overgrazing just to mention but few.
42 The International Tropical Timber Organization (ITTO) [4] estimated that, eight hundred and
43 fifty (850) million hectares of tropical forest and forest lands could be forest edge through human
44 induced activities such as logging and agricultural practices.

45 In Gashaka-Gumti National park (GGNP), forest fragmentation is a serious problem to the
46 environment as it affects the social activity and the economy of nation as a whole. Gashaka-
47 Gumti forest is one of the revenues generating sources to the nation through its timber
48 production, wildlife conservation and tourism. The forest servicing River Benue, Donga and
49 River Taraba tributaries as they flow through it. These rivers serve as the transportation routes in
50 the states as well as fishing. If the occurring of forest fragmentation is not controlled, it may lead
51 to the loss of all these benefits and the products of the climatic variations resulting into various
52 north-south degradations of habitats and ecosystems [5]. The habitat support more than 1,340
53 species of animals among which is 274 mammalian species, making it the 8th highest in Africa
54 [5]. Dauda et al [6] revealed that forest fragmentation of the park led to the withdrawal of the
55 above mention services. Besides, the park serves as carbon sequestration and contributing good
56 health of the people. The distribution of National parks in Nigeria was done to preserve and to
57 protect the natural resources especially the forest from fragmentation.

58 The ecosystem of the park loss its economic value as forest fragmentation keeps on occurring
59 [6]. The Government of Nigeria introduced laws and policies that bound the illegal activities in
60 GGNP to protect and to preserve the forests. Trespassers if arrested are prosecuted. In spite of
61 these laws, the forest continues to be fragmented. The failure of this management policy could be
62 attributed to; the negligent in supervision, inadequate training of the insufficient personnel and
63 lack of motivation on the part of forestry officials. Other ill effects of the management policy
64 are; Government pressure on revenue generation without regard for biodiversity conservation,
65 active collusion of forestry officers, politicians interest, village chiefs and merchant loggers in
66 illegal logging and ultimately forest destruction. The activities that result in forest destruction or
67 fragmentation has been linked with the economic decline of the national park and global climate
68 change, hence it must be halted [7]. Therefore, there is need to use the fragmentation index with
69 the available geospatial techniques to assess forest fragmentation in GGNP in Taraba /Adamawa
70 states with view to develop data base for monitoring.

71 The aim of the study is to analyze the land transformation taking place in the Gashaka-Gumti
72 National Park from 1987– 2014, with a view of identifying the different land use/land cover
73 types within the Gashaka-Gumti National Park; Evaluate the spatial pattern of land
74 transformation in Gashaka-Gumti National Park and analyze the trend and rate of land
75 transformation in Gashaka-Gumti National Park.

76 **Functions and Objectives of the National Park Service in Nigeria**

Nigerian Conservation Foundation [NCF], [8] reported that the Nigeria National Park Service has the statutory responsibilities for the following, amongst others functions, which are to:

    (i)   preserve, enhance, protect and manage vegetation and wild animals in the National Parks;

    (ii)   advise the Federal Government on the development and preservation policy of the National Parks including the financial requirements for the implementation of such policy, and to wildlife species, biotic communities, sites of special interest or of aesthetic value, the Service considers may be declared as National Parks under this Act [9]

    (iii)   conserve some selective and representative samples of wildlife communities in Nigeria with the aimed at the establishment of an ecologically and geographically balanced network of protected areas under the jurisdiction and control of the Federal Government [10]. The protection and the conservation of wildlife throughout Nigeria so that the abundance and diversity of their species are maintained at the optimum level commensurate with other forms of land use, in order to ensure the continued existence of wildlife for the purpose of their sustainable utilization for the benefit of the people are the priority [11].

    (iv)   reserve outstanding scenic, natural, scientific, recreational and other values in the National Parks, and to protect and maintain of crucial wetlands and water catchment's areas [12].

NCF (2016) reported that the government of Nigeria has the vision to manage and regulate the use of these unique ecosystems designated as National Parks by such means and measures to preserve and conserve Nigeria's heritage, particularly the fauna and flora, the habitats they live in, and the unique sceneries they afford. Its mission is to also provide human benefits and enjoyment in such manner and by such means so that these are left unspoiled for generations to come. www.panthora.org recorded that the vision was also to develop a network of National Parks (Table 1 & Figure 1) that can compete favourably with other National Parks in the world and to achieve this; the Park Service is making efforts to put in place Operational Management Plans for each Park, and Systems Plan for the entire country.

Table 1: The distribution of National parks in Nigeria with location and sizes

S/N	NAME	STATE(S)	HEAD OFFICE	SIZE
1	Chad Basin	Borno/Yobe	Maidugari	2,258 sq.km
2	Cross River	Cross River	Akampa	4,000 sq.km
3	Gashaka-Gumti	Adamawa/Taraba	Serti	6,731 sq.km
4	Kamuku	Kaduna	BirninGwari	1,121 sq.km

5	Kainji Lake	Kwara/Niger	New Bussa	5,382 sq.km
6	Okomu	Edo	Arakhuan-Udo	202.24 sq.km
7	Old Oyo	Oyo	Oyo	2,512 sq.km
Estimated Total Conservation Area				22,206.24 sq.km

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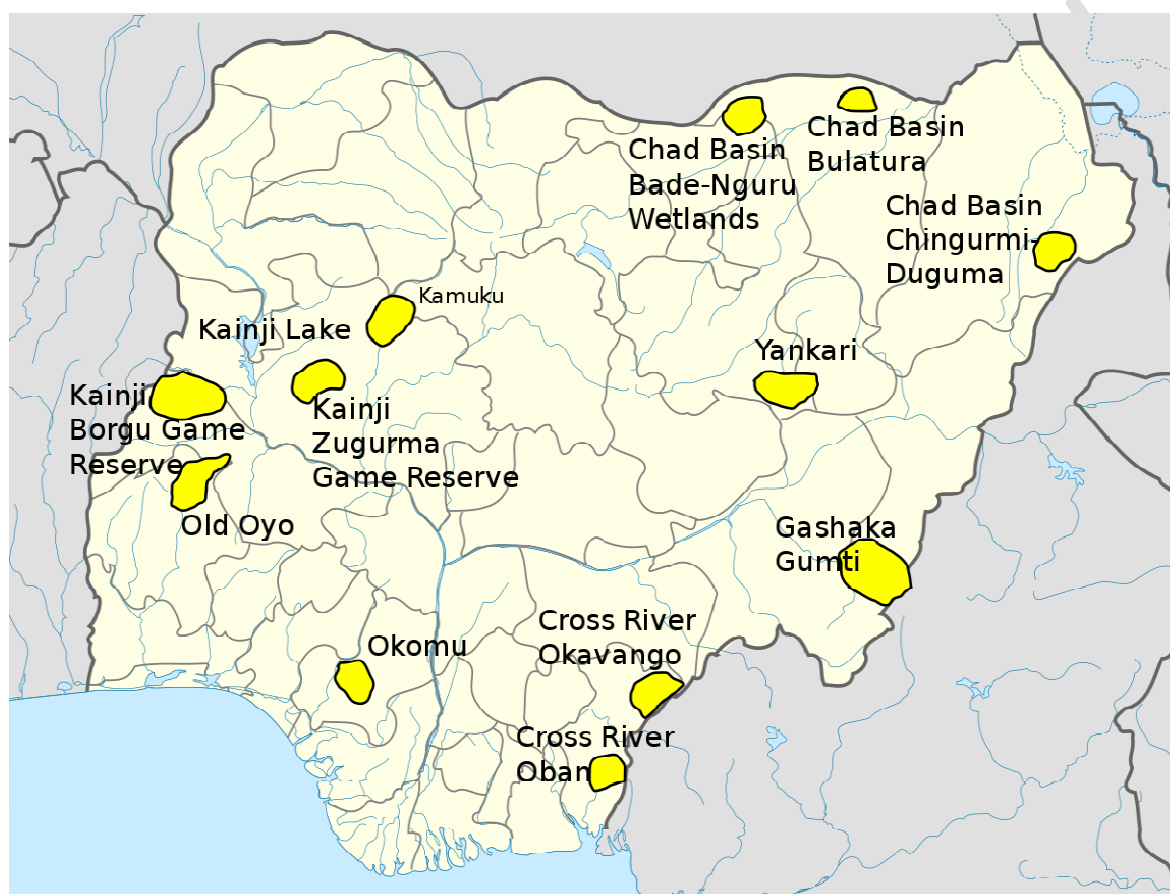
Figure 1: Location of National Parks and Game Reserves

Source: NCF, [8]

Materials and Methods

Location and Size: Gashaka-Gumti National Park (GGNP) is located in the mountainous region of north-eastern Nigeria, adjacent to the international border with Cameroon, and immediately to the north of Mambilla Plateau [13]. It is the largest and most scenic of all the seven National Parks in Nigeria. This conservation area lies between latitude 6° 55' and 8° 05' north, and

117   longitude 11°11' and 12°13' east (Figure 2) and covers a total area of 6,731 sq.km [14]. Located

118   in Adamawa and Taraba States, the Park is contiguous with Faro and TchabalMbado National

119   Parks in the Republic of Cameroon [15].
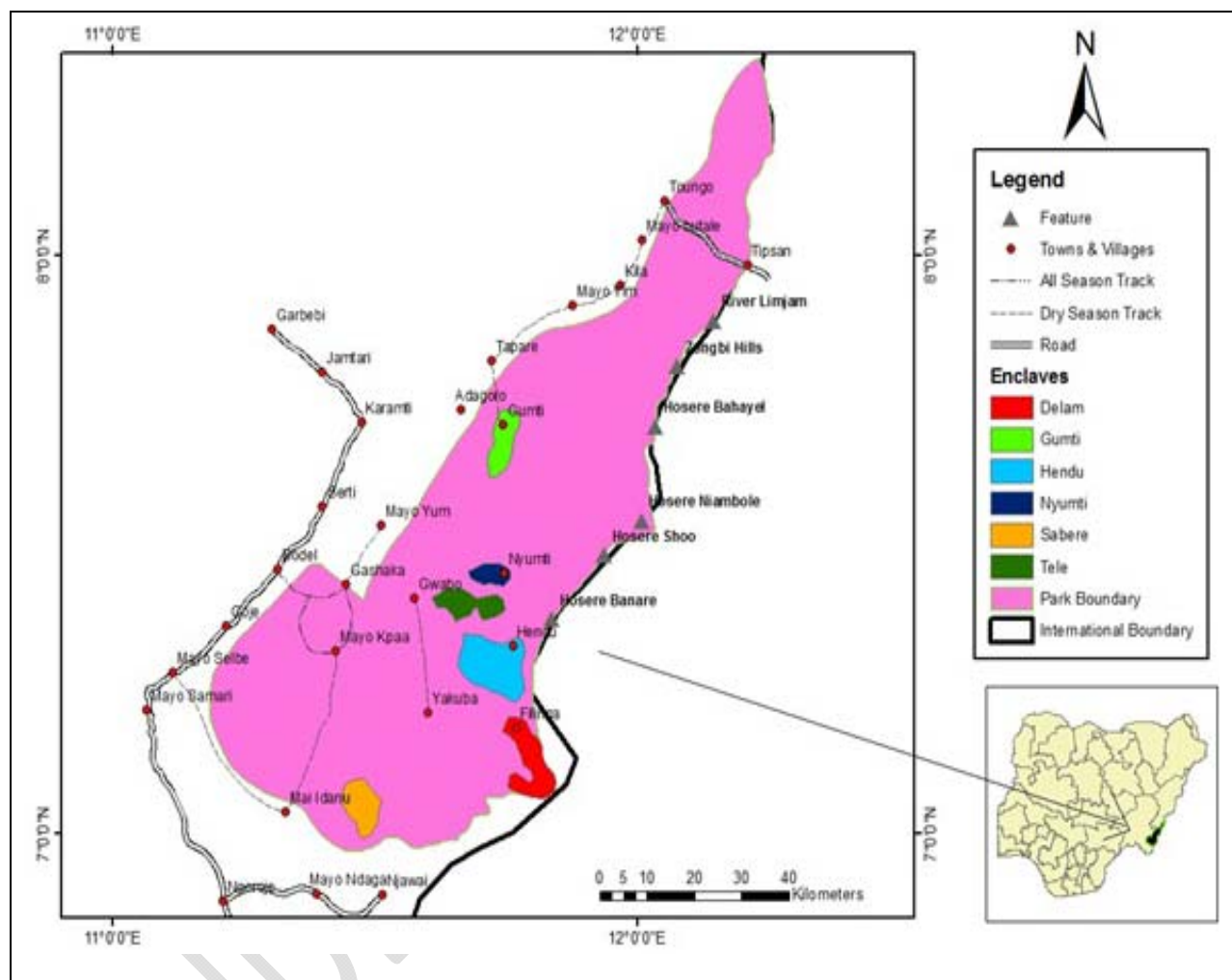
120   **Figure 2**: Map of the Study Area

121   The Park experiences varying pleasant weather conditions, depending on one's location within

122   the Park [16]. These range from tropical dry humid, tropical moist humid in the lowlands to sub-

123   tropical highland weather on the high plateau around Chappal Waddi, Sabere and Fillinga [13].

124   In fact, the hidden corner of West Africa that is Gashaka-Gumti National Park is surely one of

125   Africa's best places [17]

126   [18] observed that Gashaka-Gumti National Park (GGNP) consists of savannah, dry deciduous

127   woodland, fresh water swamp vegetation, lowland gallery forest, mountain forest riparian forest

128 and cold mountain grassland. The Park is divided into two sectors; the Northern Gumti and
129 Southern Gashaka. The northern Gumti sector is characterized by tall grassland, trees with
130 usually short boles and broad leaves [19]. In southern Gashaka sector, moist guinea savannah
131 predominates. The climate is broadly characteristic of guinea savannah zone which is an
132 intermediate between the humid wet climate of the forest zone and hot dry climate of the Sudan
133 and Sahel savannah [14]. Rainfall commences in April and lasts to late November with a yearly
134 approximate rainfall ranging from 300mm to 1200mm and dry season usually last from
135 December to March [19]

136 The altitude ranges from about 457 meters (1,499 ft) in the northern flatter corner of the park, up
137 to 2,419 meters (7,936 ft) at Chappal Waddi. Nigeria's highest mountain in the park's southern
138 sections [20]. It is an important water catchment for the Benue River. There is abundant river
139 flow even during the markedly dry season. Enclaves for local Fulani pastoralists exist within the
140 park boundary that allow for farming and grazing [17]

141 In terms of vegetation, the multiple regions of the Gashaka Gumti National Park lead to its
142 diversity of wildlife. In the Northeastern area of the park, it is relatively flat allowing for savanna
143 woodlands. In particular, these woodlands are the Sudan Guinea savanna woodlands, covered in
144 coarse, tall grasses and fringing forests with some striking vegetation, such as the intense red
145 leaves of *Brachystegia eurycoma* and the great white flowers of *Berlinia grandiflora*. Lions,
146 African elephants, African buffalo, waterbuck, and many more animals are housed here. As you
147 move east, the highlands, specifically the montane grasslands and shrublands, occur within the
148 mountainous regions of the park [18]. The canopy of the montane forest is rarely closed,
149 allowing for rich vegetation on the highland floor. The tallest trees are often stragglers, like the
150 ficus and other species of fig. Within and near the highlands, vast lowland rainforests, tropical
151 and subtropical moist broadleaf forests, begin to take over [18]. The rainforests are dense, hot,
152 and humid. The forest vegetation is dominated by woody species, mainly tall trees. This region
153 contains many different species ranging from chimpanzees to leopards to giant forest hogs,
154 creating the most diverse variety of species in this particular biome [9]. The park is officially
155 labeled as one of Africa's "Important Bird Areas" with more than 500 species found here. In
156 regards to species adaptations, plants have long tap roots that descend far into the ground
157 reaching the deep water tables of the savanna biome. In the woodlands area of Gashaka National

158 Park trees have thick bark which aides in wildfire protection [8]. Additionally, the trunks of these
159 trees store water during the dry season as well as their leaves that fall during the dry season that
160 occurs over the winter months to conserve water. The grasses in the savanna biome also hold
161 adaptations to avoid overgrazing of the diverse animal culture of the national park. Some of these
162 adaptations include sharp or bitter tasting grasses for some animals to deter depletion of the
163 grasslands biome [18]. Many animals that live in the savanna have long legs or wings that allow
164 migrations to be accomplished easier; while others have the ability to burrow through adaptation
165 to access cooler temperatures or raise their young underground [8]. Aside from climate, other
166 factors that influence the vegetation and wildlife of Gashaka Gumti National Park are
167 environmental hazards, deforestation, urbanization, poachers from the Cameroonian border, and
168 human activities, such as a yearly burning that has turned the once semi-deciduous forest into a
169 grassy woodland. Some of the animals that are impacted by the illegal poaching are chimpanzees
170 and other species of monkeys, which is why the Gashaka Primate Project was created. The
171 project helps to contain the monkey populations and stop the system of illegal poaching [8].

172 Geologically, The Gashaka-Gumti National Park is approximately two-thirds of Nigeria's land,
173 which places it within the middle of the African Plate. Since it is not located near a fault line,
174 major earthquakes do not occur here. At times, some tremors can be felt and this can be due to
175 the close proximity to the mostly inactive Ifewara fault line which is linked into the Atlantic
176 Fracture System. The land that Gashaka-Gumti is located on and its underlain by the pre-
177 Cambrian Basement Complex. The pre-Cambrian Basement Complex and the Ifewara fault line
178 have previously contributed to the movement and formation of geology and landforms in the
179 area. The only hazard that affects the national park is landslides [21]. This geologic hazard
180 occurs because of the sedimentary rocks that are in the area. The sedimentary rocks in the region
181 are known to be mineralized with lead and zinc. The pre-Cambrian Basin also is considered the
182 "oldest, crystalline, solid foundation in the country" and contains the igneous and metamorphic
183 rock. The sedimentary rock is found in the basins that separate the basement complex landmass.
184 The hazard of landslides and the main type of rock is defined as sedimentary, which leads to
185 erosion and weathering of landforms within the park [21]

186 The Northern Section of Gashaka-Gumti is characterized by flat woodlands and grasslands,
187 while the Southern portion of the park is characterized by mountains and deep slopes [21]. The

188 mountainous region of GashakaGumti National Park provides an optimal landform of the
189 forested slopes for the local watershed, which pours into the Taraba River. This waterway is the
190 major tributary to the second largest river in Nigeria, the Benue. The rich vegetation along the
191 slopes of the mountains that allows a "trickle-down" effect to occur with rain is vital to the
192 mainstay of these rivers. Without the slow movement of water through this watershed, the dry
193 season would cause detrimental issues to the river water levels due to the vast evaporation that
194 occurs during this time [15]. Different landforms that contain liquid water, such as swamps,
195 rivers, and lakes each support their own unique communities of plants and animals. For example,
196 rivers provide havens for several varieties of fish, otters, hippos, and crocodiles. Inferring from
197 common clues of glacial impact and residue, Gashaka-Gumti National Park seems to hold certain
198 characteristics of glacial impacts. For instance, the National Park is characterized by flowing 'V'
199 shaped valleys and waterfalls, which allude to similar themes of a glacial presence at one point in
200 the history of the region. Furthermore, these rugged terrains, steep slopes and plunging valleys,
201 Gashaka-Gumti's iconic characteristics could also be attributed to wind erosion. This correlates
202 with the region's relationship with the Sahara Desert. Erosion also occurs from heavy rains
203 during the wet season [21]

204 **Methods:** The dataset used for the study are satellite imageries from United State Geological
205 survey (USGS) website. Other data include administrative maps, as well as topographical data of
206 the study area. The data used in this study are multi-temporal satellite images which include:
207 Landsat Thematic Mapper (TM), Landsat Enhanced Thematic Mapper plus (ETM+) and Landsat
208 Operational Land Imager (OLI). These images were extracted for the study area on; 1987, 2000
209 and, 2014 with path 186/185 and, and row 055/054 respectively. The images were mosaic to
210 cover the study Area. This provided the spatial data base on which the classification of land
211 cover was carried out. The Landsat imageries were downloaded from the official website
212 http//www.earthexplorer.usgs.gov. All sensors have spatial resolution of 30m (Table 2 and 3).
213 The primary data was collected from the field through the measurement of vegetation parameters
214 on the physical attribute of land cover types namely, Farm land (edge), Build-up area, dense
215 forest, savannah and Bare surface. Addition ground reference data were collected with
216 observations for the 'unsupervised' classification. Number of stands of each species found in a
217 quadrat measuring 10 meters by 10 metres were observed and counted.

218 The study area was delineated using clipping method in IDRISI software tool, identifiable from
219 the scanned and geo referenced 1: 500,000 Topographic maps covering the study area. From the
220 topographic map, the contour and drainage networks were extracted and populated with their
221 various features and other values respectively using onscreen digitization process and saved into
222 the work used to clip (sub-map). ArcGIS 10.3 and IDRISI selva were used in this study.

223 **Table 2: Characteristics of Data Used**

S/N	Type	Format	Scale Resolution	Date/Source
1	Topography	Analogue	1:500,000	**1991**
2	Demographic Data	Analogue		**NPC, 2006**
3	Administrative Map	Analogue	1:500,000	**Administrative Office, GGNP Serti, Taraba State**

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225 **Table 3: Characteristic of Satellite Image Data**

S/N	Data type	Form	Path/Row	Date Acquisition	Scale-Resolution	Source-Website.
1	Landsat image-MSS	Digital	186/055, 186/054 185/054	1987	30m	USGS
2	Landsat image-TM	Digital	186/055, 86/054 185/054	2000	30m	USGS
3	Landsat image-LDCM	Digital	186/055, 186/054 185/054	2014	30m	USGS

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227 **Image Processing**

228 The images were pre-processed to correct the spectral variation resulting from sensor differences
229 before the study area is extracted from each dataset. False Color Composite (FCC) was created

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230 using near-infrared, red and green Bands (432,432 and 654) for each of the images respectively
231 as reported by Gonzalez et al., [22]. The selection of Band combination was done to enhance our
232 ability to clearly distinguish vegetation types from non-vegetated land use. The pattern of change
233 is determined using the post classification comparison method proposed by Babb et al., [23]. The
234 co-ordinates of some location were obtained using Global Positioning System (GPS) to identify
235 plant species density in the study area (GGNP).

236 **Table 4: The selected training sites (dominant land cover types in the study area)**

S/N	Training sample	Description
1	Build-up area	Area occupied by people for habitation
2	Dense Forest	Area cover with undisturbed forest
3	Riparian forest	Forest cover under which is full of water bodies or rivers.
4	Savannah	Area of open land that is cover with grass and woodland
5	Bare Surface	Area of empty space
6	Farm land	Area occupied with anthropogenic activities such as farming.

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238 **Post-Classification Comparison**

239 Many methods such as, Image overlay, change vector analysis, principal component analysis,
240 image rationing, change detection in forest cover, post classification comparison and Image
241 overlay were used in this research. In this technique, images of different dates were classified
242 and labeled individually. Using supervised classification, the classified Images were then
243 compared and the forest edge areas extracted and are determined using IDRISI software. Post-
244 classification comparison was used to detect dense forest from other classes, and changes
245 detection in general Land Use. Figure 3 shows the flow diagram of the study.
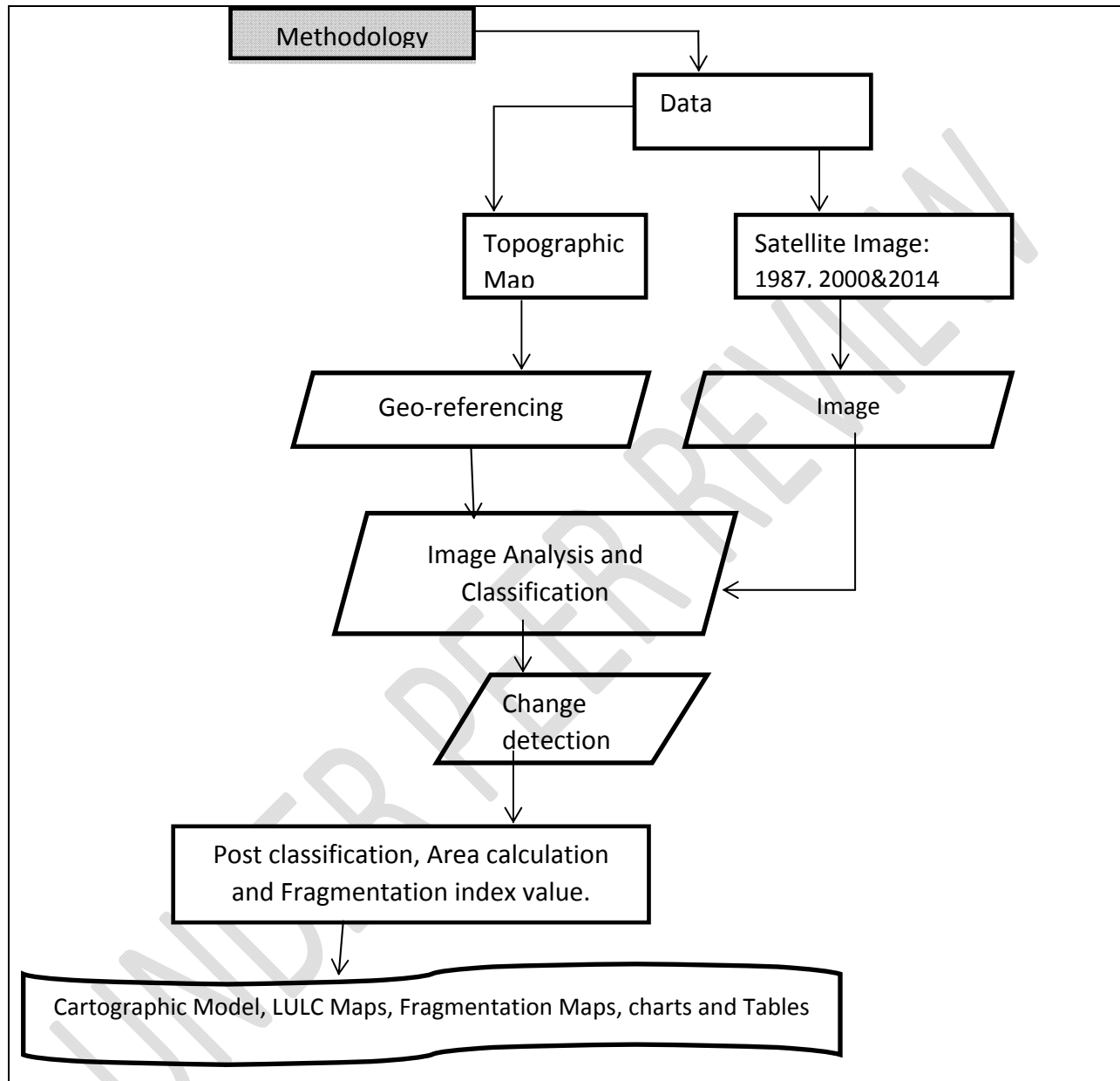
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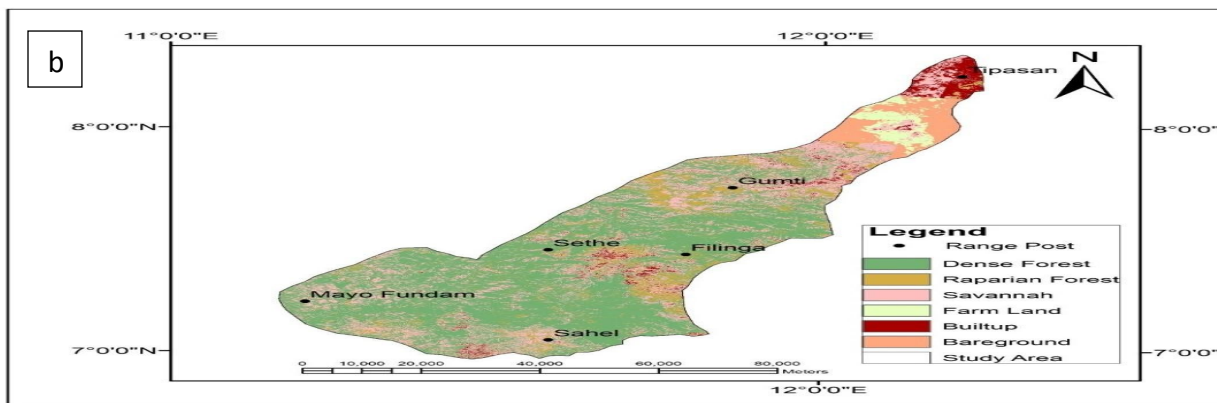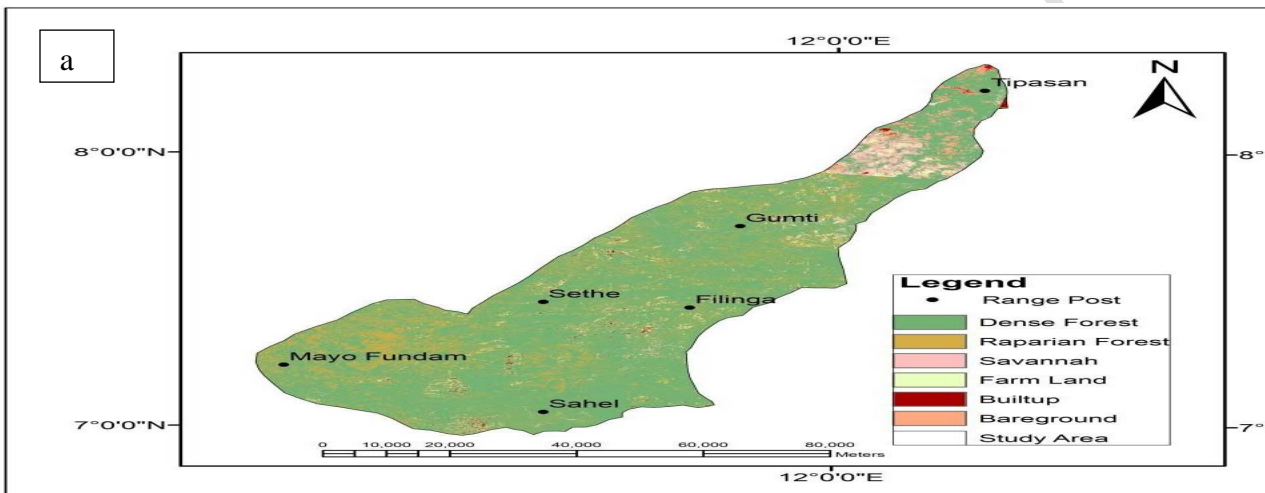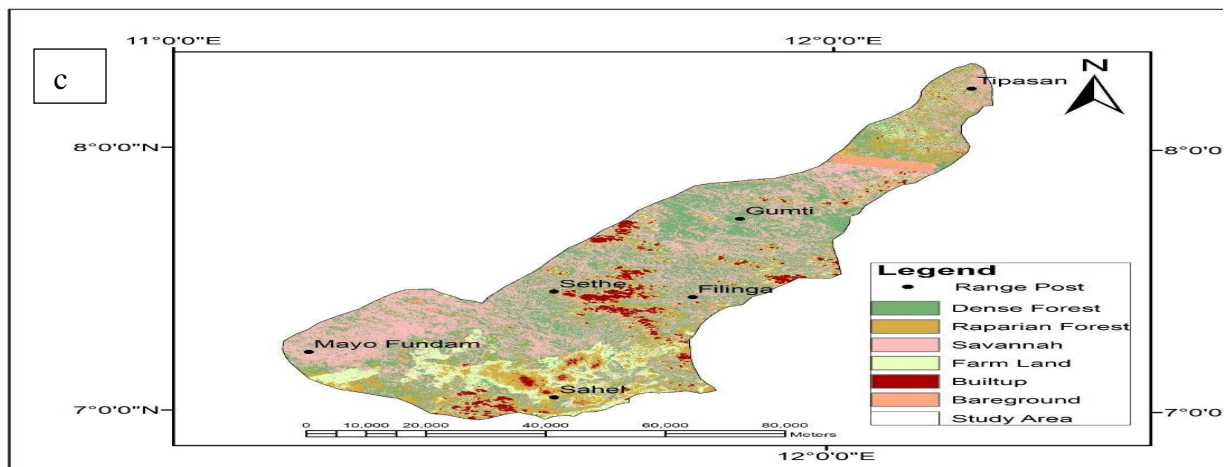**Figure 3**: Flow diagram for the procedures of land transformation of GGNP.

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257 **RESULTS AND DISCUSSION**

258 **Landscape/Land Cover Types within GGNP**

Fig 4: **Classified Image of Landsat Images of (a) 1987, (b) 2000 and (c) 2014**

Fig 4 a,b and c shows the maps from the supervised classification. There are six (6) LULC classes distinguished after the classification for 1987, 2000 and 2014. These classes include dense forest, riparian forest, savannah, built-up, bare ground and farmland. Fig 4a shows that most of the park is covered by dense forest, while few build-up areas were located around Tipasan range post, this is also reflected by the numerous farmlands that are found within that area. According to the National Park Service Act (Section 29) on the demarcation of National Parks, settlements were not supposed to be located within the park as it's been noted in this image. In figure 4b, it can be observed that there is a significant transformation in the spatial distribution of the land use/land cover types located in the Gashaka-Gumti National Park. Worthy of note is the transformation of the once dense forest areas to savanna vegetation type covered by grassland and bare ground. There is also a gradual disappearance of riparian forest in the area. Increase in the built up areas which has become more obvious in the Tipasan range post and also around Sethe and Filinga range posts, leading to cutting down of more trees for fuel wood, buildings and also to pave way for farmlands, which has resulted in the loss of the once dense forested areas. In the 2014 as presented in Fig 4c, it can be observed that virtually most of the dense forest areas have been transformed to another landcover/landuse type. There is a shift in the built-up areas from Tipasan range post towards Sethe, Filinga and Sahel range posts.

Trend and Rate of Land Transformation of GGNP

Table 5: Analysis of the Dynamic Pattern of Land Transformation in GGNP

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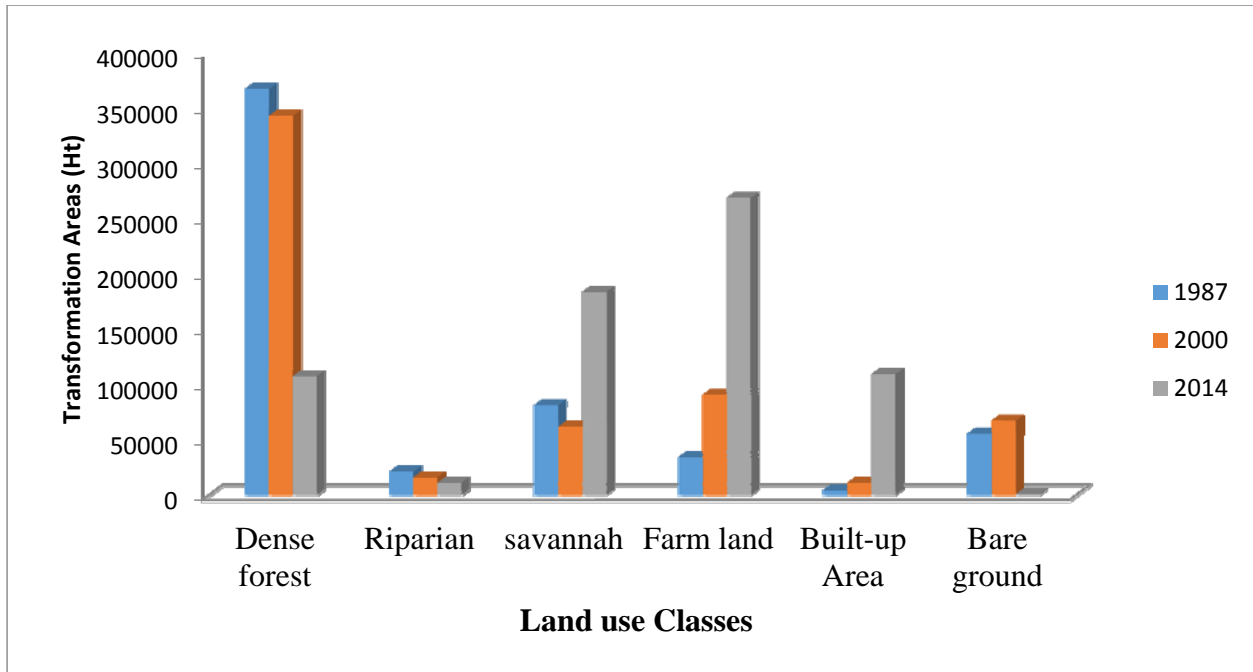| S/N	Classes of Forest	Transformation in the Area in Years (Hectares)					
		1987	% change	2000	% change	2014	% change
1	Dense forest	367500	5.45	343,300	5.1	107,600	1.59
2	Riparian	21300	0.316	16,000	0.23	11,000	0.16
3	Savannah	81260	1.2	62,100	0.92	183,800	2.73
4	Farm land	34400	0.51	90700	1.34	269,000	3.99
5	Built-up	4476	0.66	11,070	0.16	109,300	1.62
6	Bare ground	55685	5.27	67450	0.10	1107	0.023
	Total	**564621**		**590620**		**379407**	

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280

281   **Table 6: Image Overlay and Change Detection**

S/N	LULC	Rate of change detection for Image overlay (Hectares)			
		1987/2000	% change	2000/2014	% change
1	Dense forest	-24200	3.60	-235700	35.02
2	Riparian forest	-5300	0.79	-5000	0.74
3	Savanna	-19160	2.75	121700	18.08
4	Farm land	56300	8.36	63800	9.48
5	Built-up area	6594	0.98	1400	0.21
6	Bare ground	11785	1.75	-66343	9.86

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400000

350000

300000

250000

200000

150000

100000

50000

0

Transformation Areas (Ht)

Dense forest   Riparian   savannah   Farm land   Built-up Area   Bare ground

Land use Classes

■ 1987
■ 2000
■ 2014

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Figure 4.a, b and c are the supervised classification for 1987, 2000 and 2014 images of GGNP indicating the land-use. The analysis indicated that dense forest which occupied 367,500 hectares at 62.2% of the total area of the park (Table 5) in 1987 have been converted into farmland and built-up area. This reduced the dense forest to 343, 300 hectares by year 2000 and 107, 600 hectares in 2014 respectively. The significant decrease of the dense forest in the study area during the period of study and the increase of farmland and built-up was as a result of the anthropogenic disturbances by the farmers living within the park whose source of livelihood is farming and collection of forest fruits. The riparian forest i.e. forest along water axis of the Taraba River, decreased from 21,300 hectares in 1987 at 3.6% to16, 000 hectares in 2000 at 2.7% and further to11, 000 hectares (1.8%) by 2014. The cause of these decreases was the conversion of the forest to agricultural land (fig.4.a, b, c). Savannah vegetation was also found in the study area but it is concentrated in the northern part of the study area and occupied a total area of 81,260 hectares at 13% in 1987, reduced to 62,100 hectares at 10.5% in 2000 and increased to 183,800 hectares at 31.1% of the total area in 2014. The significant change from 1987 to 2000 was due to the conversion of the riparian forest land into agricultural land and built-up land as the population of the farmers increased. It was also reported that there was massive illegal logging in the study area by the youths from 2013 to 2014 [24]. This may be the

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301 reason for the increase of Savannah land covers in 2014 and the decrease in both dense forest
302 and riparian forest.

303 The farmland covered an area of 34,400 hectares at 5.8% in 1987 and it was found mostly
304 around the northern part and few areas within the range post of the GGNP. It increased to 90,
305 700 hectares at 15.3% of total area in 2000 and further increased to 269, 000 hectares at 45.5% in
306 2014. The increase in the farmland is as results of increase in population in the area. It was also
307 reported during the oral interview that the increase in the population was as result of the
308 insurgences cases in part of the Northeastern states (Borno, Yobe and Adamawa) that led to the
309 massive immigration of farmers to the GGNP area.

310 Built-up area occupied total area of 4,476 hectares at 7.5% in 1987. It is found around the range
311 post are and very pronounced in the northern part of the park. The built up kept increasing to
312 11,070 hectares at 1.81% in 2000 and decreased to10.930 hectares at1.85% in 2014.
313 Significantly, as the number of immigrants increased from 1987 to 2000, it also led to the
314 increase of the built-up areas. But the reverse is the case with 2000 and 2014. The reason of this
315 change was that there was information that the insurgents were shifting their base towards the
316 park to hide from security forces and some of the people living within the area became afraid and
317 deserted their houses and resettled in the nearby towns and villages that are outside the park,
318 leaving their houses to grow outgrown by bushes and became savannah in 2014.

319 Bare ground occupied 55,685.4% hectares from the total area of the GGNP in 1987. It increased
320 to 67,450 hectares at11.4% in 2000 and reduced to1107 hectares at 01.8 in 2014. The increase of
321 the bare ground from 1987 to 2000 was as a result of illegal grazing in the park in the northern
322 part of the park. The information received during the field survey was that there was fire disaster
323 in the northern part of the park during the period under study in which the area was rendered
324 bare. It might be concluded here that natural disaster was also responsible for increase of the bare
325 ground in the park. The decrease of the bare ground to 1107 hectares in 2014 might have some
326 socio-economic significance. As the immigrants increase, the numbers of farmers also increased
327 in which some of the bare ground were converted to agricultural land

328 **CONCLUSION**

329 At present, global natural habitats face an immense crisis that has overtaking previous records.
330 Specifically, habitat destruction in Nigeria national parks is more pervasive for 'wholesale
331 extinction' of biodiversity. Identifying and delineating such 'key biodiversity area' is therefore
332 important for prioritizing conservation planning. Outcomes of such study generate valuable data
333 which is important for regions like this particularly in the north eastern states of Nigeria.

334 The result indicated that Dense Forest which occupies 62.2% of the total area of the parkin1987
335 have been converted into farmland and buildup land so that the total area other dense forest has
336 now reduced in 2000 and subsequently reduced again in 2014. It was revealed that significant
337 decrease of the dense forest in the study area during the period understudy and the increase of
338 farm land and built up was as a result of the anthropogenic disturbances by the farmers living
339 within the area in searching for food to survive during needs. The riparian forest (forest along
340 waterside) was also decreased 3.6% to 2.7% in year 2000, and finally reduced to 1.8%in
341 2014.The cause of these decreases was the conversion of the forest to agricultural land.

342 Gashaka-Gumti National Park is thought to be the key plant species diversity area, but many
343 parts of the park have become less capable to perform that role and thus suffering to protect
344 valuable flora (plant species) and fauna within their legislative boundaries in particular and their
345 surrounding ecosystems in general. In this study, the relationship between the forest covers and
346 its associated LULC classes were investigated and various thematic maps were developed. The
347 main LULC types identified in the study are Dense forest, Savannah, Agricultural land bare
348 soil/sand, and built-up. It was observed that vegetation has changed remarkably from the period
349 1987-2014. This decrease in vegetation has caused higher forest fragmentation in the area as a
350 result of anthropogenic activities.

351 Based on the result of the study, the following suggestions are made:

352 i. More comprehensive and continuous study of land use and land cover and its harmful
353   effects may provide necessary information to examine the efficiency of the existing
354   protected area systems as well as to identify potential areas for systematic conservation
355   planning.

356   ii.   Further analysis of these studies is needed to better explain the impact of the factors on
357   forest cover change considering other factors such as rainfall, soil moisture etc., and the
358   study could reach a higher accuracy for forest cover change detection.

359   iii.   Performing multi sensor data classification using neural networks by combination of
360   ancillary data (i.e. elevation and aspect) with the Landsat image data would improve the
361   classification result and produce higher accuracy than the use of Landsat image data only.

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422

423

424   **APPENDIX**

425   **IMAGES**

426

427

428   **A. GATE OF GNNP**

429

430   **B: BUILT-UP AREA**

Gashaka Gumti National Park

431

C. DENSE FOREST

432

433   **D: DEFORESTED AREA**

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436   **E: CULTIVATED AREA**

437

438   **F: BARE AREA**

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440 **G: RIPARIAN FOREST**

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