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Editor-in-Chief

Alabi S. O. Soneye
Department of Geography, University of Lagos
AkokaYaba, Lagos, Nigeria, 101017
Tel: +234-802-312-6221
Email: asoneye@unilag.edu.ng; asoneye@yahoo.com

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Deforestation and land-cover changes in the forest reserves of SW Nigeria

DEFORESTATION AND LAND-COVER CHANGES IN THE FOREST RESERVES OF SOUTHWEST NIGERIA

Mayowa J. FASONA (Corresponding Author)
Department of Geography, University of Lagos, Akoka-Yaba, Lagos, NIGERIA
Tel: 234-802-312-7998; Email: mfasona@unilag.edu.ng; mfasona@gmail.com

Akinlabi O. AKINTUYI
Department of Geography, University of Lagos, Akoka-Yaba, Lagos, NIGERIA
Tel: 234-803-347-1323; Email: aakintuyi@unilag.edu.ng;
akin_akintuyi@yahoo.com

Samuel K. UDOFIA
Laboratory for Remote Sensing and Cartography
Department of Geography, University of Lagos, Akoka-Yaba, Lagos, NIGERIA
Tel: 234-802-075-9633; Email: ubongsam@gmail.com

Tamarabrakemi M. AKOSO
Laboratory for Remote Sensing and Cartography
Department of Geography, University of Lagos, Akoka-Yaba, Lagos, NIGERIA
Tel: 234-805-616-5319; Email: tamaramicheal@gmail.com

Ajibade N. ARIORI
Laboratory for Remote Sensing and Cartography
Department of Geography, University of Lagos, Akoka-Yaba, Lagos, NIGERIA
Tel: 234-806-910-4754; Email: nasiruaji@yahoo.com

Peter A. ADEONIPEKUN
Laboratory of Paleobotany/Palynology
Department of Botany, University of Lagos, Akoka-Yaba, Lagos, NIGERIA
Tel: 234-818-348-9108; Email: padeonipekun@unilag.edu.ng;
p1adeonipekun@yahoo.com

Oludare O. AGBOOLA
Department of Botany, University of Lagos, Akoka-Yaba, Lagos, NIGERIA
Tel: 234-803-431-0062; Email: dareagboola@unilag.edu.ng;
dipod2001@yahoo.com

Gbenga E. OGUNSANWO
Department of Botany, University of Lagos, Akoka-Yaba, Lagos, NIGERIA
Tel: 234-703-161-9928; Email: gbengaogunsanwo@gmail.com

Oluwatoyin T. OGUNDIPE

Department of Botany, University of Lagos, Akoka-Yaba, Lagos, NIGERIA
Tel: 234-802-320-1618; Email: toyin60@yahoo.com; oogundipe1@unilag.edu.ng

Alabi S. O. SONEYE

Department of Geography, University of Lagos, Akoka-Yaba, Lagos, NIGERIA
Tel: 234-802-312-7998; Email: asoneye@unilag.edu.ng; asoneye@yahoo.com

Ademola S. OMOJOLA

Department of Geography, University of Lagos, Akoka-Yaba, Lagos, NIGERIA
Tel: 234-803-322-8622; Email: aomojola@unilag.edu.ng;
demola_omojola@yahoo.com

ABSTRACT

As part of the sustainable wood resource supply and ecosystems management strategies, colonial Nigeria government designated/gazetted some areas as forest reserves. These reserves have over the years suffered from poor inventory, depletion and poor management. This study was carried out to the status and evaluate the land-cover changes in forest reserves located Southwest Nigeria. Triangulated approach consisting of social surveys, Remote Sensing and GIS analyses and field investigation was adopted. Archived maps and interview with senior forestry officers provide data on the extent, management and challenges of the reserves. Information on the land-cover conditions was sourced from time-series Landsat image data provide. Both digital pixel-based and semi-automated feature-based image classification and interpretation techniques were adopted. Validation of interpreted maps was accomplished using collateral information from base maps and land-cover-tied GPS coordinates accumulated on the field. Forest reserves covered between 11,825.18 km^2 and 12,443.77 km^2 (i.e. 15 to 16 % of SW Nigeria) and many of them were created before 1960. Primary (undisturbed) natural forests within the reserves decreased from about 26% in 1986 to 8.3% and 0.1% in 2006 and 2016 respectively. Minimally disturbed forests constitute about 7.6%, 2.8% and 11.9% in 1986, 2006 and 2016 respectively. Area covered by mixture of tree crop and secondary forest within the reserves increased from 1% in 1986 to 3.8% and 12.4% in 2006 and 2016 respectively. Teak/Gmelina is fast dominating the reserves and has consistently increased from about 3.7% in 1986 to 18.4% in 2016. Lack of fund and ineffective policy implementation are major challenges facing the management of the reserves. Concrete efforts must be made to reseed, regenerate and revitalize the reserves with indigenous species so as to prevent total loss of natural forest in the reserves in the near future.

KEYWORDS: Forest Reserves, Protected Areas, Deforestation, Land-Cover Change, Forest Management Challenges, GIS and Remote Sensing, Southwest Nigeria

Mayowa J. Fasona, Akinlabi O. Akintuyi, Samuel K. Udofia, Tamarabrakemi M. Akoso, Ajibade N. Ariori, Peter A. Adeonipekun, Olukare O. Agboola, Gbenga E. Ogunsanwo, Oluwatoyin T. Ogundipe, Alabi O. Soneye, Ademola S. Omojola

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INTRODUCTION

Background

Forests are critical to the long-termprotection and sustainability of landscape geodiversity. In addition to wood, timber and non-timber products, they provide essential ecosystem services including miscellaneous raw materials, artifacts and materials for spiritual purposes (Isichei, 1995; Ostrom and Nagendra, 2006). Forests have the ability to yield multiple non-wood forest products necessary for rural livelihoods with significant economic benefits and without adverse effects on the forest (Agrawal, 2007). In Nigeria, forests provide the primary source of fuel for majority of rural households, up to about 84% in Southwest (SW) Nigeria (Fasona *et al.*, 2015). In order to guarantee sustainable exploitation of forest resources and to also, preserve its ability to continue to perform its ecological function, legal regimes are often imposed on land with some areas designated as forest reserves and /or protected areas with exclusive government right or some form of co-management rights with local communities.

Forest Reserves (FR) and Protected Areas (PA) serve several purposes including wood production, catchment protection, soil protection, wildlife conservation, gene bank, wetland protection, climate regulation, and recreation. They supply vital ecosystems good and services which are important to human well-being. FR and PA also serve as barriers against disasters and stable source of resources and refugia for endangered plant and animal biodiversity (Wright *et al.*, 2007; Mansourian *et al.*, 2009). In recent times, terrestrial protected areas have also become a centerpiece of global efforts to reduce carbon emissions especially from tropical deforestation (Nolte *et al.*, 2012). Natural forests which have declined globally with about 74%,now falls into the category of 'other naturally regenerated forest' which are modified and degraded primary forest (FAO, 2016a). Planted forests established for the purpose of wood production and/or protection of soil and water help to reduce pressure on natural forests. Forest plantation as increased globally since 1990, and by about 6.4 % in West Africa between 2000 and 2010 (FAO, 2011).

Forest Reserves and Forest Management in SW Nigeria

Forest reserves were established in Nigeria to serve as repositories of the primary habitats of the forest and woodland ecosystems (Salami, 1999) and to ensure sustainable wood production. These lands are held in trust for the local communities by the states (for reserves) and Federal Government (for National Parks). Active forestry management in Nigeria dates back to 1896 in the Colony and Protectorate of Lagos. The Shasha forest reserve (which was later divided into Shasha, Omo and Oluwa forest reserves (after the defunct Western Region was balkanized into states) was created in 1925 with a 460ha Strict Nature Reserve (SNR) established at its core as inviolate plot in 1946 (Isichei, 1995). Biosphere reserve are supposed to be site for present and future biodiversity conservation and to safeguard the genetic diversity of species for continued evolution. They are also benchmark for long term ecosystems changes.

Isichei (1995) estimated the Nigeria forest and woodland estate to be about 60million hectares around1897, but has declined to about 9.6million hectares (mainly within forest reserves, much of which is degraded) with only 2.4million hectares in the forest zone. Excessive logging, de-reservation, expanding land area devoted to agricultural production, and proliferation of commercial plantations especially cocoa, oil palm and rubber, and population pressure constitute serious problem for natural forests and forest reserves in SW Nigeria (Isichei, 1995; Oates, 1995; FAO and FMEnV, 2001; Oke and Odebiyi, 2007; USAID, 2013; FGN, 2015 a&b; Ayanlade, 2016).

The Tropical Shelterwood System (TSS) and the Taungya System were the natural forest regeneration systems employed in forest management in SW Nigeria in the early days. According to Oates (1995), the TSS, introduced in 1945, involved cutting climbers and non-commercial species in the understorey, and poisoning middle-storey shade-casting trees. The TSS was abandoned in the early 1960s. The Taungya System which became increasingly important after the abandonment of the TSS, is a farming system where farmers participate in forest plantation establishment by nurturing tree seedlings during cropping on land allocated to them within forest reserve (Isichei, 1995; Oates, 1995). Due to lack of funding for forest management activities and the invasion of the reserves by migrant farmers, the Taungy System broke down and farmers concentrated on caring for their cash and food crops leading to expansion of farms within the reserves (Oates, 1995). Forest regeneration through natural reseeding and planting of indigenous tree species did not receive sustained attention after those initial attempts. Due to diminishing extent of accessible land available for forestry, rate of logging well beyond the maximum sustainable yield, and variable and slow response of natural forest to silviculture treatment, forest plantation became regarded as economically attractive alternative (Isichei, 1995). Initially native species including *Milicia exclesia, N. diderrichii, Entandrophragma* spp.*, Guarea spp., Terminalia* spp.*, Khaya* spp.*, and Lophira alata,* were experimented. The 1960s witnessed the development of afforestation and forest plantation projects within the forest reserves with exotic species especially T*ectona grandis and Gmelina arborea.* According to Onyekwelu *et al.* (2006) 80% of about 224,524.00 ha of plantations established in Nigeria by 1996 were made up of exotics. Although *Gmelina* was introduced around 1932, it became the dominant plantation in southern Nigeria following expansion of interest in it as pulpwood (Isichei, 1995). It has over the years emerged as the dominant plantation species in Oluwa and Omo forest reserves and by 1996, 89% and 91% of total plantations established in Oluwa and Omo respectively were *Gmelina* (Onyekwelu *et al., 2006).*

Unsustainable logging driven by heavy annual revenue targets, polewood extraction, fuel wood and charcoal production, crop cultivation, urban growth, transportation, population increase and poverty have remained the important drivers of deforestation and forest degradation in SW Nigeria (FAO-FMEnV, 2001;Fasona *et al.,* 2018). In many of the states of the SW Nigeria, no single forest reserve has been created in the post-colonial era. There is poor documentation of the status and changes within the reserves as forest managers lack basic spatial inventory data on the extent and status of

existing reserves. There have been few studies on the status and spatial pattern of change within the forest reserves focusing on specific reserves such as Omo FR (Isichei, 1995), Oluwa and Omo FR (Onyekwelu *et al.,* 2006), Idanre, Owo and Ala FR (Odebiyi and Oke, 2007), Oluwa FR (Salami *et al.,* 1999), Ife Nature Reserve (Eludoyin and Iyanda, 2018) and Ifon FR (Akinsoji, 2018). Similarly, no study has yet focused on, let alone compared changes across all the reserves. Thus, this study spatially inventorizes and evaluates the trends of land-cover changes across all the reserves and protected areas in SW Nigeria.

MATERIALS AND METHOD

Study Area

The SW region of Nigeria is roughly defined by latitudes 6° 00' N and 9° 15' N and longitudes 2° 45' E and 6° 00' E. It covers about 76,852 km^2 (i.e. 8.5 % of the Nigeria landmass) and consists of the six states of Ekiti, Lagos, Ogun, Ondo, Osun and Oyo **(Figure 1)**. Based on the projected population for 2011, the region has a population of 32,566,010 which represents 20% of Nigeria's population (NBS, 2012) with a density of around 423 ppkm^2.

The climate is tropical, characterized by a sub-humid Koppen's A_w climate with distinct wet and dry seasons (Kottek *et al.,* 2006). Average temperature is about 27 °C. Rainfall is bimodal with mean annual range between 900 mm and 3000 mm. Due to complex terrain and land surface heterogeneity, the impact of mesoscale climate processes predominates and accounts for over 75 % of total rainfall received in the region (Omotosho and Abiodun, 2007).
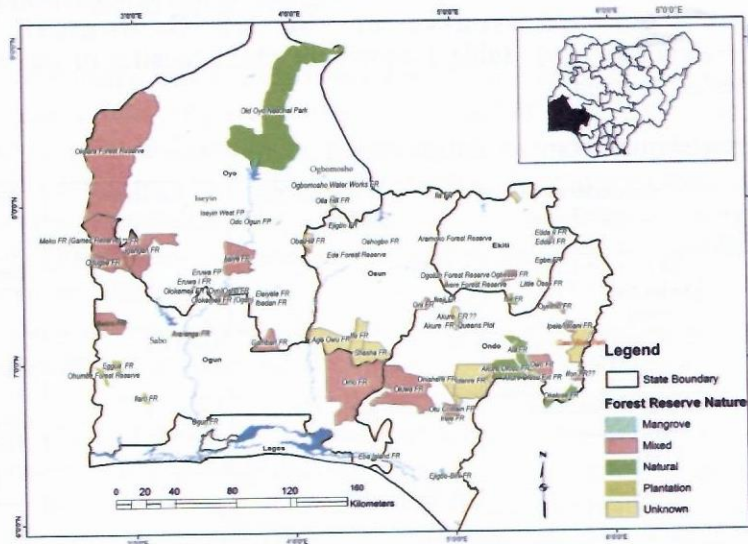

Figure 1: The southwest Nigeria showing the Forest Reserves and protected areas
Sources: Map compiled from 1:500,000 base maps as field data collated from the states Forestry Departments

The region straddles the forest and savanna woodland. It has Nigeria's largest remaining tracts of lowland rainforest after the Cross River Basin (USAID, 2013). Forest reserves and protected areas in SW Nigeria covers between 11,825 and 12,444 km². The rainforest zone which consists mainly of disturbed, degraded and modified naturally regenerated forest is dominated by the Omo-Shasha (with Ago Owu and Ife)-Oluwa FR complex corridor (shared by Ogun, Osun and Ondo states) and the Onishere-Idanre-Akure Ofosu-Ala-Owo-Okeluse FR complex in Ondo State. The reserves serve the primary purpose of wood production, biodiversity conservation, and protection of soil and water catchment. The forest complex also, performs climate regulation function and serves as a significant medium of carbon sink, though no part of it has been designated for any REDD+ and carbon credits and financing initiatives.

Study Procedure
The study utilized a triangulated approach that includes social surveys, GIS extraction of forest reserve data from base maps, and interpretation of remote sensing imageries to generate the land-cover status for 1986, 2006 and 2016.

Extraction of forest reserve data from existing Base maps
Current maps of the reserves across SW Nigeria are difficult to find even in the government offices. The Nigerian 1:500,000 series map (Fifth edition) sheets 5, 9 and 10 (sourced from the map archive of the Department of Geography, University of Lagos) published by the Federal Surveys, Nigeria in 1960 was used as the base. The maps were scanned and exported into Arc GIS software (www.esri.com) for georeferencing and extraction of spatial boundary data of forest reserves.

Land-cover status of forest reserves from Remote Sensing data
Multi-temporal Landsat TM, ETM and OLI imageries for 1986, 2006 and 2016 were downloaded from the archive of the US Geological Survey (www.earthexplorer.usgs.gov). Table 1 shows the characteristics of the maps and satellite imageries accessed.

Table 1: Characteristics of spatial data accessed

Year of Map production/Date of Image acquisition	Map series name /Satellite Sensor	Scale/Spatial Resolution (metres)	Correction level/Band	Sheet/Path and Row
1960	The Nigerian 1:500,000 series map (Fifth edition)	1:500,000		Sheet 5, 9 and 10
December, 1986	Landsat 4 Thematic Mapper (TM)	30	Level 1-T	189-55 190-55 190-56 191-54 191-55 191-56
December, 2006	Landsat 7 Enhanced Thematic Mapper (ETM)	30, panchromatic: 15m	Level 1-T	
January, 2016	Landsat (8)	30, panchromatic: 15m	Level 1-T	

The image classification and interpretation follow a derived land-use/land-cover classification schema (following Anderson *et al.,* 1976) (Table 2).

Table 2: Land-use and Land-cover classes adopted

Prim ary Code	Primary Classes	Secon dary code	Secondary Classes	Prima ry Code	Primary Classes	Second ary Code	Secondary Classes
1	Forest	10	Undisturbed Forest	5	Agriculture	53	Mix of Tree Crop and Secondary Forest
1	Forest	11	Minimally Disturbed Forest	6	Wetland	61	Mangrove
1	Forest	12	Highly Disturbed Forest	6	Wetland	62	Swamp
2	Built-up Area	21	Urban	6	Wetland	63	Marshland
2	Plantation	31	Teak/Gmelina	7	Bare Surface	71	Rock/Montane Forest
4	Woodland	41	Savanna Woodland	8	Water	81	River/Lake
5	Agriculture	51	Intensive Arable Cultivation	9	Grassland	91	Coastal Grassland
5	Agriculture	52	Fallow with Scattered Arable Cultivation	9	Grassland	92	Savanna Grassland/Shrubland

Due to the complexity and heterogeneity of the land-cover of SW Nigeria which spans across the mangrove, forest and savanna ecosystems and the concomitant confusing spectral signatures, the image interpretation task adopted a two-level analysis. It combines the digital pixel-based classification method with semi-automated feature-based image interpretation techniques. The band inspections and combinations and image classification were performed using *Idrisi Taiga* software (www.clarklabs.org). An initial iso-clustering classification consisting of 20 clusters was performed. After evaluation, the clusters were regrouped to 16 representing the identifiable classes based on field training data collected from base maps and about 640 land-cover-tied GPS coordinates accumulated on the field.

The classified image was exported into *ArcGIS* 10.3 software (www.esri.com) and converted into vector polygons. The second round of classification was performed through semi-automated process by dissolving the polygons based on the secondary land-cover code and recoding, where necessary. The final interpretation and validation followed feature identification by visual analysis based on field data, topographic base maps, FORMECU land-cover and vegetation data for 1976-78 and 1995. Collateral information on place-names and settlements proved to be very useful in the interpretation and validation of some land-cover especially agriculture and tree crop areas that dominates a large part of the rain forest zone.

Generation of final land-cover/land-use statistics

The final interpreted land-cover data was clipped with the forest reserve polygon data within ArcGIS software to generate the land-cover data within the reserves. Summary land-cover statistics were generated and percentage contribution of each land-cover classes for 1986, 2006 and 2016 were computed. The general trend and magnitude of changes in land-cover within the years were established.

Social surveys - Interview with Forest Officers

Key informant interviews were conducted with senior forestry and environmental officers across the six states. The questionnaire instrument includes questions on the number and extent of forest reserves and the challenges of managing the forest reserves and protected areas. Table 3 summarizes some characteristics of the survey.

Table 3: Government Key Information survey (n=26)

State	Percent	Designation	Percent	Sector/Department	Percent
Ogun	34.6	Permanent Secretary	3.8	Afforestation	3.8
Oyo	11.5	Director	11.5	Agricultural services	3.8
Lagos	15.4	Deputy Director	26.9	Nature Conservation	3.8
Ondo	15.4	Officer 1	30.8	Forestry	61.5
Osun	3.8	Officer 2	19.2	Natural resources	23.1
Ekiti	19.2	Not indicated	7.2	Non-Governmental Organization	3.8
Total	100.0	Total	100.0	Total	100.0

Ogun state has the highest percentage of respondents with about 35 % and the forestry sector dominates the survey at 61.5 %.

RESULTS AND DISCUSSION

Extent of Forest Reserves across the States

The coverage of forest reserves and protected area in SW Nigeria as retrieved from field interview and existing base maps are shown in Table 4. The total number of forest reserves and protected areas range from 49 to 65 and covered between 11,825.18km^2 and 12,443.77km^2. Ondo State has the highest number of 17 followed by Ekiti and Oyo States with 10 each. The field interview did not yield information on the number of forest reserves in Osun State. However, from the base maps, Oyo State has the highest of 19, followed by Ondo with 16, Osun with 11, Ogun with 10 and Ekiti with 8 reserves.

Table 4: Area and Number of Forest Reserves and Protected Area across the SW States

Sn	State	Surface area of the State	Number of FR retrieved from Field Survey	Number of FR retrieved from base map	Area of FR retrieved from field Survey (km^2)	Area of Forest Reserves from base map (km^2)	Field survey area of FR (as percent of total state area)	Map area of FR (as percent of total State area)
1	Ekiti	5,435	10	8	224.73	211.78	4.13	3.90
2	Lagos	3,671	3	1	100.04	22.90	2.73	0.62
3	Ogun	16,400	9	10	2731.62	2580.53	16.66	15.73
4	Ondo	15,820	17	16	2832.24	2893.56	17.90	18.29
5	Osun	9,026	0	11	0.00	901.21	0.00	9.98
6	Oyo	26,500	10	19	5936.55	5833.79	22.40	22.01
	SW Nigeria	76,852	49	65	11,825.18	12,443.77	15.39	16.19

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Generally, the sizes of individual FR and PA range from about 0.26 km^2 for Ogunpa FR to over 2,500 km^2 for Okpara FR and the Old Oyo National Park (see Appendix 1 for the sizes of each FR). Oyo State has the highest reserved areas with over 5000 km^2 (i.e. about 22 % of the state). Ondo and Ogun States have between 2500 and 2900 km^2 of their lands covered (i.e. between 15 and 18.5 % of the states). Ekiti and Lagos States have the least both in terms of reserved area and percent of the State. FR covered less than 250 km^2 (less than 5% for Ekiti), and between 23 and 100 km^2 (0.6 to 2.73%) for Lagos.

The total area under reservation or protection has not significantly increased since independence. In Ekiti State, 10 reserves were reported during the interview and 8 located on base maps which suggest the creation of additional two reserves since 1960. Lagos State reported 3 with only one found on the map and Ondo reported 17 with 16 found on the map. On the other hand, Oyo State reported 10 reserves while 19 were found on the map and Ogun reported 9 with 10 found on the map. These suggest de-reservation in Oyo and Ogun states. The contiguous Upper Ogun and Oyo Ile forest reserves in 1991 became the Old Oyo National Park (the only national park in SW Nigeria) managed on behalf of the Federal Government by the National Park Service.

Land-Cover Changes in the Forest Reserves
Table 5 shows the changes in land-cover classes within the forest reserves and Figures 2, 3 and 4 show the static land-cover for the years 1986, 2006 and 2016.

Forest
Natural forest which consists of undisturbed (primary forest), minimally disturbed and highly disturbed (secondary forest) accounts for about 4,722.1km^2, 3,506.2km^2 and 1,580km^2 in 1986, 2006 and 2016 respectively. In specific terms, undisturbed forests (i.e. primary forests) declined from about 3,266.3km^2 (26.4% of the reserve area) in 1986 to 1,026.2km^2 (8.3%) and mere 6.7km^2 (0.1%) in 2006 and 2016 respectively. Minimally disturbed forests declined from 7.6% in 1986 to 2.8% in 2006 and increased to 11.9% in 2016. The increase from 2006 to 2016 may have suggested the primary forest transiting into minimally disturbed forests. Highly degraded/disturbed forests increased from 4.2% in 1986 to 17.3% in 2006 (suggesting significant disturbance) and account for only 0.8% in 2016. This decline is likely caused by tree and arable crops within the reserves. Specifically, primary forests lost about 3,260km^2 in the 30years from 1986 to 2016 which represents about 108.6km^2 per annum.

The spatial land-cover patterns show that the reserves in the rainforest zones are significantly affected by deforestation. The Omo-Shasha-Ago Owu-Ife-Oluwa reserve complex suffered significantly with most of the primary forests in 1986 taken over by Teak/*Gmelina* plantations and mixture of tree crops and secondary forests in 2006 and 2016. Field visits reveal large extent of cocoa plantation inside the reserves especially around the Omo-Shasha-Ago Owu-Ife-Oluwa reserve complex. Other forest reserves including the Onishere-Akure Ofosu-Idanre-Owo and Okeluse reserve complex have

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also been significantly affected by outright loss and degradation of primary forests. The Akure FR in Aponmu (near Akure) has lost almost two-third of its primary forest cover in 1986 and the small remaining tract is now being considered for the Queens Plot Strict Nature Reserve. Other smaller reserves, Ogbesse, Ise (Ekiti State), Onigambari and Ijaiye (Oyo State), Oni (Osun state) and Ipele-Idoani and Osse River Park (Ondo State) have been significantly degraded with substantial parts taken over by Teak/*Gmelina* plantations.

As noted earlier, unsustainable logging driven by heavy annual revenue targets, polewood extraction, fuelwood and charcoal production, and tree crop cultivation are the most significant proximate drivers of forest loss in the reserves. Forest degradation, according to GOFC-GOLD (2016), represents a persistent direct human-induced decrease in forest carbon stocks, with measured canopy cover remaining above the threshold for definition of forest and no change in land-use. In the reserves of SW Nigeria, the forest cover is significantly altered and the forest becomes more disturbed. Except for small patches in some of the reserves, primary, undisturbed lowland rainforests are almost completely gone and are being replaced by' other naturally regenerated forest'.

Savanna woodland

Savanna woodland represents the most extensive land-cover covering roughly 40% of the reserves. The savanna woodland did not change much from about 44% in 1986 to 42% and 41% in 2006 and 2016 respectively. It is the major vegetation in the Old Oyo National Park. It also covers the extensive Okpara, Igangan, Odugbe and Meko Forest and Games reserve all in the sparsely populated western border areas with Benin Republic. The woodlands are very significant for wood production purposes, game reserves, ecotourism, and importantly, they protect the headwaters of the major rivers of SW Nigeria including the Okpara, Ofiki, Oyan, Ogun, Oba and Oshun Rivers.

Teak/Gmelina

Teak/Gmelina *(with few areas of Eucalyptus)* is becoming the dominant plantations in SW Nigeria. Teak/Gmelina in the reserves increased from about 460.6km^2 (3.7%) in 1986 to 1,312.7km^2 (10.6%) in 2006 and 2,277.5km^2 (18.4%) in 2016. This means that Teak/*Gmelina* has already overtaken the natural forests in the reserves. They are found virtually in all the reserves but appear more dominant in the reserves of the rainforest zone including the Omo-Shasha-Ago Owu-Ife-Oluwa reserve complex and the Akure Ofosu-Idanre-Onishere-Owo-Okeluse and Ifon forest reserves. In the absence of natural reseeding of indigenous forest trees, Teak/Gmelina has become the only means of afforestation and reforestation across the reserves and may completely replace the natural forest in the near future if the current rate of deforestation continues. Other small reserves across Ekiti, Ogun, Osun, Oyo and Ondo States also, have substantially domination of Teak/*Gmelina*.

Discussion with forestry officers suggests that several private individuals going into silviculture are interested in Teak/*Gmelina* for the production of hard and soft woods. Teak and Gmelina appears to be replacing even the *Ficus* species in the village square

across the SW. Although they are good for wood production, they signal danger for the indigenous tree species and for the remaining natural forests. Monoculture plantations have limitations in supporting virile and productive ecosystems and rich plant and animal biodiversity and in carbon storage.

Table 5: Change in Area of Landcover classes within the forest reserves, 1986 - 2016

Pry Code	Primary Class	Secondary code	Secondary Class	Area sqkm 1986	Percent 1986	Area sqkm 2006	Change % 2006	Area sqkm 2016	Change % 2016	Change area 1986-2006	Change % 1986-2006	Change area 2006-2016	Change % 2006-2016	Change area 1986-2016	Change % 1986-2016
1	Forest	10	Undisturbed Forest	3266.3	26.4	1026.2	8.3	6.7	0.1	-2240.2	-18.1	-1019.5	-8.2	-3259.6	-26.4
1	Forest	11	Minimally Disturbed Forest	936.9	7.6	343.1	2.8	1474.6	11.9	-593.8	-4.8	1131.5	9.2	537.7	4.4
1	Forest	12	Highly Disturbed Forest	518.9	4.2	2136.9	17.3	98.7	0.8	1618.0	13.1	-2038.3	-16.5	-420.2	-3.4
2	Built-up Area	21	Urban	75.8	0.6	75.1	0.6	237.0	1.9	-0.7	0.0	161.9	1.3	161.2	1.3
3	Plantation	31	Teak/Gmelina	460.6	3.7	1312.7	10.6	2277.5	18.4	852.1	6.9	964.9	7.8	1817.0	14.7
3	Plantation	34	Rubber	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0
4	Woodland	41	Savanna Woodland	5490.8	44.4	5231.6	42.3	5115.7	41.4	-259.2	-2.1	-115.9	-0.9	-375.1	-3.0
5	Agriculture	51	Intensive Arable Cultivation	254.6	2.1	1125.0	9.1	482.5	3.9	870.3	7.0	-642.5	-5.2	227.8	1.8
5	Agriculture	52	Fallow with Scattered Arable Cultivation	738.1	6.0	222.8	1.8	25.6	0.2	-515.2	-4.2	-197.2	-1.6	-712.5	-5.8
5	Agriculture	53	Mix of Tree Crop and Secondary Forest	119.6	1.0	475.0	3.8	1532.0	12.4	355.4	2.9	1057.0	8.6	1412.4	11.4
6	Wetland	61	Mangrove	5.6	0.0	7.4	0.1	1.8	0.0	1.7	0.0	-5.6	0.0	-3.9	0.0
6	Wetland	62	Swamp	64.1	0.5	39.8	0.3	11.3	0.1	-24.3	-0.2	-28.5	-0.2	-52.8	-0.4
6	Wetland	63	Marshland	1.3	0.0	5.7	0.0	25.7	0.2	4.4	0.0	20.0	0.2	24.4	0.2
7	Bare Surface	71	Rock/Montane Forest	106.7	0.9	340.5	2.8	16.6	0.1	233.8	1.9	-323.9	-2.6	-90.1	-0.7
8	Water	81	River/Lake	62.8	0.5	12.9	0.1	9.9	0.1	-49.9	-0.4	-3.0	0.0	-52.8	-0.4
9	Grassland	91	Coastal Grassland	0.0	0.0	2.2	0.0	6.2	0.0	2.2	0.0	3.9	0.0	6.1	0.0
9	Grassland	92	Savanna Grassland/Shrubland	254.6	2.1			493.3	4.0	-254.6	-2.1	493.3	4.0	238.6	1.9
100	Unclassified	100	Unclassified (cloud cover)					541.7	4.4	0.0	0.0	541.7	4.4	541.7	4.4
				12356.8	100.0	12356.9	100.0	12356.8	100.0	0.0	0.0	-0.1	0.0	0.0	0.0

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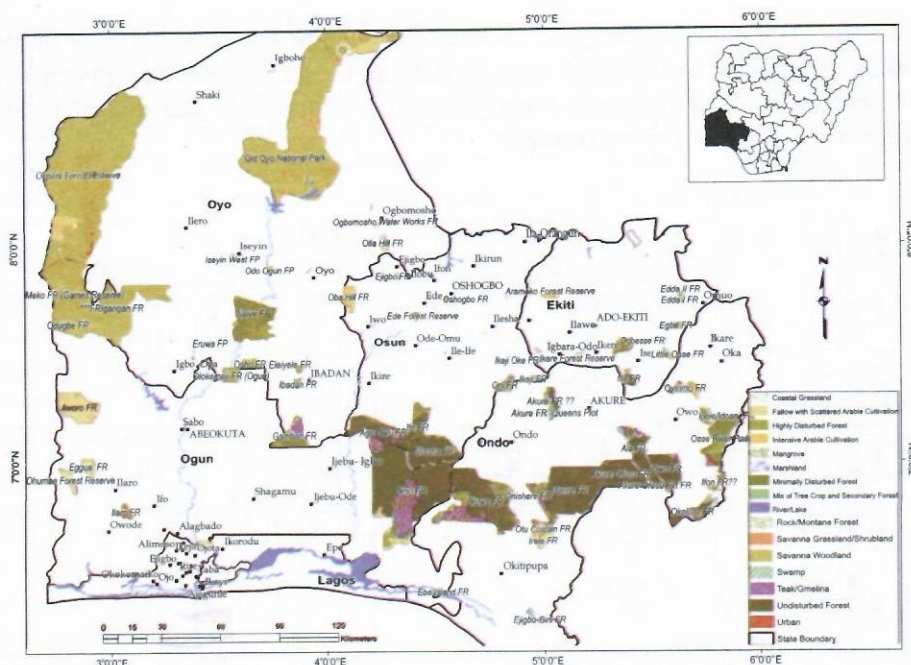
Figure 2: Status of the Forest Reserves and Protected areas in SW Nigeria in 1986
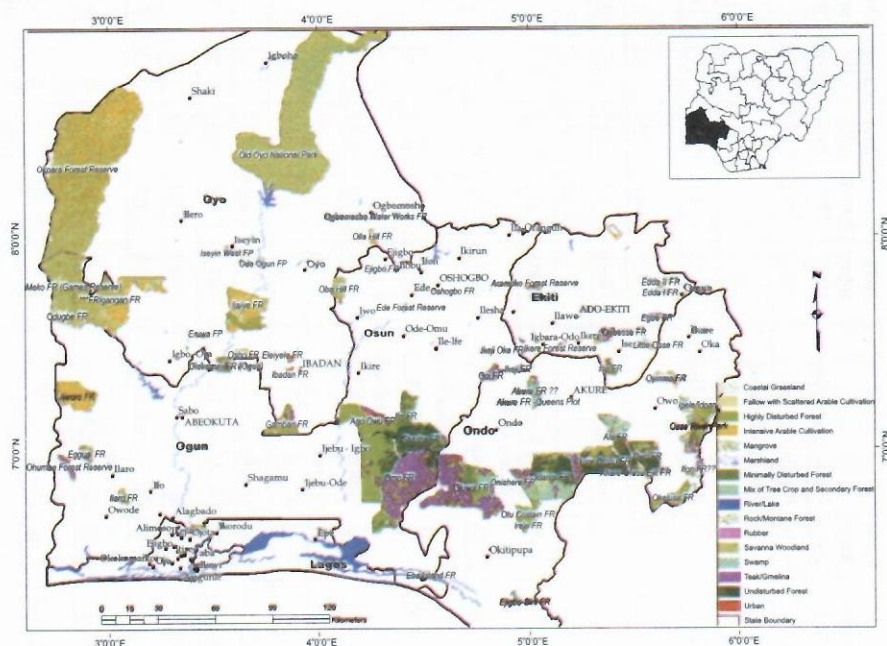Source: Map compiled from interpretation of Landsat TM imagery (December 1986)

Figure 3: Status of the Forest Reserves and Protected areas in SW Nigeria (2006)
Source: Map compiled from interpretation of Landsat ETM imagery (December 2006)
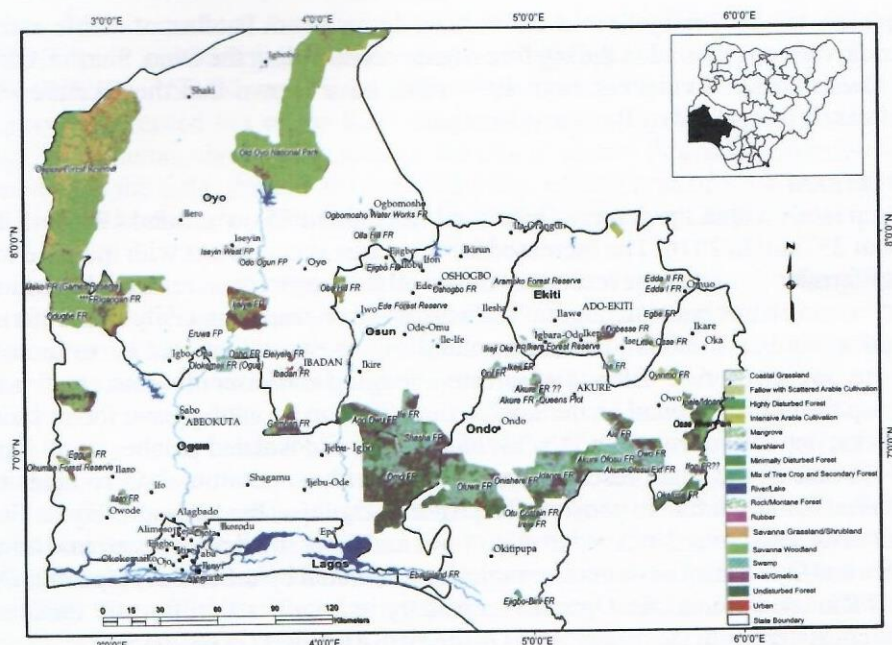
Mayowa J. Fasona, Akinlabi O. Akinneyi, Samuel K. Udofia, Tamarabrakeni M. Akinu, Ajibade N. Ariori, Peter A. Adeonipekun, Oludare O. Agboola, Gbenga E. Ogunsanwo, Oluwatoyin T. Ogundipe, Alabi O. Soneye, Ademola S. Omojola

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Figure 4: Status of the Forest Reserves and Protected areas in SW Nigeria in 2016
Source: Map compiled from interpretation of Landsat OLI imagery (January 2016)

Cultivation

Tree and arable crop cultivation remain one of the significant threats to the reserves. Intensive arable cultivation within the reserves increased from about 254.6km^2 in 1986 to 1,125km^2 in 2006 and declined to 482km^2 in 2016. Tree crops (mixed with secondary forests) within the reserves has consistently increased from about 1% in 1986 to 3.8% in 2006 and 12.4% in 2016. In total, farming in the reserves (intensive arable cultivation, fallow with scattered arable cultivation and mixture of tree crop and secondary forest) generally increased from about 9.1% in 1986 to 10.9% in 2006 and 16.5% in 2016. This is consistent with the assessment of USAID on Nigeria's biodiversity and tropical forests as well as observation in the Nigeria NBSAP report (USAID, 2013; FGN, 2015a) and Akinsoji (2018) on the status of Ifon FR in Ondo State.

Farmland constitutes one of the greatest indicators of disturbance and encroachment into the forest reserves and protected area. Patches of arable cultivation are now found in virtually all the government reserves. The statistics reported here would likely underestimate the extent of farmland encroachment into the reserves because of the difficulty of mapping small, discontinuous tree crops including cocoa, oil palm and banana within the forests. Some of the small forest reserves across the states – including Oyimo and Ipele/Idoani (Ondo), Egbe, Aramoko, Edda I &II (Ekiti), Ede and Oba Hills (Osun), Odo Ogun, Ijaiye, Olla hills and Ogbomosho water works (Oyo) and Ilaro FR (Ogun) have been seriously encroached by farmland. Some small reserves around Iseyin and the Odo Ogun FR situated along the Iseyin-Oyo Road have been

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completely taken over by farmland and thus, de-reserved. Patches of arable and tree crop cultivation are found in the big forest reserves including the Omo, Shasha, Oluwa, Ago Owu and Ife. Evidences from field visits have shown that the Okeluse FR is significantly threatened by Banana plantation.

Built-up area

Built-up lands within the reserves increased from about 75km² around 1986 and 2006 to about 237km² in 2016. The increased built-up area is consistent with increase in the area of farmlands within the reserves. Almost all the major forest reserves have human enclaves and camps housing migrant and seasonal tree crop (especially cocoa) farmers as well as timber workers. These communities are expanding leading to increased pressure on the reserves. Effects of selective logging and discontinuous small holder tree crop farms also abound on the satellite imageries in form of gaps in forest canopy, log decks, network of roads and tracks, clearances, and isolated patches small human camps. Some of the small reserves once located within and around urban areas have been overtaken by urban expansion. The Aremo, Ogunpa, Ibadan and Eleiyele Forest Reserves located around the Ibadan metropolis and other small reserves around Lanlate and Eruwa (Oyo State) have been completely overtaken by urban development. Ogun River FRlocated around the Ogun River estuary in Lagos is significantly threatened. This is consistent with the observations in the NBSAP report (FGN 2015a).

Wetland

Despite the importance of wetlands as biodiversity hotspots, the area of wetlands in the reserves remains at less than 0.5% from 1960 to present. Eba Island FR (about 23km²) and Ejigbo Bini FR (about 19km²) both in Ondo State and Ogun River FR in Lagos (about 22.9km²) arethe only wetland reserves found on the map. Although forest officers in Lagos State also listed Ologe (47.8km²) and Yewa Creek as new FR in Badagry and Ikorodu areas of the state, there is no sufficient location information to evaluate their current status. The lack of protection could explain the substantial wetland conversion with concomitant biodiversity loss and environmental problems (especially flooding) in the coastal SW Nigeria.

Protected Area and Strict Nature Reserve

The Old Oyo National Park established in 1991 (the only National Park in SW Nigeria) is located in the northern savanna woodland part of Oyo State. Like the rest of the National Parks in Nigeria, access is limited to recreation and scientific/education purposes, although that has not totally prevented poaching, grazing and bush fire. There are also Strict Nature Reserves (SNR) created by some of the states in few of the reserves. These SNR harbours perhaps the last vestige of the original primary rainforest that once dominated these reserves in the past. According to Ogun State Forestry Department, a 1000ha area has been demarcated for SNR deep inside the Omo FR. Some evidence of this was seen in the areas around *Erin* Camp (Elephant Camp) during the field work. Located about 15km northwest of Omo Sawmill village, north of the Omo River, the Erin Camp (an initiative of the Nigerian Conservation Foundation – NCF- to protect the remaining forest elephant habitat) consists of undisturbed primary

forests. Further north of *Erin* Camp, in Shasha FR is the Shasha SNR, one of the UNESCO man and biosphere (MaB) sites – and perhaps the only legally protected public SNR site in SW Nigeria. In Ondo State, the Queens Plot, a 1000ha (10km^2) SNR has also been carved out of the last vestige of primary forest inside the Akure FR located in Aponmu, about 10km west of the city of Akure. According to information gleaned from the field, there is also a plan to demarcate an area of SNR from the Osse River Park located around Ifon, about 20km east of Owo town in Ondo State.

Communities and private organizations are also, not totally left out in the efforts to promote forest and woodland conservation in SW Nigeria. As part of its conservation portfolio across Nigeria, the Nigerian Conservation Foundation (NCF), the flagship conservation non-governmental conservation organization in Nigeria, successfully created and managed the only SNR in Lagos State. Located in the heart of the sprawling, highbrow Lekki Peninsula, the 78ha Lekki Conservation Centre, the only natural green area in the Lagos metropolis, holds the last vestige of what could be considered the original natural flora of Metropolitan Lagos. In Ekiti State, the Forestry Department also mentioned the Otun Herbal Heritage Center, a 10ha community-owned herbal plants conservation area located around Otun-Ekiti, about 40km north of Ado-Ekiti. Some of these SNR are not properly demarcated and are too small to be mapped using medium resolution imageries. The total area covered by SNR is, therefore, very small when compared to the total area of the reserves.

The NCF initiated the Omo-Shasha-Oluwa (OSO) Forest Elephant Project. The OSO Elephant project aims to protect the Forest Elephant migration corridor in the SW Nigeria which stretches from the Omo-Shasha-Oluwa forest complex to Okeluse FR and Osse River Park areas of Ondo. The NCF is actively engaging the Ogun, Osun and Ondo State governments and communities inside the reserves through advocacy and education. However, a lot of huddles remain to be crossed because the forestry sector remains the primordial revenue generation targets across the three states. Perhaps, alternative economics such as REDD+ initiative and Payment for Environmental Services (PES) arrangements that also guarantee income to governments on forest will be necessary to command their attention. This will also involve social and community involvement, the delineation of high conservation value forests, and international forest management certification schemes (FAO 2016a,b; GOFC-GOLD, 2016). At present, community involvement in forest management activities is very low, no conservation value forests and corridor have been delineated and no certification scheme exists for any forest in SW Nigeria.

With regards to the communities, environmental and biodiversity conservation awareness remains low. More importantly, the knowledge and practice of alternative livelihoods to forest remain significantly low (Fasona *et al., 2018*). In March 2018, the killing of a forest elephant by a group of local hunters in some small villages along the Elephant migration corridor around Idanre town (12km south of Akure) was widely reported (https://www.vanguardngr.com/2018/03/idanre-hues-cries-killing-elephant/). This suggests that sustained education and advocacy efforts and resources to reach the vast number of villages and hamlets located around the forest reserves and

Mewewé J. Fasona, Akinlabi O. Akintuyi, Samuel K. Udofia, Tamarubrakemi M. Akoso, Ajibade N. Ariori, Peter A. Adeonipekun, Oludare O. Agboola, Gbenga E. Oguntowowo, Oluwatoyin T. Ogundipe, Alabi O. Soneye, Ademola S. Omojola

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corridor is important.

Challenges of managing Forest Reserves and Protected Areas

Results from the field survey suggest that 77% of the respondents agreed that the states have policies on forestry and forest management but agreed that the staff strength of the forestry departments is inadequate to meet the overwhelming responsibilities of forest management in their states. Figure 5 shows the major challenges faced by forest
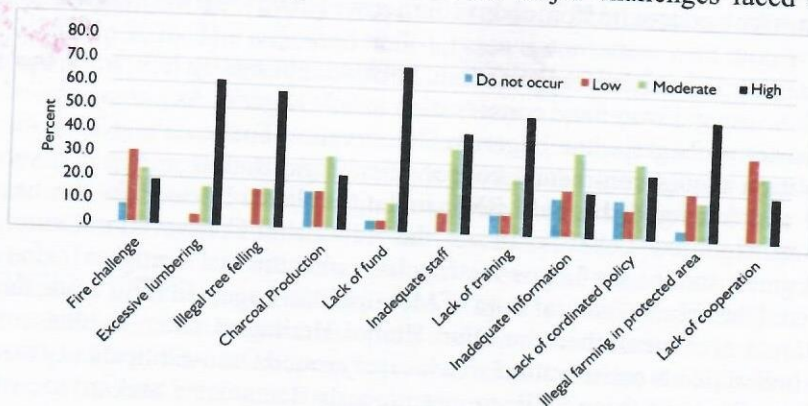

Figure 5: Major challenges faced by managers of forest reserves and protected areas in study areas

Perhaps the challenges can be summed into two: lack of fund and ineffective policy implementation. This is consistent with the results from USAID's Nigeria biodiversity and tropical forests assessment report (USAID 2013). Most forestry officers do not think existing policies are effective and achieving their targets. Many important metrics of sustainable forest management are not effective (FAO, 2006). The over-commercialization of the forest reserves with heavy emphasis on revenue targets by the states increases deforestation, forest degradation and unsustainable logging. It also encourages corruption tendency in the forestry sector (USAID 2013).

CONCLUSION

Forest resources information is indispensable to the management of forest reserves and protected areas. This paper documents the location, extent and current status of the government reserves through the social surveys, GIS analysis of base maps and remote sensing analysis of existing reserves. The results show that between 11,825.18km^2 and 12,443.77km^2 representing between 15 and 16% of SW Nigeria are covered by FR and protected areas. Natural forest has declined very fast and *Gmelina* plantations have become much widespread and may completely replace natural forests except conscious regenerative efforts are pursued.

Lack of fund and ineffective policy implementation are major challenges facing the forest reserve managers. Forest governance around the world is improving with increasing commitments on forests to carbon credits, international certification and

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multilateral conservation commitments and agreements. The Nigeria's document on the Nationally Determined Contributions to the Paris Agreement has the target to reduce Nigeria's contribution to global carbon emission by reducing land-use and land-use and forestry (LULUF) induced carbon emission. The forest reserves have a significant role to play, if this is to be achieved. Efforts must be put in place to revitalize, reseed and regenerate the reserves with indigenous forest species. New reserves should be established across the states to increase area under protection. The highland/montane forests offered a great potential for this. The SNR should be gazette and backed by law to protect them from degradation. Engagement of local communities in the reserves and around the wildlife corridors must be increased. They must be recognized as important stakeholder with incentives to engage in co-management of the reserves and wildlife corridors.

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Appendix 1:

Forest Reserves and Protected Areas in SW Nigeria

Sn	State	Forest Reserve/Protected area	*Nature	Area retrieved from field survey (in km2)	Area generated from GIS analysis of base maps(in km2)
1	Ekiti	Aramoko Forest Reserve	Plantation	19.66	18.11
2	Ekiti	Ogotun Forest Reserve	Natural	15.69	3.47
3	Ekiti	Ogotun Forest Reserve	Natural		4.80
4	Ekiti	Ikere Forest Reserve	Plantation	14.19	11.88
5	Ekiti	Ise FR	Natural	56.77	41.33
6	Ekiti	Ogbesse FR	Mixed	72.52	61.19
7	Ekiti			0.00	25.05
8	Ekiti	Egbe FR	Mixed	10.22	15.36
9	Ekiti	Edda I FR	Mixed	9.06	5.98
10	Ekiti	Edda II FR	Mixed		5.76

11	Ekiti	Little Osse FR	Plantation	26.62	18.85
12	Lagos	Ogun FR		52.20	22.90
13	Lagos	Ologe		47.84	
14	Lagos	Yewa Creek			
15	Ogun	Odugbe FR	Mixed	0.00	142.62
16	Ogun	***FR	Mixed	0.00	136.33
17	Ogun	Aworo FR	Mixed	212.99	239.19
18	Ogun	Ohumbe Forest Reserve	Plantation	46.08	44.54
19	Ogun	Eggua FR	Plantation	41.47	45.77
20	Ogun	Ilaro FR	Plantation	46.08	34.60
21	Ogun	Omo FR	Mixed	1368.06	1264.64
22	Ogun	Olokemeji FR (Ogun)	Mixed	58.88	48.21
23	Ogun	Arakanga FR	Natural	2.39	1.70
24	Ogun	Meko FR (Games Reserve)	Mixed	954.88	621.38
25	Ogun	Edun Strean FR	Natural	0.79	1.55
26	Ondo	Eba Island FR	Mangrove	18.13	23.09
27	Ondo	Ejigbo-Bini FR	Mangrove	0.00	19.22
28	Ondo	Akure Ofosu FR	Natural	401.45	277.34
29	Ondo			0.00	31.66
30	Ondo	Idanre FR		540.50	535.57
31	Ondo	Onishere FR		0.00	113.69
32	Ondo	Otu Costain FR	Mixed	0.00	76.85
33	Ondo	Irele FR		0.00	31.42
34	Ondo	Oluwa FR	Mixed	878.16	792.07
35	Ondo	Ala FR	Natural	199.43	187.68
36	Ondo	Akure FR??		69.93	61.20
37	Ondo	Akure Ofosu Ext FR		20.89	21.08
38	Ondo	Owo FR	Mixed	242.16	199.29
39	Ondo	Okeluse FR	Natural	114.40	128.73
40	Ondo	Osse River Park		282.30	248.65
41	Ondo	Ipele/Idoani FR	Mixed	41.44	34.16
42	Ondo	Oyinmo FR	Mixed	23.45	66.49
43	Ondo	Akure FR -Queens Plot	Natural	0.00	6.94
44	Ondo	Ifon FR??	Mixed	0.00	38.43
45	Osun	Shasha FR		0.00	281.41
46	Osun	Ife FR		0.00	166.95
47	Osun	Ago Owu FR		0.00	297.63
48	Osun	Ejigbo FR		0.00	3.56
49	Osun	Ede Forest Reserve	Ede FR	0.00	13.46
50	Osun	Oshogbo FR		0.00	1.95
51	Osun	Ikeji FR	Plantation	0.00	16.95
52	Osun	Oni FR	Mixed	0.00	49.50

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53	Osun	Ikeji Oke FR	Natural	0.00	4.34
54	Osun	Ila FR	Plantation	0.00	2.57
55	Osun	Oba Hill FR		0.00	62.89
56	Oyo	Okpara Forest Reserve	Mixed	2486.40	2506.51
57	Oyo	Igangan FR	Mixed	396.27	370.86
58	Oyo	Gambari FR	Mixed	114.31	137.31
59	Oyo	Ibadan FR		0.00	5.14
60	Oyo	Ogunpa FR		0.00	0.26
61	Oyo	Aremo FR		0.00	0.64
62	Oyo	Eleiyele FR		0.00	9.70
63	Oyo	Osho FR	Mixed	37.04	37.83
64	Oyo	Ijaiye FR	Mixed	284.91	367.61
65	Oyo	Eruwa II FR		0.00	0.44
66	Oyo	Eruwa I FR		0.00	0.60
67	Oyo	Lanlate (Otuma) I FR		75.07	0.32
68	Oyo	Lanlate (Otuma) II FR			0.30
69	Oyo	Eruwa FP	Plantation	0.00	0.43
70	Oyo	Eruwa FP	Plantation	0.00	0.50
71	Oyo	Odo Ogun FP	Plantation	0.00	8.93
72	Oyo	Iseyin West FP	Plantation	6.80	1.21
73	Oyo	Iseyin Central FP	Plantation		1.23
74	Oyo	Iseyin East FP	Plantation		0.33
75	Oyo	Olla Hill FR		23.00	19.28
76	Oyo	Ogbomosho FP	Plantation	0.00	1.97
77	Oyo	Ogbomosho Water Works FP	Plantation	0.00	3.78
78	Oyo	Oloyan Forest Reserve		0.00	0.73
79	Oyo	Old Oyo National Park	Natural	2512.00	2345.76
80	Oyo	Olokemeji FR (Oyo)	Mixed	0.75	12.12
				11825.18	12443.77

[*] As noted by the Forest Officers