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Effect of Bush Fire on Plant Seedlings in the University of Port Harcourt Biodiversity Conservation Center, Nigeria

Chimezie Ekeke[1*] and Chinedum Alozie Ogazie[1]

[1]*Department of Plant Science and Biotechnology, Faculty of Science, University of Port Harcourt, P.M.B. 5323 Choba, Port Harcourt, Rivers State, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Authors CE and CAO designed the study, performed the statistical analysis and wrote the protocol. Author CE wrote the first draft of the manuscript, managed the analyses of the study and literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

We investigated the effect of fire on understory plant species density in University of Port Harcourt Biodiversity Centre four months after fire incident. This is aimed at the knowing the ability of the forest to recover from bush fire. Twenty four (4 m x 4 m) plots (14 burnt and 10 un-burnt or control) were mapped out. The plant seedlings in these plots were sampled, identified and enumerated. The diversity, relative abundance, relative frequency, relative diversity, species importance value, family importance value and seedling density were determined. A total of 53 plant species belonging to 35 families were identified in the area studied. The un-burnt (control) plots had 11 species with 9 plant families while the burnt (impacted) plots had 52 species and 33 families. Fabaceae and Rubiaceae families had the maximum number of species in the control plots, while Asteraceae, Poaceae and Fabaceae families had the maximum number of species in the burnt plots. Based on the habit of the plant species identified, there is difference in the number of plant species, seedling density, relative abundance, species density and importance values (dominance)

**Corresponding author: E-mail: ekeke.uche@uniport.edu.ng, ekeke.uc@gmail.com;*

between the burnt and the control plots. In the burnt plots lianas, grasses, herbs, shrubs and trees had 8, 7, 21, 9 and 7 species respectively while in the control plots we recorded 2, 0, 2, 3 and 4 for lianas, grasses, herbs, shrubs and trees respectively but the relative abundance of lianas and trees in the control plots were less than that of burnt plots. Seedling density in the burnt plots varied from 57 to 9091 seedling ha^{-1}; *Alchornea cordifolia* had the highest relative frequency of 9.63%. In the unburnt (control) plots relative frequencies of the species were relatively higher than the burnt plots. *Baphia nitida* (16.67%) had the maximum relative frequency while *Picralima nitida, Elaeis guineensis, Spigelia anthelmia* and *Cissus rependa* had the least values of 5.56% each. The relative diversity of the different families of plant seedlings in the study area varied from 0.0 to 9.67 in burnt plots and 6.33 to 14.26 for control plots. In the burnt plots, FIV varied from 0.81 to 21.05 while it ranged from 12.05 to 13.41 in the control plots. Euphorbiaceae (11.38%) had the highest relative frequency in the burnt plots. Fabaceae (17.14%) which was the second largest in the burnt plots was had the maximum relative frequency in the control plots while Araceae, Poaceae and Apocyanaceae (5.71% each) had the least values. The seedling density in burnt plots varied from Poaceae (15987 ha^{-1}) to Onagraceae and Smilaceae (66 ha^{-1} each). In the control plots the family densities are as follows: Rubiaceae (8542 ha^{-1}); Poaceae and Apocyanaceae (1042 ha^{-1} each). This showed that fire stimulates the germination of certain seeds and promote the growth of certain plants in secondary succession and that the Centre has high potential of recovering from the fire incident however, we recommend that the forest be protected from any sort of fire to conserve and preserved the biodiversity of this Center. It is therefore important to conduct further study in order to monitor the impact of other environmental factors on the recovery of the burnt flora.

Keywords: Understory species; density; diversity; bush fire; species abundance.

1. INTRODUCTION

Anthropogenic activities (deforestation, logging, forest fires and exploitation of natural resources) in the tropics have significantly increased emission of greenhouse gases [1]. Fire changes the structure of forests base on its intensity and severity [2-3]. This could lead to changes in forest species composition, diversity and abundance [2,4-9]. Intensive forest fire could significantly affect plant seeds and regeneration of such plant species [10,11] and can change the community structure of such ecosystem [12-14]. Moderate bush fire leads to the accumulation of litter on the soil surface [15] and burning of litter in the forest floor increases the organic content and other nutrient composition of the soil and further changes soil chemical characteristics [3,16-21]. In some situation, fire could be used in forest management [22-23]. Forest fire in most cases has negative effects on the ecosystem. Some of which include threat to the biodiversity and species extinction [24-26] and the ability of burnt forest to facilitate secondary succession or natural regeneration of indigenous species in its understory species could allow the restoration of biodiversity in degraded lands [27-28].

The University of Port Harcourt Biodiversity Centre is a forest conserved for over 50 years. It acts as carbon sink for the University Park and the adjoining communities. In January, 2016 the forest was extensively burnt and most of the plant and animal species in the Centre were deeply affected. The fire also resulted to habitat destruction, death of several plant, animal and insect species especially the crawling insects. This also resulted in the fragmentation of the forest. It is against this background that we investigated the effect of the fire on the understory plant species in order to determine the seedling density, diversity, relative abundance, relative frequency, relative diversity, importance value indices and the potential/capacity of the forest to recover from the fire incident.

2. MATERIALS AND METHODS

2.1 Study Area

The study area is located in University of Port Harcourt Biodiversity Center, Rivers State, Nigeria (N04° 35 38 - N04° 54’ 27 to E006° 54’ 50 - E006° 55’ 23) and the sampling map is shown in Fig. 1. This region contains natural and indigenous species and is a pure even-aged forest. In the study area, rainy season commences around April and extends to October. A little dry spell is experienced about the third or fourth week in August commonly called August break. This trend is however fast changing due to the current climate change regime. Dry season is experienced between November and March.

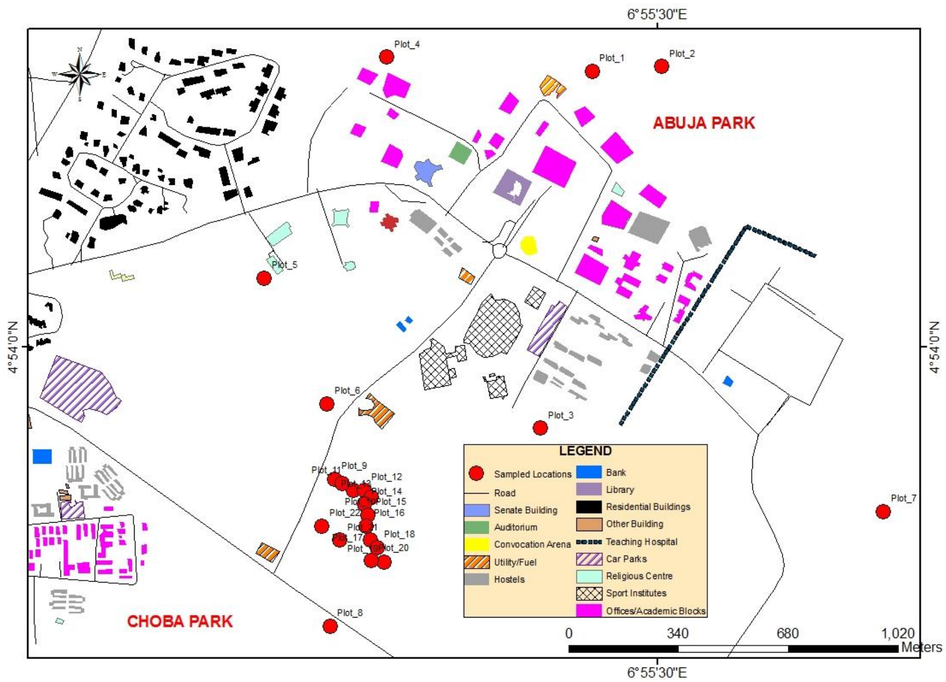

Fig. 1. Map showing the sample points

The relative humidity values varied in the study area from 54.6 - 87.5%. Periods of very low humidity occur between December to February during the harmattan spell.

2.2 Data Collection and Analysis

Twenty four (4m x 4m) quadrats (14 burnt and 10 un-burnt or control) were mapped out (Fig. 1). The plant seedlings were sampled and identified [29–31]. Inventory of plant seedlings in these quadrats were taken and the diversity, relative abundance, relative frequency, relative diversity, species importance value, family importance value and seedling density were determined [14,32–37].

$$\text{Seedling density (ha}^{-1}\text{)} = \frac{\text{Total number of species in all plots x 10000}}{\text{Total number of plots sampled}}$$

$$\text{Relative abundance (\%)} = \frac{\text{Total number of individuals of the species in all plots x 100}}{\text{Total number of species sampled}}$$

In this study we calculated Species Importance Value (SIV) and Family Importance Value (FIV) as follows:

Species Importance Value (SIV) = Species relative frequency + Species relative density.

Where:

$$\text{Species relative abundance (\%)} = \frac{\text{Total number of individuals of the species in all plots x 100}}{\text{Total number of species sampled}}$$

$$\text{Species relative density (\%)} = \frac{\text{Total number of individual of the species x 100}}{\text{Total number of species sampled}}$$

Family Importance Value (FIV) = Family relative frequency + Family relative density.

Where:

$$\text{Family relative abundance(\%)} = \frac{\text{Total number of individuals of the family in all the plots} \times 100}{\text{Total number of species sampled}}$$

$$\text{Family relative density (\%)} = \frac{\text{Total number of individual species of the family} \times 100}{\text{Total number of plots sampled}}$$

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Floristic composition

In the study area, a total of 53 plant species belonging to 35 families were identified. The un-burnt (control) plots had 11 plant species with 9 plant families while the burnt (impacted) plots had 52 plant species and 33 families (Table 1). In the control plots, Fabaceae and Rubiaceae families had the maximum number of plant species, two species each while the other families had one plant species each. In burnt plots, Asteraceae and Poaceae families had five plant species each, Apocyanaceae (4 plant species), Fabaceae and Rubiaceae families (3 plant species each), Araceae, Commelinaceae, Convolvulaceae, Cyperaceae and Euphorbiaceae (2 plant species each) while the remaining families had one species each. Based on the habit of the plant species identified, we observed increase in number of plant species, seedling density, relative abundance, species density and importance values (dominance) between the burnt and the control plots. For instance, in the burnt plots lianas, grasses, herbs, shrubs and trees had 8, 7, 21, 9 and 7 plant species respectively while in the control plots we recorded 2, 0, 2, 3 and 4 for lianas, grasses, herbs, shrubs and trees respectively (Table 2) but the relative abundance of lianas and trees in the control plots were less than that of burnt plots.

3.1.2 Species seedling density (ha^{-1})

The individual species seedling density in the burnt plots studied varied from 57 seedling ha^{-1} to 9091 seedling ha^{-1}. The maximum seedling density (seedling ha^{-1}) was recorded by *Digitaria* sp. while *Culcasia scandens, Elytropus chilensis, Indigofera hirsuta*, *Ipomoea involucrata, Ludwigia abyssinica*, *Phyllanthus* sp., and *Smilax anceps* have the least seedling density of 57 seedling ha^{-1} (Table 1). Other values recorded include; *Macrosphyra longistyla* (8977 seedling ha^{-1}); *Paliosota hirsute* (6364 seedling ha^{-1}); *Vigna* sp. (6136 seedling ha^{-1}); *Alchornea cordifolia* (5568 seedling ha^{-1}); *Paspalum conjugatum* (5227 seedling ha^{-1}); *Disotis rotundifolia* (3977 seedling ha^{-1}); *Sterculia tragacantha* (3636 seedling ha^{-1}); *Platostoma* sp. (2614 seedling ha^{-1}); *Brachiaria lata* (2557 seedling ha^{-1}); Sedges (2159 seedling ha^{-1}); *Oldenlandia lancifolia* (1705 seedling ha^{-1}); *Funtumia* sp. (1591 seedling ha^{-1}); *Baphia nitida* (1307 seedling ha^{-1}); Vicoa leptoclada (1193 seedling ha^{-1}), *Cissus reppenda* (1136 seedling ha^{-1}), *Urena lobata* (1136 seedling ha^{-1}), *Acroceras zizanioides* (1023 seedling ha^{-1}), *Ipomoea* sp. (966 seedling ha^{-1}), *Lindernia crustacea* . (909 seedling ha^{-1}), *Picralima nitida,* (795 seedling ha^{-1}), *Marantochloa cuspidata* (739 seedling ha^{-1}), *Coccinnia barteri*. (682 seedling ha^{-1}), *Combretum platypterum, Panicum laxum*, *Setaria pumila*, (568 seedling ha^{-1}), *Cleistopholis patens* (511 seedling ha^{-1}), *Crinum firmifolium* (455 seedling ha^{-1}), *Commelina* sp., *Spermacoce ocymoides*, *Spigelia anthelmia* (398 seedling ha^{-1}), *Ageratum conyzoides* (341 seedling ha^{-1}), *Acioa* sp., *Adenia gumefera*, *Harungana madagascariensis,* and *Trema orientalis* (seedling ha^{-1} each), *Chromolenea ordorata* *Vernonia* sp, *Ficus* sp, and *Melastomastrum capitatum*, (227 seedling ha^{-1} each), *Elaeis guineensis* and *Mikamia cordata* (170 seedling ha^{-1} each), *Cleome rutidosperma*, *Cyathula prostrata* and *Tabernaemontana* sp. (114 seedling ha^{-1} each). The relative abundance followed the same sequence as seedling density and varied from 11.834% to 0.074%.

Table 1. Species seedling density, relative abundance, relative frequency, relative diversity and species importance value of the plants in the study area

S/N	Species name	Family	SD (ha^{-1})	RA (%)	RF (%)	RD (%)	SIV
Unburnt (control) plots							
1	*Picralima nitida* Durand & Hook.	Apocyanaceae	1042	3.521	5.556	9.837	15.393
2	*Elaeis guineensis* Jacq.	Araceae	1250	4.225	5.556	10.132	15.687
3	*Chromolenea ordorata* (L.) R.M. King & H. Rob.	Asteraceae	1458	4.930	11.111	9.879	20.991
4	*Alchornea cordifolia* (Schum. & Thonn.) Müll.-Arg.	Euphorbiaceae	2917	9.859	11.111	8.558	19.669
5	*Baphia nitida* Lodd.	Fabaceae	6250	21.127	16.667	8.569	25.236
6	*Vigna sp*	Fabaceae	3125	10.563	8.333	8.947	17.280
7	*Spigelia anthelmia* Linn.	Longaniaceae	1042	3.521	5.556	9.837	15.393
8	*Acroceras zizanioides* (Kunth) Dandy	Poaceae	8542	28.873	8.333	6.536	14.870
9	*Macrosphyra longistyla* (DC.) Hiern	Rubiaceae	1458	4.930	11.111	9.879	20.991
10	*Spermacoce ocymoides* Burm. f.	Rubiaceae	2500	8.451	13.889	9.55	23.439
11	*Cissus rependa* Vahl.	Vitaceae	1042	3.521	5.556	9.837	15.393
Burnt plots							
1	*Cyathula prostrata* (L.) Blume	Amaranthaceae	114	0.148	0.741	0	0.741
2	*Crinum firmifolium Baker f.*	Amaryllidaceae	455	0.592	0.741	0	0.741
3	*Cleistopholis patens* (Benth.) Engl. & Diels	Annonaceae	511	0.666	2.963	3.765	6.728
4	*Funtumia* sp	Apocyanaceae	1591	2.071	1.481	1.956	3.437
5	*Picralima nitida* (Stapf) T.Durand & H.Durand	Apocyanaceae	795	1.036	2.963	3.952	6.915
6	*Elytropus chilensis* (A. DC.) Muell-Arg.	Apocyanaceae	57	0.074	0.741	0	0.741
7	*Tabernaemontana sp*	Apocyanaceae	114	0.148	1.481	3.982	5.463
8	*Culcasia scandens* P. Beauv.	Araceae	57	0.074	0.741	0	0.741
9	*Syngonium podophyllum* Schott.	Araceae	1193	1.553	1.481	3.975	5.456
10	*Elaeis guineensis* Jacq.	Arecaceae	170	0.222	1.481	3.656	5.138
11	*Ageratum conyzoides* L.	Asteraceae	341	0.444	2.222	3.144	5.366
12	*Chromolenea ordorata* (L.) R. M. King & H. Rob.	Asteraceae	227	0.296	2.222	3.768	5.99
13	*Vernonia* sp	Asteraceae	227	0.296	1.481	3.982	5.463
14	*Mikamia cordata* (Burm.f.) B. L. Rob.	Asteraceae	170	0.222	0.741	0	0.741
15	*Disotis rotundifolia* (Sm.) Jac.	*Balsaminaceae*	3977	5.178	2.222	2.886	5.108
16	*Acioa* sp	Chrysobalanaceae	284	0.370	1.481	3.866	5.347
17	*Cleome rutidosperma* DC.	Cloemaceae	114	0.148	0.741	0	0.741
18	*Combretum platypterum* (Welw.) Hutch. & Dalziel	Combretaceae	568	0.740	0.741	0	0.741
19	*Paliosota hirsuta* (Thunb.) K. Schum	Commelinaceae	6364	8.284	3.704	3.418	7.122

S/N	Species name	Family	SD (ha^{-1})	RA (%)	RF (%)	RD (%)	SIV
20	*Commelina* sp	Commelinaceae	398	0.518	0.741	0	0.741
21	*Ipomoea involucrata* P. Beauv.	Convolvulaceae	57	0.074	0.741	0	0.741
22	*Ipomoea* sp	Convolvulaceae	966	1.257	2.963	3.41	6.373
23	*Coccinnia barteri* (Hook. f.) Keay	Cucurbitaceae	682	0.888	2.222	3.905	6.127
24	*Paspalum conjugatum* Berg.	Poaceae	5227	6.805	2.222	2.636	4.858
25	Sedges	Cyperaceae	2159	2.811	0.741	0	0.741
26	*Phyllanthus* sp	Euphorbiaceae	57	0.074	0.741	0	0.741
27	*Alchornea cordifolia* (Schum. & Thonn.) Müll.-Arg.	Euphorbiaceae	5568	7.249	9.63	3.655	13.284
28	*Baphia nitida* Lodd.	Fabaceae	1307	1.701	4.444	2.942	7.387
29	*Indigofera hirsuta* Linn.	Fabaceae	57	0.074	0.741	0	0.741
30	*Vigna* sp	Fabaceae	6136	7.988	4.444	2.462	6.906
31	*Harungana madagascariensis* Lam. ex Poiret	Hypericaceae	284	0.370	1.481	3.866	5.347
32	*Platostoma* sp	Lamiaceae	2614	3.402	3.704	1.387	5.091
33	*Lindernia crustacea* (L.) F. Muell.	Linderniaceae	909	1.183	1.481	3.8	5.282
34	*Spigelia anthelmia* Linn.	Loganiaceae.	398	0.518	1.481	3.437	4.918
35	*Urena lobata* L	Malvaceae	1136	1.479	0.741	0	0.741
36	*Marantochloa cuspidata* (Roscoe) Milne-Redh.	Maranthaceae	739	0.962	1.481	1.558	3.039
37	*Melastomastrum capitatum* (Vahl.) A. & R. Fern	Melastomataceae	227	0.296	0.741	0	0.741
38	*Ficus* sp	Moraceae	227	0.296	1.481	3.982	5.463
39	*Ludwigia abyssinica* A. Rich	Onagraceae	57	0.074	0.741	0	0.741
40	*Adenia gumefera* (Harv.) Harms.	Passifloraceae	284	0.370	0.741	0	0.741
41	*Acroceras zizanioides* (Kunth) Dandy	Poaceae	1023	1.331	2.222	3.144	5.366
42	*Brachiaria lata* (Schumach.) C.E.Hubb.	Poaceae	2557	3.328	1.481	0.612	2.094
43	*Digitaria* sp	Poaceae	9091	11.834	3.704	3.631	7.335
44	*Panicum laxum* Sw.	Poaceae	568	0.740	0.741	0	0.741
45	*Setaria pumila (*Poir.) Roem & Schult.	Poaceae	568	0.740	0.741	0	0.741
46	*Macrosphyra longistyla* (DC.) Hiern	Rubiaceae	8977	11.686	6.667	3.256	9.923
47	*Oldenlandia lancifolia* (Schumah.) DC.	Rubiaceae	1705	2.219	0.741	0	0.741
48	*Spermacoce ocymoides* Burm. f.	Rubiaceae	398	0.518	1.481	3.437	4.918
49	*Smilax anceps* Willd.	Smilaceae	57	0.074	0.741	0	0.741
50	*Sterculia tragacantha* Lindl.	Sterculiaceae	3636	4.734	2.222	3.202	5.425
51	*Trema orientalis* Linn. Blume	Ulmaceae	284	0.370	0.741	0	0.741
52	*Cissus rependa* Vahl.	Vitaceae	1136	1.479	4.444	3.328	7.773

Note: SD – Seedling density; RA – Relative abundance; RF – Relative frequency; RD – Relative diversity; SIV – Species importance value; ha – Hectare

3.1.3 Species relative frequency

In the burnt plots, a total of 52 plant species were identified. Among the species *Alchornea cordifolia* had the highest relative frequency of 9.63%. This is followed by *Macrosphyra longistyla* (6.67%), *Vigna* sp, *Baphia nitida* Lodd. and *Cissus rependa* (4.44% each), *Digitaria* sp, *Paliosota hirsuta* and *Platostoma* sp. (3.70% each), *Ipomoea* sp, *Picralima nitida* and *Cleistopholis patens* (2.96% each), *Paspalum conjugatum*, *Disotis rotundifolia, Sterculia tragacantha*, *Acroceras* sp, *Coccinnia barteri*, *Ageratum conyzoides* and *Chromolenea ordorata* (2.22% each), *Brachiaria lata, Funtumia* sp, *Vicoa leptoclada*, *Lindernia crustacean, Marantochloa cuspidata, Spermacoce ocymoides*, *Spigelia anthelmia*, *Acioa* sp., *Harungana madagascariensis*, *Vernonia* sp, *Ficus* sp., *Elaeis guineensis* and *Tabernaemontana* sp. (1.48% each). The least value 0.74% was recorded by Sedges, *Oldenlandia lancifolia*, *Urena lobata, Combretum platypterum*, *Panicum laxum*, *Setaria pumila*, *Crinum firmifolium*, *Commelina* sp., *Adenia gumefera, Trema orientalis, Melastomastrum capitatum*, *Mikamia cordata, Cleome rutidosperma*, *Cyathula prostrata, Culcasia scandens, Elytropus chilensis, Indigofera hirsuta*, *Ipomoea involucrata, Ludwigia abyssinica*., *Phyllanthus* sp. and *Smilax anceps*. In the unburnt (control) plots relative frequencies of the species were relatively higher than the burnt plots. *Baphia nitida* (16.67%) had the maximum relative frequency. The relative frequencies of the other species include; *Picralima nitida, Elaeis guineensis Spigelia anthelmia* and *Cissus rependa* (5.56% each), *Vigna sp* and *Acroceras zizanioides* (8.33% each), *Chromolenea ordorata, Alchornea cordifolia* and *Macrophylla longistylis* (11.11% each) and *Spermacoce ocymoides sp* (13.89%).

3.1.4 Species relative diversity

Among the species sampled, *Vernonia* sp., *Ficus* sp. and *Tabernaemontana* sp. had the maximum relative diversity of 3.98. This is followed by *Syngonium podophyllum* and *Picralima nitida* (3.98 each), *Coccinnia* sp. (3.905), *Acioa* sp. and *Harungana madagascarensis* (3.87 each), *Lindernia crustacean,* (3.80), *Chromolenea ordorata* (3.77), *Cleistopholis patens* (3.77), *Elaeis guineensis* (3.67), *Alchornea cordifolia* (3.66), *Digitaria* sp. (3.63), *Spermacoce ocymoides* and Spigelia *anthelmia* (3.44 each), *Paliosota hirsuta* (3.42), *Ipomoea* sp (3.41), *Cissus rependa* (3.33), *Macrosphyra longistyla* (3.26), *Sterculia tragacantha* (3.20), *Acroceras zizanioides* and *Ageratum conyzoides* L. (3.14 each), *Baphia nitida* (2.94), *Disotis rotundifolia* (2.89), *Paspalum conjugatum* (2.64), *Vigna* sp. (2.46), *Funtumia* sp. (1.96), *Marantochloa cuspidata* (1.56), *Platostoma* sp. (1.39), *Brachiaria lata* (0.61) while Sedges, *Oldenlandia lancifolia*, *Urena lobata, Combretum platypterum, Panicum laxum, Setaria pumila*, *Crinum firmifolium*, *Commelina* sp., *Adenia gumefera, Trema orientalis, Melastomastrum capitatum*, *Mikamia cordata, Cleome rutidosperma*, *Cyathula prostrata, Culcasia scandens, Elytropus chilensis, Indigofera hirsuta*, *Ipomoea involucrata, Ludwigia abyssinica*., *Phyllanthus* sp. and *Smilax anceps* (0.0 each).

3.1.5 Burnt area species importance value (SIV)

The species importance value in the burnt areas showed the following sequence: *Alchornea cordifolia* (13.28), *Macrosphyra longistyla* (9.92), *Cissus rependa* (7.77), *Baphia nitida* (7.39), *Digitaria* sp. (7.34), *Paliosota hirsuta* (7.12), *Picralima nitida* (6.92), *Vigna* sp. (6.91), *Cleistopholis patens* (6.73), *Ipomoea* sp. (6.37), *Coccinnia barteri*. (6.13), *Chromolenea ordorata* (5.99), *Vernonia* sp., *Ficus* sp. and *Tabernaemontana* sp. (5.46), *Vicoa leptoclada* and *Sterculia tragacantha* (5.46), *Acroceras zizanioides* and *Ageratum conyzoides* (5.37 each), *Acioa* sp. and *Harungana madagascariensis* (5.35 each), *Lindernia crustacea* (5.28), *Elaeis guineensis* (5.14), *Disotis rotundifolia* (5.11), *Platostoma* sp. (5.09), *Spermacoce ocymoides* and *Spigelia anthelmia*. (4.92), *Paspalum conjugatum* (4.86), *Funtumia* sp. (3.44), *Marantochloa cuspidate* (3.04), *Brachiaria lata* (2.09) and Sedges, *Oldenlandia lancifolia*, *Urena lobata, Combretum platypterum, Panicum laxum, Setaria pumila*, *Crinum firmifolium*, *Commelina* sp., *Adenia gumefera, Trema orientalis, Melastomastrum capitatum*, *Mikamia cordata, Cleome rutidosperma*, *Cyathula prostrata, Culcasia scandens, Elytropus chilensis, Indigofera hirsuta*, *Ipomoea involucrata, Ludwigia abyssinica*., *Phyllanthus* sp. and *Smilax anceps* (0.74 each) Table 2.

3.1.6 Family relative diversity

The relative diversity of the different families of plant seedlings in the study area varied from 0.0 to 9.67 in burnt plots and 6.33 to 14.26 for control plots (Table 3). In the burnt plots, the relative diversities of the plant families include: Euphorbiaceae (9.67), Poaceae (7.97), Rubiaceae (7.86), Asteraceae (7.83), Fabaceae (6.64), Vitaceae (6.06), Apocyanaceae (5.98) Commelinaceae (5.59), Annonaceae (5.30), Convolvulaceae (4.70), Cyperaceae (4.52), Cucurbitaceae (4.36), Sterculiaceae (3.57), Balsaminaceae (3.22), Moraceae (2.80), Araceae (2.78), Chrysobalanaceae (2.72), Linderniaceae (2.67), Loganiaceae (2.42), Lamiaceae (2.27), Maranthaceae (1.10), Amaranthaceae, Amaryllidaceae, Cloemaceae, Combretaceae, Malvaceae, Melastomataceae, Onagraceae, Passifloraceae, Smilaceae and Ulmaceae (0.0) while in the control plots we recorded; Fabaceae (14.26), Vitaceae (14.28), Asteraceae (12.72), Euphorbiaceae (11.02), Longaniaceae (9.13), Rubiaceae (6.67), Araceae (6.52), Poaceae and Apocyanaceae (6.33 each), Rubiaceae (2.72) Table 2. This indicates that the fire exposed the forest canopy and enhanced the germination of the seeds of the members of these families that are in the soil but were prevented from germination by the shed from the forest canopy.

Table 2. Composition of plant seedlings in the study area based on their habit

Habit	No. of species	SD (ha^{-1})	RA (%)	SIV
Burnt plots				
Lianas	8	3839	5.97	38.02
Grasses	7	16785	26.1	31.86
Herbs	21	31293	48.65	50.78
Shrubs	9	8214	12.77	46.58
Trees	7	4196	6.52	32.78
Control plots				
Lianas	2	2422	21.83	61.47
Grasses	0	0	0	0
Herbs	2	1789	15.49	64.04
Shrubs	3	4298	38.73	58.15
Trees	4	1953	17.61	77.80

Note: SD – Seedling density; RA – Relative abundance; Sp. - Species; SIV – Species importance value; ha – Hectare

3.1.7 Family importance value (FIV)

In the Burnt Sites, FIV varied from 0.81 to 21.05 while it ranged from 12.05 to 13.41 in the control plots. Euphorbiaceae family had the maximum FIV in the burnt sites. This is followed by Fabaceae (17.21), Rubiaceae (15.99), Poaceae (15.29), Asteraceae (14.33), Apocyanaceae (12.48), Vitaceae (10.93), Commelinaceae (9.65), Annonaceae (8.55), Convolvulaceae (7.95), Cyperaceae (7.78), Cucurbitaceae (6.80), Lamiaceae (6.33), Sterculiaceae (6.01), Balsaminaceae (5.66), Araceae (5.22), Moraceae (4.43), Chrysobalanaceae (4.35), Linderniaceae (4.30), Loganiaceae (4.044), Maranthaceae (2.72) and Amaranthaceae Amaryllidaceae, Cloemaceae, Combretaceae, Malvaceae, Melastomataceae, Onagraceae, Passifloraceae, Smilaceae, Ulmaceae and Unknown (0.81 each). On the other hand, Fabaceae had the highest FIV in the control plots while other families include; Vitaceae (28.56), Asteraceae and Rubiaceae (24.15 each), Euphorbiaceae (22.45), Longaniaceae (17.70), Rubiaceae (15.24), Araceae (12.24), Poaceae and Apocyanaceae (12.05 each).

3.1.8 Family relative frequency (%)

In the burnt plots we observed that Euphorbiaceae (11.38%) had the highest relative frequency. This is followed by Fabaceae (10.57%), Rubiaceae (8.13), Poaceae (7.32), Asteraceae, Apocyanaceae (6.50% each), Vitaceae (4.878%), Commelinaceae and Lamiaceae (4.065%), Annonaceae, Convolvulaceae, Cyperaceae (3.25 each), Cucurbitaceae, Sterculiaceae, Balsaminaceae, Araceae (2.44% each) and Moraceae, Chrysobalanaceae, Linderniaceae, Loganiaceae and Maranthaceae (1.63% each) while Amaranthaceae, Amaryllidaceae, Cloemaceae, Combretaceae, Malvaceae, Melastomataceae, Onagraceae, Passifloraceae, Smilaceae, Ulmaceae and Unknown had the lowest relative frequency (0.81%) (Table 3). On the other hand, in the control plots Fabaceae (17.14%) which was the second largest in the burnt plots was had the maximum relative frequency. The relative frequencies of other families in the control plots include; Vitaceae (14.29%), Asteraceae Rubiaceae and Euphorbiaceae (11.43% each); Longaniaceae and Rubiaceae (8.57% each); Araceae, Poaceae and Apocyanaceae (5.71% each).

3.1.9 Family seedling density

The seedling density in the control and burnt plots are relatively different. In burnt plots we had Poaceae (15987ha^{-1}), Rubiaceae (12829 ha^{-1}), Fabaceae (8684 ha^{-1}), Cyperaceae (8553ha^{-1}), Commelinaceae (7368ha^{-1}), Euphorbiaceae (6842ha^{-1}), Balsaminaceae (4605 ha^{-1}), Sterculiaceae (4211 ha^{-1}), Lamiaceae (3026 ha^{-1}), Apocyanaceae (2895 ha^{-1}), Vitaceae (1316 ha^{-1}), Malvaceae (1316), Convolvulaceae (1184 ha^{-1}), Asteraceae (1118 ha^{-1}), Linderniaceae (1053 ha^{-1}), Araceae and Maranthaceae (855 ha^{-1}), Cucurbitaceae (789 ha^{-1}), Combretaceae (658 ha^{-1}), Annonaceae (592 ha^{-1}), Amaryllidaceae (526 ha^{-1}), Loganiaceae (461 ha^{-1}), Chrysobalanaceae (329 ha^{-1}), Passifloraceae (329 ha^{-1}), Ulmaceae (329 ha^{-1}), Moraceae and Melastomataceae (263 ha^{-1} each), Amaranthaceae and Cloemaceae (132 ha^{-1} each), Onagraceae, Smilaceae and Unknown (66 ha^{-1} each). In the control plots the family densities are as follows: Rubiaceae (8542 ha^{-1}), Fabaceae (6250 ha^{-1}), Longaniaceae (3125 ha^{-1}), Euphorbiaceae (2917 ha^{-1}), Vitaceae (2500 ha^{-1}), Asteraceae (1458 ha^{-1}), Rubiaceae (1458 ha^{-1}), Araceae (1250 ha^{-1}), Poaceae and Apocyanaceae (1042 ha^{-1} each). The family seedling densities in the burnt plots are relatively higher than in the control plots.

3.1.10 Family relative abundance (%)

The family relative abundance in the study area varied from 0.07% in the burnt plots to 28.78% in the control plots (Table 3). In the burnt plots, Poaceae (17.97%) had the maximum value while the values for the other families are as follows: Rubiaceae (14.42%), Fabaceae (9.76%), Cyperaceae (9.62%), Commelinaceae (8.284%), Euphorbiaceae (7.69%), Balsaminaceae (5.18%), Sterculiaceae (4.73%), Lamiaceae (3.40%), Apocyanaceae (3.25%), Vitaceae and Malvaceae (1.48% each), Convolvulaceae (1.33%), Asteraceae (1.26%), Linderniaceae (1.18%), Araceae and Maranthaceae (0.96%), Cucurbitaceae (0.89%), Combretaceae (0.74%), Annonaceae (0.67%), Amaryllidaceae (0.59%), Loganiaceae (0.52%), Chrysobalanaceae and Passifloraceae (0.37%), Ulmaceae (0.37%), Moraceae and Melastomataceae (0.30%), Amaranthaceae and Cloemaceae (0.15% each), Onagraceae, Smilaceae and *Syngonium podophyllum* (0.07% each). On the other hand, in the control plots, Rubiaceae (28.87%) had the maximum value while the values like Fabaceae Longaniaceae Euphorbiacea, Vitaceae, Asteraceae, Rubiaceae, Araceae had 21.13%, 10.56%, 9.86%, 8.45%, 4.93%, 4.93% and 4.23% respectively. Poaceae and Apocyanaceae had the least value 3.52%.

3.2 Discussion

Anthropogenic activities have strongly impacted on biodiversity at local and global levels and resulting in introduction of new species, reduction in indigenous species and species extinctions [15,38-40]. In the same way, the changes in ecosystem productivity resulting from humans land use pattern also contribute to alteration in the nutrient cycle [40-41] and species diversity and productivity [42-47]. Some of these human induced activities include bush burning and has been practiced in many parts of the world as an accepted integral part of the traditional farming system [48,49,50]. In many countries, fire is used for hunting, clearing of agricultural land, maintaining grass lands, controlling pests and removing dry vegetation and crop residues to promote agricultural productivity [48] and in some cases a natural ecological tool [51]. However, fire has been noted to have adverse effects like soil degradation [17-21], encourages accumulation of litter on the surface of the soil [15] and threatens wild endangered species [24] in the ecosystem.

The findings of this study showed that burning affects species diversity, frequency and number of specimen per plot. For instance, in the burnt plots, the range (mean ± standard deviation) number of species per plot is 2 – 10 (6.389 ± 2.085) while in the control plots it is 3 – 8 (5.833 ± 1.507). Also, the number of plant families, genera and species in the burnt and control plots varied. In the burnt plots we had 33 plant families, 51 genera and 52 species. In contrast, the control plots had 10 families, 11 genera and 11 species. In a similar study, [52-54] have reported that bush burning results to reduction in plant species diversity, number of plant species per plot and in the total number of species per plot. Fire can also affect plant community by reducing the dominance of certain plant species or single species and on the other hand enhance the abundance of some other ones [12,26,54-57]. In our study, we noted that *Alchornea cordifolia* and *Macrosphyria longisata* were the dominant plants in the burnt plots while in the control plots, *Cissus rependa* was the dominant plant. Although *Alchornea cordifolia, Baphia nitida, Spermacoce ocymoides* and *Chromolenea ordorata* were the next dominant species in the control plots, there was an increase in the density of *Alchornea cordifolia* and other dominant species found in the burnt plots are not the dominant plants in the control plots (Tables 1 and 2). Furthermore, we observed that two of the species (*Elaeis guineensis* and *Chromolenea ordorata*) recorded in the control plots were not recorded in burnt plots but were replaced by other species. This confirms the fact that fire encourages the emergent of plant species suppressed by the forest canopy and support the ecology of secondary succession as reported by [52].

Table 3. Family seedling density, relative abundance, relative frequency, relative diversity and species importance value of the plant in the study area

S/N	Family	No. of genus	SD	SE	SDS (ha^{-1})	RA (%)	RF (%)	RD (%)	FIV
Burnt plots									
1	Amaranthaceae	1	0.00	0.00	132	0.15	0.81	0.00	0.81
2	Amaryllidaceae	1	0.00	0.00	526	0.59	0.81	0.00	0.81
3	Annonaceae	1	1.31	0.95	592	0.67	3.25	5.30	8.55
4	Apocyanaceae	3	1.48	0.71	2895	3.25	6.50	5.98	12.48
5	Araceae	3	0.69	0.63	855	0.96	2.44	2.78	5.22
6	Asteraceae	4	1.94	0.93	1118	1.26	6.50	7.83	14.33
7	Balsaminaceae	1	0.80	0.73	4605	5.18	2.44	3.22	5.66
8	Chrysobalanaceae	1	0.67	0.97	329	0.37	1.63	2.72	4.35
9	Cloemaceae	1	0.00	0.00	132	0.15	0.81	0.00	0.81
10	Combretaceae	1	0.00	0.00	658	0.74	0.81	0.00	0.81
11	Commelinaceae	1	1.38	0.86	7368	8.28	4.07	5.59	9.65
12	Convolvulaceae	2	1.16	0.84	1184	1.33	3.25	4.70	7.95
13	Cucurbitaceae	1	1.08	0.98	789	0.89	2.44	4.36	6.80
14	Cyperaceae	2	1.12	0.81	8553	9.62	3.25	4.52	7.78
15	Euphorbiaceae	2	2.39	0.91	6558	7.32	9.90	5.80	15.71
16	Fabaceae	3	1.64	0.64	8684	9.76	10.57	6.64	17.21
17	Lamiaceae	1	0.56	0.35	3026	3.40	4.07	2.27	6.33
18	Linderniaceae	1	0.66	0.95	1053	1.18	1.63	2.67	4.30
19	Loganiaceae.	1	0.60	0.86	461	0.52	1.63	2.42	4.04
20	Malvaceae	1	0.00	0.00	1316	1.48	0.81	0.00	0.81
21	Maranthaceae	1	0.27	0.39	855	0.96	1.63	1.10	2.72
22	Melastomataceae	1	0.00	0.00	263	0.30	0.81	0.00	0.81
23	Moraceae	1	0.69	1.00	263	0.30	1.63	2.80	4.43
24	Onagraceae	1	0.00	0.00	66	0.07	0.81	0.00	0.81
25	Passifloraceae	1	0.00	0.00	329	0.37	0.81	0.00	0.81
26	Poaceae	5	1.97	0.90	15987	17.97	7.32	7.97	15.29
27	Rubiaceae	3	1.94	0.84	12829	14.42	8.13	7.86	15.99
28	Smilaceae	1	0.00	0.00	66	0.07	0.81	0.00	0.81
29	Sterculiaceae	1	0.88	0.80	4211	4.73	2.44	3.57	6.01
30	Ulmaceae	1	0.00	0.00	329	0.37	0.81	0.00	0.81
31	Vitaceae	1	1.50	0.84	1316	1.48	4.88	6.06	10.93
32	Hypericaceae	1	0.67	0.97	284	0.37	1.48	3.87	5.35
33	Unknown	1	0.00	0.00	66	0.07	0.81	0.00	0.81
Unburnt or control plots									
1	Poaceae	1	0.67	0.97	1042	3.52	5.71	6.33	12.05
2	Euphorbiaceae	1	1.17	0.85	2917	9.86	11.43	11.02	22.45
3	Fabaceae	2	1.52	0.85	6250	21.13	17.14	14.26	31.41
4	Asteraceae	1	1.35	0.98	1458	4.93	11.43	12.72	24.15
5	Vitaceae	1	1.52	0.94	2500	8.45	14.29	14.28	28.56
6	Araceae	1	0.69	1.00	1250	4.23	5.71	6.52	12.24
7	Rubiaceae	1	0.71	0.65	8542	28.87	8.57	6.67	15.24
8	Apocyanaceae	1	0.67	0.97	1042	3.52	5.71	6.33	12.05
9	Rubiaceae	1	1.35	0.98	1458	4.93	11.43	12.72	24.15
10	Longaniaceae	1	0.97	0.88	3125	10.56	8.57	9.13	17.70

Note: No. – Number; RA – Relative abundance; freq. – Frequency; RF – Relative frequency; RD – Relative diversity; SD - Seedling density; SIV – Species importance value; ha – Hectare

We also noted that fire increased richness of the plant species. This is evident as there are more plant species in the burnt plots than the control plots. This phenomenon has been reported by several authors [6,57–59]. In their study Marozas [6] stated that surface fire leads to richness of land vegetation cover and preliminary substitute species generally help further richness. They also noted that most pioneer species appear in burnt regions within 1–3 years after a fire incident. In another study in Missouri Ozarks forests, North America, Hartmann and Heumann [57] observed that fire led to an increase in the understory species diversity. Also, Hutchinson [58] stated that fire led to an increase of herbaceous species diversity and Taft [60] reported that richness and diversity of understory species increased after fire. Thus the finding of our work is in line with these studies on the basis that we recorded increase in the number of plant species and seedling density of lianas, grasses, herbs, shrubs and trees in burnt plots. However, we recorded decrease in plant diversity during this study and this therefore support [7–8,61], who observed that diversity of plant species reduced in the early years after a fire incident.

4. CONCLUSION

The findings of this work showed that when vegetation structure is affected by fire, it creates a process of forest renewal. In this case, fire stimulated the germination of certain seeds and promoted the growth of certain plants in the forest due to change in soil chemistry resulting from the burning of litter and the exposure of plant seeds to favourable conditions that encourage dormancy breaking and germination of the seeds. This however lead to decrease in the initial seedling density and dominance of herbs, shrubs and lianas but enhanced the emergence of grasses. It is therefore important to conduct further study in order to monitor the impact of other environmental factors on the recovery of the burnt flora.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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