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Floristic Composition, Diversity, and Ecology for Conservation of Lower Agno Watershed Forest Reserve, Mountain Province, Philippines

NELSON M. PAMPOLINA
ORCID NO. 0000-0003-0486-364X
nmpampolina@up.edu.ph
Forest Biological Sciences, College of Forestry and Natural Resources
University of the Philippines Los Baños
Laguna, Philippines

ERICSON E. CORACERO
ORCID NO. 0000-0002-2569-3179
ericson.coracero@g.batstate-u.edu.ph
College of Agriculture and Forestry
Batangas State University - The National Engineering University
Batangas, Philippines

KENNETH O. ECO
ORCID NO. 0000-0002-3061-1385
koeco@up.edu.ph
Visayas State University
Leyte, Philippines

KESHIA N. TINGSON
ORCID NO. 0000-0001-6888-8825
kntingson1@up.edu.ph
Institute of Renewable Natural Resources, College of Forestry and Natural Resources
University of the Philippines Los Baños
Laguna, Philippines

ABSTRACT

The paper shows the floristic species composition, structure, and diversity, including the ecological importance of the portion of Lower Agno Watershed Forest Reserve. Through quadrat and transect surveys, this study assessed six forest ecosystems, three grassland ecosystems, and five riparian sites. There were 41 tree species, 91 understorey species, 87 ground cover species, and 69 riparian species. Dominant species include *Pinus kesiya* Royle ex. Gordon, *Chromolaena odorata* (L.) King, *Miscanthus* sp., *Wikstroemia ovata* C.A. Mey ex Meisn, *Ayapana triplinervis* (Vahl) R.M. King & H. Rob, *Leucaena leucocephala* (Lam.) de Wit, *Saccharum spontaneum* L., and *Lantana camara* L. Forest ecosystems had secondary growth trees with a mean diameter ranging from 17 to 43 cm and mean height of 10 to 18 m. Results showed that the area was moderately diverse, with H' ranging from 2.26 to 2.90 and having a similarity index ranging from 0 to 50%. The site was ecologically important, home to 47 natives, nine endemic, nine internationally threatened, and four nationally threatened species. Regarding soil and plant nutrients, the values obtained were within the normal range for N, P, and K except for *Alnus japonica* (Thunb.) Steud. which acted as an accumulator with very high Cu content (53 ppm), making it an essential species in rehabilitating areas dominated by highly mineralized soil. Results could serve as baseline information vital in devising conservation and protection strategies to manage better and preserve the site.

Keywords: Riparian ecosystem, forest ecosystem, grassland ecosystem, flora, diversity, plant similarity index

INTRODUCTION

The Philippines is one of the world's megadiverse countries, with 70-80% of the world's plant and animal species (Lagat & Causaren, 2019). The country is also one of the biodiversity hotspots home to a total of 240 national parks and protected areas as of 2013 under the Republic Act No. 7586 or the National Integrated Protected Areas System (NIPAS) (Biodiversity Management Bureau, 2015). These areas cover a total of 5.45 million ha, equivalent to 14.2% of the country's total area. In addition, another provision extended the coverage by adding 94 more protected areas from different regions through the Republic Act No. 11038, also known as the Expanded National Integrated Protected Areas System (ENIPAS). This provision aims to maintain and protect the country's ecologically essential areas and natural resources from human exploitation (Official Gazette, 2017).

Conservation and protection of natural resources have been a global problem challenging the environmental warriors and protectors (Prakash Kala, 2017). Significant factors in declining natural resources, forest cover, and biodiversity include exploitation, destructive disturbance, and other harmful human interferences (Slingenberg et al., 2009). On the other hand, some of the considerable elements of well-preserved biodiversity are the trees and plants that serve as habitats for other biological beings in the forests (Bütler et al., 2013). Thus, floristic assessments and ecology studies are vital to know the status of an area and the factors affecting its conditions for better management and conservation, especially in protected areas such as Lower Agno Watershed Forest Reserve (LAWFR).

Proclamation No. 2320 of 1983 established Lower Agno as a "watershed forest reservation to protect, maintain or improve its water yield for hydroelectric, irrigation and other ecological enhancement purposes and providing restraining mechanisms for inappropriate land-use and forest exploitation" (Official Gazette, 1983). The National Power Corporation also manages the watershed for hydroelectric power. This protection should have conserved the biological resources within the area. Thus, it is essential to look at the environmental situations in the area, especially the biodiversity aspect.

OBJECTIVES OF THE STUDY

This current study aimed to determine the floristic species composition and diversity of the ecosystems within the study site. Specifically, the study wanted to describe the ecosystems' structure, compute the diversity indices of flora species in the area, compare the similarity among ecosystem types, identify ecologically essential species, and assess the nutrient content of soil and plants thriving in the area.

MATERIALS AND METHODS

Study Site

The study sites are geographically located within the Lower Agno Watershed Forest Reserve (LAWFR) (Fig. 1). The LAWFR area is around 393.04 km2 covering portions of Pangasinan (2 municipalities) and Benguet (4 towns). There is a total of 40 barangays within the watershed forest reserve comprising 5 from Pangasinan (San Manuel – 1 and San Nicolas – 4) and 35 from Benguet (Baguio – 19, Bokod – 2, Itogon – 8, and Tuba – 4). The forest reserve is bounded by Barangay Loacan, Itogon, Benguet (North); Barangay Camindoroan, San

Nicolas, Pangasinan (South); Barangay Camp 4, Tuba, Benguet (East); and Barangay Pito, Bokod, Benguet (West). The sampling sites for the ecological study was found in barangays Ampucao (yellow part of map) and Camp 3 (pink part of map) within the municipalities of Itogon and Tuba, Benguet, respectively.

The study covered three major ecosystem types: forest, grassland ecosystem covered with pioneer species, and riparian vegetation. Forest ecosystems included six sites which were Dipterocarp Forest, Mossy Forest, Pine Forest Park, POKIS (Pine-Alnus-Coffee Reforestation), BUMOLO (Pine Reforestation), and Secondary Forest (Fig. 2). There were three grassland ecosystems: Grassland 1, Grassland 2, and Grassland 3 (Fig. 3). Lastly, riparian vegetation included the following sites: Bued River, Balog River, Benguet Creek, Albian River, and artificial waterbody near Grassland 3 (Fig. 4).

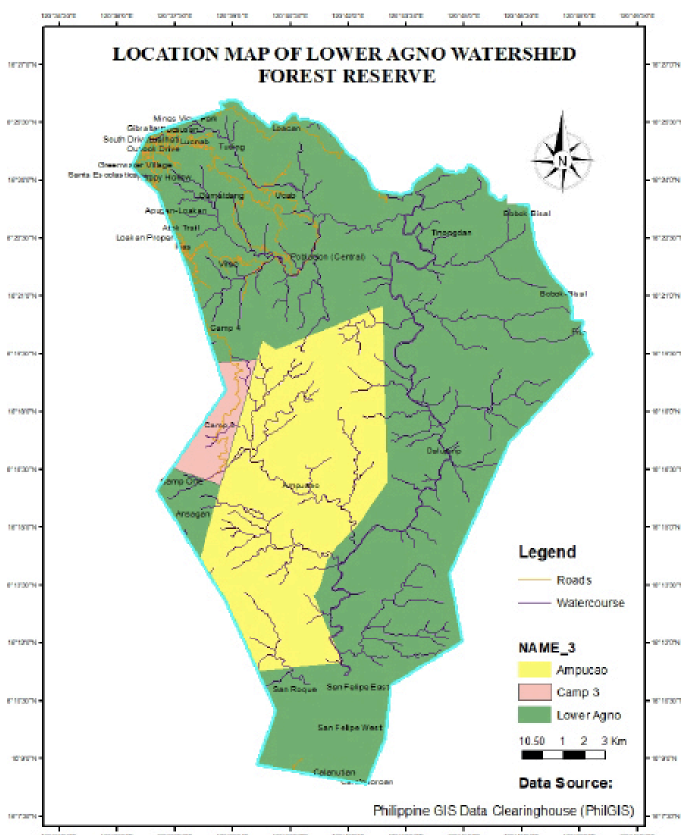

Figure 1. Location map of Lower Agno Watershed Forest Reserve

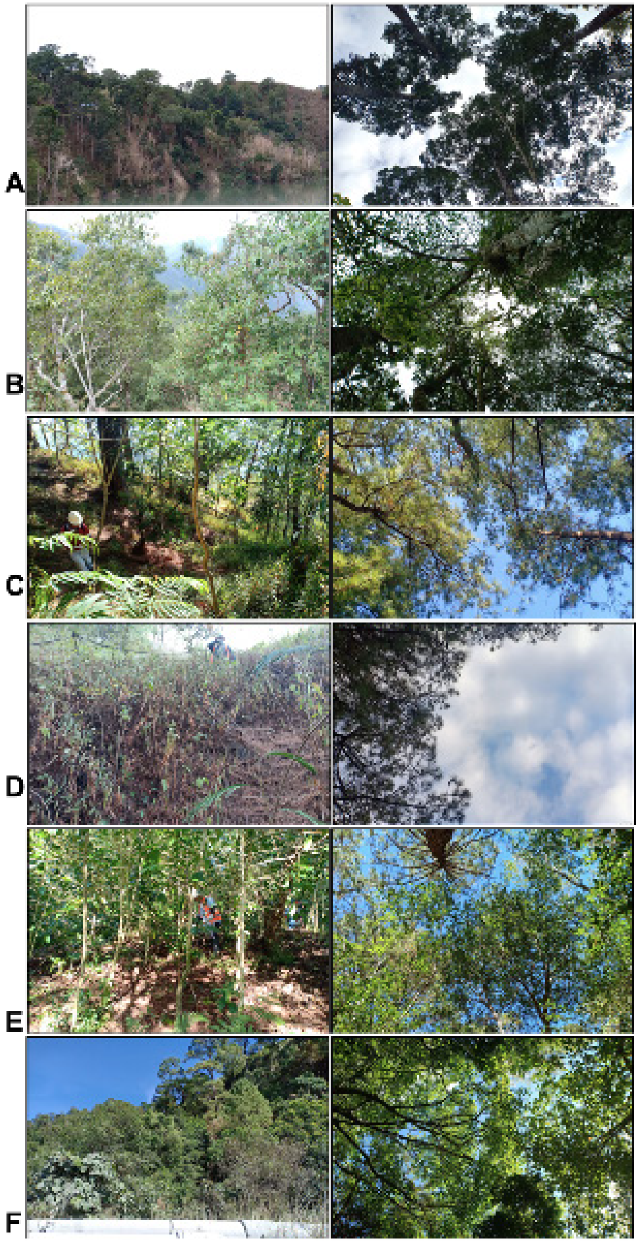

Figure 2. Photographs of vertical and horizontal profiles of forest ecosystem sites in Tuba and Itogon, Benguet. A Mossy Forest (MF) B Dipterocarp Forest (DF) C Pine Forest Park (PFP) D Bumolo E Pokis F Secondary Forest (SF).

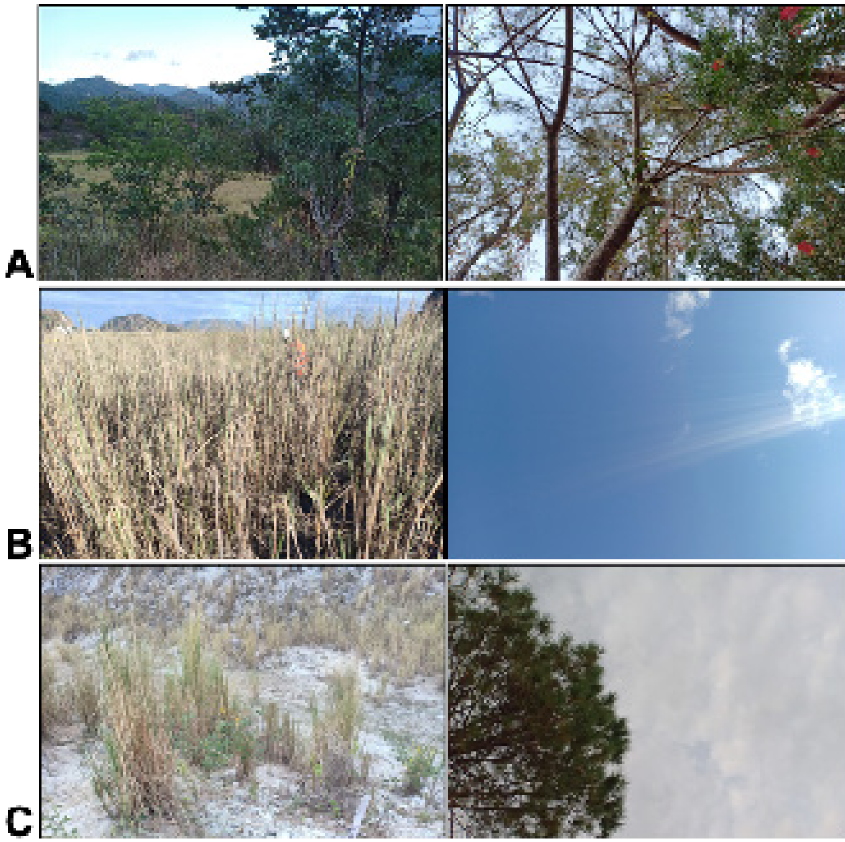

Figure 3. Photographs of vertical and horizontal profiles of grassland sites in Tuba and Itogon, Benguet. A Grassland 1 (G1), B Grassland 2 (G2), C Grassland 3 (G3).

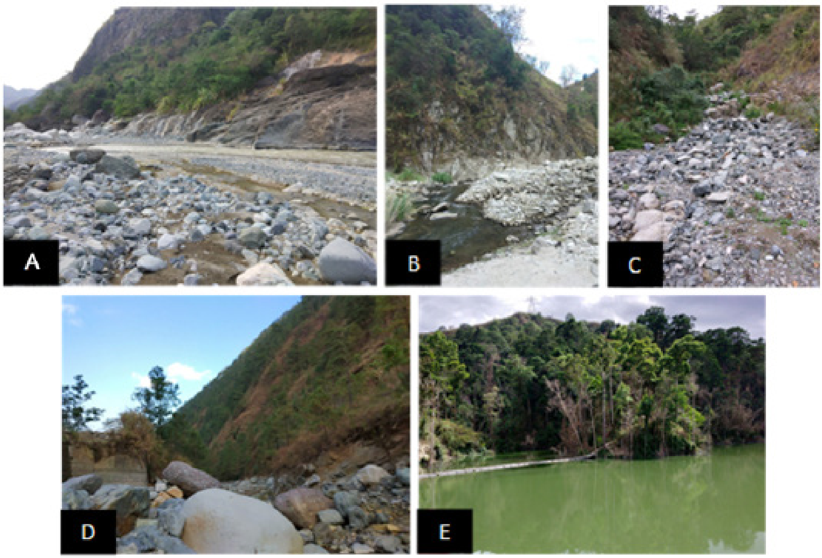

Figure 4. Permanent Sampling Sites for Riparian Vegetation Assessment. A Bued River, B Balog Creek, C Benguet Creek, D Albian Creek, and E Grassland 3.

Data Collection

In each sampling site, 10x10 meter quadrats were established approximately along a kilometer transect (Figure 5). The quadrats formed were nested to survey floral components in the upper canopy (trees), understorey (saplings and shrubs), and ground cover (regenerants or wildlings and forest litter) across vertical and horizontal layers in each ecosystem. The sampling dimension for each layer was 10x10m for canopy, 5x5m for understorey, and 1x1m for undergrowth cover. Sampling plots were established and placed with boundary markers filled with cement for permanent demarcation in future long-term ecological monitoring. We also tied in orange tags on the corner of every sampling plot to locate the boundaries of each quadrat quickly.

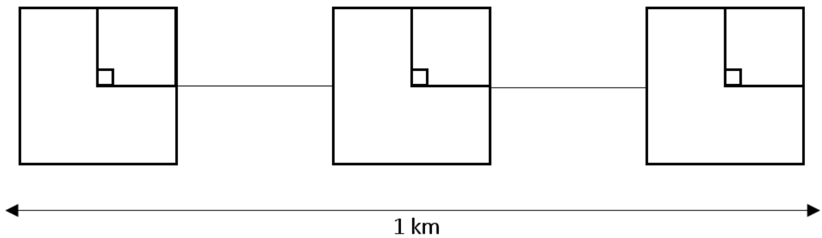

Figure 5. Nested quadrat layout per site for forest and grassland ecosystems

The study recorded at least 10 cm diameter individuals at breast height (DBH) for tree species. Biometrics like DBH, merchantable and total height, and location of trees were measured using diameter tape, meter tape, and handheld GPS, respectively. The researchers tagged each tree with recycled aluminum cans nailed by a rivet at DBH level within the 10 x 10 m marked plots for better monitoring.

Individuals of each understorey species were identified, counted to determine density, and recorded. Understorey species within the 5 x 5 m plot have DBH below 10 cm with a height of at least 1 m. During the dry sampling, we attached tags to the understorey species for better monitoring of the area. Ground cover within a 1 x 1 m plot includes plant species less than a meter in height. Plants were identified and counted, including seedlings, ferns, herbs, and grass. Percentage cover of forest litter (leaves, branches, twigs, etc.) were measured, taking note of soil bareness.

For the riparian vegetation assessment, the researchers laid a 50m transect parallel to the river on each riparian area. In areas where the laying of the transect is not feasible, purposive sampling was still carried out following the 50m transect length. Species were identified in the field based on morphological characteristics.

Diversity Indices Computation

The data were encoded in Microsoft Excel, and parameters for diversity assessment were computed using Paleontological Statistics Software Package for Education (PAST v3.14), a free statistical software. Below are the parameters for diversity indices:

- Number of taxa (S) – number of species
- Total number of individuals (n)
- Simpson evenness index (E) – the measure of the evenness of a community

with values ranging from 0 to 1

• Shannon index (entropy) (H') – diversity index, which uses the number of individuals and number of taxa as parameters with values ranging from 0 to 4. Zero dictates a low value of diversity with a single taxon in a community

Fernando Biodiversity Scale was used as a reference in interpreting the computed diversity indices (Table 1).

Table 1

Fernando Biodiversity Scale (Fernando, 1998)

Relative Values	Shannon Index	Evenness Index
Very High	3.5 and above	0.75 – 1.00
High	3.0 – 3.49	0.5 – 0.74
Moderate	2.5 – 2.99	0.25 – 0.49
Low	2.0 – 2.49	0.15 – 0.24
Very Low	1.9 and below	0.05 – 0.14

Similarity and Dissimilarity Indices Computation

A similarity index was used to compare the similarity of plant species composition between the two sites. The similarity index used was Jaccard Similarity, which only considers the plant species present and disregards the abundance of each species. The formula used was:

$$J_s = \frac{a}{(a + b + c)}$$

Where *a* is the number of species present in both sites, *b* is the number of species found in Site A but not in Site B, and *c* is the number of species found in Site B but not in Site A (Oluyinka Christopher, 2020). The dissimilarity index, on the other hand, was obtained by subtracting the Js from 1 or 100%.

Endemism, Indigeneity, and Conservation Statuses Assessment

The species endemism, indigeneity, and conservation status of identified plants were based on the International Union for Conservation of Nature (IUCN, 2021), DAO 2017-11 (Updated National List of Threatened Philippine Plants and Their Categories) (DENR, 2017), and Leonard Co's Digital Flora of the

Philippines (Pelser et al., 2011 onwards). This series of information will provide appropriate species for consideration in rehabilitation, conservation, ecological succession, and other essential values for ecosystem sustainability and resiliency.

Nutrient Analysis

For plant tissue analysis, fully expanded leaves (100 g) from selected species in each ecosystem were randomly collected at approximately the upper 1/3 of the crown or tip of the branches. Samples from ten dominant species were chosen in all sites though only eight were cleaned and processed for oven drying at 60°C for about 50 hours. Five species were further selected based on their dominance and indigeneity in the area: *Alnus japonica* (Thunb.) Steud. Or Alnus, *Saccharum spontaneum* L. or Talahib, *Anisoptera thurifera* (Blanco) Blume or Palosapis, *Pinus kesiya* Royle ex. Gordon or Benguet Pine, and *Eurya japonica* Thunb. or Bogna. Samples were ground in Wiley mill for acid digestion to analyze nitrogen, phosphorus, potassium, and copper.

For soil nutrient analysis, about 300 grams of soil samples were collected at the rhizosphere (1- 20 cm depth) layer using a trowel and adequately labeled for transport. Samples were air dried, pulverized, and weighed 50 g for pH, OM, P, K, and Cu analysis. Both soil and tissue samples were brought to the Analytical Soils Laboratory in the University of the Philippines Los Baños, Laguna, the Philippines, for chemical analysis of nutrients.

RESULTS AND DISCUSSION

Tree Species Composition, Structure, and Diversity

The study listed 41 morphospecies belonging to 30 genera and 26 families with 140 individuals. The most populous families were Pinaceae (43 individuals), Betulaceae (23 individuals), and Dipterocarpaceae (15 individuals). *Pinus Kesiya* Royle ex. Gordon or Benguet Pine was the most abundant and lone species from Pinaceae with 43 individuals (30.7%). The high number of individuals of Benguet Pine was expected, given that this species is restricted in the northern part of Luzon, mainly in Benguet, Philippines. Other research studies, such as the study in Benguet, also found P. kesiya as the most dominant species in the forest ecosystem surveyed (Lumbres et al., 2014).

The diameter of tree species recorded varied from 10 cm to 65.4 cm. The lowest tree DBH was recorded from *Buchanania arborescens* (Blume) Blume, while the highest was from *P. kesiya*. The mean DBH per site ranged from 17 cm to 43 cm, while the mean total height ranged from 10 to 18 meters being a secondary growth forest. This range of values dictates that the forest ecosystem had moderately large-sized trees having several species with more than 20 cm in diameter (Elzinga et al., 2005).

Overall, tree diversity values obtained were generally moderate based on Fernando Biodiversity Scale (H' = 2.90, E = 0.88). However, the evenness of species in the area must be commended, especially in the mossy forest with the highest diversity (H' = 2.12), considering the surveyed area of only 90 m2. There were several studies in and out of the Philippines on tree diversity. A survey in Mount Pangasugan, Baybay City, Philippines, revealed diversity values ranging from 3.09 to 4.53, which were also considered very high, possibly because it is inside the reservation of the Visayas State University, which prioritizes its protection (Polinar & Muuss, 2010). On the other hand, a study in Musuan Bukidnon yielded an H' value of 1.21, considered very low (Olipenda et al., 2013). Studies with higher values had more strict and systematic management; otherwise, the computed values would be the opposite.

Understorey Species Composition and Diversity

There was 91 morphospecies recorded from the sites coming from 74 genera and 38 families with a total of 614 individuals. Dominant sapling species (forest trees) found were *Miscanthus* sp. and *Wikstroemia ovata* C.A. Mey. Ex Meisn. Meanwhile, *Chromolaena odorata* (L.) King and Robinson and *Lantana camara* L. were the most dominant shrubs species which is more than half of the understorey species population listed. C. odorata was found to be an invasive species, thus, signifying its high individual count (Pelser et al., 2011 onwards). Notably, *S. spontaneum* was dominant in grassland ecosystems as pioneer species withstanding harsh environments.

Overall understorey diversity of the area was also classified as moderate with a considerably even distribution of individuals per species (H' = 2.818, E = 0.83). The studies computing for the lone diversity of understorey species are lacking. A study in Sierra Madre Mountain Range computed the overall diversity of trees and understorey with values from 1.695 to 3.242 (Malabrigo et al., 2014). This is relatively higher than that of the sampling areas in LAWFR.

Ground Cover Diversity and Composition

A total of 87 morphospecies from 71 genera and 40 families with 1247 individuals were listed. The most dominant species were *Ayapana triplinervis*

(Vahl) R.M. King & H. Rob in forest ecosystems while the invasive *C. odorata* for the tailings storage facilities that are still rehabilitating from the impact of human disturbance. Ground coverage was mainly done by forest litter (30-50%) which is essential in soil conservation and organic matter decomposition (Krishna & Mohan, 2017).

Ground cover diversity was low (H' = 2.258) especially in tailing storage facilities which were also recovering from the impact of human interference. Thus, pioneering ground cover species are still dominant such as the invasive species of *C. odorata* before returning to the old ecosystem form with the help of rehabilitation activities such as reforestation, protection, and replanting activities.

Riparian Vegetation Diversity and Composition

There were 69 species under 31 families in the riparian flora of LAWFR. Of the 31 families: 24 are angiosperms, only 1 is a gymnosperm, and six belong to the pteridophyte group. Bued river was home to Fabaceae species (18%), represented by the common plants *Phanera purpurea* (L.) Benth. and *Leucaena leucocephala* (Lam.) de Wit. These species are leguminous and reported to have a mycorrhizal relationship. They were the dominant species since they were the only tree species in that area; thus, they are more resilient. This study observed that these two species flower during the wet season. In the Balog River, Lamiaceae (29%) and Asteraceae (29%) are the most dominant, with the rocky topography of the site and as prolific seeders, members of this family were able to dominate.

In Albian creek, the species were evenly distributed among families, with each family represented only by one species. Although as compared to other sites, Albian had the highest number of plant families represented, that is, about 55% of the total number of families recorded. In Benguet creek, Asteraceae (26%), Poaceae (21%), and Urticaceae (16%) were the most represented families in terms of the number of species. Members of Asteraceae and Poaceae are known to be pioneer species as they can establish quickly. While the presence of tree species under Urticaceae indicates that natural succession is happening in this river, as evidenced by the establishment of tree species along the riverbanks. In terms of phenology, the majority of the species in Benguet creek flower during the midyear, at the start of the wet season. In GRASSLAND3, the vegetation is dominated by Asteraceae (38%) and Poaceae (19%). This indicates that for this site, vegetation is at the pioneer stage and is still very vulnerable given the nature of the site. Nevertheless, the establishment of these species indicates that succession is beginning to happen and that other species will get recruited to rehab the site naturally if it is well-maintained.

The area is considered moderately diverse, with a Shannon index (H') value of 2.56 and a very high Evenness Index value of 0.91. The obtained diversity value was relatively higher compared with a study done in Lower Agusan River, Philippines, with an H' value of 1.338, which dictates very low diversity (Sarmiento et al., 2017). On the other hand, a study in Albay, Philippines, revealed a riparian diversity higher than the present study. It had H' values ranging from 2.43 to 3.15 (Naval & Florece, 2007).

Similarity and Dissimilarity Indices of Species

The study computed the similarity indices between sites to know the differences in species composition. The sampling sites in Lower Agno revealed a similarity index ranging from 0 to 50% (Table 2). The majority of the sites had no similarity in terms of tree species present. Only Bumolo had a 50% similarity with Pine Forest Park and Pokis, which P. kesiya dominated. For understorey species, the similarity among sites ranges from 0 to 28.6% (Table 3). The areas with more than 20% similarity were Grassland 1 – Grassland 2 (21.4%), Grassland 3 – Bumolo (25%), and Grassland 2 – Grassland 3 (28.6%). For ground cover, the similarity index ranged from 0 to 28.6% (Table 4). There were only two site comparisons with no similarity at all, with a 100% dissimilarity index: Pokis – Grassland 3 and Secondary Forest – Grassland 3. Most sampling sites have a 0% similarity or 100% dissimilarity index compared with other sites. Thus, each area can be highly unique in terms of species composition.

Table 2

Similarity index of tree species composition in LAWFR sampling sites

	Dipterocarp Forest	Mossy Forest	PFP	Bumolo	POKIS	Secondary	Grassland 1	Grassland 3
Dipterocarp Forest	1	0.039	0.000	0.000	0.000	0.0435	0.000	0.000
Mossy forest	0.038	1	0.071	0.077	0.071	0.000	0.000	0.000
PFP	0.000	0.071	1	0.500	0.333	0.000	0.000	0.000
Bumolo	0.000	0.077	0.500	1	0.500	0.000	0.000	0.000
POKIS	0.000	0.071	0.333	0.500	1	0.000	0.111	0.000
Secondary	0.043	0.000	0.000	0.000	0.000	1	0.000	0.000
Grassland 1	0.000	0.000	0.000	0.000	0.111	0.000	1	0.125
Grassland 3	0.000	0.000	0.000	0.000	0.000	0.000	0.125	1

Table 3

Similarity index of understorey species composition in LAWFR sampling sites

	Dipterocarp Forest	Mossy	PFP	Bumolo	POKIS	Secondary Forest	Grassland 1	Grassland 2	Grassland 3
Dipterocarp Forest	1	0.067	0.068	0.077	0.031	0.055	0.047	0.029	0.028
Mossy	0.067	1	0.000	0.040	0.063	0.024	0.036	0.000	0.000
Pine Forest Park	0.068	0.000	1	0.190	0.000	0.025	0.167	0.188	0.176
Pine Forest Plantation	0.077	0.040	0.190	1	0.000	0.029	0.095	0.167	0.250
POKIS	0.031	0.063	0.000	0.000	1	0.000	0.000	0.000	0.000
Secondary Forest	0.055	0.024	0.025	0.029	0.000	1	0.054	0.000	0.000
Grassland 1	0.047	0.036	0.167	0.095	0.000	0.054	1	0.214	0.125
Grassland 2	0.029	0.000	0.188	0.167	0.000	0.000	0.214	1	0.286
Grassland 3	0.028	0.000	0.176	0.250	0.000	0.000	0.125	0.286	1

Table 4

Similarity index of ground species composition in LAWFR sampling sites

	Dipterocarp Forest	Mossy	PFP	Bumolo	Pokis	Secondary	Grassland 1	Grassland 2	Grassland 3
Dipterocarp Forest	1	0.179	0.114	0.133	0.083	0.057	0.139	0.105	0.143
Mossy	0.179	1	0.238	0.235	0.040	0.043	0.273	0.160	0.188
PFP	0.114	0.238	1	0.286	0.143	0.034	0.259	0.207	0.136
Bumolo	0.133	0.235	0.286	1	0.038	0.087	0.160	0.200	0.176
Pokis	0.083	0.040	0.143	0.038	1	0.034	0.097	0.061	0.000
Secondary	0.057	0.043	0.034	0.087	0.034	1	0.032	0.031	0.000
Grassland 1	0.139	0.273	0.259	0.160	0.097	0.032	1	0.233	0.080
Grassland 2	0.105	0.160	0.207	0.200	0.061	0.031	0.233	1	0.120
Grassland 3	0.143	0.188	0.136	0.176	0.000	0.000	0.080	0.120	1

Species of Ecological Importance

The area is home to several ecologically essential plants, including the native, endemic, and threatened species. Identifying these species can help assess a site's ecological importance, which can be a baseline information for drafting conservation and protection plans (Biodiversity Management Bureau, 2015).

Forty-four (47) species of native plants were recorded in sites from 28 families, wherein six species came from Dipterocarpaceae (Table 5). These species are valuable in preserving the natural ecosystem composition in an area (Rawat & Agarwal, 2015).

Table 5

Taxonomic list of Philippine native species found in the area

Family	Species	Common/Local Name
Actinidiaceae	*Saurauia elegans* Fern. -Vill.	Uyok
Anacardiaceae	*Buchanania arborescens* (Blume) Blume	Balinghasai
Anacardiaceae	*Semecarpus cuneiformis* Blanco	Ligas
Boraginaceae	*Ehretia philippinensis* A.DC.	Dapdap
Casuarinaceae	*Casuarina equisetifolia* L.	Agoho
Clusiaceae	*Garcinia binucao* (Blanco) Choisy	Binukaw
Clusiaceae	*Cratoxylum formosum* (Jack) Dyer	Salinggogon
Commelinaceae	*Commelina benghalensis* L.	Alikbangon
Cyperaceae	*Cyperus rotundus* L.	Mutha
Dipterocarpaceae	*Shorea contorta* S. Vidal	White Lauan/Lawa-an
Dipterocarpaceae	*Shorea polysperma* Merr.	Tanguile
Dipterocarpaceae	*Anisoptera thurifera* (Blanco) Blume	Palosapis
Dipterocarpaceae	*Dipterocarpus alatus* Roxb. Ex G. Don.	Hairy-leaf Apitong
Dipterocarpaceae	*Dipterocarpus grandiflorus* (Blanco) Blanco	Apitong
Dipterocarpaceae	*Shorea guiso* (Blanco) Blume	Guijo
Euphorbiaceae	*Macaranga tanarius* (L.) Müll.Arg.	Binunga
Fabaceae	*Ormosia calavensis* Azaola ex Blanco	Bahai
Hydrangeaceae	*Deutzia pulchra* S. Vidal	-
Lamiaceae	*Callicarpa formosana* Rolfe	Tambabasi
Lamiaceae	*Gmelina arborea* Roxb.	Gmelina/Melina
Lauraceae	*Cinnamomum camphora* Nees & Eberm.	Camphor
Malvaceae	*Grewia multiflora* Juss.	Danglin
Malvaceae	*Hibiscus rosa-sinensis* L.	Gumamela
Melastomataceae	*Melastoma malabathricum* L.	Malatungaw
Menispermaceae	*Pericampylus glaucus* (Lam.) Merr.	Silong-pugo
Moraceae	*Artocarpus blancoi* (Elmer) Merr.	Antipolo
Moraceae	*Ficus balete* Merr.	Balete
Moraceae	*Ficus ampelas* Burm. f.	Aplas/Upling gubat
Moraceae	*Ficus nota* (Blanco) Merr.	Tibig
Moraceae	*Ficus septica* Burm. F.	Hauili
Myrtaceae	*Eucalyptus deglupta* Blume	Bagras
Oleaceae	*Chionanthus ramiflorus* Roxb.	-
Pentaphylacaceae	*Eurya japonica* Thunb.	Bogna
Phyllanthaceae	*Glochidion rubrum* Blume	-
Pinaceae	*Pinus kesiya* Royle ex Gordon	Benguet Pine
Pittosporaceae	*Pittosporum pentandrum* (Blanco) Merr.	Mamalis
Poaceae	*Schizostachyum lumampao* (Blanco) Merr.	Buho
Poaceae	*Cynodon dactylon* (L.) Pers.	Kawad-kawad
Poaceae	*Saccharum spontaneum* L.	Talahib
Rubiaceae	*Neonauclea bartlingii* (DC.) Merr.	Lisak/Tikem
Sapindaceae	*Guioa koelreuteria* (Blanco) Merr.	Alahan
Sapindaceae	*Mischocarpus pentapetalus* (Roxb.) Radlk.	Ambalag
Strombosiaceae	*Strombosia philippinensis*	Tamayuan
Symplocaceae	*Symplocos lancifolia* Sieb. & Zucc.	-
Thelypteridaceae	*Amphineuron terminans* (J.Sm.) Holttum	Lokdo
Thymelaeaceae	*Wikstroemia ovata* C.A. Mey. Ex Meisn.	Salago
Urticaceae	*Leucosyke capitellata* (Poir.) Wedd.	Alagasi

A total of nine endemic species of plants belonging to seven families were recorded. Most of these species were represented by trees and bamboo (Table 6). Among the species listed were found in dipterocarp, secondary, and mossy forests which are all ideal for conservation areas.

Table 6

Taxonomic list of Philippine endemic species found in the area

Family	Species	Common/Local Name
Actinidiaceae	*Saurauia elegans* Fern. -Vill.	Uyok
Boraginaceae	*Ehretia philippinensis* A.DC.	Dapdap
Clusiaceae	*Garcinia binucao* (Blanco) Choisy	Binukaw
Dipterocarpaceae	*Shorea contorta* S. Vidal	White Lauan/Lawa-an
Dipterocarpaceae	*Shorea polysperma* Merr.	Tanguile
Moraceae	*Artocarpus blancoi* (Elmer) Merr.	Antipolo
Moraceae	*Ficus balete* Merr.	Balete
Poaceae	*Schizostachyum lumampao* (Blanco) Merr.	Buho
Rubiaceae	*Neonauclea bartlingii* (DC.) Merr.	Lisak/Tikem

A total of 16 morpho-species from 10 families were on the list of assessed species based on the IUCN Redlist (IUCN, 2021) and DAO 2017-11 (DENR, 2017) (Table 7). All those species were listed in the IUCN Red List, while only four were in DAO 2017-11. In the list created by IUCN, nine species had true threatened classifications, of which two were critically endangered (CR), one was endangered (EN), and six were vulnerable (VU). In contrast, the remaining seven have assessments but are not threatened, including one near threatened (NT) and six with least concern (LC). For the DAO 2017-11, 4 species in the site were vulnerable (VU). As observed, all threatened species in the Philippines (DAO 2017-11) found in the area belong to the family Dipterocarpaceae or the country's hardwood.

Table 7

Taxonomic list of threatened species found in the area

Family	Scientific Name	IUCN Redlist	DAO 2017-11
Betulaceae	*Alnus japonica* (Thunb.) Steud.	LC	Not in the list
Clusiaceae	*Cratoxylum formosum* (Jack) Dyer	LC	Not in the list
Commelinaceae	*Commelina benghalensis* L.	LC	Not in the list
Cyperaceae	*Cyperus rotundus* L.	LC	Not in the list
Dipterocarpaceae	*Shorea contorta* S. Vidal	CR	VU
Dipterocarpaceae	*Shorea polysperma* Merr.	CR	VU
Dipterocarpaceae	*Dipterocarpus grandiflorus* (Blanco) Blanco	EN	VU
Dipterocarpaceae	*Anisoptera thurifera* (Blanco) Blume	VU	Not in the list
Dipterocarpaceae	*Dipterocarpus alatus* Roxb. Ex G. Don.	VU	VU
Dipterocarpaceae	*Shorea guiso* (Blanco) Blume	VU	Not in the list
Fabaceae	*Senna spectabilis* (DC.) H.S. Irwin & Barneby	LC	Not in the list
Moraceae	*Artocarpus blancoi* (Elmer) Merr.	VU	Not in the list
Myrtaceae	*Eucalyptus deglupta* Blume	VU	Not in the list
Poaceae	*Saccharum spontaneum* L.	LC	Not in the list
Urticaceae	*Boehmeria heterophylla* Wedd.	NT	Not in the list
Urticaceae	*Boehmeria multiflora* C.B. Rob.	VU	Not in the list

Plant and Soil Nutrients

The results of the nutrient analysis in plants showed that Alnus (*A. japonica*) had the highest amounts of N (3%), P (0.2%), K (0.94%), and Cu (53 ppm) (Figures 6 & 7). It was higher than the copper content result of the study in Marinduque in the Philippines, wherein the Jatropha curcas' leaves had Cu of 24.66ppm (Aggangan et al., 2017). *Alnus* exhibited an excluder kind of plant because of its capacity to accumulate higher copper and, therefore, is vital in reforestation. The nutrient values of indigenous species sampled, such as Palosapis, Benguet Pine, and Bogna, were close to the average level, suggesting their site adaptability. The case of Talahib was far lower than the required level. However, the species appeared aggressive in all grassland ecosystems, indicating their role in ecological succession. The study used the guide of the University of Idaho as the basis for the standard values of N (0.5 - 5%), P (0.1 - 0.5%), and Cu (2 - 20 ppm) (Maller, 2004). Overall, the mean nutrient levels of all plants were near the normal amount, which was evident because of the absence of toxicity and deficiency symptoms being within the norm except for high copper in Alnus.

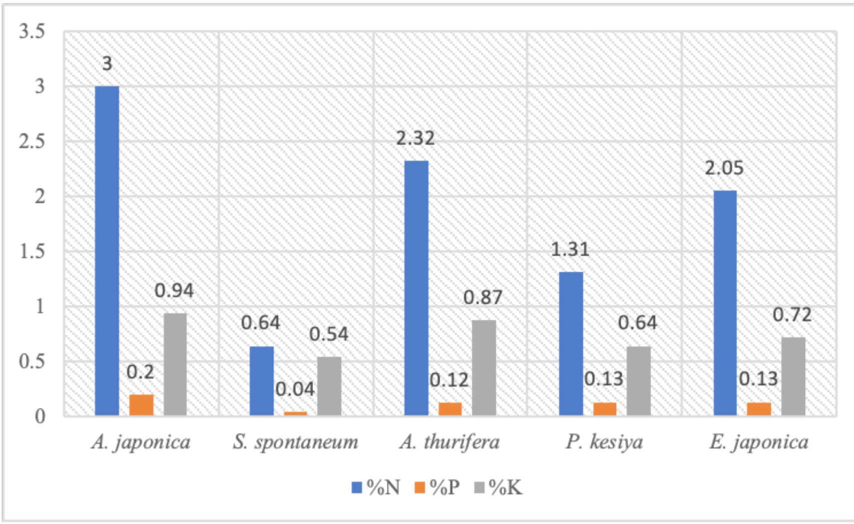

Figure 6. Nutrient percentages found in plant tissues tested.

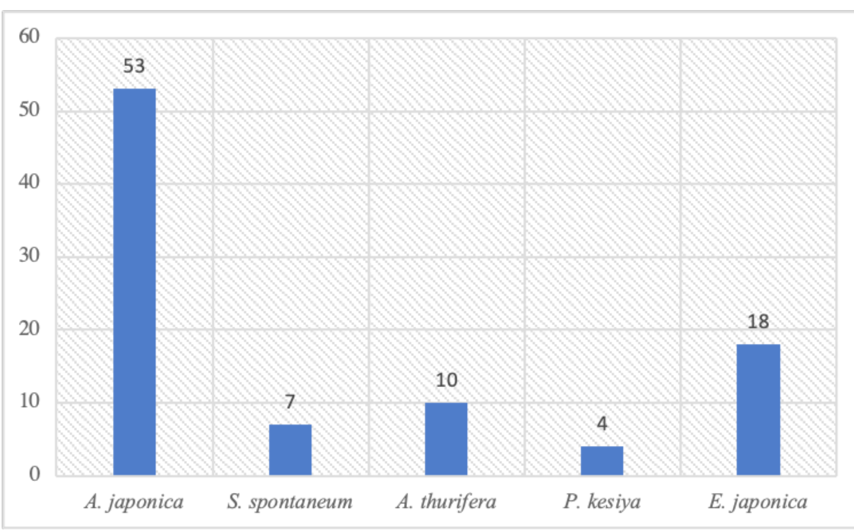

Figure 7. Amount of copper (ppm) found in plant tissues tested.

The status of the soil condition in sampling areas showed that Mossy Forest was the most fertile, followed by Dipterocarps, Pine Forest Park, Grassland 1, and Grassland 2 (Figure 8). The soil's copper content ranged from 9 to 108 ppm, with Pine Forest Park having the lowest value and Mossy Forest with the highest value. These copper content values were relatively higher than a study conducted in Brazil, with copper ranging from 10 to 80 ppm (dos Santos et al., 2013). On the other hand, the copper values were lower than the research conducted among wild plants with 30 to 250 ppm of copper (Brun et al., 1998). Thus, this present study in LAWFR lies between the median of other studies signifying no toxicities in the area. The pH values of all sites were within the normal growth range of 5.5–6.5 except for Pine Forest Park, which is 5.0. The organic matter content was medium (Pine Forest Park and Dipterocarps to very high (Mossy Forest), but Grassland 2 and Grassland 1 exhibited low amounts. The amount of P in soil was higher than 20 ppm, where Dipterocarps and Pine Forest Park showed the highest values. All other sites were near the standard value, like Mossy Forest and Grassland 2. The soil's acidity was within the normal values across sites favoring the availability of minerals, possibly due to microorganisms that sustain pH. Except for Alnus, with high Cu indicating its potential as a future remediator, standard values of elements and organic matter were observed for the tested plants. Soil pH ranged from 5-6.5, which is favorable for plant growth.

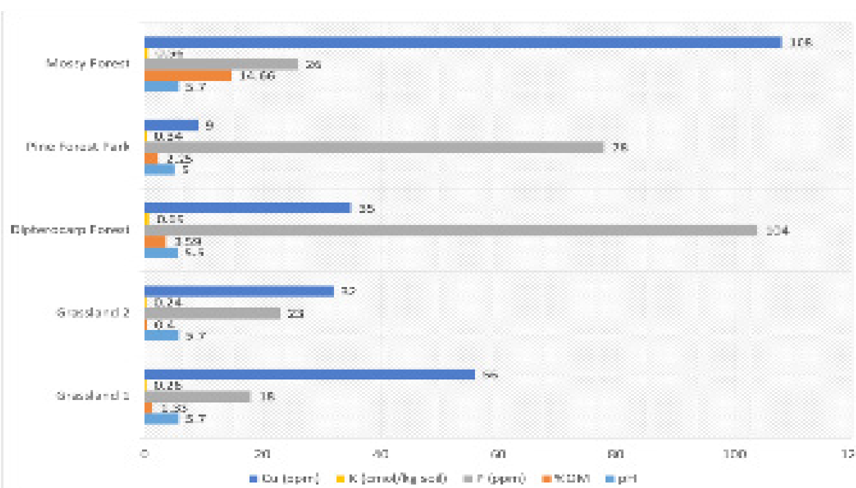

Figure 8. Soil status in terms of copper (Cu), potassium (K), phosphorus (P), organic matter, and pH in selected sites of Lower Agno Watershed Forest Reserve. Note (Standard values: pH (5.5 – 6.5), OM (>6% - very high, <1% - very low), P (>20 – very high, <10 low), K (>1.20 – very high, <0.10 – very low).

CONCLUSIONS

The study area was moderately diverse, composed of 41 tree species, 91 understorey species, 87 ground cover species, and 69 riparian species dominated by *P. kesiya, C. odorata, Miscanthus sp., W. ovata, A. triplinervis, L. leucocephala, S. spontaneum*, and *L. camara*. Forest ecosystems were secondary growth which generally had large trees mainly contributed by Benguet Pine. The area was ecologically important, with several native, endemic, and threatened species that shall be a priority for conservation and protection. However, there were also some invasive plant species needing adequate attention. Regarding soil and nutrient contents, the results were within the normal range except for *A. japonica* which accumulated very high copper and other nutrients. This result revealed the potential of *Alnus* as a suitable rehabilitation species in highly mineralized and metallic sites.

RECOMMENDATIONS

The study suggests the importance of intervention measures to improve plant diversity and protect the native, endemic, and threatened species.

Plate 1. Actual photographs of representative native plant species taken in the area: A. *Pinus kesiya* Royle ex. Gordon (Benguet Pine), B. *Deutzia pulchra* S. Vidal, C. *Saurauia elegans* Fern. -Vill. (Uyok), D. *Eucalyptus deglupta* Blume (Bagras), E. *Neonauclea bartlingii* (DC.) Merr. (Lisak/Tikem). F. *Saccharum spontaneum* L. (Talahib). (Photos taken by E.E. Coracero)

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