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Floral composition in diverse restoration models utilizing *Calliandra calothyrsus* in Mt. Kitanglad, Lirongan, Talakag, Bukidnon

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Abstract

Biodiversity is critical to the ecosystem and human well-being. However, it is under threat due to deforestation and unsustainable practices that destroy the habitats. This study aimed to assess the biodiversity composition in the restoration area implemented in Mount Kitanglad, Bukidnon. The restoration model studied uses *Calliandra calothyrsus*, a large shrub to eliminate cogon grass and weeds in the early stages of restoration. A comprehensive biodiversity assessment was done in the restoration sites utilizing Calliandra following the Biodiversity Assessment and Monitoring System. Results showed 64 plant species from 32 families across the nine restoration sites. *Calliandra calothyrsus* correspondingly was the most abundant species, followed by planted *Pinus kesiya* and *Falcataria falcata*, indicating dominance of the family Fabaceae. Among sampling sites, the Shannon Species Diversity Index is moderate and did not vary among sites, with sites of young Calliandra at 2.728, followed by site with young mature Calliandra (2.693) and site with Calliandra and Indigenous Forest trees (2.667). The measure of evenness reached its highest value at site with young Calliandra (0.7737), showing a more even abundance of different species compared with the site of old Calliandra (0.3071) showing species dominance by *Calliandra calothyrsus*. Conservation status evaluations found endangered species of *Cyathea contaminans* and *Shorea negrosensis*, highlighting the importance of focused conservation efforts. The study revealed a diverse flora in the restoration areas influenced by a number of environmental factors. These results offer important insights for improving restoration strategies and biodiversity protection on Mt. Kitanglad.

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Introduction

Biodiversity refers to the diversity of life on Earth, including species diversity, environmental diversity, and genetic variation within species. The presence of biodiversity contributes to the proper functioning of an ecosystem. Accordingly, ecosystems with higher diversity are more stable and adapt better to environmental changes, leading to increased productivity (Cardinale *et al.*, 2012). Biodiversity is crucial for key ecological services like nutrient cycling and carbon sequestration (Tilman *et al.*, 2014). Biodiversity is vital for human health, ensuring access to clean water and nutritious food (Bongaarts, 2019). Additionally, it has cultural and aesthetic significance, enhancing recreation and tourism opportunities.

Restoration ecology is essential for addressing deforestation and habitat degradation. Lirongan is near Mt. Kitanglad, a protected area known for its rich biodiversity, standing at 2,899 meters above sea level. This area is preserved under Philippine Republic Act 8978 of 2000 due to its unique ecological value and contains significant plant species, including 42.8% pteridophytes, 33.3% gymnosperms, and 2.6% angiosperms (Amoroso, 2012; Amoroso *et al.*, 2016). The Hineleban Foundation Inc. (HFI) launched a reforestation program to counter challenges like deforestation in March 2020. Focused on restoring the lower areas of Mt. Kitanglad, it utilizes C. calothyrsus and Indigenous Forest Trees (IFT) while promoting sustainable livelihoods for the Indigenous community. The initiative aims to improve the ecological health of watersheds through planting and removing invasive weeds. In the early years, wildflowers and cogon grass hindered the establishment of planted species. However, C. calothyrsus eventually limited cogon grass growth, allowing native saplings to flourish. HFI employed three planting techniques: (a) Enhancement Planting to improve biodiversity, (b) Simultaneous Planting in enclosed areas, and (c) *C. calothyrsus* Planting, which involved clearing weeds with community consent.

C. calothyrsus is a fast-growing, nitrogen-fixing tree that enhances soil fertility and provides wildlife habitat, making it ideal for restoration efforts (Jha *et al.*, 2014). Its presence boosts biodiversity and supports conservation (Jha *et al.*, 2014; Reyes and Baguhin, 2018). With growing interest in restoring Mount Kitanglad, focused research on *C. calothyrsus* is essential, as previous studies have often overlooked its importance, hence, this study is essential in offering insights for the conservation strategies in Mount Kitanglad and similar areas. This study examines the environmental benefits of *C. calothyrsus* and emphasizes its importance in restoration models at Mount Kitanglad. It aims to identify plant species in restoration sites, compare floral diversity across different models, and assess how these models impact plant diversity and abundance from 2020 to 2023. This study aims to assess the biodiversity composition in the restoration models implemented in Mount Kitanglad, with the presence and impact of *C. calothyrsus*. This study seeks to identify and document the plant species found in restoration sites and to assess the impact of various restoration models on the diversity and abundance of flora.

Materials and methods

Study area and sampling sites

The Mt. Kitanglad Range in Bukidnon, Philippines, shares summit boundaries with portions of Baungon, Talakag, Lantapan, Impasug-ong, Sumilao, Libona, Manolo Fortich, and the City of Malaybalay. Barangay Lirongan is located in Talakag at roughly 8.0530 N and 124.8297 E with an elevation of 1,411.2 meters (masl) (PhilAtlas) (Table 1). It is populated mainly by indigenous peoples from the Bukidnon and Higaonon tribes, with a rich cultural legacy connected to the land. Traditional agricultural techniques in these areas include using organic fertilizers, crop rotation, and intercropping (Lorena, 2016).

Fig. 1, map of the Sampling site showing the points location at Hineleban Foundation Inc., with corresponding codes per restoration model site

Table 1. Description of the sampling sites

Site	Description of area	Location	Sampling station		Calliandra age
			Area code	Area type	
1	Young *C. calothyrsus* with Indigenous Forest Trees	Slope	CCIFT1	Young CC with IFT	3 yrs, 5-mos
2	Young *C. calothyrsus* with Indigenous Forest Trees	Slope	CCIFT2	Young CC with IFT	3 yrs, 5-mos
3	Old mature - *C. Calothyrsus*	Slope	OCC1	Old mature CC	18-23 yrs
4	Old mature - *C. Calothyrsus*	Slope	OCC2	Old mature CC	18-23 yrs
5	Old mature - *C. Calothyrsus*	Riverbank	OCC3	Old mature CC	18-23 yrs
6	Young *C. Calothyrsus*	Lowland	YCC1	Young CC	3 yrs, 6 mos
7	Young *C. Calothyrsus*	Lowland	YCC2	Young CC	3 yrs, 6 mos
8	Young *C. Calothyrsus*	Lowland	YCC3	Young CC	3 yrs, 6 mos
9	Young-mature *C. Calothyrsus*	Riverbank	YMC	Young mature CC	6 yrs

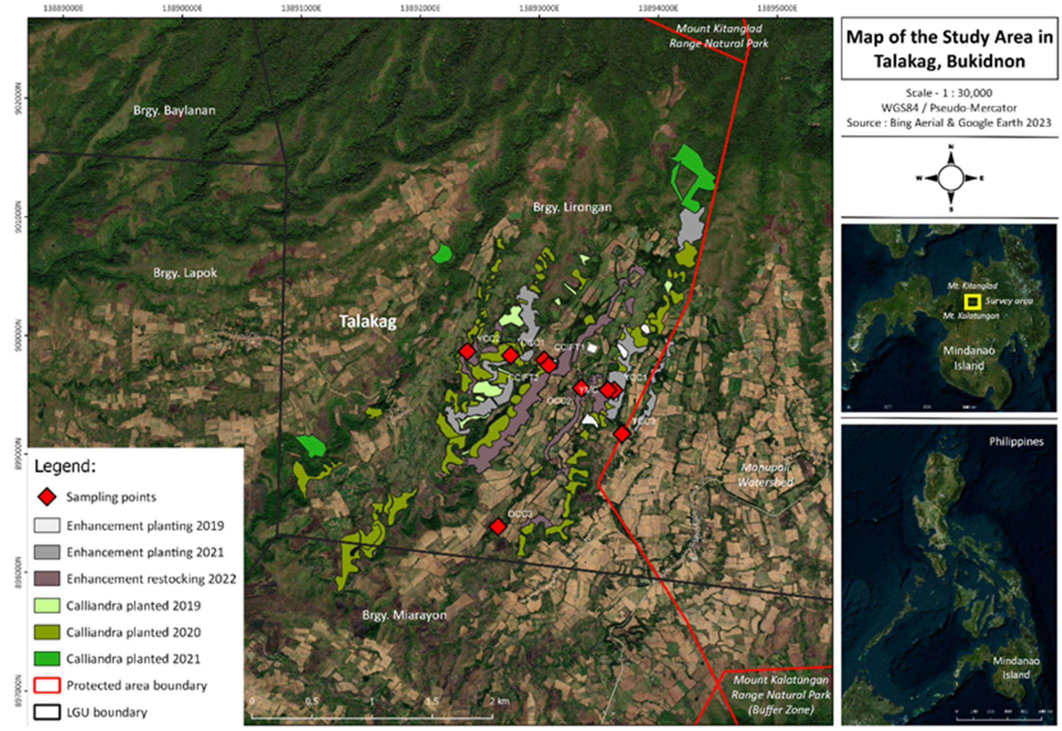

Fig. 1. Map of the sampling site showing the points location at Hineleban Foundation Inc., with corresponding codes per restoration model site

The study was conducted in the restoration sites of the Hineleban Foundation within the slopes, gullies, and riverbanks, which covered an area of 47,270 hectares and had geographical coordinates ranging from 124°48'0" E to 124°49'0" E and 8°33'0" N to 8°50'0" N, with an elevation ranging from 1,500 to 1,700 meters above sea level (Fig. 1). The sampling points established in the area consist of nine sites. Three sites were subjected to riparian regeneration, with the implementation of a pioneer species, *C. calothyrsus*. Two sites were utilized for improvement and simultaneous planting, of *C. calothyrsus* as a pioneering species followed by Indigenous Forest trees (IFT) from 2020 to March 2023 as part of the HFI tree-growing for enhancement program. Four sampling sites were covered with mature *C. calothyrsus* vegetation. The area was planted with Indigenous Forest trees (IFT) last March 2023 as part of the HFI tree-growing project to enhance the location.

Accordingly, the sampling stations are classified following the HFI codes.

1. Sampling sites with young Calliandra (5 sites)

1.1 Young Calliandra (Code YCC1, YCC2, YCC3)
C. calothyrsus was introduced at three different plain sites and has grown to an age three years and six months. In two sampling areas (YCC1 and YCC2), planting of indigenous forest trees were done in March 2023. While in YCC3, Calliandra was exclusively planted along the perimeter, acting as both a boundary and a fenced enclosure for the area.

1.2 Young Calliandra and Indigenous Forest Trees (IFT) (Code CCIFT1, CCIFT2)
Another sampling station includes two sites located on slope elevations, planted with *C. calothyrsus*, aged three years and five months, alongside Indigenous Forest Trees (IFT).

During the enhancement planting activities in March 2023, Indigenous Forest trees successfully grew in two sampling areas.

2. Sampling sites with mature Calliandra (4 sites)
2.1 Young mature Calliandra (Code YMC)
Site YMC, located along a riverbank, has six-year-old *C. calothyrsus* planted alongside perennial vegetation and fern wildings. In 2023, Indigenous Forest Trees (IFT) were also introduced on the site as part of the enhancement planting activities.

2.2 Mature-old Calliandra (Code OCC1, OCC2, OCC3)
Three (3) sites that are inhabited with 18–23-year-old *C. calothyrsus* vegetation were also selected. OCC1 and OCC2 are located on slope elevations, while OCC3 is positioned along a riverbank. Furthermore, mature Caribbean pine trees are also present in OCC1, where simultaneous planting of *C. calothyrsus* and Indigenous Forest Trees (IFT) was carried out.

Data collection
A modified line transect method was employed for sampling. In each sampling site, a 2000-meter transect line was established following standard sampling techniques (Madulid, 1989; Zapanta *et al.*, 2019). The transect began at the edge of the restoration site, close to the access trails, and extended through areas rich in diverse flora species. Following the established methodology of the Biodiversity Assessment and Monitoring System (BAMS) by the Biodiversity Management Bureau (Cruz *et al.*, 2017; Terbio *et al.*, 2022), a total of five to nine 20 x 20-meter plots were systemically placed at 250-meter intervals along the transect line within the restoration site. A Global Positioning System (GPS) was used to record the location of each plot.

Within these 20 × 20-meter quadrats, vegetation was assessed. The number of individuals of intermediate species, shrubs, and saplings was recorded within 5 × 5-meter sub quadrats placed inside the 20 × 20-meter quadrat. Additionally, the understory species (grasses and other plant species less than 1 m tall) was determined inside the 20 × 20-meter quadrats. An opportunistic survey was conducted to document all flora species, including trees, shrubs, and ferns, found along the transect line and extending up to 5 meters away from each plot, ensuring a comprehensive inventory of the plant diversity in the restoration site.

Plants recorded were identified from family to species level, categorized into distinct plant groups, and documented GPS coordinates for location tracking. Representative plant specimens were photographed for accurate identification and labeling. Photographs of unknown species were matched to digital images from resources such as the International Plant Names Index (IPNI) and Plants of the World Online (www.plantsoftheworldonline.org). The species identified were further confirmed using available flora assessment and monographs from Merrill (1876-1956); Zamora *et al.* (1986); Zamora (1991); Madulid (1991, 1995); and Amoroso (2011, 2012). The distribution of plants and their endemism were cross-referenced through an online database, Co's Digital Flora of the Philippines (www.philippineplants.org/index.html). The conservation status of each species was assessed based on the International Union for Conservation of Nature's (IUCN 2020) updated assessments and the Updated List of Threatened Philippine Plants and Their Categories from the Department of Environment and Natural Resources Administrative Order (DAO 2017–11).

Data analysis

The Paleontological Statistics (PAST v4.03) software was utilized to calculate the diversity indices of each sampling site. Species diversity was assessed using the Shannon-Wiener Diversity Index (H'), which considers both species richness (the number of species present) and evenness (the distribution of individuals among species) (Shannon and Wiener, 1963).

Additionally, the Evenness Index (E) was calculated to assess the variations in species abundances within a given community. This index quantifies the degree of uniformity in species distribution, providing valuable insights into the structural stability and functional balance of ecological communities (Wen *et al.*, 2010; Terbio *et al.*, 2022). The interpretation of diversity indices follows the classification framework proposed by Fernando (1998), which serves as a standardized tool for assessing biodiversity, ecological integrity, and species richness across different environmental contexts.

The Simpson's Diversity Index (D) was also computed as a complementary measure of species evenness. This index estimates the probability that two randomly selected individuals from a community belong to the same species, serving as a standard measure of dominance. Simpson's Index (D) ranges from 0 to 1, where values closer to 0 indicate high diversity, while values near 1 suggest dominance by a few species (Barcelona Field Studies Center, 2018).

Results and discussion

Species composition

A biodiversity assessment conducted at the base of the protected area in Lirongan, Mt Kitanglad identified 64 plant species across the nine restoration sites belonging to 32 families. The species list and abundance data are provided in Table 2. The assessment recorded 1798 flora species individuals, with *C. calothyrsus* Meisn. as the most abundant and present across all sites with a total of 308 individuals. Among the tree species, *Pinus kesiya* Royle ex Gordon was the most abundant with 102 individuals followed by *Falcataria falcata* (L.) Greuter & R.Rankin (88) and *Eucalyptus deglupta* Blume (25) individuals.

The Indigenous Forest Trees in the area, such as *Castanopsis philipensis* (Blanco) S. Vidal, *Shorea negrosensis* Foxw., and *Cinnamomum mercadoi* S. Vidal, were recorded in lower numbers compared to other tree species. However, many of these native species are still saplings stage, as they were introduced through the annual enhancement plantation program, which started in 2020. Their current abundance may increase as they mature over time. By contrast, fast-growing species such as *Calliandra calothyrsus* (present in all restoration sites) and *Falcataria falcata* (dominant in YCC3) were more dominant in most sites. While these species contribute to rapid biomass accumulation and soil stabilization (Palaso *et al.*, 2023; Hughes *et al.*, 2024), their long-term ecological impact on native biodiversity requires further study (Table 2).

Table 2. Plant species identified in restoration site

Scientific name	Common name	Sampling site area								
		Young CC with IFT1	Young CC with IFT2	Old mature CC1	Old mature CC2	Old mature CC3	Young CC1	Young CC2	Young CC3	Young mature CC
Asteraceae										
Ageratum conyzoides L.						5			35	
Blumea balsamifera (L.) DC.	Gabon	15	10							
Chromolaena odorata (Linn) R.M. King & H. Rob	Hagonoi								5	
Crassocephalum crepidioides (Benth.)							10	7		4

S.Moore										
Mikania micrantha Kunth					7				8	
Tithonia diversifolia (Hemsl.) A. Gray	Wild sunflower					35	20		25	
Athyriaceae										
Diplazium esculentum (Retz.) Sw.	Pako			7	8	7		4		6
Balsaminaceae										
Impatiens montalbanica Hook.f.						12		10		
Bignoniaceae										
Spathodea campanulata P. Beauv.	African tulip	6	4							2
Bombacaceae										
Camptostemon philippinensis (S.Vidal) Becc.	Gapas-gapas			1				1		
Cannabaceae										
Trema orientalis (L.) Blume	Anabiong	1	1	1	1					
Combretaceae										
Lumnitzera racemosa Willd.	Kulasi	4	2	5				3		
Terminalia catappa L. Combretaceae	Talisai	2	2	3						
Terminalia microcarpa Decne.	Kalumpit	1	1	2						
Cordiaceae										
Cordia dichotoma G.Forst., Prodr.	Anonang							1		1
Cyatheaceae										
Cyathea contaminans (Wall.) Copel.	Anonotong			5	5		2	3		3
Cyperaceae										
Scleria scrobiculata Nees & Meyen				15	10	8		12		
Davalliaceae										
Davallia denticulata (Burm. f.) Kuhn				7		9				
Dennstaedtiaceae										
Pteridium aquilinum (L.) Kuhn	Bracken fern	20	12			32	50	18		15
Dipterocarpaceae										
Dipterocarpus alatus Roxb. ex G.Don	Hairy leaf Apitong			1	1					1
Dipterocarpus grandiflorus (Blanco) Dipterocarpaceae	Apitong				1					
Dipterocarpus kunstleri King	Broad-winged Apitong			1						1
Parashorea malaanonan (Blanco) Merr.	Bagtikan			1						1
Shorea contorta S. Vidal	White Lauan	3	2	3			1	1		1
Shorea negrosensis Foxw.	Red Lauan	1	1	2			1	1		1
Fabaceae										
Arachis hypogaea L.	Ground nut			12	8					
Arachis pintoi Krapov. & W.C.Gregory	Pintoi peanut				7	15				
Calliandra calothyrsus Meisn.	Calliandra	15	17	75	35	48	57	6	30	25
Falcataria falcata (L.) Greuter & R.Rankin	Falcata								88	

Mimosa diplotricha C.Wright							7			12
Mimosa pudica L.	Makahiya			12			18			
Fagaceae										
Castanopsis philipensis (Blanco) S. Vidal	Ulayan	1	2	1				2		1
Fagaceae										
Castanopsis psilophylla Soepadmo	Katii	2	1	3				1		1
Quercus subsericea A.Camus		1	1	1				1		1
Hypoxidaceae										
Curculigo capitulata (Lour.) Kuntze, Rev. Gen. Pl.	Abang-abang			1				1		1
Lauraceae										
Cinnamomum burmannii (Nees & T.Nees) Blume		1	1							1
Cinnamomum camphora (L.) J.Presl.	Salinsinganon	1	2	1				1		1
Cinnamomum iners Reinw—ex Bl.		1	1	1				1		
Cinnamomum mercadoi S. Vidal	Kalingag	2	1	2				2		1
Melastomataceae										
Medinilla myrtiformis (Naudin) Triana						9				6
Moraceae										
Ficus hispida L.f.	Tangkulubas	1	3	2			1			2
Ficus sp.	Timbog	2	1	1	2					
Musaceae										
Musa textilis Née	Abaka		6							
Musa sapientum L.					3				15	
Myrtaceae										
Eucalyptus deglupta Blume	Bagras tree	5	4	6	3			3		4
Nephrolepidaceae										
Nephrolepis cordifolia (L.) K. Presl		5	7	4		3				
Nyctaginaceae										
Ceodes umbellifera J.R.Forst. & G.Forst.	Anuling			1			1			
Orchidaceae										
Spathoglottis plicata Blume		1	1	2	2	3				
Phyllanthaceae										
Antidesma pentandrum (Blanco) Merr.	Bignai			1				1		
Pinaceae										
Pinus kesiya Royle ex Gordon	Pine tree	1	1	92			3	2		3
Piperaceae										
Piper aduncum L.	Buyo-buyo	18	10		12	8				
Poaceae										
Bambusa vulgaris Schrad. ex J.C.Wendl.	Bamboo			3	2			2		1
Pennisetum purpureum Schumach.	Napier					15	12			
Centotheca latifolia Trin.				8		6				
Centotheca sp.				3		4				
Imperata cylindrica (L.) P.Beauv.	Cogon			25	18		15			

Paspalum conjugatum Linn.	Carabao grass							17	23	12
Saccharum spontaneum L.	Talahib				6		3	8		5
Thysanolaena maxima (Roxb.) Kuntze	Luway	12	18			12		10		10
Selaginellaceae										
Selaginella auriculata Spring.						19				
Solanaceae										
Cestrum nocturnum L.	Dama de Noche				15				30	
Thelypteridaceae										
Macrothelypteris torresiana (Gaudich.) Ching		12	17		10		9	13		
Verbenaceae										
Lantana camara L.					12		18			15
Stachytarpheta cayennensis (Rich.) Vahl							15		34	
Over-all total number of species		26	27	36	21	18	18	27	10	29
Over-all total number of individuals		134	129	311	168	250	243	132	293	138
Over-all Total number of species										64
Over-all Total number of families										32
Over-all Total number of individuals										1798

Grasses dominated the ground cover across nearly all the sampling sites, with *Thysanolaena maxima* Roxb. Kuntze being the most dominant species. This was followed by *Imperata cylindrica* (L.) P. Beauv and *Macrothelypteris torresiana* (Gaudich.) Ching. Among shrubs, *Tithonia diversifolia* (Hemsl.) A. Gray had the highest recorded abundance, with 80 individuals, followed by *Lantana camara* L. (49 individuals) and *Stachytarpheta cayennensis* (Rich.) Vahl (45 individuals), all belonging to the Family Verbenaceae. Pteridophytes were also prevalent, with *Pteridium aquilinum* (L.) Kuhn being the most abundant species, followed by *Diplazium esculentum* (Retz.) Sw. (32) and *Davallia denticulata* (Burm. f.) Kuhn (16) individuals recorded.

Species conservation status and ecological distribution

The conservation status of each plant species was assessed using the guidelines provided by the International Union for Conservation of Nature (IUCN) 2024 Red List and the Department of Environment and Natural Resources Administrative Order (DENR-DAO) 2017-11, as listed in Table 3. There are two species that are classified as endangered by the Philippines (DENR), one under the global standards (IUCN) and two classified by both guidelines.

Cyathea contaminans is classified as Endangered (EN) only by DENR, while *Camptostemon philippinensis* was classified as endangered by both DENR and IUCN. Five species from the Dipterocarpaceae family were identified as Vulnerable (VU) by DENR- as follows: *Dipterocarpus alatus*, *D. grandifloras*, *D. kunstleri*, *Shorea contorta*, and *S. negrosensis*. Additionally, two vulnerable species, *Eucalyptus deglupta* and *D. alatus*, were categorized as Vulnerable by the IUCN. Two species were designated as Other Threatened Species (OTS) by DENR, these were *Quercus subsericea* and *Cinnamomum mercadoi*. Three species were classified as Near Threatened (NT) according to the IUCN database; these were *Castanopsis philipensis*, *Quercus subsericea*, and *Musa textilis*. The remaining species were considered of Least Concern by IUCN, while there was no available record for other species.

Deforestation and habitat destruction have rapidly progressed in the Philippines, leaving only 20% of forests intact as of 2019 (Zapanta *et al.*, 2019). In Mt. Kitanglad, additional endangered plant species may still be unidentified, underscoring the need for comprehensive biodiversity assessments. Establishing baseline data on both disturbed and less disturbed areas within the Mt. Kitanglad Range Natural Park is crucial for conservation efforts.

Table 3. Taxonomic listing of plants species conservation and distribution arranged alphabetically by family

Species name	Local name	DAO 2017-11	IUCN	Ecological status
Asteraceae				
Ageratum conyzoides L.				N/N
Blumea balsamifera (L.) DC.	Gabon		LC	N
Chromolaena odorata (Linn) R.M. King & H. Rob	Hagonoi			I/N
Crassocephalum crepidioides (Benth.) S.Moore				N/N
Mikania micrantha Kunth				N/N
Tithonia diversifolia (Hemsl.) A. Gray	Wild sunflower			I/N
Athyriaceae				
Diplazium esculentum (Retz.) Sw.	Pako/edible fern		LC	N
Balsaminaceae				
Impatiens montalbanica Hook. f.				N
Bignoniaceae				
Spathodea campanulata P. Beauv.	African tulip		LC	I/N
Bombacaceae				
Camptostemon philippinensis (S. Vidal) Becc.	Gapas-gapas	EN	EN	N
Cannabaceae				
Trema orientalis (L.) Blume	Anabiong		LC	N
Combretaceae				
Lumnitzera racemosa Willd.	Kulasi		LC	N
Terminalia catappa L.	Talisai		LC	N
Terminalia microcarpa Decne.	Kalumpit		LC	N
Cordiaceae				
Cordia dichotoma G.Forst., Prodr.	Anonang		LC	N
Cyatheaceae				
Cyathea contaminans (Wall.) Copel.	Anonotong	EN	LC	N
Cyperaceae				
Scleria scrobiculata Nees & Meyen				N
Davalliaceae				
Davallia denticulata (Burm. f.) Kuhn				N
Dennstaedtiaceae				
Pteridium aquilinum (L.) Kuhn	Bracken fern		LC	N
Dipterocarpaceae				
Dipterocarpus alatus Roxb. ex G.Don	Hairy leaf Apitong	VU	VU	N
Dipterocarpus grandiflorus (Blanco) Blanco	Apitong	VU	EN	N
Dipterocarpus kunstleri King	Broad-winged Apitong	VU	LC	N
Parashorea malaanonan (Blanco)	Bagtikan		LC	N
Shorea contorta S. Vidal	White Lauan	VU	LC	N/E
Shorea negrosensis Foxw.	Red Lauan	VU	LC	N/E
Fabaceae				
Arachis hypogaea L.	Ground nut			N/N
Arachis pintoi Krapov. & W.C.Gregory	Pintoi peanut			C/N
Calliandra calothyrsus Meisn.	Calliandra			C/N
Falcataria falcata (L.) Greuter & R.Rankin	Falcata		LC	N/N
Mimosa diplotricha C.Wright	Makahiya		LC	N/N
Fagaceae				
Castanopsis philipensis (Blanco) S. Vidal	Ulayan		NT	N/E
Castanopsis psilophylla Soepadmo	Katii			N
Quercus subsericea A.Camus		OTS	NT	N
Hypoxidaceae				
Curculigo capitulata (Lour.) Kuntze, Rev. Gen. Pl.	Abang-abang			N
Lauraceae				
Cinnamomum burmannii (Nees & T.Nees) Blume			LC	N/E
Cinnamomum camphora (L.) J.Presl.	Salinsinganon		LC	C/N
Cinnamomum iners Reinw. ex Bl.			LC	N
Cinnamomum mercadoi S. Vidal	Kalingag	OTS	LC	N/E
Melastomataceae				
Medinilla myrtiformis (Naudin) Triana				N
Moraceae				
Ficus hispida L.f.	Tangkulubas		LC	N/E
Ficus sp.	Lagasi			N
Musaceae				
Musa textilis Née	Abaka		NT	N/E
Musa sapientum L.				N

Myrtaceae			
Eucalyptus deglupta Blume	Bagras tree	VU	N
Nephrolepidaceae			
Nephrolepis cordifolia (L.) K. Presl			N
Nyctaginaceae			
Ceodes umbellifera J.R.Forst. & G.Forst.	Anuling	LC	N
Orchidaceae			
Spathoglottis plicata Blume			N
Phyllanthaceae			
Antidesma pentandrum (Blanco) Merr.	Bignai		N
Pinaceae			
Pinus kesiya Royle ex Gordon	Pine tree/Khasia Pine	LC	N
Piperaceae			
Piper aduncum L.	Buyo-buyo	LC	N/N
Poaceae			
Bambusa vulgaris Schrad. ex J.C.Wendl.	Bamboo		C/N
Pennisetum purpureum Schumach.	Napier	LC	I/N
Centotheca latifolia Trin.			N
Centotheca sp.			N
Imperata cylindrica (L.) P.Beauv.	Cogon	LC	N
Paspalum conjugatum Linn.	Carabao grass	LC	N/N
Saccharum spontaneum L.	Talahib	LC	N
Thysanolaena maxima (Roxb.) Kuntze	Luway		N
Selaginellaceae			
Selaginella auriculata Spring.			N
Solanaceae			
Cestrum nocturnum L.	Dama de Noche	LC	C/N
Thelypteridaceae			
Macrothelypteris torresiana (Gaudich.) Ching			I/N
Verbenaceae			
Lantana camara L.			N/N
Stachytarpheta cayennensis (Rich.) Vahl			N/N

Legend: ES – Ecological Status (N/E- Native/ Endemic; I/N- Nonnative or Introduced; C/N- Nonnative or Cultivated; N/N- Nonnative or Naturalized); CS- Conservation Status (CR- Critically Endangered; EN- Endangered; VU- Vulnerable; OTS- Other Threatened Species; OWS-Other Wildlife Species) based on DENR AO. No. 2017-11 List of Threatened Philippine Plants and their Categories; and (CR – Critically Endangered; EN – Endangered; VU – Vulnerable; NT – Near-threatened; OTS – Other Threatened Species; LC – Least Concern) based on the International Union for Conservation of Nature (IUCN) (2020).

According to Zapanta *et al.* (2019), even disturbed forests continue to support endemic and endangered species, highlighting their ecological and economic significance. This underscores the importance of restoration programs, which play a key role in mitigating species loss and maintaining ecosystem balance. Several Philippine endemic species are at risk of becoming threatened or endangered, requiring urgent conservation measures to ensure their long-term survival in natural habitats. Some of the species identified in this study are already included in indigenous forest tree lists and are being used for enhancement planting in restoration sites. Increasing the number of these native tree species in reforestation programs can enhance biodiversity and support ecosystem recovery in the area.

For ecological status, 64 species can be found in the Philippines. Out of these, 58% or 37 species are widely distributed throughout the country but are native to the Philippines, such as *Camptostemon philippinensis* (S. Vidal) Becc., *Trema orientalis* (L.) Blume, *Castanopsis psilophylla* Seopadmo, and *Thysanolaena maxima*. The 15% or 10 species were widely distributed and naturalized. These species include *Ageratum conyzoides* L., *Falcataria falcata*, *Piper aduncum*, *Paspalum conjugatum*, and *Lantana camara*. The 11% or seven species were Philippine endemic. These species include *Cinnamomum mercadoi* S. Vidal, *Cinnamomum burmanni* (Nees & T.Nees) Blume, *Shorea contorta* S. Vidal, *Shorea negrosensis* Foxw., *Musa textilis* Née, *Ficus hispida* L.f., and *Castanopsis philipensis* (Blanco) S. Vidal. Moreover, 8% of the species, or the five species, were widely distributed and were introduced and cultivated. These species include *Macrothelypteris torresiana* (Gaudich.) Ching, *Chromolaena odorata* (Linn) R.M. King & H. Rob, *Tithonia diversifolia* (Hemsl.) A. Gray, *Spathodea campanulate* P. Beauv., and *Pennisetum purpureum* Schumach were introduced. At the same time, *Arachis pintoi* Krapov. & W.C.Gregory, *C. calothyrsus*, *Cinnamomum camphora* (L.) J.Presl, *Cestrum nocturnum* L., and *Bambusa vulgaris* Schrad. Ex J.C.Wendll were widely cultivated (Fig. 2).

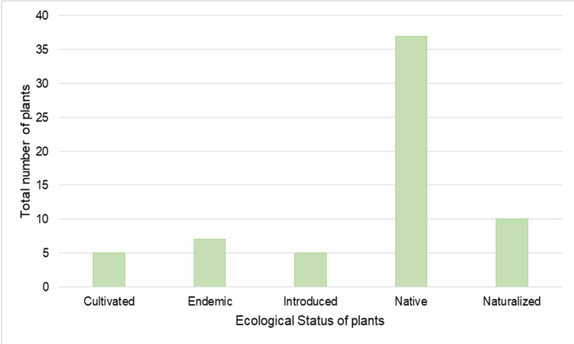

Fig. 2. The ecological distribution status of recorded plants in Lirongan, Talakag, Bukidnon

Table 4. Diversity indices for the plant species at sampling sites in Lirongan, Talakag, Bukidnon

Sampling sites	No. of species	No. of individuals	Simpson index (D')	Shannon index (H')	Evenness (E)
CCIFT1	26	134	0.9177	2.61	0.5231
CCIFT2	27	129	0.9228	2.667	0.533
OCC1	36	311	0.8417	2.403	0.3071
OCC2	21	168	0.914	2.607	0.6457
OCC3	18	250	0.9062	2.546	0.7087
YCC1	18	243	0.8741	2.308	0.5585
YCC2	27	132	0.9299	2.728	0.5669
YCC3	10	293	0.8469	2.046	0.7737
YMC	29	138	0.921	2.693	0.5093

Species diversity, abundance, and evenness

The diversity indices for the nine sampling sites show varied levels of species richness, abundance, and evenness. Sites with Young *C. calothyrsus* and Indigenous Forest Trees (CCIFT1 and CCIFT2) both have low Simpson Index values (0.9177 and 0.9228) and moderate Shannon Index values (2.61 and 2.667), indicating low diversity and high dominance but moderate evenness (0.5231 and 0.533). While in sites with Old mature *C. calothyrsus*, OCC1 has the highest species count (36) and 311 individuals and has a higher Simpson Index (0.8417), indicating more diversity but low evenness (0.3071), suggesting species dominance. OCC2 and OCC3 both have low Simpson Index values (0.914 and 0.9062), with moderate Shannon Index values (2.607 and 2.546) and moderate to high evenness (0.6457 and 0.7087). Site with young *C. calothyrsus* (YCC1 and YCC2) show higher Simpson Index values (0.8741 and 0.9299), indicating more diversity, with YCC2 having the highest Shannon Index (2.728) and moderate evenness (0.5669). YCC3, with only 10 species, shows high evenness (0.7737) despite a low Shannon Index (2.046). Site with young mature Calliandra (YMC) has low Simpson (0.921) and high Shannon (2.693) indices, with moderate evenness of 0.5093 (Table 4).

The diversity indices reveal varying levels of species diversity across the sampling sites. Site 7 (YCC2) and Site 9 (YMC) exhibit the highest diversity with Shannon-Weiner indices of 2.728 and 2.693, respectively, indicating moderately high diversity and healthy ecosystems with a good balance of species. Sites 1 (CCIFT1), 2 (CCIFT2), 4 (OCC2), and 5 (OCC3) show moderate diversity, reflecting a fair mix of species and relatively balanced ecosystems. In contrast, Site 8 (YCC3) has the lowest diversity with an index of 2.046, suggesting fewer species or significant dominance by some species. The Shannon-Weiner Evenness for the recorded plants at sampling sites highlights varying levels of species balance. Site 8 (YCC3) has the highest evenness at 0.7737, indicating a balanced ecosystem with no single species dominating. Sites 1 (CCIFT1), 2 (CCIFT2), 4 (OCC2), 5 (OCC3), 6 (YCC1), 7 (YCC2), and 9 (YMC) exhibit moderate evenness, reflecting a reasonable level of species balance with some variation. Conversely, Site 3 (OCC1) shows the lowest evenness at 0.3071, suggesting significant species dominance and less balance. The Simpson Diversity Index shows differences in species diversity across the sampling sites. Notably, Site 3 (OCC1) and Site 8 (YCC3) emerge as the most diverse, featuring indices of 0.8417 and 0.8469, respectively. Site 6 (YCC1) is moderately diverse, with an index of 0.8741. On the other hand, the least diverse sites are Site 2 (CCIFT2), with an index of 0.9228, Site 7 (YCC2), with an index of 0.9299 and Site 9 (YMC), with an index of 0.921.

Conclusion

This study evaluates the role of *C. calothyrsus* in ecological restoration at Hineleban Foundation, Incorporated, identifying 64 plant species from 32 families. The findings highlight the ecological importance of these sites for species conservation. The Shannon-Wiener Diversity Index (H') and Evenness Index (E') reveal variations in species richness and structural complexity across sites, influenced by site conditions and restoration efforts.

Notable species such as *C. calothyrsus*, *P. kesiya*, and *T. maxima* thrive under current conditions, potentially impacting native flora recovery. Of the identified species, 58% are native to the Philippines, with 11% endemic, emphasizing the area's support for indigenous flora. However, endangered species like *C. contaminans* and *C. philippinensis* highlight urgent conservation needs, particularly for vulnerable Dipterocarp species. The lower abundance of native forest trees suggests a need for additional management strategies for their establishment. The results support previous studies indicating that even disturbed areas can be refuges for ecologically significant species.

Recommendations

Prioritizing the conservation of native and endemic species

Efforts to restore and conserve biodiversity and maintain ecosystem balance are important because native species are better adapted to local conditions and are essential for supporting wildlife.

Proactive management of introduced species

Monitoring and controlling introduced species is crucial to mitigate their negative effects on native ecosystems. This may include removing invasive species and promoting the growth of native vegetation.

Community-based monitoring

Collaboration among local communities, government agencies, non-profit organizations, and other stakeholders is essential for the long-term success of these initiatives. Local communities play a vital role in ensuring the sustainability of ecosystems and protecting biodiversity. Successful restoration efforts also require adaptive management strategies, which include ongoing monitoring and evaluation.

Investing in research and capacity building

This is crucial for enhancing restoration ecology, improving techniques, and developing local expertise in conservation. Such initiatives equip stakeholders with the necessary tools for informed decision-making and effective restoration outcomes. This will also help identify challenges and opportunities, allowing for adaptability in complex environmental conditions.

This investment is crucial for fostering innovation, improving processes, and addressing challenges. By prioritizing research, new knowledge, and insights can be generated.

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