Ambient Science, 2018: Vol. 05(2); 44-50
DOI:10.21276/ambi.2018.05.2.aa01

ambient
SCIENCE
Vol. 5(2): 44-50
Year 2018

Published by: National Cave Research and Protection Organization, India

AMBIENT APPRAISAL

Vegetation of the Ultramafic Soils of Hinatuan Island, Tagana-An, Surigao Del Norte: an Assessment as Basis for Ecological Restoration

Roger T. Sarmiento

College of Forestry and Environmental Sciences, Caraga State University, Ampayon, Butuan City, Philippines, 8600

Study Area: Surigao del Norte, Philippines
Coordinates: 9.753367° to 9.813161° N;
125.696155° to 125.741308° E

Keywords: Biodiversity, Nickel mining, Stand composition and structure, Native flora.

Abstract

Serpentine soils are generally poor in species diversity, show a high degree of endemism, and are always under threat due to anthropogenic and mining activities. In Hinatuan Island, Philippines, species diversity and density of trees were assessed in three selected sites comprising mostly of Leptospermum-Xanthostemon-Alstonia community. A total of 2,134 individuals with dbh >5 cm were recorded from 10 sampling stations and account to a density of 5,325 trees ha-1¬. About 135 vascular plant species belonging to 57 families and 109 genera were also encountered in the island, 42% of which were classified as trees. Despite the richness and density of species, the island ecosystem was classified to have very low Shannon-Weiner diversity index (H' = 0.7738) overall. With the implementation of full-scale mining in the future, conservation and reforestation measures should be in place with native and indigenous tree species primarily considered for ecological restoration.

Introduction:

The Philippines contains a diverse range of forest formations that occur over different substrates and are often associated with distinct vegetation (Fernando et al., 2008; Ata et al., 2016). One forest formation is developed over ultramafic soils (frequently called ultrabasics or serpentines). In the past, very little was known about the geology and flora of ultramafic environments especially for the countries of Southeast Asia. But, several accounts are now available such as the ultramafic sites reported in the State of Odisha in India (Brooks, 1987), Mount Silam in Sabah, Malaysia (Proctor *et al.*, 1988), Mount Piapi in the Talaud Islands, Indonesia (Proctor *et al.*, 1994), Mount Giting-Giting on Sibuyan Island, Philippines (Proctor *et al.*, 1998), and Mount Kinabalu in Sabah (Aiba & Kitayama, 1999). Among them, in the Philippines, a number of ultramafic soil environments such as in Zambales in Central Luzon, Claver in Surigao del Norte (Ata *et al.*, 2016), and Carrascal in Surigao del Sur (Sarmiento & Demetillo, 2017) were exploited for the "Nickel mining". As per the report of Department of Environment & Natural Resources -Mines and Geosciences Bureau, there are 48 registered metallic mines in the Philippines, 23 are located in Caraga Region where 20 of which are engaged in nickel mining.

The vegetation of ultramafic rocks is often sparse, stunted and has rare and endemic in nature. Because of the high concentrations of metallic elements such as Mg, Cr, and Ni, vegetation evolved into "hyperaccumulation" as the mechanism that is hypothesized to allow plants to survive on serpentine soils (Baker & Brooks, 1989). The ecology of serpentine systems is particularly interesting considering the high proportion of endemic plant species, their typical adaptive morphologies, and the distinctive structure of serpentine communities.

Recently, the minerals industry is switching towards the environmentally responsible operations, through changes in its economic, environmental, and social practices. Conserving biodiversity is a key component for improving the environmental performance, primarily because most mining involves vegetation damage by clearance or by the surface disposal of wastes, often in pristine areas. Conservation and rehabilitation programs must always be embedded in management plans. In the preparation and revision of this, appropriate knowledge on the biological resource is vital. The present study aimed to determine the current composition and diversity pattern of the existing terrestrial flora within Hinatuan Island and to provide information on their conservation status and make recommendations for the ecological restoration of the island. The list of species provided herein is not a comprehensive documentation but merely reflect on the biodiversity richness of the island ecosystem.

Author: rtsarmiento@carsu.edu.ph

ISSN- 2348 5191 (Print) & 2348 8980 (Electronic)

Ambient Science, 2018: Vol. 05(2); 44-50
DOI:10.21276/ambi.2018.05.2.aa01

Methodology:

Study area: the Tagana-an Nickel Mining Project of the Hinatuan Mining Corporation is located in Hinatuan Island, Brgy. Talavera, Tagana-an, Surigao del Norte. The island is one of the 11 islands under the political jurisdiction of Tagana-an at about 24 kilometers East of Surigao City.

Hinatuan Island has an approximate total land area of 1,275.00 hectares, around 773.77 hectares is covered by an approved Mineral Production Sharing Agreement (MPSA 246-2007-XIII) executed by and between HMC and the Philippine Government in the year 2007. Based on satellite images and reconnaissance survey, the land use of the island can be classified into the following: a) built-up areas; b) mined out areas; c) reforestation areas; d) grasslands; e) coconut groves; f) secondary growth forest; g) natural bare lands; h) swampy areas; i) mangrove areas.

Vegetation sampling: sampling procedure was based on a standard line transect method. Total 3 to 4 quadrats having the dimension of 20 m x 20 m were laid out along each transect at an interval of 150 to 500 m apart depending on the terrain and density of the prevailing vegetation. A GPS receiver was used to determine coordinates with the upper right corner used as the reference. All plants inside quadrat with >5 cm dbh were recorded. Plants encountered in the transect line were also tabulated to form the checklist.

Species identification and nomenclature: species identification was done on the field itself. Field manuals and publications referring to the Philippine flora included Zamora & Co. (1986), Madulid (2002), Primavera (2009) were utilized to aid identification. Online website "PhytoImages" (*http://www.phytoimages.siu.edu/*) was also used to compare photographed species. Unfamiliar species were posted online thru a social media group Co's Digital Flora of the Philippines (a public group of the botanists, foresters, biologists and other plant enthusiasts) to confirm species identification. The scientific nomenclature and conservation status of species were cross-checked in the databases of The Plant List (*http://www.theplantlist.org*) and The IUCN Redlist of Threatened Species (*http://www.iucnredlist.org*), respectively.

Data analysis: data was encoded on a spreadsheet and analyzed using the vegetational analysis formula for species importance value (SIV). The SIV was computed as the sum of the relative frequency, relative density and relative dominance of a species in a community (SIV= RFreq+RDom+RDen). An SIV provides a better index than density alone on the importance or function of a species in a habitat and also gives rank or order for a particular species within the community (Odum & Barret, 2005).

Shannon-Wiener (H') diversity index, species richness and evenness, on the other hand, the same were computed using the PAST Statistical Software.

Results and Discussion:

Field observations of sites: the Hinatuan Island ecosystem could be described as a secondary forest on an ultramafic soil environment. It has as a unique assemblage of vascular and non-vascular flora from coastal areas to steep slopes and land surface in higher grounds. The vegetation types are generally represented by- mangrove (Plate-1a), coastal/beach, secondary growth, agroforest, grasslands (Plate-1b), and farmlands. The mangrove areas are located on the southern portion of the island fronting seawaters and coastal areas along Lipata and Cortez. The ecosystem was dominated by *Rhizophora apiculata* and other associated species like *Xylocarpos granatum*, *Terminalia catappa*, and *Barrigtonia asiatica*.

Grassland areas were observed on the different parts of the island being dominated by *Imperata cylindrica* with marginal land shrubs such as *Ficus pseudopalma* and *Commersonia bartramia*. Towards higher elevation, species composition gradually changed to *Decranopteris* and *Lygodium* communities. A small portion on the lower elevation near the reforestation site was dominated by another fern species called Bracken fern (*Pteridium aquilinum*) with sparse individuals of *C. bartramia, Macaranga bicolor*, and *Ficus septica*. The species

Plate-1: Panoramic views of the different land uses within Hinatuan Island. a) Mangrove areas, b) Grasslands, c) Coconut grooves and, d) Secondary forest beside active mine sites.

Ambient Science, 2018: Vol. 05(2); 44-50
DOI:10.21276/ambi.2018.05.2.aa01

composition of disturbed lands in the island was different from other ultramafic sites in Northern Mindanao and were mostly dominated by *Trema orientalis* like the ultramafic environs in Tubay and Carrascal (Sarmiento & Demetillo, 2017).

Coconut groves exist on the narrow isthmus and along coastlines (Plate-1c). Alongside slopes and steep ravines were patches of secondary growth forest dominated by various species of vascular plants (Plate-1d). In a transect in Lipata, Cortez area, plant community was composed of *Leptospermum, Orania, Gymnostoma* species. The transect west of mine base camp was dominated by *Leptospermum, Xanthostemon, Alstonia* communities, while the mangrove-beach forest was dominated by *Rhizophora, Xylocarpus, Pandanus* community. A number of *Nepenthes* species and ground orchid species were also encountered along buffer zones of waterways. (Plate: 2).

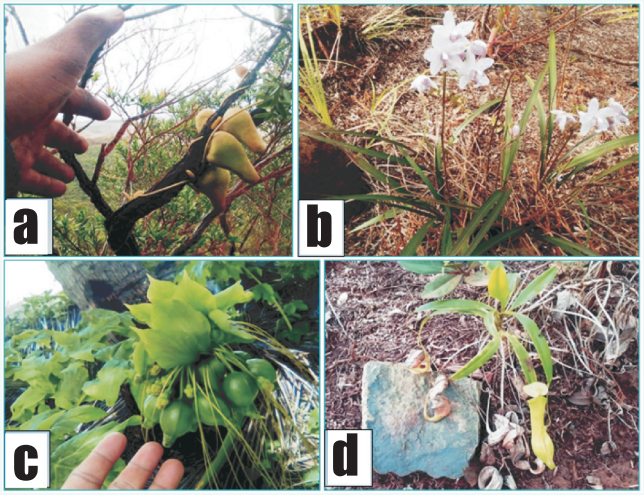

Plate-2: Some noteworthy species observed in the island.
a) *Dischidia major*, b) *Spathoglottis tomentosa*,
c) *Tacca leontopetaloides*, d) *Nepenthes alata*

Flora diversity: a total of 135 vascular plant species belonging to 57 families and 109 genera were encountered. The families with the most number of species were Fabaceae (15 species), followed by Moraceae (10), Myrtaceae (8) and Rubiaceae (6) while for the genera were Ficus (5 species), Pandanus (4) and Artocarpus & Lygodium with 3 species each. Based on habitat where the species were encountered, 40% (54 of 135) of the identified species were found on secondary growth forest, 22% (30 of 135) were in coastal/beach areas as well as in reforestation/ cultivated areas, and only 16% (21 of 135) were found in marginal lands and grassland areas. (Table-1)

Transect 1 was generally composed of a community of *Leptospermum, Xanthostemon* and *Alstonia* species. The transect has a species richness of 6 and a Shannon Diversity Index (H') of 0.7048 which was classified to be "very low". The species *Leptospermum amboinense, Xanthostemon verdugonianus* and *Alstonia parviflora* were regarded as the most important species in the area having the highest SIV. The plant community has a mean diameter of 7.67±1.51 cm comprising young growth trees. The area has a mean population density of 164 individuals per 400 m^2 or about 4,100 trees $hectare^{-1}$ (41 trees per $100m^2$). Basal area was computed to be 10,634.30 cm^2 where *L. amboinense* occupying most of the area followed by *X. verdugonianus* and *A. parviflora*. (Table-2; Plate-3).

Table-1: List of vascular species encountered in the study area

S. no	Scientific Name	Island Habitat	IUCN Status
Family: Acanthaceae			
1.	*Avicennia officinalis*	Coastal/Beach Forest	LC
Family: Anacardiaceae			
2.	*Anacardium occidentale*	Cultivated/Reforestation	NA
3.	*Buchanania arborescens*	Secondary Forest	NA
4.	*Cerbera manghas*	Coastal/Beach Forest	NA
5.	*Dracontomelon dao*	Coastal/Beach Forest	NA
6.	*Mangifera indica*	Cultivated/Reforestation	DD
Family: Annonaceae			
7.	*Annona muricata*	Coastal/Beach Forest	NA
8.	*Alstonia macrophylla*	Secondary Forest	LC
9.	*Alstonia parvifolia*	Secondary Forest	NA
10.	*Dischidia major*	Secondary Forest	NA
Family: Araceae			
11.	*Epipremnum pinnatum*	Secondary Forest	NA
Family: Araliaceae			
12.	*Polyscias nodosa*	Secondary Forest	NA
Family: Arecaceae			
13.	*Adonidia merrillii*	Cultivated/Reforestation	LR/NT
14.	*Nypa fruticans*	Coastal/Beach Forest	LC
15.	*Orania decipiens*	Secondary Forest	LR/NT
Family: Asparagaceae			
16.	*Dracaena angustifolia*	Secondary Forest	NA
17.	*Dracaena reflexa*	Coastal/Beach Forest	NA
Family: Asteraceae			
18.	*Ageratum conyzoides*	Grassland/Disturbed	NA
19.	*Bidens pilosa*	Grassland/Disturbed	NA
Family: Bombacaceae			
20.	*Camptostemon philippinense*	Coastal/Beach Forest	EN
Family: Cannabaceae			
21	*Trema orientalis*	Secondary Forest	NA
Family: Capparaceae			
22.	*Capparis zeylanica*	Secondary Forest	NA
Family: Caricaceae			
23.	*Carica papaya*	Cultivated/Reforestation	DD
Family: Casuarinaceae			
24.	*Casuarina equisetifolia*	Secondary Forest	NA
25.	*Gymnostoma rumphianum*	Secondary Forest	NA
Family: Combretaceae			
26.	*Terminalia catappa*	Cultivated/Reforestation	NA
27.	*Terminalia surigaensis*	Coastal/Beach Forest	NA
Family: Convolvulaceae			
28.	*Ipomoea pes-caprae*	Coastal/Beach Forest	NA
29.	*Merremia peltata*	Secondary Forest	NA
Family: Cyatheaceae			
30.	*Cyathea contaminans*	Grassland/Disturbed	NA
Family: Cycadaceae			
31.	*Cycas circinalis*	Coastal/Beach Forest	EN

Ambient Science, 2018: Vol. 05(2); 44-50
DOI:10.21276/ambi.2018.05.2.aa01

Family: Cyperaceae		
32. *Baumea rubiginosa*	Grassland/Disturbed	NA
Family: Dennstaedtiaceae		
33. *Pteridium aquilinum*	Grassland/Disturbed	LC
Family: Ebenaceae		
34. *Diospyros ebenoides*	Coastal/Beach Forest	EN
35. *Diospyros philippinensis*	Cultivated/Reforestation	EN
Family: Euphorbiaceae		
36. *Excoecaria agallocha*	Coastal/Beach Forest	LC
37. *Jatropha curcas*	Cultivated/Reforestation	NA
38. *Macaranga bicolor*	Secondary Forest	VU
39. *Macaranga tanarius*	Secondary Forest	NA
40. *Melanolepis multiglandulosa*	Cultivated/Reforestation	NA
Family: Fabaceae		
41. *Acacia auriculiformis*	Cultivated/Reforestation	LC
42. *Acacia mangium*	Cultivated/Reforestation	NA
43. *Arachis pintoi*	Cultivated/Reforestation	NA
44. *Bauhinia integrifolia*	Secondary Forest	NA
45. *Bauhinia monandra*	Grassland/Disturbed	NA
46. *Caesalpinia pulcherrima*	Cultivated/Reforestation	NA
47. *Calopogonium mucunoides*	Coastal/Beach Forest	NA
48. Delonix regia	Cultivated/Reforestation	LC
49. *Falcataria moluccana*	Cultivated/Reforestation	NA
50. *Indigofera tinctoria*	Coastal/Beach Forest	NA
51. *Leucaena leucocephala*	Cultivated/Reforestation	NA
52. *Ormosia calavensis*	Secondary Forest	NA
53. *Pongamia pinnata*	Coastal/Beach Forest	LC
54. *Pterocarpus indicus*	Cultivated/Reforestation	VU
55. *Samanea saman*	Cultivated/Reforestation	NA
Family: Flagellariaceae		
56. *Flagellaria indica*	Secondary Forest	NA
Family: Gleicheniaceae		
57. *Dicranopteris linearis*	Grassland/Disturbed	NA
Family: Goodeniaceae		
58. *Scaevola sericea*	Secondary Forest	NA
59. *Scaevola micrantha*	Secondary Forest	NA
Family: Graminae		
60. *Cenchrus pedicellatus*	Grassland/Disturbed	NA
61. *Cenchrus setaceus*	Grassland/Disturbed	NA
62. *Eleusine indica*	Grassland/Disturbed	NA
63. *Urochloa mutica*	Grassland/Disturbed	NA
Family: Hypericaceae		
64. *Cratoxylum formosum*	Secondary Forest	LR/LC
65. *Cratoxylum sumatranum*	Secondary Forest	NA
Family: Clusiaceae		
66. *Garcinia venulosa*	Secondary Forest	NA
Family: Lauraceae		
67. *Beilschmiedia glomerata*	Secondary Forest	NA
Family: Lecythidaceae		
68. *Barringtonia asiatica*	Coastal/Beach Forest	LR/LC
69. *Petersianthus quadrialatus*	Cultivated/Reforestation	NA
Family: Lygodiaceae		
70. *Lygodium circinnatum*	Grassland/Disturbed	NA
71. *Lygodium flexuosum*	Grassland/Disturbed	NA
72. *Lygodium scandens*	Grassland/Disturbed	NA
Family: Malvaceae		
73. *Commersonia bartramia*	Secondary Forest	NA
74. *Heritiera littoralis*	Secondary Forest	LC
75. *Hibiscus tiliaceus*	Coastal/Beach Forest	NA
76. *Urena lobata*	Grassland/Disturbed	NA
Family: Meliaceae		
77. *Azadirachta indica*	Coastal/Beach Forest	NA
78. *Xylocarpus granatum*	Coastal/Beach Forest	LC
Family: Moraceae		
79. *Artocarpus altilis*	Cultivated/Reforestation	NA
80. *Artocarpus communis*	Cultivated/Reforestation	NA
81. *Artocarpus multifidus*	Secondary Forest	NA
82. *Ficus balete*	Secondary Forest	NA
83. *Ficus cumingi*	Cultivated/Reforestation	NA
84. *Ficus pseudopalma*	Grassland/Disturbed	NA
85. *Ficus septica*	Secondary Forest	NA
86. *Ficus ulmifolia*	Secondary Forest	NA
87. *Parartocarpus venenosus*	Secondary Forest	NA
88. *Trophies philippinensis*	Secondary Forest	NA
Family: Moringaceae		
89. *Moringa oleifera*	Cultivated/Reforestation	NA
Family: Musaceae		
90. *Musa sapientum*	Cultivated/Reforestation	NA
91. *Musa textilis*	Coastal/Beach Forest	NA
Family: Muntingiaceae		
92. *Muntingia calabura*	Cultivated/Reforestation	NA
Family: Myrsinaceae		
93. *Aegiceras floridum*	Coastal/Beach Forest	NT
Family: Myrtaceae		
94. *Eucalyptus deglupta*	Cultivated/Reforestation	NA
95. *Eucalyptus globulus*	Cultivated/Reforestation	NA
96. *Leptospermum amboinense*	Secondary Forest	NA
97. *Psedium guajava*	Cultivated/Reforestation	NA
98. *Syzygium brevicymum*	Secondary Forest	NA
99. *Syzygium simile*	Secondary Forest	NA
100. *Tristaniopsis micrantha*	Secondary Forest	NA
101. *Xanthostemon verdugonianus*	Secondary Forest	VU
Family: Nepenthaceae		
102. *Nepenthes alata*	Secondary Forest	LR/LC
Family: Ochnaceae		
103. *Brackenridgea fascicularis*	Secondary Forest	NA
Family: Orchidaceae		
104. *Spathoglottis tomentosa*	Secondary Forest	NA
Family: Palmae		
105. *Calamus merrillii*	Secondary Forest	NA
106. *Cocos nucifera*	Cultivated/Reforestation	NA
107. *Heterospathe elata*	Secondary Forest	NA
Family: Pandanaceae		
108. *Pandanus copelandii*	Secondary Forest	NA
109. *Pandanus simplex*	Coastal/Beach Forest	NA
110. *Pandanus spiralis*	Coastal/Beach Forest	NA
111. *Pandanus tectorius*	Coastal/Beach Forest	NA
Family: Passifloraceae		
112. *Passiflora foetida*	Grassland/Disturbed	NA
Family: Poaceae		
113. *Dinochloa luconiae*	Secondary Forest	NA
114. *Imperata cylindrica*	Grassland/Disturbed	NA
115. *Paspalum conjugatum*	Grassland/Disturbed	NA
116. *Saccharum spontaneum*	Grassland/Disturbed	NA
Family: Phyllanthaceae		
117. *Phyllanthus niruri*	Secondary Forest	NA
Family: Proteaceae		
118. *Helicia paucinervia*	Secondary Forest	NA
119. *Helicia rubosta*	Secondary Forest	NA
Family: Pteridaceae		
120. *Acrostichum aureum*	Coastal/Beach Forest	LC

Ambient Science, 2018: Vol. 05(2); 44-50
DOI:10.21276/ambi.2018.05.2.aa01

Family: Rhizophoraceae		
121. *Carallia brachiata*	Secondary Forest	NA
122. *Rhizophora apiculata*	Coastal/Beach Forest	LC
Family: Rubiaceae		
123. *Gardenia jasminoides*	Cultivated/Reforestation	NA
124. *Morinda citrifolia*	Secondary Forest	NA
125. *Myrmecodia tuberosa*	Secondary Forest	NA
126. *Neonauclea media*	Coastal/Beach Forest	NA
127. *Scyphiphora hydrophyllacea*	Coastal/Beach Forest	LC
128. *Timonius timon*	Coastal/Beach Forest	NA
Family: Santalanaceae		
129. *Exocarpos latifolius*	Secondary Forest	NA
Family: Sapotaceae		
130. *Chrysophyllum cainito*	Cultivated/Reforestation	NA
Family: Taccaceae		
131. *Tacca leontopetaloides*	Coastal/Beach Forest	LC
Family: Thymelaceae		
132. *Wikstroemia indica*	Secondary Forest	NA
Family: Urticaceae		
133. *Leucosyke capitellata*	Secondary Forest	NA
Family: Verbenaceae		
134. *Lantana camara*	Grassland/Disturbed	NA
135. *Stachytarpheta jamaicensis*	Secondary Forest	NA

Table-2: Values of ecological parameters for Transect 1, Uphill West side of mine base camp

MD	Density	BA(cm)^2	Imp V	SDI (H')	Even. I (e)
Leptospermum amboinense					
9.70	128	9,459.00	1.9410	0.1934	0.1080
Xanthostemon verdugonianus					
5.80	27	713.40	0.5043	0.2970	0.1658
Alstonia parviflora					
8.70	6	356.70	0.2519	0.1210	0.0675
Tristaniopsis micrantha					
8.00	1	50.30	0.1017	0.0311	0.0174
Ormosia calavensis					
7.30	1	41.90	0.1009	0.0311	0.0174
Commersonia bartramia					
6.50	1	33.20	0.1001	0.0311	0.0174
Total N = 6					
7.67 ± 1.51	164	10,654.30	3.0000	0.7048	0.3933

MD-Mean diameter, BA-Basal area, Imp V- Important Value, SDI- Shannon Diversity Index, Even. I- Evenness Index.
Notes: Diversity category: Very high (H' > 3.5000); High (3.0000 3.4999); Moderate (2.5000 2.9999), Low (2.0000 2.4999), and Very low (< 1.9999).

Table-3: Values of ecological parameters for Transect 2, Lipata-Cortez area (Legends & Notes are same as in Table-2)

MD	Density	BA(cm)^2	Imp V	SDI (H')	Even. I (e)
Leptospermum amboinense					
9.50	52	3,685.90	0.7105	0.3645	0.1315
Xanthostemon verdugonianus					
7.90	21	1,029.40	0.3229	0.2640	0.0952
Gymnostoma rumphianum					
13.40	15	2,115.40	0.3080	0.2195	0.0792
Pandanus tectorius					
11.30	15	1,504.30	0.2626	0.2195	0.0792
Alstonia parviflora					
13.60	9	1,307.40	0.2406	0.1599	0.0577
Dracaena angustifolia					
9.70	11	812.90	0.2161	0.1819	0.0656
Buchanania arborescens					
11.30	9	902.60	0.1811	0.1599	0.0577
Orania decipiens					
14.50	7	1,155.90	0.1582	0.1352	0.0488
Syzygium brevistylum					
6.20	6	181.10	0.1385	0.1215	0.0438
Leucosyke capitellata					
6.20	5	151.00	0.1007	0.1069	0.0385
Artocarpus multifidus					
9.40	3	208.20	0.0927	0.0735	0.0265
Exocarpus latifolius					
8.40	2	110.80	0.0793	0.0540	0.0195
Carallia brachiata					
6.70	3	105.80	0.0557	0.0735	0.0265
Cratoxylum formosum					
7.80	2	95.60	0.0488	0.0540	0.0195
Morinda citrifolia					
4.60	2	33.20	0.0442	0.0540	0.0195
Heritiera littoralis					
8.90	1	62.20	0.0402	0.0313	0.0113
Total N = 16					
9.34±1.53	163	13,461.70	3.0000	2.2733	0.8199

Table-4:Values of ecological parameters for Transect-3, Mangrove area towards tower (Legends & Notes are same as in Table-2)

MD	Density	BA(cm)^2	Imp V	SDI (H')	Even. I (e)
Leptospermum amboinense					
8.60	171	9,913.70	0.9335	0.3410	0.1180
Rhizophora apiculata					
11.55	93	9,709.10	0.6897	0.3566	0.1234
Xanthostemon verdugonianus					
8.70	27	1,585.30	0.1940	0.2033	0.0703
Mangifera indica					
28.40	3	1,900.40	0.1338	0.0427	0.0148
Pandanus tectorius					
16.50	5	1,069.10	0.1096	0.0635	0.0220
Xylocarpus granatum					
21.60	3	1,099.30	0.1046	0.0427	0.0148
Orania decipiens					
12.30	6	712.90	0.0997	0.0729	0.0252
Polyscias nodosa					
13.60	3	435.80	0.0805	0.0427	0.0148
Macaranga tanarius					
12.40	3	362.30	0.0778	0.0427	0.0148
Dracaena angustifolia					
7.20	4	162.90	0.0736	0.0535	0.0185
Calamus merrillii					
8.30	3	162.30	0.0706	0.0427	0.0148
Leucosyke capitellata					
5.70	3	76.60	0.0674	0.0427	0.0148
Alstonia parviflora					
16.00	1	201.10	0.0659	0.0176	0.0061
Avicenia officinales					
4.30	2	29.00	0.0627	0.0309	0.0107
Annona muricata					
6.80	1	36.30	0.0599	0.0176	0.0061

Ambient Science, 2018: Vol. 05(2); 44-50
DOI:10.21276/ambi.2018.05.2.aa01

Barringtonia asiatica					
3.50	1	9.60	0.0589	0.0176	0.0061
Bauhinia integrifolia					
3.40	1	9.10	0.0589	0.0176	0.0061
Cerbera manghas					
2.80	1	6.20	0.0588	0.0176	0.0061
Total N = 18					
10.65±2.78	330	27,481.00	3.0000	1.4660	0.5072

Plate-3: View of *L. amboinense* dominated area along transect 1.

Transect 2 was located along Lipata-Cortez area from lower elevation towards steep ravines and higher grounds of active mining sites. The vegetation of the area was described as an association of *Leptospermum, Orania* and *Gymnostoma* community. The *L. amboinense* was still the most abundant species having an average density of 52 individuals per 400 m^2. In comparison to the other transects (Transect 1 and 3), Transect 2 had the highest Shannon's Diversity Index (H') with a value of 2.2733 but still considered low based on a diversity scale. Larger diameter species such as *G. rumphianum, A. parviflora* and *Orania decipiens* exists in the area, but since *L. amboinense* has the highest density, it occupies more space and thus has the highest SIV in the plant community. The transect had a higher richness comprising 16 species and a mean dbh of 9.34±1.53 cm occupying a cumulative basal area of 13,461.70 cm2 for all. Along the line yet outside sampling plots were taller trees *G. rumphianum, Buchanania arborescens* and other species in ravines and waterways, however were not included in the analysis yet formed part of the species list. (Table-3).

Transect 3 was established on a mangrove cove near the base camp towards a higher elevated beach forest. It had the highest species richness with 18 species but has a unique assemblage of species composition as each quadrat in the same transect was significantly different from each other. The first quadrat was established on the hilltop portion of the secondary forest where *L. amboinense* and *X. verdugonianus* were the most dominant species. The third quadrat was situated on a mangrove cove close to the mine base camp and dominated by *Rhizophora apiculata* occupying 80-95% of the 20 m x 20 m quadrat. The second quadrat on the other hand was on stationed a steep slope between the *Leptospermum, Xanthostemon* and the *Rhozophora* dominated community. It is composed of a mixture of beach and secondary forest and the presence of several lianas and other climbing plants were prevalent. The terrain can be described as rocky and lose and the presence of large boulders was a safety concern during the survey. (Table-4).

The species with the highest SIV was still *L. amboinense* followed by *R. apiculata* as the species were the most dominant in its respective quadrat. Some large trees reaching 30 cm dbh were present, however, the transect had a mean dbh of 10.65±2.78 cm only. Considering species evenness for all transects, Transect 2 has the evenest distribution of species with evenness index of 0.8199, followed by Transect 3 (0.5072) and Transect 1 (0.3933). It simply denotes that transects with high evenness value have a more uniform composition and distribution and no or only a few are dominants over the area.

Forest Stand Structure: a total of 2,134 individuals with dbh >5 cm were recorded from the sampling stations. This number account to a species density of 5,325 trees ha-1 or an average of 213 trees per 20 m x 20 m sampling quadrat. The computed density was relatively higher compared to the density of the 2-hectare permanent biodiversity plots in Mt. Makiling at 4,403 trees ha^{-1} (Malabrigo, 2016) and the 16-hectare permanent forest plot in Palanan, Isabela at 4,999 trees ha^{-1} (Co *et al.*, 2006). This is understandable since forests over ultramafic soils are described as vegetation where plants are usually stunted, small trunk diameter and grow closer together (Madulid, 2002), forming a dense community. The average height of all trees inside the plots ranges from 2.97±0.75 m to 5.26±0.84 m. The beach/mangrove areas were comparatively taller than the secondary growth forest and trees on the marginal and grassland areas. The vegetation on the beach/mangrove areas is a mixture of tall trees such as *T. catappa, Polyscias nodosa* and *Mangifera indica* while vegetation on secondary forest are dominated by *L. amboinse* and *X. verdugonianus* which are naturally stunted being a slow growing species.

Total 42% of the identified species are classified as trees, 23% were accounted as shrubs, 19% as herbaceous species both annuals and perennials, 7% were vines both woody and non-woody, 5% were palms and palm like species, while the remaining 4% are ferns and fern allies.

Conservation status and ecologically important species: out of the 135 species identified 127 are found to be indigenous in the Philippines of which 53 are endemic or are exclusively found only in the country. 6% of the enumerated species were classified as introduced in the island either for rehabilitation or ornamental purposes. Among the exotics recorded include *Acacia auriculiformis, Acacia mangium, Delonix regia* and *Falcataria molucanna*.

The island ecosystem has a number of ecologically sensitive species categorized as "Endangered" based on IUCN Redlist of Threatened Species. Among the list include *Camptostemon philippinense, Cycas circinalis,*

Diospyros ebenoides, and *Diospyros philippinensis.* Vulnerable species include *X. virdugonianus, Macaranga bicolor*, and *Pterocarpus indicus*.

Some noteworthy species observed in the island were the following: (Plate- 2a to d)

Conclusion:

Results of the intensive study revealed that the vegetation of the forests over ultramafic soil environments of Hinatuan Mining Corporation in Hinatuan Island, Brgy. Talavera, Tagana-an, Surigao del Norte holds a remarkable diversity of trees and other vascular plants species. It also showed very high species endemism and harbored a significant number of ecologically threatened trees. The information developed from this survey study can help to provide the significant information on the dynamics of the plant species in an ultramafic environment wherein the island ecosystem was subjected to mining activities. This study as well gives critical importance for the future research activities in the area. The established transect stations could be a principal venue for current and planned efforts of the Hinatuan Mining Corporation towards attaining better conservation and rehabilitation programs. The information on the ecological status of the biodiversity in the island should be disseminated to advocate conservation..

Acknowledgements:

The author would like to thank the management and staff of Hinatuan Mining Corporation for the logistics and financial assistance during field survey and to Dr. Romell A. Seronay, Chief, Center for Research in Environmental Management and Eco-Governance of Caraga State University for the publication support.

References:

Aiba, S. & Kitayama, K. (1999): Structure, composition and species diversity in an altitude-substrate matrix of rainforest tree communities on Mount Kinabalu, Borneo. *J. Plant Ecol.*, 140(2):139–157.

Ata, J.P., Luna, A.C., Tinio, C.E., Quimado, M.O., Maldia, L.S., Abasolo, W.P. & Fernando, E.S. (2016): Rapid assessment of plant diversity in ultramafic soil environments in Zambales and Surigao del Norte, Philippines. *Asian J. Biodivers.,* 7(1):4-16.

Co, L.J., La Frankie, J.V., Lagunzad, D.A., Passion, K.A.C., Consunji, H.T., Bartolome, N.A., Yap, S.L., Molina, J.E., Tongco, M.D.C., Ferreras, U.F., Davies, S.J. & Ashton, P.S. (2006): **Forest Trees of Palanan, Philippines: A Study in Population Ecology**. Pub. by: Diliman : Center for Integrative and Development Studies, University of the Philippines.313 p.

Fernando, E.S., Co, L.L., Lagunzad, D.A., Gruezo, W.S., Barcelona, J.F., Madulid, D.A., Lapis, A.B., Texon, G.I., Manila, A.C. & Zamora, P.M. (2008):Threatened plants of the Philippines: a preliminary assessment. *Asia Life Sci.,* 3(Suppl.):1-52.

Madulid, D.A. (2002): **A pictorial guide to the noteworthy plants of Palawan. Palawan Tropical Forestry Protection Program.** Pub. by: Palawan Tropical Forestry Protection Program. 74 p.

Malabrigo, P.L. Jr., Umali, A.G.A., Tiburan, C.L. Jr., Pampolina, N.M., Balatibat, J.B., Tinio, C.F., Abasolo, W.P., Luna, A.C. & Boncodin, J.C. (2016): Tree Diversity and Stand Structure of Permanent Biodiversity Monitoring Area in Mount Makiling. *Asian J. Biodivers.*, 7(1):17-30.

Nickrent, D.L., Costea, M., Barcelona, J.F., Pelser, P.B. & Nixon, K. (2006+): PhytoImages. Online Data: http://www.phytoimages.siu.edu.

Odum EP, Barret GW. 2005. **Fundamentals of Ecology. Fifth Edition**. Pub. by: Cengage, Singapore 068808. 624 p.

Proctor, J., Baker, A.J.M., Van Balgooy, M.M.J., Bruijnzeel, L.A., Jones, S.H. & Madulid, D.A. (2000): Mount Bloomfield, Palawan, Philippines: Forests on Greywacke and Serpentinized Peridotite. *Edinburgh J. Bot.*, 57(1):121-139.

Proctor, J., Lee, Y.F., Langley, A.M., Munro, W.R.C. & Nelson, T. (1988): Ecological studies on Gunung Silam, a small ultrabasic mountain in Sabah, Malaysia 1. Environment, forest structure and floristics. *J. Ecol.*, 76(2):320–340.

Proctor, J., van Balgooy, M.M.J., Fairweather, G.M., Nagy, L. & Reeves, R.D. (1994): A preliminary re-investigation of a plant geographical 'El Dorado'. *Tropical Biodivers.*, 2(2)303–316.

Sarmiento, R.T. & Demetillo, M.T. (2017): Rapid Assessment on Tree Diversity of Nickel Mining Sites in Carrascal, Surigao del Sur, Philippines. *J. Biodivers. Environ. Sci.*, 10(4):201-207.