**Seed Bank Dynamics and Above-Ground Species Composition in Secondary Tropical Forests of Anambra State, Nigeria: Implications for Biodiversity Conservation**

**ABSTRACT**  
The study examines the comparative analysis of soil seed bank in two secondary forests; Unizik Conservation Forest and Orebe Village Forest in Amansea both located in Awka North and South Local Government Areas of Anambra State, Nigeria. These forests are crucial for biodiversity conservation and ecosystem restoration, particularly in the face of increasing deforestation and land-use changes. Through ecological surveys, soil sampling, and seed bank analysis, this research assesses soil properties, species composition, and seed bank diversity to evaluate their potential for regeneration and long-term sustainability. Results indicate that species composition analysis reveals a diverse assemblage of plant families, with Asteraceae, Euphorbiaceae, Fabaceae, and Rubiaceae being dominant in both forests. Seed bank analysis at varying soil depths highlights the resilience and regenerative capacity of the forests, with dominant species such as Ageratum conyzoides and Eleusineindica playing a significant role in forest recovery. The Sørensen Similarity Index (SSI) values indicate a moderate to high level of species similarity between the two forests, suggesting shared ecological conditions. The findings underscore the importance of maintaining soil health and seed bank diversity for sustainable forest management. This study provides essential data for conservation planning, emphasizing targeted interventions to enhance soil fertility, biodiversity, and ecosystem resilience in secondary tropical forests.

**KEYWORDS:** Secondary forests, Biodiversity conservation, Seed bank composition, Ecosystem resilience, Sustainable forest management, Tropical forest regeneration

**1. INTRODUCTION**  
Rainforests are forest ecosystems characterized by high levels of rainfall, a closed canopy, and high species diversity. While tropical rainforests are the most well-known type, rainforests are found globally, including temperate regions in Canada, the United States, and parts of the former Soviet Union. Tropical rainforests typically occur in the equatorial zone between the Tropic of Cancer and the Tropic of Capricorn, where warm temperatures and consistent year-round sunlight prevail. These forests transition into other forest types depending on altitude, latitude, soil conditions, flooding, and climate, forming a mosaic of vegetation that contributes to the remarkable biodiversity of the tropics [1].

Tropical forest landscapes are undergoing rapid changes due to expanding human populations and economic growth. These forests play a disproportionate role in global carbon and energy cycles [2] and support approximately 50% of described species, with an even larger proportion of species yet to be documented [3]. Understanding anthropogenic changes in tropical forests is therefore critical for addressing global climate change, conserving biodiversity, and managing the transition to secondary forests.

Across the tropics, secondary forests are regrowing on abandoned agricultural lands, areas cleared for development, and regions affected by large-scale natural disturbances such as cyclones and fires. Together, degraded old-growth forests (impacted by road construction, selective logging, recurrent fires, fragmentation, and overhunting) and secondary regrowth forests account for roughly half of the world’s remaining tropical forest [4]. Despite the increasing extent of secondary forests in many tropical regions [5], their role in biodiversity conservation remains poorly understood. Wright and Muller-Landau [6] argue that secondary forest regrowth may mitigate mass extinctions in the tropics by compensating for the loss of old-growth habitats. This hypothesis has sparked debate about the potential of secondary forests to serve as a "safety net" for tropical biodiversity [7, 8, 9].

Many tropical species are threatened by habitat loss, fragmentation, and degradation, while others demonstrate resilience to changes in forest extent, quality, and surrounding habitat matrices [8]. Secondary forests provide critical resources for wildlife [10], ecosystem services [11], and forest products. They also play a significant role in global carbon cycles [12] and hold considerable conservation value. While tropical secondary forests can recover animal species diversity within 20–40 years [13], they typically support fewer tree species than old-growth forests [14, 15]. The species composition of plant and animal communities often differs between secondary and old-growth forests [13, 14, 15], with weedy species becoming more widespread and homogenizing species composition over large areas. The long-term conservation value of secondary forests depends on the proportion of species restricted to old-growth habitats.

An essential aspect of crop ecology is the soil weed seed bank, which serves as a critical component of cropping systems and management. The soil seed bank represents the reservoir of viable seeds or vegetative propagules capable of regenerating natural vegetation. In agroecosystems, the soil seed bank is primarily associated with weeds, and understanding its size and species composition can help predict future infestations, develop population models, and inform soil and cultural management strategies [16]. Baker [17] defined the soil seed bank as the reservoir of ungerminated seeds capable of replacing annual adult plants lost to natural mortality, diseases, or disturbances. Similarly, Simpson et al. [18] described the soil seed bank as all viable seeds present in the soil or mixed with soil debris.

For annual species, the soil seed bank is the origin of their life cycle and a key factor in their persistence. In perennial species, the seed bank is complemented by vegetative propagules such as tubers, rhizomes, and stolons [19]. The study of soil seed banks dates back to 1859, when Charles Darwin observed seedling emergence from lakebed soil samples. The first scientific paper on the subject, published in 1882, documented seed distribution at various soil depths. Since then, weed seed banks have been extensively studied in agricultural science due to their economic impacts, while forest regeneration and restoration ecology have also explored their significance [20].

Seed banks are classified based on seed longevity. Transient species retain viable seeds only until the next germination opportunity, while persistent species can survive beyond this period, often for several years. Long-term persistent species, such as Chenopodium album (Lambsquarters), can remain viable for up to 40 years, with rare cases surviving up to 1,600 years [16]. In contrast, species like Agrostemmagithago (Corncockle) form no persistent seed bank, relying solely on seeds produced during the growing season.

Despite their ecological importance, there is limited information on the distribution, abundance, and diversity of soil seed banks within the secondary forests of Nnamdi Azikiwe University, Awka Campus. Rapid development within the university has led to vegetation clearance, threatening plant families and causing some species to go extinct while others emerge. This loss hinders the documentation of plant families in the secondary forest, as some species can no longer be identified or found. The absence of a soil seed bank has significant implications for species dynamics, as vegetation cannot regenerate from stored seeds following disturbances. Seed banks are dynamic entities, with seed density and species composition varying over time and space [21].

Seed banks play a critical role in plant community dynamics, particularly in disturbed or changing environments. However, a comprehensive understanding of seed bank composition, including seed viability, dormancy, and germination dynamics, remains incomplete. Investigating the seed bank’s role in species persistence and recovery is essential for guiding restoration efforts and predicting vegetation responses to environmental changes. This study aims to conduct an ecological analysis of soil seed banks in two secondary forests in Awka North and South, Anambra State.

**2. MATERIALS AND METHODS**

**2.1 Study Area**

The study was carried out in Awka North and South Local Government Areas Anambra state, Nigeria. It lies within the tropical rain and evergreen forest with a tropical climate that is humid all year round; although the humidity varies with the seasons. The rainy season spans from March to October and is bimodal with a two-week break of rainfall in August (August break). The mean annual rainfall in the southeast is 2000m while the average annual temperature is between 250C and 280C with relative humidity of about 98% during the rainy season and between 50% and 60% during dry season (ADP, 2010).

Two secondary forests were selected from different zones of the study area based on their high floristic composition:

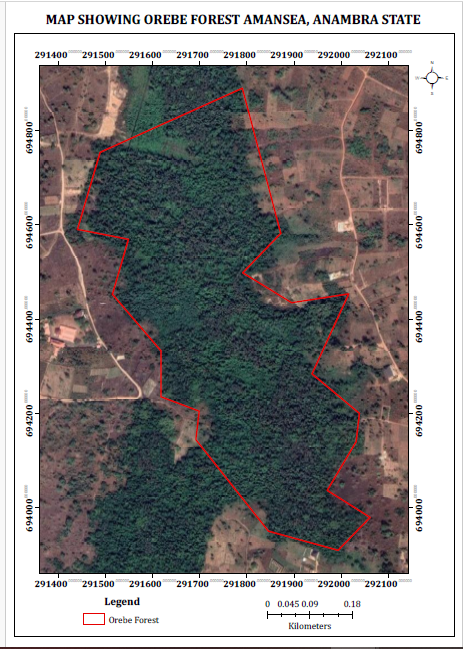
## Unizik conservation forest (Site 1)

## Orebe village forest Amansea (Site 2)

## 

**Figure 1: Aerial Map Showing the Nnamdi Azikiwe Conservation Forest Awka South LGA**

Source: Iroka*et al.,* [22].



**Figure 2: Aerial Map Showing the Orebe Forest AmanseaAwka South LGA**

## 2.2 Ecological Survey for Seed Bank Analysis

## Four quadrats were marked in each plot where the soil seed bank different levels were collected. The samples were collected by drilling a soil auger (a hollow, metal frame) into the soil of the plots. To obtain representation for each plot, a total of 21 cores for the entire sampling area were used. The depths at which the soil samples were gathered from each site with a soil auger was categorized (0-5cm, 6-10cm and 11-15cm). To guard against heat and mold damage in the field, samples were kept in separate bags, shaded, and dried by air [23]. Prior to estimating the composition of soil seed banks, soil core samples from each depth was blended to create a composite sample [23, 24] to quantify the abundance of species existing in the soil seed bank through seed emergence techniques .

**2.3 Collection and Identification of Plants for Above Ground Species Composition**

Identification and recording of different plant species was done using morphological features of leaves and stem. Key to identification of Nigerian trees and Flora of West Tropical Africa were used for the proper identification of the trees encountered [25, 26, 27, 28, 29].

## Seed Bank Analysis

## 2.4.1 Seedling Emergence Test

## Soil samples collected from each study site were spread into round plastic trays of 29cm x 20cmx 6cm, which were used as germination trays. Each plastic tray was perforated at the base at 1cm and the perforation was covered with cotton wool to avoid leakage of soil samples and to facilitate drainage of excess water in the samples. The soil samples (15 of them) were kept in a screen house near the Botany laboratory, Department of Botany of Nnamdi Azikiwe University, Awka, Anambra State. The size of the screen house was 212cm X 154cm and height of 190cm. The screen house was roofed with plastic roofing sheets to allow light penetration. The plastic trays were placed on a wooden basement of about 40cm from the floor. The experiment commenced on 10/04/2024 and ended in 18/10/2024. The soils were watered daily to field capacity (about 100cm of tap water) for about six months and the soils were stirred every two weeks for light effects on germination. Also, the soils were stirred continuously to identify germinated seedlings. Emerged seedlings were counted and recorded at 3weeks, when germination commenced and then every week. At 12weeks then most of the germinated seedlings finished their life cycles and for the remaining 3 months, only dormant seedlings emerged at sporadic intervals. The experiment in the screen house lasted for six months. Each soil sample was replicated twice giving a total of 30 soil samples.

## The germinated seedlings were collected for identification by using relevant manuals and through searching the internet pages. The daily temperature of the screen house was the same with the prevailing atmospheric temperatures for the period of the experiment. Photographs of seedlings were taken and identification was confirmed by taxonomist Dr. Iroka C. F. and with the aid of plant flora and monographs. Also, soil samples were stirred after each assessment to stimulate germination by bringing to the surface other seeds that might have been deeply buried. The emerged seedlings were identified, counted, recorded and discarded.

## 2.5 Computation of Data

## After sampling, in order to quantify specie density and specie abundance the following statistical analysis was computed as follows:

## Density = No of each specie

## Total area sampled.

## Relative density = Density of each species X 100

## Total density of all species 1

## Frequency = No of times a specie occurred X 100

## Total no of times searched for 1

## Relative freq. = Frequency of each specie X 100

## Total frequency of all species 1

## Important value Index (IVI) = Relative density + Relative frequency.

## Species Diversity

## Shannon – Wiener index of diversity was used to determine the species diversity of the sampled plots using the formulae:

Where:

H= the Shannon diversity index

Pi = fraction of the entire population made up of species

S = number of species encountered

*∑ =* sum from species 1 to s

## In = natural logarithm

## 2.7 Weed Seed Bank Estimation

## The number (size) of weed seeds in the seed bank (Y) per land area (m²) was estimated by multiplying the number of seeds in soil sample (G) by the inverse ratio of the volume of soil in the auger sample to the volume of soil in 1 m² area sampled to the depth of the auger (15 cm) [30].

## Volume of soil from the auger sample (V1)

## V1 = π r²h, where π = 22/7, r = radius of the auger and h= depth of sampling

## Volume of soil from 1 m² area sampled (V²)

## V2 = L x B x H, where L = length, B = breadth and H = depth of sampling.

## G = number of emerged weed seedling per soil sample.

## % Viability will be determined= No. seed Density- No germinated seeds X 100.

## Seed longevity = No of viable X duration of experiment.

## Seed Abundance =no. of observed germinant in the soil seed bank [31].

## Relative seed abundance of species = species seed abundance/ total no of species observed[31].

## Seed density= seed abundance/Total area of soil sampled.

## The Importance value index will be determined by adding all the relative values of each species.

**2.8 Sørensen Similarity Coefficient (CS)**

This measures similarity in species composition for two, A and B according to method of Ogunleye *et al*[32].

CS = D x 100

D+A+B 1

Where:

D = Number of species found in both sites

A = Number of species found only in site A

B = Number of species found only in site B. Expressed as a percentage of similarity or dissimilarity.

CS for forest 1 and 2 = D x 100

D+A+B 1

CS for forest 2 and 1 = D x 100

D+B+A 1

## 2.9 Data Analysis

The data collected were analyzed using one- way analysis of variance (ANOVA) to ascertain the significant difference within factors at a 5% level of probability.

1. **RESULTS**

**3.1 Species Composition in Amansea Secondary Forest**

Table 1 showed the species abundance of Amansea secondary forest. From the table, *Chromolaena odorata* (Asteraceae) had a density of 0.16, a relative Frequency of 4.52 and Importance Value Index (IVI) of 7.27. This showed that *Chromolaena odorata* is a highly prevalent species in this forest, as indicated by its high density, frequency, and IVI. It plays a significant role in the ecosystem due to its wide distribution and abundance. *Kyllinga pumila* (Cyperaceae) had a density of 0.52 and a relative frequency of 2.78 with a high IVI of 11.75. *Newbouldia laevis* (Bignonaceae) and *Monechima ciliatum* (Acanthaceae) had a density of 0.62 and 0.64 respectively with a relative frequency of 2.43 and 3.13; an IVI of 13.25 and 14.29 showed that these species are ecologically important within the forest community. *Spermacoce octodon* (Rubiaceae) had a density of 0.75 and a relativefrequencyof 7.65 with a high IVI of 20.73. With the highest IVI among all species in this forest site, *Spermacoce octodon* is the most significant species in this forest. Its high density and frequency suggest it is both abundant and widely distributed.

From the table, species with high IVIs, such as *Spermacoce octodon, Newbouldia laevis*, and *Chromolaena odorata*, are key structural and functional components of the forest, contributing significantly to biomass, habitat structure, and ecosystem processes. The variety of species from different families, such as Acanthaceae, Amaranthaceae, Asteraceae, and Euphorbiaceae, indicates a diverse and healthy ecosystem. This diversity enhances resilience to environmental changes and disturbances. High IVI species should be prioritized in conservation and management efforts due to their critical ecological roles. Preserving these species can help maintain overall forest health and stability.

**Table 1: Composite table of Species Abundance of Amansea Secondary Forest**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Plant species** | **Family** | **Total no Plant spp.** | **Density (M-2)** | **Relative Density (%)** | **Frequency (%)** | **Relative Frequency (%)** | **IVI (%)** |
| *Hypoestes forskalei* | Acanthaceae | 26 | 0.05 | 0.9 | 40 | 1.39 | 2.29 |
| *Monechima ciliatum* | Acanthaceae | 23 | 0.05 | 0.8 | 30 | 1.04 | 1.84 |
| *Cyathula prostrate* | Amaranthaceae | 7 | 0.01 | 0.24 | 10 | 0.35 | 0.59 |
| *Celosia leptostachyma* | Amaranthaceae | 4 | 0.01 | 0.14 | 10 | 0.35 | 0.49 |
| *Ageratum conyzoides* | Asteraceae | 46 | 0.09 | 1.6 | 60 | 2.09 | 3.69 |
| *Aspilia africana* | Asteraceae | 74 | 0.15 | 2.57 | 65 | 2.26 | 4.83 |
| *Chromolaena odorata* | Asteraceae | 79 | 0.16 | 2.75 | 130 | 4.52 | 7.27 |
| *Hyptis suavolens* | Asteraceae | 9 | 0.02 | 0.31 | 25 | 0.87 | 1.18 |
| *Newbouldia laevis* | Bignonaceae | 31 | 0.62 | 10.82 | 70 | 2.43 | 13.25 |
| *Dalium guineense* | Caesalpinaceae | 2 | 0 | 0.07 | 5 | 0.17 | 0.24 |
| *Daniella oliveria* | Caesalpinaceae | 3 | 0.01 | 0.1 | 10 | 0.35 | 0.45 |
| *Combretum hispidium* | Combretaceae | 17 | 0.03 | 0.59 | 35 | 1.22 | 1.81 |
| *Terminalia catappa*L. | Combretaceae | 6 | 0.01 | 0.21 | 10 | 0.35 | 0.56 |
| *Aneilema benijnense* | Commelinaceae | 10 | 0.02 | 0.35 | 30 | 1.04 | 1.39 |
| *Ipomea involucrate* | Convulvaceae | 10 | 0.02 | 0.35 | 5 | 0.17 | 0.52 |
| *Erograstis ciliaris* | Cyperaceae | 2 | 0 | 0.07 | 20 | 0.7 | 0.76 |
| *Cyperus difformis* | Cyperaceae | 59 | 0.12 | 2.05 | 45 | 1.56 | 3.62 |
| *Kyllinga pumila* | Cyperaceae | 258 | 0.52 | 8.97 | 80 | 2.78 | 11.75 |
| *Alchornea cordifolia* | Euphorbiaceae | 34 | 0.07 | 1.18 | 50 | 1.74 | 2.92 |
| *Manniophyton fulivum* | Euphorbiaceae | 100 | 0.2 | 3.48 | 95 | 3.3 | 6.78 |
| *Bridelia micrantha* | Euphorbiaceae | 18 | 0.04 | 0.63 | 5 | 0.17 | 0.8 |
| *Acalypha fimbriata* | Euphorbiaceae | 24 | 0.05 | 0.83 | 50 | 1.74 | 2.57 |
| *Ricinodendron heudelotti* | Euphorbiaceae | 68 | 0.14 | 2.37 | 25 | 0.87 | 3.23 |
| *Desmodium scorpiurus* | Fabaceae | 12 | 0.02 | 0.42 | 15 | 0.52 | 0.94 |
| *Isoberlina doki* | Fabaceae | 1 | 0 | 0.03 | 5 | 0.17 | 0.21 |
| *Anthonotha macrophylla* | Fabaceae | 5 | 0.01 | 0.17 | 20 | 0.7 | 0.87 |
| *Polycarpaea coryrnbosa* | Lamiaceae | 2 | 0 | 0.07 | 5 | 0.17 | 0.24 |
| *Hyptis spicigera* | Lamiaceae | 70 | 0.14 | 2.43 | 70 | 2.43 | 4.87 |
| *Melastomastrum capitatum* | Lamiaceae | 10 | 0.02 | 0.35 | 20 | 0.7 | 1.04 |
| *Vitex doniana* | Lamiaceae | 1 | 0 | 0.03 | 5 | 0.17 | 0.21 |
| *Anthocleista djalonesis* | Lognaniaceae | 4 | 0.01 | 0.14 | 45 | 1.56 | 1.7 |
| *Heterotis roundifolia* | Melastomaceae | 14 | 0.03 | 0.49 | 40 | 1.39 | 1.88 |
| *Mimosa invisa* | Mimosaceae | 92 | 0.18 | 3.2 | 80 | 2.78 | 5.98 |
| *Echinochloe colona* | Poaceae | 35 | 0.07 | 1.22 | 40 | 1.39 | 2.61 |
| *Andropogon gayanus* | Poaceae | 94 | 0.19 | 3.27 | 25 | 0.87 | 4.14 |
| *Digitaria gayanus* | Poaceae | 14 | 0.03 | 0.49 | 40 | 1.39 | 1.88 |
| *Paspalum congugatum* | Poaceae | 12 | 0.02 | 0.42 | 70 | 2.43 | 2.85 |
| *Morinda lucida* | Rubiaceae | 131 | 0.26 | 4.56 | 190 | 6.6 | 11.16 |
| *Mitracarpus villosus* | Rubiaceae | 10 | 0.02 | 0.35 | 35 | 1.22 | 1.56 |
| *Nauclea latifolia* | Rubiaceae | 15 | 0.03 | 0.52 | 45 | 1.56 | 2.09 |
| *Oldenlandia corymbosa* | Rubiaceae | 9 | 0.02 | 0.31 | 20 | 0.7 | 1.01 |
| *Spermacoceo ctodon* | Rubiaceae | 376 | 0.75 | 13.08 | 220 | 7.65 | 20.73 |
| *Glyphae brevis* | Tiliaceae | 246 | 0.49 | 8.56 | 115 | 4 | 12.55 |
| *Hypoestes forskalei* | Acanthaceae | 33 | 0.07 | 1.15 | 55 | 1.91 | 3.06 |
| *Monechima ciliatum* | Acanthaceae | 321 | 0.64 | 11.17 | 90 | 3.13 | 14.29 |
| *Cyathula prostrate* | Amaranthaceae | 72 | 0.14 | 2.5 | 30 | 1.04 | 3.55 |
| *Celosia leptostachyma* | Amaranthaceae | 22 | 0.04 | 0.77 | 35 | 1.22 | 1.98 |
| *Ageratum conyzoides* | Asteraceae | 40 | 0.08 | 1.39 | 50 | 1.74 | 3.13 |
| *Aspilia africana* | Asteraceae | 2 | 0 | 0.07 | 10 | 0.35 | 0.42 |
| *Chromolaena odorata* | Asteraceae | 9 | 0.02 | 0.31 | 10 | 0.35 | 0.66 |
| *Hyptis suavolens* | Asteraceae | 14 | 0.03 | 0.49 | 25 | 0.87 | 1.36 |
| *Newbouldia laevis* | Bignonaceae | 21 | 0.04 | 0.73 | 65 | 2.26 | 2.99 |

**3.2 Species Composition in Unizik Secondary Forest**

Table 2 showed the species abundance of Unizik secondary forest. From the table, *Landolphia owerriensis* (Apocynaceae) showed a high relative density (7.76) and frequency (173.33), with a significantly high IVI (15.36), indicating it is a prominent species within the forest. *Newbouldia laevis* (Bignonaceae) exhibited the highest IVI (20.86) among all species, with a relative density of 11.8 and a relative frequency of 206.67. This species is highly important in the forest community. *Lonchocarpus cyanescens* (Fabaceae) had a density of (0.28) and relative density (14.69), along with a significant IVI (18.64), suggesting its critical role in the ecosystem. *Elaeis guineense* (Arecaceae)on the other hand, showed a relatively low density (0.05) and IVI (6.53), this species is important but less dominant when compared to others like *Newbouldia laevis*. Also, *Combretum racemosum* (Combretaceae) showed lower values with a density of 0.06, a relative density of 2.94, and an IVI of 6.01, making it a less significant species in the community.

IVI is a critical measure as it combines multiple factors to reflect the ecological significance of a species. From the table, *Newbouldia laevis* and *Lonchocarpus cyanescens* topped the list with high IVIs, indicating their dominance and ecological importance in the forest. *Landolphia owerriensis* also stood out due to its high frequency and relative density, suggesting it is widespread and abundant.

High IVI species like *Newbouldia laevis* and *Lonchocarpus cyanescens* are likely to be key structural and functional components of the forest, contributing significantly to biomass, habitat structure, and ecosystem processes.The table reflects a diverse plant community with species from various families, indicating a healthy, and biodiverse ecosystem. High diversity can enhance resilience to environmental changes and disturbances.

**Table 2: Composite table of Species Abundance of Unizik Secondary Forest**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Plant species** | **Family** | **Total no Plant spp.** | **Density (M-2)** | **Relative Density (%)** | **Frequency (%)** | **Relative Frequency (%)** | **IVI (%)** |
|  |  |  |  |  |  |  |  |
| *Acanthus montanus* | Acanthaceae | 17 | 0.01 | 0.75 | 13.33 | 0.58 | 1.33 |
| *Cissus araloides* | Ampellidaceae | 10 | 0.01 | 0.44 | 23.33 | 1.02 | 1.46 |
| *Landolphia owerriensis* | Apocynaceae | 17 | 0.15 | 7.76 | 173.33 | 7.6 | 15.36 |
| *Cocos nucifera* | Arecaceae | 2 | 0 | 0.09 | 6.67 | 0.29 | 0.38 |
| *Raphia spp* | Arecaceae | 2 | 0 | 0.09 | 6.67 | 0.29 | 0.38 |
| *Elaeis guineense* | Arecaceae | 59 | 0.05 | 2.59 | 90 | 3.95 | 6.53 |
| *Gongronema latifolium* | Ascelpiadiaceae | 33 | 0.04 | 2.32 | 66.67 | 2.92 | 5.25 |
| *Chromolaena odorata* | Asteraceae | 4 | 0 | 0.18 | 13.33 | 0.58 | 0.76 |
| *Newbouldia laevis* | Bignonaceae | 49 | 0.22 | 11.8 | 206.67 | 9.06 | 20.86 |
| *Bombax buonopozense* | Bombacaceae | 4 | 0 | 0.18 | 13.33 | 0.58 | 0.76 |
| *Ceiba pentandra* | Bombacaceae | 9 | 0.01 | 0.39 | 13.33 | 0.58 | 0.98 |
| *Orginia spp* | Bromeliaceae | 18 | 0.02 | 0.79 | 23.33 | 1.02 | 1.81 |
| *Dacryodes edulis* | Buseraceae | 15 | 0.01 | 0.66 | 33.33 | 1.46 | 2.12 |
| *Dalium guineense* | Caesalpinaceae | 13 | 0.04 | 1.89 | 116.67 | 5.11 | 7 |
| *Combretum racemosum* | Combretaceae | 67 | 0.06 | 2.94 | 70 | 3.07 | 6.01 |
| *Combretum spp* | Combretaceae | 22 | 0.02 | 0.96 |  |  |  |
| *Terminalia catappa* | Combretaceae | 3 | 0 | 0.13 | 3.33 | 0.15 | 0.28 |
| *Terminalia glaucescens* | Combretaceae | 17 | 0.01 | 0.75 | 23.33 | 1.02 | 1.77 |
| *Palisota hirsute* | Commelinaceae | 57 | 0.05 | 2.5 | 80 | 3.51 | 6.01 |
| *Cnestis ferruginea* | Connaraceae | 8 | 0.01 | 0.35 | 13.33 | 0.58 | 0.94 |
| *Ipomoea asarifolia* | Convovulaceae | 10 | 0.01 | 0.44 | 13.33 | 0.58 | 1.02 |
| *Ipomoea involucrate* | Convulvaceae | 20 | 0.02 | 0.88 | 23.33 | 1.02 | 1.9 |
| *Cyperus iria* | Cyperaceae | 40 | 0.03 | 1.75 | 33.33 | 1.46 | 3.22 |
| *Rhychosperma corymbosa* | Cyperaceae | 1 | 0 | 0.04 | 3.33 | 0.15 | 0.19 |
| *Discorea bulbifera* | Dioscoreaceae | 3 | 0 | 0.13 | 10 | 0.44 | 0.57 |
| *Alchornea cordifolia* | Euphorbiaceae | 15 | 0.01 | 0.66 | 16.67 | 0.73 | 1.39 |
| *Phyllanthus amarus* | Euphorbiaceae | 30 | 0.03 | 1.32 | 40 | 1.75 | 3.07 |
| *Baphia nitida* | Fabaceae | 1 | 0 | 0.04 | 3.33 | 0.15 | 0.19 |
| *Crotalaria retusa* | Fabaceae | 4 | 0 | 0.18 | 10 | 0.44 | 0.61 |
| *Gliricidia sepium* | Fabaceae | 27 | 0.02 | 1.18 | 40 | 1.75 | 2.94 |
| *Lonchocarpus cyanescens* | Fabaceae | 35 | 0.28 | 14.69 | 90 | 3.95 | 18.64 |
| *Milletia arborea* | Fabaceae | 25 | 0.02 | 1.1 | 43.33 | 1.9 | 3 |
| *Mucuna flagellipes* | Fabaceae | 44 | 0.06 | 3.25 | 216.67 | 9.5 | 12.74 |
| *Pterocarpus osun* | Fabaceae | 5 | 0.03 | 1.32 | 23.33 | 1.02 | 2.34 |
| *Garcinia cola* | Guttiferae | 13 | 0.01 | 0.57 | 33.33 | 1.46 | 2.03 |
| *Harungana madagascarensis* | Hypericaceae | 6 | 0.01 | 0.26 | 6.67 | 0.29 | 0.56 |
| *Napolena imperalis* | Lecythidaceae | 10 | 0.03 | 1.75 | 60 | 2.63 | 4.38 |
| *Utricularia spp* | Lentibulariaceae | 18 | 0.03 | 1.67 | 43.33 | 1.9 | 3.57 |
| *Anthocleista djalonesis* | Gentianaceae | 33 | 0.04 | 1.89 | 30 | 1.32 | 3.2 |
| *Sida acuminate* | Malvaceae | 14 | 0.01 | 0.61 | 23.33 | 1.02 | 1.64 |
| *Urena lobata* | Malvaceae | 9 | 0.01 | 0.39 | 20 | 0.88 | 1.27 |
| *Sphenocentrum jollayanus* | Menispermaceae | 2 | 0 | 0.09 | 10 | 0.44 | 0.53 |
| *Mimosa pudica* | Mimosaceae | 22 | 0.03 | 1.4 | 36.67 | 1.61 | 3.01 |
| *Parkia clappertonia* | Mimosaceae | 24 | 0.02 | 1.05 | 43.33 | 1.9 | 2.95 |
| *Ficus spp* | Moraceae | 10 | 0.03 | 1.75 | 40 | 1.75 | 3.51 |
| *Treculia africana* | Moraceae | 6 | 0.08 | 3.95 | 60 | 2.63 | 6.58 |
| *Calatia spp* | Nymph aceae | 5 | 0 | 0.22 | 10 | 0.44 | 0.66 |
| *Olaxv iridis* | Olacaeae | 11 | 0.01 | 0.48 | 16.67 | 0.73 | 1.21 |
| *Leptuna spp* | Oleraceae | 13 | 0.01 | 0.57 | 30 | 1.32 | 1.89 |
| *Cassia spp* | Papilionaceae | 23 | 0.02 | 1.01 | 66.67 | 2.92 | 3.93 |
| *Dalbergia saxatilis* | Papilonaceae | 4 | 0 | 0.18 | 3.33 | 0.15 | 0.32 |
| *Barteria fistula* | Passifloraceae | 11 | 0.01 | 0.48 | 6.67 | 0.29 | 0.77 |
| *Barteria nigeritiana* | Passifloraceae | 12 | 0.01 | 0.53 | 6.67 | 0.29 | 0.82 |
| *Hernia podocarpus* | Podocarpaceae | 7 | 0.01 | 0.31 | 13.33 | 0.58 | 0.89 |
| *Morinda lucida* | Rubiaceae | 11 | 0.01 | 0.48 | 10 | 0.44 | 0.92 |
| *Nauclea latifolia* | Rubiaceae | 46 | 0.04 | 2.02 | 56.67 | 2.48 | 4.5 |
| *Ruthmania whitfieldii* | Rubiaceae | 11 | 0.02 | 0.96 | 40 | 1.75 | 2.72 |
| *Citrus aurantium* | Rubiaceae | 1 | 0 | 0.04 | 6.67 | 0.29 | 0.34 |
| *Chrysophyllum albida* | Sapotaceae | 2 | 0.01 | 0.48 | 20 | 0.88 | 1.36 |
| *Smilax spp* | Similaceae | 15 | 0.01 | 0.66 | 16.67 | 0.73 | 1.39 |
| *Cola gigantia* | Sterculiaceae | 7 | 0.02 | 1.27 | 40 | 1.75 | 3.03 |
| *Cola hispida* | Sterculiaceae | 10 | 0.09 | 4.56 | 36.67 | 1.61 | 6.17 |
| *Cola nitida* | Sterculiaceae | 6 | 0.01 | 0.26 | 16.67 | 0.73 | 0.99 |
| *Glyphae brevis* | Sterculiaceae | 9 | 0.01 | 0.39 | 23.33 | 1.02 | 1.42 |
| *Sterculia tragacantha* | Sterculiaceae | 4 | 0 | 0.18 | 6.67 | 0.29 | 0.47 |
| *Triumfetta spp* | Tiliaceae | 22 | 0.02 | 0.96 | 36.67 | 1.61 | 2.57 |
| *Musanga cecropioides* | Utricaceae | 19 | 0.02 | 0.83 | 46.67 | 2.05 | 2.88 |
| *Vitex doniana* | Verbenaceae | 32 | 0.06 | 3.16 | 86.67 | 3.8 | 6.96 |
| *Costus afer* | Zingerberaceae | 28 | 0 | 0.09 | 6.67 | 0.29 | 0.38 |

**3.3 Species Abundance of Seed banks at Unizik Secondary Forest at Soil Dept of 0-5cm**

Table 3 showed species abundance of seed banks at Unizik Secondary Forest at Soil Depth of 0-5cm. The table presents data on the abundance and importance of different species within a specified soil depth. From the table, *Eleusine indica* has the highest seed density of 818 seeds/m², accounting for 38.42% of the total seed density; it also showed the highest importance value (IVI) at 53.87%, indicating its significant presence and role in the seed bank. *Ageratum conyzoides* and *Phyllanthus niruri* follow with high seed densities of 164 and 491 seeds/m², respectively. *Ageratum conyzoides* has an IVI of 23.25%, while *Phyllanthus niruri*has an IVI of 30.72%. Other species like *Acalypha ciliata*, *Cleome viscose*, and *Euphorbia heterophylla* among others, have a seed density of 82 seeds/m², contributing equally to the relative seed density and frequency (3.90% each).

Dominance and Diversity: *Eleusine indica* dominance is evident from its high seed density and IVI. Its significant presence suggests it is well-adapted to the environmental conditions of the Unizik Secondary Forest.

Species Distribution: The even distribution of seed density and frequency percentages for several species (e.g., *Acalypha ciliata, Euphorbia heterophylla*) indicates a balanced representation in the seed bank, though less dominant than *Eleusine indica*.

The high IVI of *Eleusine indica* implies its crucial role in the ecosystem. The presence and distribution of various species suggest a diverse seed bank, essential for forest regeneration and resilience.

**Table 3: Species Abundance of Seed banks at Unizik Secondary Forest at Soil Dept of 0-5cm**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Species** | **Seed density (M-2)** | **Seed Rel. Density (%)** | **Seed Freq (%)** | **Seed relative freq (%)** | **IVI (%)** |
| 1 | *Aciola bateris* | 82 | 3.90 | 33 | 7.66 | 11.60 |
| 2 | *Ageratum conyzoides* | 164 | 7.70 | 67 | 15.55 | 23.25 |
| 3 | *Cleome rutidosperma* | 82 | 3.90 | 33 | 7.66 | 11.60 |
| 4 | *Dissotis runtoidifolia* | 82 | 3.90 | 33 | 7.66 | 11.60 |
| 5 | *Eleusine indica* | 818 | 38.42 | 67 | 15.55 | 53.87 |
| 6 | *Euphorbia heterophylla* | 82 | 3.90 | 33 | 7.66 | 11.60 |
| 7 | *Euphorbia hirta* | 82 | 3.90 | 33 | 7.66 | 11.60 |
| 8 | *Oldenlandia corymbosa* | 82 | 3.90 | 33 | 7.66 | 11.60 |
| 9 | *Phyllantus amarus* | 82 | 3.90 | 33 | 7.66 | 11.60 |
| 10 | *Phyllantus niruri* | 491 | 23.06 | 33 | 7.66 | 30.72 |
| 11 | *Spigelia anthelmia* | 82 | 3.90 | 33 | 7.66 | 11.60 |
|  | **Total** | 2129 | 100 | 431 | 100 | 200 |

**3.4 Species Abundance of Seed banks at Unizik Secondary Forest at Soil Dept of 6-10cm**

The table provided the seed density per square meter for each species. *Ageratum conyzoides* has the highest seed density with 327 seeds per square meter, making up 44.37% of the total seed density. *Ageratum conyzoides* stands out with the highest relative seed density at 67%, indicating its dominance in the seed bank at this soil depth.Almost all species expect *A. conyzoides* have the same frequency value of 14.22.The IVI combines relative density and frequency to assess the overall importance of each species in the ecosystem; *Ageratum conyzoides* again shows the highest IVI at 73.25%, indicating its significant role in the seed bank composition.The table highlights the dominance of *Ageratum conyzoides* in the seed bank at this soil depth, both in terms of seed density and importance value. This data is crucial for understanding the ecological dynamics and potential species regeneration in the Unizik Secondary Forest.

**Table 4: Species Abundance of Seed banks at Unizik Secondary Forest at Soil Dept of 6-10cm**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Species** | **Seed density (M-2)** | **Seed Rel. Density (%)** | **Seed Freq (%)** | **Seed relative freq (%)** | **IVI (%)** |
| 1 | *Adiantum* sp | 82 | 11.13 | 33 | 14.22 | 25.35 |
| 2 | *Commelina diffusa* | 82 | 11.13 | 33 | 14.22 | 25.35 |
| 3 | *Ageratum conyzoides* | 327 | 44.37 | 67 | 28.88 | 73.25 |
| 4 | *Asystacia gigantic* | 82 | 11.13 | 33 | 14.22 | 25.35 |
| 5 | *Euphorbia hirta* | 82 | 11.13 | 33 | 14.22 | 25.35 |
| 6 | *Phyllantus amarus* | 82 | 11.13 | 33 | 14.22 | 25.35 |
|  | **Total** | 737 | 100 | 232 | 100 | 200 |

**3.5 Species Abundance of Seed banks at Unizik Secondary Forest at Soil Dept of 11-15cm**

This table showed the number of seeds per square meter for each species. ***Ageratum conyzoides*** has the highest seed density with 2373 seeds per square meter, contributing 65.88% to the total seed density. ***Ageratum conyzoides*** dominates with a relative seed density of 67%. All species have varying frequencies, with ***Ageratum conyzoides*** having the highest relative frequency at 18.36%. ***Ageratum conyzoides*** stands out with the highest IVI, indicating its significant presence and influence within this soil depth in the forest. ***Ageratum conyzoides*** is the most dominant species at the soil depth of 11-15cm in the Unizik Secondary Forest.

**Table 5: Species Abundance of Seed banks at Unizik Secondary Forest at Soil Dept of 11-15cm**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Species** | **Seed density (M-2)** | **Seed Rel. Density (%)** | **Seed Freq (%)** | **Seed relative freq (%)** | **IVI (%)** |
| 1 | *Ageratum conyzoides* | 2373 | 65.88 | 67 | 18.36 | 84.24 |
| 2 | *Commelina diffusa* | 82 | 2.28 | 33 | 9.04 | 11.32 |
| 3 | *Euphorbia hirta* | 82 | 2.28 | 33 | 9.04 | 11.32 |
| 4 | *Kyllinga erecta* | 82 | 2.28 | 33 | 9.04 | 11.32 |
| 5 | *Laportea ovaliformis* | 82 | 2.28 | 33 | 9.04 | 11.32 |
| 6 | *Oldenlandia corymbosa* | 164 | 4.55 | 67 | 18.36 | 22.91 |
| 7 | *Phyllantus amarus* | 82 | 2.28 | 33 | 9.04 | 11.32 |
| 8 | *Phyllantus niruri* | 573 | 15.91 | 33 | 9.04 | 11.32 |
| 9 | *Poulzozia gunieense* | 82 | 2.28 | 33 | 9.04 | 11.32 |
|  | **Total** | 3602 | 100 | 365 | 100 | 200 |

**3.6 Species Abundance of Seed banks at Amansea Secondary Forest at Soil Dept of 0-5cm**

This table showed the species abundance of seed bank at Amansea secondary forest. From the table, ***Eleusine indica*** has the highest seed density with 2373 seeds per square meter, making up 37.65% of the total seed density. ***Ageratum conyzoides*** and ***Eleusine indica*** had the highest relative seed densities at 100%. ***Ageratum conyzoides*** and ***Eleusine indica*** had the highest frequency values of 21.46. ***Eleusine indica*** had the highest seed relative frequency at 52.03%. The table showed the dominance of ***Eleusine indica*** in the seed bank at the soil depth of 0-5cm, both in terms of seed density and seed relative frequency. This species appears to play a significant role in the ecosystem of Amansea Secondary Forest at this soil depth.

**Table 6: Species Abundance of Seed banks at Amansea Secondary Forest at Soil Dept of 0-5cm**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Species** | **Seed density (M-2)** | **Seed Rel. Density (%)** | **Seed Freq (%)** | **Seed relative freq (%)** | **IVI (%)** |
| 1 | *Ageratum conyzoides* | 1309 | 20.77 | 100 | 21.46 | 42.23 |
| 2 | *Commelina diffusa* | 82 | 1.30 | 33 | 7.08 | 8.38 |
| 3 | *Euphorbia hirta* | 1555 | 24.67 | 67 | 14.38 | 39.05 |
| 4 | *Asystacia gigantic* | 82 | 1.30 | 33 | 7.08 | 8.38 |
| 5 | *Eleusine indica* | 2373 | 37.65 | 67 | 14.38 | 52.03 |
| 6 | *Euphorbia heterophylla* | 164 | 2.60 | 67 | 14.38 | 16.98 |
| 7 | *Phyllantus amarus* | 82 | 1.30 | 33 | 7.08 | 8.38 |
| 8 | *Phyllantus niruri* | 573 | 9.09 | 33 | 7.08 | 16.17 |
| 9 | *Poulzozia gunieense* | 82 | 1.30 | 33 | 7.08 | 8.38 |
|  | **Total** | 6302 | 100 | 466 | 100 | 200 |

**3.7 Species Abundance of Seed banks at Amansea Secondary Forest at Soil Dept of 6-10cm**

The table 7 showed the dominance of ***Kyllinga erecta*** in the seed bank at the soil depth of 6-10cm in Amansea Secondary Forest. ***Kyllinga erecta*** has the highest seed density with 982 seeds per square meter, making up 59.95% of the total seed density. ***Kyllinga erecta*** is the most dominant with a relative seed density of 100%. ***Ageratum conyzoides*** has the highest frequency value of 18.36%, indicating it is found relatively often in the sampled area. ***Kyllinga erecta*** again shows dominance with a seed relative frequency of 87.34%. Its high seed density and relative frequency indicate its significant presence and role in the ecosystem at this soil depth.

**Table 7: Species Abundance of Seed banks at Amansea Secondary Forest at Soil Dept of 6-10cm**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Species** | **Seed density (M-2)** | **Seed Rel. Density (%)** | **Seed Freq (%)** | **Seed relative freq (%)** | **IVI (%)** |
| 1 | *Ageratum conyzoides* | 164 | 10.01 | 67 | 18.36 | 28.37 |
| 2 | *Cleome rutidosperma* | 82 | 5.01 | 33 | 9.04 | 14.05 |
| 3 | *Commelina diffusa* | 82 | 5.01 | 33 | 9.04 | 14.05 |
| 4 | *Euphorbia hirta* | 82 | 5.01 | 33 | 9.04 | 14.05 |
| 5 | *Kyllinga erecta* | 982 | 59.95 | 100 | 27.39 | 87.34 |
| 6 | *Laportea ovaliformis* | 82 | 5.01 | 33 | 9.04 | 14.05 |
| 7 | *Phyllantus amarus* | 82 | 5.01 | 33 | 9.04 | 14.05 |
| 8 | *Phyllantus niruri* | 82 | 5.01 | 33 | 9.04 | 14.05 |
|  | **Total** | 1638 | 100 | 365 | 100 | 200 |

**3.8 Species Abundance of Seed banks at Amansea Secondary Forest at Soil Dept of 11-15cm**

Table 8 presented the prominence of ***Ageratum conyzoides*** and ***Spigelia anthelmia*** in the seed bank at the soil depth of 11-15cm in the Amansea Secondary Forest. ***Ageratum conyzoides, Laportea aestuans***, and ***Spigelia anthelmia*** each have a seed density of 164 seeds per square meter, making up 15.38% of the total seed density. ***Ageratum conyzoides*** and ***Spigelia anthelmia*** both have a high relative density value at 67%. ***Ageratum conyzoides*** and ***Spigelia anthelmia*** have the highest frequency values at 16.83%. ***Ageratum conyzoides*** and ***Spigelia anthelmia*** have the highest seed relative frequency values, both at 32.21%. Their high seed density and relative frequency indicate their significant presence and influence in this soil depth's ecosystem.

**Table 8: Species Abundance of Seed banks at Amansea Secondary Forest at Soil Dept of 11-15cm**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Species** | **Seed density (M-2)** | **Seed Rel. Density (%)** | **Seed Freq (%)** | **Seed relative freq (%)** | **IVI (%)** |
| 1 | *Ageratum conyzoides* | 164 | 15.38 | 67 | 16.83 | 32.21 |
| 2 | *Dissotis runtoidifolia* | 82 | 7.69 | 33 | 8.29 | 15.98 |
| 3 | *Euphorbia hirta* | 82 | 7.69 | 33 | 8.29 | 15.98 |
| 4 | *Kyllinga erecta* | 82 | 7.69 | 33 | 8.29 | 15.98 |
| 5 | *Laportea ovaliformis* | 164 | 15.38 | 33 | 8.29 | 23.67 |
| 6 | *Mitracarpus scaber* | 82 | 7.69 | 33 | 8.29 | 15.98 |
| 7 | *Phyllantus amarus* | 82 | 7.69 | 33 | 8.29 | 15.98 |
| 8 | *Phyllantus niruri* | 82 | 7.69 | 33 | 8.29 | 15.98 |
| 9 | *Poulzozia gunieense* | 82 | 7.69 | 33 | 8.29 | 15.98 |
| 10 | *Spigeliaanthelmia* | 164 | 15.38 | 67 | 16.83 | 32.21 |
|  | **Total** | 1066 | 100 | 398 | 100 | 200 |

**3.9 Species Diversity Index for the Above Ground Plants of the Two Forest Communities**

With 53 species found in Amansea forest and 69 species found in unizik forest; table 9 showed that the Unizik forest had a higher number of species compared to the Amansea forest, indicating greater species richness. The index (H') which measures species diversity in a community showed that **Amansea forest had** H' value of 2.93 and Unizik forest had H' value of 3.29. By implication, the Unizik forest had a higher Shannon Weiner index, suggesting it is more diverse in terms of species composition than the Amansea forest. For the **H max (Maximum Diversity) which** represents the maximum possible diversity in a perfectly even community where all species are equally abundant; **Amansea forest had a** H max value of 3.89 while **Unizik forest had a H** max value of 3.98. For the equitability or evenness which measures how evenly the individuals are distributed across the different species, Amansea forest had an equitability value of 0.72 while Unizik forest had an equitability value of 0.83. Since this equitability value ranges from 0 to 1, where values closer to 1 indicate a more even distribution; Unizik forest has a higher equitability value, indicating a more even distribution of individuals among its species compared to the Amansea forest. In summary, **Unizik forest** is richer in species, more diverse, and has a more even distribution of species compared to the **Amansea forest**.

**Table 9: Shannon Weiner Species Diversity Index for the above ground plant in the two forests**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Community Type** | **Total Number of Species** | **H1** | **H max** | **Equitability** |
| Amansea forest | 53 | 2.93 | 3.895 | 0.72 |
| Unizik forest | 69 | 3.29 | 3.98 | 0.83 |

**3.10 Shannon Weiner Seed Bank Diversity Index for the Two Forest Sites**

Table 10 showed the Shannon Weiner seed band diversity for the two forest sites. The highest emergence was seen in Unizik forest at 0-5 cm depth with 11 species. **Amansea forest at 0-5 cm soil depth had a** H’ value of 1.594, which was the highest diversity at this depth; while **Unizik forest at 11-15 cm soil depth had a** H’ value of 1.715 (highest diversity in this forest). For the **H max (Maximum Diversity),Amansea forest at 11-15 cm soil depth** had a H max value of 1.609; while **Unizik forest at 0-5 cm soil depth had a** H max of 1.386. The highest equitability was observed in **Amansea forest at 6-10 cm soil depth** with 0.994, indicating a very even distribution of species. In summary, **Unizik forest** showed a high diversity index at the shallowest soil depth (0-5 cm) with the highest species emergence and a high equitability, suggesting a well-balanced species distribution. **Amansea forest** had a notable diversity at deeper soil levels (11-15 cm), also maintaining high equitability values, indicating a stable species distribution at this depth.

**Table 10: Shannon Weiner Seed Bank Diversity Index for the Two Forest Sites**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Community Type** | **Total Number of Emergence** | **H1** | **H max** | **Equitability** |
| Amansea forest at 0-5 cm soil depth | 9 | 0.898 | 1.099 | 0.817 |
| Amansea forest at 6-10 cm soil depth | 8 | 0.689 | 0.693 | 0.994 |
| Amansea forest at 11-15 cm soil depth | 10 | 1.594 | 1.609 | 0.991 |
| Unizik forest at 0-5 cm soil depth | 11 | 1.715 | 1.886 | 0.922 |
| Unizik forest at 6-10 cm soil depth | 6 | 0.637 | 0.693 | 0.918 |
| Unizik forest at 11-15 cm soil depth | 9 | 0.854 | 1.086 | 0.948 |

**3.11** **Sørensen Similarity Index of above ground Species composition for the two Forests**

Table 11 showed the Sørensen Similarity Index of approximately 0.414 for the two forest sites and this indicates that there is a moderate level of similarity between the species composition of the secondary forest community in Amansea and the forest community at Nnamdi Azikiwe University. This value suggests that while there are common species between the two sites, there are also significant differences in species composition.

**Table 11: Sørensen Similarity Index of above ground Species composition for the Two Forests**

| **Site** | **Total Species (A)** | **Total Species (B)** | **Common Species (C)** | **Sørensen Similarity Index (SSI)** |
| --- | --- | --- | --- | --- |
| Amansea | 43 | 68 | 23 | 0.414 |
| Nnamdi Azikiwe University | 68 | 43 | 23 | 0.414 |

**3.12 Sørensen Similarity Index of above ground Species composition for the Two Forests**

The Sørensen Similarity Index is highest for the 6-10 cm soil depth (0.86), indicating a high similarity in species composition between the Unizik and Amansea Secondary Forests at this depth. The SSI for the 11-15 cm soil depth is also high (0.84), suggesting a strong similarity in species composition at this depth. The SSI for the 0-5 cm soil depth is lower (0.70) but still indicates a moderate level of similarity between the two sites. This analysis provides insights into the similarity of seed bank species composition between the two sites at different soil depths.

**Table 12: Sørensen Similarity Index of Species composition at Different soil Depths in the Two Forests**

| **Soil Depth (cm)** | **Total Species (Unizik)** | **Total Species (Amansea)** | **Common Species** | **Sørensen Similarity Index (SSI)** |
| --- | --- | --- | --- | --- |
| 0-5 | 11 | 9 | 7 | 0.70 |
| 6-10 | 6 | 8 | 6 | 0.86 |
| 11-15 | 9 | 10 | 8 | 0.84 |

**4. DISCUSSION**

The Unizik Secondary Forest exhibited a diverse range of plant species across various families, indicating a complex and ecologically rich ecosystem. Notable families include **Asteraceae, Euphorbiaceae, Fabaceae**, and **Rubiaceae**. Similarly, the Amansea Secondary Forest demonstrated high biodiversity, with significant representation from families such as **Acanthaceae, Asteraceae, Cyperaceae, Euphorbiaceae, Fabaceae, Poaceae**, and **Rubiaceae**. The above-ground species composition of a forest refers to the variety and abundance of plant species visible above the soil surface. This composition is crucial for understanding the forest's biodiversity, ecosystem functions, and conservation potential. Studies have shown that above-ground biomass and species diversity are closely linked, with diverse forests often exhibiting higher biomass and carbon storage capacity [32]. In the case of the Unizik and Amansea Secondary Forests, species composition is influenced by factors such as soil type, climate, and human activities. For instance, the presence of dominant species like Ageratum conyzoides and Commelina diffusa in both forests suggests similar ecological conditions and management practices [33].

The seed bank composition at different soil depths revealed the diversity and potential for regeneration. At the **0–5 cm depth** (Table 3), Eleusine indica dominated (38.42% relative density), indicating its prolific seed production and potential for rapid colonization. At the **6–10 cm depth** (Table 4), Ageratum conyzoides was the most abundant (44.37% relative density), demonstrating its ability to maintain a persistent seed bank. At the **11–15 cm depth** (Table 5), Ageratum conyzoides again dominated (65.88% relative density), reflecting its resilience and importance in the seed bank. Similarly, the seed bank composition at Amansea exhibited significant diversity. At the **0–5 cm depth** (Table 6), Eleusine indica was the dominant species (37.65% relative density), mirroring the pattern observed in the Unizik forest. At the **6–10 cm depth** (Table 7), Kyllinga erecta was highly abundant (59.95% relative density), indicating its capacity for seed persistence. At the**11–15 cm depth** (Table 8), Ageratum conyzoides and Spigelia anthelmia were prominent, suggesting their critical role in seed bank dynamics at this depth.

The seed bank refers to the collection of viable seeds present in the soil, which can germinate and contribute to forest regeneration. Seed banks are critical for forest restoration, especially in degraded areas, as they provide a reservoir of species that can repopulate the area [34]. The composition of the seed bank can differ from the above-ground vegetation due to factors such as seed dispersal mechanisms, seed dormancy, and soil conditions. In the Unizik and Amansea Secondary Forests, the seed bank composition at different soil depths (0–5 cm, 6–10 cm, and 11–15 cm) shows a mix of herbaceous and woody species [33, 35]. The presence of species like Ageratum conyzoides and Commelina diffusa in the seed banks indicates their potential for natural regeneration and biodiversity maintenance [33, 36].

The **Sørensen Similarity Index (SSI)** provides a quantitative measure of the similarity between the species compositions of the two forests above ground and at different soil depths. At the **0–5 cm depth**, the SSI of 0.70 indicates a moderate level of similarity, suggesting that while there are common species, there are also distinct differences in species composition. At the **6–10 cm depth**, the SSI of 0.86 indicates a high level of similarity, reflecting similar ecological conditions and species dynamics in the seed banks at this depth. At the **11–15 cm depth,** the SSI of 0.84 also indicates high similarity, highlighting shared species and ecological processes between the two forests at this soil depth. The Sørensen Similarity Index (SSI) is a measure of the similarity between two communities based on species composition, ranging from 0 (no similarity) to 1 (complete similarity) [34]. In this case, the SSI values for different soil depths indicate a high level of similarity between the Unizik and Amansea Secondary Forests, especially at the 6–10 cm depth (SSI = 0.86).

Understanding the species composition and seed bank dynamics of these forests is essential for effective conservation and management. The high similarity in species composition suggests that both forests share similar ecological conditions and management practices, which can be leveraged for conservation efforts [34, 37, 38]. Additionally, the presence of a diverse seed bank indicates the potential for natural regeneration and resilience against disturbances [34, 36]. The high biodiversity in both above-ground and seed bank compositions suggests robust ecosystem functions, such as nutrient cycling, habitat provision, and resilience to disturbances. Dominant species like Ageratum conyzoides and Eleusine indica play critical roles in both forests, contributing to their structural integrity and regenerative capacity. The high similarity in species composition (SSI values) between the two forests highlights the potential for collaborative conservation efforts. Maintaining and enhancing seed bank diversity is crucial for forest regeneration, especially in disturbed areas. Conservation strategies should focus on protecting both above-ground vegetation and the seed banks. The detailed analysis of the above-ground species composition and seed bank dynamics in the Unizik and Amansea Secondary Forests underscores the importance of biodiversity for ecosystem health and resilience. The high similarity in species composition at various soil depths suggests shared ecological conditions and processes, providing opportunities for integrated conservation and management efforts [34, 39].

In summary, the above-ground species composition and seed bank composition of the Unizik and Amansea Secondary Forests provide valuable insights into their biodiversity and conservation potential. The high similarity in species composition and the presence of a diverse seed bank highlight the importance of these forests for maintaining ecosystem functions and supporting biodiversity [34, 36, 37]. The seed bank composition at various soil depths reveals the potential for forest regeneration and resilience. Common species in both seed banks, such as Ageratum conyzoides, Euphorbia hirta, Phyllanthus amarus, and Phyllanthus niruri, highlight their dominance and adaptability. At the **0–5 cm depth,** Eleusine indica dominated in Unizik (38.42% relative density) and Amansea (37.65% relative density), indicating its widespread seed presence and potential for rapid colonization. At the **6–10 cm depth**, Ageratum conyzoides was highly abundant in Unizik (44.37% relative density) and Amansea (10.01% relative density), showing its seed persistence and regenerative potential. At the **11–15 cm depth,** Ageratum conyzoides continued to dominate in both forests, reflecting its importance in the seed bank.

The comprehensive analysis of species composition and seed bank dynamics in the Unizik and Amansea Secondary Forests reveals critical insights into their ecological health and regeneration potential. The higher nutrient levels in Amansea support a richer species composition, while the better soil structure and moisture retention in Unizik contribute to a diverse and resilient ecosystem. The presence of common species across different soil depths in the seed banks highlights the forests' potential for natural regeneration and long-term stability.

### 5.0 CONCLUSION

The comparative study of the Unizik and Amansea secondary forests provides critical insights into the ecological dynamics of these forest ecosystems. By analyzing soil properties, above-ground species composition, and seed bank composition, this study enhances our understanding of the factors driving biodiversity, soil health, and forest regeneration potential. Both forests exhibited a rich diversity of plant species, with notable representation from families such as Asteraceae, Euphorbiaceae, Fabaceae, and Rubiaceae. The presence of common species, including Ageratum conyzoides and Chromolaena odorata, in both forests suggests similar ecological conditions and highlights the potential for shared conservation strategies. The seed bank composition at various soil depths revealed the resilience and regenerative capacity of both forests. Species such as Ageratum conyzoides and Eleusine indica dominated the seed banks, reflecting their adaptability and ecological significance in forest regeneration. The high Sørensen Similarity Index (SSI) values between the seed banks of the two forests further emphasized their ecological similarities. These findings are crucial for developing effective conservation and management strategies aimed at preserving biodiversity and ensuring sustainable forest regeneration.

### DECLARATION OF AI USAGE

Author(s) hereby declare that generative AI technologies such as Large Language Models have been used during the writing and editing of this manuscript. The details of AI usage are as follows:

1. **Name and Version**: ChatGPT-4, Open AI.
2. **Model and Source**: Open AI's Large Language Model (GPT-4).
3. **Usage Details**:
   * Assisted in refining the language and clarity of the manuscript.
   * Suggested improvements in structuring methodology and discussion sections.
   * Provided recommendations for incorporating relevant comparative studies and recent literature.

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