Available online at https://www.worldnewsnaturalsciences.com/

World News of Natural Sciences

An International Scientific Journal

WNOFNS 68 (2026) 80-87 EISSN 2543-5426

Assessment of soil seed bank with diversity and abundance of herbaceous vegetation in Adekunle Ajasin University Botanical Garden, Nigeria

Otitoloju Kekere* and **Victor Temiloluwa Faluyi**

Department of Plant Science & Biotechnology, Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria

*E-mail address: otito.kekere@aaua.edu.ng

ABSTRACT

Botanical gardens are important habitats for plant biodiversity, yet the effects of routine management on herbaceous communities and their regenerative capacity remain poorly documented in tropical Africa, particularly Nigeria. This study investigated how management intensity influenced herbaceous species diversity, abundance, and soil seed bank composition in the Adekunle Ajasin University Botanical Garden, Nigeria. During the 2025 wet season, twenty 1 m × 1 m quadrats were randomly placed in each of two areas of the garden: the developed area (DA) and the undeveloped area (UA). Above-ground herbaceous vegetation was enumerated and identified to the species level, while soil samples (0–10 cm depth) from the same quadrats were assessed for seed bank over eight weeks period. Density, frequency, relative density, relative frequency, Shannon–Wiener diversity (H′), evenness (E), and association index were calculated. Eleven herbaceous species belonging to six families were found in the study area. *Chromolaena odorata, Desmodium scorpiurus*, and *Cyperus rotundus* occurred in both areas. The DA was dominated by *Cynodon dactylon* (density 5.75 ind. m^{-2}, H′ = 0.36, E = 0.78), whereas the UA was dominated by *Pennisetum purpureum* (12.55 ind. m^{-2}, H′ = 0.48, E = 0.84). Soil seed bank composition closely mirrored standing vegetation (Sorensen similarity 0.88–0.91), but the UA exhibited higher herbaceous diversity and seed density. Regular maintenance in the DA significantly reduced herbaceous diversity but favoured disturbance-tolerant species, while the UA contained greater diversity and richer seed bank than DA. These findings provide baseline data on Adekunle Ajasin University Botanical Garden, and highlight the need for management strategies that could integrate conservation objectives with aesthetic maintenance in tropical botanical gardens.

Keywords: Botanical garden, Herbaceous vegetation, Soil seed bank, Conservation

(Received 20 June 2026; Accepted 18 July 2026; Date of Publication 19 July 2026)

1. INTRODUCTION

Herbaceous plants – non-woody species that complete their life cycle within one or two growing seasons – form a dynamic and often overlooked component of tropical ecosystems. They contribute substantially to primary productivity, nutrient cycling, soil stabilisation, forage provision, and medicinal resources (Ogunkunle *et al*., 2022). In Nigeria's humid and sub-humid areas, rapid urbanisation, agricultural expansion, and invasive species have dramatically reduced native herbaceous cover while favouring a small suite of disturbance-tolerant taxa (Chukwuma *et al*., 2021; Onyekwelu *et al*., 2023; Akomolafe *et al*., 2024). Botanical gardens, originally established for taxonomic display and education, have increasingly been recognised as critical urban refugia and living laboratories for studying plant responses to anthropogenic pressures (Westwood *et al*., 2021; Akinyemi and Olatunji, 2021). Management intensity is a key driver of plant community structure in designed landscapes. Frequent mowing, weeding, and ornamental planting create repeated disturbance regimes that select for short-statured, fast-growing, grazing- or trampling-tolerant species such as *Cynodon dactylon* and *Eleusine indica* (Adeyemi *et al*., 2022; Ogunkunle *et al*., 2022). In contrast, areas receiving minimal intervention often retain taller native grasses (e.g., *Pennisetum purpureum*), forbs, and a more balanced community (Nabirye *et al*., 2020; Ilori *et al*., 2020).

The soil seed bank further mediates long-term community trajectories, acting as a reservoir of regenerative potential that reflects both current vegetation and historical legacies (Bulu *et al*., 2023; Wu *et al* 2024, Li *et al*., 2025). Impacts of soil properties on species diversity and structure in *Alternanthera philoxeroides*-invaded and native plant communities. *Plants*, 13(9): 1196.). Despite their conservation mandate, most African botanical gardens lack quantitative baseline data on herbaceous layers and seed banks (Akinyemi and Olatunji, 2021).

The Adekunle Ajasin University (AAUA) Botanical Garden in Akungba-Akoko, Ondo State, Nigeria (7°28′N, 5°44′E), provides an ideal model system. Spanning 32.04 ha within the humid tropical climate (annual rainfall 1,500–2,000 mm), it contains a regularly maintained "developed area" (≈2.40 ha, mowed and weeded regularly) and a largely undisturbed "undeveloped area (≈30 ha). These adjacent areas experience identical macroclimate and edaphic conditions but differ sharply in disturbance frequency, offering a quasi-experimental framework to isolate management effects.

This study therefore aimed to identify and document the herbaceous flora of the AAUA Botanical Garden; quantify diversity and abundance using standard phytosociological indices; compare species composition, diversity, and dominance between developed and undeveloped areas; assess soil seed bank composition and compare it with standing vegetation; and evaluate the regenerative and conservation implications of observed patterns. This was to provide the first detailed inventory and comparative analysis of herbaceous communities and seed banks in the garden to fill a critical knowledge gap in this area which could be useful in biodiversity conservation in a typical university botanical garden in the tropics.

2. MATERIALS AND METHODS

2. 1. Study Area

The study was conducted at the Adekunle Ajasin University (AAUA) Botanical Garden. It is located in the University Campus at Akungba-Akoko, Ondo State, Nigeria (7°28′N, 5°45′E;

elevation ≈370 m a.s.l.). The garden occupies 32.04 ha within the lowland rainforest–derived savanna transition area. Climate is humid tropical with mean annual rainfall of 1 500–2 000 mm, concentrated between April and October, and mean annual temperature of 27 °C. Soils are deeply weathered ferralitic (Ultisol) with slightly acidic pH (5.5–6.2).

The garden is made up of two distinct areas:

1) "Developed Area" (≈2.40 ha)- regularly mowed (every 3–4 weeks), manually weeded, and planted with ornamental shrubs and lawn grasses.
2) "Undeveloped Area (≈30 ha): receives no mowing, weeding, or planting; vegetation develops naturally with occasional foot traffic only.

Both areas are situated on flat terrain with similar soil type and topography, ensuring that differences in vegetation and seed bank are attributable primarily to management intensity.

2. 2. Vegetation Sampling

Fieldwork was carried out during the peak of raining season (July–August 2025) when herbaceous cover and seed germination potential were highest. Twenty 1 m × 1 m quadrats were randomly placed in each area. Within each quadrat, all herbaceous individuals (grasses, sedges, forbs, and seedlings ≥5 cm tall) were identified to species level using the "Plants of the World Online" as well as texts of Akobundu and Agyakwa (1998) and Flora of West Tropical Africa by Hutchinson and Dalziel (1972). Voucher specimens were deposited in the AAUA Herbarium.

Phyto-sociological parameters were calculated using standard methods (Shannon and Wenier, 1963; Kent, 2012). Density (D) = S/D where S = the total number of individuals of the species in all quadrats, and Q = the total number of quadrats studied. Relative density (RD) = Density of a given species/Total densities of all the species x 100.

Frequency (F) = Number of quadrats in which the species occurred/Total number of quadrats studied x 100. Relative frequency (RF) = Frequency of a given species/Total frequencies of all the species x 100. Abundance (A) = Total number of individuals of the species in all the quadrats/number of quadrats in which they occurred x100. Shannon Wiener Diversity Index (H) = -Σ iPLog iP where iP = S (the number of individuals in a species)/N (the number of total individuals in a sample). Evenness (E) n = H/H_{max} where H_{max} = maximum diversity possible. Association index = simple presence/absence similarity between developed and undeveloped areas.

2. 3. Soil Seed Bank Assessment

A soil monolith (20 cm x 20 cm x 10 cm depth) was excavated from the centre of each quadrat, yielding a sampled volume of about 4 000 cm^3 per quadrat (0.04 m^3 total per area). Samples were air-dried for 72 h, sieved (4 mm mesh) to remove roots and stones, and spread as a 1 cm layer over sterilised sand in perforated plastic trays (30 cm × 40 cm) in a shade-house (50% natural light).

Trays were watered daily to field capacity. Emerging seedlings were identified, counted, and removed weekly for eight weeks. Un-germinated samples were stirred at week 6 to expose buried seeds. After eight weeks, the remaining soil was examined under a stereomicroscope for any additional identifiable seeds, but none was found.

3. RESULTS

3. 1. Floristic Composition

A total of 11 herbaceous species belonging to six families were recorded across both areas (Table 1). Seven species occurred in each area, with three species, *Chromolaena odorata, Desmodium scorpiurus* and *Cyperus rotundus* common to both areas. The developed area was characterised by lawn-forming and ruderal species, whereas the undeveloped area contained taller grasses and broad-leaved forbs (Table 2). In the developed area, *Cynodon dactylon* was the dominant species while *Pennisetum purpureum* was the most dominant in the undeveloped area (Table 3).

Table 1. Floristic composition of herbaceous plant species in the developed and undeveloped areas of Adekunle Ajasin University botanical garden.

Herbaceous plant species	Family	Common name	Developed area	Undeveloped area
Cynodon dactylon	Poaceae	Bermuda grass	+	-
Eleusine indica	Poaceae	Goosegrass	+	-
Panicum maximum	Poaceae	Guinea grass	+	-
Sida acuta	Malvaceae	Common wireweed	+	-
Chromolaena odorata	Asteraceae	Siam weed	+	+
Desmodium scorpiurus	Fabaceae	Tick clover	+	+
Cyperus rotundus	Cyperaceae	Nut grass	+	+
Pennisetum purpureum	Poaceae	Elephant grass	-	+
Tridax procumbens	Asteraceae	Coat buttons	-	+
Ageratum conyzoides	Asteraceae	Goat weed	-	+

Table 2. Phyto-sociological parameters of herbaceous plant species in the developed and undeveloped areas of Adekunle Ajasin University botanical garden.

Phytosociological parameter	Developed area	Undeveloped area
Total individuals recorded	391	656
Mean density (ind. m^{-2})	19.55	32.80

Species richness (S)	7	7
Shannon–Wiener index (H′)	0.36	0.48
Evenness (E)	0.78	0.84
Association index	0.82	0.85

Table 3. Dominant herbaceous plant species in the developed and undeveloped areas of Adekunle Ajasin University botanical garden.

Parameter	Developed area	Undeveloped area
Dominant plant species	*Cynodon dactylon*	*Pennisetum purpureum*
Density (ind./m^2)	5.75	12.55
Frequency (%)	100	100
Relative density (%)	29.41	38.22
Relative frequency (%)	15.15	14.29
Abundance	5.75	12.55

3. 2. Soil Seed Bank Composition and Density

Soil seed bank composition (Table 4) shows that the seed bank mirrored the standing vegetation with high fidelity (Sørensen similarity coefficient = 0.91 developed, 0.88 undeveloped). Mean viable seed density was significantly higher in the undeveloped area (33.85 seedlings m^{-2}) than in the developed area (19.55 seedlings m^{-2}). *Cynodon dactylon* likewise dominated the developed area seed bank (27.71% relative density), while *Pennisetum purpureum* again dominated the undeveloped area seed bank (31.95% relative density). Ecological indices for the seed bank were identical to those of the above-ground vegetation in each area (H′ = 0.36 vs. 0.48; E = 0.78 vs. 0.84).

Table 4. Herbaceous plant species and soil seed bank composition in the developed and undeveloped areas of Adekunle Ajasin University botanical garden.

Species	Standing vegetation of developed area	Seed bank composition of developed area	Standing vegetation of undeveloped area	Seed bank composition of undeveloped area
Cynodon dactylon	+	+	-	-

Eleusine indica	+	+	-	-
Panicum maximum	+	+	-	-
Sida acuta	+	+	-	-
Chromolaena odorata	+	+	+	+
Desmodium scorpiurus	+	+	+	+
Cyperus rotundus	+	+	+	+
Pennisetum purpureum	-	-	+	+
Tridax procumbens	-	-	+	+
Alternanthera sessilis	-	-	+	+
Ageratum conyzoides	-	-	+	+

All the eleven species detected in the standing vegetation were represented in the seed bank of their respective areas, confirming strong vegetation–seed bank congruence. No additional species were found exclusively in the seed bank.

4. DISCUSSION

The contrasting herbaceous communities observed in the developed and undeveloped areas of the AAUA Botanical Garden illustrate a classic ecological response to disturbance intensity. Regular mowing and weeding in the developed area created a regime of repeated biomass removal and soil compaction that strongly favoured short-statured, prostrate, fast-growing species capable of rapid regrowth from stolons or basal meristems. *Cynodon dactylon* emerged as the clear dominant, consistent with its well-documented adaptation to lawns and heavily trafficked areas across tropical Africa (Adeyemi *et al*., 2022; Ogunkunle *et al*., 2022). Its dominance suppressed taller native grasses and most broad-leaved forbs, resulting in significantly lower Shannon–Wiener diversity (H′ = 0.36) than others, and a community structure typical of urban green spaces under intensive management (Chukwuma *et al*., 2021).

In contrast, the absence of mowing in the undeveloped area allowed the establishment of tall, clump-forming grasses led by *Pennisetum purpureum*. The higher light penetration to the soil surface, reduced physical damage, and accumulation of litter created conditions suitable for a broader suite of native forbs (*Tridax procumbens, Alternanthera sessilis, Ageratum conyzoides*), yielding higher diversity (H′ = 0.48) and evenness (E = 0.84).

These patterns align closely with observations from minimally disturbed Nigerian forest edges and secondary regrowth (Ilori *et al*., 2020; Onyekwelu *et al*., 2023), and from East African wetlands where cessation of grazing rapidly increased herbaceous richness (Nabirye *et al*., 2020). The soil seed bank exhibited remarkable congruence with standing vegetation in both areas, indicating that current management regimes are the primary filter shaping future community assembly. This tight vegetation–seed bank relationship is characteristic of frequently disturbed tropical systems where persistent seed banks of ruderal species dominate (Bulu *et al*., 2023). The significantly higher viable seed density in the undeveloped area reflects reduced mechanical disruption and greater seed rain from tall, prolific seed producers such as *Pennisetum purpureum* and *Chromolaena odorata*. Conversely, repeated soil surface exposure and removal of standing biomass in the developed area likely depleted the transient seed bank of most native species while enriching it with highly persistent, disturbance-adapted taxa (*Cynodon dactylon, Eleusine indica*). These findings carry direct implications for restoration and management of tropical botanical gardens. Left to natural regeneration, the developed area would rapidly revert to a low-diversity Cynodon-dominated sward rather than recover native herbaceous flora.

5. CONCLUSION AND RECOMMENDATIONS

This study provides the first quantitative documentation of management-driven divergence in herbaceous diversity and seed bank composition within a Nigerian university botanical garden. The results reinforce global evidence that even modest reductions in maintenance intensity can yield substantial biodiversity gains in urban green infrastructure. Regular management practices (mowing and weeding) in the developed area significantly reduced species diversity and promoted a low-diversity, disturbance-tolerant community dominated by *Cynodon dactylon*, whereas the minimally disturbed undeveloped area sustained higher diversity, greater evenness, and a richer native flora led by *Pennisetum purpureum*. The soil seed bank closely reflected standing vegetation in both areas, confirming that current management regimes are the primary determinant of future regenerative potential.

These findings demonstrate that even within a small urban botanical garden, management intensity is a powerful driver of herbaceous community structure and resilience. To optimise the garden's educational and conservational roles, it is recommended that active intervention—such as selective topsoil removal, introduction of native propagules from the undeveloped area, or reduced mowing frequency—would be required to restore higher diversity. The undeveloped area, despite its large size (≈30 ha), functions as a critical in-situ reservoir of native germplasm and should be formally protected as a conservation reference area. Establishing permanent monitoring plots and integrating native herbaceous species into landscape design would enable the AAUA Botanical Garden to fulfill its dual role as both an aesthetic campus feature and a functional contributor to regional plant conservation.

References

[1] Adeyemi, T. O., Ogundipe, O. T. and Olowokudejo, J. D. (2022). Application of Shannon-Wiener diversity index in assessing herbaceous plant diversity in Nigerian urban parks. *Journal of Ecology and Natural Environment*, 14(4), 112–120

[2] Akinyemi, D. S. and Olatunji, O. A. (2021). Botanical gardens as tools for biodiversity conservation and environmental education in Nigeria. *Journal of Tropical Ecology*, 37(4), 123–130

[3] Akobundu, I. O. and Agyakwa, C. W. (1998). A handbook of West African weeds (2nd ed.). International Institute of Tropical Agriculture.

[4] Akomolafe, G. F., Rosazlina, R., and Omomoh, B. (2024). Soil seed bank dynamics of two invasive alien plants in Nigeria: Implications for ecosystem restoration. *AoB Plants* 16(2), 1-9

[5] Bulu, Y. I., Ahmed, R. O., Fadayomi, O. D. and Kekere, O. (2023). Soil seed bank studies of *Tithonia rotundifolia* invaded fallow land and its competitive association with *Chromolaena odorata*. *Notulae Scientia Biologicae*, 15(1), Article 11380

[6] Chukwuma, E. C., Adekoya, A. A., and Adebayo, A. G. (2021). Assessment of herbaceous vegetation diversity in Nigerian savannas using quadrat sampling techniques. *African Journal of Ecology*, 59(2), 456–465

[7] Hutchinson, J., and Dalziel, J. M. (1954–1972). Flora of West Tropical Africa (2nd ed., Vols. 1–3, revised by R. W. J. Keay & F. N. Hepper). Crown Agents for Oversea Governments and Administrations.

[8] Ilori, O. J., Ojo, L. O. and Olokesusi, A. F. (2020). Herbaceous species diversity in a Nigerian savanna ecosystem. *African Journal of Plant Science*, 14(9), 372–380.

[9] Kent, M. (2012). *Vegetation description and data analysis: A practical approach* (2nd ed.). Wiley-Blackwell.

[10] Li, L., Zhang, J., Shi, Z., Kang, B., Du, Z., He, M., Ning, Y., & Li, J. (2025). Soil seed bank characteristics and influencing factors of vegetation succession after 8–14 years reclamation projects in Tianjin, China. *Ecological Engineering*, 220, Article 107730

[11] Nabirye, M., Naigaga, R. and Ssemwanga, M. (2020). Contribution of urban home gardens to plant diversity and household livelihoods in Uganda. *African Journal of Environmental Science and Technology*, 14(10), 345–353

[12] Ogunkunle, A. T. J., Oladele, F. A. and Adewole, T. A. (2022). Diversity and distribution of herbaceous plants in urban green spaces in southwestern Nigeria. *Plant Science Today*, 9(3), 201–210

[13] Onyekwelu, J. C., Olajide, O. and Stimm, B. (2023). Land use change impacts on herbaceous plant communities in Nigerian forest reserves. *Biodiversity and Conservation*, 32(5), 789–804

[14] Shannon, C.E. and Wiener, W. (1963). The Mathematical Theory of Communication. University of Illinois Press, Urbana, 127 p.

[15] Westwood, M., Cavender, N. and Meyer, P. (2021). Botanical gardens as solutions to the plant extinction crisis. *Plants, People, Planet*, 3(4), 345–356

[16] Wu, H., Liu, Y., Zhang, T., Xu, M. and Rao, B. (2024). Impacts of soil properties on species diversity and structure in Alternanthera philoxeroides - invaded and native plant communities. *Plants*, 13(9): 1196