GIS-Supported Survey and Biodiversity Assessment in a Derived Savannah Ecosystem

John A. Oyedepo, Ph.D.[*1]; Moses O. Oyatogun, Ph.D.[2]; Abimbola O. Jayeola, Ph.D.[2]; and Olusegun Oladoye, Ph.D.[2]

[1]Environmental Resources and Conservation Research Programme of the Institute of Food Security Environmental Resources and Agricultural Research.
[2]Department of Forestry and Wild Life Management, College of Environmental Resources Management Federal University of Agriculture, P.M.B. 2240, Abeokuta, Nigeria.

Email: johnoyedepo@yahoo.com*
Telephone: +234 803 248 5583

ABSTRACT

Assessment of relics of natural vegetation of a derived-savannah ecosystem within the campus of the Federal University of Agriculture, Abeokuta Nigeria was conducted by combining ground surveys with Geospatial technologies. The study aimed at investigating conservation capacity and wildlife of the remaining habitats within the University land. 1x1km grid cells were laid on the Landsat TM image of the campus acquired for year 2014.

Supervised classification of the Landsat image was conducted using 5% maximum likelihood. Training sets were created from field notes from reconnaissance survey. 25% of the cells that fell on the densely vegetated areas were selected for inventory. Twenty-five 1 km transects were created in all; using cattle trails, human footpaths and vehicle tracks. Fauna inventory were conducted at 250 m intervals along all transects.

Results image analysis revealed that many of the vegetation-cover are fragmentized into patches by human activities such as farming, logging and buildings. Total area of natural vegetation is only 5.14 km2; 5 percent of the reserve area within the University land. In the survey, 121 animals were recorded including 79 birds, 29 mammals and 11 reptile species.

The observability and abundance index rated Bush buck and grass cutter highest with 8.14 and 7.75, respectively; and sighting frequencies of 21 and 20, respectively. Warthogs, hare, civet cats and forest genets are evidently threatened. The vegetation around a sacred grove within the campus and portion of the conservation reserved area were identified for protection. To reduce further human impacts creation of a zone of influence around critically important areas was suggested.

(Keywords: geographic information system, GIS, ecological mapping, Federal University of Agriculture, Abeokuta, Nigeria)

INTRODUCTION

Mapping and assessment of ecological habitats makes extremely important contributions to the future earth initiative (Segan et al., 2016). Survey and mapping help to properly gain required insight on the link between condition of habitats and the biota in them (Maes et al., 2013).

The importance of habitat mapping in assessing the carrying capacity of vegetation relics to support conservation of large mammal of the lowland rain forest of Nigeria have been underscored by Ogunsesan et al. (2009). Mapping in ecosystem are of particular importance since they provide means of timely assessments and analysis. According to Smith *et al*., (2011), habitat survey (including mapping) is the method of gathering information about the ecology of a site. This makes the use of satellite remote sensing and Geographical Information System relevant tools in charting and recording ecological information.

The relevance of geospatial technology in ecological mapping stems from the need for a system that can seamlessly incorporate environmental data from different sources and of different units of measurements as characterized by the ecosystem.

Satellite remote sensing presents a bird view of ecological units; this provides opportunity of capturing the geographic boundaries and also conducting change assessment of the area of study over time. Recent advances in remote-sensing technology and the processing of remote-sensing data through geographic information systems (GIS) present ecologists and resource managers with a tremendously valuable tool to work with (AFFPC, 2013). It is also possible to store up data from the ecosystem in a retrieval system for future update. Geospatial technologies also provide opportunities for change assessment, presents trends while also revealing factors associated with the observed trends (Brown, 2009).

The increasing urbanization, human population growth and extensive use of agricultural land during recent decades have resulted in significant loss of habitats in the rural landscapes. It is certain that many species and ecosystems will disappear over the next few decades going by the rate of unsustainable human extraction and decimation of natural habitats.

Within the Federal University of Agriculture, Abeokuta alone, habitat loss arising from clearance of large number of hectares for building construction and farming activities, annual forest fire from nomadic pastoralists and the radical combing of the bush by large number of local hunters have resulted in gross decimation and potential annihilation of the wildlife resources within the campus.

The concern is that the remaining natural vegetation in FUNAAB are now confined into a pockets (Salami, 2013) and as they are getting smaller, chances are that the area once regarded as rain forest becomes gradually replaced by the Guinean Forest-Savanna or it turns into fragmented mosaics (Victorino, 2011), which can no longer conserve wildlife as it becomes too small to support the roaming range of large mammals (Ogunsesan et al., 2011). Today several internally displaced primates have lost their habitats in the University and are now seeking refuge in the zoological park (Pers.com, 2016).

In this paper, an investigation of the extent and condition of the vegetation of FUNAAB land mass and the status of their wildlife populations was conducted using geospatial technologies and ground survey techniques.

MATERIALS AND METHODOLOGY

The study area is geographically described by latitudes $7^0 13^1$N and $7^0 20^1$N and by longitudes $3^0 20^1$E and $3^0 28^1$E) enclosing approximately 10,000 hectares (ha) of land area (Figure 1).

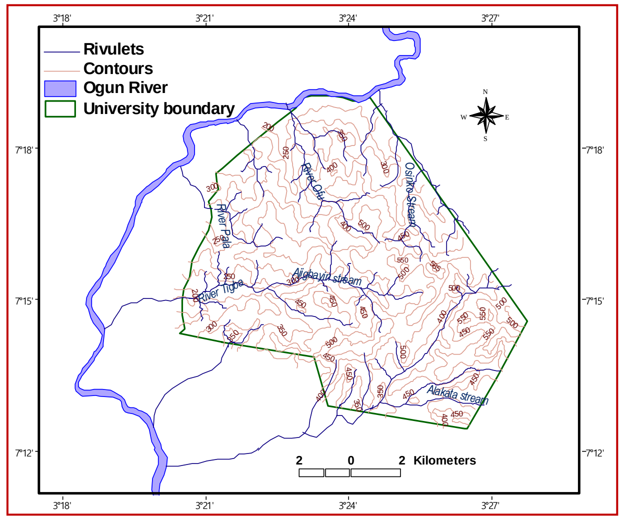

Figure 1: Drainage and Relief of the Federal University of Agriculture Abeokuta, Nigeria.

The area which is north of Abeokuta City, encloses the land mass of the Federal University of Agriculture Abeokuta campus. It is characterized by undulating with extensively mild slopes bounded into six zones and punctuated in parts by ridges, isolated residual hills and plateaus, valley landscapes with low lands all of which present an interesting and picturesque landscape suitable for all kinds of games including, birds, antelopes, primates, and warthogs (Savage, 2010).

The riparian strip along Ogun River and other rivulets presents a safe haven for reptiles such as crocodiles and pythons (IFSERAR, 2012). The area is mainly drained by Ogun River and other streams namely: Oshinko, Ole, Alakata, Arakanga, Pala, Olu, Tigba and Ajigbayin (Ufoegbune*et. al*., 2010). The climate is humid tropical type, characterized by wet and dry seasons (Filho, 2016).

Materials used for the mapping exercise include a hand-held GPS receiver, a digital camera, a waterproof bag, and a personal computer for field work. Other tools provided for the field work include girth tapes, Haga altimer, and a customized data collection system.

Prior to the actual field work, a reconnaissance survey was conducted for the purpose of 'ground truthing' in order to develop a base-map and the strategy for the actual field survey. Foremost, Landsat Enhanced Thematic Mapper (ETM) of 2014 was downloaded from the Global Land Cover facility web site.

The 8 band image was first subjected to standard principal component analysis (PCA), 3 major components were then extracted and utilized for the false color composite (FCC). The FCC was geo-referenced and then subjected to unsupervised classification into three clusters based on what was observed during the reconnaissance survey. The contiguous classes on the image were grouped together and vectorized as distinct units to which were assigned land use/ land cover classes.

In order to protect the wild fauna from impact of anthropogenic activities, the critical areas of the ecosystem were identified. The GPS coordinates of the locations of the wildlife were taken and added as point symbols to the base map which then translated into a vulnerability index map.

Further, a 3-ring buffer of 200 meters interval was created around the critical zones. By placing notable warning signs at these three zones, a wild life protection districts would have been created. Thus, there would be the sanctuary and corridor prohibiting negative human incursion and interference.

Different woodlands identified during the reconnaissance survey were selected as the strata for the inventory. The map of the densely vegetated areas of the land was gridded into 1 km x 1 km and five percent (5%) of the grids were selected taking into consideration the strata.

The coordinates of the center of each grid was determined and uploaded unto a GPS. On the land, a total of 25 transects were created within each cell. The center was located and transect walk began at the cell boundary (located by the hand-held GPS receiver). Each of the (5%) grid cell selected was sampled using the Point Center Quarter (PCQ) method of assessment. At every point assessed, boundless quadrat with the known center is established for trees and ground flora measurement. The closest vascular plant with diameter at breast height (dbh) $\geq$ 5 cm to the center of the quadrat was selected for assessment. Its distance to the center and dbh and total height were measured with girth tapes and Haga altimer as required for each quart, thus 4 selections per quarter were made. At the end of the exercise, the checklist of plant species used categorizes the plants according to their taxonomic characteristics. Also the frequency of occurrence, abundance, density per hectare and volume were estimated.

Inventory of wild fauna in the study area was conducted alongside with the flora inventory within the same PCQ described above. Both direct and indirect method of assessment of wild fauna was adopted for the study. This include direct sighting of animals present during survey and adoption of all visible signs of the presence of the animal as indication that the animal is likely to be present on site. These include foot prints, burrow, holes, nests, food remnants, tracks, trails, fecal droppings, body pelage and so on. Checklists of animal species suspected to be present on site, abundance, population density of available species encountered during the survey were estimated. In addition to calculating area occupied by major categories of vegetation (e.g., natural forest, farmland), the density of large trees was also recorded. Locations of ecological niches and the associated fauna were tabulated in a spreadsheet against the coordinates and were imported into the GIS for database creation and vulnerability mapping.

Data Analysis

The study adopted the techniques described in Nautiyal *et al*., (2015) to compute relative frequency, density and relative density, following Phillips (1959).

$$\text{Frequency} = \frac{\text{No of sampling units (quadrates) in which a species occurs}}{\text{Total number of sampled units studied}} \text{ X } 100$$

$$\text{Density} = \frac{\text{Total no of individuals in all sampling units}}{\text{Total no of sampled units studied}} \times 100$$

Abundance

$$= \frac{\text{Total No of individual in all sampling units}}{\text{Total No of sampled units of occurrence}}$$

The basal area was calculated using the following formula:

Basal area of a single tree = $\pi \times r^2$.

Where r = radius, $\pi = 3.14$

Basal cover (m^2/ha) for shrub and tree species obtained by adding value of all species together and presented as follows:

$$BC = \frac{\sum_{i=1}^{sh} BASh}{PA}, \qquad BC = \frac{\sum_{k=1}^{m} BAT}{PA}$$

Where BC = basal cover or basal area, Sh = shrubs, and m = tree and BASh and BAT arebasal area for shrub, tree species respectively, and PA = plot area or quadrat. The total basal cover calculated by the multiplying mean basal cover and density of the species.

Relative Density (RD)

$$= \frac{\text{Number of individual of a species}}{\text{Total number of ndividual of all species}} \times 100$$

RESULTS AND DISCUSSION

The images in Figure 2 and Figure 3 are the results of the false color composite of the Landsat image used.

The unsupervised classification of the image produced six clusters as shown in the classified image in the Figure 4.

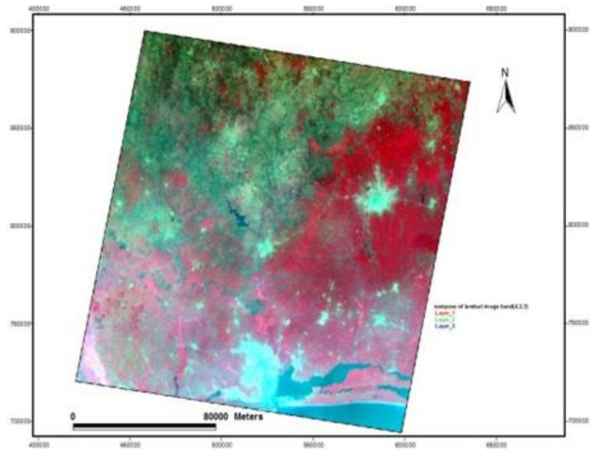

Figure 2: False Color Composite of Landsat (ETM) Image of Study Area.

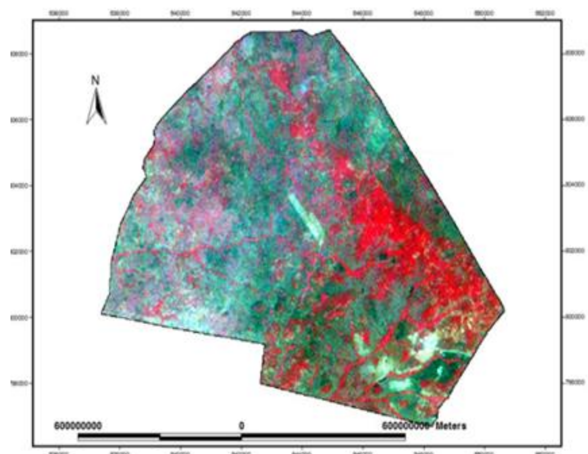

Figure 3: False Color Composite of Landsat (ETM) Image (right) Clipped into University Map (left).

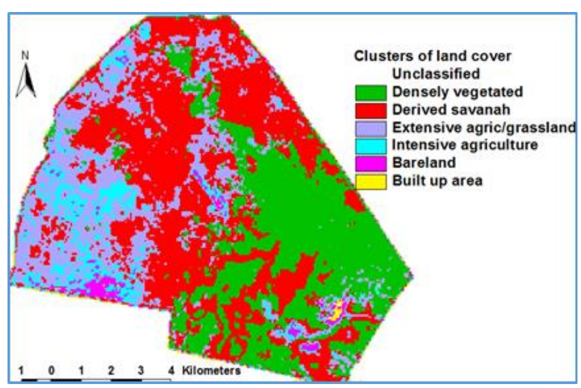

Figure 4: Unsupervised Classification of the Image.

Since the interest of the study is in the vegetated areas that can be managed for biodiversity and wild life conservation, the six clusters produced from the unsupervised classification were further merged into four major land cover types as presented in the Table1.

Table 1: Land Cover Types and Percentage Area Occupied by Each Category.

S/N	Land cover categories	Area (ha)	% Total Area
1	Bareland /Built up areas	355.72	3.91
2	Densely vegetated areas	2639.23	29.02
3	Derived savanna	3901.20	42.89
4	Extensive agriculture/grassland	2199.03	24.18

The map extracted from the image is as presented in the Figure 5.

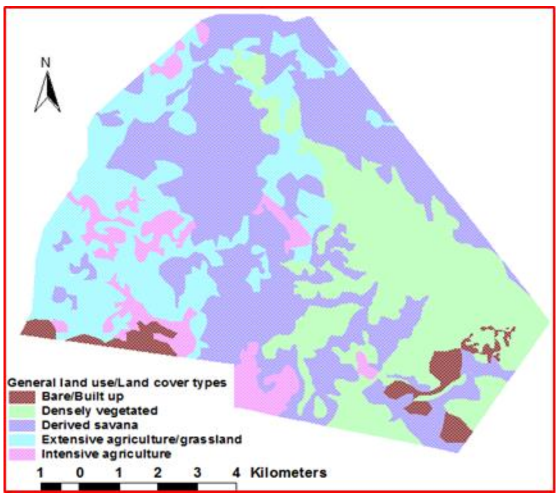

Figure 5: Land Use/Land Cover Classification of the Area as Extracted from the Image.

Result of flora and fauna survey are presented in tables below. The Frequency of occurrence and abundance of flora species is presented in Table 2.

Daniella olivera and *Anogeisus leocarpus* were the two most abundant tree species with abundance indices of 41.06 and 20.29 respectively while aspilia Africana and chromolaenaodorata were the most abundant ground flora species.

Table 2. Frequency of Occurrence and Abundance of Tree Species.

S/N	Tree species	Frequency of occurrence	Abundance
1	*Daniella oliveri*	850	**41.06**
2	*Anona senegalensis*	30	1.45
3	*Anacardium occidentale*	40	1.93
4	*Blighia sapida*	20	0.97
5	*Albizia zygia*	30	1.45
6	*Albizia lebeck*	10	0.48
7	*Tamarindusindica*	40	1.93
8	*Bridelia micrantha*	30	1.45
9	*Bridelia ferigunea*	30	1.45
10	*Bambusa vulgaris*	40	1.93
11	*Anogeisus leocarpus*	420	**20.29**
12	*Sterculier tracagantha*	20	0.97
13	*Sterculier rhinopetala*	10	0.48
14	*Terminalia ivorensis*	170	8.22
15	*Combretum bracteaunm*	20	0.97
16	*Anthonotha macrophylla*	10	0.48
17	*Anthocleista vogelli*	20	0.97
18	*Azadiracta indica*	20	0.97
19	*Parkia biglobosa*	90	4.36
20	*Vitelaria paradoxa*	10	0.48
21	*Dicrostachiscenera*	20	0.97
22	*Philliostigma thonningii*	30	1.45
23	*Alcornia cordiflora*	40	1.93
24	*Vitexdoniana*	10	0.48
25	*Parinarirobusta*	10	0.48
26	*Parinaricuratellifolia*	10	0.48
27	*Cleistopholis patens*	10	0.48
28	*Ficus exasperata*	10	0.48
29	*New bouldialaevis*	10	0.48
	Total	2090	100

Table 3: Frequency of Occurrence and Abundance of Ground Flora Species.

S/N	Plant Species	Freq	Abund
1	*Achyranth esaspera*	50	3.59
2	*Anchomanis difformis*	30	2.16
3	*Andropogon gayanus*	110	7.91
4	*Andropogon tectorum*	100	7.19
5	*Aspila africana*	140	**10.08**
6	*Chromolaena odorata*	270	**19.42**
7	*Cochlospermum planchoni*	50	3.59
8	*Cochlospermum tinctorum*	90	6.47
9	*Digitaria longiflora*	50	3.59
10	*Dioscorea prahensilis*	60	4.32
11	*Hibiscus sabdarifa*	80	5.76
12	*Hyparhenia involucrata*	70	5.04
13	*Hyparhenia rufa*	20	1.44
14	*Hyparheniasub plumosa*	80	5.76
15	*Mormodic acharantia*	30	2.16
16	*Panicum maximum*	40	2.88
17	*Parinari robusta*	40	2.88
18	*Tephrosia braceolata*	80	5.76
	Total	1390	100

Table 4 presents the frequency occurrence and abundance of reptiles as shown with monitor lizard being the most abundant of the reptiles in the area.

Table 4: Frequency Occurrence and Abundance of Reptiles.

S/N	Species	Scientific names	Freq of sighting	Abundance
1	Yellow stripe snake	*Psamophis sibilans*	3	0.37
2	Royal python	*Python regius*	15	1.84
3	Rock python	*Python sebae*	12	1.47
4	Black cobra	*Naja melanoleuca*	8	0.98
5	Monitor Lizard	*Veranus niloticus*	33	4.05

The mammals found in the area are presented in Table 5 below. The two most abundant species are also the most voluminous in the area.

Table 5: Frequency Occurrence and Abundance of Mammals.

S/N	Species	Scientific names	Freq of sighting	Abun
1	Bush pig	*Hylochoerus minertzagheni*	30	3.69
2	Bushbuck	*Tragelaphus scriptus*	63	**7.74**
3	Red flanked duicker	*Cephalophus rufilatus*	30	3.69
4	Maxwell Duicker	*Cephalophus maxwelli*	42	5.16
5	Rock hyrax	*Procavia ruficeps*	12	1.47
6	Cane rat	*Thryonomis swinderianus*	60	**7.37**
7	Crested porcupine	*Hystrix cristata*	3	0.37
8	Fruit bat	*Rousethus smithii*	3	0.37
9	Giant rat	*Cricetomys ganbianus*	12	1.47
10	Ground squirrel	*Epix erusebii*	42	5.16
11	Hare	*Lepus capensis*	45	5.53
12	African Civet cat	*Viverra civetta*	21	2.58
13	Forest Genet	*Genetta macullatta*	21	2.58
14	Serval cat	*Genetta trigrina*	5	0.61
15	Red Patas Monkey	*Erythrocebus patas*	33	4.05
16	Senegal bush baby	*Galago senegalensis*	1	0.12
17	Mona monkey	*Cercopithecus mona*	3	0.37

In Table 6 the relative density of tree species together with the computed dbh, height, basal area and volume of tree species in the densely forested area is presented.

Table 7 shows the frequency, occurrence and abundance of birds in the study area.

Table 6: Dbh, Height, Basal Area, Volume and Relative Density of Tree Species.

Plant Species	Total dbh	Total height (m)	No of trees	Total Basal area (m/ha)	Total volume	Density /ha	Relative density /ha
Albizia africana	1.29	27.3	3	1.013	27.663	848.33	12.17
Albizia coriara	0.2	6.4	1	0.157	1.005	106.28	0.5
Albizia lebeck	0.33	3.2	1	0.259	0.829	1890.35	9.04
Albizia zygia	2.03	73.4	3	1.595	117.04	997.22	14.31
Anacardium occidentale	2.63	20.8	5	2.066	42.97	754.73	18.05
Anogeisus leocarpus	18.3	324.8	21	14.375	**4668.89**	215.65	21.66
Anona senegalensis	0.93	23.2	3	0.731	16.948	360.51	5.17
Anthocleista vogelli	1.33	17.2	2	1.045	17.969	692.52	6.62
Anthonotha macrophylla	1.33	3.5	1	1.06	3.711	730.46	3.49
Azadiracta indica	0.78	25.4	2	0.613	15.562	452.12	4.06
Blighia sapida	0.72	7.9	2	0.565	4.468	369.82	3.53
Brideliabferigunea	0.43	11.3	3	0.338	3.817	1600	22.96
Bridelia micrantha	0.84	10.6	3	0.66	6.994	1136.22	16.3
Cleistopholis patens	0.69	20.2	2	0.542	10.948	2620.84	25.16
Combretum spp	0.22	5.1	3	0.173	0.881	1736.11	24.92
Daniella oliveri	40.86	544.79	91	32.095	**17485.32**	1142.72	499.72
Dicrostachys cinerea	2.25	43	6	1.767	75.997	1162.19	33.36
Ficus exasperate	0.53	34	1	0.416	14.154	976.56	4.67
Newbouldialaevis	0.42	27	1	0.33	8.907	1890.35	9.04
Parinari curatellifolia	0.23	8	1	0.181	1.445	625	2.99
Parinari robusta	0.72	16.4	3	0.566	9.275	1306.43	18.75
Parkia biglobosa	4.97	110.2	9	3.904	430.214	430.03	18.51
Philliostigma thonningii	2	59.5	7	1.571	93.474	777.76	26.04
Pisidium guajava	0.54	11.1	2	0.424	4.708	3086.42	29.53
Spondia mombin	0.32	8.2	1	0.251	2.062	1371.74	6.56
Sterculier rhinopetala	0.32	7.2	1	0.251	1.81	39.06	0.18
Sterculier tracagantha	3.34	28.3	4	2.623	74.247	1508.15	28.86
Tamarindus indica	1.91	36.9	8	1.5	55.361	1040.58	39.83
Terminaliaivorensis	6.82	224.8	17	5.357	1204.278	484.91	39.44
Vitelaria paradoxa	0.16	5	1	0.126	0.6284	594.88	2.84
Vitex doniana	0.61	8	1	0.479	3.833	1479.29	7.07

Table 7: Frequency Occurrence and Abundance of Birds.

S/N	Species	Scientific names	Freq of sighting	Abundance
1	Hammerkop	*Scopus umbretta*	18	2.21
2	Bronze maninkin	*Lonchura cucullata*	24	2.95
3	Fish Eagle	*Haliatus vocifer*	3	0.37
4	Francolin	*Francolinus bicalcaratus*	42	5.16
5	Glossy Sterlin	*lamptotornis spp.*	24	2.95
6	Grey Heron	*Ardea cinerea*	15	1.84
7	Grey hornbill	*Tockus nasutus*	30	3.69
8	Grey plantain eater	*Crinifer piscator*	3	0.37
9	Helmeted guinea fowl	*Numida meleagris*	12	1.47
10	Lily trotter	*Actophilornis africana*	3	0.37
11	Lizard buzzard	*Kaupifalcomono gramicus*	3	0.37
12	Mourning Dove	*Streptopeliade cipens*	6	0.74
13	Mosque swallows	*Hirundo senegalenses*	30	3.69
14	Plainbacked pipit	*Anthus leucophrys*	3	0.37
15	Long tail Shrike	*Corvinella corvine*	13	1.60
16	Pied crow	*Corvus albus*	3	0.37
17	Red Bishop	*Euplecte sorix*	15	1.84
18	Senegal coucal	*Centropus senegalensis*	1	0.12
19	Village weaver	*Ploceus cucullatus*	5	0.61
20	White faced tree duck	*Dendrocygna vidulata*	1	0.12
21	Willow warbler	*Phylloscopus trochillus*	4	0.49
22	Wood pecker	*Dendropicos fuscescens*	6	0.74
23	Senegal fire finch	*Lagonosticta senegala*	6	0.74
24	Barn Owl	*Tyto alba*	4	0.49
25	Harrier hawk	*Polyboroides radiates*	5	0.61
26	Cattle egret	*Bulbulcus ibis*	15	1.84
27	Senegal parrot	*Poicephalus senegalus*	5	0.61
28	Red headed plantain eater	*Corythaeo lacristata*	18	2.21

Bush buck and cane rat were the most abundant of all mammals found while francolin is the most abundant of the birds.

The map in Figure 6 is an example of ecological vulnerability index map for threatened species based on the GIS data.

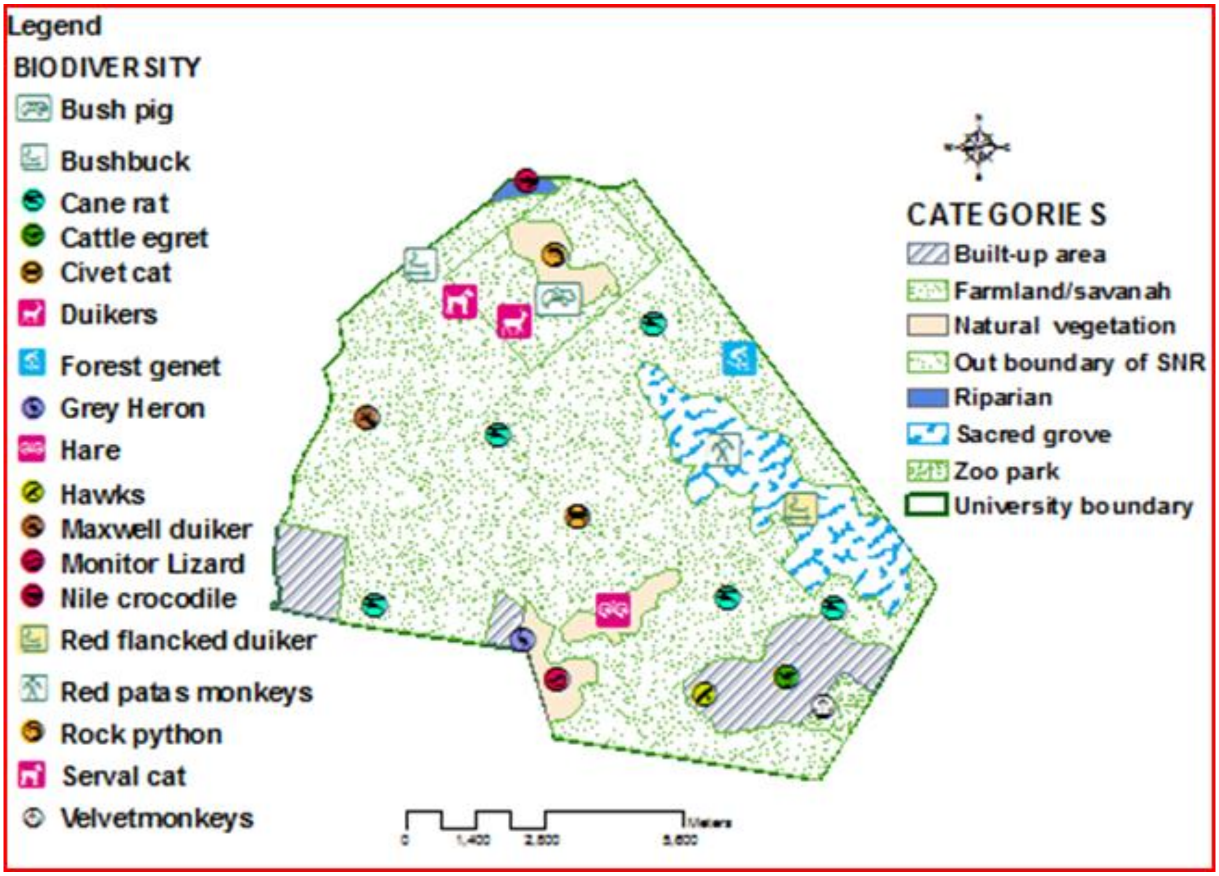

Figure 6: Ecological Vulnerability Index Map for Threatened Species.

It was essential to place the locations of wild fauna on a map so as to help in protection decision support and targeting of interventions

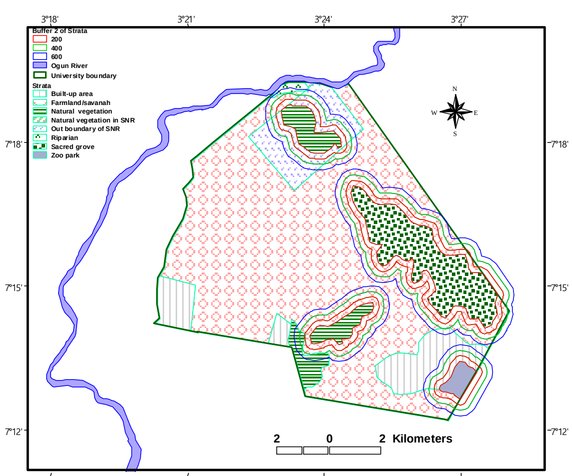

Figure 7: Zone of Influence Created around Critical Biotopes with Conservation Capacity.

From the land cover classification, it is clear that only 29% of the total land area in the campus still retain some potential to harbor wild life species. There are many farms inside the university land mass even areas regarded as strictly prohibited have been opened up by farmers. Only pockets of the University land are forested. The traditional method of preservation has made the north eastern part of the campus the most fertile and the most conserved area, since no poaching, logging, farming or nomadism is permitted. Even in what appears as extensive densely vegetated areas are gradually being opened up for farming activities except areas regarded as sacred grove by enclaves within the University.

The decimation of natural habitats attributed to perturbation from man in form of farmland clearing, over grazing, bush fire, excessive logging and charcoal making. Recently, the University cleared about one hundred hectares of the natural greenery, thereby displacing a lot of animal species and destroying many plant species. Hunters reported that monkeys, antelopes and hares that once flourished in the campus are now becoming extinct and rare to find. If this continues many wild life species will no longer be contained in their natural habitats. Migration and loss of rare species might be inevitable.

There are however signs that large animals and reptiles are still present in the northern parts of the area. For instance, warthogs, bush pigs, Serval cats, civet cats, bush buck, Maxwell duicker and other antelopes are still relatively frequent towards nature reserve and Ogun river. Other animals commonly sighted include the primates, green and black mambas, puff adder, royal and rock pythons, monitor lizards and the Nile crocodile. However, mammals are now generally becoming scarce throughout the survey area because of ruthless poaching by hunters. During a standard 1 km transect it was rare to see very many large mammals. Evidence of human hunting was found in all over the survey areas.

In order to be able to preserve the remaining wildlife population, there is the need to protect their sensitive ecological niches and biotopes since the area still retain some level of their ecological integrity. Creating buffers as zone of influence around the identified patches of vegetation will protect the habitats that are critically important for continued sustainability of the wildlife. Three concentric buffers of 200 meters distance between rings will give the wild life protection zone of 600 meter from the center of the wild life sanctuaries.

CONCLUSION

It can be concluded that some patches of biotopes in the campus still retain some level of ecological conservation potentials and as such, concerted efforts as suggested in should be directed at reduction of human impact. All anthropogenic activities in the campus should be outside the 600 meter buffers. And all human presence within the protected forests should be completely stopped to allow for regeneration. Maps on forest ecology should be widely circulated and made easy to interpret and readily available to local communities.

REFERENCES

1. American Forests' Forest Policy Center (AFFPC) 2013. “Remote Sensing and GIS in Ecosystem Management. Island Press. 382 pages. ISBN: 9781610913096Pub Date: April 2013 URL: http://islandpress.org/book/remote-sensing-and-gis-in-ecosystem-management

2. Brown, K. 2009. “Integrating Mapping and Data Analysis to Find Hidden Trends, Patterns and More”. http://www.ebizq.net/topics/bi/features/11091.html

3. Lawrence, E. and W.D. Henderson. 2005. *Henderson’s Dictionary of Biology*. Lawrence: London, UK. 748pp.

4. Maes, J., A. Teller, M. Erhard, C. Liquete, L. Braat, P. Berry, B. Egoh, P. Puydarrieux, C. Fiorina, F. Santos, M.L. Paracchini, H. Keune, H. Wittmer, J. Hauck, I. Fiala, P.H. Verburg, S, Condé, J.P. Schägner, J. San Miguel, C. Estreguil, O. Ostermann, J.I. Barredo, H.M. Pereira, A. Stott, V. Laporte, A. Meiner, B. Olah, G.E. Royo, R. Spyropoulou, J.E. Petersen, C. Maguire, N. Zal, E. Achilleos, A. Rubin, L. Ledoux, C. Brown, C. Raes, S. Jacobs, M. Vandewalle, D. Connor, and G. Bidoglio. 2013. “Mapping and Assessment of Ecosystems and their Services. An Analytical Framework for Ecosystem Assessments under Action 5 of the EU Biodiversity Strategy to 2020”. Publications office of the European Union: Luxembourg.

5. Martin, E. and R.S. Hine. 2000. *Oxford Dictionary of Biology (4th Ed)*. Oxford University Press: New York, NY. 641pp.

6. Ogunsesan, D., J. Oyedepo, J. Oates, C.O. Adeofun, R. Ikemeh, and R. Bergl. 2011. “GIS-Supported Survey of Low-Land Rain Forests in SW Nigeria”. *AGR.* 18(4): 14.

7. Salami, W.A. 2013. “Geoinformatics of Land Use/Land Cover Change in the Federal University of Agriculture Abeokuta”. An unpublished Master of Forestry Degree in the College of Forestry and Wild life Management of Federal University of Agriculture: Abeokuta Nigeria.

8. Segan, D.B., K.A. Murray, and J.E.M. Watson. 2016. “A Global Assessment of Current and Future Biodiversity Vulnerability to Habitat Loss–Climate Change Interactions”. *Global Ecology and Conservation*. 5:12-21.

9. Ufoegbune, G.C. J.A. Oyedepo, A. Awomeso, and O. Eruola. 2010. “Spatial Analysis of Municipal Water Supply in Abeokuta Metropolis, South Western Nigeria”. *REAL CORP 2010 Proceedings*. Tagungsband: Vienna, Austria. 18-

20 May 2010. http://www.corp.at. M. Schrenk, V. Vasily, P. Popovich, and P. Zeile (eds.).

10. Victorino, T.J. 2011. “Guinean Forest-Savanna Mosaic Log Press: *Science*. 30 Oct 2011:104.

ABOUT THE AUTHORS

Dr John A. Oyedepo is a Senior Research Fellow at the Environmental Resources and Conservation Research Programme of the Institute of Food Security, Environmental Resources and Agricultural Research of the Federal University of Agriculture, Abeokuta Nigeria where he also lectures and supervises students in remote sensing of the environment. He holds a PhD in Environmental Resources Management and a Master of Environmental Management and Protection degrees from the Federal University of Agriculture, Abeokuta Nigeria. He also holds a Master of Science degree (M.Sc.GIS) in Geographic Information Systems from the University of Ibadan, Nigeria. He is a member of Environmental Information Systems in Africa (EIS-Africa) and Association of American Geographers (AAG). His research interests are in environmental resources/biodiversity conservation which he pursues through Precision agriculture, Early Warning Systems, and applications of Unmanned Aerial Vehicles to environment and agriculture.

Dr. Moses Oyatogun is a Senior Lecturer in the Department of Forestry and Wildlife Management of the Federal University of Agriculture, Abeokuta Nigeria. He was the Director of the University Zoological park until year 2017. He holds a Ph.D. degree in Wildlife Management. He is a member of many professional bodies including Wildlife Management Society of Nigeria (WIMSON) His current research interest if in forestry and wild life conservation which he pursues through biogas production to safe forestry, wildlife and habitats from decimation arising from uncontrolled fossil fuel consumption for energy in Africa.

Dr. Abimbola O. Jayeola and **Dr. Olusegun Oladoye**, are research faculty at the Department of Forestry and Wild Life Management, College of Environmental Resource Management at the Federal University of Agriculture in Abeokuta Nigeria. Both have research interests in habitat and wildlife conservation as well as the development of geospatial tools for natural resource management.

SUGGESTED CITATION

Oyedepo, J.A., M.O. Oyatogun, A.O. Jayeola, and O. Oladoye. 2018. “GIS-Supported Survey and Biodiversity Assessment in a Derived Savannah Ecosystem”. *Pacific Journal of Science and Technology*. 19(2):388-398.

Pacific Journal of Science and Technology