Original Article

Floral assessment and conservation prioritization in Dugo Watershed, Mountain Province, Northern Philippines

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Received: 31 Jul. 2025 || Revised: 10 Jan. 2026 || Accepted: 22 April 2026 || Available online: 4 May 2026

ISSN: 1656-4707
E-ISSN: 2467-5903
Homepage: www.palawanscientist.org

How to cite:
Gaya SA, Parao MR. 2026. Floral assessment and conservation prioritization in Dugo Watershed, Mountain Province, Northern Philippines. The Palawan Scientist. 18(1):151-161. https://doi.org/10.69721/TPS.J.2026.18.1.16

ABSTRACT

Forests play a key role in biodiversity conservation supporting local livelihoods. These ecosystems face threats from agricultural expansion, forest fires, and unsustainable land use practices. This study focused on assessing woody species diversity, their conservation status, biogeography, and local use values, and established a geospatial database in Dugo Watershed in Tadian, Mountain Province. The goal was to provide baseline data for conservation planning of the watershed. Nineteen plots recorded 81 woody species from 60 genera and 36 families. Dominant species included *Pinus kesiya* Royle ex Gordon and *Ficus benguetensis* Merr. The Shannon-Wiener Diversity Index measured 2.84, indicating moderate species diversity in the area. There are 14 species classified as threatened woody species consisting of: three endangered, four near threatened, two other threatened, and five vulnerable. High-priority species such as endangered *Guioa acuminata* Radlk. and vulnerable *Saurauia bontocensis* Merr. are endemic with specific habitat requirements, making them highly sensitive to disturbance. The presence of several endemic species further underscores the watershed's conservation value. Documented species use range from ecological functions to economic and cultural purposes, indicating strong potential for community-based stewardship. Geographic Information System (GIS) showed the distribution of species to support monitoring and management. The findings emphasize the need for community-based conservation efforts, habitat restoration, and regular monitoring to strengthen the watershed's biodiversity and ecological resilience.

Keywords: biodiversity, community-based conservation, GIS, local use values, woody species

INTRODUCTION

The Philippines is recognized as one of the 18 mega-biodiverse countries of the world (CBD 2020). According to Pelser et al (2011), Philippine vascular plants comprise approximately 290 families and 10,220 recorded species, of which about 51.3% are endemic. This rich biodiversity provides resources and services to local communities, including food, clean water, climate regulation, and cultural values (Shin et al. 2022; Sharma and Birman 2024). However, human activities such as agricultural expansion, forest conversion, and unsustainable resource use, combined with climate change, continue to threaten these ecosystems (Wang et al. 2021; Prakash and Verma 2022). As a result, there is a need to focus conservation efforts on areas that are important for preserving biodiversity.

The Philippine biodiversity conservation priorities identified critical areas for conservation and the importance of conducting floral assessment to guide these initiatives (Ong 2002). The urgency of these efforts is underscored by the fact that only 3% remains as the country's primary vegetation which is the lowest percentage among the world's biodiversity hotspots (Campbell et al. 2016). Moreover, the ongoing discovery of endemic species underscores the increasing value of the remaining fragments of both primary and secondary native vegetation as natural capital for the Philippines (Peng et al. 2017).

Despite the presumed rich biodiversity of the Cordillera region publicly available and site-specific biodiversity data remain limited (Baoanan et al. 2020). This knowledge gap is particularly evident in small watersheds like Dugo Watershed where baseline information on species composition, distribution, and conservation status is lacking. Establishing such baseline data is essential for guiding conservation planning and sustainable management because forest ecosystems are vital for maintaining biodiversity and supporting the livelihoods of nearby communities (Oldekop et al. 2020). As these ecosystems lose functionality, the flow of these services is disrupted, posing risks to both biodiversity and human well-being. Therefore, protecting these areas requires a comprehensive approach that considers both ecological and socio-economic factors, including the integration of community-based strategies (Bauyot et al. 2024).

The Cordillera Administrative Region is home to diverse plant life, which includes species found in lowland and montane forests (Baoanan et al. 2020). However, these forests are under threat from various activities, such as forest fires and expansion to vegetable farms (Paltiyan-Bugtong et al. 2022). Tadian is a rural municipality in the southwestern part of Mountain Province in the Northern Philippines (Figure 1). It is currently facing similar biodiversity conservation challenges. Anthropogenic activities have impacted the biodiversity of these areas, sometimes before species can be properly documented, and some species may have already been lost.

Dugo Watershed is a communally managed forest within Tadian that plays a critical role in supplying water to nearby communities and among the few remaining forested areas in the municipality. Although the watershed is locally managed, it is not formally protected under the National Integrated Protected Areas System (NIPAS) and E-NIPAS system. Current management practices focus primarily on water resource protection and land-use regulation, while species-level biodiversity assessment and conservation prioritization remain limited. Furthermore, the area faces ongoing threats from agricultural expansion, forest fires, and unsustainable land use practices. As van Beijnen and Jose (2020) showed in a similar case, the absence of formal protective status in a watershed allows disturbances to pose serious threats to endemic species, underscoring the urgency of establishing protection measures for Dugo Watershed.

This study assessed the woody species diversity, evaluated their conservation status, biogeography, and local use values, and established a geospatial database for monitoring to support future conservation activities in Dugo Watershed. Baseline data on woody species diversity and spatial distribution in Dugo Watershed will provide essential information to monitor ecosystem changes over time (Castillo et al. 2021). Species status and geographical data were documented (BMB and GIZ Gmbh 2017) to identify taxa requiring immediate conservation action. In this study, woody species were defined functionally as plants with a persistent above-ground stem that remains over time and through changing environmental conditions (Gray 1887; FitzJohn et al. 2014). Only trees and shrubs were included, while lianas, palms, tree ferns and bamboo were excluded.

The outcomes of this study are intended to support the development of conservation strategies for the watershed. The findings will help shape community-based conservation initiatives and support decision-making by the DENR and Local Government Units (LGUs) in making informed decisions. The study will also serve as a resource for researchers and students working on floral biodiversity and conservation planning in the future.

METHODS

Study Site

The municipality of Tadian is located in the southwestern part of Mountain Province, Northern Philippines (Figure 1). It is bounded on the west by the municipality of Cervantes, Ilocos Sur, on the east by the municipality of Bauko, Mountain Province, on the south by the municipality of Mankayan, Benguet, and on the north by the municipality of Besao, Mountain Province. Being at the center of different forest types, like pine forests and broad-leaf forest, diversity could be higher in this area. The municipality has an approximate land area of 14,942 ha (Tadian LGU 2000).

The Dugo Watershed is in Tadian, Mountain Province, and covers about 440 hectares. It consists of secondary forest with Benguet pine (*Pinus kesiya* Royle ex Gordon, 1840) and broadleaf trees. Other land uses include agroforestry areas, rice fields, vegetable gardens, and residential zones. The watershed lies at an elevation of 1,000 to 1,860 meters above sea level and is one of the few remaining forested areas in the municipality. The terrain includes steep to moderately steep slopes. Based on Corona's system of classification, the area falls under Climatic Type I, with two seasons: the wet season ("deam") and the dry season ("tiagew") (Tadian LGU 2000).

Sampling Sites

Nineteen (19) sampling plots were established in the existing forested watershed area. Potential plot locations were first systematically generated in QGIS Ver. 3.22.9 at 300 m intervals. This systematic generation resulted in 26 potential plot locations. From these points, 19 plots were randomly selected using QGIS randomization tools to ensure unbiased representation across the forested watershed area. The number of plots was determined using Cochran's formula (1977) for a population of 26 potential plot locations, with a confidence level of 90%, a precision of ±10%, and an estimated proportion of 0.5, resulting in 19 plots. Each plot measured 40 m × 40 m.

Diversity Assessment

All woody species (trees and shrubs) found within each plot were identified, documented, and geotagged. Species identification was conducted in the field, with scientific names and classifications verified using Co's Digital Flora of the Philippines (Pelser et al. 2011) and Plants of the World Online (POWO 2024). Species that could not be identified were further verified with the help of plant taxonomist. No herbarium specimens were collected, but field observations and reference verification ensured accurate species identification. Density, frequency, and dominance were used to compute the importance value of woody species (Guron et al. 2019).

Diversity Indices

Species diversity in the Dugo Watershed was assessed using several diversity indices (Guron et al. 2019). These included the Shannon-Wiener Diversity Index (H'), Simpson's Diversity Index (D), and Margalef's Richness Index (R). Computations were performed using Microsoft Excel 2016. The formulas for each diversity index were as follows:

Shannon-Wiener diversity index (H)

$$H = \sum_{i=l}^{S} pi(\ln pi)$$

where: H = Shannon-Wiener diversity index
pi = Number of individuals of species i/ total number of samples
S = Number of species or species richness
ln = the natural logarithm

Simpson's diversity index (D)

$$D = 1 - \sum_{i=l}^{s} \frac{ni(ni-1)}{N(N-1)}$$

where: ni = total individual of species i
N = total number of individual of all species
S = number of species or species richness

Margalef's Richness Index (R)

$$R = \frac{(S-1)}{\ln(N)}$$

where: R = richness
S = number of species
N = number of individuals (of all species)

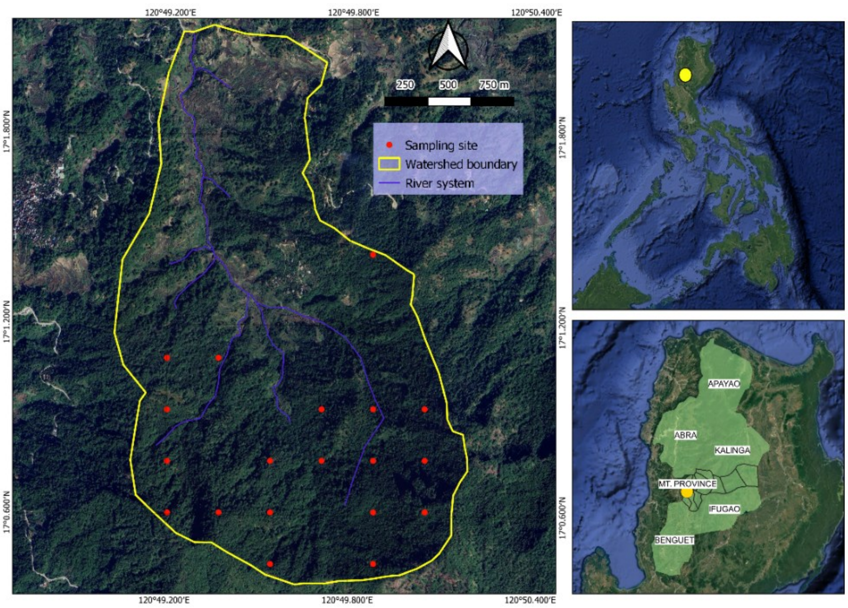


Figure 1. Map of Philippines, the Cordillera Administrative Region, showing the sampling sites.

Conservation Status, Biogeography and Use Value

The conservation status of all recorded woody species was assessed using the IUCN Red List of Threatened Species (IUCN 2025) and the DENR Administrative Order (DAO) 2017-11: Updated National List of Threatened Philippine Plants (DENR 2017). Species that were not assessed or were absent from the IUCN Red List and national conservation records were designated as Not Evaluated**.** Distribution status was assessed using Co's Digital Flora of the Philippines to determine whether species are endemic, indigenous, or introduced. Documenting endemic species is critical for identifying conservation priorities as their restricted range makes them more vulnerable to extinction (Manes et al. 2021; Orsenigo et al. 2018). Indigenous and introduced species were also recorded to complete understanding of the local flora. Information on species uses including food, medicine, construction, cultural significance, and ecological services were obtained through interviews with local communities. This information provides context for the perceived conservation value and potential threats to plant species within the watershed.

GIS Mapping and Database

Field data were processed using QGIS to map the locations of all identified woody species within each sampling plot. A geospatial database was developed in QGIS to store species attributes, including diameter at breast height (DBH), scientific name, family, distribution status, and documented uses. The database provides a baseline for visualizing spatial patterns and supporting biodiversity monitoring in the watershed.

RESULTS

Woody Species Composition and Diversity

A total of 81 woody species (Table 1) with 60 genera and 36 families were documented in Dugo Watershed (Figure 2). Among these, the genus *Ficus* had nine, which was the highest number of species. On the other hand, the genera *Ardisia* and *Pittosporum* each had three species. At the family level, Moraceae had nine species, followed by Rubiaceae, with seven, and Euphorbiaceae, with five.

In terms of importance value (IV), results showed that *P. kesiya* had the highest IV at 111.38, indicating its dominant presence and influence on the community structure (Table 2). Following this, *Ficus benguetensis* Merr., (1905), has an IV of 9.98, which also reflects its importance. Other notable species include *Pipturus asper* Wedd., (1854), with an IV of 8.19, and *Eurya coriaceae* Merr., (1910), at 7.85.

The diversity indices used for Dugo Watershed were a Shannon-Weiner Diversity Index of 2.84, a Margalef's Species Richness Index of 11.78, a Pielou's Evenness Index of 0.65, and a Simpson's Dominance Index of 0.81.

Conservation Status, Biogeography and Use Value

Several species found in the watershed were listed as threatened (Figure 3). The results revealed that three species were classified as endangered, four nearly threatened, two as other threatened, and five as vulnerable. The rest are categorized as least concern, which indicates that they were not currently at risk, and not evaluated, meaning they have not been assessed or evaluated by the reports used. Key species classified as Endangered include *Guioa acuminata* Radlk., (1914), *Pterocarpus indicus* Willd (1802), and *Wendlandia philippinensis* Cowan, (1932). These species were at high risk of extinction due to specific habitat requirements and threats such as habitat loss. Species classified as Near Threatened include *E. coriacea, Leea philippinensis* Merr., (1906)*, Mussaenda benguetensis* Elmer, (1906) and *Vaccinium benguetense* S. Vidal, (1886). These species were at risk, requiring monitoring and habitat protection to prevent further declines. Species classified as Other Threatened include *Aphanamixis polystachya* (Wall.) R. Parker, (1931) and *Pittosporum ramosii* Merr., (1920) which face specific threats such as habitat loss. Species classified as Vulnerable

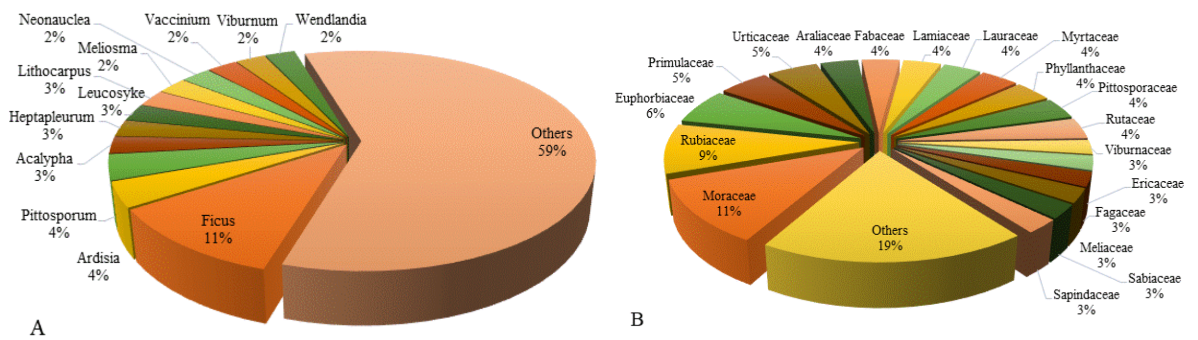


Figure 2. Proportion of documented genera (A) and families (B) in the study site. Categories with less than 1.2% of the total were grouped as "Others".

Table 1. List of woody species identified.

	Scientific name	Family Name	Conservation status
1	*Acalypha angatensis* Blanco	Euphorbiaceae	Not Evaluated
2	*Acalypha cardiophylla* Merr.	Euphorbiaceae	Least Concern
3	*Alnus japonica* (Thunb.) Steud.	Betulaceae	Least Concern
4	*Alphitonia excelsa* (Fenzl) Reissek ex T. Mitch.	Rhamnaceae	Least Concern
5	*Aphanamixis polystachya* (Wall.) R.Parker	Meliaceae	Other Threatened
6	*Aralia bipinnata* Blanco	Araliaceae	Least Concern
7	*Archidendron clypearia* (Jack) I.C.Nielsen	Fabaceae	Least Concern
8	*Ardisia pyramidalis (Cav.) Pers.*	Primulaceae	Not Evaluated
9	*Ardisia* Sw.	Primulaceae	Not Evaluated
10	*Ardisia warburgiana* Mez	Primulaceae	Not Evaluated
11	*Bischofia javanica* Blume	Phyllanthaceae	Least Concern
12	*Boehmeria* Jacq.	Urticaceae	Not Evaluated
13	*Bridelia* Willd.	Phyllanthaceae	Not Evaluated
14	*Buddleja asiatica* Lour.	Scrophulariaceae	Least Concern
15	*Callicarpa pedunculata* R.Br.	Lamiaceae	Least Concern
16	*Cinnamomum* Schaeff.	Lauraceae	Not Evaluated
17	*Clausena anisum-olens* (Blanco) Merr.	Rutaceae	Least Concern
18	*Croton* L.	Euphorbiaceae	Not Evaluated
19	*Crypteronia paniculata* Blume	Crypteroniaceae	Least Concern
20	*Decaspermum parviflorum* (Lam.) A.J.Scott	Myrtaceae	Least Concern
21	*Eugenia* L.	Myrtaceae	Not Evaluated
22	*Euonymus cochinchinensis* Pierre	Celastraceae	Least Concern
23	*Eurya coriacea* Merr.	Pentaphylacaceae	Near Threatened
24	*Ficus ampelos* Burm.f.	Moraceae	Least Concern
25	*Ficus benguetensis* Merr.	Moraceae	Least Concern
26	*Ficus concinna* (Miq.) Miq.	Moraceae	Least Concern
27	*Ficus cuneiformis C.C.Berg*	Moraceae	Not Evaluated
28	*Ficus minahassae* (Teijsm. & de Vriese) Miq.	Moraceae	Least Concern
29	*Ficus nota* (Blanco) Merr.	Moraceae	Least Concern
30	*Ficus pseudopalma* Blanco	Moraceae	Not Evaluated
31	*Ficus ruficaulis* Merr.	Moraceae	Least Concern
32	*Ficus septica* Burm.f.	Moraceae	Least Concern
33	*Glochidion luzonense* Elmer	Phyllanthaceae	Not Evaluated
34	*Gmelina arborea* Roxb. ex Sm.	Lamiaceae	Least Concern
35	*Guioa acuminata* Radlk.	Sapindaceae	Endangered
36	*Harpullia arborea* (Blanco) Radlk.	Sapindaceae	Least Concern
37	*Heptapleurum blancoi* (Merr.) Lowry & G.M.Plunkett	Araliaceae	Not Evaluated
38	*Heptapleurum* Gaertn.	Araliaceae	Near Threatened
39	*Homalanthus macradenius* Pax & K.Hoffm.	Euphorbiaceae	Least Concern
40	*Ilex crenata* Thunb.	Aquifoliaceae	Not Evaluated
41	*Itea macrophylla* Wall.	Iteaceae	Not Evaluated
42	*Kanapia monstrosa* (A.Rich.) Arriola & Alejandro	Rubiaceae	Not Evaluated
43	*Leea philippinensis* Merr.	Vitaceae	Near Threatened
44	*Leucaena leucocephala* Lamk	Fabaceae	Not Evaluated
45	*Leucosyke capitellata* (Poir.) Wedd.	Urticaceae	Not Evaluated
46	*Leucosyke* Zoll. & Moritzi	Urticaceae	Least Concern
47	*Lithocarpus jordanae* (Laguna) Rehder	Fagaceae	Vulnerable
48	*Lithocarpus woodii* (Hance) A.Camus	Fagaceae	Vulnerable
49	*Litsea cordata* (Jack) Hook.f.	Lauraceae	Least Concern
50	*Maesa indica* (Roxb.) Sweet	Primulaceae	Least Concern
51	*Mallotus mollissimus* (Geiseler) Airy Shaw	Euphorbiaceae	Least Concern
52	*Melicope* sp1 J.R.Forst. & G.Forst.	Rutaceae	Not Evaluated
53	*Meliosma* Blume	Sabiaceae	Not Evaluated
54	*Meliosma* Blume	Sabiaceae	Not Evaluated
55	*Melodinus* J.R.Forst. & G.Forst.	Apocynaceae	Not Evaluated
56	*Micromelum minutum* (G.Forst.) Wight & Arn.	Rutaceae	Least Concern
57	*Mussaenda benguetensis* Elmer	Rubiaceae	Near Threatened
58	*Neolitsea microphylla* Merr.	Lauraceae	Vulnerable
59	*Neonauclea* Merr.	Rubiaceae	Not Evaluated
60	*Neonauclea reticulata* (Havil.) Merr.	Rubiaceae	Least Concern
61	*Pinus kesiya* Royle ex Gordon	Pinaceae	Least Concern
62	*Pipturus asper* Wedd.	Urticaceae	Least Concern
63	*Pittosporum moluccanum* (Lam.) Miq.	Pittosporaceae	Least Concern
64	*Pittosporum pentandrum* (Blanco) Merr.	Pittosporaceae	Least Concern
65	*Pittosporum ramosii* Merr.	Pittosporaceae	Other Threatened

	Scientific name	Family Name	Conservation status
66	*Premna oblongata* Miq.	Lamiaceae	Least Concern
67	*Prunus* L.	Rosaceae	Not Evaluated
68	*Psidium guajava* L.	Myrtaceae	Least Concern
69	*Pterocarpus indicus* Willd.	Fabaceae	Endangered
70	*Pterophylla* D.Don	Cunoniaceae	Not Evaluated
71	*Saurauia bontocensis* Merr.	Actinidiaceae	Vulnerable
72	*Solanum lasiocarpum* Dunal	Solanaceae	Not Evaluated
73	*Tarennoidea wallichii* (Hook.f.) Tirveng. & Sastre	Rubiaceae	Not Evaluated
74	*Toona calantas* Merr. & Rolfe	Meliaceae	Vulnerable
75	*Turpinia sphaerocarpa* Hassk.	Staphyleaceae	Least Concern
76	*Vaccinium barandanum* S.Vidal	Ericaceae	Not Evaluated
77	*Vaccinium benguetense* S.Vidal	Ericaceae	Not Evaluated
78	*Viburnum luzonicum* Rolfe	Viburnaceae	Least Concern
79	*Viburnum odoratissimum* Ker Gawl.	Viburnaceae	Least Concern
80	*Wendlandia luzoniensis* DC.	Rubiaceae	Least Concern
81	*Wendlandia philippinensis* Cowan	Rubiaceae	Endangered

Table 2. Top 15 species with the highest importance value (IV).

Scientific name	Relative Density	Relative Frequency	Relative Dominance	Importance Value
Pinus kesiya Royle ex Gordon	42.94	7.76	60.68	111.38
Ficus benguetensis Merr.	3.36	4.57	2.06	9.99
Pipturus asper Wedd.	2.91	2.74	2.54	8.19
Eurya coriacea Merr.	4.04	1.83	1.99	7.85
Toona calantas Merr. & Rolfe	1.57	2.28	3.33	7.18
Alnus japonica (Thunb.) Steud.	2.13	3.20	1.85	7.17
Homalanthus macradenius Pax & K.Hoffm.	2.69	2.74	1.69	7.12
Ficus ampelos Burm.f.	3.25	2.28	1.18	6.71
Ficus septica Burm.f.	1.57	3.65	1.41	6.63
Gmelina arborea Roxb. ex Sm.	2.02	2.28	1.90	6.20
Kanapia monstrosa (A.Rich.) Arriola & Alejandro	2.35	2.28	1.20	5.84
Heptapleurum blancoi (Merr.) Lowry & G.M.Plunkett	1.57	2.28	1.82	5.68
Wendlandia luzoniensis DC.	1.46	3.20	0.81	5.47
Euonymus cochinchinensis Pierre	1.35	2.74	1.03	5.12
Acalypha angatensis Blanco	1.79	2.28	1.03	5.11

include *Lithocarpus jordanae* (Laguna) Rehder, (1919), *Lithocarpus woodii* (Hance) A. Camus, (1931), *Neolitsea microphylla* Merr., (1906), *Saurauia bontocensis* Merr., (1915), and *Toona calantas* Merr. & Rolfe, (1908). These species play critical ecological roles and require habitat protection and regeneration efforts.

Figure 4 shows the proportion of species by distribution status in the study area. The results indicated that 60.49% of the species were indigenous, reflecting the watershed's rich native biodiversity. The presence of 14.81% endemic species could indicate the role of the area as a habitat for species found only in the Philippines. The remaining species were introduced.

Species were recorded based on use categories (Figure 4). Ecological use was noted in 87.65% of species. Multipurpose use was noted in 8.64%, and economic use in 3.70%. A few were recorded with cultural use such as *P. kesiya* and *T. calantas*, but they were counted under multipurpose use. Which explain why the cultural use category is 0%.

Spatial Database of Woody Species

The spatial database developed through GIS was used for the mapping of woody species within the established quadrats. Each point represents a species and contains information such as scientific name, family name, height, diameter at breast height (DBH), information about its endemism or status, and uses (Figure 5). These maps highlight the geographic distribution of species, particularly those that are threatened and can be used in monitoring their population in the future.

DISCUSSION

Woody Species Composition and Diversity

The presence of 81 species reflects the existing vegetation structure in the watershed. The dominance of *Ficus* species shows their ecological importance, as they contribute to vegetation structure and provide food for animals (Berg and Corner 2005). Being pioneer plants, they indicate constant exposures to disturbance. *Ficus* species can grow as epiphytes, hemi-epiphytes, or trees, allowing them to adapt to different environments. These characteristics make them a key component of the watershed vegetation.

The genera *Pittosporum* and *Ardisia* also contribute to the biodiversity of the watershed. These plants are valued for their medicinal properties and contain phytochemicals that have potential applications (Kobayashi and De Mejia 2005; Linh et al. 2024). However, difficulty in identifying some species and limited studies on their uses have led to their underutilization.

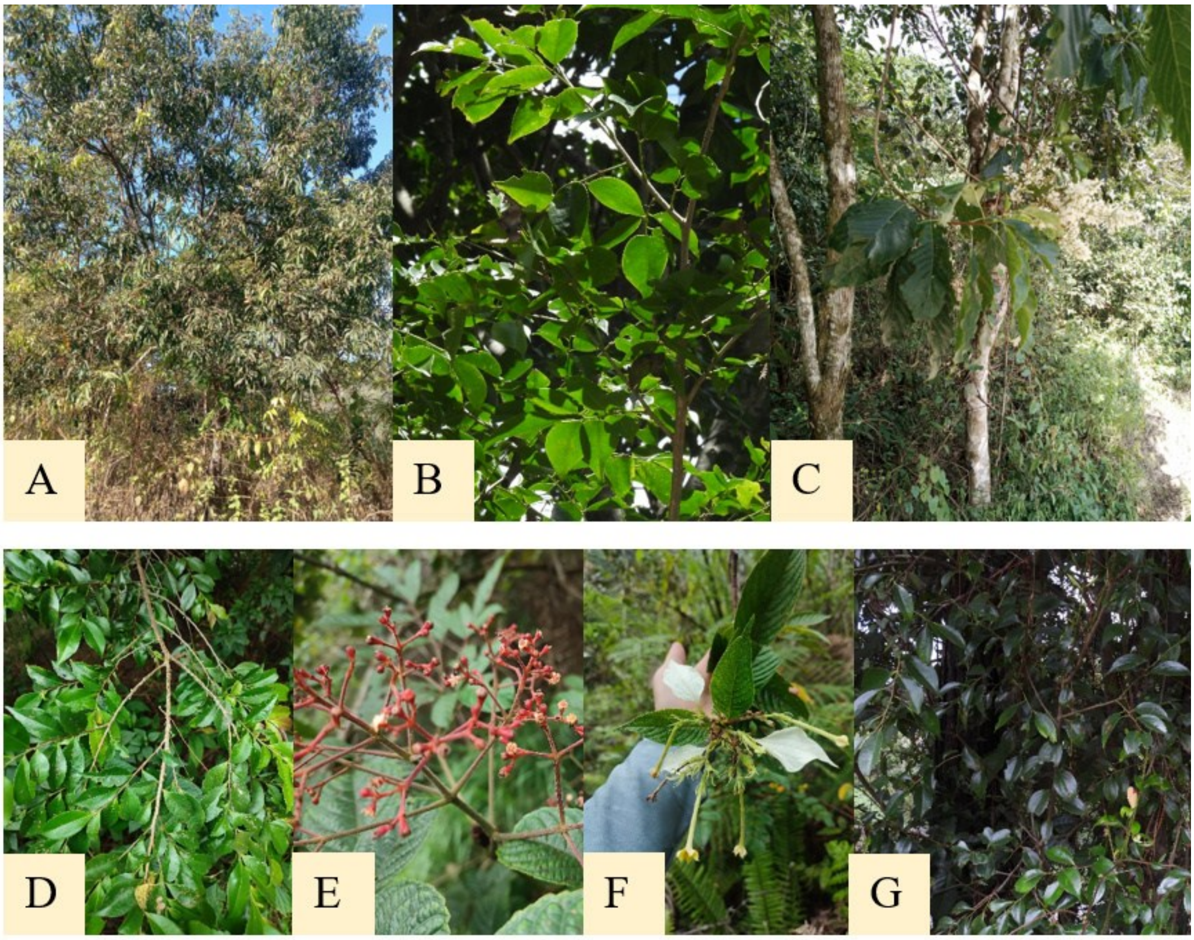


Figure 3. Threatened species of Dugo Watershed (A) *Guioa acuminata* Radlk, (B) *Pterocarpus indicus* Willd., (C) *Wendlandia philippinensis* Cowan, (D) *Eurya coriacea* Merr., 1910, (E) *Leea philippinensis* Merr., 1906, (F) *Mussaenda benguetensis* Elmer, 1906, and (G) *Vaccinium benguetense* S.Vidal, 1886.

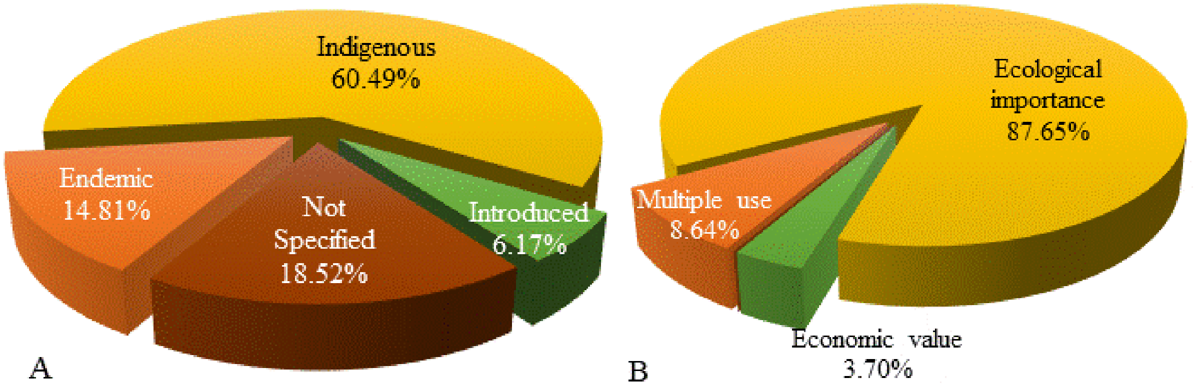
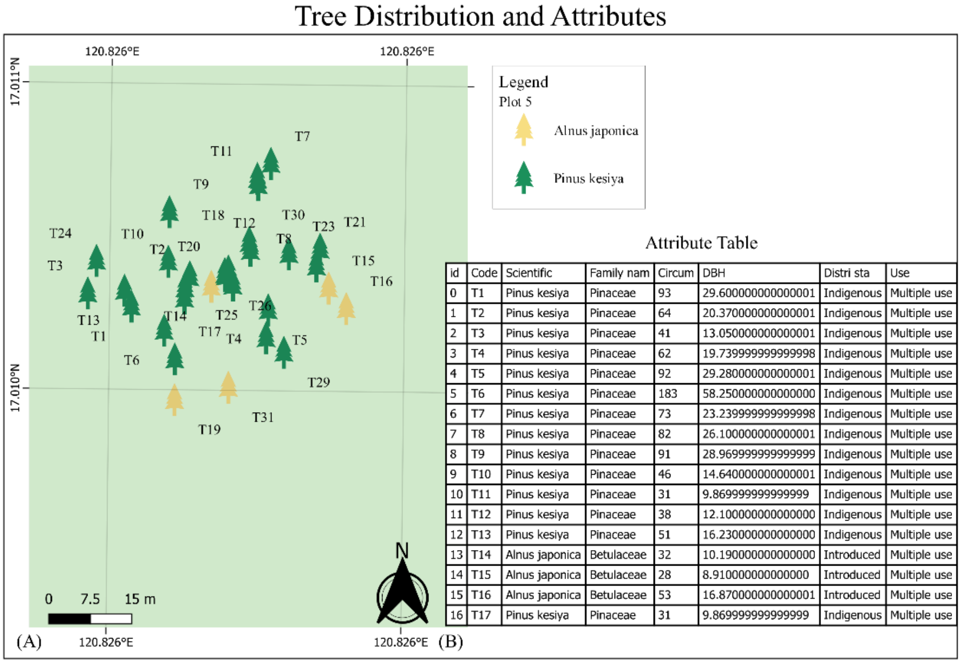


Figure 4. Proportion of species by distribution status (A), and distribution of species by their uses B.



id	Code	Scientific	Family nam	Circum	DBH	Distri sta	Use
0	T1	Pinus kesiya	Pinaceae	93	29.600000000000001	Indigenous	Multiple use
1	T2	Pinus kesiya	Pinaceae	64	20.370000000000001	Indigenous	Multiple use
2	T3	Pinus kesiya	Pinaceae	41	13.050000000000001	Indigenous	Multiple use
3	T4	Pinus kesiya	Pinaceae	62	19.739999999999998	Indigenous	Multiple use
4	T5	Pinus kesiya	Pinaceae	92	29.280000000000001	Indigenous	Multiple use
5	T6	Pinus kesiya	Pinaceae	183	58.250000000000000	Indigenous	Multiple use
6	T7	Pinus kesiya	Pinaceae	73	23.239999999999998	Indigenous	Multiple use
7	T8	Pinus kesiya	Pinaceae	82	26.100000000000001	Indigenous	Multiple use
8	T9	Pinus kesiya	Pinaceae	91	28.969999999999999	Indigenous	Multiple use
9	T10	Pinus kesiya	Pinaceae	46	14.640000000000001	Indigenous	Multiple use
10	T11	Pinus kesiya	Pinaceae	31	9.869999999999999	Indigenous	Multiple use
11	T12	Pinus kesiya	Pinaceae	38	12.100000000000000	Indigenous	Multiple use
12	T13	Pinus kesiya	Pinaceae	51	16.230000000000000	Indigenous	Multiple use
13	T14	Alnus japonica	Betulaceae	32	10.190000000000000	Introduced	Multiple use
14	T15	Alnus japonica	Betulaceae	28	8.910000000000000	Introduced	Multiple use
15	T16	Alnus japonica	Betulaceae	53	16.870000000000001	Introduced	Multiple use
16	T17	Pinus kesiya	Pinaceae	31	9.869999999999999	Indigenous	Multiple use

Figure 5. Distribution of woody species within the sampling area (A) Tree distribution map of Plot 5 as sample; (B) Attribute table showing species information.

The families Moraceae, Rubiaceae, and Euphorbiaceae are the most dominant in the watershed. These families are recognized as pantropical rainforest families and indicators of tropical conditions (Wurdack et al. 2005; Corlett and Primack 2011; Delprete and Jardim 2012). Although a few species that belongs to these families are endemic to the area.

The watershed is dominated by Benguet pine. This species is dominant in the whole Cordillera Administrative Region (CAR) in the Northern Philippines. It is considered as one of the most important trees in CAR, both economically and culturally (Lumbres and Lee 2014). Its dominance is partly due to local preference for the wood of the species being termite resistant and the frequent forest fires, which hinder the growth of broad-leaf species, thus maintaining pine prevalence. In the Dugo watershed, forest fires occur almost every two years due to human activities. Community initiatives and united efforts locally known as "galatis", such as establishing fire lines help mitigate these fires. The species also grows well in soils with low fertility (Galindo-Jaimes et al. 2002). It also occupies extensive forest area in the Cordillera Mountain Range (Clemente 2024), highlighting the resilience and adaptability of *P. kesiya*.

The computed diversity indices reflect a community with moderate species diversity and balanced representation. Key species such as *P. kesiya* and *F. benguetensis* contribute to ecological stability, and the Simpson's Dominance Index indicates dominance of these two species. Maintaining diverse plant species is essential for supporting the ecological functions and resilience of the watershed (Walker et al. 1999). Studies of other areas in Benguet, such as the Alno communal mixed forest and Talinguroy Research Station, show higher diversity indices (Lumbres et al. 2014; Guron et al. 2019). Mt. Ulap in Benguet also shows varied but generally higher diversity (Guron et al. 2022). Difference in biodiversity indices can be due to various factors like climatic conditions, soil characteristics, forest management practices, disturbance regimes, historical land use, and elevation, which can influence species diversity (Kumar and Ram 2005). Effective management in Mt. Ulap leads to higher biodiversity, with these areas undergoing secondary succession towards broadleaf forests (Guron et al. 2022).

Frequent forest fires caused by human activities remain a major challenge in the watershed. These fires favor *P. kesiya* and limit the growth of broadleaf species. While occasional fires can help regenerate fire-adapted species, frequent and intense fires cause habitat loss, species decline, and changes in soil and water conditions (Shivaprasad et al. 2025). Managing these fires is a major challenge for watershed conservation. Future research should focus on how ecosystems recover and build resilience after forest fires, examining vegetation, soil, and biodiversity changes while considering climate, topography, and human interventions to guide sustainable conservation and management practices (Nolan et al. 2021; Walia et al. 2025).

Limited information on underutilized species like *Pittosporum* and *Ardisia* also poses a challenge. Although these species are present in the watershed, their ecological roles, uses and conservation status are still poorly documented. Studies show that neglected and underutilized species can support sustainable food security because of their resilience, nutritional value, and socio-economic benefits (Knez et al. 2024; Onawo and Egboduku 2025). Further research is therefore needed to document these species and assess their potential value so they can be included in conservation and management planning for the watershed.

Conservation Status, Biogeography and Use Value

The presence of threatened woody species in the watershed highlights its importance for biodiversity conservation. *Guioa acuminata* classified as Endangered and *S. bontocensis* classified as Vulnerable were observed to be restricted to limited areas within the watershed. In particular, *S. bontocensis* was recorded in locations near streams, indicating an association with water-available sites. These species thrive only in specific habitats (POWO 2024), making them highly sensitive to disturbance. As mentioned by Manes et al. (2021), the restricted ranges of species mean that they are often at greater risk of extinction because threats such as climate change, and habitat loss can affect their population. This pattern of threatened and endemic species concentrated in specific habitats reinforces the need for targeted conservation (Arzaga and Banaticla-Hilario 2025).

The documentation of endemic species further supports the conservation value of the watershed for species found only in the Philippines. In contrast, several introduced species were also recorded, including *Alnus japonica* (Thunb.) Steud., (1840), *Gmelina arborea* Roxb. ex Sm., (1810), and *Psidium guajava* L., (1753) are introduced. *Alnus japonica* was introduced in the locality for its nitrogen-fixing capabilities and as a source of organic fertilizer or compost. Unfortunately, it became invasive in other areas (Paltiyan-Bugtong et al. 2022). The two other species, *G. arborea* and *P. guajava,* were also introduced. *Gmelina arborea* has become popular in the country as a source of timber. It has been a common species being planted in reforestation efforts, yet it is known to be exotic. Well-intended reforestation using non-native trees can harm native biodiversity (van Beijnen and Jose 2020). *Psidium guajava*, also not native to the country, is believed to have originated elsewhere and was introduced by the Spaniards. The adaptability of the guava tree to various soils and climates has enabled its naturalization in tropical and sub-tropical regions worldwide (Singh 2011).

Most species of the watershed were identified for their ecological roles. Most of these species are native, and the local community recognizes the importance of these species in preventing soil erosion, improving water retention, providing shelter to habitats. Species with multiple uses include *A. japonica* (shade for coffee, dried leaves as mulch, firewood), *Bischofia javanica* Blume, (1827) (timber, used to cure ulcer but is not widely known in the community), and *P. kesiya* (timber, firewood, house construction, cultural value). Species with economic value include *G. arborea* (timber), *P. indicus* (timber), and *P. guajava* (food, edible). Examples of species contributing to ecological functions include *Crypteronia paniculata* Blume, (1827) (helps prevent soil erosion) and *F. benguetensis* (food for animals). Species identified with cultural value include *P. kesiya* and *T. calantas* (for woodcraft). *Pinus kesiya* is widely used in traditional practices, such as house and coffin construction, firewood for household use and community gatherings and celebration. Its collection from the "Batangan" (forest land) is managed by the community in accordance with customary laws, reflecting an existing community-based management system that supports sustainable resource use. Similar practices have been documented among other indigenous groups (Bauyot et al. 2024).

Given their threatened status and limited distribution, species such as *G. acuminata* and *S. bontocensis*, should be formally included in local protection policies. The LGU can enact rules limiting their collection while promoting their propagation in community nurseries. Similarly, underutilized species like *Pittosporum* and *Ardisia* can be integrated into small-scale restoration and agroforestry programs, providing both ecological benefits and potential economic use. These measures can be supported through targeted community workshops and monitoring programs.

Spatial Database of Woody Species

The GIS database combines geographic location with specific species attributes, aiding informed decisions in forest management and conservation efforts. The use of GIS technology provided the LGU a valuable tool for assessing and monitoring the forested area within the watershed.

Areas dominated especially of threatened species should be prioritized for protection. Areas dominated by *P. kesiya* and those frequently affected by fires are suitable for restoration through enrichment planting of native broadleaf species. Continuous establishment of fire lines, regular patrolling, and targeted enrichment planting can be implemented to enhance biodiversity and conserve the watershed.

The findings emphasize the need for targeted conservation actions to protect high-priority species like *G. acuminata* and *S. bontocensis*. These species need immediate attention due to their endemism and specific habitat requirements, which makes them vulnerable to disturbance. Efforts should focus on habitat protection and restoration for species with limited distribution. This will help prevent further habitat loss and promote natural regeneration. Community-based conservation initiatives should be prioritized. Expanding programs like "galatis" can strengthen fire prevention and engage locals in addressing threats like forest fires, illegal logging and other unsustainable land-use practices. In addition, regular monitoring and further research on threatened species and underutilized plants, such as *Pittosporum* and *Ardisia*, are essential. This will help safeguard their ecological and economic importance and support informed conservation strategies.

Overall, the study underscores the importance of maintaining biodiversity and ecological stability in the Dugo Watershed. Strengthening these aspects will ensure the watershed's resilience and provisions of continued ecosystem services and resources for surrounding communities. The spatial database created through GIS technology also provided a valuable tool for mapping and managing the woody species, and supports effective forest management and conservation planning.

FUNDING

The study was funded through the authors' personal resources.

GENERATIVE AI STATEMENT

This manuscript used Grammarly tool to assist in language refinement and clarity improvement.

ETHICAL CONSIDERATIONS

All activities ensure minimal disturbance to natural habitat and complied the local permissions.

DECLARATION OF COMPETING INTEREST

The authors declare that there is no competing interests to any authors.

ACKNOWLEDGMENTS

We acknowledge the support of the Local Government Unit of Barangay Lubon, Tadian, and all individuals who assisted in this study. We also thank the Western Philippines University and the anonymous reviewers for comments and suggestions.

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ROLE OF AUTHORS: *SFAG - responsible for data gathering, analysis, and writing the results and discussion sections; MRP - responsible to the improvement and enhancement of the article*

Responsible Editor: Dr. Dave P. Buenavista