SOIL SEED BANK, FLORISTIC COMPOSITION AND CARBON STOCK IN THE SECONDARY FOREST AT COCOA RESEARCH INSTITUTE OF NIGERIA, IBADAN

By

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ABSTRACT

Exploration of Soil Seed Bank (SSB), Floristic Composition (FC) and Carbon Stock (CS) represents a standard approach to determining the health of a forest ecosystem. Anthropogenic disturbances change the composition, physiognomy and health of the forest. The SSB diversities are key components of ecosystem resilience for restoration of many plants after forest disturbances. However, there is dearth of information on effect of season and soil depth on SSB as it relates to vegetation, and CS in Secondary Forests (SF) in Nigeria. Therefore, SSB, FC and CS in the SF atCocoa Research Institute of Nigeria (CRIN), Ibadan, were investigated.

Twenty five 50 m x 50 m main plots were randomly mapped out in the SF of CRIN to enumerate tree species in Wet Season (WS) and Dry Season (DS). Within each plot, five 10 m x 10 m sub-plots were randomly mapped out to enumerate shrubs. Three quadrats (1 m x 1 m) were laid in the sub-plots to enumerate herbaceous species. Soil samples were collected at 0-5 cm (Shallow Topsoil-ST) and 5-15 cm (Deep Topsoil-DT) from five points within each main plot and each bulked in both seasons following standard procedures to determine SSB composition and diversity. Bulked soils (1kg) were each spread in 150 germination trays (1200 cm^3) in completely randomised design to monitor seedling emergence for 24 weeks in the screen house. Relative Importance Value (RIV) and community structure indices (Dominance, Shannon-Wiener, Equitability and Jaccard) of the vegetation and SSB at ST (SSB-ST) and DT (SSB-DT) were determined. Estimation of CS (ton/ha) of trees (with girth ≥30 cm) was carried out using a non-destructive method and allometric equations.

A total of 219 plant species from 59 families which included 63 trees, 34 shrubs and 86 herbaceous species were identified. In the WS, *Triplochiton scleroxylon* (5.6%), *Lonchocarpus griffonianus* (8.8%) and *Chromolaena odorata* (25.2%) had the highest RIV while in the DS, *Terminalia superba* (5.0%) *Lonchocarpus cyanescens* (8.6%) and *C. odorata* (12.3%) were highest among trees, shrubs and herbs, respectively. In the SSB, *C. odorata* had highest RIV in WS (13.9%-ST and 16.8%-DT) and *Peperomia pellucida* in the DS (10.4%-ST and 13.4%-DT). Dominance was 0.03, 0.03, 0.11, 0.08 and 0.11; Shannon-Wiener was 3.81, 3.60, 3.54, 3.10 and 2.61; while Equitability was 0.92, 0.93, 0.75, 0.80 and 0.74 for trees, shrubs, herbs, SSB-ST and SSB-DT, respectively. In both seasons, vegetation were perfectly similar (C=100%) for trees and shrubs, but less similar (76.4%) for herbaceous species. Jaccard was 19.0-28.1%, 0% and 0.0-1.7% for SSB/herbs, SSB/shrubs and SSB/trees, respectively. Similarity

(Jaccard) was the least (29.6%) between DT-WS and ST-DS and the highest (75.0%) between DT-WS and ST-WS in SSB. The total CS of SF was 19.46 and the highest value of 2.84 for *Albizia coriaria* alone.

There were high diversity and random distribution of species with low restoration potential and resilience for trees and shrubs, but high potential for herbs in secondary forest of Cocoa Research Institute of Nigeria, Ibadan. The trees of the secondary forest had potential for accumulating carbon.

Keywords: Seedling emergence, Floristic species diversity, Species composition, Carbon stock

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CERTIFICATION

We certify that this work was carried out by Moussa **SEYNI BAYDO** in the Department of Crop Protection and Environmental Biology, University of Ibadan.

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DEDICATION

This work is dedicated to my late parents, Mr Seyni Baydo and Mrs Seyni Laki Moumouni, whose best education and love are with me always. I pray that they continue to rest in peace and may Allah (SWT) reward them with His Paradise. Ameen.

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CHAPTER ONE

1.0 Introduction

Soil seed bank is vital in sustaining the vegetative structure of a forest, particularly in preserving indigenous plant species. It is also a pointer to the regenerative potential of forest ecosystems (Nishihiro *et al*., 2016). Soil seed bank is an assemblage of viable seeds which exist in the soil with an inherent restoration ability (Hossain and Begum, 2015). It is important and provides crucial information for understanding vegetation dynamics in the various ecosystems (Ma *et al*., 2013) as it has the potential for vegetation recovery. The soil seed bank provides chronology on the status of the standing vegetation and its restoration capability in an ecosystem (Andreu *et al*., 2009). Several studies have documented the vital roles of seed bank investigation around the world with the aim of restoration and reforestation (Leck, 2013), succession (Bossuyt and Hermy, 2014), monitoring anthropogenic disturbances and invasive species and management interventions (Kinloch and Friedel, 2015).

Douh *et al*. (2014) referred to seed bank as all the viable seeds in the soil that are capable of replacing adult plants which have disappeared for various reasons and have created a vacuum in the ecosystem. Soil seed bank dynamics are vital for the natural recovery of degraded ecosystems (Koh *et al*., 2013). Santos *et al*. (2018) stated that the soil seed bank comprises two categories of seeds which are allochthonous (seeds that originate from a distance and may be exotic) and autochthonous (seeds from within the ecosystem). Seeds help in conservation because they can tolerate adverse conditions better than the plant itself (Helion, 2015). This further explains the perseverance of seed banks in the soil as a strategy that species can use to establish themselves in a plant community.

Floristic composition in secondary forests presented a perfect relationship with established forest community composition, engendering an equilibrium model (Norden *et al*., 2009). The sufficient safeguard and sustainable management of a tropical rain forest need better information on its floristic composition. For proper conservation and management strategies of the forest, quantitative information is required on the diversity, population structure, and distribution patterns of species (Andel, 2001). Information on the floristic composition and structure of the secondary forest is key to understanding the larger dynamics of forest area and for finding key elements of plant diversity (Akinyemi and Oke, 2014).

Forest environments are home to biodiversity and offer foodstuff and other important resources to survive on land (Atomsa and Dibbisa, 2019). Vegetation composition and forests' structure are strongly associated with ecological factors, such as climate and topography (Khan and Uma, 2001).

Carbon is stored in large amounts in tropical forests, therefore, there is the need for an accurate method of estimation (Djomo *et al*., 2016). Un-Redd-Programme (2014) recorded a non-destructive method of estimation in secondary forests by using allometric equations to estimate biomass volume and carbon stocks from a measurement of tree parameters like stem diameter at breast height (DBH) and tree height.

Justification of the study

Anthropogenic and natural disturbances change the composition, physiognomy and health of forest (Adedeji *et al*., 2015). This may promote species invasion which may influence change in species richness and oftentimes, community structure and loss of indigenous species (Santos *et al*., 2018). Soil seed bank and carbon stock of African tropical forests are poorly studied in spite of the important role that they could play in natural restoration cycle (Douh *et al*., 2014).The soil seed bank diversities are a key component of ecosystem resilience for the restoration of many plants after forest disturbances (Taiwo *et al*., 2018). However, there is a dearth of information on carbon stock in secondary forests and the effect of season and soil depth on soil seed bank as well as vegetation in Nigeria (Yan *et al*., 2010). Therefore, there is a need to investigate the implications of soil seed bank for forest vegetation restoration and its importance for stocking carbon in a secondary forest in Ibadan, Nigeria.

Aim and objectives of the study

The main objective is to evaluate the level of carbon stock in trees species, effect of season and soil depth on Soil Seed Bank and vegetation in the Secondary Forest of Cocoa Research Institute of Nigeria (CRIN).

The specific objectives include:

- To assess the effect of soil depth on germinability, density and species composition in the Soil seed bank;
- To assess the variation that exists between seasons and the density of the seed bank flora and standing vegetation of CRIN Secondary Forest;
- To evaluate the similarities between floristic composition of the standing vegetation and soil seed banks in the CRIN Secondary Forest; and
- To estimate the biomass and evaluate the level of carbon stock potential of trees species in the CRIN Secondary Forest.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Vegetation and climate of Nigeria

Nigeria had an estimated population of 206 million people in 2020 over a total land area of 983,213 km^2. The country is located between latitude 9.0820 ^oN, and longitude 8.6753 ^oE in West Africa; and shares boundaries with Cameroon and Chad in the east, the Republic of Benin in the east and west, and Niger Republic in the North (Balogun, 2001). Some of the unique and widely known geographical attributes of the country include Obudu Plateau, Adamawa highlands, Jos Plateau, Mambilla Plateau, the Niger Delta basin, and the Rivers Niger and Benue. The vegetation of Nigeria is distinctively characterized by forests, savanna and montane (Adakayi, 2000).

Vegetation belts are defined by interrelations between climate and plants. The forests which constitute a large stretch of dense tropical rainforests and savanna are currently the two broad vegetation belts in Nigeria, though with transition zones in-between. However, anthropogenic activities such as deforestation, clear cutting and burning of crop lands have led to a drastic reduction of the tropical rainforests, which Agbelade *et al*. (2017) report to have covered one-third of the country.

2.2 Soil Seed Bank

Seed banks play prominent roles in ecological resilience and are a driver for restoration potentials for many plant groups (Jiang *et al*., 2013). The role of Soil seed banks in the ecological productivity of natural forests cannot be overemphasized. Taiwo *et al*. (2018) opined that seed density and germinability are the critical success factors for plant restoration under favourable environmental conditions.

The plant composition of the soil seed bank after natural or anthropogenic perturbations is determined by the historical nature of the site since it provides species for vegetation resilience (Kalamees and Zobel, 2002). The age of forest establishment may also determine the potential of the soil seed bank in its capacity for seeds storage in other ecosystems outside temperate region. Guevara and Gomez-Pompa (1972) observed that a large amount of seeds deposition increased over time in older successional plant communities but seed deposition and species richness decreased over time at older plant communities in temperate forest, notwithstanding small seed banks in some young forests (Pickett and McDonnell, 1989).

The seed bank plays a crucial role in determining the composition and spatial structure of understorey plant communities in clear-cut areas following soil disturbances (Kalamees and Zobel, 2002). At the same time, it may contribute to plant regeneration in old growths. Tree fall which creates gaps is fundamental to the development of natural forest stands (Attiwill, 1994). In such tree-fall gaps, the uprooting of trees opens up the canopy and allows for favourable conditions needed for germination of seeds in the seed bank (Mayer *et al*., 2004).

Seed bank is a vital part of plant communities (Oke and Odebiyi, 2007) and can be used to forecast secondary succession (Oberhauser, 1997). The role of the seed bank in forest regeneration is very important as they carry genetic materials of basic plant component from generation to generation (Khurana and Singh, 2001). Lavorel *et al*. (2004) reported that the presence or absence of seed bank in the soil indicates the natural restoration level in a forest ecosystem. Apart from accommodating seeds, the seed bank presents an existing history of non-living vegetation, which have disappeared definitively. Restoration of forest environment can be pre-determined from results obtained from seed bank to data analysis (Cabin and Marshal, 2000).

2.3 Seasonal patterns in seed dormancy variations

When environmental conditions necessary for germination are available, seed dormancy can prevent germination. Nevertheless, seeds can cycle in and out of an undeveloped state during this period (Baskin and Baskin, 2014). Majority of plant seeds are inactive at maturity period (primary dormancy).This progression is stated as the second period of dormancy and adjusts periodic development in plant seeds (Baskin and Baskin, 1998).

When a seed is detached from a plant and spreads on the surface, it may grow instantly or persevere in the soil until favourable conditions become appropriate for germination, consequently establishing a soil seed bank (Shen *et al*., 2007). Variations in field behaviour of seeds are overseen by changes in two mechanisms of the system: "Environment" and "Seed" (Carol, 1984). There are frequently marked seasonal variations in the physical and chemical environment near the seed. In the tropics with two seasons, wet and dry seasons, the wet season is the growing period for annuals, while their seeds go into dormancy during the dry season when the conditions are unfavourable for the growth of seedlings. Awodoyin and Ogunyemi (2003) reported that dormancy enables most tropical plants to survive dry seasons and provide insurance against total eradication of populations from the ecosystem.

2.4 Soil seed banks and vegetation

Soil seed bank is important for the promotion of vegetation restoration (Lu *et al*., 2010). They offer a history of past and present plant species and embody the structure of the upcoming population (Fisher *et al*., 2009). When a seed is dispersed from the mother plant and reaches the soil surface, it may germinate immediately or persist on or in the soil until conditions become suitable for germination, thus forming a soil seed bank (Wang *et al*., 2013). The soil seed bank of an ecosystem can provide fundamental information on the status of the standing vegetation and its recovering potential. Also, there is a correlation between the species composition of the seed bank and the composition of the above ground vegetation (Sanderson *et al*., 2007). Moreover, it is the main point that the association between soil seed bank and above-ground vegetation have an original potential to measure revegetation potential (Wang *et al*., 2013).

2.5 Floristic Composition

Forest structure is defined by a number of factors such as frequency, density, abundance and cover, species composition, trophic and temporal variations. Therefore, forest structure is a concept that relates to species distribution patterns, species quantities and species diversity (Pappoe *et al*., 2010). Plant populations are defined as a group of functionally similar species populations that thrives in the same period and space (Mwaura and Kaburu, 2009).

A number of indices of diversity have been proposed by ecologists which are widely used for the study of plant communities such as Sorensen (1948), Simpson (1949), Shannon Wiener (1963) and Whittaker (1975). Sorensen (1948) derived formulae to assess the similarity between habitats or communities based on species composition. Simpson's (1949) index is considered as a measure of species dominance; as species diversity increases, the Simpson's index decreases (Magurren, 1988). Due to the lack of species dominance, tropical forests harbour high species diversity (Pappoe *et al*., 2010). The richness of forest ecosystem is influenced by the number of species present in the area. The more the species per unit area, the higher the richness will be (Pascal and Pellissier, 1996). A richness of seedlings reflects a high regeneration potential of the forest (Pappoe *et al.,* 2010) while girth class distribution analysis gives the scenario of the forest stand structure.

Kirby and Potvin (2007) studied the linkage between biodiversity and carbon storage in a disturbed forest in Panama and observed that there was no immediate linkage between carbon storage and species diversity. Habitat may not contribute to carbon storage increase. Poorter *et al*. (2015) stated that in forests and agroforests, species diversity contributes immensely to carbon storage per hectare but not the number of species.

2.6 Forest and threats from various disturbances

Forest is the largest biological deposit for above-ground carbon stock on land (Valbuena *et al*., 2016). They are areas of land cover defined by trees. Forest biodiversity helps to promote socio-economic activities. However, human activities have continuously impacted forest species diversity and ecological structure. Many researchers have worked on the effect of human perturbations on forest structure and plants diversity (Chittibabu and Parthasarathy, 2000). Human activities are causes of forest degradation, causing landscape fragmentation which on a large scale reduces biodiversity, as reported Roy and Tomar (2000). Forest biodiversity helps to promote socio-economic activities. Anthropogenic perturbations such as fuel-wood extraction, timber and farm operations like shifting cultivation are causes of deforestation resulting in landscape fragmentation and loss of biodiversity.

Therefore, pragmatic steps are required to mitigate the gradual but increasing loss of forest reserves. Soil seed bank is a proven and essential approach for restoration and regeneration of the forest. This is because the soil seed bank is an essential makeup of flora restoration and succession of the plant population (Fenner, 1992). This suggests that the regeneration of natural vegetation is determined by the composition of total abundance of reproductive parameters, such as viable seeds, vegetative propagules and litters in the seed bank (Shiferaw *et al*., 2018). Soil seed bank has a definite life span classification in the soil as: below one year, one to five years which is short-term, and above five years which is long-term persistent (Bakker *et al*., 1996).

2.7 Nature and state of Secondary Forest

Secondary forests are forests that are recovering by natural processes from previous natural or human disturbances over time. The different classifications of secondary forests are premised on stand age, vegetation description, and biophysical characteristics of the landscape, among others. Some of the common disturbances of natural and human causes leading to secondary forests include natural catastrophes (fire, flooding, and hurricanes) and deforestation. Richards (1966) defined Secondary Forests as the replacement of primary vegetation communities by secondary vegetation. Similarly, Blaser and Sobagal (2002) describe Secondary Forests as the colonization and replacement of woody vegetation cover that was formally removed by a human incursion into the forest. Secondary vegetation is an agglomeration of several trees, shrubs, climbers and tall understorey plants; the components of the forest are not stable and comprise various strata. The secondary forest can become primary forest when primary forest components are gradually introduced, even with no incursion of human disturbances such as animal grazing, deforestation for logging and frequent fires. The transformation of secondary forest is insured by available seeds of the plant and ecological status of the forest (Smith *et al*., 1998).

According to Macchi *et al*. (2008), wildfires are the central causes of forest loss or its transformation. Either directly or indirectly, it impacts forest re-growth by burning seed, seedlings and standing vegetations (UNESCO, 1978). Fire damages seed, seedlings and trees. Fire, nevertheless, has little or no impact on plant organs buried few centimetres under the soil. The large presence of perennial shrubs emergence after the impact of fire on seeds is a great indication of moist vegetation disturbance in West Africa (Swaine, 1992).

2.8 Deforestation

The result of disturbances on biodiversity is a subject that has attracted the attention of a large number of ecologists worldwide (Uniyal *et al*., 2010). Deforestation and fragmentation are main agents of degradation in forest ecosystems, causing loss of biodiversity (Blasco *et al*., 2000). The ecological disturbances are responsible for changes in floristic composition, species diversity and the structure of the forests (Addo-Fordjour *et al*., 2009).

The rate of deforestation in the world is valued as 1113.7 billion hectares per year. However the compensated new Forest commonly called Secondary Forest are less important than the half of the deforestation rate (FAO, 2010). The Secondary Forests have also been impacted by climate change and anthropenic activities, thus, aggregate menaces of storms, and illnesses. The protocol of Kyoto contains the agreement to avoid deforestation instead taking the engagements to achieve it.

According to FAO 2016, Africa lost the maximum percentage of tropical Forest compared to the others continents for a period of the last three decades. Africa is accumulating deforestation at double the world's rate. Almost 90 % of West Africa's Tropical Forest has been destroyed (UNEP, 2018).

Deforestation in Nigeria is the principal percentage of natural forest in Africa. in the past five years, it has missed more than half of its natural Forest (FAO, 2010). One major reason contributing to the continent's high rates of deforestation is the need of 90% of its population on timber as firewood for heating and culinary.

2.9 Biomass and Carbon Stock

In the tropics, the fast increasing population is the cause of the continuous and intense abuse of forest and forest capitals for economic benefits. In the last decade, the rate at which forest disappeared and degraded in developing countries has been a great concern. The disappearance of about 13 million hectares of forest on annual basis has been due to land-use change by natural causes, mostly by agriculture (Ogunleye *et al.*, 2004).

Trees are crucial in biomass and carbon stocking, where fixation of atmospheric carbon is achieved during the process of photosynthesis and excessive carbon are deposited as biomass. Also, the changes in the amount of carbon source of forests are impacted by human activities through emissions from fossil fuel and exploitation/use of biomass (Nowak and Crane, 2002). Carbon stock of trees increases by a proportional increase in the amount of carbon deposited in plant and growth of biomass. FAO (2010) reported that young tree stands have the potential for increased carbon deposit than old-growth stage. The composition of the biomass of the trees in a forest contains standing vegetation comprising all above-ground and below ground living parts. An estimate of the biomass in the stem is determined from the tree height, diameter, and girth size at different heights (Phalla *et al.*, 2018).

2.10 Methods for Vegetation Sampling

Vegetation sampling methods have been defined for quantifying vegetation attributes (Kent and Coker, 1992). The primary goal of flora surveys is to typify as many vegetation forms as possible within a study area (Morellato *et al.*, 2010). Sampling theory emphasizes randomization in order to provide a probability structure for statistical analysis or to give credibility to the statistical model used (Morellato *et al*., 2010). Numerous vegetation sampling techniques have been outlined for quantifying vegetation attributes (Kent and Coker, 1992; Sanyaolu *et al*., 2018).

Since it is generally impossible to study an entire Forest area, researchers typically rely on sampling to acquire a representative section of the area to perform an experiment or observational study (Hamed, 2016). The most common sampling designs used in vegetation sampling are simple random sampling and stratified random sampling (Valerie and John, 1997).

The random sampling is the basic sampling technique where a group of plots (a sample) can be selected for study from the entire area. Each plot is chosen entirely by chance and each area of the site has an equal chance of being included in the sample (Clark *et al*., 2012).

There may often be factors which divide up the plot into sub-plots and we may expect the measurement of interest to vary among the different sub-plots. This has to be accounted for when a sample is selected from the area in order to obtain a sample that is representative of the area. This is attained by stratified sampling. A stratified sample is obtained by taking samples from each stratum or subplot of an area (Helion, 2005).

In line transect sampling, substantially more ground can be covered in a given time than for quadrat sampling, for which all plants within quadrats must be counted if plant abundance is to be estimated without bias (Buckland *et al*., 2008). In many circumstances, standard line transect sampling is very effective for plant populations.

2.11 Plant species diversities parameters and assessment

2.11.1 Species abundance

Species abundance is a measure of the amount of species in a sample. Plant population attributes that measure abundance includes plant density, plant frequency, plant foliar cover and species biomass (Ogwu *et al*., .2016). Other parameters that can be used in the assessment of plant communities include relative density (RD), Relative frequency (RF), abundance (A), Relative dominance (RDo), Relative Importance Value (RIV) and Importance Value Index (IVI) (Agbelade et al., 2016)

2.11.2 Plant diversity

Species diversity can be considered as the measure of the number of species, where each species is weighed by its abundance.The importance of plant to life on earth is enormous. Animals (including humans) depend on plant directly or indirectly for various reasons such as food, air, medicine, genetic resource, habitats and aesthetic qualities (Akinyemi and Oke, 2014).

Species diversity is one of the most frequently sampled attribute in vegetation studies (Chittibabu and Parthasarathy, 2000). Species diversity has two main components which are species richness and species evenness (Kent and Coker, 1992). A well-known concept is that an increase in sampling area increases species richness detection (Bobo *et al*., 2006). Evenness is a measure of the variety of the species. Species Richness refers to varieties of species found in a community (or genera, families, etc.). Generally, Biodiversity measurement that typically focuses on the species' level and diversity is one of the most important indices which are used for evaluation of ecosystems at different scales (Ahmed *et al*., 2015).

Diversity is always measured in units of the number of species. Beta diversity is generally thought of as the change in diversity among various Alpha diversities (Variation in species composition and geographic regions) (Moreno and Halffter, 2001). There exists a wide variation of techniques for calculating Beta diversity, among which similarity measures are the simplest and the most frequently used for calculating Beta diversity from abundance or presence/absence data (Salami and Akinyele, 2018). Both diversity and similarity indices can be used to compare differences among groups or samples from groups (Magurran, 1988). There are several diversity indices available for measuring and comparing land communities. Common diversity indices include species richness (S), Shannon-Wiener's diversity (H'), Simpson's diversity (D), Simpson's evenness (E), Berger-Parker dominance and Equitability (Pascal and Pellissier, 1996).

2.11.3 Shannon–Wiener Index

This is one of the most usually used indices in environmental studies. Its values range from 0 to 4.6. However, in most cases, the values range from 1.5 to 3.5. The Shannon diversity index combines both species richness and abundance. It is calculated by multiplying a species' proportional abundance by the natural log of that number (Deka *et al*., 2012). A rich ecosystem with high species diversity has large value of Shannon-Wiener index, while an ecosystem with little diversity has a low Shannon-

Wiener index. The main factors of the reduction in Shannon diversity and evenness in invaded vegetation are the cover and height of invading species and differences between height and cover of invading and dominant native species, independent of species identity (Agboola and Muoghalu, 2015).

2.11.4 Simpson's Index of Species Dominance (D)

The measure of dominance therefore (1-D) measures species diversity. As D increases, diversity decreases. Thus, the Simpson diversity index is regularly expressed as 1-D or 1/D. Where 1-D is used as the index, it ranges from 0 to 1, and values near to 1 show a community of many species with equally low abundances, while numbers close to 0 express fewer species with one of them clearly dominant. The lowest value for D is one, showing only one type of species (monoculture). A high value of D suggests a stable and ancient site (Agboola and Muoghalu, 2015).

2.11.5 Similarity indices

Numerous similarity indices have been proposed to measure the degree to which species composition of quadrats is alike. Conversely, dissimilarity coefficients assess the degree to which quadrats or group of samples differ in composition. Jaccard's coefficient is one of the commonly used similarity indices. It is the simplest index developed to compare flora (Chao *et al*., 2004). Jaccard (1912) developed the method to assess the distribution of the flora of the alpine zone. Jaccard coefficient is widely used to assess similarity using presence/absence data. The method ignores information about abundance of species.

The Jaccard similarity index (sometimes called the Jaccard similarity coefficient) compares members for two sets to see which members are shared and which are distinct. It is a measure of similarity for two sets of data, with a range from 0% to 100% (Jaccard, 1912). The higher the percentage, the more similar the two populations. Although it is easy to interpret, it is extremely sensitive to small sample sizes and may give erroneous results, especially with very small samples or data sets with missing observations (Zhong *et al*., 2017).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study area

The study was carried out in the Secondary Forest at the Cocoa Research Institute of Nigeria (CRIN) Ibadan, Oyo State, Nigeria (Figure 3.1). CRIN was established by the Federal Government of Nigeria through the Nigeria Research Institute in 1964 (Atanda, 1977). The CRIN estate falls within the transitory rainforest savanna vegetative of Nigeria and is located within coordinates 07^{o} 12.157' and 07^{o} 13.260' North and 003^{o} 51.093' and 003^{o} 52.290' East (Obatolu, 2014). The CRIN was established to produce Cocoa and later expanded to include coffee, cashew, kola and tea (Onyekwelu and Olaniyi, 2012). It is located at Km 14 Ijebu-Ode Road, Idi-Ayunre, Oluyole Local Government, Ibadan, Oyo State, Nigeria. The estate covers a total land area of 621.80 hectares (Figure 3.2) and is divided into nine research zones with different crop plantations within each zone (Agbelade *et al*., 2016).

The Institute is bounded in the North by Ibadan, on the West by River Ona, on the East by the main road of Ibadan to Ijebu-ode and by Gambari Forest reserve in the South. The research institute, in addition to the nine zones, also contains the main road, Senior Staff quarters, Main Lab, Screen Houses, Plant Nursery, Plantation and state management, Library, Maintenance and Senior Staff Clubhouse (Figure 3.3) (Obatolu, 2014).

Sampling was conducted in 25 plots that were established and randomly located using Global Positioning System (GPS; Garmin model). The study plots and their coordinates are shown in Table 3.1.

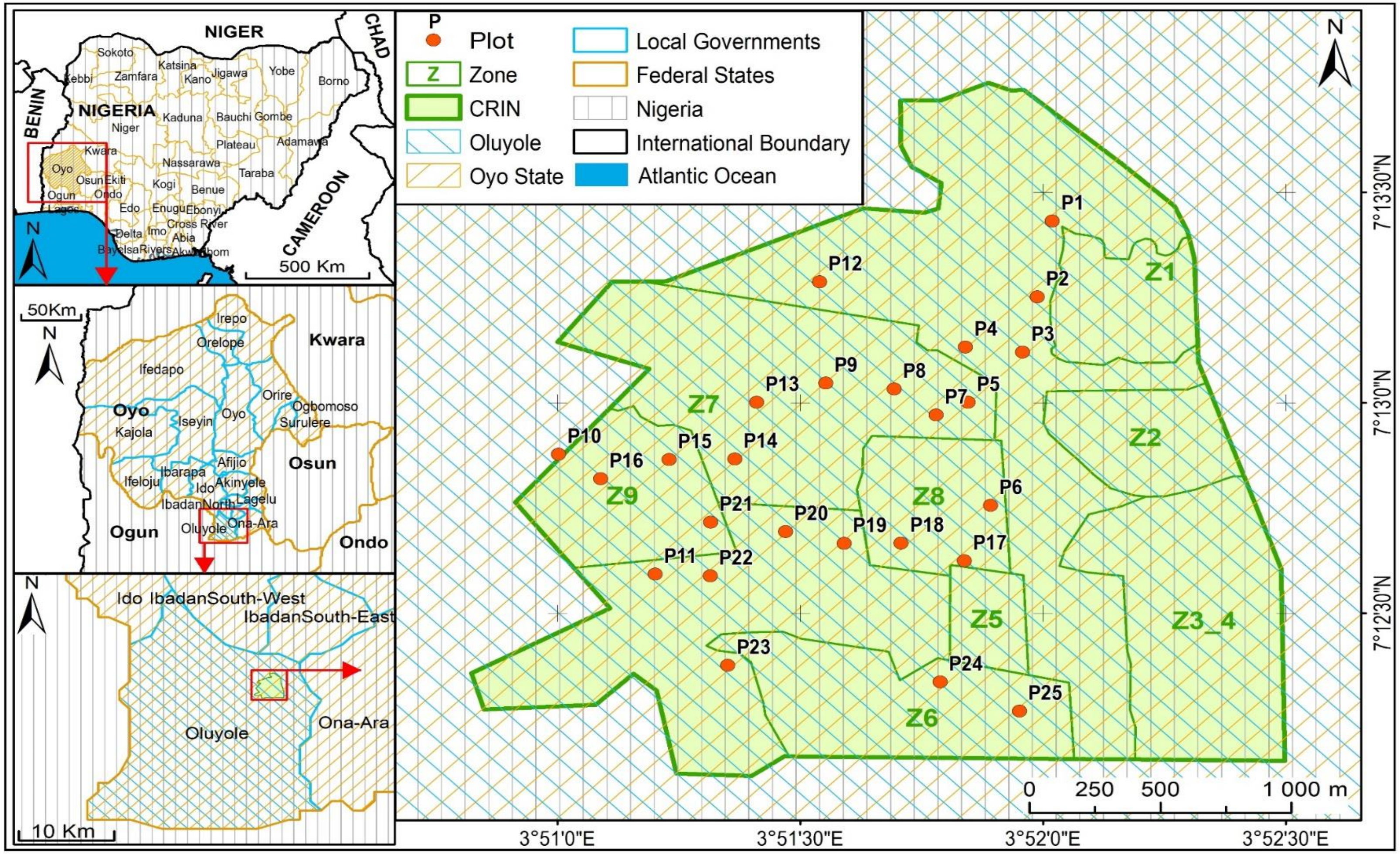

Figure 3.1: Selected Plots and Transects in CRIN Headquarters Ibadan, Oluyole LG and Oyo State widen and inset Map of Nigeria

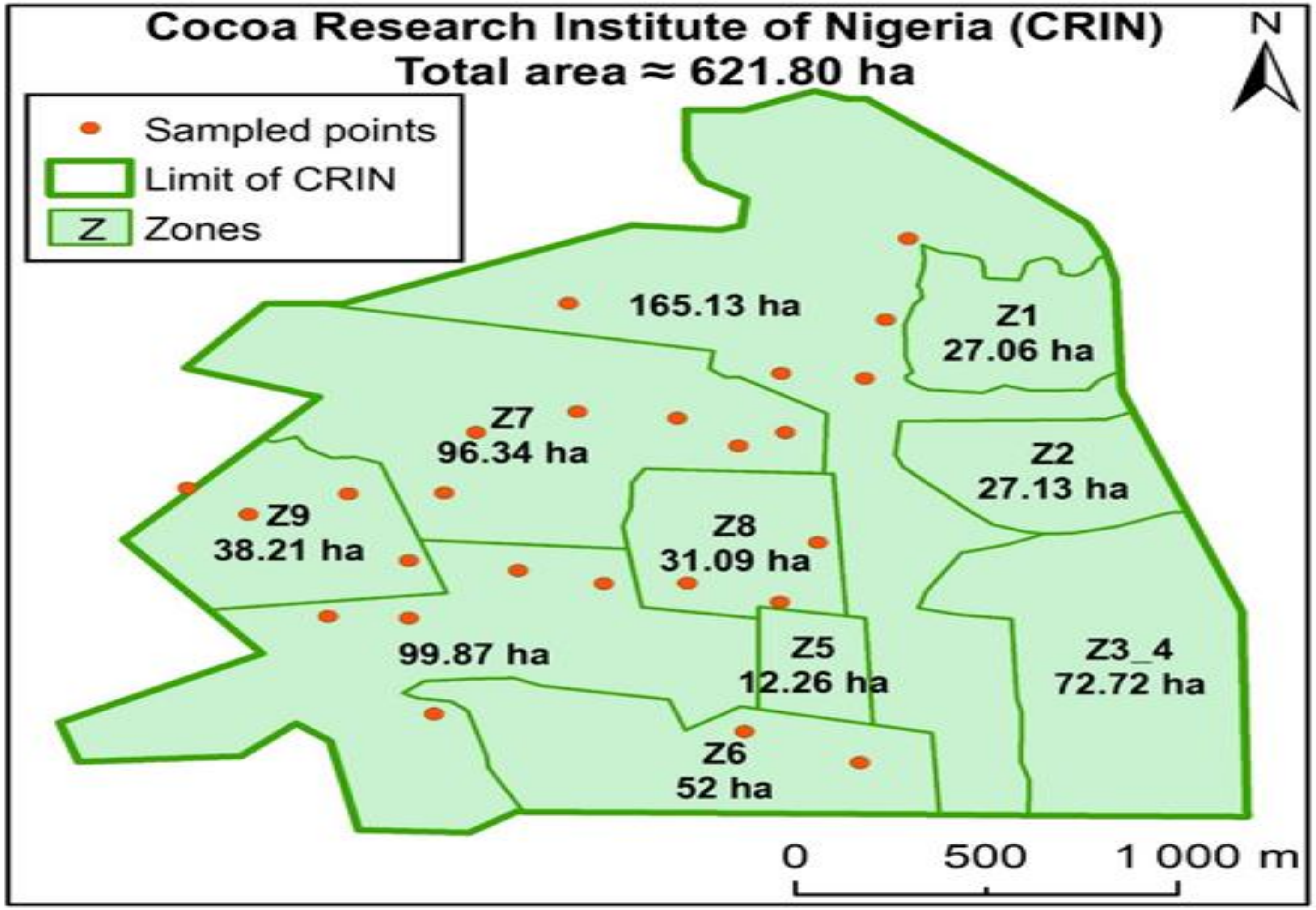

Figure 3.2: Samples points across the nine research zones located in CRIN headquarters, Ibadan

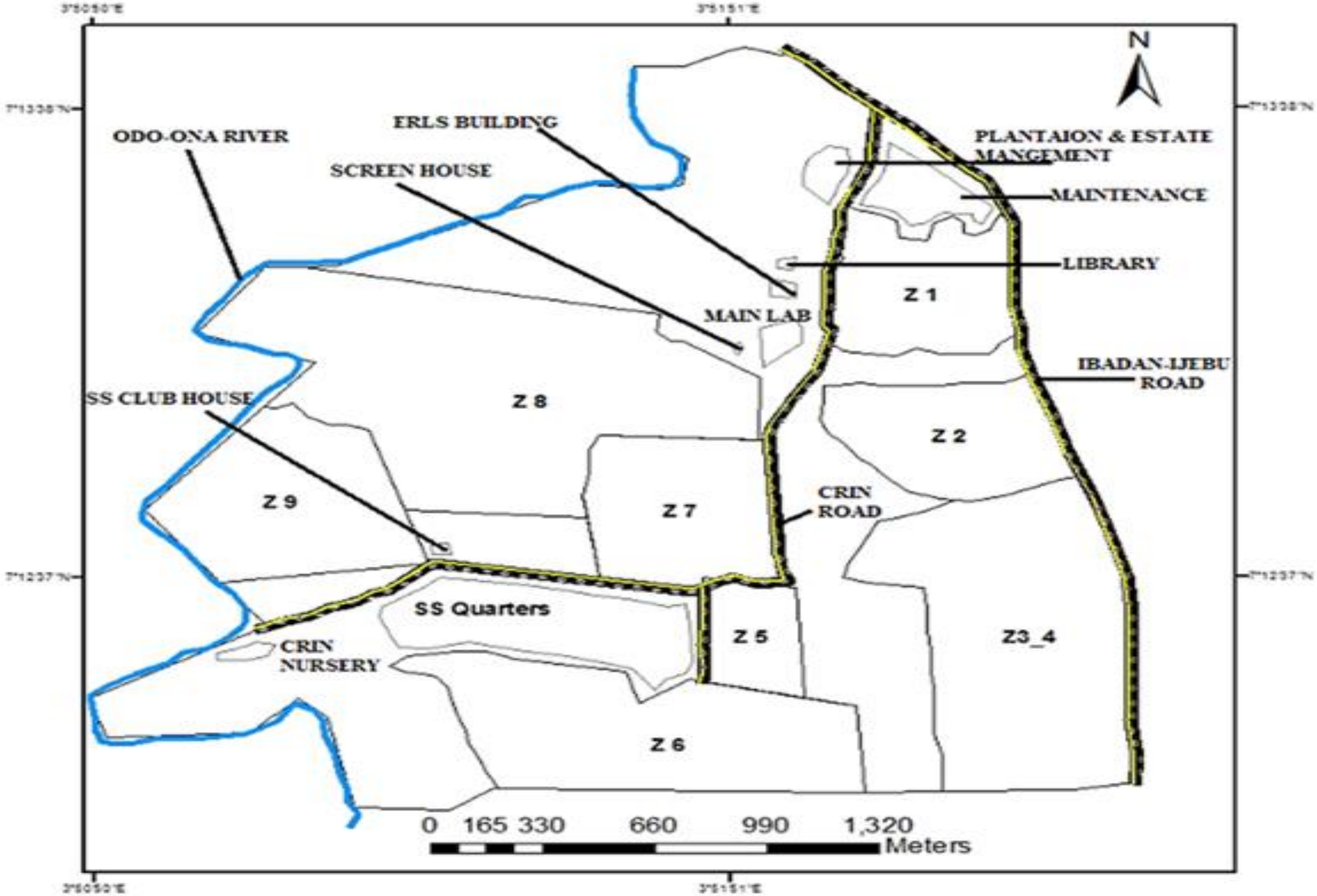

Figure 3.3: Map of Cocoa Research Institute Headquarters, Ibadan Oyo state, Nigeria

Table 3.1: Experimental Plots and their coordinates in the fragmented zones

Fragmented Zones (Z)	**Plot number (P)**	**Latitude (°N)**	**Longitude (°E)**	**Altitude (m)**
Z_1	P1	7.22386	3.86699	147
	P2	7.22085	3.86647	136
	P3	7.21867	3.86597	145
Z_2	P4	7.21887	3.86401	151
	P5	7.21668	3.8641	136
	P6	7.2126	3.86487	128
$Z_{3\&4}$	P7	7.21618	3.863	141
	P8	7.21721	3.86156	141
	P9	7.21744	3.85921	141
Z_5	P10	7.21462	3.85004	115
	P11	7.20988	3.85335	130
Z_6	P12	7.22145	3.859	131
	P13	7.21668	3.85684	145
	P14	7.21444	3.85609	134
	P15	7.21441	3.85383	127
	P16	7.21365	3.85148	120
Z_7	P17	7.2104	3.86397	130
	P18	7.21111	3.8618	145
	P19	7.21109	3.85984	132
	P20	7.21156	3.85783	121
	P21	7.21194	3.85526	137
Z_8	P22	7.20981	3.85525	117
	P23	7.20627	3.85585	125
Z_9	P24	7.20561	3.86314	133
	P25	7.20445	3.86586	135

3.2 Methods

The study included three fundamental aspects which are the floristic composition, the soil seed bank analysis, and the carbon stock of the tree species in the Secondary Forest of CRIN, Ibadan, Nigeria.

3.2.1 General data collection

3.2.1.1 Field Period study

The data collection on floristic and soil samples were conducted in the wet (July-August, 2018) and dry (January-February, 2019) seasons. The seed bank study was done between July and December, 2018 for the wet season sample and January and June 2019 for the dry season sample in the screen house of Crop Protection and Environmental Biology (CPEB), University of Ibadan, Ibadan, Nigeria.

3.2.1.1.1 Field study

3.2.1.1.2 Study site

Data collection

The secondary forest in the study area is fragmented due to establishment of crop plantations. The plots were laid within each fragment with the number of plots varying between 2 and 5 depending on the expanse. There were nine of such fragment zones (figure 3.2). Each plot was 50m x 50m and was used for the enumeration of trees species. Within each plot, five subplots (10m x 10m) were marked at the four corners and at the centre (Figure 3.4) to the enumeration of shrubs species to have a total of 125 subplots. For the enumeration of herbaceous species, three subplots (each 1m x 1m) were randomly placed within each subplot to have a total of 375 plots. The above enumerations were conducted for each season.

A complete inventory of plant species was done in the main plot (trees), subplot (shrubs) and quadrats (herbaceous) and was carried out between July and August for the wet season and January to February for the dry season. The trees and shrub plants were identified by their local and scientific names with the help of a forester who speaks the local language and the herbaceous were identified with the help of the West African weeds (Akobundu *et al*., 2016) and those that could not be identified were collected each day, preserved and taken to the CRIN Laboratory for identification with the help of a taxonomist.

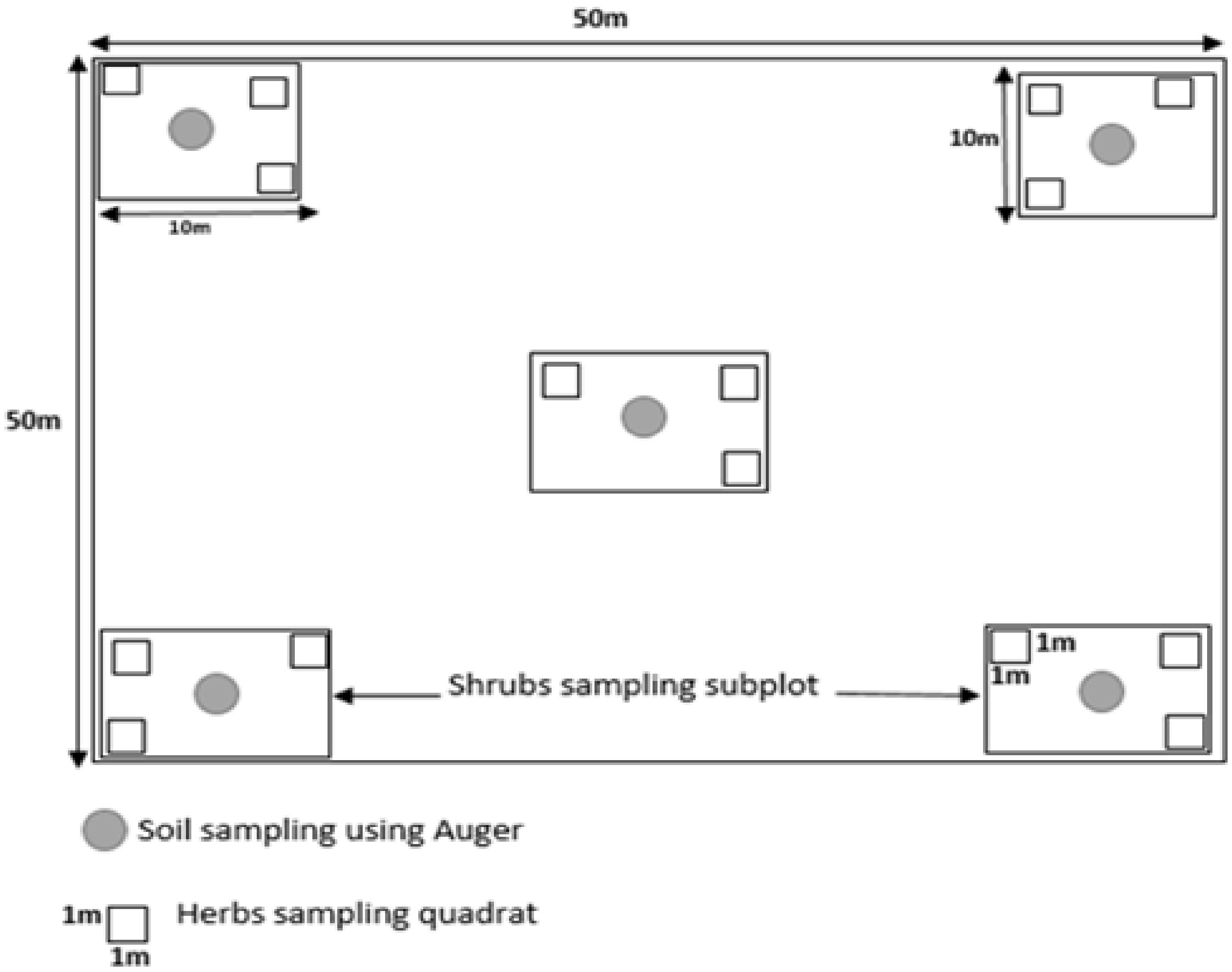

Figure 3.4: Main Plot Sampling (50m x 50m for the tree enumeration; 10m x 10m for shrubs enumeration and 1m x 1m for enumeration of herbs)

Plant species identification

The identification of herbaceous seedlings following Akobundu *et al*. (2016) and trees followed Gbile Soladoye (2002) and Aigbokhan (2014).

Soil collection and analysis for physicochemical properties

The soil samples were taken from each twenty-five (25) main plots from 0-15 cm depth. From each main plot, five samples were randomly taken at the four corners and one at the centre. The soil samples were mixed and bulked in a single sample per plot. Soil samples were packed in plastic bags and appropriately labelled and transported to the Crop Protection Environmental Biology laboratory. The soils were air-dried for two weeks, ground and sieved to have 25 whole soil samples. One kilogram was taken from each soil category, appropriately labelled and taken to the Forest Research Institute of Nigeria (FRIN) laboratory for soil analysis following standard procedures.

3.2.1.1.3 Experiment 1: Effect of soil depth on germinability, density and species composition of the soil seed bank

3.2.1.1.4 Study site

The soil sample used for this experiment was collected from CRIN Secondary forest, Ibadan, Nigeria and soil seed bank experimentation was carried out in the screen house of the CPEB Department, University of Ibadan, Nigeria.

Data collection

Soil Sampling and Collection

The soil samples were collected with five replications in four corners and one at the centre of the main plot using soil auger (Figure 3.4) at two depths (0-5 and 5-15cm depth). The five samples from each main plot were bulked to a single sample per layer and per plot. The soil samples were collected in plastic bags, and appropriately labelled and transported to the department of Crop Protection and Environmental Biology laboratory where it was air-dried for two weeks and used for seed bank enumeration under nursery conditions in the screen house of the department of Crop Protection and Environmental Biology, Ibadan.

Soil seed bank sampling and germination

After air-drying, soil samples were sorted by hand to remove pieces of root, pebbles, and coarse woody debris from the soil samples, then one kilogram of each soil category was measured using a digital weighing balance (Plate 3.1) and spread evenly in 150 germination pots of 20cm x 20cm surface dimension by 3cm depth. Pots were arranged in a completely randomized design (CRD) and replicated 3 times and monitored for 24weeks for plant species germination in the screen house (Plate 3.2). All pots were monitored daily, watered lightly with 500ml every 2 days' interval, and upturned three weeks' interval for up to 24weeks following Abella and Springer (2008). Newly emerged seedlings were identified by using the Handbook of West African Weeds (Akobundu *et al*., 2016), counted, recorded and removed (Oke *et al*., 2010) to allow other seeds to germinate (Plate 3.3). Unidentified seedlings were tranferred to other pots and continued to grow until identification was possible.

Soil was also upturned at three weeks' interval to allow the seeds at the bottom of the pot an opportunity for new germination. When no new germination was observed (for up to a week), soil samples were mixed again and emergence was monitored for another period of three weeks to ascertain no further emergence (Tadros and Samarah, 2012).

3.2.1.1.5 Experiment 2: Assessment of the variation between seasons and the density of the seed bank flora and above-ground vegetation of CRIN Secondary Forest

3.2.1.1.6 Experiment 3: Evaluation of the similarities between floristic composition of the standing vegetation and soil seed banks in the CRIN Secondary Forest

The procedures used for experiment 1 was followed for experiments 2 and 3

Plate 3.1: The tray (20 x 20 cm Surface dimension x 3 cm depth) used for Soil seed bank study (A = balance and the plate; B = One kilogram of soil)

Plate 3.2: Experimental layout of the soil seed bank studies in the Screen house of CPEB department

Plate 3.3: Seedlings of the flora of seed bank of secondary forest of CRIN in the wet season of 2018 (Inset seedling being removed)

3.2.1.1.7 Experiment 4: Estimation of biomass and evaluation of the level of carbon stock potential of trees species in the CRIN Secondary Forest.

Study site

The experiment was carried out at CRIN secondary Forest, Ibadan, Nigeria.

Data collection

The allometric equations were used to estimate the volume of carbon stock in the CRIN secondary forest. The non-destructive sampling method of above-ground biomass estimation was used (Valbuena *et al*., 2016).

The data from the field (25 sample plots measuring 2500m^2), were taken between July and August (wet season) and between January and February (dry season) in the CRIN secondary forest (2018 and 2019).

At both seasons, a 50 x 50m plot each was used for enumeration of trees species. In each plot, the individuals of each tree species with girth ≥30cm were measured for height and diameter at breast height (i.e. 1.3m above ground) using a meter tape. The heights of trees were measured using Hagar altimeter (Kalaba *et al*., 2013). All the stems having girth <30cm were counted and recorded as shrubs in the five 10 x10 m subplots evenly located within each 50 x 50m plots following Valbuena *et al*.(2016).

3.3 Meteorological information in CRIN secondary Forest

The secondary data used in this study, the monthly rainfall, average monthly relative humidity and average monthly temperature were obtained from the website of the National Aeronautics and Space Administration (NASA, 2020). The series is a complete daily data over the period of 2018 and 2019 and was done by the calculation of the monthly averages. The evolution is obtained by plotting the monthly averages. Trends are observed on the curves representing the evolution of these parameters in the study area.

3.4 Data Analysis

Paleontological Statistics Software (PAST 3.0) (Hammer, 2011; Awodoyin *et al*., 2013) were used to analyse species abundance, relative density, relative frequency, relative importance values (RIV) and importance values index (IVI) and community structure indices (Dominance_D, Simpson index_1-D, Shannon-Wiener_H`, Equitability_E and Jaccard-J).

3.4.1 Vegetation Data Analysis

To describe the floristic composition, the species density, vegetation structure, soil seed bank depth and seasonal variation in the seed bank and carbon sequestration of CRIN secondary forest, the following analyses were carried out:

3.4.1.1 Density of species

The density of species (Ds): The density refers to the number of individuals of a species per specified unit area. In this study, the density was calculated at the $1m^2$ unit level for herbs, $100m^2$ unit level for shrubs, $2500m^2$ unit level for trees and $0.04m^2$ unit level for Seed bank, then extrapolated to calculate the density per hectare for all level.

$$\boldsymbol{Ds = \frac{Total\ number\ of\ individuals\ of\ a\ species\ in\ all\ quadrats}{Total\ area\ of\ \mathrm{all}\ quadrats\ layed}} \quad (\mathbf{1})$$

3.4.1.2 Relative Density of the species

Relative Density of Species (RD): This is the percentage density of one species in relation to the total density of all the species. The relative density was calculated using equation 2 following Kent and Coker (1992); Sanyaolu *et al*. (2018).

$$\boldsymbol{Relative\ density(RD)\% = \frac{Density\ of\ a\ species}{Total\ density\ of\ all\ species}\ X\ 100} \quad (\mathbf{2})$$

3.4.1.3 Frequency of the species

Frequency (F): It is a measure of the degree of uniformity in the species spatial distribution. It is given by the percentage quadrats that contain at least an individual of a species. This was calculated with equation (3) following Kent and Coker (1992) and Sanyaolu *et al*. (2018).

$$\boldsymbol{(F)\% = \frac{Number\ of\ quadrats\ in\ which\ the\ species\ occured}{Total\ Number\ of\ quadrats\ layed} X100} \quad (\mathbf{3})$$

3.4.1.4 Relative frequency of the species

Relative frequency (RF): It provides a good idea of the level of dispersion of a particular species in an area, relative to the number of all the species present. The RF was calculated using Equation 4 following Kent and Coker (1992) and Sanyaolu *et al*. (2018).

$$\boldsymbol{Relative\ Frequency(RF)}\ \% = \frac{\boldsymbol{Frequency\ of\ a\ species}}{\boldsymbol{Total\ frequency\ of\ all\ species}} \boldsymbol{X100} \qquad (\mathbf{4})$$

3.4.1.5 Relative Importance Value (RIV) of the species

The importance of a species is a measure of its relative contribution to the entire community. It determines the entire importance of each species in the population. Equation 5 was used to calculate the RIV following Kent and Coker (1992) and Sanyaolu *et al*. (2018).

$$\boldsymbol{RIV}(\%) = \frac{\boldsymbol{Relative\ Density + Relative\ Frequency}}{\mathbf{2}} \qquad (\mathbf{5})$$

3.4.2 Diversity Index

3.4.2.1 Jaccard index of community similarity (SCJ)

The Jaccard similarity index (J) was used to estimate the species composition similarity between different soil seed banks and standing vegetations. The extent of overlap of plant species between communities was calculated using equation 6 following Kent and Coker (1992) and Awodoyin *et al*. (2013).

$$\boldsymbol{SCJ} = \frac{\boldsymbol{W}}{(\boldsymbol{A+B-W})} \boldsymbol{X100} \qquad (\mathbf{6})$$

Where A = Total number of species in Sample A, B = Total number of species in sample B, and W = Total number of species found in both A and B. It is a measure of resemblance for the two groups of data, with a range from 0% to 100%. The greater the percentage, the similar the two sets are.

3.4.2.2 Shannon diversity index

To measure the species diversity, the Shannon index (H') was determined using the equation (7) for the secondary forest and all the plots following Kent and Coker (1992) and Awodoyin *et al.* (2013).

$$\boldsymbol{H' = -\sum_{I=1}^{S} p_i ln p_i} \; (\mathbf{7})$$

Where pi = ni/N; ni is the number of individual trees present for species i; N is the total number of individuals, and S is the total number of species. ni = Napierian logarithm (2.303 x log10). The value ranges from 0 to 4.6. Value 0 indicates dominance by one species as obtained in a mono-crop situation while high values indicate that there are many species, each with few individuals.

3.4.2.3 Equitability

Equitability /Evenness (E): The mode of distribution and the species evenness within groups was calculated with the species equitability formula using Salami and Lawal (2018) and using equation (8).

$$\boldsymbol{E = \frac{H'}{ln(S)}} \qquad (\mathbf{8})$$

Where E is the equitability index, H′ is the Shannon diversity index, S is the total number of species in each community, and Ln is the natural logarithm. The value may range from 0 to 1. When individuals are evenly distributed among all species (random distribution), the value tends towards one (1). It tends toward 0 when one or few species have most individuals in the community (patterned distribution: regular or contiguous) (Kent and Coker, 1992; Hammer, 2011; and Awodoyin *et al.*, 2013).

3.4.2.4 Dominance Index (D)

The Dominance Index (Do) is calculated using the formula (9) as follows:

$$\boldsymbol{D = \sum (n/N)^2} \qquad (\mathbf{9})$$

Where n is the number of individuals of a particular species and N is the total number of individuals of all species found in the community. It is 1 – Simpson index and ranges from 0 when all species are equally present and 1 when one species dominates the community as it is the situation in a mono-crop community (Kent and Coker, 1992;.Hammer, 2011; and Awodoyin *et al.*, 2013).

3.4.3 Trees parameters calculations

3.4.3.1 Diameter at breast height

The diameter at breast height (DBH) was obtained from girth (cm) by using equation 11

$$\boldsymbol{DBH(cm) = \frac{Mean\ girth}{3.143}} \qquad (\mathbf{11})$$

3.4.3.2 Height

The height (H) was measured using the Hagar altimeter for each individual tree with a varying distance (15m, 30m and 50m) from the tree and was calculated using equation (12)

$$\boldsymbol{H\ (m) = \frac{(Top\ Reading - Bottom\ Reading)}{Range}\, x\ Distance} \qquad (\mathbf{12})$$

3.4.3.3 Determination of basal area

The basal area of all trees in the sample plots was calculated using this formula (13) and following Adekunle *et al.*(2014)

$$\boldsymbol{BA\ = \frac{\pi D^2}{4}} \qquad (\mathbf{13})$$

Where BA = basal area (m^2), D = DBH (cm) and: π = pi (3.143). The total BA for each plot was obtained by adding the BA of all trees in the plot. This formula was used for tree species only.

3.4.3.4 Importance Value Index

The Importance Values Index (IVI) was estimated using Equation (14), which is a summation of the relative density, relative basal area and relative frequency of species (Kalaba *et al.,* 2013).

$$\boldsymbol{IVI = \frac{(Relative\ density + Relative\ basal\ area + Relative\ frequency)}{3}} \quad (\mathbf{14})$$

3.4.3.5 Biomass estimation (Y) and Carbon stock (CS)

To estimate the biomass (Y) in CRIN Secondary Forest, the best-fit pantropical model was adopted following Chave *et al*. (2014) and for biomass estimation in tropical wet forests following Adekunle *et al.* (2014). Rajkumar and Parthasarathy (2008), Hiratsuka *et al.* (2006) and USAID (2006) also adopted this model for biomass estimation in tropical forest ecosystems during their studies.

$$\boldsymbol{Biomass\ per\ tree\ (Y) = 0.0673\ (p\ (DBH)^2 X\ h)^{0.976}} \qquad (\mathbf{15})$$

Where, p ($g.cm^{-3}$) = Wood density of tree, h (m) = height of the tree, and DBH (cm) = Diameter at breast height.

The non-destructive method was used and the wood density of each tree was obtained by using the work of Bolza *et al*. (1972) in African timbers. To find the approximate wood density value of each species, the published database: the Global wood density database (Zanne *et al*., 2009) and the African Wood Density Database (Carsan *et al.*, 2012) were used. The wood densities were found by searching the species, genera and family of each species in the database (Table 4.25).

Biomass estimation was used to quantify the amount of carbon stock in the ecosystem from the general knowledge that carbon is about 50% of biomass estimate (Samalca., 2007). For calculations of carbon stock in trees, the IPCC stock difference method was used following the relation (16) below:

$$\boldsymbol{Carbon\ stock\ per\ tree = \frac{Biomass\ of\ the\ tree}{2}} \qquad (\mathbf{16})$$

Carbon stock in plot = summation of carbon stocks of all trees in the plot

3.4.4 Soil data Analysis

Laboratory methods for soil parameters analysis

Twenty-five randomly collected soil samples were air-dried in the Ecology Laboratory of the CPEB department, University of Ibadan at room temperature for two weeks. The soils were ground before sieving through 2mm and 0.5mm mechanical sieves. One Kg of each soil sample was appropriately labelled in twenty-five pots and taken to Forest Research Institute of Nigeria (FRIN) laboratory for analyses. The soil physical and chemical properties were followed standard procedures.

The soil pH was determined in a 1:1 ratio mixture of soil and distilled water (Mclean, 1982). Ten grams of 2mm sieved and air-dried soil was weighed into a 50 ml beaker. Ten millilitres of distilled water was added and the mixture was stirred with a glass rod for 5 minutes. A glass-electrode pH meter was placed in the suspension to measure the pH. The electrode was rinsed with deionized water and wiped dry after each reading. Result obtained was reported as soil pH measured in water.

Total organic carbon

The soil organic carbon (OC) was determined using the Walkley-Black wet-oxidation method. The Reagents and procedure used, were following standard procedures. The Organic carbon was calculated using formula (17):

$$\%\,\boldsymbol{OC} = \frac{(\boldsymbol{meqK_2Cr_2O_7} - \boldsymbol{meqFeSO_4})\ \boldsymbol{x}\ \mathbf{0.003}\boldsymbol{x}\mathbf{100}\boldsymbol{x}(\boldsymbol{f})}{\boldsymbol{Wt.\ of\ air - dry\ soil}} \qquad (\mathbf{17})$$

Where f (correction factor) = 1.33

me = Normality of solution x ml of solution used

$$\%\,\boldsymbol{organic\ matter} = \%\,\boldsymbol{OC} \times \mathbf{1.724} \qquad (\mathbf{18})$$

(Walkley and Black, 1934).

Determination of Total Nitrogen

This was carried out using the Regular Macro-Kjeldah Method (Black, 1965). The **reagents and procedure used were following** standard procedures. The N was calculated using the formula (21) as follows:

$$\%\,\mathbf{N} = \frac{\mathbf{T\ x\ M\ x\ 14\ x\ 100}}{\mathbf{Wt.\ of\ soil\ used}} \qquad (\mathbf{19})$$

Where T = titre value and M = molarity of HCl

The available phosphorus, exchangeable acidity and exchangeable bases, the textural class and the particle size analysis used for determining the percentage of silt and clay in soil that were used, were following standard procedures. The particle size were calculated using the hydrometer method (Day, 1965).

$$A. silt\ and\ clay = \frac{corrected\ 1 - minute\ reading}{Weight\ of\ sample} \tag{20}$$

$$B. \%\ clay = \frac{corrected\ 2 - hour\ reading}{Weight\ of\ sample} \tag{21}$$

$$C. \%\ silt = A - B \tag{22}$$

$$D. \%\ sand(coarse\ and\ fine\ sand) = 100\% - (A + B) \tag{23}$$

CHAPTER FOUR

4.0 RESULTS

4.1 Floristic composition and plant diversity

This chapter presents the results of the analyses of plant species carried out on floristic composition and the species diversities of the herbaceous, shrubs and trees species in secondary Forest of Cocoa Research Institute of Nigeria (Plate 4.1) and the soil seed bank germination experiments in the rainy season and dry seasons of 2018 and 2019. The chapter also shows similarity indices of the season among vegetations and soil seed bank depth, the importance values index of trees species, plant biomass and carbon stock estimation potentials of the secondary forest.The Presence-Absence of all species enumerated in the study area is presented in Appendix 6.

4.1.1 Plant species composition

4.1.1.1 Herbaceous plant species composition

A total of 86 herbaceous (86 in wet and 70 in dry) species belonging to 70 genera (70 in wet and 57 in dry) and 25 families (24 in wet and 21 in dry) were enumerated in this study (Table 4.1). Among these, Poaceae family had the highest number of species (20) followed by family Asteraceae (12 species); three families, namely: Cyperaceae, Euphorbiaceae and Fabaceae had five species each. The families Acanthaceae and Commelinaceae had four species each followed by Nyctaginaceae, Rubiaceae, and Solanaceae and Urticaceae which had three species each. The four families of Caesalpiniodeae, Convolvulaceae, Lamiaceae, and Malvaceae had 2 species each while the remaining 10 families Amaranthaceae, Combretaceae, Connaraceae, Cucurbitaceae, Dennstaedtiaceae, Dioscoreaceae, Loganiaceae, Pedaliaceae, Piperaceae, Portulacaceae had one species each. A view of CRIN Secondary Forest with the populations of *Ipomoea involucrata* and *Andropogon tectorum* is showed in plates 4.3 and 4.4.

Table 4.1: Herbaceous species composition on selected plots in Secondary Forest of Cocoa Research Institute of Nigeria, Ibadan

S/N	FAMILY	Species composition
1	ACANTHACEAE (4)	*Acanthus montanus* (Nees) T. Anders
		Asystasia gangetica (linn.) T. Anders
		Blepharis maderaspatensis (Linn.) Heine & Roth
		Rungia dimorpha S. Moore
2	AMARANTHACEAE (1)	*Celosia argentea* L.
		Pupalia lappacea (linn.) Juss.
3	ASTERACEAE (12)	*Ageratum conyzoides* Linn.
		Aspilia africana (Pers.) C.D. Adams
		Bidens pilosa Linn.
		Chromolaena odorata (L.) R.M. King & Robinson
		Cleome rutidosperma D.C.
		Conysa sumatrensis (Retz.) walker
		Emilia coccinea (Sims) G. Don
		Melanthera scandens (Schum. &Thonn) Roberty
		Sclerocarpus africanus Jacq.ex Murr.
		Synedrella nodiflora Gaertn.
		Tithonia diversifolia (Hermsl.) A. Gray
		Tridax procumbens Linn.
4	CAESALPINIODEAE (2)	*Chamaecrista mimosoides* (L.) Greene
		Senna hirsuta (Linn.) Irwin & Barneby
5	COMBRETACEAE (1)	*Combretum hispidum* Laws.
6	COMMELINACEAE (4)	*Aneilema beniniense (P. Beauv.) Kunth*
		Commelina benghalensis L.
		Commelina erecta L.
		Palisota hirsuta (Thunb) K.Schum.
7	CONNARACEAE (1)	*Cnestis ferruginea* DC.
8	CONVOLVULACEAE (2)	*Ipomoea involucrata*Forsk

		Ipomoea triloba Linn
9	CUCURBITACEAE (1)	*Momordica charantia* Linn.
10	CYPERACEAE (5)	*Cyperus amabilis* Vahl
		Cyperus esculentus Linn.
		Cyperus rotundus Linn.
		Fuirena umbellata Rottb.
		Mariscus longibracteatus Cherm.
11	DENNSTAEDTIACEAE (1)	*Pteridium aquilinum* (Linn.) Kuhn
12	DIOSCOREACEAE (1)	*Tacca leontopetaloides* (L.)
13	EUPHORBIACEAE (5)	*Croton lobatus* L.
		Euphorbia hirta Linn.
		Mallotus oppositifolius (Geisel.) Mull. Arg.
		Phyllanthus niruri (Schum. & Thonn.) Learndri
		Spurge heterophylla Linn.
14	FABACEAE (5)	*Calopogonium mucunoides* Desv.
		Crotalaria retusa Linn.
		Desmodium scorpiurus (Sw.) Desv.
		Mimosa pudica Linn.
		Schrankia leptocarpa DC.
15	LAMIACEAE (2)	*Sida linifolia* Juss. Ex Cav.
		Solenostemon monostachyus (P. Beauv.) Brig.
16	LOGANIACEAE (1)	*Spigelia anthelmia* Linn.
17	MALVACEAE (2)	*Abutilon mauritianum* (Jacq.)
		Sida acuta Burn. F.
18	NYCTAGINACEAE (3)	*Boerhavia coccinea* Mill.
		Boerhavia diffusa L.
		Boerhavia erecta L.
19	PEDALIACEAE (1)	*Sesamum alatum* Thonning
20	PIPERACEAE (1)	Peperomia pellucida
21	POACEAE (20)	*Andropogon tectorum* Schum. & Thonn.
		Axonopus compresus (Sw.) P. Beauv.
		Bambusa vulgaris Schrad.
		Brachiaria deflexa (Schumach.) C. E. Hubbard

		Brachiaria falcifera (Trin.) Stapf
		Brahiaria lata (Schumach.) C.E. Hubbard
		Cynodon dactylon (Linn.) Pers.
		Digitaria exilis (Kippist) Stapf.
		Digitaria horizontalis Willd.
		Eleusine indica (L.)Gaertn.
		Eragrostis tremulla Steud.
		Imperata cylindrica (L.) Raeusch
		Oplismenus burmannii (Retz.) P.Beauv.
		Panicum laxum Sw.
		Panicum maximum Jacq.
		Paspalum scrobiculatum Linn.
		Perotis indica (Linn.) O. Ktze
		Setaria barbata (Lam.) Kunth
		Setaria longiseta P. Beauv.
		Setaria megaphylla (Steud.) Dur. & Schinz
22	PORTULACACEAE (1)	*Talinum fructicosum* (L.) Juss.
23	RUBIACEAE (3)	*Oldenlandia corymbosa* Linn.
		Richardia scarbra L.
		Spermacoce ocymoides Burm.F.
24	SOLANACEAE (3)	*Solanum macrocarpon* L.
		Solanum nigrum L.
		Solanum torvum Swartz
25	URTICACEAE (3)	*Laportea aestuans* (Linn.) Chew.
		Laportea avalifolia (Schum.) Chew
		Pouzolzia guineensis Benth.

4.1.1.2 Shrub plants species composition

A total of 34 shrub species belonging to 32 genera and 17 families in each season (wet and dry) were recorded in this study (Table 4.2). Among these, family Rubiaceae had the highest number of species (8) followed by Fabaceae (4 species). Apocynaceae and Euphorbiaceae had three species each. The families of Connaraceae, Solanaceae, and Tiliaceae had two species each while the remaining 10 families Agavaceae, Bignoniaceae, Arecaceae, Capparidaceae, Icacinaceae, Meliaceae, Musaceae, Ochidaceae, Olacaceae, Sapindaceae, and Verbanaceae had only one species each.

4.1.1.3 Trees plants species composition

A total of 63 plants species from 48 genera and 29 families were counted in both seasons (rainy and dry) in this study (Table 4.3). Among these, family Fabaceae had the highest number of species (13) followed by Malvaceae and Moraceae which had six species each, where Apocynaceae had four species. Nine families, namely: Boraginaceae, Combretaceae, Euphorbiaceae, Irvingiaceae, Meliaceae, Rutaceae, Sapindaceae, Sterculiaceae and Ulmaceae had two species while the remaining 16 families of Anacardiaceae, Annonaceae, Arecaceae, Bignoniaceae, Bombacaceae, Celtidaceae, Clusiaceae, Lamiaceae, Loganiaceae, Mimosaceae, Myristicaceae, Phyllanthaceae, Rubiaceae, Sapotaceae, Solanaceae, and Verbenaceae had one species each. The tree wood utilization composed of 40 species in timber Forest Products (TFP), 14 species in Non-timbers Forest Products (NTFP) and 9 species in food crop (FC) are also found in Table 4.3.

4.1.1.4 Seed bank plants species composition

A total number of 78 species, 61 genera and 21 families including 76 herbaceous seedlings (emergence of some seedlings showed in Plate 4.5) and two trees seedlings were recorded in Table 4.4. In the wet season, the soil seed bank had 40species, 36 genera and 16 families (in which, 32 species, 29 genera and 16 families belonged to the topsoil and 24 species, 23 genera and 16 families belonged to the deepest soil). The dry season had 78 species, 59 genera and 23 families (in which, 68 species, 56 genera and 21 families belonged to the topsoil and 53 species, 43 genera and 20 families belonged to the deepest soil (5-15cm)). Among all these, Poaceae family had the highest number of species (17), followed by Asteraceae (11 species), Amaranthaceae and Fabaceae which had seven species each; Cyperaceae and Euphorbiaceae had five species each while Commelinaceae had four species. Three families, namely: Rubiaceae, Solanaceae, Talinaceae had the lower value (two species each) followed by Malvaceae, Nyctaginaceae, Papilionoideae, and Urticaceae which had two species each. The remaining eight families Acanthaceae, Cleomaceae, Convolvulaceae, Cucurbitaceae, Loganiaceae, Moraceae, Piperaceae and Portulacaceae had one species each.

Table 4.2: Shrubs species composition on selected plots in Secondary Forest Cocoa Research Institute of Nigeria, Ibadan

S/N	Family	Species composition
1	AGAVACEAE (1)	*Dracaena deisteiliana* Engl
2	APOCYNACEAE (3)	*Hunteria umbellata* (K.Schum) Hailier
		Pleioceras barteri Baill.
		Rauwolfia vomitoria Afzel
3	ARECACEAE (1)	*Elaeis guineensis* Jacq.
4	BIGNONIACEAE (1)	*Markhamia tomentosa* (Benth) K.Schum ex Engl
5	CAPPARIDACEAE (1)	*Euadenia trifoliata* Oliv.
6	CONNARACEAE (2)	*Agelaea obligua* (P.Beauv.) Baill.
		Cnestis ferruginea DC
7	EUPHORBIACEAE (3)	*Alchornia cordifolia* (Schum. & Thonn.)
		Jatropha curcas Linn.
		Microdesmis puberula Hook. F. ex Planch
8	FABACEAE (4)	*Acacia macrostachya* Reichenb. ex Benth.
		Angylocalyx oligophyllus Bak. F.
		Lonchocarpus cyanescens (Schum. & Thonn.) Benth
		Lonchocarpus griffonianus (Baill.) Dunn.
9	ICACINACEAE (1)	*Icacinia trichanta* Oliv.
10	MELIACEAE (1)	*Trichilia prieuriana* A. Juss
11	MUSACEAE (1)	*Musa paradisiaca* L.
12	OCHIDACEAE (1)	*Rytiginia umbellata* Thom.
13	RUBIACEAE (8)	*Coffea canephora* Pierre ex A.Froehner

		Corynanthe pachyceras K.Schum
		Euclinia longifolia Salisb.
		Keetia venosa (Oliv.) Bridson
		Pavetta corymbosa (DC.) F.N. Williams
		Psilanthus ebracteolatus (Hiern) Hiern.
		Psychotria fimbriatifolia R.D. Good
		Psychotria sciandephora Hiern
14	SAPINDACEAE (1)	*Deinbollia pinnata* Schum. & Thonn.
15	SOLANACEAE (2)	*Solanum erianthum* D. Don
		Solanum torvum Sw
16	TILIACEAE (2)	*Desplatsia subericarpa* Bocq.
		Grewia mollis Juss.
17	VERBANACEAE (1)	*Clerodendron capitatum* Willd
Total :	17	34

Table 4.3: Trees species composition on selected plots in Secondary Forest of Cocoa Research Institute of Nigeria, Ibadan

S/N	Family	Species composition	Utilization
1	ANACARDIACEAE (1)	*Anacardium occidentale* L.	TFP
2	ANNONACEAE (1)	*Cleistopholis patens* Engl. & Diels	NTFP
3	APOCYNACEAE (4)	*Alstonia boonei* De Wild.	NTFP
		Funtumia africana (Benth.) Stapf	TFP
		Plumeria rubra L.	TFP
		Rauvolfia vomitoria Afzel.	FC
4	ARECACEAE (1)	*Elaeis guineensis* Jacq.	TFP
5	BIGNONIACEAE (1)	*Newbouldia laevis* (P.Beauv.) Seem.	TFP
6	BOMBACACEAE (1)	*Ceiba pentandra* (L.) Gaertn.	TFP
7	BORAGINACEAE (2)	*Cordia millenii* Baker	TFP
		Cordia platythyrsa Baker	NTFP
8	CELTIDACEAE(1)	*Celtis zenkerii* Engl.	TFP
9	CLUSIACEAE (1)	*Garcinia kola* Hecke	FC
10	COMBRETACEAE (2)	*Terminalia ivorensis* A. Chev.	NTFP
		Terminalia superba Engl. & Diels	FC
11	EUPHORBIACEAE (2)	*Ricinodendron heudelotii* Pierre ex Hecke	TFP
		Macaranga barteri Mull.Arg	TFP
12	FABACEAE (13)	*Afzelia africana* Sm. & Pers.	FC
		Albizia adianthifolia Schumach.	TFP
		Albizia coriaria [Welw. ex] Oliv.	TFP
		Albizia ferruginea (Guill. & Perr.) Benth.	TFP
		Albizia glaberrima (Schumach. & Thonn.).	NTFP
		Albizia gummifera (J.F.Gmel) C.A.Sm.	NTFP
		Albizia julibrissin Baker	FC
		Anthonotha marcrophyla P. Beauv.	TFP
		Brachyestegia eurycoma Harms.	FC
		Senna abbreviata Oliv.	NTFP
		Erythrophleum suaveolens Guill. & Perr.	TFP

		Gliricidia sepium (Jacq.) Walp.	TFP
		Millettia thonningii Schumach. & Thonn.	TFP
13	IRVINGIACEAE (2)	*Irvingia gabonensis* Baill.	FC
		Irvingia grandifolia (Engl.) Engl.	TFP
14	LAMIACEAE (1)	*Tectona grandis* L.f.	NTFP
15	LOGANIACEAE (1)	*Anthocleista nobilis* G.Don	TFP
16	MALVACEAE (6)	*Bombax buonopozense* P.Beauv.	TFP
		Cola millenii K.Schum	TFP
		Pterygota macrocarpa K.Schum.	NTFP
		Sterculia setigera Delile	TFP
		Theobroma cacao L.	FC
		Triplochiton scleroxylon K.Schum.	TFP
17	MELIACEAE (2)	*Cedrela odorata* L.	TFP
		Trichilia emetica Vahl	TFP
18	MIMOSACEAE (1)	*Albizia zygia* (DC.) J.F.Macbr.	NTFP
19	MORACEAE (6)	*Artocarpus heterophyllus* Lam.	TFP
		Ficus asperifolia Miq.	TFP
		Ficus capensis Thunb.	NTFP
		Ficus exasperate Vahl	FC
		Ficus thonningii Blume	TFP
		Milicia excelsa (Welw.) C.C.Berg	TFP
20	MYRISTICACEAE (1)	*Pycnanthus angolensis* Carl L.	NTFP
21	PHYLLANTHACEAE (1)	*Bridelia micrantha* (Hochst.) Baill.	TFP
22	RUBIACEAE (1)	*Morinda lucida benth*	TFP
23	RUTACEAE (2)	*Citrus sinensis* (L.) Osbeck	TFP
		Zanthoxylum zanthoxyloides Lam.	TFP
24	SAPINDACEAE (2)	*Blighia sapida* K. D. Koenig	NTFP
		Lecaniodiscus cupanioides Planch.	TFP
25	SAPOTACEAE (1)	*Gambeya albida (G. Don)*	TFP
26	SOLANACEAE (1)	*Solanum aethiopicum* L.	TFP
27	STERCULIACEAE (2)	*Cola acuminata* Schott & Endl	TFP
		Cola gigantea A. Chev.	TFP
28	ULMACEAE (2)	*Celtis integrifolia* L.	NTFP

		Holoptelea grandis (Hutch.) Mildbr.	TFP
29	VERBENACEAE (1)	*Gmelina arborea* Roxb. ex Sm	TFP

TFP = Timber Forest Products, NTFP = Non-Timber Forest Products, FC = Food Crop

Table 4.4: Seed Bank species composition on selected plots in the Secondary Forest of Cocoa Research Institute of Nigeria, Ibadan

S/N	FAMILY	Species composition
1	ACANTHACEAE (1)	*Asystasia gangetica* (L.) T. Anderson
2	AMARANTHACEAE (6)	*Gomphrena celosioides* Mart.
		Altermanthera sessilis (Linn) Dc
		Amaranthus cruentus (L.)
		Amaranthus spinosus Linn.
		Amaranthus viridis Linn.
		Cyathula prostrata (L) Blume
3	ASTERACEAE (11)	*Ageratum conyzoides* Linn.
		Aspilia africana (Pers.) C.D. Adams
		Chromolaena odorata (L.) R.M. King
		Emilia praetermissa (Sims) G. Don
		Melanthera scandens (Schum. & Thonn)
		Synedrella nodiflora Gaertn.
		Tithonia diversifolia (Hermsl.) A. Gray
		Tridax procumbens Linn.
		Vernonia amygdalina Del.
		Vernonia cinerea (L.) Less
		Vernonia galamensis (Cass.) Less
4	CLEOMACEAE *(1)*	*Cleome rutidosperma* D.C.
5	COMMELINACEAE (4)	*Commelina africana* Benth.
		Commelina benghalensis L.
		Commelina diffusa Burm.f.
		Commelina erecta L.
		Palisota hirsuta (Thunb) K.Schum.
6	CONVOLVULACEAE (1)	*Ipomoea involucrata P*. Beauv.
7	CUCURBITACEAE (1)	*Momordica charantia* Linn.
8	CYPERACEAE (5)	*Cyperus amabilis* Vahl
		Cyperus haspan Linn.
		Cyperus rotundus Linn.
		Cyperus tuberosus Rottb.

		Mariscus alternifolius Vahl
9	EUPHORBIACEAE (5)	*Croton lobatus* Linn.
		Euphorbia graminea Jacq.
		Euphorbia heterophylla L.
		Euphorbia hirta Linn.
		Phyllanthus niruri (Schum. & Thonn.)
10	FABACEAE (7)	*Albizia julibrissin* Baker
		Caesalpinia pulcherrima (L.) Sw
		Centrosema pubescens Benth.
		Desmodium scorpiurus (Sw.) Desv.
		Mimosa Pigra Linn..
		Mucuna pruriens (Linn.) DC.
		Senna occidentalis (L.) Link,
11	LOGANIACEAE (1)	*Spigelia anthelmia* Linn.
12	MALVACEAE (2)	*Sida acuta* Burn. F.
		Corchorus tridens Linn.
13	MORACEAE (1)	*Ficus exasperata* Vahl.
14	NYCTAGINACEAE (2)	*Boerhavia diffusa* L.
		Boerhavia erecta L.
15	PIPERACEAE (1)	*Peperonia pelucida* Kunth
16	POACEAE (17)	*Andropogon tectorum* Schum &Thonn.
		Axonopus compresus (Sw.) P. Beauv
		Brachiaria deflexa (Schumach.) C. E. Hubbard ex Robyns
		Brachiaria deflexa (Schumach.)
		Brahiaria lata (Schumach.) C.E. Hubbard
		Dactyloctenium aegyptium (Linn.)
		Digitaria horizontalis Willd.
		Eleusine indica (L.)Gaertn.
		Eragrostis tremula Hochst. Ex Steud.
		Megathyrsus maximus (Jacq.)
		Oplismenus burmannii (Retz.) P.Beauv.
		Panicum maximum Jacq.

		Paspalum conjugatum Berg.
		Pennisetum pedicellatum Trin.
		Setaria barbata (Lam.) Kunth
		Setaria longiseta P. Beauv.
		Setaria megaphylla (Steud.)
17	PORTULACACEAE (1)	*Portulaca grandiflora* Hook.
18	RUBIACEAE (3)	*Oldenlandia corymbosa* Linn.
		Pentodon pentandrus (Schum. & Thonn.)
		Spermacoce octodon (Hepper) Lebrun.
19	SOLANACEAE (3)	*Physalis angulata* Linn.
		Physalis micrantha Linn.
		Solanum nigrum
20	TALINACEAE (2)	*Talinum fructicosum* (L.) Juss.
		Triumfetta cordifolia A. Rich.
21	URTICACEAE (2)	*Laportea aestuans* (Linn.) Chew.
		Pouzolzia guineensis Benth.

4.1.2 Plants enumerations and Relative Importance Value (RIV) during wet season

4.1.2.1 RIV and herbaceous plant species composition in wet season

A total of 26,229 individuals were recorded to belong to 86 species. Among the species identified, *Chromolaena odorata* (Plate 4.2) had the highest Relative Importance Value (RIV) of 25.21%, followed by *Cyperus rotundus* (8.11%), *Setaria megaphylla* (5.13%), *Andropogon tectorum* (4.13%), *Cynodon dactylon* (3.19%), *Commelina benghalensis* (2.44 %), *Fuirena umbellate* (2.41 %), *Solanum macrocarpon* (2.33%), *Crotalaria retusa* (2.19%), and *Ageratum Conyzoides* (1.99%) while the species with low relative importance values were *Panicum maximum* (0.05%), *Celosia argentea* (0.05%), *Laportea avalifolia* (0.05%), *Momordica Charantia* (0.05%), *Ipomoea aquatica* (0.08%), *Brahiaria lata* (0.11%), *Cleome rutidosperma* (0.11%), *Senna hirsuta* (0.11%), *Emilia coccinea* (0.12%), and *Melanthera scandens* (0.12%) (Table 4.5).

4.1.2.2 RIV and shrubs species composition in the wet season

The results showed a total number of 2,199 individuals of shrubs belonging to 34 species (Table 4.6). *Lonchocarpus griffonianus* had the highest RIV (8.8%) followed by *Markhamia tomentosa* (8.5%), *Solanum erianthum* (7.7%), *Psychotria sciandephora* (6.7%), *Pavetta corymbosa* (5.3%), *Lonchocarpus cyanescens* (4.3%), *Psilanthus ebracteolatus* (4,4%), *Rauwolfia vomitoria* (4.3%), *Agelaea obligua* (4.0%) and *Euclinia longifolia* (3.7%). The lowest RIV (0.07%) belonged to *Dracaena deisteiliana* (0.1%) followed by *Keetia venosa* (0.5%), *Pleioceras barteri* (0.6%), *Desplatsia subericarpa* (0.6%), *Alchornia cordifolia* (0.8%), *Grewia mollis* (0.8 %), *Elaeis guineensis* (0.8 %), *Icacinia trichanta* (1.3%), *Psychotria fimbriatifolia* (1.3%), and *Trichilia prieuriana* (1.3%) (Table 4.6).

4.1.2.3 RIV and trees species composition in the wet season

A total of 912 individuals of trees belonging to 63 species (Table 4.7) were identified in the rainy season in the forest. Among these, the most abundant species was *Triplochiton scleroxylon* with the highest RIV (5.64%) followed by *Terminalia superba* (4.99%), *Pterygota macrocarpa* (3.91%), *Funtumia Africana* (3.89%), *Celtis zenkerii* (3.84%), *Anthocleista nobilis* (3.60%), *Sterculia setigera* (3.50%), *Celtis integrifolia* (3.20%), *Irvingia grandifolia* (3.13%), and *Irvingia gabonensis* (3.03%). The low RIV

(0.24%) were *Albizia adianthifolia*, *Brachyestegia eurycoma*, *Gambeya albida*, and *Lecaniodiscus cupanioides* followed by *Citrus sinensis* (0.29%), *Terminalia ivorensis* (0.35%), *Albizia ferruginea* (0.40%), *Caesapinia bonduc* (0.46%), *Cola gigantea* (0.46%) and *Ricinodendron heudelotii* (0.48%) (Table 4.7).

4.1.2.4 RIV and species composition of Seed Bank (0-5 cm depth) during the wet season

The results showed a total of 4,212 individuals and 32 species comprising in 16 families (Table 4.8). The species with the highest RIV (13.98%) were *Chromolaena odorata*, *Cyperus rotundus* (7.44%), *Ageratum Conyzoides* (7.14%), *Setaria barbata* (6.07%), *Peperomia pellucida* (5.29%), *Talinum fructicosum* (5.06%), *Bachiaria deflexa* (4.98%), *Aspilia Africana* (4.31%), *Corchorus Tridens* (4.14%), and *Commelina erecta* (3.59%) while the lowest were *Sorghum bicolor* (0.43%), *Oplismenus burmannii* (0.45 %), *Commelina benghalensis* (0.65%), *Mucuna pruriens* (0.68%), *Amaranthus viridis* (1.03%), *Tridax procumbens* (1.03%), *Phyllanthus niruri* (1.11%), *Boerhavia diffusa* (1.12%), *Momordica Charantia* (1.16%) and *Euphorbia hirta* (1.42 %).

4.1.2.5 RIV and species composition of Seed Bank (5-15 cm depth) during the wet season

The species inventory shows a total of 1,499 individual seedlings which belong to 24 species (Table 4.9). *Chromolaena odorata* had the highest relative importance value (16.83%) followed by *Cyperus rotundus* (15.76%), *Talinum fructicosum* (8.66%), *Ageratum Conyzoides* (7.68%), *Brachiaria deflexa* (7.5 %), *Peperomia pellucida* (5.69 %), *Spigelia anthelmia* (5.47 %), *Corchorus Tridens* (5.17%), *Setaria barbata* (5.17%) and *Aspilia Africana* (2.69%). The low RIV were *Euphorbia hirta* (0.63 %), *Synedrella nodiflora* (0.8%), *Momordica Charantia* (0.83%), *Amaranthus viridis* (0.93%), *Commelina benghalensis* (0.93%), *Commelina erecta* (1.03%), *Boerhavia diffusa* (1.36%), *Oldenlandia corymbosa* (1.46%), and *Portulaca grandiflora* (1.59%) (Table 4.9).

4.1.3 Plants enumerations Relative Importance Value (RIV) during dry season

4.1.3.1 RIV and herbaceous plants species composition in dry season

The results showed a total of 13,490 individuals and 70 species. *Chromolaena odorata* had the highest relative importance value (12.27%) followed by Aspilia africana (5.72%), *Cyperus rotundus* (4.73%), *Tridax procumbens* (3.98%), *Cyperus amabilis*

(3.63%), *Crotalaria retusa* (3.32%), *Peperomia pellucida* (3.25%), *Andropogon tectorum* (2.94%), *Axonopus compresus* (2.31%), and *Bidens pilosa* (2.31 %), while the lower RIV belonged to *Combretum hispidum* (0.14%) followed by *Chamaecrista mimosoide*s (0.25%), *Ageratum conyzoides* (0.27%), *Momordica Charantia* (0.30 %), *Cnestis ferruginea* (0.32%), *Pouzolzia guineensis* (0.33%), *Tacca leontopetaloides* (0.34%), *Acanthus montanus* (0.35%), *Sida linifolia* (0.35%) and *Brachiaria falcifera* (0.37%) (Table 4.10).

4.1.3.2 RIV and shrubs species composition in the dry season

Results obtained revealed a total number of 1,659 individuals and 34 species of shrubs (Table 4.11). *Lonchocarpus cyanescens* had the highest RIV (8.6%) followed by *Lonchocarpus griffonianus* (7.4%), *Rauwolfia vomitoria* (6.5%), *Markhamia tomentosa* (5.6%), *Solanum torvum* (5.4%), *Psychotria fimbriatifolia* (5.4%), *Rytiginia umbellata* (4.6 %), *Agelaea obligua* (3.9%), *Microdesmis puberula* (3.48%), *Euclinia longifolia* (3.9%) and *Cnestis ferruginea* (3.8%) while the lowest RIV (0.1 %) belonged to *Dracaena deisteiliana* followed by *Keetia venosa* (0.7%), *Psilanthus ebracteolatus* (0.7 %), *Desplatsia subericarpa* (0.7%), *Alchornia cordifolia* (0.1%), *Grewia mollis* (1.0%), *Elaeis guineensis* (1.0%), *Solanum erianthum* (1.3%), *Icacinia trichanta* (1.6%), and *Psychotria sciandephora* (1.6 %).

4.1.3.3 RIV and trees species composition in the dry season

A total of 887 individual trees belonging to 63 species (Table 4.12) were identified in the dry season in the forest. Among these, the most abundant species with the highest RIV (5.66%) was *Terminalia superba* followed by *Triplochiton scleroxylon* (4.99%), *Pterygota macrocarpa* (3.97%), *Funtumia Africana* (3.95%), *Celtis zenkerii* (3.89%), *Anthocleista nobilis* (3.65%), *Sterculia setigera* (3.56%), *Celtis integrifolia* (3.24%), *Irvingia grandifolia* (3.16%) and *Irvingia gabonensis* (3.07%) while the species' lowest RIV (0.24%) were *Afzelia* africana, *Brachyestegia eurycoma*, *Chrysophyllum albdum*, and *Lecaniodiscus cupanioides* followed by *Citrus sinensis* (0.30%), *Terminalia ivorensis* (0.35%), *Albizia gummifera* (0.41), *Caesapinia bonduc* (0.47%), *Cola Cola gigantea* (0.47%) and *Ricinodendron heudelotii* (0.48%).

Table 4.5: Floristic composition and RIV of herbaceous plants in wet season of CRIN secondary Forest

S/N	Species composition	Abundance	Density	F (%)	RD (%)	RF (%)	RIV (%)
1	*Abutilon mauritianum*	22	0.06	3.20	0.08	0.43	0.25
2	*Acanthus montanus*	17	0.05	1.87	0.06	0.25	0.16
3	*Ageratum Conyzoides*	465	1.24	16.53	1.77	2.20	1.99
4	*Andropogon tectorum*	1089	2.90	30.93	4.15	4.11	4.13
5	*Aneilema beniniense*	84	0.22	7.73	0.32	1.03	0.67
6	*Aspilia africana*	363	0.97	14.13	1.38	1.88	1.63
7	*Asystasia gangetica*	253	0.67	19.47	0.97	2.59	1.78
8	*Axonopus compresus*	116	0.31	8.00	0.44	1.06	0.75
9	*Bambusa vulgaris*	39	0.10	4.53	0.15	0.60	0.38
10	*Bidens pilosa*	36	0.10	4.27	0.14	0.57	0.35
11	*Blepharis maderaspatensis*	283	0.75	6.67	1.08	0.89	0.98
12	*Boerhavia coccinea*	63	0.17	3.47	0.24	0.46	0.35
13	*Boerhavia diffusa*	26	0.07	2.13	0.10	0.28	0.19
14	*Boerhavia erecta*	18	0.05	1.60	0.07	0.21	0.14
15	*Brachiaria deflexa*	19	0.05	1.87	0.07	0.25	0.16
16	*Brachiaria falcifera*	166	0.44	17.33	0.63	2.30	1.47
17	*Brahiaria lata*	22	0.06	1.07	0.08	0.14	0.11
18	*Calopogonium mucunoides*	37	0.10	4.27	0.14	0.57	0.35
58	*Celosia argentea*	6	0.02	0.53	0.02	0.07	0.05
20	*Chamaecrista mimosoides*	36	0.10	2.40	0.14	0.32	0.23
21	*Chromolaena odorata*	9742	25.98	99.73	37.17	13.25	25.21
22	*Cleome rutidosperma*	12	0.03	1.33	0.05	0.18	0.11
23	*Cnestis ferruginea*	156	0.42	5.87	0.60	0.78	0.69
24	*Combretum hispidum*	277	0.74	9.33	1.06	1.24	1.15
25	*Commelina benghalensis*	491	1.31	22.67	1.87	3.01	2.44
26	*Commelina erecta*	274	0.73	11.73	1.05	1.56	1.30
27	*Conysa sumatrensis*	230	0.61	9.33	0.88	1.24	1.06
28	*Crotalaria retusa*	674	1.80	13.60	2.57	1.81	2.19
29	*Croton lobatus*	44	0.12	4.53	0.17	0.60	0.39

30	*Cynodon dactylon*	921	2.46	21.60	3.51	2.87	3.19
31	*Cyperus amabilis*	49	0.13	5.07	0.19	0.67	0.43
32	*Cyperus esculentus*	111	0.30	5.33	0.42	0.71	0.57
19	*Cyperus rotundus*	2561	6.83	48.53	9.77	6.45	8.11
34	*Desmodium scorpiurus*	27	0.07	2.13	0.10	0.28	0.19
35	*Digitaria exilis*	65	0.17	2.13	0.25	0.28	0.27
36	*Digitaria horizontalis*	249	0.66	18.40	0.95	2.44	1.70
37	*Eleusine indica*	206	0.55	14.40	0.79	1.91	1.35
38	*Emilia coccinea*	25	0.07	1.07	0.10	0.14	0.12
39	*Eragrostis tremulla*	40	0.11	1.60	0.15	0.21	0.18
40	*Euphorbia hirta*	52	0.14	1.87	0.20	0.25	0.22
41	*Fuirena umbellata*	510	1.36	21.60	1.95	2.87	2.41
42	*Imperata cylindrica*	149	0.40	10.93	0.57	1.45	1.01
43	*Ipomoea involucrata*	13	0.03	0.80	0.05	0.11	0.08
44	*Ipomoea triloba*	120	0.32	9.87	0.46	1.31	0.88
45	*Laportea aestuans*	129	0.34	10.93	0.49	1.45	0.97
46	*Laportea avalifolia*	6	0.02	0.53	0.02	0.07	0.05
47	*Mallotus oppositifolius*	30	0.08	1.33	0.11	0.18	0.15
48	*Mariscus longibracteatus*	83	0.22	1.60	0.32	0.21	0.26
49	*Melanthera scandens*	36	0.10	0.80	0.14	0.11	0.12
50	*Mimosa pudica*	49	0.13	1.07	0.19	0.14	0.16
51	*Momordica charantia*	7	0.02	0.53	0.03	0.07	0.05
52	*Oldenlandia corymbosa*	154	0.41	12.80	0.59	1.70	1.14
53	*Oplismenus burmannii*	135	0.36	9.87	0.52	1.31	0.91
54	*Palisota hirsuta*	16	0.04	2.40	0.06	0.32	0.19
55	*Panicum laxum*	232	0.62	11.47	0.89	1.52	1.20
56	*Panicum maximum*	7	0.02	0.27	0.03	0.04	0.03
57	*Paspalum scrobiculatum*	158	0.42	8.80	0.60	1.17	0.89
33	*Peperomia pellucida*	86	0.23	4.80	0.33	0.64	0.48
59	*Perotis indica*	10	0.03	1.60	0.04	0.21	0.13
60	*Phyllanthus amarus*	105	0.28	7.20	0.40	0.96	0.68
61	*Pouzolzia guineensis*	138	0.37	6.67	0.53	0.89	0.71
62	*Pteridium aquilinum*	77	0.21	2.40	0.29	0.32	0.31

63	*Pupalia lappacea*	101	0.27	5.07	0.39	0.67	0.53
64	*Richardia scarbra*	40	0.11	3.20	0.15	0.43	0.29
65	*Rungia dimorpha*	192	0.51	8.53	0.73	1.13	0.93
66	*Schrankia leptocarpa*	130	0.35	7.20	0.50	0.96	0.73
67	*Sclerocarpus africanus*	20	0.05	2.13	0.08	0.28	0.18
68	*Senna hirsuta*	9	0.02	1.33	0.03	0.18	0.11
69	*Sesamum alatum*	220	0.59	9.60	0.84	1.28	1.06
70	*Setaria barbata*	136	0.36	8.00	0.52	1.06	0.79
71	*Setaria longiseta*	50	0.13	3.73	0.19	0.50	0.34
72	*Setaria megaphylla*	1779	4.74	26.13	6.79	3.47	5.13
73	*Sida acuta*	96	0.26	5.60	0.37	0.74	0.56
74	*Sida linifolia*	46	0.12	4.00	0.18	0.53	0.35
75	*Solanum macrocarpum*	301	0.80	26.40	1.15	3.51	2.33
76	*Solanum nigrum*	66	0.18	3.20	0.25	0.43	0.34
77	*Solanum torvum*	165	0.44	4.53	0.63	0.60	0.62
78	*Solenostemon monostachus*	74	0.20	2.93	0.28	0.39	0.34
79	*Spermacoce ocymoides*	218	0.58	8.00	0.83	1.06	0.95
80	*Spigelia anthelmia*	129	0.34	6.13	0.49	0.81	0.65
81	*Spurge heterophylla*	126	0.34	4.80	0.48	0.64	0.56
82	*Synedrella nodiflora*	132	0.35	5.60	0.50	0.74	0.62
83	*Tacca leontopetaloides*	138	0.37	5.60	0.53	0.74	0.64
84	*Talinum fructicosum*	128	0.34	5.60	0.49	0.74	0.62
85	*Tithonia diversifolia*	43	0.11	2.13	0.16	0.28	0.22
86	*Tridax procumbens*	274	0.73	12.80	1.05	1.70	1.37
	Total	26229	69.94	752.80	100.06	100.00	100.03

F = Frequency; RD = Relative Density: RF = relative frequency; RIV = Relative Importance Value.

Table 4.6: Floristic Composition and RIV of Shrubs in the wet season of CRIN secondary Forest

S/N	Species	Abundance	Density	RD (%)	F (%)	RF (%)	RIV (%)
1	*Acacia macrostachya*	39	0.31	1.77	12.0	2.4	2.1
2	*Agelaea obligua*	86	0.69	3.91	20.0	4.0	4.0
3	*Alchornia cordifolia*	16	0.13	0.73	4.0	0.8	0.8
4	*Angylocalyx oligophyllus*	21	0.17	0.95	8.8	1.8	1.4
5	*Clerodendron capitatum*	27	0.22	1.23	7.2	1.5	1.3
6	*Cnestis ferruginea*	53	0.42	2.41	18.4	3.7	3.1
7	*Coffea canephora*	41	0.33	1.86	17.6	3.6	2.7
8	*Corynanthe pachyceras*	64	0.51	2.91	20.0	4.0	3.5
9	*Deinbollia pinnata*	42	0.34	1.91	12.0	2.4	2.2
10	*Desplatsia subericarpa*	10	0.08	0.45	4.0	0.8	0.6
11	*Dracaena deisteiliana*	1	0.01	0.05	0.8	0.2	0.1
12	*Elaeis guineensis*	17	0.14	0.77	4.0	0.8	0.8
13	*Euadenia trifoliata*	30	0.24	1.36	8.0	1.6	1.5
14	*Euclinia longifolia*	129	1.03	5.86	8.0	1.6	3.7
15	*Grewia mollis*	17	0.14	0.77	4.0	0.8	0.8
16	*Hunteria umbellata*	40	0.32	1.82	8.0	1.6	1.7
17	*Icacinia trichanta*	21	0.17	0.95	8.0	1.6	1.3
18	*Jatropha curcas*	121	0.97	5.50	4.0	0.8	3.2
19	*Keetia venosa*	6	0.05	0.27	4.0	0.8	0.5
20	*Lonchocarpus cyanescens*	98	0.78	4.45	24.0	4.8	4.7
21	*Lonchocarpus griffonianus*	180	1.44	8.18	46.4	9.4	8.8
22	*Markhamia tomentosa*	186	1.49	8.45	42.4	8.6	8.5
23	*Microdesmis puberula*	53	0.42	2.41	12.0	2.4	2.4
24	*Musa paradisiaca*	62	0.50	2.82	20.8	4.2	3.5
25	*Pavetta corymbosa*	171	1.37	7.77	14.4	2.9	5.3
26	*Pleioceras barteri*	7	0.06	0.32	4.0	0.8	0.6
27	*Psilanthus ebracteolatus*	78	0.62	3.55	25.6	5.2	4.4
28	*Psychotria fimbriatifolia*	22	0.18	1.00	8.0	1.6	1.3

29	*Psychotria sciandephora*	156	1.25	7.09	31.2	6.3	6.7
30	*Rauwolfia vomitoria*	74	0.59	3.36	25.6	5.2	4.3
31	*Rytiginia umbellata*	66	0.53	3.00	16.0	3.2	3.1
32	*Solanum erianthum*	163	1.30	7.41	40.0	8.1	7.7
33	*Solanum torvum*	79	0.63	3.59	4.0	0.8	2.2
34	*Trichilia prieuriana*	23	0.18	1.05	8.0	1.6	1.3
	Total	2199	17.6	99.95	495.2	100	100.0

Table 4.7: Floristic composition and RIV of trees plant in the wet seasonof CRIN Forest of CRIN Secondary Forest

S/N	Species	Abundance	Density	F (%)	RD (%)	RF (%)	RIV (%)
1	*Afzelia africana*	4	0.16	8	0.44	0.74	0.59
2	*Albizia adianthifolia*	1	0.04	4	0.11	0.37	0.24
3	*Albizia coriaria*	14	0.56	28	1.54	2.58	2.06
4	*Albizia ferruginea*	4	0.16	4	0.44	0.37	0.40
5	*Albizia glaberrim.*	19	0.76	8	2.08	0.74	1.41
6	*Albizia gummifera*	15	0.6	4	1.64	0.37	1.01
7	*Albizia julibrissin*	47	1.88	8	5.15	0.74	2.95
8	*Albizia zygia*	18	0.72	8	1.97	0.74	1.36
9	*Alstonia boonei*	7	0.28	16	0.77	1.48	1.12
10	*Anacardium occidentale*	8	0.32	4	0.88	0.37	0.62
11	*Anthocleista nobilis*	32	1.28	40	3.51	3.69	3.60
12	*Anthonotha marcrophyla*	9	0.36	24	0.99	2.21	1.60
13	*Artocarpus heterophyllus*	9	0.36	16	0.99	1.48	1.23
14	*Blighia sapida*	7	0.28	12	0.77	1.11	0.94
15	*Bombax buonopozense*	1	0.04	4	0.11	0.37	0.24
16	*Brachyestegia eurycoma*	21	0.84	32	2.3	2.95	2.63
17	*Bridelia micrantha*	5	0.2	4	0.55	0.37	0.46
19	*Cedrela odorata*	7	0.28	20	0.77	1.85	1.31
20	*Ceiba pentandra*	13	0.52	32	1.43	2.95	2.19
21	*Celtis integrifolia*	28	1.12	36	3.07	3.32	3.20
22	*Celtis zenkerii*	33	1.32	44	3.62	4.06	3.84
24	*Citrus sinensis*	2	0.08	4	0.22	0.37	0.29
25	*Cleistopholis patens*	6	0.24	8	0.66	0.74	0.70
26	*Cola acuminata*	17	0.68	12	1.86	1.11	1.49
27	*Cola gigantea*	5	0.2	4	0.55	0.37	0.46
28	*Cola millenii*	20	0.8	32	2.19	2.95	2.57
29	*Cordia millenii*	9	0.36	24	0.99	2.21	1.60
30	*Cordia platythyrsa*	8	0.32	20	0.88	1.85	1.36
31	*Elaeis guineensis*	7	0.28	4	0.77	0.37	0.57

32	*Erythrophleum suaveolens*	6	0.24	4	0.66	0.37	0.51
33	*Ficus asperifolia*	4	0.16	16	0.44	1.48	0.96
34	*Ficus capensis*	18	0.72	28	1.97	2.58	2.28
35	*Ficus exasperate*	8	0.32	12	0.88	1.11	0.99
36	*Ficus thonningii*	5	0.2	12	0.55	1.11	0.83
37	*Funtumia africana*	4	0.16	16	0.44	1.48	0.96
38	*Gambeya albida*	34	1.36	44	3.73	4.06	3.89
23	*Garcinia kola*	1	0.04	4	0.11	0.37	0.24
39	*Gliricidia sepium*	7	0.28	12	0.77	1.11	0.94
40	*Gmelina arborea*	12	0.48	8	1.32	0.74	1.03
41	*Holoptelea grandis*	8	0.32	12	0.88	1.11	0.99
42	*Irvingia gabonensis*	14	0.56	4	1.54	0.37	0.95
43	*Irvingia grandifolia*	25	1	36	2.74	3.32	3.03
44	*Lecaniodiscus cupanioides*	20	0.8	44	2.19	4.06	3.13
45	*Macaranga barteri*	1	0.04	4	0.11	0.37	0.24
46	*Milicia excelsa*	9	0.36	8	0.99	0.74	0.86
47	*Millettia thonningii*	3	0.12	8	0.33	0.74	0.53
48	*Morinda lucida*	13	0.52	28	1.43	2.58	2.00
49	*Newbouldia laevis*	9	0.36	16	0.99	1.48	1.23
50	*Plumeria rubra*	41	1.64	36	4.5	3.32	3.91
51	*Pterygota macrocarpa*	3	0.12	8	0.33	0.74	0.53
52	*Pycnanthus angolensis*	7	0.28	16	0.77	1.48	1.12
53	*Rauvolfia vomitoria*	2	0.08	8	0.22	0.74	0.48
18	*Ricinodendron heudelotii*	25	1.00	8	2.74	0.74	1.74
54	*Senna abbreviata*	13	0.52	8	1.43	0.74	1.08
55	*Solanum aethiopicum*	3	0.12	8	0.33	0.74	0.53
56	*Sterculia setigera*	37	1.48	32	4.06	2.95	3.50
57	*Tectona grandis*	31	1.24	4	3.4	0.37	1.88
58	*Terminalia ivorensis*	3	0.12	4	0.33	0.37	0.35
59	*Terminalia superba*	54	2.16	44	5.92	4.06	4.99
60	*Theobroma cacao*	30	1.2	24	3.29	2.21	2.75
61	*Trichilia emetica*	20	0.8	20	2.19	1.85	2.02
62	*Triplochiton scleroxylon*	49	1.96	64	5.37	5.9	5.64

63	*Zanthoxylum zanthoxyloides*	17	0.68	20	1.86	1.85	1.85
	Total	912	36.48	1084	100	100	100

Table 4.8: Floristic Composition and RIV of Seed Bank (0-5 cm) depth of CRIN Secondary Forestin the wet season

S/N	Species composition	Abundance	Density	RD (%)	F (%)	RF (%)	RIV (%)
1	*Ageratum conyzoides*	395	39.5	9.38	44	4.91	7.14
2	*Amaranthus viridis*	30	3	0.71	12	1.34	1.03
3	*Aspilia africana*	213	21.3	5.06	32	3.57	4.31
4	*Brachiaria deflexa*	194	19.4	4.61	48	5.36	4.98
5	*Boerhavia diffusa*	38	3.8	0.90	12	1.34	1.12
6	*Chromolaena odorata*	783	78.3	18.59	84	9.38	13.98
7	*Commelina benghalensis*	17	1.7	0.40	8	0.89	0.65
8	*Commelina erecta*	152	15.2	3.61	32	3.57	3.59
9	*Corchorus tridens*	123	12.3	2.92	48	5.36	4.14
10	*Cyathula prostrata*	125	12.5	2.97	28	3.13	3.05
11	*Cyperus rotundus*	401	40.1	9.52	48	5.36	7.44
12	*Desmodium scorpiurus*	71	7.1	1.69	48	5.36	3.52
13	*Euphorbia heterophylla*	25	2.5	0.59	32	3.57	2.08
14	*Euphorbia hirta*	26	2.6	0.62	20	2.23	1.42
15	*Laportea aestuans*	126	12.6	2.99	20	2.23	2.61
16	*Megathyrsus maximus*	27	2.7	0.64	20	2.23	1.44
17	*Melanthera scandens*	31	3.1	0.74	36	4.02	2.38
18	*Momordica charantia*	41	4.1	0.97	12	1.34	1.16
19	*Mucuna pruriens*	20	2	0.47	8	0.89	0.68
20	*Oldenlandia corymbosa*	69	6.9	1.64	24	2.68	2.16
21	*Oplismenus burmannii*	19	1.9	0.45	4	0.45	0.45
22	*Peperomia pellucida*	258	25.8	6.13	40	4.46	5.29
23	*Phyllanthus niruri*	37	3.7	0.88	12	1.34	1.11
24	*Portulaca grandiflora*	30	3	0.71	32	3.57	2.14
25	*Setaria barbata*	267	26.7	6.34	52	5.80	6.07
26	*Setaria megaphylla*	141	14.1	3.35	24	2.68	3.01
27	*Sorghum bicolor*	17	1.7	0.40	4	0.45	0.43
28	*Spigelia anthelmia*	130	13	3.09	32	3.57	3.33

29	*Synedrella nodiflora*	69	6.9	1.64	12	1.34	1.49
30	*Talinum fructicosum*	238	23.8	5.65	40	4.46	5.06
31	*Tridax procumbens*	30	3	0.71	12	1.34	1.03
32	*Vernonia cinerea*	69	6.9	1.64	16	1.79	1.71
	Total	4212	421.2	100.00	896	100.00	100.00

Table 4.9: Floristic Composition and RIV of Seed Bank (5-15 cm) depth of CRIN Secondary Forest in the wet season

S/N	Species composition	Abundance	Density	F (%)	RD (%)	RF (%)	RIV (%)
1	*Ageratum conyzoides*	171	17.1	16	11.41	3.96	7.68
2	*Amaranthus viridis*	13	1.3	4	0.87	0.99	0.93
3	*Aspilia africana*	51	5.1	8	3.40	1.98	2.69
4	*Boerhavia diffusa*	26	2.6	4	1.73	0.99	1.36
5	*Brachiaria deflexa*	106	10.6	32	7.07	7.92	7.50
6	*Chromolaena odorata*	267	26.7	64	17.81	15.84	16.83
7	*Commelina benghalensis*	13	1.3	4	0.87	0.99	0.93
8	*Commelina erecta*	16	1.6	4	1.07	0.99	1.03
9	*Corchorus tridens*	51	5.1	28	3.40	6.93	5.17
10	*Cyathula prostrata*	35	3.5	8	2.33	1.98	2.16
11	*Cyperus rotundus*	339	33.9	36	22.62	8.91	15.76
12	*Desmodium scorpiuru*	20	2	8	1.33	1.98	1.66
13	*Euphorbia heterophylla*	4	0.4	4	0.27	0.99	0.63
14	*Laportea aestuans*	16	1.6	12	1.07	2.97	2.02
15	*Melanthera scandens*	5	0.5	16	0.33	3.96	2.15
16	*Momordica charantia*	10	1	4	0.67	0.99	0.83
17	*Mucuna pruriens*	26	2.6	8	1.73	1.98	1.86
18	*Oldenlandia corymbosa*	14	1.4	8	0.93	1.98	1.46
19	*Peperomia pellucida*	52	5.2	32	3.47	7.92	5.69
20	*Portulaca grandiflora*	3	0.3	12	0.20	2.97	1.59
21	*Setaria barbata*	51	5.1	28	3.40	6.93	5.17
22	*Spigelia anthelmia*	60	6	28	4.00	6.93	5.47
23	*Synedrella nodiflora*	9	0.9	4	0.60	0.99	0.80
24	*Talinum fructicosum*	141	14.1	32	9.41	7.92	8.66
	Total	1499	149.9	404	100.00	100.00	100.00

Table 4.10: Floristic Composition and RIV of herbaceous of CRIN secondary Forest in the dry season

S/N	Species composition	Abundance	Density	F (%)	RD (%)	RF (%)	RIV (%)
1	*Acanthus montanus*	24	0.06	3.73	0.17	0.53	0.35
2	*Ageratum conyzoides*	23	0.06	2.67	0.17	0.38	0.27
3	*Andropogon tectorum*	468	1.25	17.07	3.47	2.41	2.94
4	*Aspilia africana*	955	2.55	30.93	7.08	4.36	5.72
5	*Asystasia gangetica*	89	0.24	9.33	0.66	1.32	0.99
6	*Axonopus compresus*	350	0.93	14.40	2.59	2.03	2.31
7	*Bidens pilosa*	228	0.61	20.80	1.69	2.93	2.31
8	*Blepharis maderaspatensis*	122	0.33	9.60	0.90	1.35	1.13
9	*Boerhavia coccinea*	38	0.10	5.07	0.28	0.71	0.50
10	*Boerhavia diffusa*	48	0.13	6.13	0.36	0.86	0.61
11	*Boerhavia erecta*	294	0.78	8.53	2.18	1.20	1.69
12	*Brachiaria deflexa*	82	0.22	5.07	0.61	0.71	0.66
13	*Brachiaria falcifera*	33	0.09	3.47	0.24	0.49	0.37
14	*Brahiaria lata*	156	0.42	9.60	1.16	1.35	1.25
15	*Calopogonium mucunoides*	34	0.09	4.00	0.25	0.56	0.41
17	*Chamaecrista mimosoides*	27	0.07	2.13	0.20	0.30	0.25
18	*Chromolaena odorata*	2432	6.49	49.33	18.03	6.95	12.49
19	*Cleome rutidosperma*	195	0.52	9.60	1.45	1.35	1.40
20	*Cnestis ferruginea*	31	0.08	2.93	0.23	0.41	0.32
21	*Combretum hispidum*	12	0.03	1.33	0.09	0.19	0.14
22	*Commelina benghalensis*	40	0.11	3.47	0.30	0.49	0.39
23	*Commelina erecta*	168	0.45	8.00	1.25	1.13	1.19
24	*Conysa sumatrensis*	220	0.59	10.13	1.63	1.43	1.53
25	*Crotalaria retusa*	459	1.22	22.93	3.40	3.23	3.32
26	*Croton lobatus*	241	0.64	11.73	1.79	1.65	1.72
27	*Cynodon dactylon*	245	0.65	10.93	1.82	1.54	1.68
28	*Cyperus amabilis*	686	1.83	15.47	5.09	2.18	3.63
29	*Cyperus esculentus*	65	0.17	5.87	0.48	0.83	0.65
30	*Cyperus rotundus*	865	2.31	21.60	6.41	3.05	4.73

31	*Desmodium scorpiurus*	46	0.12	5.07	0.34	0.71	0.53
32	*Emilia coccinea*	122	0.33	6.93	0.90	0.98	0.94
33	*Euphorbia hirta*	81	0.22	5.07	0.60	0.71	0.66
34	*Fuirena umbellata*	38	0.10	4.53	0.28	0.64	0.46
35	*Mallotus oppositifolius*	91	0.24	3.73	0.67	0.53	0.60
36	*Mariscus longibracteatus*	190	0.51	19.20	1.41	2.71	2.06
37	*Melanthera scandens*	156	0.42	15.73	1.16	2.22	1.69
38	*Mimosa pudica*	38	0.10	3.20	0.28	0.45	0.37
39	*Momordica charantia*	46	0.12	1.87	0.34	0.26	0.30
40	*Oplismenus burmannii*	75	0.20	5.60	0.56	0.79	0.67
16	*Palisota hirsuta*	153	0.41	17.60	1.13	2.48	1.81
42	*Panicum laxum*	171	0.46	13.87	1.27	1.95	1.61
43	*Panicum maximum*	102	0.27	6.67	0.76	0.94	0.85
41	*Peperomia pellucida*	447	1.19	22.67	3.31	3.20	3.25
44	*Perotis indica*	94	0.25	12.53	0.70	1.77	1.23
45	*Phyllanthus niruri*	95	0.25	13.60	0.70	1.92	1.31
46	*Pouzolzia guineensis*	24	0.06	3.47	0.18	0.49	0.33
47	*Pupalia lappacea*	46	0.12	4.53	0.34	0.64	0.49
48	*Richardia scarbra*	108	0.29	6.13	0.80	0.86	0.83
49	*Rungia dimorpha*	71	0.19	3.47	0.53	0.49	0.51
50	*Schrankia leptocarpa*	64	0.17	4.00	0.47	0.56	0.52
51	*Sclerocarpus africanus*	35	0.09	4.00	0.26	0.56	0.41
52	*Senna hirsuta*	116	0.31	16.27	0.86	2.29	1.58
53	*Sesamum alatum*	82	0.22	12.27	0.61	1.73	1.17
54	*Setaria barbata*	133	0.35	9.60	0.99	1.35	1.17
55	*Setaria longiseta*	115	0.31	16.00	0.85	2.26	1.55
56	*Setaria megaphylla*	171	0.46	9.60	1.27	1.35	1.31
57	*Sida acuta*	154	0.41	13.60	1.14	1.92	1.53
58	*Sida linifolia*	24	0.06	3.73	0.18	0.53	0.35
59	*Solanum macrocarpon*	53	0.14	6.93	0.39	0.98	0.69
60	*Solanum nigrum*	81	0.22	11.73	0.60	1.65	1.13
61	*Solanum torvum*	131	0.35	12.00	0.97	1.69	1.33
62	*Solenostemon monostachyus*	87	0.23	4.27	0.64	0.60	0.62

63	*Spermacoce ocymoides*	120	0.32	8.27	0.89	1.17	1.03
64	*Spigelia anthelmia*	62	0.17	7.47	0.46	1.05	0.76
65	*Spurge heterophylla*	256	0.68	15.20	1.90	2.14	2.02
66	*Synedrella nodiflora*	273	0.73	16.53	2.02	2.33	2.18
67	*Tacca leontopetaloides*	27	0.07	3.47	0.20	0.49	0.34
68	*Talinum fructicosum*	29	0.08	4.00	0.21	0.56	0.39
69	*Tithonia diversifolia*	36	0.10	5.07	0.27	0.71	0.49
70	*Tridax procumbens*	617	1.65	24.00	4.57	3.38	3.98
	Total	13490	35.97	709.33	100.01	100.00	100.00

4.11: Floristic Composition and RIV of Shrubs in the dry season of CRIN Secondary Forest

S/N	Species composition	Abundance	Density	RD (%)	F (%)	RF (%)	RIV (%)
1	*Acacia macrostachya*	39	0.31	2.35	12.0	2.8	2.6
2	*Agelaea obligua*	70	0.56	4.21	15.2	3.6	3.9
3	*Alchornia cordifolia*	16	0.13	0.96	4.0	0.9	1.0
4	*Angylocalyx oligophyllus*	21	0.17	1.26	8.8	2.1	1.7
5	*Clerodendron capitatum*	27	0.22	1.62	7.2	1.7	1.7
6	*Cnestis ferruginea*	53	0.42	3.19	18.4	4.3	3.8
7	*Coffea canephora*	29	0.23	1.74	13.6	3.2	2.5
8	*Corynanthe pachyceras*	55	0.44	3.31	16.0	3.8	3.5
9	*Deinbollia pinnata*	42	0.34	2.53	12.0	2.8	2.7
10	*Desplatsia subericarpa*	7	0.06	0.42	4.0	0.9	0.7
11	*Dracaena deisteiliana*	1	0.01	0.06	0.8	0.2	0.1
12	*Elaeis guineensis*	17	0.14	1.02	4.0	0.9	1.0
13	*Euadenia trifoliata*	30	0.24	1.80	8.0	1.9	1.8
14	*Euclinia longifolia*	98	0.78	5.89	8.0	1.9	3.9
15	*Grewia mollis*	17	0.14	1.02	4.0	0.9	1.0
16	*Hunteria umbellata*	35	0.28	2.11	8.0	1.9	2.0
17	*Icacinia trichanta*	21	0.17	1.26	8.0	1.9	1.6
18	*Jatropha curcas*	49	0.39	2.95	4.0	0.9	1.9
19	*Keetia venosa*	6	0.05	0.36	4.0	0.9	0.7
20	*Markhamia tomentosa*	93	0.74	5.59	24.0	5.7	5.6
21	*Lonchocarpus griffonianus*	122	0.98	7.34	32.0	7.6	7.4
22	*Lonchocarpus cyanescens*	149	1.19	8.96	35.2	8.3	8.6
23	*Microdesmis puberula*	45	0.36	2.71	9.6	2.3	2.5
24	*Musa paradisiaca*	41	0.33	2.47	14.4	3.4	2.9
25	*Pavetta corymbosa*	29	0.23	1.74	9.6	2.3	2.0
26	*Pleioceras barteri*	54	0.43	3.25	10.4	2.5	2.9
27	*Psilanthus ebracteolatus*	7	0.06	0.42	4.0	0.9	0.7
28	*Psychotria fimbriatifolia*	78	0.62	4.69	25.6	6.0	5.4
29	*Psychotria sciandephora*	22	0.18	1.32	8.0	1.9	1.6

30	*Rauwolfia vomitoria*	118	0.94	7.10	24.8	5.9	6.5
31	*Rytiginia umbellata*	62	0.50	3.73	23.2	5.5	4.6
32	*Solanum erianthum*	18	0.14	1.08	6.4	1.5	1.3
33	*Solanum torvum*	86	0.69	5.17	24.0	5.7	5.4
34	*Trichilia prieuriana*	23	0.18	1.38	8.0	1.9	1.6
	Total	1659.0	13.3	99.79	423.2	100	99.9

Table 4.12: Floristic Composition and RIV of trees species of CRIN secondary Forest in the dry season

S/N	Botanical names	Abundance	Density	F (%)	RD (%)	RF (%)	RIV (%)
1	*Afzelia africana*	1	0.04	4	0.11	0.37	0.24
2	*Albizia adianthifolia*	4	0.16	8	0.45	0.74	0.59
3	*Albizia coriaria*	12	0.48	28	1.35	2.58	1.97
4	*Albizia ferruginea*	13	0.52	8	1.47	0.74	1.1
5	*Albizia glaberrim.*	9	0.36	4	1.01	0.37	0.69
6	*Albizia gummifera*	4	0.16	4	0.45	0.37	0.41
7	*Albizia julibrissin*	44	1.76	8	4.96	0.74	2.85
8	*Albizia zygia*	18	0.72	8	2.03	0.74	1.38
9	*Alstonia boonei*	7	0.28	16	0.79	1.48	1.13
10	*Anacardium occidentale*	8	0.32	4	0.9	0.37	0.64
11	*Anthocleista nobilis*	32	1.28	40	3.61	3.69	3.65
12	*Anthonotha marcrophyla*	7	0.28	4	0.79	0.37	0.58
13	*Artocarpus heterophyllus*	9	0.36	24	1.01	2.21	1.61
14	*Blighia sapida*	9	0.36	16	1.01	1.48	1.25
15	*Bombax buonopozense*	7	0.28	12	0.79	1.11	0.95
16	*Brachyestegia eurycoma*	1	0.04	4	0.11	0.37	0.24
17	*Bridelia micrantha*	21	0.84	32	2.37	2.95	2.66
18	*Cedrela odorata*	7	0.28	20	0.79	1.85	1.32
19	*Ceiba pentandra*	13	0.52	32	1.47	2.95	2.21
20	*Celtis integrifolia*	28	1.12	36	3.16	3.32	3.24
21	*Celtis zenkerii*	33	1.32	44	3.72	4.06	3.89
22	*Citrus sinensis*	2	0.08	4	0.23	0.37	0.3
23	*Cleistopholis patens*	5	0.2	8	0.56	0.74	0.65
24	*Cola acuminata*	17	0.68	12	1.92	1.11	1.51
25	*Cola gigantea*	5	0.2	4	0.56	0.37	0.47
26	*Cola millenii*	20	0.8	32	2.25	2.95	2.6
27	*Cordia millenii*	9	0.36	24	1.01	2.21	1.61
28	*Cordia platythyrsa*	8	0.32	20	0.9	1.85	1.37
29	*Elaeis guineensis*	6	0.24	4	0.68	0.37	0.52

30	*Erythrophleum suaveolens*	4	0.16	16	0.45	1.48	0.96
31	*Ficus asperifolia*	18	0.72	28	2.03	2.58	2.31
32	*Ficus capensis*	8	0.32	12	0.9	1.11	1
33	*Ficus exasperate*	5	0.2	12	0.56	1.11	0.84
34	*Ficus thonningii*	4	0.16	16	0.45	1.48	0.96
35	*Funtumia africana*	34	1.36	44	3.83	4.06	3.95
36	*Gambeya albida*	1	0.04	4	0.11	0.37	0.24
37	*Garcinia kola*	7	0.28	12	0.79	1.11	0.95
38	*Gliricidia sepium*	8	0.32	12	0.9	1.11	1
39	*Gmelina arborea*	14	0.56	4	1.58	0.37	0.97
40	*Holoptelea grandis*	5	0.2	4	0.56	0.37	0.47
41	*Irvingia gabonensis*	25	1	36	2.82	3.32	3.07
42	*Irvingia grandifolia*	20	0.8	44	2.25	4.06	3.16
43	*Lecaniodiscus cupanioides*	1	0.04	4	0.11	0.37	0.24
44	*Macaranga barteri*	13	0.52	8	1.47	0.74	1.1
45	*Milicia excelsa*	9	0.36	8	1.01	0.74	0.88
46	*Millettia thonningii*	3	0.12	8	0.34	0.74	0.54
47	*Morinda lucida*	12	0.48	8	1.35	0.74	1.05
48	*Newbouldia laevis*	12	0.48	28	1.35	2.58	1.97
49	*Plumeria rubra*	9	0.36	16	1.01	1.48	1.25
50	*Pterygota macrocarpa*	41	1.64	36	4.62	3.32	3.97
51	*Pycnanthus angolensis*	3	0.12	8	0.34	0.74	0.54
52	*Rauvolfia vomitoria*	7	0.28	16	0.79	1.48	1.13
53	*Ricinodendron heudelotii*	2	0.08	8	0.23	0.74	0.48
54	*Senna abbreviata*	25	1	8	2.82	0.74	1.78
55	*Solanum aethiopicum*	3	0.12	8	0.34	0.74	0.54
56	*Sterculia setigera*	37	1.48	32	4.17	2.95	3.56
57	*Tectona grandis*	31	1.24	4	3.49	0.37	1.93
58	*Terminalia ivorensis*	3	0.12	4	0.34	0.37	0.35
59	*Terminalia superba*	52	2.08	44	5.86	4.06	4.96
60	*Theobroma cacao*	30	1.2	24	3.38	2.21	2.8
61	*Trichilia emetica*	20	0.8	20	2.25	1.85	2.05
62	*Triplochiton scleroxylon*	48	1.92	64	5.41	5.9	5.66

63	*Zanthoxylum zanthoxyloides*	14	0.56	20	1.58	1.85	1.71
	Total	887	35.48	1084	100	100	100

4.1.3.4 RIV and species composition of the soil Seed Bank (0-5 cm depth) during the dry season

The results obtained showed a total of 4,668 individual seedlings belonging to 68 species (Table 4.13). The highest RIV (10.44%) was *Peperomia pelucida* followed by *Brachiaria deflexa* (7.08%), *Chromolaena odorata* (7.08%), *Talinum fructicosum* (6.00%), *Cyperus rotundus* (4.97%), *Oplismenus burmannii* (4.59%), *Tridax procumbens* (4.03%), *Aspilia Africana* (2.78%), *Pouzolzia guineensis* (2.29%) and *Cyperus haspan* (2.21%) while four species, namely: *Centrosema pubescens*, *Ficus exasperata*, *Mormodica charantia*, and *Setaria longiseta* had similar low RIV (0.12%) followed by *Amaranthus cruentus*, *Axonopus compresus*, *Phyllanthus niruri*, *Spermacoce octodon* with RIV (0.25%) each, *Mimosa Pigra* and *Physalis angulata*with RIV (0.28%) each (Table 4.13).

4.1.3.5 RIV and species composition of Seed Bank (5-15 cm depth) during dry season

The results obtained revealed a total of 2,310 individuals and 53 species (Table 4.14). *Peperomia pellucida* had the highest RIV (13.35%) followed by *Chromolaena odorata* (11.51%), *Cyperus rotundus* (10.26%), *Talinum fructicosum* (7.30%), *Brachiaria deflexa* (7.22%), *Ageratum Conyzoides* (4.45%), *Tridax procumbens* (4.35 %), *Spigelia anthelmia* (3.74 %), *Cyperus amabilis* (2.67%) and *Setaria barbata* (2.36%) while *Cyathula prostrata*, *Euphorbia graminea*, *Physalis micrantha* and *Spermacoce octodon* had similar lowest RIV (0.24%), followed by *Caesalpinia pulcherrima*, *Commelina diffusa*, *Synedrella nodiflora* with RIV (0.27%) each. Three species, namely: *Centrosema pubescens*, *Corchorus Tridens*, *Euphorbia hirta* had similar RIV (0.29%).

Table 4.13: Floristic Composition and RIV of Seed Bank (0-5 cm) depth of CRIN Secondary Forest in the dry season

S/N	Botanical names	Abundance	Density	F (%)	RD (%)	RF (%)	RIV (%)
1	*Ageratum conyzoides*	50	5	32	1.07	1.80	1.43
2	*Albizia julibrissin*	4	0.4	16	0.09	0.90	0.49
4	*Amaranthus cruentus*	2	0.2	8	0.04	0.45	0.25
5	*Amaranthus spinosus*	8	0.8	16	0.17	0.90	0.54
6	*Andropogon tectorum*	24	2.4	20	0.51	1.12	0.82
7	*Aspilia africana*	113	11.3	56	2.42	3.15	2.78
8	*Asystasia gangetica*	9	0.9	16	0.19	0.90	0.55
9	*Axonopus compresus*	2	0.2	8	0.04	0.45	0.25
10	*Boerhavia erecta*	25	2.5	24	0.54	1.35	0.94
11	*Brachiaria deflexa*	589	58.9	88	12.62	4.94	8.78
12	*Brahiaria lata*	59	5.9	20	1.26	1.12	1.19
3	*Celosia argentea*	55	5.5	16	1.18	0.90	1.04
13	*Centrosema pubescens*	1	0.1	4	0.02	0.22	0.12
14	*Chromolaena odorata*	409	40.9	96	8.76	5.39	7.08
15	*Cleome rutidosperma*	6	0.6	12	0.13	0.67	0.40
16	*Commelina africana*	45	4.5	36	0.96	2.02	1.49
17	*Commelina benghalensis*	100	10	40	2.14	2.25	2.19
18	*Commelina erecta*	72	7.2	40	1.54	2.25	1.89
19	*Corchorus tridens*	78	7.8	28	1.67	1.57	1.62
20	*Croton lobatus*	28	2.8	16	0.60	0.90	0.75
21	*Cyathula prostrata*	17	1.7	20	0.36	1.12	0.74
22	*Cyperus amabilis*	98	9.8	28	2.10	1.57	1.84
23	*Cyperus haspan*	112	11.2	36	2.40	2.02	2.21
24	*Cyperus rotundus*	275	27.5	72	5.89	4.04	4.97
25	*Cyperus tuberosus*	52	5.2	16	1.11	0.90	1.01
26	*Dactyloctenium aegyptium*	28	2.8	40	0.60	2.25	1.42
27	*Desmodium scorpiurus*	46	4.6	16	0.99	0.90	0.94
28	*Digitaria horizontalis*	11	1.1	24	0.24	1.35	0.79
29	*Eleusine indica*	14	1.4	20	0.30	1.12	0.71

30	*Emilia praetermissa*	6	0.6	20	0.13	1.12	0.63
31	*Eragrostis tremula*	8	0.8	20	0.17	1.12	0.65
32	*Euphorbia graminea*	7	0.7	16	0.15	0.90	0.52
33	*Euphorbia heterophylla*	11	1.1	20	0.24	1.12	0.68
34	*Euphorbia hirta*	8	0.8	12	0.17	0.67	0.42
35	*Ficus exasperata*	1	0.1	4	0.02	0.22	0.12
36	*Gomphrena celosioides*	26	2.6	36	0.56	2.02	1.29
37	*Ipomoea involucrata*	20	2	28	0.43	1.57	1.00
38	*Laportea aestuans*	12	1.2	8	0.26	0.45	0.35
39	*Mariscus alternifolius*	6	0.6	12	0.13	0.67	0.40
40	*Melanthera scandens*	82	8.2	28	1.76	1.57	1.66
41	*Mimosa Pigra*	5	0.5	8	0.11	0.45	0.28
42	*Momordica charantia*	1	0.1	4	0.02	0.22	0.12
43	*Mucuna pruriens*	15	1.5	32	0.32	1.80	1.06
44	*Oldenlandia corymbosa*	5	0.5	20	0.11	1.12	0.62
45	*Oplismenus burmannii*	261	26.1	64	5.59	3.60	4.59
46	*Panicum maximum*	6	0.6	8	0.13	0.45	0.29
47	*Paspalum conjugatum*	11	1.1	16	0.24	0.90	0.57
48	*Pennisetum pedicellatum*	5	0.5	12	0.11	0.67	0.39
49	*Pentodon pentandrus*	7	0.7	16	0.15	0.90	0.52
50	*Peperomia pellucida*	754	75.4	84	16.15	4.72	10.44
51	*Phyllanthus niruri*	2	0.2	8	0.04	0.45	0.25
52	*Physalis angulata*	5	0.5	8	0.11	0.45	0.28
53	*Pouzolzia guineensis*	119	11.9	36	2.55	2.02	2.29
54	*Senna occidentalis*	7	0.7	20	0.15	1.12	0.64
55	*Setaria barbata*	39	3.9	20	0.84	1.12	0.98
56	*Setaria longiseta*	1	0.1	4	0.02	0.22	0.12
57	*Setaria megaphylla*	39	3.9	40	0.84	2.25	1.54
58	*Sida acuta*	13	1.3	20	0.28	1.12	0.70
59	*Solanum nigrum*	27	2.7	16	0.58	0.90	0.74
60	*Spermacoce octodon*	2	0.2	8	0.04	0.45	0.25
61	*Spigelia anthelmia*	48	4.8	48	1.03	2.70	1.86
62	*Synedrella nodiflora*	19	1.9	16	0.41	0.90	0.65

63	*Talinum fructicosum*	361	36.1	76	7.73	4.27	6.00
64	*Tithonia diversifolia*	49	4.9	16	1.05	0.90	0.97
65	*Tridax procumbens*	282	28.2	36	6.04	2.02	4.03
66	*Triumfetta rhomboidea*	15	1.5	20	0.32	1.12	0.72
67	*Vernonia amygdalina*	7	0.7	24	0.15	1.35	0.75
68	*Vernonia galamensis*	44	4.4	32	0.94	1.80	1.37
	Total	4668	466.8	1780	100.00	100.00	100.00

Table 4.14: Floristic composition and RIV of Seed Bank (5-15 cm) depth of CRIN Secondary Forest in the dry season

S/N	Species composition	Abundance	Density	F (%)	RD (%)	RF (%)	RIV (%)
1	*Ageratum conyzoides*	154	15.4	20	6.67	2.23	4.45
2	*Albizia julibrissin*	2	0.2	8	0.09	0.89	0.49
3	*Amaranthus viridis*	3	0.3	8	0.13	0.89	0.51
4	*Aspilia africana*	24	2.4	28	1.04	3.13	2.08
5	*Boerhavia diffusa*	2	0.2	8	0.09	0.89	0.49
6	*Brachiaria deflexa*	148	14.8	72	6.41	8.04	7.22
7	*Brahiaria lata*	54	5.4	12	2.34	1.34	1.84
8	*Caesalpinia pulcherrima*	2	0.2	4	0.09	0.45	0.27
9	*Centrosema pubescens*	3	0.3	4	0.13	0.45	0.29
10	*Chromolaena odorata*	336	33.6	76	14.55	8.48	11.51
11	*Commelina benghalensis*	27	2.7	12	1.17	1.34	1.25
12	*Commelina diffusa*	2	0.2	4	0.09	0.45	0.27
13	*Commelina erecta*	17	1.7	8	0.74	0.89	0.81
14	*Corchorus tridens*	3	0.3	4	0.13	0.45	0.29
15	*Cyathula prostrata*	1	0.1	4	0.04	0.45	0.24
16	*Cyperus amabilis*	82	8.2	16	3.55	1.79	2.67
17	*Cyperus rotundus*	371	37.1	40	16.06	4.46	10.26
18	*Cyperus tuberosus*	15	1.5	12	0.65	1.34	0.99
19	*Desmodium scorpiurus*	6	0.6	4	0.26	0.45	0.35
20	*Eleusine indica*	8	0.8	12	0.35	1.34	0.84
21	*Eragrostis tremula*	4	0.4	16	0.17	1.79	0.98
22	*Euphorbia graminea*	1	0.1	4	0.04	0.45	0.24
23	*Euphorbia heterophylla*	3	0.3	8	0.13	0.89	0.51
24	*Euphorbia hirta*	3	0.3	4	0.13	0.45	0.29
25	*Ficus exasperata*	3	0.3	8	0.13	0.89	0.51
26	*Gomphrena celosioides*	5	0.5	12	0.22	1.34	0.78
27	*Laportea aestuans*	3	0.3	4	0.13	0.45	0.29
28	*Melanthera scandens*	5	0.5	8	0.22	0.89	0.55
29	*Momordica charantia*	2	0.2	8	0.09	0.89	0.49

30	*Mucuna pruriens*	5	0.5	16	0.22	1.79	1.00
31	*Oldenlandia corymbosa*	4	0.4	4	0.17	0.45	0.31
32	*Oplismenus burmannii*	28	2.8	24	1.21	2.68	1.95
33	*Palisota hirsuta*	13	1.3	28	0.56	3.13	1.84
34	*Panicum maximum*	3	0.3	8	0.13	0.89	0.51
35	*Paspalum conjugatum*	5	0.5	8	0.22	0.89	0.55
36	*Pennisetum pedicellatum*	6	0.6	12	0.26	1.34	0.80
37	*Peperonia pellucida*	400	40	84	17.32	9.38	13.35
38	*Phyllanthus niruri*	4	0.4	8	0.17	0.89	0.53
39	*Dactyloctenium aegyptium*	2	0.2	8	0.09	0.89	0.49
40	*Physalis angulata*	9	0.9	12	0.39	1.34	0.86
41	*Physalis micrantha*	1	0.1	4	0.04	0.45	0.24
42	*Portulaca grandiflora*	14	1.4	24	0.61	2.68	1.64
43	*Setaria barbata*	47	4.7	24	2.03	2.68	2.36
44	*Setaria longiseta*	14	1.4	28	0.61	3.13	1.87
45	*Setaria megaphylla*	12	1.2	8	0.52	0.89	0.71
46	*Spermacoce octodon*	1	0.1	4	0.04	0.45	0.24
47	*Spigelia anthelmia*	49	4.9	48	2.12	5.36	3.74
48	*Synedrella nodiflora*	2	0.2	4	0.09	0.45	0.27
49	*Talinum fructicosum*	203	20.3	52	8.79	5.80	7.30
50	*Tridax procumbens*	170	17	12	7.36	1.34	4.35
51	*Triumfetta cordifolia*	14	1.4	20	0.61	2.23	1.42
52	*Triumfetta rhomboidea*	6	0.6	8	0.26	0.89	0.58
53	*Vernonia galamensis*	9	0.9	20	0.39	2.23	1.31
	Total	2310	231	896	100.00	100.00	100.00

4.1.5 Diversity indices for Vegetation types in CRIN secondary forest

4.1.5.1 Diversity indices for various plant species at CRIN secondary forest in the wet and dry season

The results of diversity indices for the plant at CRIN secondary forest in wet season 2018 and dry season 2019 are all shown in Table 4.15. The results obtained revealed that the highest number of taxa (87) and individuals (26,304) were counted both from herbaceous in the wet season. However, trees had higher number of species (64) in wet and dry seasons than shrubs with similar number of species (49) in wet and dry seasons while shrubs had the higher number of individuals in wet (3481) and dry (2,617) seasons than trees in wet (953) and dry (928) seasons. Dominance values of 0.16, 0.03 and 0.03 in the wet season and 0.06, 0.03, 0.03 in dry season respectively for herbaceous, shrubs and trees were low. That means there was no prevalence of a single species, all species were randomly established in the area in both seasons. Simpson index values 0.84, 0.97 and 0.97 in the wet season and 0.94, 0.97, 0.97 in dry season respectively for herbaceous, shrubs and trees were very high, the results show the richness of species in the area in both seasons. The Shannon index (H') values were 2.94, 3.56 and 3.81 in the wet season and 3.54, 3.63, 3.80 in dry season respectively. Herbaceous, shrubs and trees were high and close to the highest value in each vegetation type. The values obtained indicate that there are many species in both seasons, each with few individuals. Equitability index was higher in herbaceous in the dry season (0.83) than wet season (0.66); also, it was very high in shrubs in the dry season (0.93) and wet season (0.92) as well as trees in the wet season (0.92) and dry season (0.91). These values indicate that individuals are randomly distributed among all species in each season (Table 4.15).

Table 4.15: Vegetations diversity Indices in CRIN secondary forest in wet and dry season

	WSH	DSH	WSS	DSS	WST	DST
Taxa_S	87	70	49	49	64	64
Individuals_ I	26304	13490	3481	2617	953	928
Dominance_D	0.16	0.06	0.03	0.03	0.03	0.03
Simpson_1-D	0.84	0.94	0.97	0.97	0.97	0.97
Shannon_H	2.94	3.54	3.56	3.63	3.81	3.8
Equitability_E	0.66	0.83	0.92	0.93	0.92	0.91

Legend:

WSH= Field herbaceous in Wet Season   DSH = Field herbaceous in Dry Season

WSS = Field shrubs in Wet Season   DSS = Field shrubs in Dry Season

WST = Field trees in Wet Season   DST = Field trees in Dry season

4.1.5.2 Diversity indices for Seed bank species in both seasons' experimentation in CPEB screen house

The results of diversity indices for Seed bank species in both seasons in the CPEB screen house was shown in (Table 4.16). Results obtained indicate that the shallon topsoil (0-5cm) had higher values of taxa (32 and 68) and individuals (4,212 and 4,668) than the deep topsoil (5-15cm) with taxa values 24 and 53 and individuals' values 1,499 and 2,310 in wet and dry seasons respectively. The values of dominance index were very low at all depths and seasons with values of 0.08 and 0.12 respectively for 0-5cm and 5-15cm in the wet season and 0.07 and 0.10 respectively for 0-5cm and 5-15cm dry season. This means there is no prevalence of a particular species over others. Opposite to dominance, Simpson index was very high in all depths and seasons, the values were 0.92 and 0.88 respectively for 0-5cm and 5-15cm in the wet season and 0.93 and 0.90 respectively for 0-5cm and 5-15cm dry season. Consequently, the study area is very rich in species. Shannon index was relatively high in both seasons and both depths. The values were 2.94 and 2.51 respectively for 0-5cm and 5-15cm in the wet season and 3.16 and 2.70 respectively for 0-5cm and 5-15cm dry season. It implies that there was a diversity of species with relatively few numbers of individuals. The values of equitability were high in both seasons and depths with 0.85 and 0.79 respectively for 0-5cm and 5-15cm in the wet season and 0.75 and 0.68 respectively for 0-5cm and 5-15cm in the dry season, which means individuals are evenly distributed among all species (Table 4.16).

4.1.6 Distribution of various vegetation by taxonomic levels in CRIN Secondary forest

The taxonomic diversity calculated was related by the type of vegetation discovered. It was dominated by the herbaceous in terms of genera (70) and species (86) while trees had the highest number (33) of family representations (Table 4.17).

Table 4.16: Seed Bank Plant Species Diversity Indices in CRIN secondary Forest in Wet and Dry Season

Diversity indices	Wet Season Seed-bank		Dry Season Seed-bank	
	0-5cm	5-15cm	0-5cm	5-15cm
Taxa_S	32	24	68	53
Individuals_I	4212	1499	4668	2310
Dominance_D	0.08	0.12	0.07	0.10
Simpson_1-D	0.92	0.88	0.93	0.90
Shannon_H	2.94	2.51	3.16	2.70
Equitability_E	0.85	0.79	0.75	0.68

Table 4.17: Distribution of various vegetation by taxonomic levels in CRIN Secondary forest

		HERBS	SHRUBS	TREES	SB_{05}	SB_{15}
TAXONOMY	FAMILY	27	25	33	25	20
	GENERA	70	45	48	58	43
	SPECIES	86	49	63	73	53

SB_{05} = Seed Bank at 0-5 cm depth; SB_{15} = Seed Bank at 5-15 cm depth

4.1.7 Similarity index among seasons and depths of soil seed bank and vegetation type

A total of three vegetation types and two depths of the soil seed bank, all from two different seasons were compared in pairs in order to know the similarity between these vegetations and the seed bank species composition.Table 4.18 shows the highest similarity index (100%) between shrubs enumerated in the wet season (WSS) and shrubs enumerated in the dry season (DSS) on one hand and trees enumerated in the wet season (WST) and trees enumerated in dry season trees (DST) on the other hand. This was followed by the similarity index (76.40%) observed between WSH and DSH, 75% between seed bank at 0-5cm depth in wet season (WSB5) and seed bank at 5-15cm depth in rainy season (WSB15); 49.46% between seed bank at 0-5cm depth in dry season (DSB5) and seed bank at 5-15 cm depth in dry season (DSB15); 45.28% between WSB15 and DSB15; 44.07% between WSB5 and DSB15; 33.33% between WSB5 and DSB5; 29.58% between DSB5 and WSB15; 28.10% between WSH and DSB5; 24.39% between DSH and WSB5; 24.24% between DSH and DSB15; 23.89% between WSH and DSB15; 23.21% between DSH and DSB5; 23.15% between WSH and WSB5; 19.56% between WSH and WSB15, and 18.98% between DSH and WSB15. The low values of similarity index were observed between WSS and WST, DSS and DST, DSS and DST, and DSS and WST with a common value of 1.03% of similarity, followed by 1.54% common value of similarity between WST and DSB5, and between DST and DSB5, and a common value of 1.74% of similarity between WST and DSB15, and between DST and DSB15. The lowest value was 0% observed between the herbaceous enumerated in wet season (WSH) and herbaceous enumerated in dry season (DSH) compared respectively to shrubs species enumerated in wet season (WSS) and shrubs species enumerated in dry season (DSS), between Trees species enumerated in wet season (WST) and Trees species enumerated in dry season (DST) compared respectively to WSB15. The same value of similarity (0%) was observed between shrubs species enumerated in the wet season (WSS) and shrubs species enumerated in the dry season (DSS) compared respectively to various seed bank species composition found in both seasons and depths. This similarity index (0%) was also observed between trees species enumerated in the wet season (WST) and trees species enumerated in the dry season (DST) compared respectively to WSB5 and WSB15.

Table 4.18: Similarities between various vegetation types and soil seed bank based on their species composition in CRIN secondary forest

	WSH	DSH	WSS	DSS	WST	DST	WSB_5	DSB_5	WSB_{15}	DSB_{15}
WSH	--									
DSH	76.40	--								
WSS	0	0	--							
DSS	0	0	100	--						
WST	0	0	1.03	1.03	--					
DST	0	0	1.03	1.03	100	--				
WSB_5	23.15	24.39	0	0	0	0	--			
DSB_5	28.10	23.21	0	0	1.54	1.54	33.33	--		
WSB_{15}	19.56	18.98	0	0	0	0	75	29.58	--	
DSB_{15}	23.89	24.24	0	0	1.74	1.74	44.07	49.46	45.28	--

Legend :

WSH= Field Herbaceous in Wet Season
WSS = Field Shrubs in Wet Season
WST = Field Trees in Wet Season
WSB_5 = Seed Bank at 0-5 cm depth in Wet season
WSB_{15} = Seed Bank at 5-15 cm depth in Wet season

DSH = Field Herbaceous in Dry Season
DSS = Field Shrubs in Dry Season
DST = Field Trees in Dry season
DSB_5 = Seed Bank at 0-5 cm depth in Dry season
DSB_{15} = Seed Bank at 5-15 cm depth in Dry season

4.2 Relative density, frequency basal area and Importance Value Index of trees species

The relative density (RD), Relative frequency (RF), Relative basal area (RBA) and Importance Value Index (IVI) of trees in both seasons 2018 and 2019 are showed in Table 4.19. The result showed that the highest IVI and RBA belonged to *Albizia coriaria*, 6.43% and 17.38%, respectively while *Albizia ferruginea* had the lowest IVI (0.21%) and *Albizia julibrissin* had the lowest RBA (0.08%). The highest RF belonged to *Celtis integrifolia* with 5.90% while *Anacardium occidentale*, *Cleistopholis patens*, *Rauvolfia vomitoria*, *Garcinia kola*, *Terminalia superba*, *Albizia ferruginea*, *Albizia julibrissin, Erythrophleum suaveolens, Irvingia grandifolia*, *Tectona grandis*, *Trichilia emetica*, *Ficus asperifolia*, *Chrysophyllum albidum* had lowest RF values (0.37%). The highest RD belonged to *Snysepalum dulcificum* with 5.92% while four species namely *Anacardium occidentale*, *Garcinia kola*, *Albizia ferruginea*, *Ficus asperifolia* had similar low RD values which is 0.11% (Table 4.19).

4.3 Distribution of trees population according to diameter class size

The classes at breast heights (DBH), between 71-90cm diameter between 91-110cm) and 111-130cm had the highest occurrences of family and species of 28(295), 27(195) and 27(158), respectively. These values were followed by the size classes between 151-169cm (DBH), 170cm and above (DBH), and 131-150 cm (DBH), which had 20(96), 17(66) and 23(65) family and species respectively while those that fell under low size classes 51-70 and 10-30 cm (DBH) had the lowest number 14(40) and 10(36) respectively. However, the size class below 30cm had no species (Figure 4.1).

4.4 Distribution of tree population according to height class size

The class between 41-50m height had the highest number of species followed by the classes between 31-40m height and between 21-30m. The family species in the height classes were 29(403), 31(291) and 103(259), respectively. However, the height class between 21-30m height had the highest occurrence number of the family (103). It was followed by the size classes 51m height and above, and 11-20m which had family and species values of 20(83) and 16(64), respectively while the lowest number of species (7) and family (3) fell under low size class below 10 m height (Figure 4.2).

Table 4.19: Relatives density (RD), frequency (RF) and basal area (RBA) and Importance Value Index (IVI) of trees species at CRIN Secondary forest

Species	**RD (%)**	**RF (%)**	**RBA (%)**	**IVI (%)**
Afzelia africana	3.07	3.32	0.72	2.37
Albizia adianthifolia	0.77	1.85	1.29	1.3
Albizia coriaria	0.44	1.48	17.38	6.43
Albizia ferruginea	0.11	0.37	0.14	0.21
Albizia glaberrima	1.43	2.95	2.91	2.43
Albizia gummifera	3.62	4.06	1.74	3.14
Albizia julibrissin	0.22	0.37	0.08	0.22
Albizia zygia	2.74	3.32	0.87	2.31
Alstonia boonei	0.44	0.74	1.18	0.79
Anacardium occidentale	0.11	0.37	0.5	0.33
Anthocleista nobilis	1.97	2.58	1	1.85
Artocarpus heterophyllus	2.19	4.06	0.35	2.2
Blighia sapida	0.33	0.74	1.68	0.92
Bombax buonopozense	0.88	1.11	2.38	1.45
Brachyestegia eurycoma	0.66	0.74	0.84	0.75
Bridelia micrantha	0.33	0.74	0.78	0.62
Holoptelea grandis	0.99	1.48	0.74	1.07
Cedrela odorata	0.88	1.11	0.18	0.72
Ceiba pentandra	0.88	0.37	0.75	0.66
Celtis integrifolia	5.37	5.9	2.4	4.56
Celtis zenkerii	0.77	1.11	0.93	0.94
Citrus sinensis	0.22	0.74	1.51	0.82
Cleistopholis patens	0.44	0.37	1.68	0.83
Cola acuminata	3.29	2.21	0.28	1.93
Cola gigantea	2.19	1.85	2.54	2.19
Cola millenii	0.55	1.11	3.43	1.69
Cordia millenii	3.51	3.69	3.27	3.49
Cordia platythyrsa	0.99	2.21	0.61	1.27
Anthonotha marcrophyla	1.97	0.74	2.2	1.64

Elaeis guineensis	5.15	0.74	1.89	2.59
Erythrophleum suaveolens	0.55	0.37	6.78	2.56
Ficus asperifolia	0.11	0.37	0.33	0.27
Ficus capensis	0.99	0.74	1.08	0.93
Ficus exasperata	0.33	0.74	0.58	0.55
Ficus thonningii	1.43	2.58	0.87	1.63
Funtumia africana	1.54	2.58	0.64	1.59
Gambeya albida	3.4	0.37	0.8	1.52
Garcinia kola	0.11	0.37	0.74	0.41
Morinda lucida	0.77	1.48	0.37	0.87
Gliricidia sepium	2.19	2.95	0.58	1.91
Gmelina arborea	1.86	1.85	0.84	1.52
Irvingia gabonensis	0.88	1.85	0.96	1.23
Irvingia grandifolia	0.77	0.37	0.27	0.47
Lecaniodiscus cupanioides	4.06	2.95	0.58	2.53
Milicia excelsa	0.99	1.48	0.27	0.91
Millettia thonningii	0.99	2.21	1.25	1.48
Newbouldia laevis	0.77	1.48	4.36	2.2
Plumeria rubra	2.08	0.74	0.56	1.13
Pterygota macrocarpa	0.44	1.48	4.3	2.07
Pycnanthus angolensis	4.5	3.32	1.61	3.14
Rauvolfia vomitoria	1.64	0.37	0.36	0.79
Ricinodendron heudelotii	2.74	0.74	0.48	1.32
Senna abbreviata	1.86	1.11	0.47	1.15
Macaranga barteri	0.33	0.37	2.26	0.98
Solanum aethiopicum	5.92	4.06	2.67	4.22
Sterculia setigera	3.73	4.06	0.72	2.84
Tectona grandis	0.66	0.37	0.52	0.52
Terminalia ivorensis	2.3	2.95	1.2	2.15
Terminalia superba	0.55	0.37	0.44	0.45
Theobroma cacao	0.77	1.11	3.34	1.74
Trichilia emetica	1.54	0.37	1.44	1.12
Triplochiton scleroxylon	1.32	0.74	0.65	0.9

Zanthoxylum zanthoxyloides	1.43	0.74	1.48	1.22
63	100	100	100	100

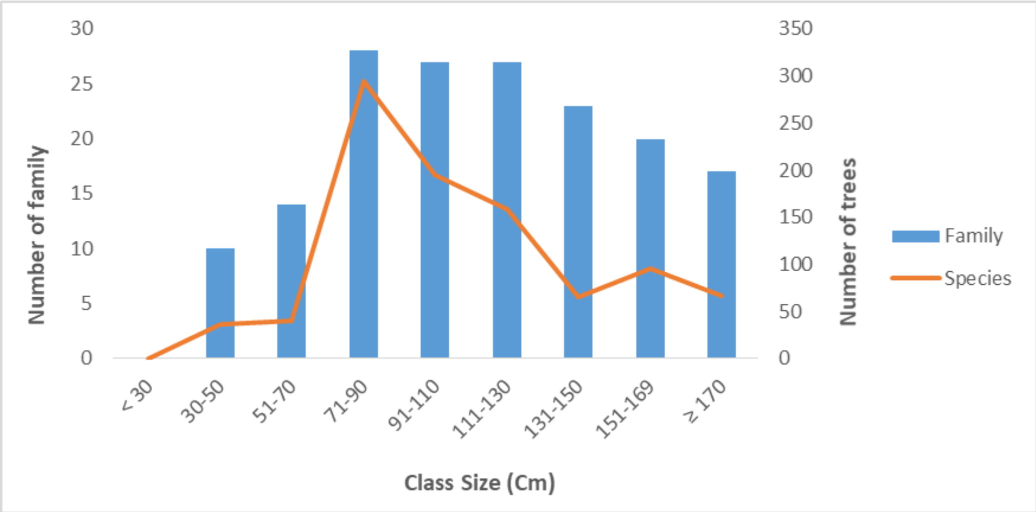

Figure 4.1: Distribution of trees species and family by diameter size in the secondary forest of CRIN in Ibadan, Nigeria

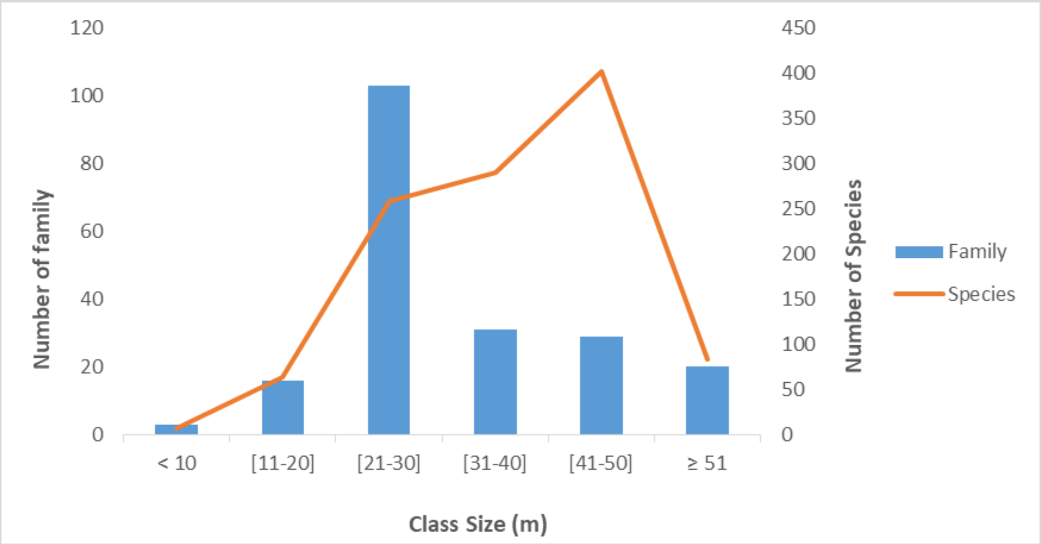

Figure 4.2: Distribution of trees species and family population by height size in the secondary forest of CRIN in Ibadan, Nigeria

4.5 Biomass and carbon Stock estimation of tree species of the secondary Forest

The biomass and the carbon stock estimation in the CRIN secondary Forest had 63 tree species which were enumerated within the selected sampled plots (Table 4.20). The result showed that the highest biomass and carbon stock belonged to *Albizia coriaria* with 5.67 ton/ha and 2.84 ton/ha respectively; followed by *Ficus exasperata* with 2.65 ton/ha and 1.32 ton/ha respectively; *Ficus capensis* with 2.01 ton/ha and 1.01 ton/ ha respectively; *Albizia adianthifolia* with 1.31 ton/ ha and 0.66 ton/ha respectively; *Ceiba pentandra* with 1.31 ton /ha and 0.66 ton/ha respectively; *Albizia zygia* with 1.29 ton/ha and 0.65 ton/ha respectively; *Bombax buonopozense* with 1.08 ton/ha and 0.54 ton/ha respectively; *Gmelina arborea* with 0.98 ton/ha and 0.49 ton/ha respectively; *Plumeria rubra* with 0.94 ton/ha and 0.47 ton/ha respectively; and *Pycnanthus angolensis* with 0.94 ton/ha and 0.47 ton/ha respectively. However the lowest biomass and carbon stock belonged to *Theobroma cacao* with 0.02 ton/ha and 0.01 ton/ha respectively; followed by *Tectona grandis* with 0.08 ton/ha and 0.04 ton/ha respectively; *Millettia thonningii* with 0.08 ton/ha and 0.04 ton/ha respectively; *Celtis integrifolia* with 0.11 ton/ha and 0.05 ton/ha respectively; *Lecaniodiscus cupanioides* with 0.12 ton/ha and 0.06 ton/ha respectively; *Ricinodendron heudelotii* with 0.13 ton/ha and 0.07 ton/ha respectively; *Macaranga barteri* with 0.14 ton/ha and 0.07 ton/ha respectively; *Anacardium occidentale* with 0.16 ton/ha and 0.08 ton/ha respectively; *Sterculia setigera* with 0.20 ton/ha and 0.10 ton/ha respectively; *Pterygota macrocarpa* with 0.21 ton/ha and 0.10 ton/ha respectively; and *Irvingia gabonensis* with 0.21 ton/ha and 0.10 ton/ha respectively. The total biomass and carbon stock for all the trees enumerated in the secondary forest was estimated at 38.91 ton/ha and 19.46 ton/ha, respectively. The biomass and carbon stock per hectare was obtained by dividing the respective value by the total area sampled.

Table 4.20: Biomass and carbon stock estimation of trees in the forest of CRIN, Ibadan, Nigeria

Trees species	**Wood Density (ton/m^3)**	**Height (m)**	**DBH (m)**	**Biomass (ton/ha)**	**Carbon Stock (ton/ha)**
Afzelia africana	0.77	40.93	1.08	0.36	0.18
Albizia adianthifolia	0.61	34.43	2.56	1.31	0.66
Albizia coriaria	0.61	50.50	2.48	5.67	2.84
Albizia ferruginea	0.61	38.00	1.86	0.77	0.39
Albizia glaberrima	0.61	41.38	1.44	0.51	0.26
Albizia gummifera	0.61	41.09	1.28	0.40	0.20
Albizia julibrissin	0.61	9.50	1.84	0.19	0.10
Albizia zygia	0.61	39.80	2.37	1.29	0.65
Alstonia boonei	0.72	48.25	1.27	0.55	0.27
Anacardium occidentale	0.47	37.40	0.96	0.16	0.08
Anthocleista nobilis	0.56	43.61	0.99	0.24	0.12
Anthonotha marcrophyla	0.58	30.22	1.72	0.51	0.26
Artocarpus heterophyllus	0.78	52.33	0.84	0.29	0.14
Blighia sapida	0.43	32.86	1.47	0.30	0.15
Bombax buonopozense	0.77	43.67	1.82	1.08	0.54
Brachyestegia eurycoma	0.67	38.80	1.12	0.32	0.16
Bridelia micrantha	0.90	37.44	1.00	0.34	0.17
Cedrela odorata	0.88	24.63	1.80	0.69	0.34
Ceiba pentandra	0.45	24.50	3.52	1.31	0.66
Celtis integrifolia	0.39	26.75	1.02	0.11	0.05
Celtis zenkerii	0.71	45.33	1.70	0.90	0.45
Citrus sinensis	0.71	41.13	1.17	0.39	0.19
Cleistopholis patens	0.83	36.84	0.99	0.29	0.15
Cola acuminata	0.45	51.00	1.70	0.65	0.33
Cola gigantea	0.65	43.00	1.74	0.82	0.41
Cola millenii K.Schum	0.94	14.77	1.63	0.36	0.18
Cordia millenii	0.60	47.90	1.73	0.82	0.41
Cordia platythyrsa	0.49	43.60	1.76	0.64	0.32

Elaeis guineensis	0.58	40.75	1.69	0.66	0.33
Erythrophleum suaveolens	0.58	38.35	0.95	0.20	0.10
Ficus asperifolia	0.64	47.72	1.65	0.80	0.40
Ficus capensis	0.51	45.62	2.03	2.01	1.01
Ficus exasperate	0.77	50.00	2.70	2.65	1.32
Ficus thonningii	0.46	32.00	1.20	0.21	0.11
Funtumia africana	0.46	39.56	1.03	0.19	0.10
Gambeya albida	0.46	41.67	1.05	0.21	0.11
Garcinia kola	0.46	33.23	1.61	0.40	0.20
Gliricidia sepium	0.72	39.21	0.97	0.26	0.13
Gmelina arborea	0.76	37.44	1.89	0.98	0.49
Holoptelea grandis	0.72	36.84	1.09	0.31	0.15
Irvingia gabonensis	0.58	37.75	0.97	0.21	0.10
Irvingia grandifolia	0.69	40.35	0.97	0.26	0.13
Lecaniodiscus cupanioides	0.95	31.00	0.62	0.12	0.06
Macaranga barteri	0.95	19.43	0.87	0.14	0.07
Milicia excelsa	0.78	36.16	1.84	0.92	0.46
Millettia thonningii	0.67	31.00	0.63	0.08	0.04
Morinda lucida	0.77	34.11	1.26	0.41	0.21
Newbouldia laevis	0.76	37.57	0.94	0.25	0.13
Plumeria rubra	0.72	40.42	1.83	0.94	0.47
Pterygota macrocarpa	0.65	39.50	0.89	0.21	0.10
Pycnanthus angolensis	0.55	45.51	1.97	0.94	0.47
Rauvolfia vomitoria	0.61	34.53	1.46	0.44	0.22
Ricinodendron heudelotii	0.62	40.80	0.72	0.13	0.07
Senna abbreviata	0.85	46.33	0.83	0.27	0.14
Solanum aethiopicum	0.46	45.89	1.66	0.57	0.29
Sterculia setigera	0.57	37.18	0.97	0.20	0.10
Tectona grandis	0.65	36.36	0.56	0.08	0.04
Terminalia ivorensis	0.77	37.33	1.42	0.56	0.28
Terminalia superba	0.77	41.20	1.41	0.62	0.31
Theobroma cacao	0.46	10.50	0.53	0.01	0.01
Trichilia emetica	0.73	47.46	1.41	0.67	0.33

Triplochiton scleroxylon	0.49	37.38	1.39	0.34	0.17
Zanthoxylum zanthoxyloides	0.67	37.38	1.16	0.34	0.17
Total				38.91	19.46

Plate 4.1: A view of Cocoa CRIN Secondary Forest, Ibadan, Nigeria

Plate 4.2: *Chromolaena odorata* during the rainy season (A) and dry season (B) at CRIN Secondary Forest, Ibadan

Plate 4.3: Population of *Ipomoea involucrata* at CRIN Secondary Forest

Plate 4.4: *Andropogon tectorum* as a typical vegetation pattern at CRIN Secondary forest, Ibadan

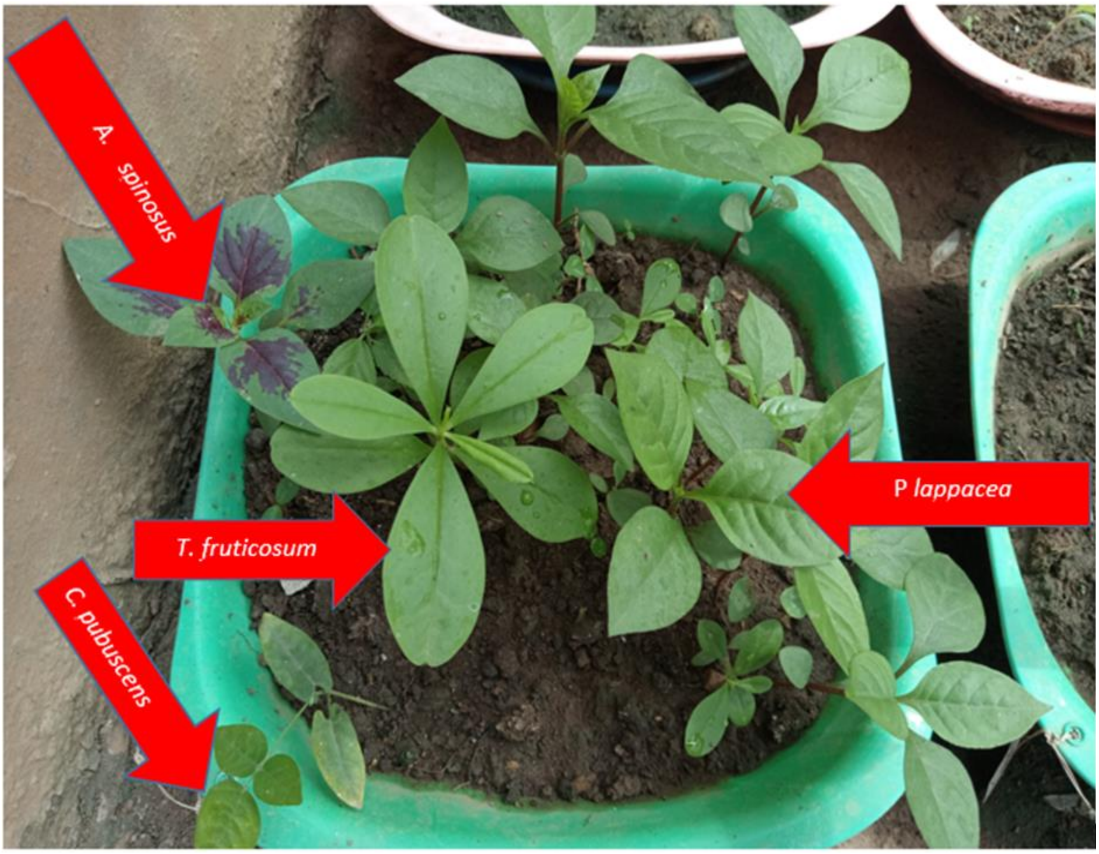

Plate 4.5: Emergence of Talinum fruticosum, Centrosema pubescens, Pupalia lappacea and Amaranthus spinosus in soil seed bank of CRIN Forest

4.6 Soil Physico-chemical parameters in CRIN secondary Forest

The mean and standard error of Physico-chemical properties of soil analyses in CRIN secondary forest are presented in Table 4.21. From the results, the mean pH was 6.32±0.10 (and the values were less than 7.0.). This concludes that the soil of CRIN secondary forest is acidic. The mean total organic carbon was 2.41±0.12 and the mean total organic matter was 4.10±0.21 (the results ranged between 1.94±0.54 and 2.81±0.21 for organic carbon and between 3.34±0.93 and 4.84±0.2 for organic matter). The mean total Nitrogen was 0.21±0.01 (the total nitrogen ranged between 0.17±0.05 % and 0.24±0.02 %). The mean cation exchanges (EC) was 22.62±1.40 (it ranged between 16.17±2.63 and 29.727±9.33 Cmol/kg). The mean soil phosphorus (P) was 73.27±5.06 mg/kg (it ranged between 59.66±5.7 and 98.37±22.48 mg/kg). The mean percentage of sand, clay and silt were 77.20±0.98, 11.28±0.63 and 11.48±0.96% (it ranged between 73.00±1.47 and 82.27±2.73%; 9.75±0.67 and 14.20±1.02%; and 7.40±1 and 15.60±1.2 % respectively). The textural class was loamy sand (Table 4.21).

4.7 Environnemental factors at secondary Forest at CRIN, Ibadan (2018 and 2019)

The highest rainfall was observed from May to October with a peak in June for both years (2018 and 2019) while it is low from November to April. It was increased with advanced year as showed by the positive R.Value witch are $R^2 = 0.0001$ in 2018 and $R^2 = 0.0835$ in 2019 (Figure 4.3).

The relative humidity was also higher in wet season than dry season for both year. The two positive R.Value showed it was increased from 2018 ($R^2 = 0.0274$) to 2019 ($R^2 = 0.1572$) (Figure 4.4). The maximum temperatures were observed in dry season than wet season. (Figure 4.5). Over between 2018 and 2019, the temperatures were incresead with the positive R.Value ($R^2 = 0.01307$ in 2018 and $R^2 = 0.1762$ in 2019).

The way, the precipitation, the relative humidity and the temperature were increased may be related to the climate change. The highest rainfall, highest relative humidity and lowest temperature in the wet season may be a factor for the most abundance and distribution of herbaceous species in the rainy season.

Table 4.21: Physico-chemical properties of the soil in CRIN secondary forest, Ibadan, Nigeria

Parameters	**Mean±SE**
pH	6.23±0.10
Organic Carbon	2.41±0.12
Organic Matter	4.10±0.21
Total Nitrogen (%)	0.21±0.01
E C (Cmol/Kg)	22.62±1.40
P (mg/Kg)	73.27±5.06
Sand (g/Kg)	776.9±0.98
Clay (g/Kg)	109.8±0.63
Silt (g/Kg)	112.6±0.96

Textural class: Loamy Sand

EC (Cation exchanges) = Na+Ca+K

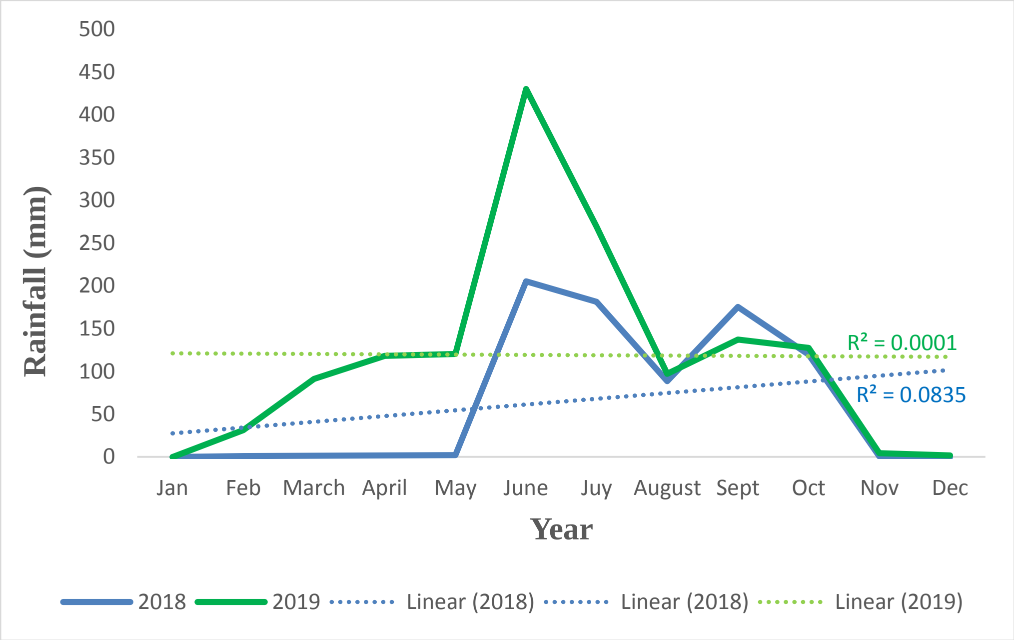

Figure 4.3: Monthly rainfall of the secondary regrowth forest of CRIN from the year 2018-2019

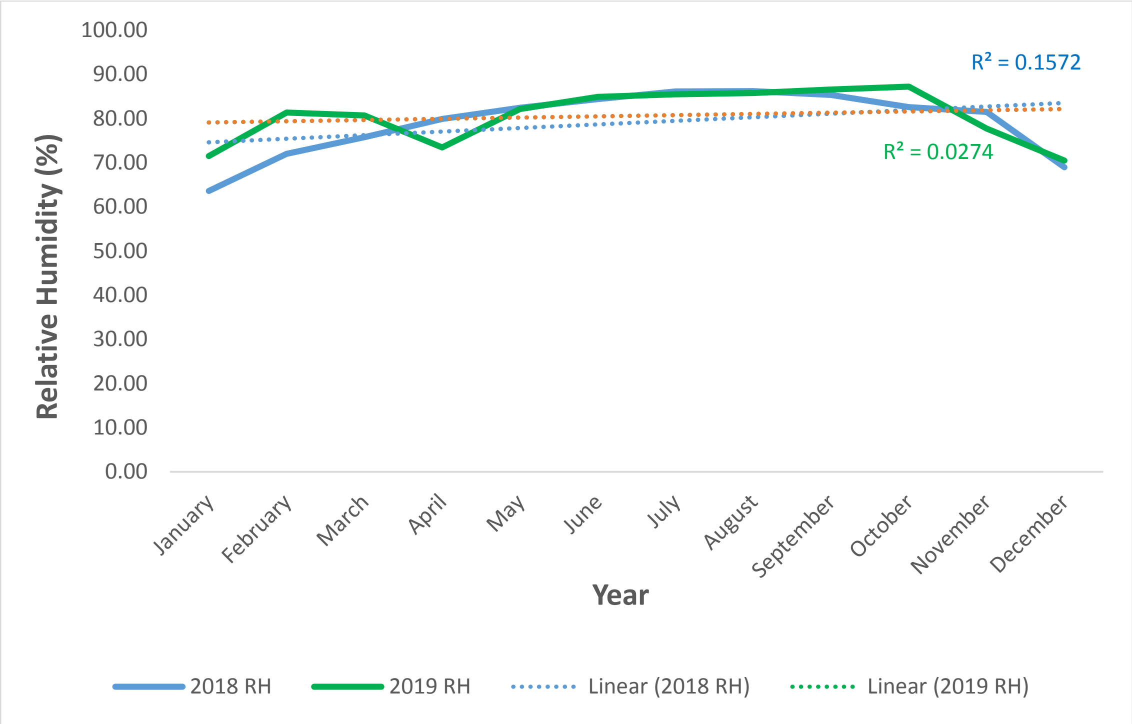

Figure 4.4: Mean monthly relative humidity of the secondary regrowth forest of CRIN from the year 2018-2019

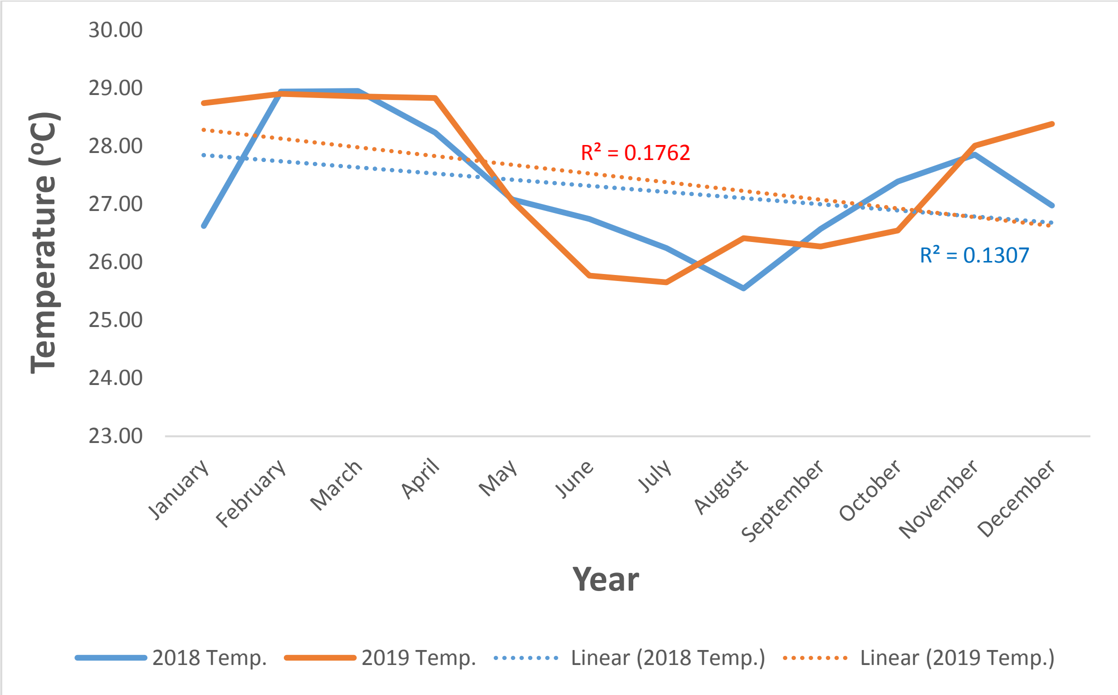

Figure 4.5: Mean monthly temperature of the secondary regrowth forest of CRIN from the year 2018-2019

CHAPTER FIVE

5.0 DISCUSSION

The species composition and diversity of flora of an ecosystem could be a veritable tool to check the seasonal changes of an ecosystem. In this study on the herbaceous, shrubs and trees composition of secondary forest of the Cocoa Research Institute of Nigeria, there were differences in the species composition, diversity and soil seed bank in the wet and dry seasons.

The micro-habitat of CRIN forest reserve was closely similar in vegetation types and species composition but varied slightly in individual species (structure) presence in the wet and dry seasons. The species composition in shrubs and trees species was similar in the rainy and dry season but there was a difference in the herbaceous species composition in the rainy and dry season. The results of this study indicated high species composition and abundance for herbs, shrubs and trees species with the herbs having the highest species abundance. This was similar to the findings of Komolafe *et al*. (2017) who opined that Ibodi forest of Southwest Nigeria contains 47 herbs and 93 trees while Tang *et al.* (2010) reported high species composition of 222 plant species in secondary vegetation communities in China comprising of 113 herbaceous species, 109 woody species (trees, shrubs, and lianas), 79 families and 183 genera.

The high species composition and abundance may be attributed to human perturbations in CRIN forest. This was similar to the assertion of Mishra *et al*. (2008) that herbaceous species dominance over shrubs and trees composition in a disturbed forest may be attributed to the presence of anthropogenic activities, including the harvest of food tree plantations (Oluwatosin and Jimoh, 2016). However, Kessler *et al.* (2005) attributed the presence of a high number of herbaceous flora in a recovery forest to the presence of few mature trees, which allows the penetration of light, thereby promoting the growth of light-loving plants known as heliophytes (Bobo *et al*., 2006; Awodoyin*et al*., 2013).

The most abundant number of herbaceous species was found in Poaceae and Asteraceae in both seasons while Rubiaceae and Fabaceae contained the most abundant shrub species, and Fabaceae, Moraceae and Malvaceae were the most abundant tree species. The abundance of Asteraceae in both rainy and dry season conforms to the study of Awodoyin *et al*. (2013) who reported that Asteraceae was found to be among the highest families of herbs in cocoa agroforest of tropical rainforest zone of Nigeria. Also, Ahmed *et al.* (2015) reported same for semi-desert region of Egypt. Notwithstanding the number of species identified for herbs, shrubs and trees, the abundance of individual species was higher in the rainy season than the dry season. *Chromolaenaodorata* (Asteraceae) occurred in both rainy and dry seasons but the species occurrence of the wet season (RIV: 25%) was higher than the dry season (RIV: 12.27%). The heavy presence and ability of *C. odorata* (nutrient sink, source of organic matter etc.) might have influenced the number of herbaceous species composition in the CRIN forest. The high occurrence of *C. odorata*, a ubiquitous species of disturbed forest in the rainforest supports the assertion of Oke and Isichei (1997) who reported that *C. odorata* is a common herb of tropical rainforest. *Chromolaena odorata,* like many of Asteraceae family, has the peculiar intense competitive ability, fast seed dispersal mechanism and high regeneration rate. The invasion of the study site by *C. odorata* might have positively influenced the number of herbaceous species flora due to previous land-use change(s), especially deforestation for cultivation. This agrees with the findings of Agboola and Muoghalu (2015) who reported a decrease in plant species composition and diversity in sites invaded by *Tithoniadiversifolia* and *C. odorata*. The high number of Rubiaceae among shrub species composition in the secondary rainforest of CRIN was supported by Ndah*et al.* (2013) who mentioned that Rubiaceae was the most prominent family of shrub in species composition, diversity and distribution in a disturbed Takamanda Rainforest, South West, Cameroun. The RIV of *Lonchocarpusgriffonianus* (Fabaceae) remains prominent in both wet and dry season but it was second in its occurrence to *Lonchocarpuscyanescens* (Fabaceae) in the dry season. *L. griffonianus* and *L. cyanescens* (Fabaceae) are pioneer species that have fast regeneration ability. They are usually abundant in disturbed forests or forests in their transition state (Bobo *et al*., 2006). However, the low number of *L. griffonianus* in the dry season may be due to its inability to tolerate vagaries of weather, resource and nutrient competition. This was supported by the findings of Ogwu *et al*. (2016) who reported that limited access to water resources may affect the survival of young trees (shrubs) in the dry season. Similarly, *L. cyanescens* which belongs to Fabaceae alongside *Lonchocarpusgriffonianus* may be a better nitrogen pump in the dry season where the decomposition by microorganism would be low due to low humidity. In a tropical rainforest, some Fabaceae like *L. cyanescens* and *L. griffonianus* have root nodules that could sequester and fix atmospheric nitrogen into the soil with the aid of Myrchorrhizal.

This was corroborated by the report of Chen (2006) who reported seasonal (water and temperature) influence on the performance of nitrogen fixation in the presence of Myrchorrhiza. Fabaceae had the highest number of tree species (12), followed by Moraceae and Malvaceae, each with six species. The high number of species composition of Fabaceae and Moraceae in Nigeria rainforest has widely been documented (Salami and Akinyele, 2018). This aligns with the findings of Adekunle (2016) and Adekunle *et al*. (2010) who reported that families such as Sterculiaceae, Meliaceae, Moraceae and Ebenaceae dominate the tropical rainforest of southwest Nigeria. The ability of Moraceae to produce a large number of seeds and quickly establish itself may account for their high presence and this was confirmed by Deka *et al.* (2012). Also, the high species composition of Fabaceae may be attributed to high competitive ability for water and other growth resources, thereby responsible for their superiority over native species (Ogwu*et al.*, 2016). The trees with the highest RIV values in both rainy and dry seasons were the most commonly found trees in the study site: *Triplochytonscleroxylon* (Malvacea), *Terminaliasuperba* (Combretaceae), *Funtumiaafricana* (Apocynaceae), *Celtiszenkeri* (Ulmaceae), *Sterculia setigera* (Malvaceae), *Irvingiagrandifolia* (Irvingianaceae) and *Irvingiagabonensis* (Irvingianaceae). The population of common trees with the exception of *Irvingiagabonensis* (Food crop tree) and *Terminaliasuperba* (Non-timber tree and Food crop) might have been sustained because of their utilization status (timber), and hence have been protected in the forest. This agrees with Ndah *et al.* (2013) who reported that overexploitation and domestic support may have been responsible for the low number of some timber species in a tropical forest of Cameroun. The number of individual tree species in the wet season (912) was higher than the dry season (887). This dynamics may be attributed to plant physiognomy, edaphic factor and anthropogenic activities including logging, firewood fetching and annual harvests of crops like *Theobroma cacao*, *Garcinia cola*, *Cola gigantea* and *Anacardiumoccidentale*. Therefore, trees with such economic importance to humans may have suffered exploitation and may be responsible for the decline in the number of tree species in a secondary forest. This assertion was supported by Komolafe *et al*. (2017), who reported that the economic value of trees may influence its selection for exploitation.

The CRIN forest is an ecosystem with a high diversity of species in distribution and abundance. This explains the high Shannon Wiener values obtained for herbs (3.56), shrubs (2.94) and trees (3.81) in both wet and dry seasons. There were, however, deviations across seasons for the diversity of each of shrubs, herbs and trees. The trees had the highest diversity in the wet season but the shrubs had the highest diversity in the dry season. There was insignificant diversity in both wet and dry seasons for herbaceous species. The seasonal similarity in herbs diversity may be attributed to the fallow management in a historically less stressed landscape. This was supported by the findings that soil conditions, inadequate rainfall pattern and excessive temperature may alter diversity and allow the support of few numbers of herbaceous flora in the forest ecosystem (Thakur, 2018).

The forest is diverse with mixed species of herbs, shrubs and trees. This was responsible for the low dominance values in the vegetation structure (herbs, trees and shrubs) of both seasons in CRIN forest. The seasonal changes did not affect co-dominance of trees; however, shrubs and herbs species co-dominance increased in the dry season. This was also explained by high evenness values obtained for trees, shrubs and herbs in both seasons. Therefore, there was more spread of various species for shrubs and herbs in the dry season than in the rainy season. The variation in seasons and species diversity agrees with the report of Lu *et al.* (2010) which suggested that high species diversity of herbs may be influenced by seasonal changes.

Also, the increase in diversity of species of herbs and shrubs in the dry season as shown by evenness values may further be attributed to other factors (like soil moisture content) apart from the climate. Moreno and Halffter (2001) and Tuomisto *et al*. (2003) suggested that landscape pattern and climatic conditions may influence species diversity of an ecosystem. It was similarly reported that ecological legacies including anthropogenic perturbation especially deforestation, intermediate succession and regeneration potential in the ecosystem of a forest which has not reached a climax. Though herbs had less number of taxa in the dry season than rainy season, the diversity was higher in the dry season than rainy season. The implication of this result is that the few species that survived the stress of dry season were all randomly distributed with no particular species dominant. This agrees with the findings of Thakur (2018) that the diversity of herbaceous species in the mixed forest was highest in a study conducted in the dry tropical forest of India.

The CRIN forest recorded high species richness (taxa) for herbs, shrubs and trees present in both seasons. The species richness of herbs was high in the rainy season but for the species richness of shrubs and trees, there was no difference across the season. The openness and closure of forest may influence species richness. The secondary forest may have a closed canopy of trees in the rainy season, which may favour the species of sciohytes, annuals and perennials. This was further stressed in the reports of Tang *et al*. (2010) and Awodoyin *et al*. (2013) that varying herbaceous species that are shade-loving (sciophytes), annuals and perennial plants are favoured in a closed canopy forest. However, high species diversity of trees indicates a resilience forest with mixed tree species population which may, however, enhance vegetation restoration for the continuous growth of the forest to climax (Tang *et al*., 2010).

The species compositions of seedlings emergence from the soil seed bank for both seasons showed insignificant variations. The highest number of plant individuals and number of seedlings species in the dry season were higher than rainy season. This was against the result obtained for the vegetation structure of the study site, in which the species and individuals in the rainy season were highest. This may be attributed to the dispersal of more seeds produced at the end of the wet season into the soil seed bank. The seeds so dispersed were going through the rest period (dormancy) in the dry season, awaiting another rainy season. Meanwhile, the seedlings species composition was similar in the wet and dry season. This, however, agrees with the findings of Ma *et al.* (2013) who reported that the species composition of seed bank was not significantly influenced by seasonal changes.

The seasonal changes affected the vegetation structure of CRIN forest as indicated by the variation in species abundance and density. Varying species density was observed for the different growth life forms (herbs, shrubs and trees) during the rainy season than the dry season. The herbaceous species had 26,229 individuals and 86 species with a density of 69.94 species.m^{-2} during the rainy seasons but 13,490 individuals and 70 species with a density of 35.97species.m^{-2} during the dry season. This could be a result of environmental factors, especially soil moisture, rainfall and relative humidity. This aligns with the work of Sanyaolu *et al*. (2018) who reported that density and abundance were higher during the wet season compared to the dry season. The variation in shrubs population was indicated by the presence of 3,481 individuals, 49 species and 27.85 species.m^{-2} in rainy season against 2,617 individuals and 49 species with 20.94 species.m^{-2} in dry season while in trees, there were 912 individuals, 63 species and 36.48 species.m^{-2} in rainy season against 887 individuals, 63 species and 35.48 species.m^{-2} in dry season. The seasonal differences in tree abundance and density may be due to the impact of anthropogenic activities (for utilization status) including felling of trees and shrubs species for firewood, furniture and conversion of secondary forest to plantation

(Cocoa, coffee, cashew, kola and tea). Also, some samplings of shrubs and trees may not be well established to survive the moisture stress, low humidity and high temperature of the dry season. Naturally, seeds are dispersed to the topsoil layer but get into lower depth during tillage or taken by burrowing insects and rodents. Oluwatosin and Jimoh (2016) stated that a lot of human disturbances extending from deforestation, hunting, harvesting NTFPs and natural forest conversion to plantation were experienced in Onigambari Forest Reserve.

The abundance, composition, number of individuals and density of species in the soil depths in the CRIN forest were influenced by season dynamics. The abundance, composition and species individual were higher during the dry season at 0-5cm and 5-15cm than rainy season. However, at the two depth layers (0-5cm and 5-15cm), the density of seed bank species identified during the dry season (68%) was higher than the wet season (32%). This could be explained by rapid seed production, dispersal, number of seeds and predominantly dormancy of some seeds at the end of the season. A similar work done by Mayor *et al*. (2003) stated that the seed density of grasses showed seasonal variation and most of the grasses showed maximum seed density in December (Dry season) when seed dispersal occurs. Seed dispersal mechanism, rapid seedling establishment and growth of some seeds may also influence the abundance and density of species. Thompson and Grime (2012) reported that seasonal variation in seed number is a function of the species rather than the ecosystem. This was further supported by Shen *et al*. (2007) who stated that seasonal dissimilarity of individual species was mainly due to differences in species phenology.

Since the abundance and densities of species were higher in the shallon topsoil (0-5cm) than the deep topsoil (5-15cm), it could be said that the shallon topsoil is better storage for dispersed seed and germination may be best at the surface than deep in the soil. Similarly, some seeds exhibit a delay in germination (seed dormancy) in the wet season and are pushed deep into the lower layer for germination. Akinola *et al*. (1998) reported that the seed emerged more in the top 5 cm. This corroborated the report by Traba *et al*. (2004) that the maximum seed density lies close to the surface. Meanwhile, Luzuriaga *et al*. (2005) stated that seed composition and abundance of species was highest at the shallow layer than deep layer. Awodoyin and Ogunyemi (2003) reported that the seeds of *Senna obtusifolia* had 100%, 50% and 0% germination at 0-4 cm, 8 cm and 16 cm soil depths respectively.

The species diversity at shallon topsoil was also higher than the deep topsoil in both wet and dry seasons as indicated by Shanon Wiener index. This agreed with the work of Zhang *et al*. (2016) who reported that the diversity distribution of the soil seed bank varied among soil layers and most seedling emergence were from the topsoil (Golos*et al*., 2016). The species richness, the even distribution of species emergence was also higher at the shallon topsoil than the deep topsoil in both seasons. This agrees with the report of Ma *et al*. (2013) who stated that both seed bank density and species richness varied knowingly in each depth layer and total for all layers among seasons. This was supported by Savadogo *et al*. (2016), who reported that seed densities were mostly highest in the top layer of the soil than bottom depth.

The abundance, density and species richness of seedlings of herbaceous plants were more represented in the seed bank than trees and shrubs. Among seedlings identified, 97% belonged to herbaceous and 3% to trees species. This is consistent with the findings of Senbeta and Teketay (2001) who stated that most of the dominant tree species in Savanna-woodland ecosystem do not accumulate in the soil seed bank. The presence of high herbaceous seedlings may be attributed to seed dormancy, soil condition and climate (decomposition of litters is highest at the rainy season). The high abundance of herbaceous species confirms findings from previous studies which reported that there are usually greater herbaceous plants seedlings than woody plants (Shen*et al*., 2007; Akinyemi*et al*., 2018; Sanyaolu*et al*., 2018).

There were high similarities among above-ground vegetations at 100%, 100% and 74% for shrubs, trees and herbs respectively across the seasons. Meanwhile, the similarities between the seed bank and above-ground vegetation (herbs, trees and shrubs) in both seasons were low as shown by Jaccard similarity index (1.54 to 28.10%). The similarity is poor compared to those reported in many previous studies, for instance, Bisseleua *et al.* (2008) reported the Jaccard similarity index of 11-34% among non-cocoa trees. The low similarities among the plots studied in a forest established the diversity and species richness of a resilient habitat (Zent and Zent, 2004). Meanwhile, Tessema *et al*. (2012) stated that the similarity between above-ground vegetation and species from seed bank was very high. This report of high similarities between above-ground vegetation and seed bank species was also confirmed by other studies (Yang and Li., 2013; Schwab and Kiehl, 2017).

The relative density (RD) of individual tree species was low with many species enumerated with RD value less than one. However, the highest RD belongs to

Synepalum dulcificum with 5.92% while four species, namely: *Anacardiumoccidentale, Garcinia kola, Albiziaferruginea, Ficusasperifolia* had similar lowest RD values of 0.11%. Ogwu *et al*. (2016) reported in a study that relative density of trees enumerated was mostly less, suggesting anthropogenic activities (from exploitation) that may lead to loss of some species and the potential threat to the sustainability of a forest. Adeniji and Olubode (2016) reported that inadequate stocking density of a monoculture plantation had made it to become a mixed species plantation and may be credited to human disturbances, especially unregulated felling of trees.

The low relative basal area (RBA) and impotance value index (IVI) indicate a mixed species habitat with a low prevalence of each species found in the study site. Many species found had RBA less than 10% while the dominant species was *Albizia coriaria* (RBA: 17.38%) and the most rarely found species was *Albiziajulibrissin* (RBA: 0.08%). A similarly low trend of species occurrence was observed where *Albiziacoriaria* had highest IVI (6.43%) and the lowest IVI was recorded for *Albiziaferruginea* (0.22%) and *Albiziajulibrissin* (0.21%). These species are mostly pioneer species in a regeneration state. The low RBA and IVI may be influenced by the legacy of the forest, where there are remnants of agroforest/food tree crops like *Anacardiumoccidentale, Garcinia kola*, *Theobroma cacao*, *Citrus sinensis*, etc which are annual crops that may allow the incursion of human exploitation (for harvest) of these agricultural products Thus, their presence reduces the basal area to tree species. Van Gemerden (2004) reported that the regeneration of a disturbed forest is enhanced by the dominance of pioneer species.

There was a difference in the number of species in the tree girth and height distribution in the study site. The low tree heights found (< 10m and 11-20m) had few families and species representation of 3 (7) and 16 (64) respectively, while the highest number of species (403) was found in tree height distribution of 41-50cm. This indicated the presence of large numbers of medium height trees in the regrowth forest. Similarly, DBH below 30cm had no species and family representation but there were fewer and increasing species and families in girth size above 30-50cm and 51-70cm. The absence of species and family at girth distribution of DBH below 30cm deviated from the findings of Zent and Zent (2004) that tree distribution of 10cm DBH had 133 to 191 species in 38 to 51 families. The number of families and species of 28 (295) was highest for girth size class 71-90 cm. Meanwhile, as the girth distribution from 71-90 cm decreased, the number of family and species increased, with distribution class at 170 cm and above containing 17 (66). The findings of this study suggested higher tree DBH (170 cm and above) than other previous studies with highest DBH of 110 cm (Zapfack *et al*., 2002) and 143 cm DBH (Bobo *et al*., 2006). This suggested that the forest had the potential to reach its climax with the characteristic presence of large trees and few selective logging activities in the forest which may explain that a regenarating forest is usually with less perturbation. This was confirmed by Zheng *et al*. (2006) who reported that the presence of large trees is an indication of a forest attaining its maturity.

The high species diversity and the presence of 63 species suggested a mixed forest which could serve as capture and storage for carbon. A mixed tree species forest provides great ecosystem function in carbon stock while the capacity of carbon uptake by various tree species varies (Houghton *et al*., 2009). The study conducted in the CRIN secondary forest indicated that an abundance of species composition in an area may not indicate a significant increase in carbon stock. Adeniji and Olubode (2016) reported variation in the amount of carbon contributed per tree with the dominant tree not being the largest contributor in the carbon stock. The increasing biomass of trees may be directly proportional to the carbon stock of trees. For instance, *Albizia coriaria* and *Ficus exasperate* had the highest biomass of 5.67 ton/ha and 2.65 ton/ha and the highest carbon stock of 2.84 ton/ha and 1.32 ton/ha respectively for trees in CRIN secondary forest. The biomass and carbon stock obtained from *Albizia coriaria*at CRIN forest is higher than what was reported in India where *Mallotus phillippensis* had the highest biomass and carbon stock of 3,729.76 kg/ha and 1,864.88 kg/ha, respectively and what was obtained in Nigeria on Celtis Zenkeris with a biomass of 1,299.64kg/ha and 649.82kg/ha respectively (Adekunle *et al*., 2014). Also, the total carbon stock in CRIN was higher than India and previous study in Nigeria at 5,360.84kg/ha and 4,897.82kg/ha, respectively.

Meanwhile, the abundance of *Albiziacoriaria* (12 in dry and 14 rainy season) and *Erythrophleumsuaveolens* (4 in both seasons) were few with the highest species abundance recorded for *Terminaliasuperba* (52; 54 in dry and rainy season) and *Triplochytonscleroxylon* (48; 49 in dry and rainy season). Therefore, the most abundant species may not contribute to the highest carbon stock but basically, the biomass (size) of the species contributed significantly to the carbon stock of trees in a given area. It was similarly reported that species co-dominance contributed significantly to carbon stock and species monoculture (Adeniji and Olubode, 2016). The carbon stock of this study area was estimated using CRIN trees diameter, height and wood density. This was similar to carbon estimation by Djomo *et al.* (2016) who stated that equations mixing diameter, height and wood density provided the best tools for estimation of total biomass in the three forest types and carbon estimation. The capacity of CRIN forest in stocking carbon is 19.46 ton/ha. This is lesser than the carbon stock potential of an India forest (82.41 ton/ha) and 78.29 ton/ha in Nigeria with biomass of 164.82 ton/ha and carbon stock of 156.73 ton/ha respectively (Adekunle *et al*., 2014). This is comparatively lower than 129 Mg/ha of CO_2 that average tropical forest in the world would sequester representing 50% of above-ground biomass (Samalca *et al*., 2007) of 278 Mg/ha in the world (Clark *et al*., 2001). The carbon storage potential of an area depends on the biomass of tree composition but is less dependent on the number of species and species richness (Chen, 2006; Munishi *et al*., 2011). The world Forest accounts for 90% of world biomass and the forest is a major carbon storage than any other ecosystem (Dixon *et al*., 2011). Adekunle *et al*. (2014) opined that carbon stock may also be influenced by biomass (Fonseca *et al*., 2011) environmental factors like soil (type, depth and nutrients), forest landscape and climatic condition.

The high relative humidity, precipitation and low temperature in the wet season are typical of a tropical forest and and incresead with advanced year. This may be have influenced the performance of the regrowth forest of CRIN. These environmental factors may have favoured the growth and transformation activity in CRIN herbaceous species between rainy and dry seasons. The environmental factors influenced species with low density in allowing decomposition of leaf and root litters due to light and precipitation penetration (Chen, 2006). The low nitrogen but high organic carbon obtained in the CRIN forest soil (Loamy Sand) may be attributed to the utilization of soil nitrogen by *Albizia coriaria* and *Erythrophleum suaveolens* which are family of Fabaceae. *Albizia coriaria* and *Erytrophlum suaveolens* obtained nitrogen from the soil and the influence of myrrchorhizal fungi decomposes the nitrogen for uptake by the plant. The tree composition and diversity affected the rate of decomposition by myrrchorizal fungi which therefore affected the amount of nitrogen and carbon available in the forest (Van der Heijden*et al*., 1998; Chen, 2006).

CHAPTER SIX

6.0 SUMMARYAND CONCLUSION

This study was carried out to explore the role of the soil seed bank in forest restoration. It determined the floristic composition in the soil seed bank in order to ascertain its similarity with the plant species of the enumerated standing vegetation of CRIN secondary Forest. Also, the study explored the effect of soil depth, season and soil physicochemical properties on seed germinability, density and composition of the soil seed bank. The study further estimated the biomass and carbon stock potential of the standing tree species of the secondary forest using non-destructive methods.

The study revealed the following:

1. There were 39,719 individuals, 219 species, 163 genera and 59 families. For both seasons, 86 herbaceous plants in 70 genera and 27 family were enumerated.
2. The five families, namely: Piperaceae, Asteraceae, Rubiaceae, Fabaceae and Poaceae were the dominant ones in this study with the highest number of species in the herbaceous community.
3. *Chromolaena odorata, Peperomia pelucida, Lonchocarpus griffonianus, Lonchocarpus griffonianus, Triplochiton scleroxylon and Terminalia superba*are were the dominant species from the study.
4. The highest numbers of taxa and individuals were recorded for the herbaceous plant both in rainy and dry seasons.
5. The dominance values calculated showed that in both seasons, there is no prevalence of single species and all species were evenly established in the study area.
6. The Shannon value index (H’) values obtained indicated that there was high species diversity but with few individuals. The equitability index values were shown in both seasons that individuals are randomly distributed among all species.
7. Seed bank studies showed that the topsoil (0-5cm) had higher values of taxa, genera, family and individuals than the low layer in the rainy and dry seasons.

8. The values of dominance index were very low in all depths and seasons. Shannon index and equitability values were high in both seasons and depths. From this study, we recorded higher number of species in the dry season than the wet season and more at the topsoil that the deep soil. The highest similarity was observed among seasons and depths and between seed bank and above-ground biomass. This specified that vigorous preservation and maintainable supervision of the secondary forest would make it possible for the said forest to continue to provide goods and facilities that are essential for the institute and local population. However, it has been detected that the cumulative with anthropogenic interferences are mortifying the secondary forest and alternative silviculture should be espoused in marginal.
9. The highest Importance Value Index and the relative basal area belonged to *Albizia coriaria*. The highest number of tree population distribution was found in girth size class 71-130 cm and the number of trees population in the highest class (41-50 m) was 403.
10. The highest biomass, carbon stock belongs to *Albizia coriaria*.

Based on the results and conclusion of the study, the subsequent recommendations needed to be considered:

1) Research in soil seed bank should be encouraged in institutions in order to have a wide interest in institution plantation's restoration, biological diversity conservation, vegetation succession and sustainable vegetation communities.
2) Government policy must be more rigorous for rational protection of remaining forests especially land-use conversion for agriculture and urbanization leading to shifting in flora, the preponderance of floral species. These are potential threats that lead to biodiversity loss, elevate greenhouse gas emission especially CO_2 and ultimately, exacerbate climate change. These perturbations are of great economic, social and environmental damage on a local and global scale with usual challenges in their mitigation. Many studies agreed that bad policies and poor management practices are usually one of the most important reasons for deforestation in the tropics.
3) National and international commitments should be strengthened to safeguard the productive and protective forest capacity of all countries in a path to social, economic and environmental objectives.

REFERENCE

Abella, S.R. and Springer, J.D. 2008. Estimating soil seed bank characteristics in ponderosa pine forests using vegetation and forest-floor data. *USDA Forest Service RMRS-RN*-35 35.9: 1–8.

Adakayi, P. E. 2000. Climate. In Dawan, P. D. (ed.). Geography of Abuja Federal Capital Territory. *Famous/Asanlu Publishers, Minna, Niger State, Nigeria* 9-23.

Addo-Fordjour, P.; S. Obeng, A.K.A. and Addo, M.G. 2009. Floristic composition, structure and natural regeneration in a moist semi-deciduous forest following anthropogenic disturbances and plant invasion. *International Journal of Biodiversity and Conservation* 1(2): 21–37.

Adedeji O.H., Tope-Ajayi O.O., Abegunde O.L. 2015. Assessing and Predicting Changes in the Status of Gambari Forest Reserve, Nigeria Using Remote Sensing and GIS Techniques. *Journal of Geographic Information System* 3(07): 1-17

Adekunle, V.A.; Nair, N.K.; Srivastava, A.K. and Singh, N.K. 2014. Forest Science and Technology Volume yield, tree species diversity and carbon hoard in protected areas of two developing countries. *Forest Science and Technology* 0.0: 1–15.

Adekunle, V.A.J. 2016. Conservation of Tree Species Diversity In Tropical Rainforest Ecosystem Of South-West Nigeria. *Journal of Tropical Forest Science* 18(2): 91–101.

Adekunle, V.A.J.; Olagoke, A.O. and Ogundare, L.F. 2010. Rate of timber production in a tropical rainforest ecosystem of South- western Nigeria and its implications on sustainable forest management. *Journal of Forestry Research* 21(2): 225–230.

Adeniji, S. A., and Olubode, O.S. 2016. Woody flora diversity and carbon sequestration of university of Ibadan Teak plantation: A conservation for climate change mitigation in Southwest Nigeria. *Best journal* 13(3):18-23.

Agbelade, A.D., Onyekwelu, J.C. and Apogbona O. 2016. Assessment of Urban tree species population and diversity in Ibadan, Nigeria. *Environmental and Ecology Research* 4.4: 185-192.

Agbelade, A.D., Onyekwelu, J.O and Oyun, M.B. 2017. Tree species richness, diversity and vegetation index for Federal Capital Territory, Abuja, Nigeria. *International Journal of Forestry Research* 1: 12.

Agboola, O.O. and Muoghalu, J.I. 2015. Changes In Species Diversity , Composition , Growth And Reproductive Parameters Of Native Vegetation Invaded By Chromolaena Odorata And Tithonia Diversifolia In Osun State , Southwest Nigeria. *FUTA Journal of Research in Sciences* (2): 217–230.

Ahmed, D.A.; Manal, F.; Saeed, N.M. and Awad, M.A. 2015. Effect of the recent land use on the plant diversity and community structure of Omayed Biosphere Reserve, Egypt. *Global Ecology and Conservation* 4: 26–37.

Aigbokhan, E.I. 2014. Annotated checklist of vascular plants of southern Nigeria – a quick reference guide to the vascular plants of southern Nigeria: *A systematic approch. Uniben Press, Benin* City. 346.

Akinola, M.O., Thompson, K. and Buckland, S. M. 1998. Soil seed bank of an upland calcareous grassland after 6 years of climate and management manipulations. *Journal of Applied Ecology* 35:544–552.

Akinyemi, D.S. and Oke, S.O. 2014. Floristic Composition and Structural Diversity of Shasha Forest Reserve. *Not Sci Biol* 6(4): 433–440, https://doi.org/10.1583/nsb649373.

Akinyemi, D.S.; Oseni, S.R. and Oke, S.O. 2018. Acta Oecologica Effect of heat on soil seedbank of three contrasting physiognomies in Shasha forest reserve, Southwestern Nigeria. *Acta Oecologica* (20): 1–9.

Akobundu, I. O., Ekeleme, F., Agyakwa, C. W., Ogabie, C. A. 2016. A handdbook of West African weeds. Third edition. *International Institute of Tropical Agriculture* (IITA) 3(381).

ANDEL T. V. 2001. Floristic composition and diversity of mixed primary and secondary forests in northwest Guyana. *Biodiversity and Conservation* 10: 1645–1682

Andreu, M.G., Hedman, C.W., Friedman, M.H. and Andreu, A.G. 2009. Can Managers Bank on Seed Banks When Restoring Pinus taeda L. Plantations in Southwest Georgia? *Restoration Ecology* 17.5: 586-596.

Atanda OA. 1977. The Third Nigerian Cocoa Breeding Programme: A progress report 1977. In: *5th International Cocoa Research Conference Ibadan*. 85-90.

Atomsa, D. and Dibbisa, D. 2019. Floristic composition and vegetation structure of Ades forest, Oromia regional state, West Hararghe zone, Ethiopia. *Tropical Plant Research* 6(1): 139–147, https://doi.org/10.22271/tpr.2019.v6.i1.020

Attiwill, P.M. 1994. The disturbance of forest ecosystems: the ecological basis for conservative management. *For. Ecol. Manage* 63: 247–300.

Awodoyin, R.O. and Ogunyemi, S. 2003. Germination of seeds of sickle pod as affected by pre-germination treatments, fruit maturity and depth of sowing: *Implication in sown fallow management Muarik Bulletin* 6: 44-52.

Awodoyin, R.O.; Akinyemi, C.Y.; Bolanle, O.O. and Antiabong, I.C. 2013. Spatial Distribution and Abundance of Solanecio Biafrae (Olive & Heirne) C. Jeffrey and structure of Weed Communities in some Cocoa Plots in Ekiti, Oyo and Cross River states, Nigeria. *Ife Journal of Science* 15.3: 661–676.

Bakker, J. P., Pschold P., Strykstra, R. J., Bekker, R.M., and Thompson, K. 1996. Seed bank and seed dispersal: important topics in restoration ecology. *Acta Botanica Neerlandica* 45: 461-490.

Balogun, O. 2001. The Geography of its Development, the Federal Capital Territory.*University Press, Ibadan, Nigeria*.

Baskin, C.C. and Baskin, J.M. 1998. Seeds. Ecology, biogeography, and evolution of dormancy and germination. *Annals of Botany* 86: 705–707.

Baskin, J.M. and Baskin, C.C. 2014. A classification system for seed dormancy. *Seed Science Research* 14: 1–16.

Bisseleua, D.; Herve, B. and Stefan, V. 2008. Plant biodiversity and vegetation structure in traditional cocoa forest gardens in southern Cameroon under different management. *Biodivers Conserv* 17: 1821–1835.

Black C. A. 1965. Methods of Soil Analysis, Part I. Physical and Mineralogical properties. American Society of Agronomy, Madison, WI, USA.

Blasco, A., Ortega, J.A., Santacreu, M.A. 2000. Selection for uterine capacity. I. Genetic trends and correlated response in components of litter size. *7th World Rabbit Congress.Valencia* 4-7 July 2000.

Blaser, J., and Sabogal, C. 2002. Management strategies for degraded landscapes. Draft guidelines for the restoration of degraded primary forests, the management of secondary forests and the rehabilitation of degraded forest land in tropical regions. *Draft report prepared on behalf of ITTO as basis for deliberations of the Expert Panel. Bern, Switzerland*.

Bobo, K.S.; Waltert, M.; Sainge, N.M.; Njokagbor, J.; Fermon, H. and Mu, M. 2006. From forest to farmland : species richness patterns of trees and understorey plants along a gradient of forest conversion in Southwestern Cameroon. *Biodiversity and Conservation* 15: 4097–4117.

Bolza, E. and Keating, W.G. (1972). African timbers: the properties, uses and characteristics of 700 species. *Division of Building Research, CSIRO, Melbourne, Australia.* 710.

Bossuyt, B. and Hermy, M. 2014. Seed bank assembly follows vegetation succession in dune slacks. *Journal of Vegetation Science* 15: 449-456.

Braun-Balanquet, J. 1965. Plant sociology: he study of plant communities. Hafner Print Book: English: 1st ed reprinted. 224-415

Buckland, S.T., Borchers, D.L., Johnston, A. Henrys, P.A. and Marques, T.A. 2008. Line Transect Methods for Plant Surveys. Biometrics 2: 989–998.

Cabin, R.J., and Marshal, D.L. 2000. The demographic role of soil Seed bank I. Spartial and temporal comparison of below and above ground population of desert mustard Lesqurerella fendleri. *Journal of Ecology* 88:283-292.

Carol, J. 1984. The Germination Requirements Of Naturally Buried Seeds With Particular Reference To Fluctuating Temperatures. *Research Theses Main Collection, University of Plymouth*. 298.

Carsan S, Orwa C, Harwood C, Kindt R, Stroebel A, Neufeldt H, and Jamnadass R. 2012. African Wood Density Database. *World Agroforestry Centre, Nairobi*. http://www.worldagroforestry.org/treesandmarkets/wood/

Chao A., Chazdon R., Colwell R., Shen T.J. 2004. A new Statistical approach for assessing similarity of species composition with incidence and abundance data. Corppus ID: 17175264.

Chave, J.; Duque, A.; Eid, T.; Fearnside, P. M.; Goodman, R. C.; Henry, M.; Martinez–Yrizar, A.; Mugasha, W. A.; Muller-Landau, H. C.; Mencuccini, M.; Nelson, B. W.; Ngomanda, A.; Nogueira, E.M.; Ortiz-Malavassi, E.; Pelissier, R.; Ploton, P.; Ryan, C. M.; Saldarriaga, J.G.; Vieilledent, G.. 2014. Improved allometric models to estimate the aboveground biomass of tropical trees. *Global Change Biology* 20:3177–3190.

Chen, X. 2006. Tree Diversity, Carbon Storage, and Soil Nutrient in an Old-Growth Forest at Changbai Mountain, Northeast China. *Communications in Soil Science and Plant Analysis* 37: 363–375.

Chittibabu, C.V. and Parthasarathy, N. 2000. Attenuated tree species diversity in human-impacted tropical evergreen forest sites at Kolli hills, Eastern Ghats, India. *Biodiversity and Conservation* 9: 1493-1519.

Clark, D.A.; Brown, S.; Kicklighter, D.W.; Chambers, J.Q. and John, R. 2001. Measuring Net Primary Production in Forests : Concepts and Field Methods. *Ecological Applications* 11(2): 356–370.

Day, P. R. 1965. Particle fractionation and particle size analysis. In: Black, C.A. (Ed) Methods of soil analysis part I. Agronomy 9:545-567.

Deka, J.; Tripathi, O.P. and Khan, M.L. 2012. Urban growth trend analysis using Shannon Entropy approach – a case study in north east India. *International Journal of Geomatics and Geosciences* 2(4): 1–8.

Dixon, J.M.; Marazita, M.L.; Beaty, T. and Murray, J.C. 2011. Cleft lip and palate: synthesizing genetic and environmental influences. *Nat Rev Genet* 12(3): 167–178.

Djomo, A.N.; Picard, N.; Fayolle, A.; Henry, M.; Ngomanda, A.; Ploton, P.; et al. 2016. Tree allometry for estimation of carbon stocks in African tropical forests. *An International Journal ofForest Research* 25(July): 446–455.

Douh C., Daïnou K., Loumeto J. J., Fayolle A., Doucet J.-L., 2014. Explorer la banque de graines du sol pour mieux comprendre la dynamique de régénération des forêts tropicales africaines (synthèse bibliographique). *Biotechnologie, Agronomie, Société et Environnement,* 18: 558-565. http://hdl.handle.net/2268/174538

Food and Agriculture Organization.2010. Global Forest Resources Assessment. *FAO Forestry Paper, Rome* 163:373.

Food and Agriculture Organization. 2016. Climate Change, Agriculture and Food security. ISBN 978-92-5-109374-0. *FAO report document*, 194p

Fenner, M. S. 1992. The Ecology of Regeneration in Plant Community.*UK: C.A.B. International* 2:11-235.

Fisher, J., Loneragan, W., Dixon, K., and Veneklaas, E. 2009. Soil seed bank compositional change constrains biodiversity in an invaded speciesrich woodland. *Biol. Conserv* 142.2:256–269.

Fonseca, W.; Federico, E.A.; Rey-Benayas; J.M. 2011. Carbon accumulation in aboveground and belowground biomass and soil of different age native forest plantations in the humid tropical lowlands of Costa Rica. *New For*. 2011, doi: 10.1007/s11056-011-9273-9.

Gbile Z. O. and Soladoye M. O. 2002. Vernacular names of Nigerians plants (Yoruba). *Forest Research Institute of Nigeria, Ibadan. 2nd Edition*

Golos, J.P., Dixon, W.K; Erickson, E.T. 2016. Plant recruitment from the soil seed bank depends on topsoil stockpile age, height, and storage history in an arid environment. *Restoration Ecology*, 24(2): 53–61 DOI:https://doi.org/10.1111/rec.12389.

GUEVARA, S. and GOMEZ-POMPA, A. 1972. Seeds from surface soils in a tropical region of Veracruz, Mexico. *Journal of the Arnold Arboretum* 53:312-335.

Hamed T. 2016. Sampling Methods in Research Methodology; how to choose a sampling technique for research. International Journal of Academic Research in Management (IJARM). 5(2): 18-27

Hammer, O. 2011. Paleontological Statistics Version 2.08. *Natural History Museum, University of Oslo* 210.

HELION, E. 2005. Importance de la banque de graines dans la dynamique de la végétation des prairies subalpines (*Col du Lautaret*).

Hiratsuka M., Toma T., Diana R., Hadriyant D., and Morikawa Y. 2006. Biomass Recovery of Naturally Regenerated Vegetation after the 1998 Forest Fire in East Kalimantan. *Indonesia JARQ.* 40: 277–282 http://www.jircas.affrc.go.jp.

Hossain, M.M. and Begum, M. 2015. Soil weed seed bank : Importance and management for sustainable crop production- A Review. J. *Bangladesh Agril. Univ.* 13(2): 221–228.

Houghton, R.A.; Hall, F. and Goetz, S.J. 2009. Importance of biomass in the global carbon cycle. *Journal of Geophysical Research* 114: 1–13.

Jaccard, P. 1912. The Distribution of the Flora of the Alpine Zone. New Phytologist, 11, 37-50.

Jiang, D.M., Wang, Y.C., Oshida, T., Luo, Y.M., Wang, H.M. and Zhou, Q.L. 2013. Review of research on soil seed banks in desert regions. *Disaster Advances* 6.3: 315–322.

Kalaba, F.K.; Quinn, C.H. and Dougill, A.J. 2013. The role of forest provisioning ecosystem services in coping with household stresses and shocks in Miombo woodlands, Zambia. *Ecosystem Services* 5: 143–148.

Kalamees, R., and Zobel, M. 2002. The role of seed bank in gap regeneration in a calcareous grassland community. *Ecology,* 83.4: 1017–1025.

Kent M. and Coker P. 1992. Vegetation Description and Analysis. A Pratical Approach. *Bellhaven Press* 76-112.

Kessler, M.; Keßler, P.J.A.; Gradstein, S.R.; Bach, K.; Schmull, M. And Pitopang, R. 2005. Tree diversity in primary forest and different land use systems in Central Sulawesi, Indonesia. *Biodiversity and Conservation* 14: 547–560.

Khan, M.L. and Uma, S. 2001. Only for academic Effect of seed weight, light regime and substratum microsite on germination and seedling growth of Quercus semiserrata Roxb. *Tropical Ecology* 42(1): 117–125.

Khurana, E. And Singh, J.S. 2001. Ecology of tree seed and seedlings: Implications for tropical forest conservation and restoration. *Current Science* 80: 748-757.

Kinloch, J. and Friedel, M.H. 2015. Soil seed reserves in arid grazing lands of central Australia. Part 1: seed bank and vegetation dynamics. *Journal of Arid Environments* 60: 133-161.

Kirby, K.R. and Potvin, C. 2007. Variation in carbon storage among tree species: Implications for the management of a small-scale carbon sink project. *Forest Ecology and Management* 246 (2-3): 208–221.

Koh, J., Ueda, T., Morimoto, Y. 2013. Evaluation of using soil seed bank and commercial seeds in nature revegetation. *Journal of the Japanese Society of Revegetation Technology*; 32:62–67.

Komolafe, A.A.; Adegboyega, S.A. and Akinluyi, F.O. 2017. A Review of Flood Risk Analysis in Nigeria. *American journal of environnemental sciences* 157–166.

Lavorel S, Lebreton JD, Debussche M, Lepart J. 2004. Nested spatial patterns in seed bank and vegetation of Mediterranean Oldfields. *Journal of Vegetation Science* 2:367–376.

Leck, M.A. 2013. Seed-bank and vegetation development in a created tidal freshwater wetland on the Delaware River, Trenton, New Jersey, USA. *Wetlands* 23: 310-343.

Lu, Z.J., Li, L.F., Jiang, M.X., Huang, H.D., and Bao, D.C. 2010. Can the soil seed bank contribute to revegetation of the drawdown zone in the Three Gorges reservoir region? *Plant Ecol.* 209.1:153–165.

Luzuriaga, A.L.; Escudero, A.; Olano, J.M. and Loidi, J. 2005. Regenerative role of seed banks following an intense soil disturbance. *Acta Oecologica* 27: 57–66.

Ma, M.J., Zhou, X.H. and Du, G.Z. 2013. Effects of disturbance intensity on seasonal dynamics of alpine meadow soil seed banks on the Tibetan Plateau. *Plant Soil* 369:283–295.

Macchi, M., Oviedo G., Gotheil, S., Cross, K., Boedhihartono, A., Wolfangel, C., Howell, M. 2008. Indigenous and traditional peoples and climate change. Indigenous and traditional peoples and climate change. *IUCN Issues Paper*. http://cmsdata.iucn.org/downloads (Online).

Magurren, A.E. 1988. Ecological Diversity and its Measurement. *Princeton University Press, Princeton*, NJ, USA.

Mayer, P., Abs, C., and Fischer, A. 2004. Colonisation by vascular plants after soil disturbance in the Bavarian Forest - key factors and relevance for forest dynamics. For. *Ecol. Manage* 188:279–289.

Mayor, M.D.; Boo, R.M.; Pelaez, D. V. and Elia, O.R. 2003. Seasonal variation of the soil seed bank of grasses in central Argentina as related to grazing and shrub cover. *Journal of Arid Environments* 53: 467–477.

McLean, E. O. 1982. Soil pH and lime requirement. In Page, A. L., R. H. Miller and D. R. Keeney (eds.) Methods of soil analysis. Part 2 - Chemical and microbiological properties. (2nd Ed.). *Agronomy* 9:199-223.

Mishra, R.K.; Upadhyay, V.P. And Mohanty, R.C. 2008. Vegetation ecology of the Similipal biosphere reserve, Orissa, India. *Applied Ecology and Environmental Research* 6(2): 89–99.

Moreno, C.E. and Halffter, G. 2001. Spatial and temporal analysis of α, β and γ diversities of bats in a fragmented landscape. *Biodiversity and Conservation* 10: 367–382.

Morellato, L.P.C.; Camargo, M.G.G.; Eça, F.F.D.; Luize, B.G.; Mantovani, A. and Hudson, I.L. 2010. The Influence of Sampling Method, Sample Size, and Frequency of Observations on Plant Phenological Patterns and Interpretation in Tropical Forest Trees. Springer Science+Business Media 2.5: 99–121.

Munishi, P. K. T., Wilfred, N. N., Nshare, J. S., Moe, S. R., Shirima, D. D., and Kilungu, H. H. 2011. Valley bottom wetlands can serve for both biodiversity conservation and local livelihoods improvements. *Ecosystem Biodiversity. InTech*. 474 pp. https://www.intechopen.com/books/ecosystems-biodiversity

Mwaura, F. and Kaburu, Æ.H.M. 2009. Spatial variability in woody species richness along altitudinal gradient in a lowland-dryland site, Lokapel. *Biodivers Conserv* 18: 19–32.

National Aeronautics and Space Administration. 2020. *Meterology data downloaded*. https://power.larc.nasa.gov/data-access-viewer/

Ndah, N.R.; Andrew, E.E. and Bechem, E. 2013. Species composition, diversity and distribution in a disturbed Takamanda Rainforest, South West, Cameroon. *African Journal of Plant Science* 7(12): 577–585.

Nishihiro, J., Nishihiro M.A. and Washitani I. 2016. Restoration of wetland vegetation using soil seed banks: lessons from a project in Lake Kasumigaura, Japan. *Landscape and Ecological Engineering*; 2.2:171–176.

Norden, N., Chazdon, R. L., Chao, A., Jiang, Y.-H., & Vílchez-Alvarado, B. (2009). Resilience of tropical rain forests: tree community reassembly in secondary forests. *Ecology Letters*, 12(5), 385–394. doi:10.1111/j.1461-0248.2009.01292.x

Nowak DJ, Crane D.E. 2002. Carbon storage and sequestration by urban trees in the USA. *Environ. Pollut*. 116: 381-389.

Obatolu B.O. 2014. Carbon Stock estimation of Theobroma cacoa (Cocoa) varieties in Ibadadan, Oyo State, Nigeria. *Master of Science (Umbuplished paper*). University of Ibadan.

Oberhauser U. 1997. Secondary forest regeneration beneath pine (Pinus kesiya) plantations in the Northern Thai highlands: A chronosequence study. *Journal Forest Ecology and Management* 256:114-120.

Ogunleye, A.J.; Adeola, A.O.; Ojo, L.O. and Aduradola, A.M. 2004. Impact of farming activities on vegetation in Olokemeji Forest Reserve, Nigeria. *Global Nest* 6.2: 131-140.

Ogwu, M.C.; Osawaru, M.E. and Obayuwana, O.K. 2016. Diversity and Abundance of Tree Species in the University of Benin, Benin City, Nigeria. *Applied Tropical Agriculture* 21(3): 46–54.

Oke, D.O., and Odebiyi, K.A. 2007. Traditional cocoa based agroforestry and forest species conservation in Ondo State, Nigeria. *Agriculture, Ecosystems and Environment* 122:305-311.

OKE, S., and ISICHEI, A.O. 1997. Floristics and Structure Of The Fallow Vegetation In The Ile-Ife Area Of Southwestern Nigeria. *Nigerian Journal of Botany* 10: 37–50.

Oke, S.; Oladipo, O.; Ndiribe, C.; Akinyemi, D. and Ojo, O. 2010. Soil seed bank dynamics in Tithonia diversifolia dominated fallowland at Ile- Ife, South-western Nigeria. *International Journal of Biological and Chemical Sciences* 3.5: 29–36.

Oluwatosin, B and Jimoh, S.O. 2016. Pattern of plant species diversity in a dry forest ecosystem of Nigeria.*Journal of Forestry Research and Management*, 13: 31-47

Onyekwelu, J.C., and Olaniyi, D.B. 2012. Socio-economic importance of urban and peri-urban Forest in Nigeria.*In*proceedings of the *6th Annual Conference of SAAT, FUTA, Adebayo, Edi, Akure, Nigeria, November*.

Pappoe, A.N., Armah, F.A., Quaye, E.C., Kwakye, P.K., and Buxton, G.N. 2010. Composition and stand structure of a tropical moist semi-deciduous forest in Ghana. *International Research Journal of Plant Science* 1.4.95-106.

Pascal, L.P, Pellissier, R. 1996. Structure and floristic composition of a tropical evergreenforest in south-west India. *J. Trop. Ecol*. 12:191-210.

Phalla, T., Ota, T., Mizoue, N., Kajisa, T., Yoshida, S., & Vuthy, M. 2018. The Importance of Tree Height in Estimating Individual Tree Biomass while Considering Errors in Measurements and Allometric Models. AGRIVITA Journal of Agricultural Science, 40(1), 131–140.

Pickett, S.T.A., and McDonnell, M.J. 1989. Changing perspectives in community dynamics: a theory of successional forces. *Trends in Ecology and Evolution* 4: 241-245.

Poorter, L.; Sande, M.T. van der; Thompson, J.; Arets, E.J.M.M.; Alarcón, A.; Álvarez-Sánchez, J.; et al. 2015. Diversity enhances carbon storage in tropical forests. *Journal of Macroecology* 1–16.

Rajkumar M, Parthasarathy N. 2008. Tree Diversity and Structure of Andaman Giant Evergreen Forests India. *Taiwania*. 53: 356–368.

Richards, P.W. 1966. The tropical rain forest. Second edition. *Cambridge University Press.*

Roy P.S. and Tomar S. 2000. Biodiversity characterization at landscape level using geospatial modelling technique. *Biol Conserv* 95(1):95–109

Salami K.D. and Lawal A.A. 2018. Description of economical trees and shrubs species in Northern part of Nigeria and their potentials. *In the Proceedings of 6th Biennial national conference of the forests and forest products society,* pp: 136-144

Salami, K.D. and Akinyele, A.O. 2018. Floristic Composition, Structure and Diversity Distribution in Omo Biosphere Reserve, OGUN STATE, NIGERIA. *Ife Journal of Science* 20(3): 639–648.

Samalca, I.K. 2007. Estimation of Forest Biomass and its Error A case in Kalimantan, Indonesia. A Thesis Assessment Board. *International Institute for Geo-information Science and Earth.* 84P.

Sanderson, M.A., Goslee, S.C., Klement, K.D., and Soder, K.J. 2007. Soil seed bank composition in pastures of diverse mixtures of temperate forages. *Agronomy Journal* 99.6:1514.

Santos, T.E.C. Dos; Silva, V.M.F. Da; Carmo, N.A.S. Do; Lazoski, C. And Cunha, A.H.A. 2018. Sotalia dolphins in their potential sympatry zone : searching for hybrids in the Amazonian estuary. *Journal of the Marine Biological Association of the United Kingdom* 1017(10): 1–5.

Sanyaolu, V.T.; Awodoyin, R.O. And Ogunyemi, S. 2018. Effect of Ornamental Plants on Adjoining Ecosystem of the Parks and Gardens, Obafemi Awolowo University, Nigeria. *Proceedings of 6th NSCB Biodiversity Conference* 2018: 90–103.

Savadogo P, Sanou L, Djibril SD, Bognounou F, Thiombiano A. 2016. Relationships between Soil seed bank and above-ground vegetation along a disturbance gradient in the W National Park trans- boundary biosphere reserve, West Africa. *Journal of Plant Ecology Journal of Plant Ecology* 10(2):349-363.

Schwab, A. and Kiehl, K. 2017. Analysis of soil seed bank patterns in an oxbow system of a disconnected floodplain. *Ecological Engineering* 100: 46–55.

Senbeta, F. and Teketay, D. 2001. Regeneration of indigenous woody species under the canopies of tree plantations in Central Ethiopia. *Tropical Ecology* 42(2): 175–185.

Shannon, C. E. and Wienner, W. 1963. The mathematical theory of communication. *Urbana University of Illinois*, 177P.

Shen, Y.; Liu, W.; Cao, M. and Li, Y. 2007. Seasonal variation in density and species richness of soil seed-banks in karst forests and degraded vegetation in central Yunnan, SW China. *Seed Science Research* 17.6: 99–107.

Shiferaw, W.; Demissew, S. and Bekele, T. 2018. "Ecology of soil seed banks : Implications for conservation and restoration of natural vegetation" : *A review*. *International Journal of Biodiversity and Conservation* 10(10): 380–393.

Simpson, R.L., Leck, M.A., and Parker, V.T. 1949. Seed banks: general concepts and methodological issues. In: Leck, M.A., V.T. Parker, and R.L. Simpson (Eds.). Ecology of Soil Seed Banks. *Academic Press, Inc., San Diego,* CA. 3-9.

Smith, J., Sabogal, C., de Jong, W., and Kaimowitz, D. 1998. Secondary forests as a resources for promoting rural development and environmental conservation in the tropics of Latin America. Occasional Paper. *Center for International forestry Research* 13.

Sorensen, T.A. 1948). A method of establishing groups of equal amplitude in plant sociology based on similarity of species content, and its application to analysis of the vegetation of Danish commons. *Biologiske Shrifter* 5: 1-34.

Swaine MD. 1992. Characteristics of dry forests in West Africa and the influence of fire. *Journal of Vegetation Science* 3:365–374.

Tadros, M. and Samarah, N. 2012. Effect of different pre-sowing seed treatments on the germination of Leucaena leucocephala (Lam.) and Acacia farnesiana (L.). *New forests* (1): 1–12. DOI: 10.1007/s11056-011-9260-1.

Taiwo, D.; Oyetayo, O. and Woghiren, A.I. 2018. The Role of Soil Seed Bank in Forest Regeneration. *Asian Journal of Research in Agriculture and Forestry* 4(1): 1–10.

Tang, C.Q.; Li, Y. and Zhang, Z. 2010. Species Diversity Patterns in Natural Secondary Plant Communities and Man-made Forests in a Subtropical Mountainous Karst Area, Yunnan, SW China. *International Mountain Society* 30(3): 244–251.

Tessema, Z.K.; Boer, W.F. De; Baars, R.M.T.; Herbert, H.T.; Tessema, Z.K.; Boer, W.F. De; et al. 2012. Influence of Grazing on Soil Seed Banks Determines the Restoration Potential of Aboveground Vegetation in a Semi-arid Savanna of Ethiopia. *Biotropica* 44(2): 211–219.

Thakur, T.K. 2018. Diversity, composition and structure of understorey vegetation in the tropical forest of Achanakmaar Amarkantak Biosphere Reserve, India. *Environmental Sustainability* 1(3): 279–293.

Thompson, A.K. and Grime, J.P. 2012. Seasonal Variation in the Seed Banks of Herbaceous Species In Ten Contrasting Habitats Seasonal Variation In The Seed Banks Of Herbaceous Species In Ten Contrasting Habitats. *British Ecological Society* 67(3): 893–921.

Traba, J.; Azcárate, F.M. and Peco, B. 2004. From what depth do seeds emerge ? A soil seed bank experiment with Mediterranean grassland species from what depth do seeds emerge ? A soil seed bank experiment with Mediterranean grassland species. *Seed Science Research* 14: 297–303.

Tuomisto, H.; Ruokolainen, K. and Yli-halla, M. 2003. Dispersal, Environment, and Floristic Variation of Western Amazonian Forests. *SCIENCE* 299: 241–244.

United Nations Educational, Scientific and Cultural Organization. 1978. Tropical Forest Ecosystems. Natural Resources Research XIV. *A State-of-Knowledge Report prepared by UNESCO/UNEP/FAO, UNESCO, Paris*.

United States Agensy for International Development. 2006. Impact of selective logging on the carbon stocks of tropical forests: Republic of Congo as a case study.

Report submitted by Winrock International (Ecosystem Services Unit 1621 N. Kent St, Suite 1200 Arlington, VA 22209) to the United States Agency for International Development. *Cooperative Agreement No. EEM-A-00-03-00006-00:21*.

Uniyal, P.; Pokhriyal, P.; Dasgupta, S.; Bhatt, D. and Todaria, N.P. 2010. Plant diversity in two forest types along the disturbance gradient in Dewalgarh Watershed, Garhwal Himalaya. *Current Science* 98(7): 938–943.

United Nations of Environment Programe. 2008. *UNEP Annual Report*. UN environment document. 106 p.

UN-Redd-Programe. 2014. Proceedings of the regional technical workshop on Tree Volume and Biomass Allometric Equations in West Africa. *CSIR-Forestry Research Institute of Ghana Kumasi, Ghana* 4:7.

Valbuena, R.; Heiskanen, J.; Aynekulu, E.; Pitkänen, S. and Packalen, P. 2016. Sensitivity of Above-Ground Biomass Estimates to Height-Diameter Modelling in Mixed-Species West African Woodlands. *Shijo Joseph, Kerala Forest Research Institute, INDIA* 11.7: 1–24.

Valerie J. E. and John H. M. 1997. Statistics Glossay. V1.1

Van der Heijden, M.G.A.; Klironomos, J.N.; Ursic, M.; Moutoglis, P.; Streitwolf-Engel, R.; Boller, T.; et al. 1998. Mycorrhizal fungal diversity determines plant diversity, ecosystem variability and productivity. *Nature* 396: 69–72.

Van Gemerden, B. S. 2004. Disturbance, Diversity and Distributions in Central Africain Rainforest. PhD Thesis, Wageningen: *Wageningen University*. 168p.

Walkley, A. and I.A. Black. 1934. An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chronic acid titration method. Soil Sci. 37: 29-37.

Wang, Y., Jiang, D., Toshio, O., & Zhou, Q. 2013. Recent advances in soil seed bank research. *Contemporary Problems of Ecology* 6.5:520-524.

Whittaker, R. H. 1975. Communities and Ecologies. Macmillan Publishing Co.INC. New York: *Collier Macmillan Publishers, London*. 385pp.

Yan, Q., Zhu, J. and Zhang, J. 2010. Spatial distribution pattern of soil seed bank in canopy gaps of various sizes in temperate secondary forests, Northeast China. *Plant Soil* 329: 469–480.

Yang, D. and Li, W. 2013. Soil seed bank and aboveground vegetation along a successional gradient on the shores of an oxbow. *Aquatic Botany* 110: 67–77.

Zanne, AE; Lopez-Gonzalez, G; Coomes, DA; Ilic, J; Jansen, S; Lewis, SL; Miller, RB; Swenson, NG; Wiemann, MC;Chave, J. 2009. *Global wood density database*. http://discovery.ucl.ac.uk/1453390/

Zapfack L., Engwald S., Sonké B., Achoundong G., Madong B.A. 2002. The impact of land use conversion on plant biodiversity in the forest zone of Cameroon. *Biodivers Conserv* 11:2047–2061.

Zent, L. and Zent, S. 2004. Floristic composition, structure, and diversity of four forest plots in the Sierra Maigualida, Venezuelan Guayana. *Biodiversity and Conservation* 13: 2453–2454.

Zhang, M.; Chen, F.; Chen, S.; Wang, Y. and Wang, J. 2016. Effects of the seasonal flooding on riparian soil seed bank in the Three Gorges Reservoir Region : a case study in Shanmu River. *Springer Plus* 5(492): 1–11.

Zheng Z, Feng Z, Cao M, Li Z, Zhang J. 2006. Forest Structure and Biomass of a Tropical Seasonal Rainforest in Xishuangbanna, Southwest China. *Biotropica*. 38: 318–327.

Zhong Z., Zheng L., Donglin C., Shaozi L. 2017. Re-raking Person Re-identification with K-Reciprocal encodind. IEEE Conference on Computer Vesion and Pattern. Corpus ID: 206595765.

APPENDIX

Appendix1: Raw data of Girth (G), Wood density (*p*), and height (H) of the sampling trees species from the CRIN Secondaryforest

Trees Species	Girth (cm)	*P* (g/cm^3)	H (m)
Afzelia africana	339.40	0.7	40.93
Albizia adianthifolia	805.20	0.55	34.43
Albizia coriaria	588.50	0.55	50.5
Albizia ferruginea	584.50	0.55	38
Albizia glaberrima	453.00	0.55	41.38
Albizia gummifera	402.45	0.55	41.09
Albizia julibrissin	576.72	0.55	9.5
Albizia zygia	443.46	0.55	39.8
Alstonia boonei	399.48	0.65	48.25
Anacardium occidentale	302.00	0.43	37.4
Anthocleista nobilis	310.37	0.51	43.61
Anthonotha marcrophyla	541.44	0.53	32
Artocarpus heterophyllus	263.96	0.71	30.22
Blighia sapida	461.24	0.39	52.33
Bombax buonopozense	572.56	0.7	32.86
Brachyestegia eurycoma	350.98	0.61	43.67
Bridelia micrantha	315.00	0.82	38.8
Cassia abbreviata	566.49	0.8	24.5
Cedrela ordorata	575.88	0.41	26.75
Ceiba pentandra	321.25	0.35	45.33
Celtis integrifolia	535.22	0.64	41.13
Celtis zenkerii	366.10	0.64	51
Chrysophyllum albidum	309.59	0.75	43
Citrus sinensis	534.73	0.41	14.77
Cleistopholis patens	545.81	0.59	47.9
Cola acuminata	512.46	0.85	43.6
Cola gigantea	543.11	0.54	40.75

Cola millenii	552.41	0.44	38.35
Cordia millenii	529.88	0.53	45.62
Cordia platythyrsa	298.84	0.53	50
Elaeis guineensis	517.71	0.58	47.72
Erythrophleum suaveolens	952.58	0.46	39.56
Ficus asperifolia	848.60	0.7	41.67
Ficus capensis	377.44	0.42	33.23
Ficus exasperate	322.93	0.42	39.21
Ficus thonningii	331.00	0.42	36.84
Funtumia africana	507.40	0.42	37.44
Garcinia kola	304.00	0.65	37.75
Gliricidia sepium	593.96	0.69	40.35
Gmelina arborea	341.90	0.65	37.44
Holoptelea grandis	304.00	0.53	31
Irvingia gabonensis	304.37	0.63	19.43
Irvingia grandifolia	195.00	0.86	36.16
Lecaniodiscus cupanioides	271.96	0.86	46.33
Macaranga barteri	576.71	0.71	31
Milicia excelsa	198.26	0.61	34.11
Millettia thonningii	397.12	0.7	36.84
Morinda lucida	295.17	0.69	37.57
Newbouldia laevis	576.11	0.65	40.42
Plumeria rubra	280.95	0.59	39.5
Pterygota macrocarpa	519.67	0.5	45.51
Pycnanthus angolensis	459.00	0.55	34.53
Rauvolfia vomitoria	227.40	0.56	40.8
Ricinodendron heudelotii	262.19	0.77	24.63
Solanum aethiopicum	522.87	0.42	45.89
Sterculia setigera	305.85	0.52	37.18
Tectona grandis	176.60	0.59	36.36
Terminalia ivorensis	444.84	0.7	37.33
Terminalia superba	442.69	0.7	41.2
Theobroma cacao	166.53	0.42	10.5

Trichilia emetica	443.13	0.66	47.46
Triplochiton scleroxylon	435.27	0.44	37.38
Zanthoxylum zanthoxyloides	365.31	0.61	37.38

Appendix 2: Presence – Absence of species enumerated in CRIN Secondary Forest

Species	RSH	DSH	RSS	DSS	RST	DST	RSB5	DSB5	RSB15	DSB15
Abutilon mauritianum	+	-	-	-	-	-	-	-	-	-
Acanthus montanus	+	+	-	-	-	-	-	-	-	-
Afzelia africana	-	-	-	-	+	+	-	-	-	-
Ageratum conyzoides	+	+	-	-	-	-	+	+	+	+
Albizia gummifera	-	-	+	+	+	+	-	-	-	-
Albizia adianthifolia	-	-	+	+	+	+	-	-	-	-
Albizia coriaria	-	-	+	+	+	+	-	-	-	-
Albizia ferruginea	-	-	-	-	+	+	-	-	-	-
Albizia glaberrima	-	-	-	-	+	+	-	-	-	-
Albizia julibrissin	-	-	+	+	+	+	-	-	-	+
Albizia zygia	-	-	+	+	+	+	-	-	-	-
Alstonia boonei	-	-	+	+	+	+	-	-	-	-
Altermanthera sessilis	-	-	-	-	-	-	-	+	-	-
Amaranthus viridis	-	-	-	-	-	-	+	+	+	+
Anacardium occidentale	-	-	-	-	+	+	-	-	-	-
Andropogon tectorum	+	+	-	-	-	-	-	-	-	-
Aneilienma beniniense	+	-	-	-	-	-	-	-	-	-
Anthocleista nobilis	-	-	+	+	+	+	-	-	-	-
Artocarpus heterophyllus	-	-	-	-	+	+	-	-	-	-

Aspilia africana	+	+	-	-	-	-	+	+	+	+
Asystasia gangetica	+	+	-	-	-	-	-	+	-	-
Axonopus compresus	+	+	-	-	-	-	-	-	-	-
Bambusa vulgaris	+	-	-	-	-	-	-	-	-	-
Bidens pilosa	+	+	-	-	-	-	-	-	-	-
Blepharis maderaspatensis	+	+	-	-	-	-	-	-	-	-
Blighia sapida	-	-	+	+	+	+	-	-	-	-
Boerhavia coccinea	+	+	-	-	-	-	-	-	-	-
Boerhavia diffusa	+	+	-	-	-	-	+	+	+	+
Boerhavia erecta	+	+	-	-	-	-	-	-	-	-
Bombax buonopozense	-	-	+	+	+	+	-	-	-	-
Brachiaria deflexa	+	+	-	-	-	-	+	+	+	+
Brachiaria falcifera	+	+	-	-	-	-	-	-	-	-
Brachyestegia eurycoma	-	-	-	-	+	+	-	-	-	-
Brahiaria lata	+	+	-	-	-	-	-	+	-	+
Bridelia micrantha	-	-	-	-	+	+	-	-	-	-
Caesalpinia pulcherrima	-	-	-	-	-	-	-	-	-	+
Caesapinia bonduc	-	-	-	-	+	+	-	-	-	-
Calopogonium mucunoides	+	+	-	-	-	-	-	-	-	-
Cedrela odorata	-	-	+	+	+	+	-	-	-	-
Ceiba pentandra	-	-	+	+	+	+	-	-	-	-

Celosia argentea	+	-	-	-	-	-	-	-	-	-
Celtis integrifolia	-	-	+	+	+	+	-	-	-	-
Celtis zenkerii	-	-	+	+	+	+	-	-	-	+
Centrosema pubescens	-	-	-	-	-	-	-	+	-	+
Chamaecrista mimosoides	+	+	-	-	-	-	-	-	-	-
Chromoleana odorata	+	+	-	-	-	-	+	+	+	+
Citrus sinensis	-	-	+	+	+	+	-	-	-	-
Cleistopholis patens	-	-	+	+	+	+	-	-	-	-
Cleome rutidosperma	+	+	-	-	-	-	-	-	-	-
Cnestis ferruginea	+	+	-	-	-	-	-	-	-	-
Coffea canephora	-	-	+	+	-	-	-	-	-	-
Cola acuminata	-	-	+	+	-	-	-	-	-	-
Cola acuminata	-	-	-	-	+	+	-	-	-	-
Cola gigantea	-	-	-	-	+	+	-	-	-	-
Cola millenii	-	-	+	+	+	+	-	-	-	-
Combretum hispidum	+	+	-	-	-	-	-	-	-	-
Commelina benghalensis	+	+	-	-	-	-	+	+	+	+
Commelina diffusa	-	-	-	-	-	-	-	-	-	+
Commelina erecta	+	+	-	-	-	-	+	+	+	+
Conysa sumatrensis	+	+	-	-	-	-	-	-	-	-
Corchorus Tridens	-	-	-	-	-	-	+	+	+	+

Cordia millenii	-	-	+	+	+	+	-	-	-	-
Cordia platythyrsa	-	-	-	-	+	+	-	-	-	-
Crotalaria retusa	+	+	-	-	-	-	-	-	-	-
Croton lobatus	+	+	-	-	-	-	-	+	-	-
Cyathula prostrata	-	-	-	-	-	-	+	+	+	+
Cynodon dactylon	+	+	-	-	-	-	-	-	-	-
Cyperus amabilis	+	+	-	-	-	-	-	+	-	+
Cyperus esculentus	+	+	-	-	-	-	-	-	-	-
Cyperus rotundus	+	+	-	-	-	-	+	+	+	+
Daniellia ogea	-	-	+	+	-	-	-	-	-	-
Desmodium scorpiurus	+	+	-	-	-	-	+	+	+	+
Digitaria exilis	+	-	-	-	-	-	-	-	-	-
Digitaria horizontalis	+	-	-	-	-	-	-	-	-	-
Dracaena mannii	-	-	+	+	+	+	-	-	-	-
Elaeis guineensis	-	-	+	+	+	+	-	-	-	-
Eleusine indica	+	-	-	-	-	-	-	-	-	-
Emilia coccinea	+	+	-	-	-	-	-	-	-	-
Eragrostis tremulla	+	-	-	-	-	-	-	-	-	-
Erythrophleum suaveolens	-	-	+	+	+	+	-	-	-	-
Euphorbia graminea	-	-	-	-	-	-	-	+	+	+
Euphorbia heterophylla	-	-	-	-	-	-	+	+	-	+

Euphorbia hirta	+	+	-	-	-	-	+	+	-	+
Ficus asperifolia	-	-	-	-	+	+	-	-	-	-
Ficus capensis	-	-	+	+	+	+	-	-	-	-
Ficus exasperata	-	-	-	-	+	+	-	+	-	+
Ficus thonningii	-	-	-	-	+	+	-	-	-	-
Fuirena umbellata	+	+	-	-	-	-	-	-	-	-
Funtumia africana	-	-	+	+	+	+	-	-	-	-
Gambeya albida	-	-	+	+	+	+	-	-	-	-
Garcinia kola	-	-	-	-	+	+	-	-	-	-
Gardenia ternifolia	-	-	-	-	+	+	-	-	-	-
Gliricidia sepium	-	-	+	+	+	+	-	-	-	-
Gmelina arborea	-	-	+	+	+	+	-	-	-	-
Gomphrena celosioides	-	-	-	-	-	-	-	+	-	+
Icacina trichantha	-	-	+	+	-	-	-	-	-	-
Imperata cylindrica	+	-	-	-	-	-	-	-	-	-
Ipomoea involucrata	+	-	-	-	-	-	-	+	-	-
Ipomoea triloba	+	-	-	-	-	-	-	-	-	-
Irvingia gabonensis	-	-	+	+	+	+	-	-	-	-
Irvingia grandifolia	-	-	+	+	+	+	-	-	-	-
Laportea aestuans	+	-	-	-	-	-	+	+	+	+
Laportea avalifolia	+	-	-	-	-	-	-	-	-	-

Lecaniodiscus cupanioides	-	-	+	+	+	+	-	-	-	-
Lindernia sp.	-	-	-	-	-	-	-	+	-	-
Mallotus oppositifolius	+	+	-	-	-	-	-	-	-	-
Mariscus alternifolius	-	-	-	-	-	-	-	+	-	-
Mariscus longibracteatus	+	+	-	-	-	-	-	-	-	-
Megathyrsus maximus	-	-	-	-	-	-	+	-	-	-
Melanthera scandens	+	+	-	-	-	-	+	+	+	+
Milicia excelsa	-	-	-	-	+	+	-	-	-	-
Millettia thonningii	-	-	-	-	+	+	-	-	-	-
Mimosa pudica	+	+	-	-	-	-	-	-	-	-
Mologus sp	-	-	-	-	-	-	-	+	-	-
Momordica charantia	+	+	-	-	-	-	+	+	+	+
Morinda lucida	-	-	+	+	-	-	-	-	-	-
Mucuna pruriens	-	-	-	-	-	-	+	+	+	+
Musa ×paradisiaca	-	-	+	+	-	-	-	-	-	-
Musa paradisiaca	-	-	+	+	-	-	-	-	-	-
Nauclea diderrichii	-	-	+	+	-	-	-	-	-	-
Newbouldia laevis	-	-	+	+	+	+	-	-	-	-
Oldenlandia corymbosa	+	+	-	-	-	-	+	+	+	+
Oplismenus burmannii	+	+	-	-	-	-	+	+	-	+
Palisota hirsuta	+	+	-	-	-	-	-	-	-	-

Panicum laxum	+	+	-	-	-	-	-	-	-	-
Panicum maximum	+	-	-	-	-	-	-	+	-	+
Paspalum scrobiculatum	+	-	-	-	-	-	-	-	-	-
Peperomia pellucida	+	-	-	-	-	-	+	+	+	+
Perotis indica	+	+	-	-	-	-	-	-	-	-
Phaseolus lunatus	-	-	+	+	-	-	-	-	-	-
Phyllanthus amarus	+	+	-	-	-	-	+	+	-	+
Phyllanthus niruri	-	-	-	-	-	-	-	+	-	-
Physalis angulata	-	-	-	-	-	-	-	+	-	+
Physalis micrantha	-	-	-	-	-	-	-	-	-	+
Plumeria rubra	-	-	-	-	+	+	-	-	-	-
Portulaca grandiflora	-	-	-	-	-	-	+	-	+	-
Pouzolzia guineensis	+	+	-	-	-	-	-	+	-	-
Pteridium aquilinum	+	-	-	-	-	-	-	-	-	-
Pterygota macrocarpa	-	-	+	+	+	+	-	-	-	-
Pupalia lappacea	+	+	-	-	-	-	-	-	-	-
Pycnanthus angolensis	-	-	-	-	+	+	-	-	-	-
Rauvolfia vomitoria	-	-	+	+	+	+	-	-	-	+
Richardia scarbra	+	+	-	-	-	-	-	-	-	-
Ricinodendron heudelotii	-	-	-	-	+	+	-	-	-	-
Rungia dimorpha	+	+	-	-	-	-	-	-	-	-

Schrankia leptocarpa	+	+	-	-	-	-	-	-	-	-
Sclerocarpus africanus	+	+	-	-	-	-	-	-	-	-
Senna abbreviata	-	-	-	-	+	+	-	-	-	-
Senna hirsuta	+	+	-	-	-	-	-	-	-	-
Senna occidentalis	-	-	-	-	-	-	-	+	-	-
Sesamum alatum	+	+	-	-	-	-	-	-	-	-
Setaria barbata	+	+	-	-	-	-	+	+	+	+
Setaria longiseta	+	+	-	-	-	-	-	-	-	-
Setaria megaphylla	+	+	-	-	-	-	+	+	-	+
Sida acuta	+	+	-	-	-	-	-	-	-	-
Sida linifolia	+	+	-	-	-	-	-	-	-	-
Snysepalum dulcificum	-	-	-	-	+	+	-	-	-	-
Solanum aethiopicum	-	-	+	+	+	+	-	-	-	-
Solanum macrocarpon	+	+	-	-	-	-	-	-	-	-
Solanum nigrum	+	+	-	-	-	-	-	-	-	-
Solanum torvum	+	+	-	-	-	-	-	-	-	-
Solenostemon monostacyus	+	+	-	-	-	-	-	-	-	-
Sorghum bicolor	-	-	-	-	-	-	+	-	-	-
Spermacoce octodon	-	-	-	-	-	-	-	+	-	+
Spermacoce Ocymoides	+	+	-	-	-	-	-	-	-	-
Spigelia anthelmia	+	+	-	-	-	-	+	+	+	+

Spurge heterophylla	+	+	-	-	-	-	-	-	-	-
Sterculia setigera	-	-	+	+	+	+	-	-	-	-
Synedrella nodiflora	+	+	-	-	-	-	+	+	+	+
Tacca leontopetaloides	+	+	-	-	-	-	-	-	-	-
Talinum fructicosum	+	+	-	-	-	-	+	+	+	+
Talinum triangulare	+	+	-	-	-	-	-	+	-	-
Tectona grandis	-	-	+	+	+	+	-	-	-	-
Terminalia ivorensis	-	-	-	-	+	+	-	-	-	-
Terminalia superba	-	-	+	+	+	+	-	-	-	-
Theobroma cacao	-	-	+	+	+	+	-	-	-	-
Tithonia diversifolia	+	+	-	-	-	-	-	-	-	-
Trichilia emetica	-	-	+	+	+	+	-	-	-	-
Tridax procumbens	+	+	-	-	-	-	+	+	-	+
Triplochiton scleroxylon	-	-	+	+	+	+	-	-	-	-
Triumfetta rhomboidea	-	-	-	-	-	-	-	+	-	+
Vernonia cinerea	-	-	-	-	-	-	+	-	-	-
Vernonia galamensis	-	-	-	-	-	-	-	+	-	+
Zanthoxylum zanthoxyloides	-	-	+	+	+	+	-	-	-	-

+ = Presence

– = Absence

Appendix 3: Data of physico-chemical properties of the soil in CRIN secondary forest, Ibadan, Nigeria from Forest Research Institute of Nigeria

Sample Label	pH	O.C	O.M	TN (%)	Na (Cmol/Kg)	Ca (Cmol/Kg)	Mg (Cmol/Kg)	K (Cmol/Kg)	Fe (Cmol/Kg)	Cu (mg/Kg)	Mn (mg/Kg)	Zn (mg/Kg)	P (mg/Kg)	% Sand	% Clay	% Silt	TC
P1_ 0-15	5.87	2.55	4.4	0.25	1.207	7.96	1.622	0.504	1800	5.2	828	118	90.87	74.6	11	14.4	SL
P2_ 0-15	6.41	2.91	3.78	0.19	1.306	21.486	2.451	0.979	420	2.5	550	56	110.72	74	11	14.4	SL
P3_ 0-15	6.2	2.2	3.8	0.19	1.416	22.665	2.668	0.801	980	1.7	460	90	59.9	89.6	9	1.4	S
P4_ 0-15	6.39	3.27	5.64	0.28	1.417	45.27	6.439	1.276	1980	2	693	116	62.07	80.6	9	10.4	LS
P5_ 0-15	6.12	2.2	3.79	0.19	1.336	14.97	2.396	1.009	860	4.2	838	488	64.49	72.6	11	16.4	SL
P6_ 0-15	6.45	1.54	2.65	0.13	1.435	21.637	1.538	0.831	1640	3.5	560	110	55.3	80.6	11	8.4	SL
P7_ 0-15	6.08	3.11	5.37	0.27	1.358	23.793	1.9	1.157	1940	3.6	900	102	85.55	80.6	9	10.4	LS
P8_ 0-15	6.36	3.11	5.36	0.27	1.444	15.24	2.156	0.949	1180	3	734	528	142.05	87.6	9	3.4	LS
P9_ 0-15	6.3	2.05	3.53	0.18	1.431	21.617	1.864	0.712	560	2.2	498	62	67.52	78.6	8.5	12.9	LS
P10_ 0-15	6.19	2.47	4.26	0.12	1.412	11.138	3.528	1.009	1460	3.9	904	261	63.28	74.6	11	14.4	SL
P11_ 0-15	5.54	1.4	2.41	0.21	1.438	16.737	1.484	0.623	540	2.3	452	194	60.5	78.6	9	12.4	SL
P12_ 0-15	6.27	1.8	3.1	0.15	1.379	19.94	2.854	0.979	1080	2.3	564	70	69.21	72.6	13	14.4	SL
P13_ 0-15	6.04	1.7	2.93	0.15	1.412	19.042	2.1	0.534	1500	2.9	441	80	64.37	70.6	11	18.4	SL
P14_ 0-15	6.25	1.82	3.14	0.16	1.407	10.808	2.303	0.742	2840	1.7	416	80	71.39	78.6	9	12.4	SL
P15_ 0-15	6.39	3.69	6.36	0.32	1.424	40.599	2.75	0.831	1740	1.5	486	110	56.63	70.6	11	18.4	SL
P16_ 0-15	6.34	1.58	2.72	0.14	1.324	20.489	2.229	0.653	1820	3.2	766	76	67.76	72.6	13	14.4	SL
P17_ 0-15	6.38	2.53	4.37	0.22	1.478	23.234	0.716	1.216	2100	1.8	598	106	104.3	75.6	13	11.4	SL
P18_ 0-15	6.09	2.65	4.57	0.23	1.44	19.481	1.961	0.475	1410	3.2	534	114	56.75	85.3	15	0.3	LS
P19_ 0-15	6.31	2.93	5.05	0.25	1.39	23.922	4.375	1.038	1740	2.5	186	192	59.65	68.6	17	14.4	SL
P20_ 0-15	6.42	1.66	2.85	0.14	1.484	20.14	1.479	0.653	1920	1.9	438	250	80.59	80.6	11	8.4	SL
P21_ 0-15	6.12	3.73	6.43	0.32	1.381	23.034	2.73	0.949	2620	6.4	759	178	52.03	70.6	15	14.4	SL

P22_ 0-15	6.75	3.01	5.19	0.26	1.344	27.022	2.615	0.979	540	2	352	84	109.63	70.6	10.5	18	SL
P23_ 0-15	6.87	2.6	4.48	0.22	1.433	11.168	1.415	0.564	1680	4.3	672	202	54.21	82.6	9	8.4	LS
P24_ 0-15	6.29	1.96	3.37	0.17	1.376	23.174	2.138	0.712	1320	3.1	976	108	65.34	76.6	15	8.4	SL
P25_ 0-15	5.55	2.17	3.74	0.19	1.417	19.012	2.669	0.771	1700	3.5	702	68	53.97	82.6	11	6.4	LS

O.C = Organic Carbon; O.M = Organic Matter; TN = Total nitrogen; Na = Sodium; Ca = Calcium; Mg= Magnesium; K = Potassium; Fe = Iron;Cu = Copper; Mn= Manganese; Zn = Zinc; P= Phosphorus; TC = Textural Classes

Appendix 4: Monthly Meteorological parameters of the study area based based on daily recordings for 2018 and 2019

Year	TEMP.MAX	TEMP.MIN	R.H_MAX	R.H_MIN	RAINFALL
January	34.49	18.76	99.16	28.01	0.00
February	35.45	22.43	99.87	44.13	1.02
March	35.27	22.63	100.00	51.54	1.27
April	33.54	22.92	100.00	59.81	0.51
May	32.67	21.49	100.00	64.86	1.78
June	31.51	21.98	100.00	68.73	2.03
July	30.08	22.40	100.00	72.25	175.26
August	29.40	21.70	100.00	72.43	119.63
September	31.03	22.12	100.00	70.68	205.49
October	32.67	22.11	100.00	65.16	181.61
November	33.27	22.44	100.00	63.04	88.65
December	34.28	19.68	99.93	37.96	0.00
January	34.98	21.12	99.94	41.57	1.82
February	34.96	22.50	99.80	47.05	4.47
March	35.14	22.40	99.36	55.56	127.51
April	34.53	23.13	100.00	61.41	31.50
May	32.77	22.83	100.00	64.34	118.11
June	31.39	22.49	100.00	70.94	269.24

July	30.18	22.57	100.00	74.40	97.03
August	30.53	22.04	3322.51	71.46	120.40
September	30.51	22.50	100.00	73.08	137.41
October	30.69	21.35	100.00	69.72	430.28
November	33.52	22.31	100.00	62.71	91.19
December	34.28	20.15	99.80	43.13	0.00

APPENDIX 5: Trees Phytosociologic Survey Card

N° Card………………....Observer's Name……………………………………..………………………..

Forest………………………Zone……… Locality…………………...………..N° Plot………………..

GPS coordinates: Lat…………………………… Long……………………………… Alt………………..

N°	**Species**	**Local names**	**Girth (cm)**	**High (m)**	
				Base	Top

APPENDIX 6: Shrubs and Herbaceous phytosociologic survey card

N° Card……………………Observer’sName………………………………………………………………………………………

Forest…………..Zone……………………………………Locality…………………...……………

N° Plot……………………..N° Subplot………..……..…N° Quadrat……….……………………

GPS coordinates: Lat…………..……..…. Long……………………....……. Alt……………

Date…………………………………………………………………………………………………..

N°	Species	Local Names	Abundance

APPENDIX 7: Vernacular names (Yoruba) of Plants species of CRIN Secondary Forest

N°	Species composition	Vernacular/Common name (CN)
1	*Abutilon mauritianum*	Furu
2	*Acacia macrostachya*	Ewebomi
3	*Acanthus montanus*	ahọn ẹ́kùn
4	*Afzelia africana*	Apa-Igbo
5	*Agelaea obligua*	Esura
6	*Ageratum conyzoides*	Imi-esu
7	*Albizia adianthifolia*	Bana-bana
8	*Albizia coriaria*	Aja-Igi
9	*Albizia ferruginea*	Ayinre-langara
10	*Albizia glaberrima*	Ayinre-oro
11	*Albizia gummifera*	Ayinre-ogo
12	*Albizia julibrissin*	Arinye
13	*Albizia julibrissin*	Ayinre bona bona
14	*Albizia zygia*	Isin-oko
15	*Alchornia cordifolia*	Ewe-ifa
16	*Alstonia boonei*	Awun
17	*Altermanthera sessilis*	Reku-reku
18	*Amaranthus cruentus*	Tẹ̀tẹ̀ pupa
19	*Amaranthus spinosus*	Dagunro
20	*Amaranthus viridis*	Tẹ̀tẹ̀
21	*Anacardium occidentale*	Kaju
22	*Andropogon tectorum*	ẹ̀rùwà dúdú
23	*Aneilema beniniense*	Ototo
24	*Angylocalyx oligophyllus*	Oko-Aja
25	*Anthocleista nobilis*	Sapo
26	*Anthonotha marcrophyla*	Abara-Apado
27	*Artocarpus heterophyllus*	Berefuru
28	*Aspilia africana*	Yunyun
29	*Asystasia gangetica*	Lobiri
30	*Axonopus compresus*	Idi
31	*Bambusa vulgaris*	Oparun

32	*Bidens pilosa*	Abere oloko
33	*Blepharis maderaspatensis*	abéròdéfẹ́
34	*Blighia sapida*	Isin
35	*Boerhavia coccinea*	ètìpọ́nọlá
36	*Boerhavia diffusa*	Etiponla, Olowojeja
37	*Boerhavia erecta*	Erect spiderling (CN)
38	*Bombax buonopozense*	Ponpola
39	*Brachiaria deflexa*	Agbàdo-Esin
40	*Brachiaria falcifera*	ata gbuin gbuin
41	*Brachyestegia eurycoma*	Ako
42	*Brahiaria lata*	Brachiaria (CN)
43	*Bridelia micrantha*	Araasa
44	*Caesalpinia pulcherrima*	Eko-omode
45	*Calopogonium mucunoides*	Calopo (CN)
46	*Cedrela odorata*	Spanish cedar (CN)
47	*Ceiba pentandra*	Araba
48	*Celosia argentea*	Shokoyokoto
49	*Celtis integrifolia*	Ita
50	*Celtis zenkerii*	Ita-gidi
51	*Centrosema pubescens*	Idire aje
52	*Chamaecrista mimosoides*	Patwa grass (CN)
53	*Chromolaena odorata*	Akintola
54	*Citrus sinensis*	Osan-mimu
55	*Cleistopholis patens*	Apako
56	*Cleome rutidosperma.*	Ekiye
57	*Clerodendron capitatum*	Feremomi
58	*Cnestis ferruginea*	Gboyin gboyin/ Omu aja
59	*Cnestis ferruginea*	Omu-aja
60	*Coffea canephora*	Kofi
61	*Cola acuminata*	Obi-abata
62	*Cola gigantea*	Oporoporo
63	*Cola millenii*	Obi-edun
64	*Combretum hispidum*	ákwụ́kwọ́ ósò

65	*Commelina africana*	gòdọgbọ
66	*Commelina benghalensis.*	gòdọgbọ
67	*Commelina diffusa*	gòdọgbọ
68	*Commelina erecta*	ìlẹ̀kẹ̀ ọ̀pọlọ́
69	*Conysa sumatrensis*	agemo kogun
70	*Corchorus tridens*	Oyoo, Jaga
71	*Cordia millenii*	Omo
72	*Cordia platythyrsa*	Akoledo
73	*Corynanthe pachyceras*	Ako-Idagbon
74	*Crotalaria retusa*	Saworo
75	*Croton lobatus*	Àjẹ̀ìofòlé or ẹÌru
76	*Cyathula prostrata*	òbóríkọ́rị́ghá
77	*Cynodon dactylon*	kóoko-ìgbá
78	*Cyperus amabilis*	Alubosa-Igbo
79	*Cyperus esculentus*	Ofio, Omu
80	*Cyperus haspan*	Abo-keregun
81	*Cyperus rotundus*	Alubosa-igbo
82	*Cyperus tuberosus*	Apari-ugun
83	*Dactyloctenium aegyptium*	ẹwa ẹsin
84	*Deinbollia pinnata*	Ogiri-egba
85	*Desmodium scorpiurus*	ẹ̀pà-ilè
86	*Desplatsia subericarpa*	Ila-erin
87	*Digitaria exilis*	Suru
88	*Digitaria horizontalis*	Eeran oko
89	*Dracaena deisteiliana*	Porogun
90	*Elaeis guineensis*	Ope, Eyin
91	*Elaeis guineensis*	Ope, Eyin
92	*Eleusine indica*	Gbegisona
93	*Emilia coccinea*	Odundun-owo
94	*Emilia praetermissa*	Brède
95	*Eragrostis tremula*	Ora-esin
96	*Erythrophleum suaveolens*	Olu-Obo
97	*Euadenia trifoliata*	Logbokiya

98	*Euclinia longifolia*	Logbokiya
99	*Euphorbia graminea*	Ajekobale
100	*Euphorbia heterophylla*	ẹgẹ́lẹ
101	*Euphorbia hirta*	Emi-ile
102	*Ficus asperifolia*	Epin
103	*Ficus capensis*	Ogabe
104	*Ficus exasperata*	Ipin
105	*Ficus exasperate*	Ipin
106	*Ficus thonningii*	Opoto
107	*Fuirena umbellata*	abo làbẹlàbẹ
108	*Funtumia africana*	Ako-ire
109	*Gambeya albida*	Baka
110	*Garcinia kola*	Orogbo
111	*Gliricidia sepium*	Agunmaniye
112	*Gmelina arborea*	Akogun
113	*Gomphrena celosioides*	Ipopo-ale
114	*Grewia mollis*	Afoforo-igbo
115	*Holoptelea grandis*	Ayo
116	*Hunteria umbellata*	Afintoto
117	*Icacinia trichanta*	Gbegbe
118	*Imperata cylindrica*	Ekan
119	*Ipomoea involucrata*	Ododo-odo
120	*Ipomoea triloba*	Atewogba
121	*Irvingia gabonensis*	Oro
122	*Irvingia grandifolia*	Alukanraba
123	*Jatropha curcas*	Ewe lapalapa
124	*Keetia venosa*	Eegun-ekun
125	*Laportea aestuans*	Fiyafiya
126	*Laportea avalifolia*	Abomolowoedun
127	*Lecaniodiscus cupanioides*	Akika
128	*Lonchocarpus cyanescens*	Elu
129	*Lonchocarpus griffonianus*	Alakiriti
130	*Macaranga barteri*	Agbaasa

131	*Mallotus oppositifolius*	Oju-eja
132	*Mariscus alternifolius*	Ikeregun
133	*Mariscus longibracteatus*	Piedmont flatsedge (CN)
134	*Markhamia tomentosa*	Akoko
135	*Megathyrsus maximus*	Guinea grass (CN)
136	*Melanthera scandens*	Agbugbo
137	*Microdesmis puberula*	Esunsun
138	*Milicia excelsa*	Iroko
139	*Millettia thonningii*	Ito
140	*Mimosa Pigra*	Ewon-agogo
141	*Mimosa pudica*	Patanmo
142	*Momordica charantia*	Ejinrin
143	*Morinda lucida*	Oruwo
144	*Mucuna pruriens*	Iwerepe
145	*Musa paradisiaca*	Ogede agbagba
146	*Newbouldia laevis*	Akoko
147	*Oldenlandia corymbosa*	Oyigi
148	*Oplismenus burmannii*	Ite-Oka
149	*Palisota hirsuta*	Jangborokun
150	*Panicum laxum*	èrughà
151	*Panicum maximum*	Ikin
152	*Paspalum conjugatum*	Iki
153	*Paspalum scrobiculatum*	ọkànli
154	*Pavetta corymbosa*	Idofun igbo
155	*Pennisetum pedicellatum*	ẹsu
156	*Pentodon pentandrus*	Hale’s pentodon (CN)
157	*Peperonia pelucida*	Rinrin
158	*Perotis indica*	Bíndìn kùréégéé (Hausa)
159	*Phyllanthus niruri*	Eyin olobe
160	*Physalis angulata*	Koropo
161	*Physalis micrantha*	Efopo
162	*Pleioceras barteri*	Ireno kekere
163	*Plumeria rubra*	Frangipani (CN)

164	*Portulaca grandiflora*	Idinle
165	*Pouzolzia guineensis*	Aboloko-piran
166	*Psilanthus ebracteolatus*	Psilanthus (CN)
167	*Psychotria fimbriatifolia*	Psychotria (CN)
168	*Psychotria sciandephora*	Akar Daldaru
169	*Pteridium aquilinum*	Bracken fern (CN)
170	*Pterygota macrocarpa*	Oporoporo
171	*Pupalia lappacea*	Ema-agbo
172	*Pycnanthus angolensis*	Akomu
173	*Rauvolfia vomitoria*	Asofeyeje
174	*Rauwolfia vomitoria*	Asofeyeje
175	*Richardia scarbra*	Itawole
176	*Ricinodendron heudelotii*	Putu
177	*Rungia dimorpha*	Alade-oko
178	*Rytiginia umbellata*	Oju-eja
179	*Schrankia leptocarpa*	Ajekobale
180	*Sclerocarpus africanus*	nli-atulu (Igbo)
181	*Senna abbreviata*	Ewe-epa
182	*Senna hirsuta*	Arunfofo
183	*Senna occidentalis*	Rere
184	*Sesamum alatum*	Ekuku-gogoro
185	*Setaria barbata*	corn grass (CN)
186	*Setaria longiseta*	àse-olongo
187	*Setaria megaphylla*	akáráká
188	*Sida acuta*	Iseketu
189	*Sida linifolia*	Iso-obo
190	*Solanum aethiopicum*	Osun
191	*Solanum erianthum*	Ewuro-Ijebu
192	*Solanum macrocarpon*	Igbagba
193	*Solanum nigrum*	Ikan-weere
194	*Solanum torvum*	Igba-yanrin-elegun-un
195	*Solanum torvum*	Ijegun-ebora
196	*Solenostemon monostachyus*	Aranpolo

197	*Spermacoce octodon*	Oko-ire
198	*Spermacoce ocymoides*	Iraole
199	*Spigelia anthelmia*	Aparan
200	*Spigelia anthelmia*	Aparàn
201	*Sterculia setigera*	Ose awere
202	*Synedrella nodiflora*	Tanaposo
203	*Tacca leontopetaloides*	Aduro-susu
204	*Talinum fructicosum*	Gbure
205	*Tectona grandis*	Igi-gedu
206	*Terminalia ivorensis*	Afara-dudu
207	*Terminalia superba*	Afara
208	*Theobroma cacao*	Koko
209	*Tithonia diversifolia*	Agbale, jogbo
210	*Trichilia prieuriana*	Urere
211	*Trichilia emetica*	Natal mahogany (CN)
212	*Tridax procumbens*	Igbalode
213	*Triplochiton scleroxylon*	Eruku
214	*Triumfetta cordifolia*	Akee-eri
215	*Vernonia amygdalina*	Ewuro
216	*Vernonia cinerea*	Bojure
217	*Vernonia galamensis*	Olopaa-kan
218	*Zanthoxylum zanthoxyloides*	Ata