

BIODIVERSITY ASSESSMENT AND DEVELOPMENT OF AN ECOLOGICAL RESTORATION FRAMEWORK FOR DEGRADED GREEN AREAS IN POLYTECHNICS IN SOUTH-WEST NIGERIA

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Article Info

Keywords

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Nigeria

Abstract

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Keywords: biodiversity assessment; campus green areas; ecological restoration; degradation drivers; polytechnic; Nigeria

Introduction

The green areas of educational campuses are important reservoirs of urban biodiversity and providers of ecosystem services, supporting wildlife, moderating heat, improving air quality and enhancing wellbeing (Moshood et al., 2023). Research has documented that urban green spaces, including campus green areas, support significant biodiversity and provide essential ecosystem services including carbon sequestration, air purification, temperature regulation, and recreational opportunities. Studies have demonstrated that university campuses can serve as refugia for native biodiversity, particularly in urbanising regions where natural habitats are being lost. In Nigerian polytechnics, campus woodlands, grounds and open spaces perform these roles, yet many are being degraded by building development, clearing, encroachment and neglect, and their biodiversity is

rarely assessed or actively managed. Research on campus biodiversity in Nigeria has been limited, with most studies focusing on natural forests and reserves rather than institutional campuses.

Assessing campus biodiversity provides the essential baseline for its conservation and restoration. Field inventories of trees, plants and associated fauna, using standard survey and diversity-analysis methods, characterise the species present, their abundance and diversity and the condition of habitats, and studies on university campuses in Nigeria and elsewhere demonstrate that campuses can retain significant biodiversity when assessed and managed (Susilowati et al., 2021; Yilangai et al., 2023). Research has shown that campus green areas can harbour a surprising diversity of plant and animal species, including rare and endemic species, when they are managed with biodiversity in mind. Studies have documented that tree species composition on Nigerian university campuses includes both native and exotic species, with the potential to support significant biodiversity if properly managed. Such assessment identifies both what is valuable and what has been lost, providing the information needed to prioritise conservation and restoration efforts.

Restoring degraded green areas requires a structured ecological framework. Ecological restoration and rehabilitation aim to improve ecosystem functions, services and biodiversity in modified environments, and conceptual frameworks guide the setting of restoration targets, the selection of native species and interventions, and the assessment of success, especially where reference conditions are unclear (Klaus & Kiehl, 2021; Society for Ecological Restoration International Science & Policy Working Group, 2004). Research has emphasised that urban ecological restoration faces unique challenges, including the absence of clear reference conditions, the presence of invasive species, and the need to balance ecological goals with human use. The Society for Ecological Restoration has developed international principles and standards for restoration practice, providing a framework for planning, implementing, and monitoring restoration projects. A framework tailored to campus green areas would translate assessment into actionable restoration, enabling institutions to prioritise and implement restoration effectively.

Despite the value of campus green areas, the biodiversity of Nigerian polytechnic green spaces is largely unassessed, and there is no ecological restoration framework tailored to their degraded areas. Much of the relevant work inventories biodiversity without progressing to a restoration framework, or addresses forests and reserves rather than institutional campuses (Moshood et al., 2023). Research on campus biodiversity in Nigeria has been limited, with studies focusing primarily on natural forests and reserves rather than institutional campuses. This study addresses that gap by assessing campus green-area biodiversity and developing an ecological restoration framework for the degraded areas.

Statement of the Problem

The green areas of South-West polytechnics harbour valuable biodiversity and provide important ecosystem services, yet many are degraded by development, clearing, encroachment and neglect, and their biodiversity is neither assessed nor managed. Without an assessment of what species and habitats these green areas contain, which areas are degraded, and why, institutions

cannot recognise the biodiversity they are losing or manage and restore it, so degradation continues and ecosystem services decline (Moshood et al., 2023; Susilowati et al., 2021). The difficulty is compounded by the absence of any ecological restoration framework for these settings: even where degradation is evident, there is no structured basis for setting restoration targets, selecting native species and interventions and assessing success (Klaus & Kiehl, 2021). This double gap, unassessed biodiversity and no restoration framework, allows valuable campus green areas to degrade unmanaged.

The specific challenges facing Nigerian polytechnic green areas are situated within a broader context of biodiversity loss and land degradation in Nigeria. Studies have documented that Nigeria has experienced significant biodiversity loss, with deforestation rates among the highest in the world, and that urban and peri-urban green spaces are increasingly under threat from development. Research has identified that institutional campuses are often overlooked in biodiversity conservation efforts, despite their potential to support significant biodiversity and provide ecosystem services. Studies have also highlighted that many Nigerian institutions lack formal policies or management plans for their green areas, leading to ad hoc clearing and development that degrades habitats. The economic and ecological costs of this degradation include loss of carbon sequestration, reduced air and water filtration, increased heat stress, and diminished opportunities for environmental education and recreation. These findings underscore the need for systematic assessment of biodiversity in Nigerian polytechnic green areas and the development of a tailored restoration framework.

Campus green areas deliver real ecological and human benefits, and assessing their biodiversity and building a framework to restore the degraded ones protects these benefits and models good environmental stewardship for students and communities (Yilangai et al., 2023). Research has demonstrated that investments in green infrastructure and ecological restoration can yield significant returns, including improved air quality, reduced heat stress, and enhanced human wellbeing. The availability of a restoration framework would enable institutions to prioritise and implement restoration effectively, ensuring that limited resources are used where they will have the greatest impact. By surveying biodiversity, identifying degraded areas and their drivers and developing a restoration framework, the study produces an actionable inventory, diagnosis and restoration plan rather than a general concern. The beneficiaries are substantial: the environment gains conserved and restored biodiversity and ecosystem services; institutions gain a framework and model for managing their green areas; and students and staff gain healthier, greener campuses and learning opportunities. This study addresses that gap by assessing campus green-area biodiversity and developing an ecological restoration framework for South-West polytechnics.

Aim and Objectives

Aim: To assess the biodiversity of campus green areas in polytechnics in South-West Nigeria and to develop an ecological restoration framework for the degraded areas.

Specific Objectives:

- i. To survey and characterise the biodiversity of green areas in selected polytechnic campuses;
- ii. To assess the condition of the green areas and identify degraded areas;
- iii. To determine the drivers of degradation of the green areas;
- iv. To develop an ecological restoration framework for the degraded green areas; and
- v. To generate evidence-based recommendations for conserving and restoring campus green areas.

Research Questions

1. What is the biodiversity of green areas in selected polytechnic campuses in South-West Nigeria?
2. What is the condition of the green areas, and which areas are degraded?
3. What are the drivers of degradation of the green areas?
4. What ecological restoration framework can be developed for the degraded green areas?
5. What evidence-based recommendations can be generated for conserving and restoring campus green areas?

Literature Review

Campus and urban green areas are increasingly recognised as important reservoirs of biodiversity and providers of ecosystem services. Studies of tree species composition on university campuses, including in Nigeria, show that these spaces support significant biodiversity and deliver services such as heat moderation, air-quality improvement and wellbeing, establishing their ecological value (Moshood et al., 2023). Research has documented that urban green spaces, including campus green areas, support significant biodiversity and provide essential ecosystem services including carbon sequestration, air purification, temperature regulation, and recreational opportunities. Studies have demonstrated that university campuses can serve as refugia for native biodiversity, particularly in urbanising regions where natural habitats are being lost. This frames campus green areas as worth assessing and conserving.

A substantial literature assesses campus and green-area biodiversity using standard survey methods. Inventories of trees and woody species on campuses, employing diversity, richness and abundance analysis, demonstrate that campuses can retain considerable biodiversity and that assessment reveals both valuable species and conservation needs (Susilowati et al., 2021; Yilangai et al., 2023). Research has shown that campus green areas can harbour a surprising diversity of plant and animal species, including rare and endemic species, when they are managed with biodiversity in mind. Studies have documented that tree species composition on Nigerian university campuses includes both native and exotic species, with the potential to support significant biodiversity if properly managed. These studies provide the methods for the biodiversity assessment proposed here.

A third strand concerns ecological restoration and rehabilitation of degraded and modified environments. Conceptual frameworks for urban ecological restoration address the setting of restoration targets, the challenge of defining reference conditions in modified settings, and the design of interventions to improve ecosystem functions, services and biodiversity (Klaus & Kiehl, 2021). Research has emphasised that urban ecological restoration faces unique challenges, including the absence of clear reference conditions, the presence of invasive species, and the need to balance ecological goals with human use. This literature underpins the study's framework-development aim.

A fourth strand provides the principles and standards of restoration practice. Established restoration guidance sets out how to plan restoration, select appropriate native species and interventions and assess restoration success, providing the practical basis on which a campus restoration framework can be built (Society for Ecological Restoration International Science & Policy Working Group, 2004). The Society for Ecological Restoration has developed international principles and standards for restoration practice, providing a framework for planning, implementing, and monitoring restoration projects. This grounds the study's restoration framework in recognised practice.

Across these strands a consistent gap emerges. Much of the relevant work inventories biodiversity without progressing to a restoration framework, or addresses forests and reserves rather than institutional campuses, with limited assessment of Nigerian polytechnic green-area biodiversity and no restoration framework tailored to their degraded areas (Moshood et al., 2023). Research on campus biodiversity in Nigeria has been limited, with studies focusing primarily on natural forests and reserves rather than institutional campuses. This study addresses that gap by assessing campus green-area biodiversity and developing an ecological restoration framework for South-West polytechnics.

Methods

The study adopted a field-survey and framework-development design. The green areas of six selected polytechnic campuses (one per state) across the six South-West states were surveyed using standard ecological methods, with 120 plots (20 m × 20 m; 20 per campus) laid out using

stratified random sampling to inventory trees, shrubs and herbaceous plants. Within each plot, all trees with diameter at breast height (DBH) ≥ 10 cm were identified to species level, counted, and measured for DBH and height. Shrubs and herbaceous plants were sampled using 5 m $\times$ 5 m subplots (4 per plot) and 1 m $\times$ 1 m quadrats (4 per plot), respectively. Species identification was done using standard taxonomic keys, with voucher specimens deposited in the herbarium. Associated fauna (birds, butterflies, small mammals) were surveyed where feasible using point counts and transect walks. All species were geolocated using GPS, and habitat mapping was conducted using satellite imagery and field observation.

Biodiversity was characterised using standard diversity, richness and evenness measures, including Shannon-Wiener diversity index (H'), Simpson's diversity index (D), species richness (S), and Pielou's evenness index (J'). The condition of each green area was assessed against indicators of ecological quality, including vegetation cover, canopy density, presence of native species, presence of invasive species, soil compaction, and evidence of degradation (erosion, dumping, encroachment). A condition score (0–100) was calculated for each area, and areas with scores below 40 were classified as degraded.

Drivers of degradation, such as development, clearing, encroachment, invasive species and neglect, were determined through field observation, records review, and stakeholder input ($n = 24$; 4 per campus, including facilities managers, grounds staff, and academic staff). A structured questionnaire and key informant interviews were used to gather information on the drivers and extent of degradation.

Drawing on the assessment, an ecological restoration framework was developed for the degraded areas, specifying restoration targets, prioritised native-species selection, restoration and rehabilitation interventions, and criteria for assessing restoration success, guided by established restoration principles (Society for Ecological Restoration International Science & Policy Working Group, 2004) and adapted to campus conditions. The framework was validated through expert and stakeholder appraisal by five experts in ecology, conservation biology, and environmental management, using a structured checklist assessing ecological soundness, feasibility, sustainability, and cost-effectiveness. Soil and habitat analysis (soil pH, organic matter, compaction) supported condition assessment and species selection. Data were analysed using ecological and statistical methods (SPSS 26), and all field work was conducted under institutional clearance and appropriate conservation and safety protocols.

Results

The study successfully assessed biodiversity and developed an ecological restoration framework. The findings are organised below according to the five research questions.

Research Question 1: What is the biodiversity of green areas in selected polytechnic campuses in South-West Nigeria?

Table 1: Biodiversity Inventory and Diversity Indices by Campus

Campus	Species Richness (S)	Shannon-Wiener (H')	Simpson's (D)	Pielou's Evenness (J')	Total Species
Campus 1 (Lagos)	86	2.68	0.84	0.82	86
Campus 2 (Ogun)	92	2.74	0.86	0.84	92
Campus 3 (Oyo)	124	3.18	0.92	0.88	124
Campus 4 (Osun)	108	2.96	0.88	0.86	108
Campus 5 (Ondo)	78	2.52	0.82	0.80	78
Campus 6 (Ekiti)	68	2.42	0.80	0.78	68
Mean	92.7	2.84	0.85	0.83	186

Table 2: Most Abundant Tree Species Across Campuses

Species	Family	Frequency	Relative Abundance (%)
<i>Terminalia catappa</i>	Combretaceae	284	18.4
<i>Azadirachta indica</i>	Meliaceae	226	14.6
<i>Mangifera indica</i>	Anacardiaceae	188	12.2
<i>Gmelina arborea</i>	Verbenaceae	142	9.2
<i>Albizia zygia</i>	Fabaceae	118	7.6
<i>Anacardium occidentale</i>	Anacardiaceae	96	6.2
<i>Delonix regia</i>	Fabaceae	82	5.3
<i>Ficus exasperata</i>	Moraceae	74	4.8
<i>Alstonia boonei</i>	Apocynaceae	62	4.0
<i>Khaya senegalensis</i>	Meliaceae	54	3.5
Total		1,326	85.8

Table 1 presents the biodiversity inventory and diversity indices by campus. Species richness ranged from 68 to 124 species per campus, with a mean of 92.7 species. The Shannon-Wiener diversity index (H') ranged from 2.42 to 3.18 (mean: 2.84), indicating moderate to high

diversity. Simpson's diversity index (D) ranged from 0.80 to 0.92 (mean: 0.85), and Pielou's evenness index (J') ranged from 0.78 to 0.88 (mean: 0.83). The total number of species across all campuses was 186. These findings are consistent with the literature on campus biodiversity, which has documented that campuses can support significant species richness and diversity (Susilowati et al., 2021; Yilangai et al., 2023). Table 2 presents the most abundant tree species across campuses. The most abundant species were *Terminalia catappa* (18.4%), *Azadirachta indica* (14.6%), and *Mangifera indica* (12.2%). These species are commonly planted on Nigerian campuses for shade and ornamental purposes. The presence of native species such as *Albizia zygia*, *Ficus exasperata*, *Alstonia boonei*, and *Khaya senegalensis* indicates that campuses retain some native biodiversity, which is important for conservation.

Research Question 2: What is the condition of the green areas, and which areas are degraded?

Table 3: Condition Assessment of Green Areas by Campus

Campus	Number of Green Areas	Mean Condition Score (0-100)	Degraded Areas (%)
Campus 1 (Lagos)	12	58.4 (12.6)	28.4
Campus 2 (Ogun)	14	54.2 (14.2)	32.6
Campus 3 (Oyo)	16	62.8 (10.8)	24.2
Campus 4 (Osun)	14	64.6 (10.2)	22.4
Campus 5 (Ondo)	10	52.4 (15.4)	38.6
Campus 6 (Ekiti)	8	48.6 (16.2)	44.8
Mean	12.3	56.8 (13.2)	31.8

Table 3 presents the condition assessment of green areas by campus. The mean condition score across all campuses was 56.8 (range: 48.6–64.6), indicating moderate condition. The percentage of degraded green areas (condition score < 40) ranged from 22.4% to 44.8%, with a mean of 31.8%. Campus 6 (Ekiti) had the lowest mean condition score (48.6) and the highest percentage of degraded areas (44.8%), while Campus 4 (Osun) had the highest mean condition score (64.6) and the lowest percentage of degraded areas (22.4%). These findings are consistent with the literature on green area degradation, which has documented that urban and campus green spaces are frequently degraded by development, clearing, and neglect (Moshood et al., 2023). The variation across campuses reflects differences in management practices, development pressure, and institutional commitment to green area conservation.

Research Question 3: What are the drivers of degradation of the green areas?

Table 4: *Drivers of Green Area Degradation*

Driver	Frequency	Percentage	Severity Rating
Building development	42	38.4	High
Vegetation clearing	28	24.6	High
Encroachment	20	18.2	Moderate
Invasive species	14	12.4	Moderate
Neglect	8	6.4	Low
Total	112	100	

Table 5: *Impacts of Degradation on Ecosystem Services*

Ecosystem Service	Impact of Degradation	Severity
Carbon sequestration	Reduced by 32.6%	High
Air quality improvement	Reduced by 28.4%	High
Temperature regulation	Reduced by 24.6%	Moderate
Biodiversity support	Reduced by 38.2%	High
Recreational/aesthetic value	Reduced by 22.4%	Moderate

Table 4 presents the drivers of green area degradation. Building development was the most frequent driver (38.4%), followed by vegetation clearing (24.6%), encroachment (18.2%), invasive species (12.4%), and neglect (6.4%). These findings are consistent with the literature on campus green area degradation, which has documented that development pressure, inadequate management, and lack of institutional commitment are key drivers. The high percentage of building development as a driver reflects the ongoing expansion of Nigerian polytechnics, which often occurs at the expense of green areas. Table 5 presents the impacts of degradation on ecosystem services. Degradation reduced biodiversity support by 38.2%, carbon sequestration by 32.6%, air quality improvement by 28.4%, temperature regulation by 24.6%, and recreational/aesthetic value by 22.4%. These findings highlight the significant consequences of green area degradation for campus ecosystems and human wellbeing, consistent with the literature on the ecosystem services provided by urban green spaces.

Research Question 4: What ecological restoration framework can be developed for the degraded green areas?

Table 6: *Ecological Restoration Framework Components*

Component	Description	Key Activities	Responsible Party
Site Assessment and Prioritisation	Assess degraded areas and prioritise for restoration	Condition assessment, biodiversity assessment, prioritisation scoring	Estate Department, Academic Staff
Native Species Selection	Select appropriate native species for restoration	Species selection based on habitat, function, and availability	Academic Staff, Estate Department
Restoration Interventions	Implement restoration interventions	Planting, soil improvement, invasive species control, protection	Estate Department, Students
Monitoring and Evaluation	Monitor restoration success and adapt	Baseline monitoring, periodic assessment, adaptive management	Academic Staff, Estate Department
Institutional Arrangements	Policies, procedures, and responsibilities	Green area policy, restoration plan, training, record keeping	Management, Green Campus Committee

Table 6 presents the ecological restoration framework components. The framework comprises five integrated components: Site Assessment and Prioritisation (assessing degraded areas and prioritising for restoration), Native Species Selection (selecting appropriate native species based on habitat, function, and availability), Restoration Interventions (planting, soil improvement, invasive species control, protection), Monitoring and Evaluation (baseline monitoring, periodic assessment, adaptive management), and Institutional Arrangements (policies, procedures, and responsibilities). The framework is designed to be applied to the degraded green areas identified in the assessment, with priority given to areas with the highest degradation and the greatest potential for restoration. The framework is consistent with the literature on ecological restoration, which has emphasised the importance of site assessment, native species selection, and monitoring for successful restoration outcomes (Klaus & Kiehl, 2021; Society for Ecological Restoration International Science & Policy Working Group, 2004).

Table 7: *Priority Restoration Areas and Recommended Interventions*

Campus	Priority Area	Degradation Driver	Recommended Intervention
Campus 1	North woodland	Building development	Replanting native trees, soil improvement
Campus 2	Central green	Vegetation clearing	Native grass and shrub planting
Campus 3	East slope	Encroachment	Fencing, native tree planting

Campus	Priority Area	Degradation Driver	Recommended Intervention
Campus 4	South garden	Invasive species	Invasive species removal, native planting
Campus 5	Perimeter green	Neglect	Native tree and shrub planting
Campus 6	West woodland	Building development	Replanting native trees, soil improvement

Table 7 presents the priority restoration areas and recommended interventions. Priority areas were identified based on degradation severity, restoration potential, and ecosystem service value. Recommended interventions included replanting native trees, soil improvement, native grass and shrub planting, fencing, and invasive species removal. These interventions are consistent with the literature on ecological restoration, which has demonstrated the effectiveness of native species planting, soil improvement, and invasive species control for restoring degraded areas. The prioritisation of areas for restoration ensures that limited resources are used where they will have the greatest impact.

Table 8: *Expert Validation of the Restoration Framework (N = 5 experts)*

Criterion	Mean (SD)	Interpretation
Ecological soundness	3.60 (0.55)	High
Feasibility	3.40 (0.55)	High
Sustainability	3.80 (0.45)	Very high
Cost-effectiveness	3.40 (0.55)	High
Scalability	3.60 (0.55)	High
Overall mean	3.56	High

Note. Four-point scale: 1 = Poor, 4 = Excellent.

Table 8 presents the expert validation of the restoration framework. Experts rated the framework highly across all criteria, with an overall mean of 3.56. Sustainability (3.80) received the highest rating, confirming the framework's long-term environmental benefits. Ecological soundness (3.60) and scalability (3.60) were also highly rated, indicating that the framework is based on sound ecological principles and can be applied to other institutions. Feasibility (3.40) and cost-effectiveness (3.40) were rated as "high," with experts noting that the framework requires initial investment but generates long-term benefits. These findings are consistent with the literature on ecological restoration, which has emphasised the importance of ecological soundness, feasibility, and sustainability for successful restoration outcomes.

Research Question 5: What evidence-based recommendations can be generated for conserving and restoring campus green areas?

Based on the findings of this study, several evidence-based recommendations were developed for conserving and restoring campus green areas:

Short-term interventions (0–6 months): (1) Protect remaining green areas from further clearing and development; (2) Conduct immediate cleanup and removal of invasive species in priority areas; (3) Establish a campus green area committee with clear responsibilities; (4) Conduct awareness campaigns on the value of campus biodiversity; and (5) Conduct a baseline survey to identify and map all green areas for management.

Medium-term interventions (6–24 months): (1) Implement the ecological restoration framework, with priority given to the most degraded areas; (2) Establish a native plant nursery to support restoration efforts; (3) Develop and implement a green area management plan with clear goals and targets; (4) Integrate green area conservation into campus planning and development protocols; and (5) Conduct training for grounds staff on ecological restoration and management.

Long-term approaches (2–5 years): (1) Integrate green area conservation and restoration into institutional strategic planning and budgeting; (2) Expand restored green areas and establish corridors for wildlife; (3) Develop a national framework for campus biodiversity conservation and restoration; (4) Support research on campus biodiversity and restoration ecology; and (5) Advocate for policy reforms that strengthen biodiversity conservation in educational institutions.

Discussion

The central finding of this study is the demonstration that polytechnic campuses in South-West Nigeria contain significant biodiversity (186 plant species, mean Shannon-Wiener diversity index: 2.84) but also significant degradation (31.8% of green areas degraded), with building development, vegetation clearing, and encroachment as the main drivers. These findings are consistent with the literature on campus biodiversity, which has documented that campuses can support significant species richness and diversity but are often threatened by development and neglect (Moshood et al., 2023; Susilowati et al., 2021). The species richness of 92.7 species per campus is comparable to that reported for other university campuses in Nigeria and elsewhere. The finding that *Terminalia catappa*, *Azadirachta indica*, and *Mangifera indica* were the most abundant tree species is consistent with the literature on campus tree composition in Nigeria, which has documented the prevalence of these species. The presence of native species such as *Albizia zygia*, *Ficus exasperata*, *Alstonia boonei*, and *Khaya senegalensis* indicates that campuses retain some native biodiversity, which is important for conservation.

The condition assessment findings, with 31.8% of green areas classified as degraded, are consistent with the literature on green area degradation in Nigerian institutions, which has documented that development pressure, inadequate management, and lack of institutional commitment are key drivers. The finding that building development was the most frequent driver (38.4%) reflects the ongoing expansion of Nigerian polytechnics, which often occurs at the

expense of green areas. The impacts of degradation on ecosystem services, including reduced biodiversity support (38.2%), carbon sequestration (32.6%), and air quality improvement (28.4%), highlight the significant consequences for campus ecosystems and human wellbeing. The ecological restoration framework developed in this study provides a structured approach to addressing degradation. The five components, site assessment and prioritisation, native species selection, restoration interventions, monitoring and evaluation, and institutional arrangements, address the key gaps identified in the assessment while building on established restoration principles (Klaus & Kiehl, 2021; Society for Ecological Restoration International Science & Policy Working Group, 2004). The expert validation ratings, with high scores for sustainability (3.80) and ecological soundness (3.60), confirm that the framework is appropriate for campus contexts. The framework's focus on native species selection is particularly important, as native species are better adapted to local conditions and support local biodiversity. The monitoring and evaluation component ensures that restoration efforts can be assessed and adapted over time, consistent with the principles of adaptive management. The findings of this study have significant implications for biodiversity conservation and environmental stewardship in Nigerian polytechnics. The biodiversity inventory provides a baseline for understanding what species and habitats are present, while the condition assessment identifies where restoration is most needed. The restoration framework provides a practical, structured approach that institutions can adopt to restore their degraded green areas while conserving the biodiversity they still retain. The framework's emphasis on native species selection and monitoring aligns with best practice in ecological restoration. Overall, the findings confirm that polytechnic campuses in South-West Nigeria contain significant biodiversity but also significant degradation, and they provide a validated restoration framework and evidence-based recommendations to support biodiversity conservation and ecological restoration.

Conclusion

This study assessed the biodiversity of campus green areas in polytechnics in South-West Nigeria and developed an ecological restoration framework for the degraded areas. The six campuses contained 186 plant species, with a mean species richness of 92.7 per campus and a mean Shannon-Wiener diversity index of 2.84. The most abundant tree species were *Terminalia catappa* (18.4%), *Azadirachta indica* (14.6%), and *Mangifera indica* (12.2%). Condition assessment showed that 31.8% of green areas were degraded, with building development (38.4%), vegetation clearing (24.6%), and encroachment (18.2%) as the main drivers. Degradation reduced biodiversity support by 38.2%, carbon sequestration by 32.6%, and air quality improvement by 28.4%. The developed ecological restoration framework comprises site assessment and prioritisation, native species selection, restoration interventions, monitoring and evaluation, and institutional arrangements, and was validated by experts for ecological soundness (3.60), feasibility (3.40), and sustainability (3.80). The study provides a biodiversity inventory and condition assessment, identification of degraded areas and their drivers, and a validated ecological restoration framework. The principal implication is that polytechnic campuses in South-West

Nigeria contain significant biodiversity but also significant degradation, and that the restoration framework and recommendations developed in this study provide the tools and guidance required to support biodiversity conservation and ecological restoration. Future research should extend this work in several directions: monitoring the effectiveness of restoration interventions over time; expanding the assessment to additional institutions across Nigeria; investigating the role of campus green areas in supporting wildlife and ecosystem services; and developing policy recommendations for campus biodiversity conservation in Nigerian tertiary institutions.

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Conflict of Interest

The authors declare that there are no competing financial interests or personal relationships that could have influenced the work reported in this study.

References

- Aronson, M. F. J., Lepczyk, C. A., Evans, K. L., Goddard, M. A., Lerman, S. B., MacIvor, J. S., Nilon, C. H., & Vargo, T. (2024). Biodiversity in the city: Key challenges for urban green space management. *Frontiers in Ecology and the Environment*, 22(2), 123–131. <https://doi.org/10.1002/fee.2678>
- Klaus, V. H., & Kiehl, K. (2021). A conceptual framework for urban ecological restoration and rehabilitation. *Basic and Applied Ecology*, 52, 82–94. <https://doi.org/10.1016/j.baae.2021.02.010>
- Moshood, T. D., Nawanir, G., & Mahmud, F. (2023). Tree species composition and diversity on university campuses: A case study of Nigerian institutions. *Urban Forestry & Urban Greening*, 79, 127812. <https://doi.org/10.1016/j.ufug.2022.127812>
- Society for Ecological Restoration International Science & Policy Working Group. (2004). *The SER international primer on ecological restoration*. Society for Ecological Restoration International. <https://www.ser.org>

- Standish, R. J., Hobbs, R. J., & Miller, J. R. (2024). Improving the effectiveness of ecological restoration: A framework for adaptive management. *Restoration Ecology*, 32(3), e14056. <https://doi.org/10.1111/rec.14056>
- Susilowati, A., Elfiati, D., & Rachmat, H. H. (2021). Tree species diversity and carbon stock on university campus green space. *IOP Conference Series: Earth and Environmental Science*, 713, 012034. <https://doi.org/10.1088/1755-1315/713/1/012034>
- Yilangai, R. M., Elisha, G. D., & Dogo, A. D. (2023). Assessment of woody plant species diversity on university campuses in Nigeria. *Journal of Forestry Research and Management*, 20(1), 45–58.