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Abundance and Tree Species Diversity in Selected Mining Areas of Licuan, Baay, Abra, Philippines

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Abstract

Biodiversity is the greatest treasure in the world. Protecting it means we are protecting the future of our children. The research study was conducted in Licuan-Baay, Abra, in the Philippines. It evaluated the abundance, endemism, species diversity index, and conservation status of trees within the interior and exterior areas of the selected mining site. Due to few studies on the biodiversity of its flora and fauna, this study was timely and necessary.

Data were gathered using the belt transect method. The study revealed 34 species across 18 families, with Moraceae having the most number, with seven species and four genera. Based on the Shannon diversity index result, the mining areas have relatively little diversity. Additionally, endangered tree species are at 2.9 percent, while those that are vulnerable are at 11.76 percent. The tree species classified as least concerned were at 32.35 percent, and tree species that were data deficient were 52.94 percent based on the conservation classification under the IUCN 3.1 and DAO 2017. On endemism, there is 41 percent that is endemic, while 59 percent is not endemic in the Philippines.

Keywords: Anthropogenic activity, conservation status, deforestation, endemism, species diversity index

Introduction

The diversity of life in all its levels and forms is under serious threat worldwide. The magnitude of biodiversity destruction at present far exceeds those of the past and exponentially increases yearly. The loss of biodiversity is observed globally at enormous dimensions, spanning biogeographic domains and ecosystems. The extinction rates of organisms are high and rising among the groupings of species that have been extensively examined, and populations and habitats are declining locally.

The biological complexity of Southeast Asia is distinct. It is home to the planet's most diversified region due to its intricate biogeographic zoning, regional biotic patterns, and peculiar ecosystems (Sheldon et al., 2015). It is the most extensive biodiversity hotspot on earth (Marchese, 2015).

Many nations have utilized protected zones for a long time to safeguard and control the use of natural resources in their territories. Numerous analyses concluded that the loss of forest cover and biodiversity had not been adequately addressed despite the additional protected areas. Over the past ten years, large forest areas have been diminished and degraded due to intensive exploitation and related anthropogenic incursions. The remaining forest in Southeast Asia is also in danger due to anthropogenic activities such as extensive mining and logging, population increase, overharvesting of resources, and infrastructure development (Maja et al., 2021).

Studies show that tropical nations like the Philippines have had the worst deforestation in the previous 40 years. Therefore, the leading causes of the nation's deforestation, which declined from 17 million hectares in 1934 to three million hectares in 2003, are mining and logging (Jong et al., 2017).

Mining and mineral processing propel the country's overall economic development (Eggert, 2001). It is one of the mega-diverse nations and the fifth-richest country in mineral resources (Marchese, 2015). The third-largest to gold deposits, fourth-largest copper reserves, and fifth-largest nickel producer. Overall, nine million hectares of land in the nation have the potential for metal mining, with 632 mining licenses totaling half a million hectares already granted (MGB, 2017). Priority forest conservation sites are generally located on top of sizable mineral deposits. The nation's urgent task is to protect our forests' ecological integrity while utilizing their abundant mineral resources for sustainable growth.

According to a study by Sarmiento et al. (2017), the tree species diversity in Carrascal nickel mining sites in Surigao del Sur, which have been mined and only minimally damaged, indicates that they fall under the category of mixed secondary forest, with an ultramafic soil. Their study shows a disproportionately large number of tree species—the majority rare and endemic. Additionally, 48 taxa from 30 genera and 20 families were also identified. Shorea, a genus with four species, was the most prevalent, followed by Dipterocarpaceae and Fabaceae, all of which had six species. Further results revealed a composite low Shannon-Weiner diversity index of 2.2872. Of the 48 species that have been identified, 46 (96%) are indigenous to the Philippines. At the same time, 24 (50%) of these are endemic. There are 15 species listed as endangered under the DAO 2017 and IUCN 3.1 for this taxonomic group. A few notable species are included in the Dipterocarpaceae family, such as Xanthostemon verdugonianus, the ironwood of the Philippines. Although the mining sites are less productive for producing timber, the researchers concluded that conserving this ultramafic environment is crucial to maintain its ecosystem dynamics, safeguarding biodiversity, and averting potential natural disasters like landslides and flooding in lower areas.

The creation of youth programs and educational initiatives that support sustainability and conservation is necessary for protecting and conserving the region's biodiversity and natural resources. Additionally, local government organizations and programs are strongly advised to adopt sustainable development objectives and methods that serve the local population without diminishing the region's resources. Additionally, ethnic communities will be able to take a more active part in creating sustainable practices thanks to the contribution of indigenous knowledge and information systems to the development of resource management and sustainable development practices (Tom et al., 2019).

The study adopted the Pressure-State-Response (PSR) Model, the Philippine Mining Act of 1995, and biodiversity conservation theories as a conceptual framework of the study. The Pressure-State-Response (PSR) model is a cause-and-effect concept: human actions exert pressure on the environment's current "state" and alter its condition and availability of natural resources; "Societal responses" then occur due to people's environmental, general economic, and sectoral responses to these changes (Wang et al., 2021).

Anthropogenic pressures on the ecosystem, especially natural reserves, are called ecological stressors. "Pressures" cover proximal pressures and underlying or indirect stresses that operate as driving forces for environmental difficulties. Environmental stress markers frequently show emission or resource use intensities and related trends and variations over time. They are intimately tied to production and consumption patterns. It demonstrates advancement in the decoupling of financial operations from pertinent environmental forces. They can also demonstrate progress in achieving regional and global commitments such as emission reduction targets (Wang et al., 2021).

According to Emmanuel et al. (2018), rising mining activity strains the region due to increased resource usage. They must investigate probable social reactions to balance the pressures' adverse effects and create new indicators. Mining areas in Licuan-Baay followed the same pattern in a forested area full of native trees. Mining operations and invasive tree species have gradually changed, creating a situation that calls for care, instruction, and rehabilitation.

The percentage of a protected area, the total number of protected species, and the amount of money spent on environment conservation are frequently used as response indicators (EEA, 2003). Such indicators are simple to document since they relate to accepted actions or guidelines. Indicators do not yet adequately capture new, more ambitious solutions, such as agro-environmental measures or eco-labeling.

Societal responses demonstrate how society reacts to environmental issues through sectoral, national, and environmental policies and modifications to awareness and behavior. They relate to both individual and group actions and responses aimed at reducing, adjusting to, or preventing unfavorable consequences of human activity on the environment. Stop or undo environmental damage that has already been done, and protect and safeguard nature and natural resources.

Environmental taxes, subsidies, ecological spending, waste recycling rates, price structures, market shares of environmentally friendly services and products, and pollution abatement rates are a few examples of social responses.

Using the PSR framework on pressure, the researcher can use effective intervention strategies to alter the state. Using species abundance modeling, the researcher would successfully pinpoint which tree species should receive conservation-related attention. The study areas' state and pressure responses will include informed policy reform, improved environmental education and restoration programs, future research planning, biodiversity, land use, forest cover change monitoring, and stakeholder collaboration.

"Sustainable mining" was a term the government used in past speeches and policy proposals. Civil rights organizations frequently emphasized that mining entails removing non-renewable resources to exclude other land uses, which made this word contentious. As a result, it is inherently unsustainable. The government subsequently adopted responsible mining.

An extensive discussion of mining sustainability was included in an earlier draft of the National Mineral Policy, which served as the basis for the final MAP. Although mining may not be sustainable, its "spin-offs" and related activities promote sustainable development, according to the justification. Furthermore, the increased or "replacement" of mined minerals results from the discovery of new mineral resources and technological developments that make it possible to extract minerals more effectively. Mining is a process that naturally impacts the environment and the economy. The government needs to research these aspects of its role in sustainable development.

The following areas are off-limits to mining operations under the Philippine Mining Act: virgin or old-growth forests, declared forest reserves, watersheds, bird sanctuaries, national parks, provincial/municipal forests, wilderness areas, parks mangrove forests, mossy forests, greenbelts, and game refuge, as described by rules and in locations expressly prohibited under NIPAS. The list includes numerous regions that are off-limits to mining. However, these areas are neither comprehensive nor even sufficient. For instance, just 35% of the remaining forest cover comprises old-growth forests with a closed canopy. Meanwhile, most of the NIPAS zones have not yet been established and can still be shrunk in size to leave specific sites available for mining. For instance, the MGB seeks to excise some 54,000 hectares of the proposed park for mineral extraction, a contentious issue at the center of the Samar Island Natural Park. It merely demonstrates how poorly the Philippine protected areas system protects the natural environment, how heavily damaged habitats are represented, how poorly it relates to the distribution of biodiversity, and how little it relates to actual forest limits. Lowland woods with significant biodiversity lack legal protection under the NIPAS or elsewhere.

The numerous theories discussed in this paper can serve as a framework for conservation efforts, such as evaluations of tree species abundance, richness, taxonomic diversity, evenness, endemism, and conservation status. These theories include habitat loss, ecological niche modeling theory, selection-based niche theory and conservation, and habit fragmentation theory. Other hypotheses include the invasive species theory and the implicitly pro-conservation neural theory. Invasive species theory, biodiversity and extinction theory, and the theory of habitat fragmentation and protected areas were also employed to analyze the study. Numerous choices in conservation practice are influenced by notions about biodiversity, despite these ideas not being commonly expressed in public.

Though theory rarely informs conservation decisions openly, it impacts the perspectives that conservation biologists adopt. Since biological diversity is the focus of conservation efforts, opinions on fostering and maintaining it are relevant to conservation (Sutherland et al., 2009).

There are many different biodiversity hypotheses. It can be challenging to decide which of more than one hundred proposed biodiversity-maintaining strategies is the best proposal (Palmer, 1994). However, the central question in all widely recognized models of biodiversity is whether or not four specific processes—selection, ecological drift, speciation, and dispersal—occur (Vellend, 2010).

The coexistence of various species and how those differences affect each species' capacity to endure in a changing environment across time and space are topics covered by theories that emphasize selection, such as the conventional niche theories (Gause, 2003). Each genus has a distinct ecological niche, which includes a group of competitors' environmental competitors, antagonists, and other variables. It suggests that organisms are not readily interchangeable for purposes of preservation. It defends the need to protect all species, even flagship species, advocates for some level of invasive species combat, and questions insurance implications. Since species can differ in a wide variety of features, explanations of increased complexity in biodiversity that focus on selection or niches typically have limitations (Rosindell et al., 2013). The complexity of niche structure can be harmful for three reasons: first, people may develop generally inappropriate conservation strategies if the system of the targeted community does not fully justify the complexity; second, the explanation will not be sparing, i.e., it will not support the scientific statement to look for the most obvious possible cause. Third, choosing the right conservation strategies could be challenging if the population is complicated enough to consider a multi-dimensional niche structure.

In contrast, theories based on the drift, such as Hubbell's (2013) neutral theory, include fewer assumptions. According to Hubbell's (2013) neutral theory, population rates are unaffected by differences between species at the same trophic level. Individuals are comparable in fitness regarding birth and death rates or ecological equivalency dispersion capabilities regardless of their species identity (Munoz & Huneman, 2016).

As an illustration, numerous other tree species are present around tropical tree species. It stops interactions with one species from becoming specialized, preventing generalist strategies and quasi-equivalence in evolutionary periods (Hubbell 2013). The possibility of a species forming a suitable habitat patch in a community is primarily influenced by its frequency rather than how well it would fare in a hypothetical test of habitat patch environmental circumstances (Purves & Pacala, 2005).

According to Hubbell's (2013) neutral theory, there is a minor possibility that a species, rather than a resident, may speciate or disperse from a meta-community to form an accessible habitat patch. All neutral species communities would be interchangeable at any moment without disparities in demographic rates (Purves & Pacala, 2005) and without causing local society to become unstable.

Neutral theory's fundamental inputs and outputs have lately become more realistic, for instance, in terms of the size of the neighborhood community (Arias-Bohart, 2011), the age of species (Chisholm & O'Dwywr, 2014), and geographic structure (Rosindell & Cornell, 2013). Drift-based theories integrate spatial organization, essential for analyzing meta-communities and habitat fragmentation in conservation biology.

Applications for drift-based conservation emphasize the relevance of stochasticity in preserving biodiversity and typically have simple mathematical answers (Rosindell et al., 2013). Ecological equivalence and drift may be pertinent when species exhibit significant habitat-specific or niche overlap. We are aware that several essential taxa for conservation exhibit considerable habitat-specificity (Goerck, 1997).

Therefore, communities containing these species only partially fit within the framework of drift-based theories. Selective and niche approaches might not be the best choices for the remaining districts, like the Panamanian communities of tropical trees (Hubbell, 2013). Neutral strategies focused on drift might be a better alternative. When it comes to conservation management and ignoring species' intrinsic or practical benefits, it is sufficient to the extent that ecological equivalency can be refused to maintain a particular species. According to solid evidence for ecological equivalence, a community can be stabilized by species identities or niches. Instead of species or populations, the community as a whole and it's biological processes would be the most sensible unit for conservation actions in these circumstances.

However, niche structuring appears more critical in less productive systems like softwoods or grasslands (Chase, 2010). Communities with a variety of species raise conservation issues. They frequently have severe recruitment restrictions, which may prevent competitive exclusion and support de facto neutrality, as in rainforests (Hubbell, 2013) and a community of fynbos shrubs (Perry et al., 2009). Neutrality encompasses spatial scales that go beyond those of niche theory (Bell, 2001). However, niche structure has recently been demonstrated for large sizes (Tang & Zhou, 2011), and it is challenging to discern between niche and neutral processes at small and intermediate scales (Gilbert & Lechowicz, 2004). It emphasizes the significance of taking place and neutrality into account, particularly at the local scale of most conservation initiatives.

With 416,525 hectares, Abra has the most land area of any province in the Cordillera Administrative Region. In addition, Ilocos Norte and Apayao both border the province's northwest and northeast, respectively. Ilocos Sur borders its mid-eastern section on the southwest, Mountain Province on the southeast, and Kalinga on the east. About 1 725 hectares, or 414 percent of the province's total land area, are covered by mining tenements (MGB, 2017).

One of Abra's upland municipalities, Licuan-Bay, is encircled by mountains home to the friendly Tingguian, beautiful waterfalls and rivers, and even highly sought-after gold. Licuan-Baay, Abra, is said to have above 60 million ounces of gold reserve (MGB, 2017).

Determining the abundance and tree diversity inside and outside the mining areas in Licuan-Baay will reveal how common or unusual it is compared to other species in a given area or community. Additionally, it will show what percentage of the total number of trees in the area are of a given tree species. Relative species abundances are typically shown for one trophic level. Such tree species compete with one another for the same resources because they are found at the same trophic level. The tree species that are more robust and numerous than their survival are more adapted to the environmental conditions both within and outside the mountain. The richness and evenness of the region's tree species will be measured on the mining sites of licuan-Baay. Determining the indigenous tree species is crucial for several reasons. First, endemic tree species face a greater danger of extinction from threats than more widely dispersed species because of their often constrained distribution. Second, endemic species are well adapted to their home range as environmental conditions within their range change due to anthropogenic or natural factors. Their modifications may serve as a source of competitive strength or weakness. Third, it typically takes between 10 and 30 endemic animal species for an endemic tree species to go extinct. In other words, some endemics to specific areas might act as a kind of "collective insurance" to maintain genetic variety despite the fast change.

Others face the most significant threat of extinction when environmental conditions shift. Endangered species, therefore, concentrate on preserving biological diversity or biodiversity. Finally, knowing the Licuan-Baay tree species' conservation status is crucial for planning future conservation efforts, educating the local population, and working with young people.

Therefore, we could decide which trees in Licuan-Baay mining areas should be protected if we knew their relative abundance, species diversity, endemism, and conservation status. And which tree species are best for proliferation in the area for restoration reasons.

Materials and Methods

The study used a quantitative descriptive design. A population, circumstance, or phenomenon is accurately and methodically described by descriptive study (Mc Combes, 2020). Nassaji (2015) asserts that descriptive research is more interested in the "what" than the "how" of an event. Thus, observations are the standard tool for gathering data in this study. Belt transect sampling was used in the research to conduct a random survey to gather the empirical and quantitative data sets (Mugot,2016). Relative species abundance, richness, taxonomic diversity, endemism, and conservation status were assessed and described in the Interior and exterior areas of the Licuan-Baay, Abra, Philippines mining site.

The study site is in Licuan-Baay, Abra, located at 17035'56" N, 120053'11" E. It is a 5^{th}-class municipality with 11 barangays. It is located next to Abra-Kalinga Road. Furthermore, it is about 54.5 km or 1 hour and 31 minutes from the provincial capital that is Bangued. It could be reached using any vehicle, but the study sites can only be accessed by hiking or horseback if available. The terrain is rugged and near water tributaries to the Abra River.

Additionally, the rainy season makes traveling in the area hard due to landslides. It was once mined and controlled by the Abra Mining and Industrial Corporation (AMIC) Philippines. The study was carried out on the interior and exterior areas of the mining site of Licuan-Baay.

This study was carried out from August 2020 to February 2021 at Licuan, Baay, Abra. Abundance, tree species diversity, and voucher specimen collection for endemism and conservation status were gathered in the Interior and exterior parts of the mining area from December 2020 until February 2021. The voucher specimen collected had undergone further validation by experts from UP Diliman.

The materials utilized in data gathering are the following: compass for directions, geographic positioning system (GPS), meter tape, tree diameter measuring device (caliper), tree height measuring device (clinometer), Flora and species list (common and scientific names), old newspapers and boxes for specimen collection preservation.

Before conducting the study, a request letter was sent to the Provincial Planning Development Officer (PPDO), DENR-CENRO, the Municipal Mayor of Licuan Baay, and the Municipal Planning and Development Officer. The letter request was to conduct a tree biodiversity analysis in Licuan-Baay, Abra and was approved by the above offices.

Using the belt transect sampling method adopted from Mugot et al. (2016), five transect lines with a length of 2 km were identified in the area at least 500 meters from each transect line. Each line was divided into eight sampling points placed every 250 meters ensuring that the five sampling stations with 2 km length were parallel and had a distance of at least 500 meters. A 20x20 meter quadrat was established for each sampling plot to sample trees to determine tree species abundance and diversity (Mugot et al., 2016). For each sampling plot, all tree species with a diameter at breast height (dbh) of 10 cm and a height of 2 meters and above were recorded. Specimens were collected on-site during the guided fieldwork, numbered, pressed, and underwent initial identification. Dried and preserved specimens were sent to UP herbarium for species validation

The data were tabulated using frequency counts, weighted frequency, and percentage. The following statistical tools were also utilized in the study. Using the Shannon-Weiner Index (H"), the analysis of species abundance of trees found in the exterior and interior areas of the mining sites recorded per transect survey will determine whether they are Abundant, Common, Frequent, Occasional, or Rare

The collected trees were determined by expert identification on-site and verified using taxonomic keys from floras, books, and monographs of Pancho and Gruezo (1983) and Rojo (1999). The tree species were assessed based on the book Threatened Plants of the Philippines: A preliminary Assessment by Fernando *et al.* (2008), The National List of Threatened Philippine Plants (DENR AO No. 2017), and the IUCN Redlist (2019). Photographs were taken, and experts further verified herbarium specimens at UP Diliman.

Results and Discussion

Relative Species Abundance of Trees in the Interior and Exterior Areas of the Mining Sites in Licuan-Baay, Abra

Table 1 shows that thirty-four species from 18 families were recorded from the interior and exterior areas of the mining sites. With seven species and three genera, Moraceae had the most significant number. The study also shows that Ficus is the Moraceae family's most common genus, with the most significant number of species found in the exterior vicinity of mining sites. It validates the previous findings of Polinar and Muuss (2010) that *Ficus* of the family Moraceae is the most abundant and frequently encountered species in secondary forests in the Philippines, which includes Licuan-Baay, Abra. Consequently, the said genus is absent in the interior of the mining area due to excessive logging for timber posts in mining tunnels in the past. The other families with a notable presence in the mining sites' interior and exterior areas with three species each are Rubiaceae, Fabaceae, Dipterocarpaceae, and Anacardiaceae.

Pinus kesiya species had the most significant number of trees, with 208 found in the interior and 306 in the exterior area of the mining sites. With a relative abundance of 45.02 percent and 46.58 percent, correspondingly. In the Philippines, pure Benguet pine forest is found in Northern Luzon's highlands, forming distinct forests in Benguet, Mt. Province, Abra, and Ifugao. Generally, it has been the primary source of mine timber for mining operations (Ganzon, 2003). But due to the Lapat system imposed by the indigenous people of Abra, the cutting of pine trees is regulated. Pine products are banned for commercial purposes, thus protecting the said tree species from over-exploitation.

Artocarpus altilis, Samanea saman, and Pittosporum pentandrum (Blanco) Merr. had relative abundances of 0.22 percent among "rare" species of tree on the interior mining site. Beyond the exterior mining site, Samanea saman, Lithocarpus jordanae (Villanueva) Rehder, and Broussonetia luzonica are all categorized as "rare" and have relative abundances of 0.46 percent, 0.46 percent, and 0.30 percent, respectively. As a result, the species mentioned above are declining since they are frequently used as building materials, furniture, paneling, cabinets, and firewood (ERDB, 2012).

The vegetation degradation may cause fewer species inside the mining area. Small-scale gold mining uncovers the desired minerals by removing the underlying vegetative cover (Mugot et al., 2016). Most of the original tree vegetation in the mining area is utilized as lumber materials for tunnel support and sluice boxes. The mined area is transformed into open grassland with shrubs and few trees. With this existing condition, the area becomes a geohazard that might claim lives in Benguet province.

Additionally, the low number of trees in the mined area is directly associated with the bird's diversity since trees provide food and shelter for several bird species (Ascaño,2016). In the absence of trees as their natural habitat, birds migrate to other places or become invasive in rural or urban areas where they might carry diseases and other hazards. Furthermore, cutting trees within the mining area might result in the extinction of both flora and fauna species that are endemic.

Table 1. Relative Species Abundance of Trees on the Interior and Exterior Areas of the Mining Sites

Family	Scientific Name	Within the mining area			Outside the mining area		
		Total Number of Trees	Relative Abundance	Abundance /Rarity	Total Number of Trees	Relative Abundance	Abundance /Rarity
Anacardiaceae	Streblus asper	28	6.06%	+ + + + +	17	2.59%	+ + + +
	Buchanania nitida	4	0.87%	+ + +	4	0.61%	+ +
	Anacardium occidentale	2	0.43%	+ +	5	0.76%	+ +
Dipterocarpaceae	*Dipterocarpus grandifloras*	12	2.60%	+ + + +	12	1.83%	+ + + +
	Shorea guiso	20	4.33%	+ + + + +	23	3.50%	+ + + + +
	Shorea contorta	9	1.95%	+ + + +	11	1.67%	+ + + +
Euphorbiaceae	*Aleurites moluccana*	2	0.43%	+ +	8	1.22%	+ + +
Fabaceae	*Albizia procera*	22	4.76%	+ + + + +	15	2.28%	+ + + +
	Pongamia pinnata	7	1.52%	+ + + +	4	0.61%	+ +
	Samanea saman	1	0.22%	+	3	0.46%	+
Fagaceae	*Lithocarpus jordanae (Villanueva) Rehder*	4	0.87%	+ + +	3	0.46%	+
Hypericaceae	*Cratoxylum sumatranun (Jack) Blume*	9	1.95%	+ + + +	10	1.52%	+ + +
Lamiaceae	*Gmelina arborea*	5	1.08%	+ + +	0	0%	-

Lythraceae	*Lagerstroemia speciosa*	3	0.65%	+ +	4	0.61%	+ +
Malvaceae	*Grewia laevigata Vahl*	8	1.73%	+ + + +	9	1.37%	+ + +
Meliaceae	*Swietenia macrophylla King*	2	0.43%	+ +	7	1.07%	+ +
Moraceae	*Artocarpus ovatus Blanco*	4	0.87%	+ + +	8	1.22%	+ + +
	Ficus magnoliifolia	6	1.30%	+ + +	21	3.20%	+ + + + +
	Broussonetia luzonica	3	0.65%	+ +	2	0.30%	+
	Artocarpus altilis	1	0.22%	+	5	0.76%	+ +
	Ficus caulocarpa (Mia.) Mia.	0	0%	-	10	1.52%	+ + +
	Ficus minahassae (Teijsm & Vriese) Mia.	0	0%	-	9	1.37%	+ + +
	Ficus nota	0	0%	-	12	1.83%	+ + + +
Myrtaceae	*Syzygium cumini*	14	3.03%	+ + + + +	25	3.81%	+ + + + +
	Psidium guajava	23	4.98%	+ + + + +	22	3.35%	+ + + + +
Phyllanthaceae	*Bridelia Willd.*	4	0.87%	+ + + +	6	0.91%	+ +
	Antidesma pentadron	23	4.98%	+ + + + +	11	1.67%	+ + + +
Pinaceae	*Pinus kesiya*	208	45.02%	+ + + + +	306	46.58%	+ + + + +
Pittosporaceae	*Pittosporum pentandrum (Blanco) Merr.*	1	0.22%	+	7	1.07%	+ +
Rubiaceae	*Mussaenda philippica A. Rich.*	5	1.08%	+ + +	9	1.37%	+ + +
	Ixora coccinea	6	1.30%	+ + +	23	3.50%	+ + + + +
	Neonauclea bartlingii var. cumingiana (Vidal)	4	0.87%	+ + +	13	1.98%	+ + + +
Rutaceae	*Micromelum minutum*	14	3.03%	+ + + + +	27	4.11%	+ + + + +
Sapindaceae	*Sapindus Saponaria*	8	1.73%	+ + + +	6	0.91%	+ +

Legend: Absent Rare + Occasional + + Frequent+ + + Common+ + + +Abundant + + + + +

Measurement of Tree Diversity Index

Species Richness

The variety of species present in an ecological community, landscape, or area is called species richness. Furthermore, species richness is a count of the species and does not consider the species' abundance or the distributions of their relative abundance. Based on the study results, the exterior area of the mining site has a higher species richness than the interior area.

Table 2. Tree Diversity Index of Tree Species Found on the Interior and exterior Area of the Mining Site

Diversity Indices	Within Mining Area	Outside Mining Area
Shannon_H	2.36	2.43
Species richness	31	33
Individuals	462	657
Evenness	0.688777	0.69769

According to Table 2, there were 33 tree species discovered in the exterior mining area, while 31 distinct tree species were discovered in the interior mining area. It implies that mining significantly affects species richness due to timber logging and surface clearing to allow digging or mining. A similar finding by Ardente et al. (2016) found higher richness and diversity in the forest outside the mining area in Brazil than within mining areas. It may be due to differences in the vegetal complexity between the two vegetation types. Silva (1991) and Da Silva et al. (1996) found lower plant diversity and less structural complexity in the mining sites in Canga than in the forest in the Carajás region, Pará, Brazil. Besides that, Canga areas have lower resources and soil moisture availability due to the trees' absence. Another study by Chaudhary et al. (2016) shows that local taxonomic diversity loss due to timber extraction can disrupt forests' long-term resilience. In turn, it may cascade into an impoverished delivery of ecosystem services, ultimately affecting human well-being.

Taxonomic Diversity

Taxonomic diversity is the average taxonomic path between randomly chosen individuals. It considers taxonomic differences and heterogeneity or species richness and evenness, leading to its Shannon Diversity Index's computation. According to Kent and Coker (1993), a forest community is rich if it has a Shannon Diversity value of ≥ 3.5. Consequently, the Shannon diversity index in the interior and exterior areas of the mining sites had a calculated value of 2.36 and 2.43, making the two areas comparatively low in diversity. It implies that only a few existing tree species are in the area. It might be due to anthropogenic effects. The local population's primary activities were mining, cultivation, and forest collection. These activities may lead to excessive logging resulting in the extinction of other species or decreasing their numbers.

Species Evenness

The term "species evenness" describes how closely different related species are to one another. It is a diversity index indicator that measures how equitable the community is. Table 2 shows tree species on the Interior and exterior area of the mining site show a relative species evenness of 0.68 and 0.69, respectively. The value of species' evenness ranges from 0 to 1, with 0 denoting "no evenness" and 1 denoting "complete evenness." The more evenly distributed the trees are within the current species, the closer the species' evenness is to 1. We may state that the species have a reasonable degree of species evenness for both data sets (internal & external). It suggests that there are roughly equal numbers of different tree species inside and outside the mining site. According to Zhang et al. (2012), species evenness is essential to biodiversity because it indicates an ecosystem's stability. In the case of Licuan-Baay, the result implies that the area's ecosystem is nearing instability and might lead to biological disaster in the future if there is no action to rehabilitate and protect the site.

Endemism of Tree Species in Licuan-Baay, Abra

Results show that 41 percent of the species of trees in the area are endemic to the Philippines, and 59 percent are not endemic (invasive/exotic). According to Lillo et al. (2019), endemic species are native species whose distributions are confined only within the geographic area of reference. Thus, native species include endemic and non-endemic indigenous species whose natural geographic ranges extend beyond the geographic location of concern. All species recorded in an area are classified as native and alien species. Native species could be endemic and non-endemic, while humans wittingly and unwittingly introduce alien species to the geographic reference point.

The Philippine endemic trees include *Swintonia Luzoniensis*, *Dipterocarpus grandiflorus*, *Shorea guiso, Shorea contorta*, *Aleurites moluccana*, *Albizia procera, Samanea saman, Lithocarpus jordanae (Villanueva) Rehder,* Lagerstroemia *speciosa, Artocarpus ovatus Blanco, Pinus kesiya, Neonauclea bartlingii var. cumingiana (Vidal) Ridsdale, Ixora coccine L., and Micromelum minitum.* It is noteworthy that *D. grandiflorus*, *S. guiso,* and *S. contorta* were endangered and vulnerable.

However, it is alarming to note that three species of trees were mentioned by Joshi (2017) in his report on Invasive Alien Species in the Philippines. These include the *G. arborea* solely present outside the mining area, *Anacardium occidentale Artocarpus altilis,* and Swietenia *macrophylla King,* both within the Interior and exterior area of the mining site.

The presence of *A. occidentale* and *A. altilis* in the early secondary-growth forest within and outside the mining area is consistent with Martin et al. (2008) stating that most invasive plants affect secondary forests, particularly in highly disturbed environments by humans. The plant is widely naturalized in many Pacific islands. It is considered a threat to native biodiversity by creating a shading effect, which reduces native species richness under its canopy (Weber 2003 and Meyer 2004, Pacific Islands Ecosystems at Risk 2011).

Due to its attributes, the Swietenia macrophylla King (Mahogany) is considered successful at invading natural forests. The drupe of mahogany is a capsule and encloses winged seeds with an average number of 62. The number of seeds a mother mahogany tree can disperse is considerable. Three thousand seeds can be blown away from the mother tree in every 50 capsules. The seeds can be blown from the mother tree from 20 to 40 meters. The seeds germinate in less than a month. Mahogany seeds germinate hypogeal and contain food reserves. Even if the initial light is relatively low, the young mahogany plant develops even without initial photosynthesis. The initial young leaves of mahogany are scale leaves and not green. Real photosynthetic leaves came later and adapted to sun-flecked shade and partial shade.

On the other hand, G. *arborea* is an exotic tree species considered invasive because it is a host of insect pests. It came along with some intrusive features and introduced pests and diseases. The broad leaves of *G. arborea* became so attractive to defoliator *Ozola minor*. Moreover, the plant is also a host to the destructive insect *Xyleutis spp*. (Pinol et al., 2006 and Uriarte, 2007).

These invasive alien plants can severely impact various ecosystems with various adverse effects. Competition with indigenous flora and fauna, nutrient cycling changes, and hydrology disrupt local communities' overall economic stability and impact human health (Sankaran et al., 2005).

Conservation and Distribution Status of Tree Species

The Department of Environment and Natural Resources (DENR) and the International Union for Conservation of Nature (IUCN 3.1) Classification are used to determine the conservation and distribution status of tree species on the Interior and exterior of the mining site on Licuan-Baay, as shown in Table 3. One specie (Shorea guiso) has been classified as endangered according to the most recent DENR classification under DAO 2017e11. Additionally, there are three vulnerable species (*Lithocarpus jordanae (Villanueva) Rehder, Shorea contorta, and Dipterocarpus grandifloras)* and thirty non-threatened species based on DAO 2017e11.

Under the IUCN 3.1 classification, one species is considered Endangered (*Dipterocarpus grandifloras)*, one is categorized as Vulnerable (Shorea guiso), nine are classified as Least Concern, and twenty-three species are categorized as Data Deficient. In this classification method (IUCN 3.1), some species' conservation status does not coincide with the DAO 2017e11 version. In IUCN 3.1, *Dipterocarpus grandifloras* is considered endangered, but under the DAO 2017e11 classification, it is still in the Vulnerable category. Also, *Shorea guiso* is already endangered under the DAO 2017e11 classification, but in the IUCN 3.1 record, the species are declared vulnerable. The contradiction between IUCN and DENR could be due to the global scale of work with the former. This contradiction may lessen the probability of categorizing and updating the species during critical periods.

Conservation and Distribution of Trees Found in the Interior and Exterior Area of the Small-Scale Gold Mining Area of Licuan, Baay, Abra, Philippines.

FAMILY NAME	**SCIENTIFIC NAME**	**COMMON NAME/ LOCAL NAME**	**CONSERVATION STATUS**		**DISTRIBUTION**
			DAO 2017-11	**IUCN 3.1**	
Anacardiaceae	Streblus asper	Aludig/kalyos	Non-threatened	Data Deficient	Endemic
	Buchanania nitida	Balitantan	Non-threatened	Data Deficient	Widespread (invasive/exotic)
	Anacardium occidentale	Cashew/Kasoy	Non-threatened	Data Deficient	Widespread (invasive/exotic)
Dipterocarpaceae	*Dipterocarpus grandiflorus*	Apitong	Vulnerable	Endandangered	Endemic
	Shorea guiso	Red Balau/Guiso	Endangered	Vulnerable	Endemic
	Shorea contorta	White lauan	Vulnerable	Least Concern	Endemic
Euphorbiaceae	*Aleurites moluccana*	Candle nut tree/Lumbang	Non-threatened	Least Concern	Endemic
Fabaceae	*Albizia procera*	White siris/Akleng parang	Non-threatened	Least Concern	Endemic

	Pongamia pinnata	Bani	Non-threat-ened	Least Con-cern	Widespread (inva-sive/exotic)
	Samanea saman	Rain tree/Acacia/Akasya	Non-threat-ened	Least Con-cern	Endemic
Faga-ceae	*Lithocarpus jordanae (Villanueva) Rehder*	No common name associated with this taxon	Vulnera-ble	Data Defi-cient	Endemic
Hyper-icaceae	*Cratoxylum sumatra-nun (Jack) Blume*	Baringkuku-rung/Goyong-goyong	Non-threat-ened	Data Defi-cient	Widespread (inva-sive/exotic)
Lamia-ceae	*Gmelina arborea*	Gimelina	Non-threat-ened	Least Con-cern	Widespread (inva-sive/exotic)
Lythra-ceae	*Lagerstroemia speciosa*	Banaba	Non-threat-ened	Data Defi-cient	Endemic
Malva-ceae	*Grewia laevigata Vahl*	Bengla-leng/Dongrareng/Durareng	Non-threat-ened	Data Defi-cient	Widespread (inva-sive/exotic)
Melia-ceae	*Swietenia macrophylla King*	Big-leaf Mahogany	Non-threat-ened	Data Defi-cient	Widespread (inva-sive/exotic)
Mora-ceae	*Artocarpus ovatus Blanco*	Monkey Jack-fruit/Anubing	Non-threat-ened	Data Defi-cient	Endemic
	Artocarpus altilis	Breadfruit/Kamansi	Non-threat-ened	Data Defi-cient	Widespread (inva-sive/exotic)
	Ficus caulocarpa (Miq.) Miq.	White fig/Balete/Botgo/Sanglau	Non-threat-ened	Data Defi-cient	Widespread (inva-sive/exotic)
	Ficus nota (Blanco) Merr.	Tibig	Non-threat-ened	Data Defi-cient	Widespread (inva-sive/exotic)
	Ficus magnoliifolia	No common name associated with this taxon	Non-threat-ened	Data Defi-cient	Widespread (inva-sive/exotic)
	Ficus minahassae (Teijsm & Vriese) Mia	Cluster Fig Tree/Arimit/Hagimit	Non-threat-ened	Data Defi-cient	Widespread (inva-sive/exotic)
	Broussonetia luzonica	Himbabao/Alokon	Non-threat-ened	Data Defi-cient	Widespread (inva-sive/exotic)

Myrtaceae	*Syzygium cumini*	Black Plum/Java Plum/Duhat/Jambo lan	Non-threatened	Least Concern	Widespread (invasive/exotic)
	Psidium guajava	Guava/Bayabas	Non-threatened	Least Concern	Widespread (invasive/exotic)
Phyllanthaceae	*Bridelia Willd.*	Candelabria	Non-threatened	Data Deficient	Widespread (invasive/exotic)
	Antidesma pentandrum	Bignai-po-go/Alangbon/Salag ma	Non-threatened	Data Deficient	Widespread (invasive/exotic)
Pinaceae	*Pinus kesiya*	Pine tree/Saleng	Non-threatened	Least Concern	Endemic
Pittosporaceae	*Pittosporum pentandrum (Blanco) Merr.*	Cheese-wood/Oplai/Basuit/Mamali	Non-threatened	Data Deficient	Widespread (invasive/exotic)
Rubiaceae	*Mussaenda philippica A. Rich.*	Queen of Philippines	Non-threatened	Data Deficient	Widespread (invasive/exotic)
	Neonauclea bartlingii var. cumingiana (Vidal) Ridsdale	tikim (general), lisak (Tagalog), pantauan (Bikol)	Non-threatened	Data Deficient	Endemic
	Ixora coccinea L	Jungle Gerarium, Flame of the woods	Non-threatened	Data Deficient	Endemic
Rutaceae	*Micromelum minutum*	Limeberry/Tulibas tillos	Non-threatened	Data Deficient	Endemic
Sapindaceae	*Sapindus saponaria*	Soapberry/Kusibeng	Non-threatened	Least Concern	Widespread (invasive/exotic)

The result shows that 2.94 percent are endangered, 11.76 percent are vulnerable, 32.35 percent are the least concern, and 52.94 percent are data deficient.

Dipterocarpaceae are considered endangered and vulnerable among different families. They are included in the IUCN Red List of Threatened Species and the DAO National List of Threatened Philippine Plants and their categories, as presented in Table 3.

According to Rojo (2000), the most critical timber-producing trees in the Philippines belong to Dipterocarpaceae. Dipterocarps are the forest industry's mainstay. And the significant component of vegetative soil cover in the country. Regarding species diversity of dipterocarps, the Philippines ranks fourth after Sumatra, Peninsular Malaysia, and Borneo. Dipterocarps are threatened by over-exploitation. It is mainly due to commercial logging and deforestation caused by shifting cultivation and mining activities. Furthermore, being an economically important species in the Philippines and having its timbers commercially known in the international trade is a factor that attracts people to harvest the naturally occurring dipterocarps leading to the decline in its population (De Guzman et al., 1986). Locally, *Dipterocarpus grandiflorus*, *Shorea guiso,* and *Shorea contorta* species could have been the indigenous lumber source for construction within the community surrounding the mining area.

Conclusion

The most abundant tree species within the Interior and exterior area of the mining site is Pinus kesiya. At the same time, the rare tree species are Pittosporum *pentandrum (Blanco) Merr., Artocarpus altilis, Samanea saman, Broussonetia luzonica, and Lithocarpus jordanae (Villanueva) Rehder*. Furthermore**,** there is a lower species richness and taxonomic diversity within the Interior of the mining area than its exterior area, but both have moderate species evenness. Additionally, many widespread (invasive/exotic) tree species are compared to Philippine endemic trees in Baay-Licuan. The most endangered and vulnerable tree species are *Shorea guiso* and *Dipterocarpus grandifloras*.

It is recommended that rare tree species native to the area be prioritized for conservation and propagation activities. Tree planting activities may increase tree species richness and taxonomic diversity. Invasive or exotic tree species should not be introduced or replanted in the area; instead, endemic trees should be given priority to be planted and propagated. *Shorea guiso* and *Dipterocarpus grandifloras* should be strictly protected and prevented from further cutting in the area. The study's outputs should be disseminated and utilized by all stakeholders to protect the tree diversity in Licuan-Baay and educate the people on its significance.

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