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Original Research Article

Effects of Fire on the Stock and Diversity of Seeds of Flora in the Forest Floor of the Scientific City of Brazzaville

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The effect of fire on the soil and the diversity of the soil is the fruit of research between two institutions: National School of Agronomy and Forestry (ENSAF) and the National Institute of Research in Exact and Natural Sciences (IRSEN). Three experimental plots have been identified to observe the response of dormant seeds to soil and their evolution after fire. In the laboratory, a portion of thirty-nine (39) cores taken from the three plots was monitored. In total 3140 seedlings were counted in plot one. In the plot two 1414 seedlings and the plot 3, this number is 3142 seedlings. The (39) cores taken from the three plots in the laboratory, there were 821 seedlings, the second plot 417 while the third plot 292 seedlings. It can be seen that the number of seedlings depends on the sampling plot and the level of the soil. After the passage of a fire, the seed bank in the soil can be reconstituted.

Keywords: Granulates, evolution, seedling, a number, banks.

INTRODUCTION

Regeneration is a fundamental part of the dynamics of tropical ecosystems and the restoration of forest lands (Bakker, et al., 2000). The term "regeneration" is frequently used, but the definitions vary both in relation to the element taken into account and by the processes involved and the spatio-temporal scales considered.

Thus, foresters consider regeneration as all the juvenile individuals of the undergrowth of arboreal species (Rollet, 1981). This definition is based on what is observable and countable. In terms of population demography, it represents a vision of future settlement. For ecologists, regeneration is often seen as a set of processes that ultimately allow for the reconstitution of the forest (Alexandre, 1982).

Natural or semi-artificial banks sometimes of soil seeds play a major role in the maintenance and evolution of biodiversity in ecosystems and natural habitats. They explain the exceptional resilience of certain ecosystems in the face of fires, for example. Indeed, according to Colin (2001) the heat of the fire favors the regeneration of certain forest species.

In the humid tropical zone, if fires are natural and infrequent, the forest has sufficient ecological resilience to replenish a plant cover that can protect the soil (in a few weeks to a few months). On this stabilized soil, the forest cover is quickly restored if the fire was of minor importance, and in a few decades to centuries if the fire was very important.

A forest takes about fifteen years to regenerate following a fire depending on the intensity and frequency of the burn. The fire acts on the seed bank through the release of nutrients, the disappearance of hydrophobic substances from the litter, the lifting of dormancy and the chemical inhibition of seeds. Forest regeneration of wet or open areas is facilitated by this means. (Colin, 2001)

The absence or the inhibition of a seed bank of the soil prevents the rapid distribution of the vegetation during the phenomenon of ecological succession; while the presence of a well-stocked soil seed bank allows the rapid development of species-rich ecosystems.

Tropical forests are characterized by the very high diversity of plants and arouse great interest from the research community for their multiple roles, both for maintaining the global balance, preserving the environment (role in mitigation and adaptation to climate change) and for the health and nutrition of the thousands of people who depend directly on them (Koubouana, et al., 2015).

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The Cité Scientifique (formerly Orstom) is home to one of the most important urban forests in the city of Brazzaville. This forest is currently in great demand by anthropogenic activities such as harvesting dead wood, deforestation of border areas for the establishment of cornfields, peanuts, potatoes and moringa.

The clearing of these forest spaces is done regularly through intentional fires. Fire has effects on vegetation, litter and seed stock in the soil or seed bank. The soil seed stock contributes to the regeneration and dynamics of the forest.

Several countries in West Africa have conducted studies on the soil seed bank, characterizing it and giving importance and role to the conservation, regeneration and restoration of natural ecosystems. To our knowledge, no study has yet been conducted on the effects of fire on the recovery of vegetation, soil and soil seed stock.

The question is: what are the effects of fire on the dynamics of the regeneration of the forest of the Scientific City through the seed bank present in the burned areas?

The general objective was to evaluate the effect of fire on the stock and the viability of seeds in the forest floor of the Cité scientifique de Brazzaville. The operational objectives are:

- evaluate the seed stock in the soil;
- evaluate the impact of fire on the viability of seeds buried in the soil;
- assess the regeneration capacity of the forest after fire;
- identify the species contained in the seed bank.

The Research Hypothesis is:

The fire causes a drop in the seed stock and the diversity of species contained in the plots of the Forest of the Scientific City of Brazzaville.

MATERIAL AND METHODS

A large number of the equipment recorded in Table 1 allowed us to do this work. Initially, it was a double dekameter to delimit the three (3) plots of 5m x 5m, then the stakes were used to materialize plots in plots. Also, metal plates had been used to indicate the numbers or the names of the parcels and plots. The auger for the removal of soil cores taken over a distance of 5 m each. Plastic pots used for storing soil cores but, other tillage equipment was used as chalk, machetes.

Methods

In this work, we used the method of counting germination (seedlings) in the field and counting germination on moist soil samples incubated in the laboratory to estimate the seed bank of the soil. Seedlings are counted one (1) time per week in each plot.

Seedlings were identified by a resource person, Botanist of the National Herbarium. The precise goal here was to obtain pioneer species and forest dynamics, and Figure 1 shows the experimental setup in an area that has undergone fire in the forest of the city of sciences of Brazzaville.

The study is carried out in three plots of 25 m² (5m x 5m) each. Each plot is subdivided into 25 plots of 1m² each. Each plot is subdivided into 4 counting plates (Figure 2). Counting on a cross-device is conducted for 4 months. Carrots (13) of soil were also collected from each plot and taken to the laboratory. The soil is watered and sprouts counted for two months.

In the laboratory

The soil cores that were sampled from an auger-based sample design 5 cm in diameter and 50 cm deep were put on a plank (Figure 3).

Then you had to water every day with a pissette; and after one to two weeks after observation, the seeds began to germinate. After we started counting the seedlings, young seedlings once reached adulthood were identified (Figure 4).

RESULTS

Estimate seed bank in the field

The estimate was made by counting the number of seedlings in each plot for four months in the rainy season. This estimate shows a high variability between the count plots (Figure 5 and 6). The number of seedlings estimated by this method changes over time.

Evolution of the number of seedlings in plot 1

Figure 7 shows that the number of seedlings varies according to count plots and time. In fact, the number of seedlings is between 6 in the P32 and P41 plots and 200 in the P54 plot. A total of 618 seedlings were recorded in October in Parcel 1 (Figure 7A). In November, 967 seedlings were counted (Figure 7B). In December 1668 seedlings (Figure 7C) were counted in the plot. The number of seedlings reached 3140 at the end of the counting period in January (Figure 7D).

Evolution of the number of seedlings in plot 2

Figure 8A shows that at the beginning of the count the number of seedlings is between 13 (plot 23 and 52) and 100 (plot 21). The total number of seedlings is 440 during the month of October while it is 928 in November (Figure 8B), 1244 in December (Figure 8C) and 1414 in January (Figure 8D).

Evolution of the number of seedlings in plot 3

In plot 3, the lowest number of seedlings is recorded in the P54 plot. On the other hand, the highest number of seedlings is recorded in plot P52 (Figure 9). The total number of seedlings counted in the plot increases significantly over time. Thus, it ranges as follows: 2024 seedlings in October <2382 seedlings in November <2816 seedlings in December <3142 in January respectively in Figure 4A, 4B, 4C and 4D.

Comparison of seed bank estimate between the three plots

Comparison of seed banks shows that plot 3 contains more seeds than plot 2 and 1 regardless of the counting time.

Estimate seed bank in the laboratory

Evolution of the number of seedlings in the soil cores of Parcel 1

Figure 10 shows that the soil cores taken from plot 1 yielded a total of 821 seedlings in two months of experimentation. The first month 170 seedlings were recorded (Figure 10A1) and 651 seedlings the second month (Figure 10B1). The number of seedlings depends on the soil sample plot.

Figure 1. Experimental plan in the field

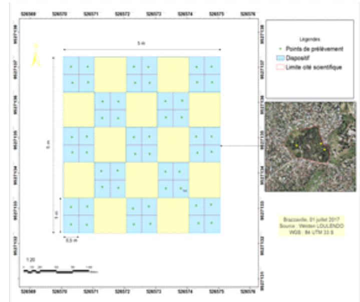

Figure 2. Device for counting seedlings

Figure 3. Experimental device of soil cores in the laboratory

Figure 4. Adult seedlings exiting soil cores at laboratory level

Figure 5. Beginning of seedling growth.

Figure 6. Seedlings having reached adult age

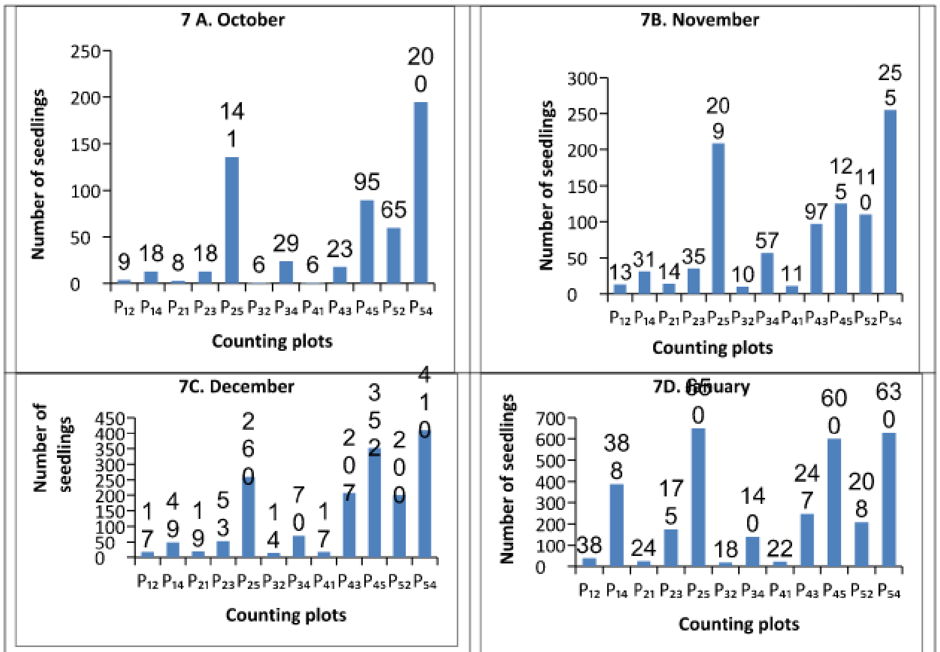

Figure 7. Evolution of the number of seedlings in plot 1

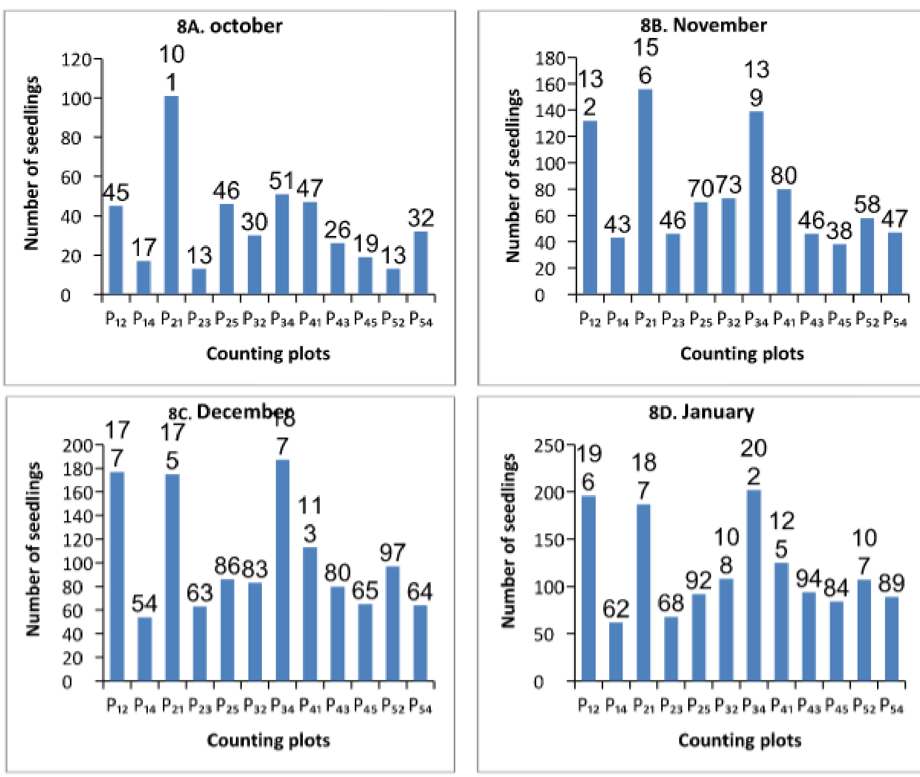

Figure 8. Evolution du nombre de plantules dans la parcelle 2

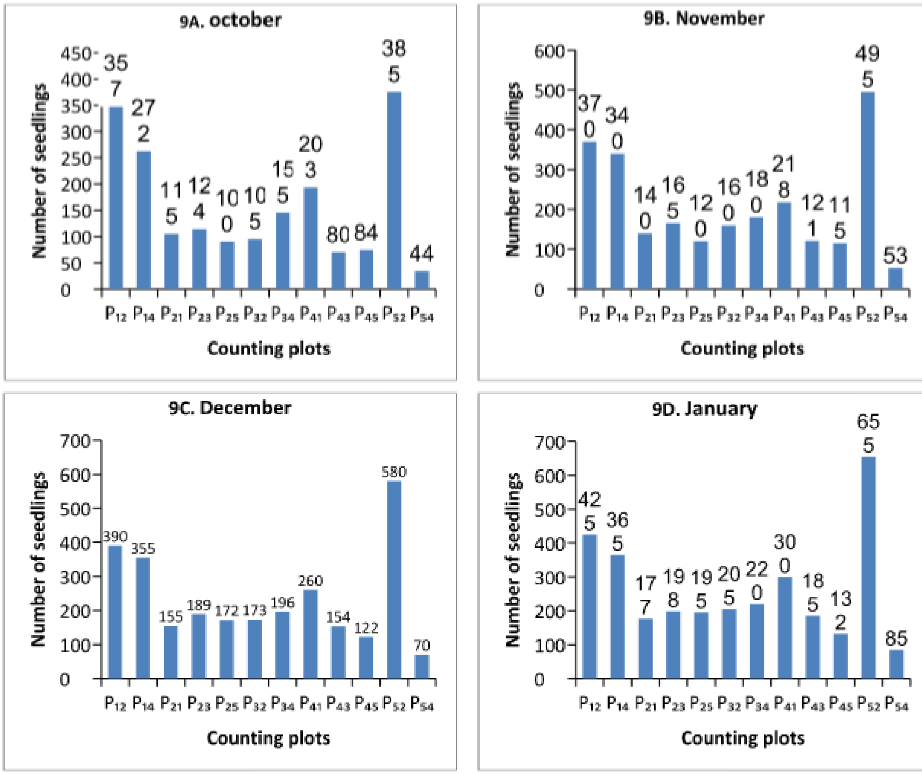

Figure 9. Evolution of the number of seedlings in plot 3

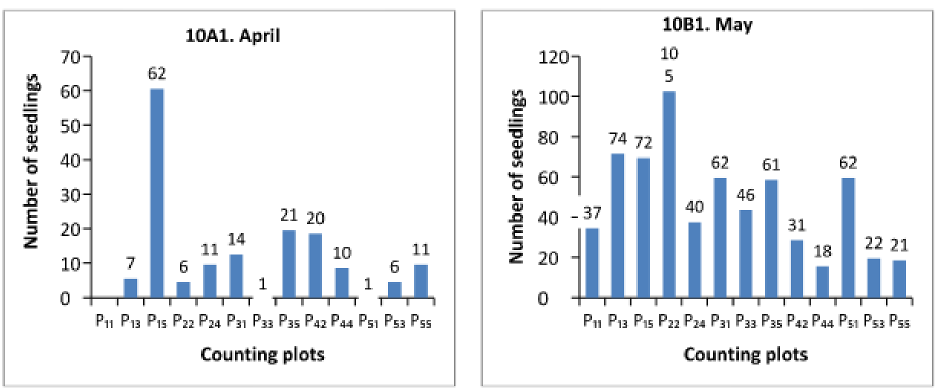

Figure 10. Evolution of the number of seedlings in the soil cores of Parcel 1

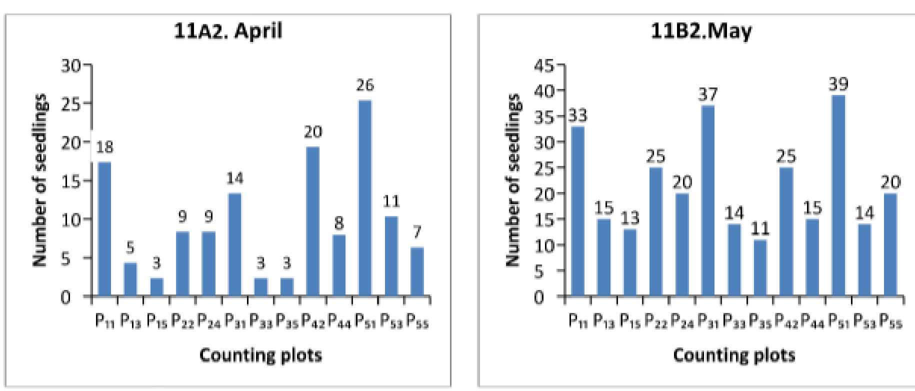

Figure 11. Evolution of the number of seedlings in the soil cores of Parcel 2

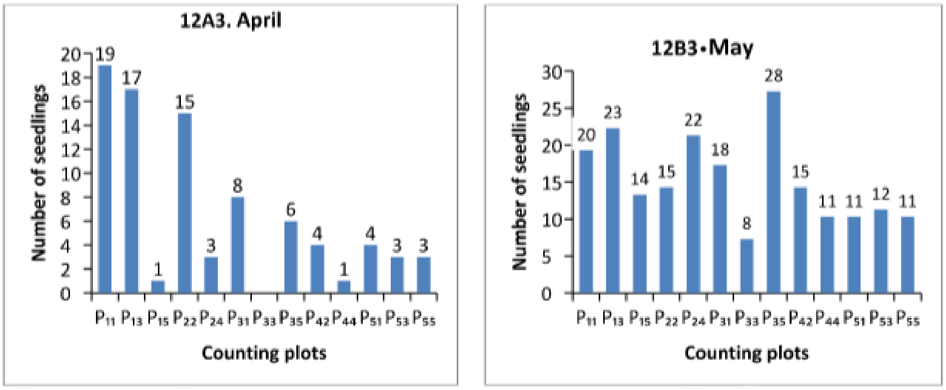

Figure 12. Evolution of the number of seedlings in the soil cores of Parcel 3

Table 1. Identification of the species contained in the seed bank in the field

Biological type	Family	Genus / species	Parcel 1	Parcel 2	Parcel 3
Thd	Amaranthaceae	*Cyathula prostrata var prostrata* (L.) Blume	35	0	985
Phgrv	Apocynaceae	*Toxocarpus brevipes (*Benth.) N.E.Br.	0	0	102
Mcph	Arecaceae	*Elaeis guineensis* Jacq.	0	72	0
Chd	Asteraceae	*Chromolaena odorata* (L.) R.King & H.Roinson	199	11	355
Mcph	Bignoniaceae	*Markhamia tomentosa* (Benth.) K. Schum. & Thonn.	0	37	97
Th	Cleomaceae	*Cleome ciliata* Schum. & Thonn.	29	9	0
Phgrv	Combretaceae	*Combretum racemosum* P. Beauv.	22	630	45
Thpr	Commelinaceae	*Aneilemia beniniensis* P. Beauv. Kunth.	162	8	0
		Commelina diffusa Burm.f.	0	16	0
Phgrv	Connaraceae	*Rourea poggeana* Gilg, Engl. Bot.	0	0	10
Mcph	Connaraceae	*Trema orientalis* L. Blume	0	0	82
Phgrv	Cucurbitaceae	*Coccinea barteri* (Hook.f.) Keay	24	13	107
Phgrvr	Cucurbitaceae	*Cogniauxia podolaena* Baillon	0	0	59
Phgrvr	Cucurbitaceae	*Cucumeropsis mannii* Naud.	0	65	14
Gr	Cyperaceae	*Cyperus imbricatus* Retz.	22	0	37
Gr	Cyperaceae	*Cyperus major* Boeck.	0	0	59
Gr	Cyperaceae	*Cyperus rotundus* (L.)	46	23	37
Phgrv	Dilleniaceae	*Tetracera alnifolia* Willd. Subsp. *Alnifolia*	0	14	0
Th	Euphorbiaceae	*Acalypha ciliata* Forssk.	0	5	0
Mcph	Euphorbiaceae	*Chaetocarpus africanus* (Pax)	10	0	26
Thd	Euphorbiaceae	*Euphorbia hirta* (L.)	30	0	0
Mcph	Euphorbiaceae	*Macaranga monandra* Müll. Arg	0	0	9
Phgrv	Euphorbiaceae	*Macaranga saccifera* (Pax)	0	0	9
Mcph	Euphorbiaceae	*Manihot esculenta.* Crantz.	30	0	0
Msph	Fabaceae-Caesalpinioideae	*Delonix regia* Bojer ex Hook.f.	0	186	46
Th	Fabaceae-Faboideae	*Aechynomene batekensis* Troch. & Koech.	24	0	0
Phgr	Fabaceae-Faboideae	*Centrosema pubescens* (Benth.) O. Ktze	253	80	0
Phgrv	Fabaceae-Faboideae	*Dalbergia kisantouensis* De Wild. & Th. Dur.	0	0	13
Msph	Fabaceae-Faboideae	*Millettia eetveldeana* (Michelï). Harms	0	0	116
Phgrv	Fabaceae-Faboideae	*Mucuna pruriens* (Med.) DC. Var *pruriens*	28	0	0
Mcph	Fabaceae-Mimosoideae	*Acacia mangium* Willd.	0	0	293
Phgrv	Lamiaceae	*Clerodondron splendens* G. Don	28	0	0
Phgrv	Lamiaceae	*Clerodondron volubile* P.Beauv	56	8	15
Ch	Malvaceae-Tilioideae	*Triumfetta rhomboidea* Jacq.	0	0	30
Gr	Marantaceae	*Trachyprhynium braunianum* (K. Schum.) Bark.	0	0	18
Phgrv	Menispermaceae	*Cissampelos owariensis* Beauv.ex DC.	0	27	0
Mcph	Moraceae	*Fucus exasperta* Vahl	0	0	30
Chpr	Nyctaginaceae	*Boerhavia diffusa* L. var.*diffusa*	9	0	5
Nph	Ochnaceae	*Rhabdophyllum affine* (Hook.f;) Van Teigh.	0	0	58
Nph	Ochnaceae	*Rhabdophyllum* welwitschii Van Teigh.	0	11	16
Nph	Olacaceae	*Olax gambecola* Baill.	0	0	41
Thd	Phyllanthaceae	*Phyllanthus amarus* Schum. & Thon.	0	50	0
Hce	Poaceae	*Anthephora cristata* (Doell) Hack.ex de Wild. & Dur.	98	0	0
Chpr	Poaceae	*Axonopus compressus* (SW.) P.Beauv.	125	0	52
Thd	Poaceae	*Eleusine indica* (L.) Gaertn.	104	12	34
Hce	Poaceae	*Megastachya múcronata* (Poir.) P. Beauv.	0	0	12

Chpr	Poaceae	*Oplismenus hirtellus* (L.) p. Beauv.	0	0	96
Chpr	Poaceae	*Ottochloa nodosa* Kunth Dandy	0	8	0
Chpr	Poaceae	*Panicum brevifolium* (L.) Gaertn.	22	0	0
Gr	Poaceae	*Paspalum conjugatum* Berg	37	0	0
Hce	Poaceae	*Setaria barbata* (Lam.) Kunth	146	48	0
Thd	Portulacaceae	*Portulaca oleracea* L.	30	0	22
Thd	Rubiaceae	*Diodia scandens* Auct.	30	0	0
Thd	Rubiaceae	*Otomera guineensis* Benth.	0	0	24
Nph	Rubiaceae	*Psychotria calva* Hiem	0	0	7
Mcph	Rubiaceae	*Rytigynia dewevrei* De Wild. & T. Durand Robyns	10	0	3
Mcph	Salicaceae	*Caloncoba welwitschii* (Oliv).Gilg,	0	0	92
Mcph	Sapindaceae	*Allophylus africanus* P. Beauv.	0	0	42
Thpr	Scrophuliariaceae	*Lindernia diffusa* Wettst.Laveronik.	1500	0	0
Chd	Solanaceae	*Solanum torvum.* SW.	0	20	44
Thd	Talinaceae	*Talinum triangulare* (Jacq.) Willd.	0	25	0
Thd	Urticaceae	*Laportea estuans* (Linn.) A.Chev.	0	36	0
Phgrv	Vitaceae	*Cissus petiolata* Hoock.f.	31	0	0

Table 2. Identification of the species contained in the seed bank in the laboratory

Biological type	Family	Genus / species	Parcel 1	Parcel 2	Parcel 3
Thd	Amaranthaceae	*Amaranthus spinosus* L.	0	0	11
Thd	Amaranthaceae	*Cyathula prostrata var prostrata* (L.) Blume	39	0	29
Chd	Asteraceae	*Chromolaena odorata* (L.) R.King & H.Roinson	0	0	35
Phgrv	Asteraceae	*Mikania cordata* (Burm.f.) BL. Robinson	29	0	25
Thpr	Commelinaceae	*Aneilemia beniniensis* (P.Beauv.) Kunth	33	0	0
Gr	Cyperaceae	*Cyperus rotundus* (L.)	39	82	19
Hce	Cyperaceae	*Fimbristylis hispidula* (Vahl) Kunth subsp.Hispidula	0	19	0
Phgrv	Fabaceae-Faboideae	*Centrosema pubescens* (Benth.) O.Ktze	21	0	0
Thd	Phyllanthaceae	*Phyllanthus amarus* Schum. & Thonn.	0	16	0
Thd	Poaceae	*Eleusine indica* (L.) Gaertn.	30	17	10
Hce	Poaceae	*Megastachya múcronata* (Poir.) P. Beauv.	0	0	15
Chpr	Poaceae	*Panicum brevifolium* (L.) Gaertn.	35	17	0
Hce	Poaceae	*Setaria barbata* (Lam.) Kunth	0	0	14
Thd	Portulacaceae	*Portulaca olaracea* L.	0	0	15
Thd	Rubiaceae	*Diodia scandens* Auct.	48	16	0
Thd	Rubiaceae	*Oldenlandia affinis* (Roem. &. Schult) DC.	176	105	66
Thd	Rubiaceae	*Oldenlandia corymbosa* (L) var.nana Bremek.	78	0	0
Thpr	Scrophuliariaceae	*Lindernia diffusa* Wettst.Laveronik.	0	17	0
Chd	Solanaceae	*Solanum turvum*. SW.	26	20	21
Thd	Talinaceae	*Talinum triangulare* (Jacq.) Willd.	0	24	0
Thd	Urticaceae	*Laportea aestuans* (Linn.) Chev.	267	84	32

Evolution of number of seedlings in soil cores of Parcel 2

A total of 417 seedlings were counted in two months of experimentation in the soil cores taken from plot 2 (Figure 11). The first month 136 seedlings were recorded (Figure 11A2) and 281 seedlings the second month (Figure 11B2). The number of seedlings depends on the soil sample plot.

Evolution of number of seedlings in soil cores of Parcel 3

Figure 12 shows that the soil cores taken from plot 3 yielded a total of 292 seedlings in two months of experimentation. The first month 84 seedlings were recorded (Figure 12A) and 208 seedlings the second month (Figure 12B). The number of seedlings depends on the soil sample plot.

Specific Wealth of Plots

Specific Wealth of Plots in the Field

Seedling identification shows that 28 species make up the seed bank in Parcel1 (Table 1). These species are distributed in 16 families. In plot 2, 24 species distributed in 20 families were observed.

The number of species counted in Parcel 3 is 39 divided into 25 families. The listed species belong to 14 biological types. The biological type of microphanerophytes (Mcph) and voluble climbing phanerophytes (Phgrv) concentrate the maximum number of species with respectively 11 species and 12 species.

The number of remaining species is distributed as follows: trained therophytes (Thd) 9 species > creeping chaméphytes (Chpr) equivalent to rhizomatous gelophytes (Gr) with 5 species > nanophanerophytes (Nph) with 4 species > hemicryptophytes (Hce), thérophtes (Th) and creeping therophytes (Thpr) with 3 species each > upright chaméphytes (Chd), mesophanerophytes (Msph) and twig-climbing phanerophytes (Phgrvr) with 2 species each > chaméphytes (Ch) and climbing phanerophytes (Phgr) with only one species.

n the plot1 the species Lindernia diffused Wettst. Laveronik. The family Scrophuliariaceae has the largest number of individuals (1500 individuals) while Combretum racemosum P. Beauv of the family Combretaceae (630 individuals) is the most represented species in the plot 2.

On the other hand, in Parcel3, it is the species Cyathula prostrata var prostrata (L.) Blume of the family Amaranthaceae with 985 individuals which dominates the whole of the species of the parcel 2.

Wealth of species in the seed bank at the laboratory

Seedling identification shows that 12 species make up the seed bank in Parcel 1 (Table 2). These species are distributed in 9 families. In plot 2, 11 species distributed in 8 families were observed.

The number of species counted in Parcel 3 is 12 in 8 families. The listed species belong to 7 biological types. The biological type of trained therophytes (Thd) concentrate the maximum number of species with 10 species.

The number of remaining species is distributed as follows: hemicryptophytes (Hce) 3 species > chaméphytes erect (Chd), climbing vanthropic phytic (Phgrv) and creeping therophytes (Thpr) with 2 species each > creeping chamerophytes (Chpr) and rhizomatous geophytes with a single species.

In the parcel 1 the species Laportea aestuans (Linn.) A. Chev.de the family Urticaceae has the largest number of individuals (267 individuals) while in the plot 2 Oldenlandia affinis (Roem. &. Schult) DC de the family of Rubiaceae (105 individuals) which is the most representative of the flora. The same species Oldenlandia affinis (Roem. &. Schult) of the family Rubiaceae (66 individuals) is most present in plot 3.

DISCUSSION

The study of the seed bank of a soil supposes the historical knowledge of the flora, namely the different vegetable successions which have manifested themselves. Because the seed bank is made up of two types of seeds: the permanent or the persistent ones, which are very much in demand in the ecology of the restoration and the temporary ones which make it possible to trace the history of the plot (Marfoua, 2008).

Soil seed banks are important for vegetation management because they contain propagules of the species that may be considered desirable or undesirable for colonization of a site after management and disturbance events (Soud, 2010).

The seed bank includes seeds in the soil profile resulting from existing on-site populations in addition to other nearby immigrant women (Gallacher, et al., 1999). The seed bank participates in the renewal dynamics of the forest in windthrow and anthropized areas.

In fact, the space released by the destruction of the forest vegetation is rapidly colonized by the recruitment of plants from the seed bank originating from the surrounding or pre-existing vegetation and the seedlings having escaped the disturbance due to the passage fire, this is the case in this study.

In fact, seeds buried in the soil are well protected and escape destruction by fire. However, the rise in heat contributes to the lifting of dormancy. In this study, 63 species in 35 families were recorded in the field after the fire. These results are consistent with those obtained in Ethiopia in 1999, 69 species for 50 families, (Anonymous, 2001).

In this study, species are divided into five biological types; while in our study the species are dispersed in fourteen biological types. According to (Marfoua, 2008), this variability depends on several characteristics specific to the species.

The number of seeds produced by each species, the viability of seeds after the passage of fire. The number of seedlings listed prefigures the number of viable seeds present in the soil during the study period. The number is estimated at 102 viable seeds per meter.

CONCLUSION AND OUTLOOK

The objective of this study was to evaluate the stock and viability of the forest seed bank of the scientific city of Brazzaville. At the end of the four months of study:

- ✓ 7696 seedlings representing viable seed of the soil stock were counted on the three plots;
- ✓ the wealth of the bank is estimated at 63 distributed species ;
- ✓ the viable seed stock is distributed among 35 families ;
- ✓ the poaceae family dominates in the recorded seeds;
- ✓ families belong to fourteen biological types.

This work deserves to be continued on a larger surface. To do this, you will need:

- ✓ To evaluate the rate of recruitment of seedlings according to the seasons and according to the 2 types of soil which exist in the scientific city such as podzols and oxisols.
- ✓ Make an inventory of the flora of the forest in order to compare the germinations observed on plots;
- ✓ Examine the long-term effects of fire on the seed bank;
- ✓ Use the flotation method to determine the size of the seed bank.
- ✓ Classify these seeds by eco-physiological type: Orthodox; recalcitrant and intermediate.

To evaluate the effect of fire on the stock and the viability of seeds in the forest floor of the Cité scientifique de Brazzaville.
In view of the foregoing it is thought that after the passing of an accidental fire, the resilience capacity found in this work shows that the seed bank dormant in the soil could replenish an initial forest if the environmental conditions are favorable.

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