

Mapping the Distribution of the Top Priority Plants in the Forests over Limestone Landscape of Samar Island Natural Park, Philippines

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Abstract

Samar Island Natural Park's (SINP) forests over limestone are biodiversity-rich ecosystems that must be safeguarded from human activities and other threats. Utilizing Geographic Information System technology, the study mapped the distribution and occurrences of the 20 top priority plants within SINP's landscapes to aid biodiversity conservation. Results revealed that *Shorea negrosensis* and *Hancea wenzeliana* are the most abundant species in SINP, with 1,150 and 715 individuals, respectively. *Cycas riuminiana*, *Draceana angustifolia*, *Lasianthus trichophlebus*, *Gymnostoma rumphianum*, *Polycias nodosa*, *Aquilaria cumingiana*, *Canarium hirsutum* and *Shorea contorta* were scarcely observed with only one to five documented individuals. These locally rare priority species should be further studied, monitored, and prioritized for conservation. This study is essential for effective conservation planning as it pinpoints the location of the priority species and provides insights on their habitat preferences and survival strategies. The results will serve as a scientific basis for drafting conservation policies and ensuring that conservation considerations, and recovery of the priority species are integrated into decision-making processes.

Keywords: Forests over limestone; Landscape conservation; Priority plants; Samar Island Natural Park; Species distribution mapping

1. Introduction

Samar Island, the Philippines' third largest island, is regarded as a biodiversity-rich island (Mittermeier *et al.*, 1997). It features one of the most widespread forests over limestone (FOL) in the country (Quimio, 2016; Tolentino *et al.*, 2020), which is habitat to a variety of endemic and threatened species adapted to limestone substrate, such as species belonging to family Dipterocarpaceae, *Ficus* species, and other species with high economic and ecological importance (Madera *et al.*, 2021; Obeña *et al.*, 2021; Villanueva *et al.*, 2021a, b; Buot *et al.*, 2022).

Forests over limestone around the world provide significant ecological services (BirdLife/FFI/IUCN/WWF, 2014), such as supporting life cycles, foods and other goods that are found only in the area (Buot *et al.*, 2022). However, these FOL in Samar Island Natural Park (SINP) face various threats such as quarrying, land conversion, and human population increase (Lillo *et al.*, 2019; Van Der Ploeg *et al.*, 2011) despite being designated as a protected area under the National Integrated Protected Areas System (NIPAS) Act of 1992. These threats

must be addressed to prevent habitat loss and disruption of ecological function and services (FAO, 2015; Buot *et al.*, 2022). But since this is very difficult to attain, the species were ranked, with the assumption that some species are more important than others (Given and Norton, 1993). The top 20 priority plant species for conservation in the FOL of SINP have been identified by Buot *et al.* (2024).

Mapping the distribution and occurrence of priority species is crucial for effective conservation planning, which often requires the integration of multiple spatial analysis techniques. Studies by Ramos *et al.* (2012) and Daipan *et al.* (2022) highlighted the need for employing various Geographic Information System (GIS) techniques to assess and interpret plant spatial distribution. This technology can interpret and analyze massive amounts of spatial data (Burrough *et al.*, 2015), which is important in species distribution (Daipan *et al.*, 2022). Ramos *et al.* (2012) georeferenced 2,067 species occurrences of 47 threatened forest trees to identify species for germplasm collection. Daipan *et al.* (2022) found that out of the 56 *Saurauia* species, 29 are distributed in a single province, seven are recorded in a specific region, and 35 species are found in a single type of climate. It has also been shown that combining field data with spatial analysis can help map the occurrence of species across different land cover classes, providing insights into habitat preferences and potential conservation priorities (Burger *et al.*, 2018; Lu *et al.*, 2019). Furthermore, using GIS to map the top priority plants in the FOL of SINP landscapes will provide baseline data, better visualization and other essential data that will support practical conservation efforts such as tracking species occurrences and distribution, genetic conservation, and resource prioritization for biodiversity surveys and specimen collections (Paquette and Messier, 2011; Ramos *et al.*, 2012), allowing for the formulation of policies, laws, and legislations (Anderson *et al.*, 2020). Hence, this study was carried out to map the top 20 priority plants within SINP's FOL landscapes for effective conservation planning. This study specifically aims to (1) map the distribution of SINP's top 20 priority plants at the local

and national scale and (2) determine the occurrence of the top priority plants in SINP's various landscapes for effective conservation planning.

2. Methodology

2.1 Data on priority species

The recorded species from the CONserve-KAIGANGAN Project 1 (Villanueva *et al.*, 2021; Obeña *et al.*, 2021) were evaluated using the Localized Conservation Priority Index (LCPI), a point scoring method used to rank the species according to the level of priority. The top 20 priority plants (Table 1) were identified by Buot *et al.* (2024) by calculating the summation of economic use, cultural use, harvesting risk, species distribution and frequency value of the species.

2.2 Mapping the top priority plants in SINP

The local and Philippine distributions of the top 20 priority plants (Table 1) were mapped using their geographic coordinates in the study sites (Buot *et al.*, 2024) and their geographic range based on Co's Digital Flora of the Philippines (CDFP) (Pelser *et al.*, 2011 onwards), respectively.

2.3 Determination of the top priority plant occurrences in the SINP landscapes

A landscape is a mosaic of interconnected natural and physical features of a specific geographic area, including man-made structures such as roads, buildings, and settlements (Goudie, 1997; Aziz and Anwar, 2019). This study utilized available secondary data from various sources (Table 2) to determine the occurrence of the top priority plants in SINP landscapes.

2.4 Spatial data analysis

Spatial data layers of the priority plants were converted into shapefiles and their distribution were extracted within the Philippine boundary layer based on CDFP data (Pelser *et al.*, 2011 onwards). A 500-meter buffer analysis of the priority

Table 1. Top 20 priority plants for conservation in SINP (Buot et al., 2024)

Rank	Scientific Name	Family
1	<i>Caryota rumphiana</i> Mart.	Arecaceae
2	<i>Aquilaria cumingiana</i> (Decne.) Ridl.	Thymelaeaceae
3	<i>Cycas riuminiana</i> M.Porte ex Regel.	Cycadaceae
4	<i>Dracaena angustifolia</i> (Medik.) Roxb.	Asparagaceae
5	<i>Oncosperma tigillarum</i> (Jack) Ridl.	Arecaceae
6	<i>Oreocnide rubescens</i> (Blume) Miq.	Urticaceae
7	<i>Kleinhovia hospita</i> L.	Malvaceae
8	<i>Diospyros blancoi</i> A.DC.	Ebenaceae
9	<i>Codiaeum</i> sp.	Euphorbiaceae
10	<i>Gymnostoma rumphianum</i> (Miq.) L.A.S.Johnson	Casuarinaceae
11	<i>Caryota cumingii</i> Lodd. ex Mart.	Arecaceae
12	<i>Artocarpus rubrovenius</i> Warb.	Moraceae
13	<i>Palaquium</i> sp.	Sapotaceae
14	<i>Hancea wenzeliana</i> (Slik) S.E.C.Sierra, Kulju & Welzen	Euphorbiaceae
15	<i>Aglaia rimosa</i> (Blanco) Merr.	Meliaceae
16	<i>Canarium hirsutum</i> Willd.	Burseraceae
17	<i>Lasianthus trichophlebus</i> Hemsl. ex F.B. Forbes & Hemsl.	Rubiaceae
18	<i>Polyscias nodosa</i> (Blume) Seem.	Araliaceae
19	<i>Shorea negrosensis</i> Foxw.	Dipterocarpaceae
20	<i>Shorea contorta</i> S.Vidal	Dipterocarpaceae

Table 2. Datasets used in the study

Datasets/Layers	Sources
Priority plants	Buot et al. (2024)
Mother trees in SINP	Madera et al. (2021)
Political boundary	PSA/NAMRIA (2020)
2020 Land cover	https://www.geoportal.gov.ph/
Soil	Department of Agriculture
Slope	NAMRIA (2020)
Elevation	https://earthexplorer.usgs.gov/
Geology	DENR-PAMB-SINP
Road and built ups	https://www.openstreetmap.org/
Landslide coordinates	DENR-MGB Region 8
Faults	DOST-PHIVOLCS (2018)

plants and its mother trees in SINP was created to assess proximity to settlements and human activities. The fault lines were georeferenced and digitized using the Active Fault Map in the municipality of Paranas (DOST-PHILVOCS, 2018) to understand the geological context of the area.

To determine the occurrences of each species, the datasets (Table 2) and the local species distribution were intersected in QGIS using the intersection technique under

the vector geoprocessing tools (Daipan et al., 2022). The output was transformed into a graph to help audience understand the findings.

To envision and analyze the distribution and occurrence of top priority plants across SINP’s landscapes, all the sets of variables were integrated by simply overlaying all the different layers in shapefile format. The analysis was done using an open-source GIS application software (QGIS version 3.30.2).

3. Results and Discussion

3.1 Distribution of the top priority plants in SINP

Figures 1 and 2 show the distribution map of the top 20 priority plants in the municipality of Paranas, Samar and Taft, Eastern Samar in SINP. There are a total of 2,000 individuals, with 834 individuals belonging to 17 species found in Paranas, Samar, and 1,166 individuals representing 8 species observed in Taft, Eastern Samar. The top 13 of these 20 priority plants are found in Paranas, Samar, and are classified as high priority species requiring strict harvesting and regulation in SINP (Buot *et al.*, 2024).

The two most abundant and widespread species, with the highest number of individuals in SINP are *S. negrosensis*, with 1,150 individuals and *H. wenzeliana*, with 715 individuals (symbolized by blue and red trees in Figures 1 and 2). This is consistent with the findings of Quimio (2016) and Madera *et al.*, (2021), who found that Dipterocarpaceae species, including *S. negrosensis*, dominate the FOL in Samar Island. Even though *H. wenzeliana*, a species endemic to Surigao and Samar Island, is abundant in SINP, its population in Surigao del Norte province has dropped, with 88 hectares of natural tree cover lost from 2001 to 2019 (GFW, 2020). *H. wenzeliana* is also a critically endangered species (IUCN, 2023). Hence, the SINP populations of this species must be properly sustained and protected.

The remaining 18 priority plants are scarce and therefore in danger of local extinction. Results also revealed that there are three (3) priority plants represented by only one individual in SINP. These very rare species are *C. riuminiana*, *G. rumphianum* and *L. trichophlebus*. The sparse and fragmented distribution of these species in SINP may accelerate species decline and possibly local extinction if they are not appropriately conserved.

Figure 3 illustrates the country-level distribution map of SINP's top priority plants for conservation. Some of the priority plants have only a few occurrences' points (Figure 3). The species with the lowest occurrence in the Philippines are *O. tigillarum*, only found in Palawan and Samar and is ranked fifth in the priority list of SINP. Another priority plant with restricted distribution is *L. trichophlebus*, a native species found only in Mindoro, Palawan, and Samar Island (Pelser *et al.*, 2011 onwards). Both of these narrowly endemic priority plants also have fewer individuals observed in SINP. *O. tigillarum*, has only three (3) individuals while *L. trichophlebus* has only one (1) individual. Species with narrow ranges are at higher risk of extinction than widespread species (Pimm *et al.*, 2014). Hence, there is an urgent need to conduct more botanical explorations at the local and national level to confirm the rareness and endemism of such species.

3.2 Occurrence of the top priority plants in the SINP landscapes

Climate

Samar Island's weather is classified into two categories, the Type II and Type IV climate (Figure 4). Five species namely *D. blancoi*, *A. rubrovenius*, *Palaquium sp.*, *H. wenzeliana*, and *S. negrosensis* are adapted to these two weather types. Individuals of *C. riuminiana*, *D. angustifolia* and *L. trichophlebus* are found exclusively in areas with Type II climate, characterized by the absence of a dry season and a very pronounced maximum rain period (Lantican, 2001). On the other hand, the other 12 priority species are adapted only to Type IV climate, in which rainfall is distributed throughout the year. Species that can adapt to any climate would have a greater chance of survival, making them resilient to other environmental stressors (Klupczynska and Ratajczak, 2021).

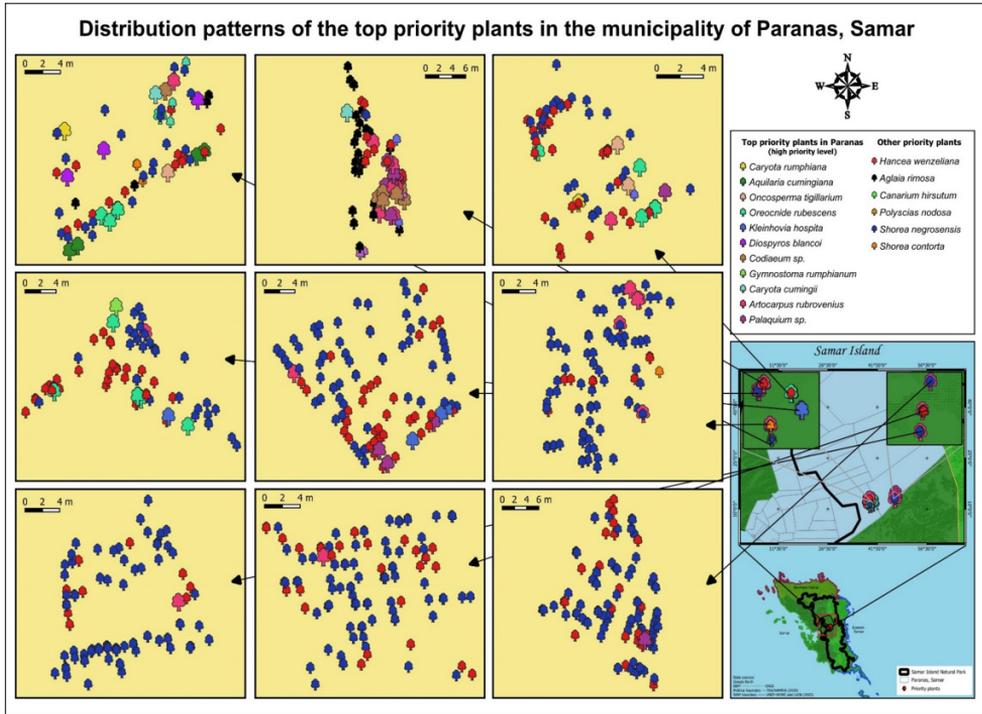


Figure 1. Distribution map of the top priority plants in Paranas, Samar

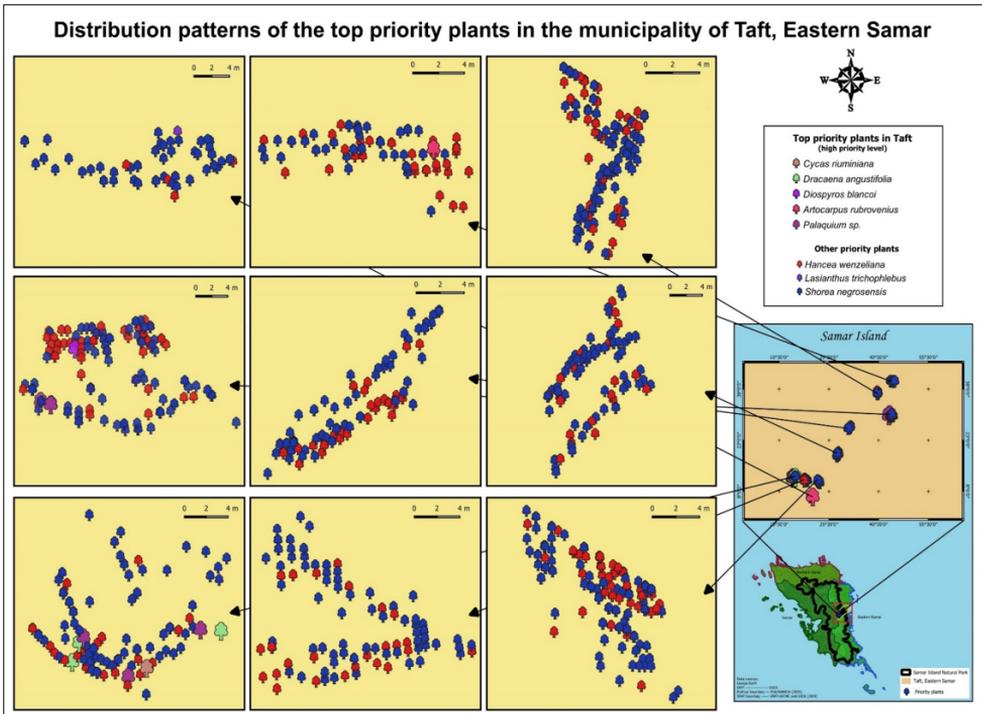


Figure 2. Distribution map of the top priority plants in Taft, Eastern Samar

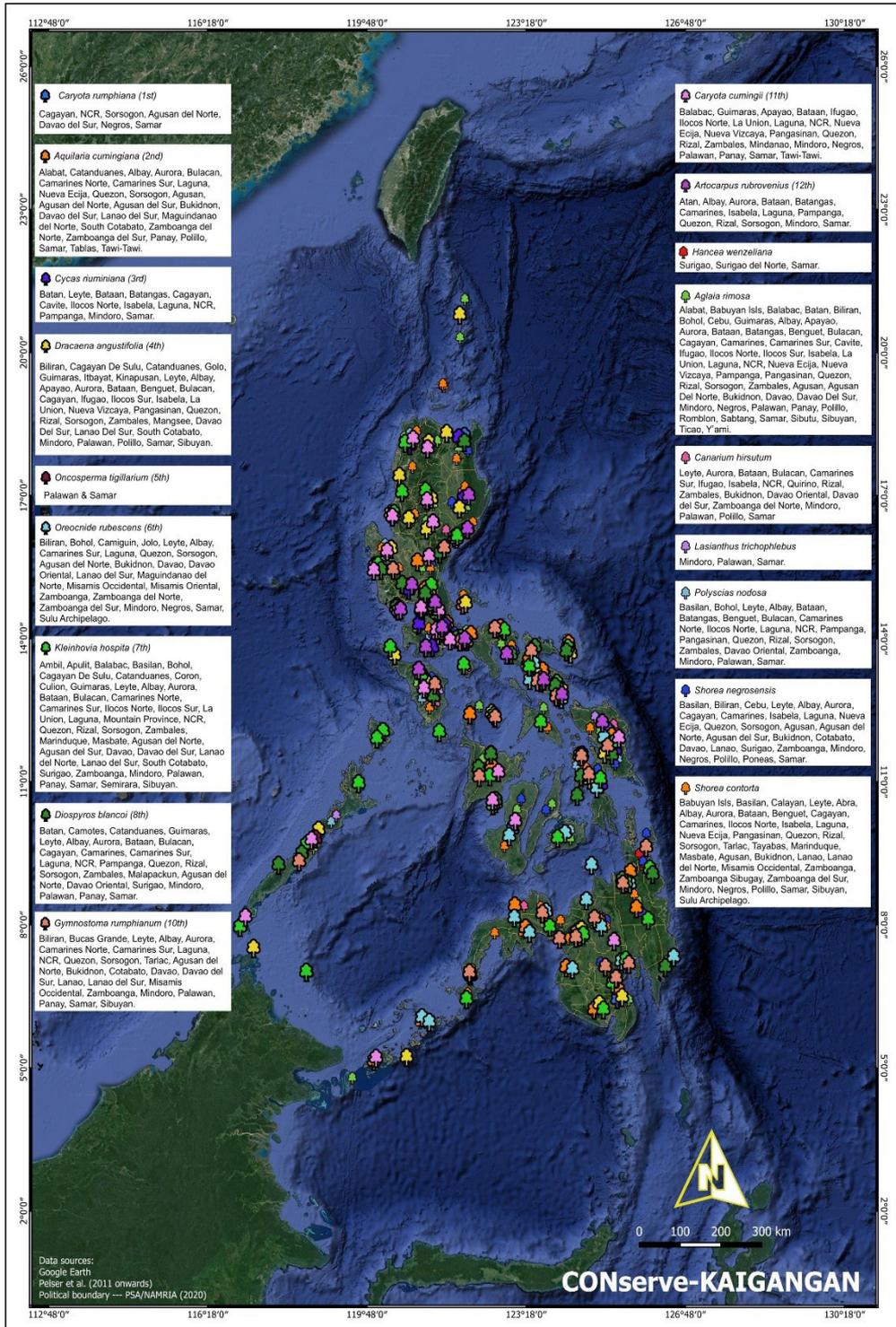


Figure 3. Country-level distribution map of SINP’s top priority plants for conservation in the Philippines

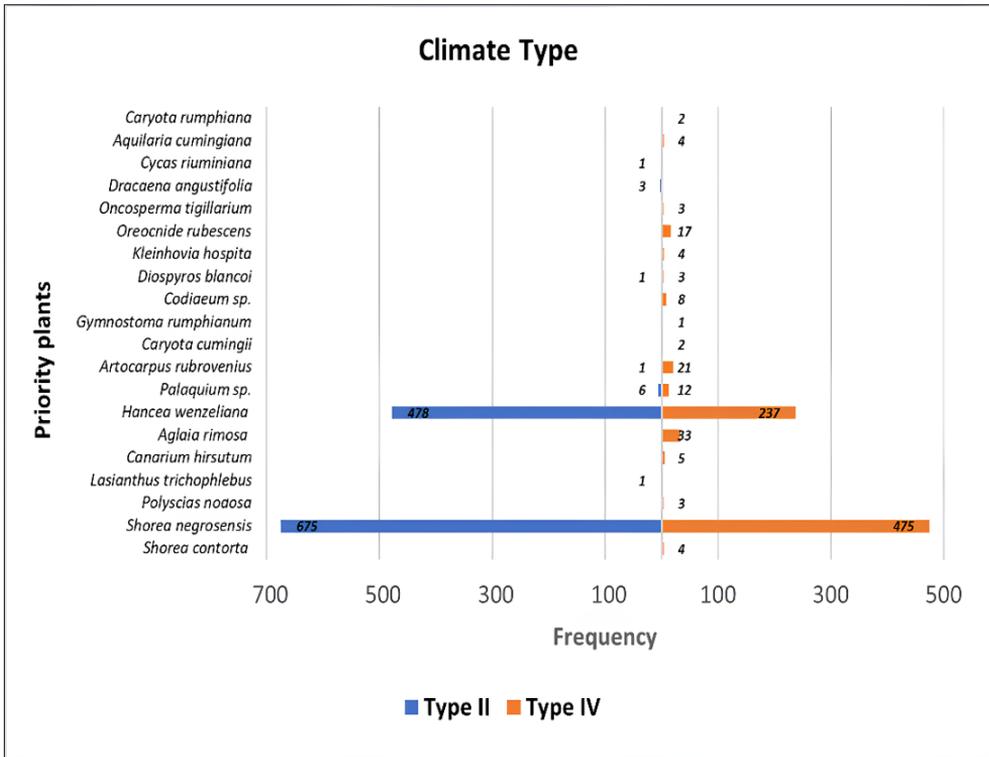


Figure 4. Top priority plant occurrences based on Climate type; priority plants intersected in Type II (blue) and Type IV climate (orange)

Soil

The top 20 priority plants were observed in two soil types in SINP, the Luisiana clay and the Faraon clay soil (Figure 5). The priority species that are adapted to both soil types may be able to thrive in other soil types. These species are *D. blancoi*, *A. rubrovenius*, *Palaquium sp.*, *H. wenzeliana*, and *S. negrosensis*. The species that are growing exclusively in Luisiana clay soil type are *C. riuminiana*, *D. angustifolia* and *L. trichophlebus*. Luisiana clay is the fourth major soil type in SINP (Samar Island Management Plant, 2007), which is very acidic, has low K levels, and has low nutrient retention (Sarimong, 2016). The other 12 priority species were observed growing only in Faraon clay soil type, the third most common soil type in SINP, which is generated from the disintegration of coralline limestone, with a black clay surface and becomes sticky and plastic when wet (Demetrio, 1968).

Geology

The top 20 priority plants were observed in two geologic profiles in SINP, the Oligocene-Miocene Limestone and the Spilitic rocks and basic flows (Figure 6). Five priority plants were found growing on both geologic profiles. This includes the *D. blancoi*, *A. rubrovenius*, *Palaquium sp.*, *H. wenzeliana* and *S. negrosensis*. According to the OMRP (1971), Oligocene-Miocene limestones are a well bedded type of limestone rock, interbedded with shales, sandstones, and silts. Conversely, spilitic rocks and basic flows are both related to volcanic activity (Weaver and Tarney, 1984). Spilitic rocks are changed volcanic rocks (Naldrett, 1974; Weaver and Tarney, 1984), while basic flows are lava flows composed of basaltic or mafic lava (Walker, 1991; Fink, 1980). Moreover, three (3) priority species in SINP namely *C. riuminiana*, *D. angustifolia* and *L. trichophlebus* were observed growing in Spilitic and basic flows, while the remaining 12 species were found in Oligocene-Miocene Limestone (Figure 6), showing their unique suitability to this geologic type.

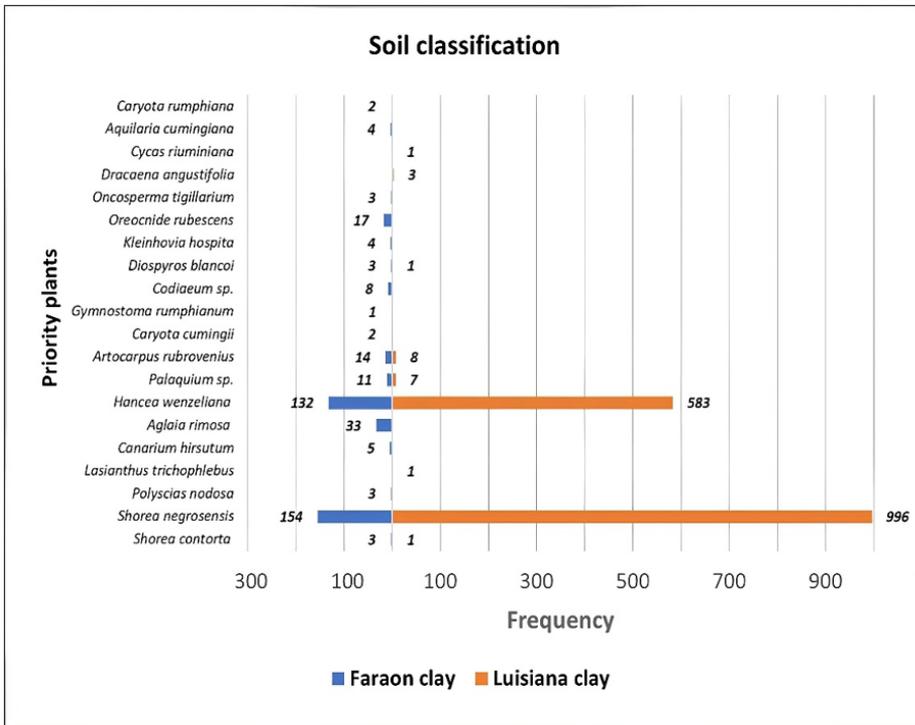


Figure 5. Top priority plant occurrences based on soil classification; priority plants intersected in Faraon clay (blue) and Luisiana clay soil (orange)

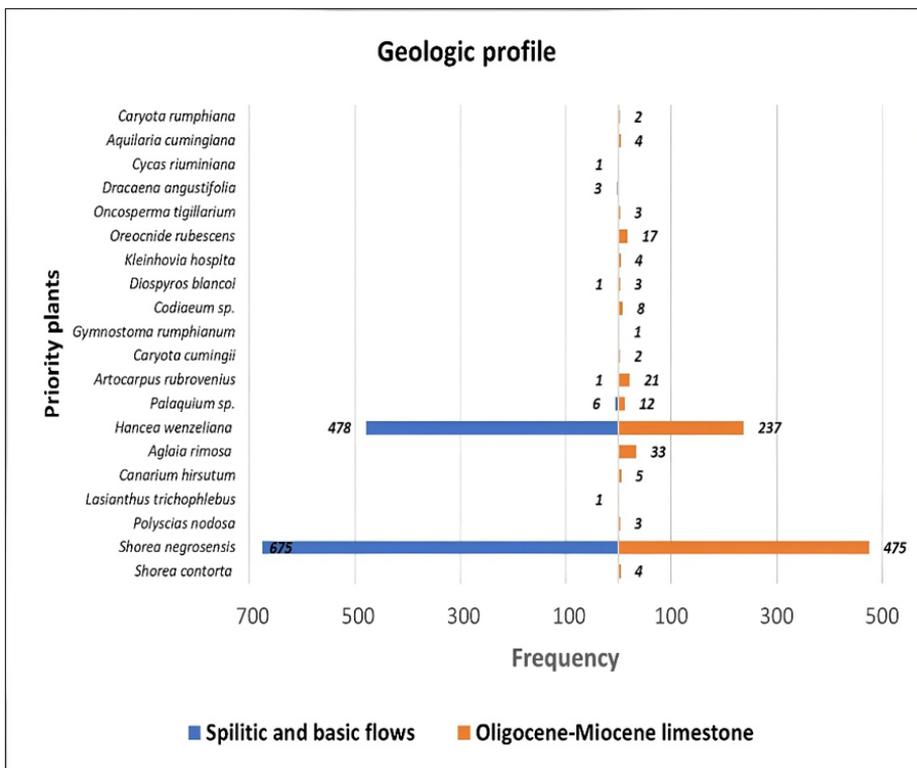


Figure 6. Top priority plant occurrences based on geologic profile; priority plants intersected in Spilitic and basic flows (blue) and Oligocene-Miocene limestone (orange)

Landcover

Figure 7 shows the top priority plants that were observed in three (3) land cover types in SINP, the open forest, brush/shrub land and closed forest areas. Eight of the top 20 priority species can only be found in one type of vegetation cover (Figure 7) and may struggle to survive due to unsuitability to other areas (Lorite et al., 2021). Four (4) priority plants (*A. cumingiana*, *C. riuminiana*, *D. angustifolia*, and *S. contorta*) grow mainly in open forests, three (3) (*G. rumphianum*, *C. hirsutum* and *P. nodosa*) in brush/shrub land, and one (*L. trichophlebus*) in a closed forest. Meanwhile, eight (8) priority species were found in both open forests and brush/shrub lands and three (3) species such as *Palaquium sp.*, *H. wenzeliana* and *S. negrosensis* were observed growing in three mentioned land cover types. These species exhibit greater flexibility to any vegetation cover, allowing for ecosystem restoration and resilience (Dawson et al., 2011).

Slope and topography

As shown in Figure 8, *Palaquium sp.*, *H. wenzeliana*, and *S. negrosensis* are the only priority plants adapted in any slope classes. Four species (*C. rumphiana*, *O. tigillarum*, *G. rumphianum*, and *S. contorta*) were observed growing in >50% slope and only two (2) species were also observed in 8-18% slope such as *C. riuminia* and *P. nodosa*. Plants that can adapt to any slope may expand their ecological niche and contribute to ecosystem stability in areas where other species are unable to thrive (Ravenscroft et al., 2010).

Elevation

Most of the priority plants were found between 150m and 400 m asl (Figure 9). Other species had specific range in elevation requirement such as *C. riuminia*, *D. angustifolia*, *C. hirsutum*, *L. trichophlebus*, and *P. nodosa*, which seen in 150 - 300m asl and only three (3) species were sited in 300 - 400m asl. Those species adapted to a certain elevation, may be less adaptable to changes, and may experience population decline (Sklenář et al., 2023).



Figure 8. Top priority plant occurrences based on slope classes; priority plants intersected in 0 - 8% (blue), 8 - 18% (green), 18 - 30% (grey), 30 - 50% (yellow) and > 50% slope (red)

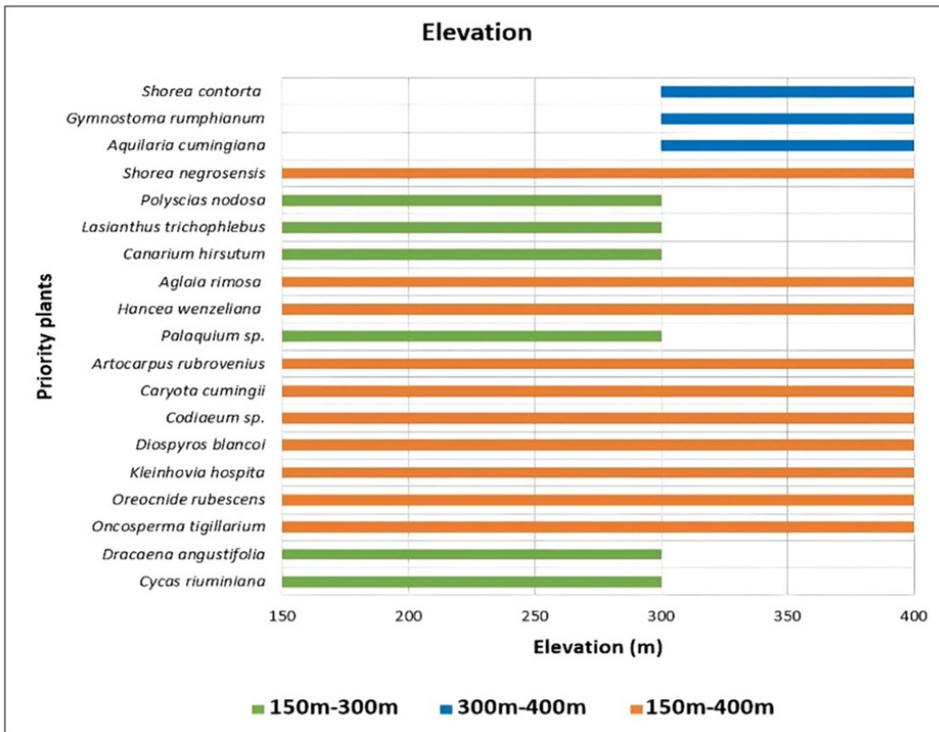


Figure 9. Top priority plant occurrences based on elevation; priority plants intersected in 150m - 300m (green), 300m - 400m (blue) and 150m - 400m elevation (orange)

Natural features and attractions

SINP offers several scenic and natural attractions such as in Figure 10. Among the top 20 priority species, *Codiaeum sp.*, *C. cumingi*, *A. rubrovenius*, *Palaquium sp.*, *H. wenzeliana*, *A. rimosa*, *C. hirsutum* and *S. negrosensis* are close to the “Ulot River adventure – TORPEDO boat extreme jump off point”, one of the main tourist attractions in Samar. These species are also close to the tourism office, and ecotrail and birding site (see Figure 11). Meanwhile, the priority plants (*A. rubrovenius*, *H. wenzeliana* and *S. negrosensis*) in San Rafael, Taft are close to the Philippine Eagle Sanctuary, Hydro Energy, AFP 8th Infantry and Camp Major Eugenio S. Daza Military Reservation area (see Figure 11). Species near these areas may provide habitat protection since they are legally protected to protect and conserve biodiversity (Adams et al., 2004). However, some tourist destinations may threaten plant populations due to unlawful activities (Mercado et al., 2022).

Some events that may alter SINP landscapes and affect top priority plants.

As shown in Figure 11, the priority plants

in Paranas such as *Codiaeum sp.*, *C. cumingi*, *A. rubrovenius*, *Palaquium sp.*, *H. wenzeliana*, *A. rimosa*, *C. hirsutum* and *S. negrosensis* are extremely close to the Central Samar fault: Paranas segment, but the top priority plants in Taft are slightly farther away from the Central Samar Fault - Canavid Segment. The Central Samar fault: Paranas segment is the second longest fault line in Samar Island, extending for approximately 13.5 kilometers from the central area of Hinabangan northwestward to the southern tip of Paranas (Samar Island Management Plant, 2007; DOST-PHIVOLCS, 2018). Indeed, this poses hazards to the priority species due to the unpredictability of seismic events (Chapman et al., 2018).

As revealed in Figure 11, the priority plants that are extremely close to the landslide prone areas are *A. rubrovenius*, *H. wenzeliana* and *S. negrosensis* populations that are found in Taft, Eastern Samar. Landslides can cause immediate plant mortality, resulting to population reduction (Zhang et al., 2020).

Though SINP is vulnerable to tropical storms and typhoons, the priority plants are not vulnerable to flooding because it occurs in



Figure 10. Some features in Samar Island Natural Park such as a) forests over limestone, b) natural cave formation, c) tourist attraction, and d) Ulot river

the mid elevation, approximately 500m from the Ulot river (Figures 9 and 11).

The island of Samar is rich in mineral reserves, which were cleared for mining exploitation, resulting in severe degradation in the protected area. Three (3) priority plants (*A. rubrovenius*, *H. wenzeliana* and *S. negrosensis*) located in Taft are quite close to the Bagacay mining area, situated in the interior part of the SINP (Figure 11). If further exploration of the area occurs, the population of priority plants may be impacted in the future.

As illustrated in Figure 11, the priority plants in SINP that are most susceptible to anthropogenic disturbances, resulting in population declines, are *Codiaeum sp.*, *C. cumingi*, *A. rubrovenius*, *Palaquium sp.*, *H. wenzeliana*, *A. rimosa*, *C. hirsutum* and *S. negrosensis*. These species are the closest to the settlement area in Paranas and are collected by the locals in Samar for different purposes. Settlements expanded into the interior portions of Samar Island and now established a permanent residence in the island's forestland. Additionally, a negative implication of tourism sites in SINP was observed by Mercado *et al.* (2022) due to an increase in population to natural attractions sites, resulting in an increase in carbon footprint and trash disposal, as well as destruction of the protected area (FAO, 2015).

4. Conclusion

This study was able to map the distribution and occurrences of the top priority plants within SINP's landscapes employing various GIS techniques. The findings show that *H. wenzeliana* and *S. negrosensis* are the two priority plants that are well adapted to SINP's diverse landscapes. Species that can adapt to various conditions have a greater chance of survival, making them more resilient to climate change and other environmental stressors. Whereas species that are restricted to certain habitats such as *C. riuminiana*, *D. angustifolia*, *L. trichophlebus*, *G. rumphianum*, *P. nodosa*, *A. cumingiana*, *C. hirsutum* and *S. contorta*, may struggle to survive. Small population size and limited distribution can lead to reduced genetic diversity, resulting to an increased risk of extinction. Furthermore, the surrounding area of the priority plants are susceptible to exploitation and climate change impacts, increasing the risk of disturbances. These results will serve as a scientific basis for the creation of conservation policies, ensuring that conservation considerations and recovery of the priority species are integrated into decision-making processes.

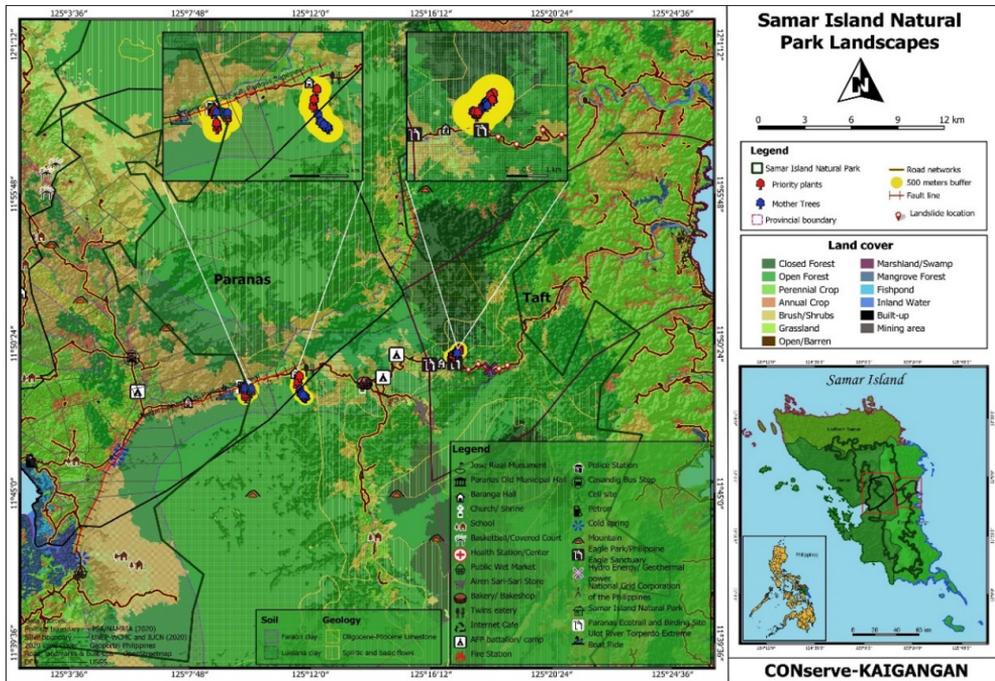


Figure 11. Map showing the distribution and occurrences of the top priority plants in SINP’s forests over limestone landscapes

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