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Rapid assessment on tree diversity of Nickel Mining sites in Carrascal, Surigao del Sur, Philippines

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Abstract

An examination of the tree species diversity of the mined and slightly disturbed nickel mining sites of Carrascal, Surigao del Sur was carried out using quadrat and transects techniques. The general assessment of the site revealed that it falls under a mixed secondary forest type over an ultramafic soil. In spite the fertility limitations of the area substrates being ultramafic, it still have a disproportionately high number of tree species and mostly are endemic and/or rare. A total of 48 taxa belonging to 30 genera and 20 families were recorded. The dominant families were Dipterocarpaceae and Fabaceae having 6 species each, and the dominant genus was *Shorea* with 4 species. The area has a composite Shannon-Weiner diversity index of 2.2872 which is considered low. As an ultramafic ecosystem, 46 species (96%) of the 48 total identified species are found to be indigenous (native) to the Philippines and of which 24 (50%) are endemic or exclusively found in the country. Conservation status of these taxa according to IUCN Red List of Threatened Species and the Philippine Red List showed that about 15 endangered species was encountered. Noteworthy species include *Xanthostemon verdugonianus* - the iron wood of the Philippines, and some premium timber producing species under the Dipterocarpaceae family. Though mining sites are considered less productive for timber production, the conservation of this ultramafic environment is highly necessary in order to stabilize ecosystem dynamics, protect biodiversity, and prevent potential impacts of natural calamities such as landslides and flooding on lower areas.

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Introduction

Nickel is an essential component utilized for a few applications, such as nickel steels, electroplating and superalloys. Expanding industrialization combined with the infrastructure development has swelled the interest for steel around the globe. The increasing demand for steel has augmented the demand for nickel mining and thus, the mining industry flourished because of the expanding interest for minerals and metals from the diverse sectors of the economy.

The Philippines, Indonesia and Australia are among the largest producer of nickel across the globe. Russia, Finland and Norway are among the major producers of nickel in Europe. Some of the other countries with significant nickel production are China, Canada, Brazil and Colombia (Transparency Market Research, 2017). In the Philippines, Nickel mining is considered a promising industry especially in the southern part of the country - the Caraga Region. According to the Department of Environment and Natural Resources - Mines and Geosciences Bureau (DENR-MGB), of the 40 registered metallic mines in the Philippines, 23 are located in Caraga Region of which 20 are engaged on nickel mining operations. The other three mines are on chromite, gold and silver mining.

Nickel mining areas are classified under laterite (ultramafic) soil types - a soil and rock type rich in iron and aluminium, and generally considered to have formed in hot and wet tropical territories. Soils derived from ultramafic rocks cover less than 1% of the Earth's land surface (Garnier *et al.* 2009). The soil show strong chemical fertility limitations due to low Ca/Mg ratio, deficiency of mineral nutrients and a high content of metals like Ni and Cr (Whittaker *et al.* 1954; Bonifacio *et al.* 1997). In the context of biodiversity, these soils are interesting because, as the fertility is limited, the vegetation is very often endemic (Garnier *et al.* 2009).

Nickel ores are extracted by means of open-pit method. The technology is considered standard for mining nickel, however, the newly installed DENR Secretary deliberately described it “madness” because of its environmental impacts (Serapio, 2016) especially that most mining sites are within a functional watershed. In the context of biodiversity, many biological organisms having ecological and scientific importance will also be displaced. Such human-induced environmental change would favor a few species that would competitively displace many other species especially endemics over the region (Tilman & Lehman, 2001).

The limitations in biodiversity particularly in these hostile and infertile mineral lands prompted to the misconception that the present biological community can’t function effectively as an ecological system. Pro-mining advocates believed that the concept of preserving a natural area in its present state is not logical. None functioning ecosystem are therefore be managed responsibly to allow the source of minerals to supply raw materials needed for the continued well-being of the society.

This study was conducted to establish and maintain a semi-permanent biodiversity observation plots within an operational mining area to serve as monitoring plots for future ecological research on biodiversity functioning as well as forest ecosystem dynamics. Specifically, it aimed to assess the diversity of trees present within the mined-out and slightly disturbed areas of the forest and also to determine the conservation status of the species. The output of this study will be a valuable input in the conception and designing of strategic options for the formulation of biodiversity conservation and rehabilitation plans of the mining organization.

Materials and methods

The study area

The study was carried out within the 50 hectare mined-out areas of the Carrascal Nickel Corporation, Inc. (CNC) located at Barangay Bon-ot, Carrascal, Surigao del Sur with UTM Zone 51P Coordinates 819376 Easting and 1036650 Northing taken at the center of the operational mining area (Fig. 1). Based on the approved Mineral Production Sharing Agreement (MPSA), CNC is part of a contract area of approximately 4,548 hectares within the Parcel I of the Surigao Mineral Reservation.

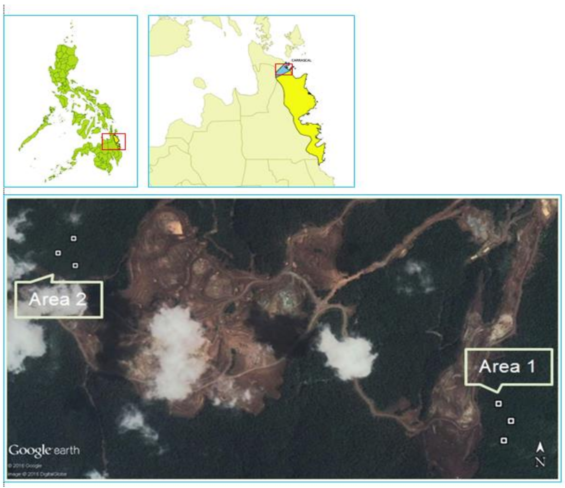

Fig. 1. Locational map showing sampling points in CNC viewed on a Google Earth Image.

Sampling Techniques

Two sampling sites (A1 & A2) were identified utilizing the map provided by CNC and coordinated with the satellite images retrieved from Google Earth. The target sites were chosen on the condition that these zones are still largely intact amidst massive mining operations on the adjacent peripheries. For each sampling site, a transect line was laid out from the edge of the forest patch towards the more undisturbed forested areas to come up with an intensive list of tree species. Aside from trees, other plant habit/groups were also recorded to describe the vegetation structure of the site. Local guides and field taxonomic keys were utilized to identify the species. For species not readily identified on field, pictures were taken using high resolution digital camera for identification later and for proper documentation. Along the transect line, three (3) sampling plots measuring 20 x 20 m were established at about 100m apart. A handheld Global Position System (GPS) receiver was used to determine its location and taken at the center of the plot. For each plot, all tree species with of dbh> 5cm and height >2m were recorded.

Herbarium Specimens

Representative samples of the species were collected, pressed, dried and prepared as herbarium specimens using standard techniques. The preserved specimens would serve as permanent records of the vegetation and floristic composition of the nickel mining site. Each specimen would always be available for study or quick reference in connection with future operations in the study area and for future conservation programmes and deposited in the herbarium of the Department of Biology, College of Arts and Sciences, Caraga State University, Butuan City, Philippines.

Data analyses

The frequency and site richness were calculated while species indices were carried out with PAST version 2.3 with probability set at the 0.05% level of significance.

Results and discussion

General Assessment of the mining area

Transect walks and walkthroughs revealed several species of flora both in the upper storey and understorey layer. Generally, the area is considered a forest over ultramafic soil that includes a mixed-dipterocarp species. The canopy structure is immensely modified becoming more diffused and allowing more light to penetrate the understorey. This permits dense growth of tangles of calamoid palms (rattans), woody lianas and epiphytes, herbaceous plants on the forest floor, pitcher plants, and saplings of the emergents. Epiphytic plants were seen in twigs and trunks of Mangkono (*Xanthostemon verdugonianus* Naves), like orchids, ferns and a parasitic plant called Ant plant (*Hydnophytum formicarium* Jack). Both sampling sites (Area 1 & Area 2) have patches of secondary growth forest and were dominated by Batino (*Alstonia macrophylla* Wall. ex G. Don), Agoho (*Casuarina equisetifolia* L.), and Mangkono (*X. vedugonianus*) communities.

As observed along the mining road, shrub species *Dicranopteris linearis* (Burm. fil.) Underw and *Melastoma malabathricum* L. (Fig. 2) grows abundantly and are useful in controlling soil erosion due to its long creeping rhizome and extensive roots system. Other associated species observed includes *Pandanus* spp., *Coryota cumingii* Lodd. ex. Mart, *Ficus* spp., woody lianas, *Paspalum conjugatum* P. J. Bergius and *Andropogon aciculatus* Retz.

Fig. 2. Climbing bamboo and woody lianas were abundant in sampling (A) area 1 and (B) Area 2 with dense tangled growth of Agsam (Dicranopteris linearis).

Tree Species Richness and diversity

Summarily, a total of 48 tree species belonging to 36 genera and 20 families were found present in the area under study (Table1). The dominant families encountered include Dipterocarpaceae and Fabaceae with 6 species each, while genus *Shorea* had the highest diversity of four (4) species.

The checklist is only an intensive list of the currently existing tree species for the presently mined and slightly mined areas and not intended to be a comprehensive list of all the flora species within the CNC concession area. The mining site has a composite Shannon-Weiner Index (H') of 2.2872 which is considered low.

Table 1. List of tree species encountered within the mining site of CNC.

Family Name	#	Scientific Name	Common Name	Sites		Ecological Status
Annacardiacea	1	*Mangifera indica*	Manga	A	A	DD
Apocynaceae	2	*Alstonia macrophylla*	Batino	1	2	LC
	3	*Alstonia scholaris*	Dita	/	/	LC
	4	*Kibatalia gitingensis*	Lanetenggubat		/	VS
	5	*Cerbera manghas*	Baraibai		/	NA
Araucariaceae	6	*Agathis philippinensis*	Almaciga	/		VS
Burseraceae	7	*Canarium asperum*	Pagsahingin	/	/	LC
Byttneriaceae	8	*Commersonia bartramia*	Kakaag		/	NA
Casuarinaceae	9	*Casuarina equesetifolia*	Agoho	/	/	NA
	10	*Gymnostoma rumphianum*	Agoho del monte	/	/	NA
Chrysobalanaceae	11	*Marangthes corymbosa*	Lauisin	/	/	NA
Clethraceae	12	*Clethra sp.*	Balangog		/	NA
Clusiaceae	13	*Calophyllum inophyllum*	Bitaog	/		LC
	14	*Callophyllum blancoi*	Bitanghol		/	NA
Combretaceae	15	*Terminalia foetidissima*	Talisaygubat	/		NA
	16	*Terminalia microcarpa*	Kalumpit		/	NA
Dipterocarpaceae	17	*Hopea acuminata*	Manggachapui		/	CES
	18	*Shorea almon*	Almon	/		CES
	20	*Shorea astylosa*	Yakal		/	CES
	22	*Shorea contorta*	White lauan		/	VS
	19	*Shorea negrosensis*	Red lauan	/		VS
	21	*Vatica manggachapoi*	Narig		/	VS
Euphorbiaceae	23	*Macaranga tanarius*	Binunga			NA
Fabaceae	24	*Adenanthera pavonina*	Malatanglin	/	/	NA
	25	*Adenanthera intermedia*	Tanglin	/	/	VS
	26	*Afzelia borneensis*	Malaipil-ipil	/	/	NA
	27	*Ormosia surigaoensis*	Bahai	/	/	CES
	28	*Pterocarpus indicus*	Prickly Narra		/	OTS
	29	*Parkia javanica*	Kupang	/		NA

Family Name	#	Scientific Name	Common Name	Sites		Ecological Status
Hypericaceae	30	*Cratoxylum sumatranum*	Paguringon	/		NA
	31	*Premna odorata*	Ilang-ilang	/		NA
Moraceae	32	*Ficus balete*	Balete		/	NA
	33	*Ficus minahassae*	Hagimit		/	NA
	34	*Ficus nota*	Tibig	/	/	NA
Myrtaceae	35	*Tristaniopsis micrantha*	Tiga		/	NA
	36	*Eucalyptus deglupta*	Bagras		/	NA
	37	*Leptospermum amboinense*	Payospos	/	/	NA
	38	*Xanthostemon verdugonianus*	Mangkono	/	/	ES
	39	*Securinega flexuosa*	Anislag	/	/	VS
Podocarpaceae	40	*Dacrydium* sp.	Mala eguem	/		NA
	41	*Dacrydium elatum*	Lokinai	/	/	LC
	42	*Podocarpus neriifolius*	Malaadelfa	/	/	LC
	43	*Podocarpus philippinensis*	Malakawayan		/	NA
	44	*Nageia wallichiana*	Malaalmaciga	/		LC
Rubiaceae	45	*Neonauclea media*	Wisak	/	/	NA
Sapotaceae	46	*Palaquium luzoniense*	Nato	/		VS
	47	*Pouteria macrantha*	White Nato	/		VS
Ulmaceae	48	*Trema orientalis*	Anabiong	/		NA

*Conservation Status: DD-Data Deficient, LC-Least Concern, CES-Critically Endangered Species, ES-Endangered Species, VS-Vulnerable Species, OTS-Other Threatened Species, NA-Not Assessed

About 116 individual trees consisting of 16 species were found present within the established semi-permanent plots in Area 1 and Area 2. Common canopy cover species include Lokinai (*Dacrydium elatum* (Roxb.) Wall.ex Hook.) and Payospos (*Leptospermum amboinense* Reinw. ex Blume) were identified to have the highest importance value of all species in the community (Table 2). Another species of high importance is the Mangkono (*X. verdugonianus*), a dominant species that is aside from being an endemic is considered having high economic value because of its durable wood for quality furnitures. The most dominant tree species is Lokinai (*D. elatum*) with 30 (about 35% of the total) individuals, followed by Payospos (*L. amboinense*), Agoho (*C. equisetifolia*), Mangkono (*X. verdugonianus*) and Kakaag (*Commersonia bartramia*). Ten of the most abundant species on site are indigenous in the Philippines of which six are Philippine endemics (Table 3

Table 2. Computed importance value for tree species encountered within the sampling site.

Species	Freq	Den	BA	RelFreq	Rel Den	Rel BA	SIV	n	P_i Ln P_i
Dacrydium elatum	0.833	125.000	4.309	12.195	25.641	31.873	69.709	30	-0.350
Leptospermum amboinense	1.000	62.500	1.944	14.634	12.821	14.382	41.836	15	-0.265
Casuarina equisitefolia	0.667	70.833	2.320	9.756	14.530	17.158	41.444	17	-0.281
Xanthostemon verdugonianus	0.667	45.833	1.469	9.756	9.402	10.862	30.019	11	-0.223
Commersonia bartramia	0.833	50.000	0.343	12.195	10.256	2.536	24.987	12	-0.235
Alstonia macrophylla	0.667	29.167	0.599	9.756	5.983	4.429	20.168	7	-0.169
Maranthes corymbosa	0.333	20.833	0.479	4.878	4.274	3.543	12.695	5	-0.136
Shorea contorta	0.167	20.833	0.539	2.439	4.274	3.983	10.695	5	-0.136
Neonauclea media	0.333	12.500	0.314	4.878	2.564	2.322	9.764	3	-0.095
Adenanthera intermidea	0.333	8.333	0.124	4.878	1.709	0.917	7.504	1	-0.041
Palaquium luzoniense	0.167	12.500	0.287	2.439	2.564	2.123	7.126	3	-0.095
Pouteria macrantha	0.167	8.333	0.332	2.439	1.709	2.456	6.604	2	-0.070
Calophyllum blancoi	0.167	8.333	0.085	2.439	1.709	0.626	4.774	2	-0.070
Cratoxylum sumatranum	0.167	4.167	0.175	2.439	0.855	1.292	4.585	1	-0.041
Calophyllun inophyllum	0.167	4.167	0.106	2.439	0.855	0.784	4.078	1	-0.041
Cerbera manghas	0.167	4.167	0.097	2.439	0.855	0.716	4.010	1	-0.041
Totals	6.833	487.500	13.5200	100.000	100.000	100.000	300.000	116	2.2872

Conservation Status of Tree Species

As basis for the protection, conservation and monitoring of the species, assessment of the status was necessary. An endangered species is defined as species that are threatened by disturbance, such that the population of the species may become extinct in the immediate future if the disturbance remains unchecked.

In spite of the fertility limitations of mining area substrates being ultramafic, these areas still have a disproportionately high number of endemic and/or rare plant species (Ent, 2011). Of the 48 species identified, 46 (96%) are found to be indigenous (native) to the Philippines of which 24 (50%) are endemic or exclusively found in the country based on the checklist of Lantican (2015).

About 15 species have been identified as threatened based on IUCN Redlist (2016-3) and the DENR Administrative Order No. 2007-01 of the Philippines. Noteworthy species includes Mangkono (*X. verdugonianus*) as the hardest wood in the Philippines and some species under.

Dipterocarpaceae family like White lauan (*Shorea contorta* Vidal), Almon (*Shorea almon* Foxw.), and Red lauan (*Shorea negrosensis* Foxw), among others.

Many of these tree species occur on only a few sites or even a single site and habitat destruction, as it occurred during mining operation, could therefore potentially result in extinction.

Fig. 3. Some ultramafic soil endemic species observed in the mining area: A. *Malaalmaciga (Nageia wallichiana)*, B. Pitcher plants (*Nepenthes* spp), C. *Mangkono* (*Xanthostemon verdugonianus*) and D. *Lokinai* (*Dacridium elatum*).

Table 3. Ten most abundant tree species in the established semi-permanent plot within the mining site.

	Common Name	Scientific Name	Abundance	Endemism
1	Lokinai	*Dacrydium elatum*	30	NE
2	Agoho	*Casuarina equisitefolia*	17	PE
3	Payospos	*Leptospermum amboinense*	15	NE
4	Kakaag	*Commersonia bartramia*	12	NE
5	Mangkono	*Xanthostemon verdugonianus*	11	PE
6	Batino	*Alstonia macrophylla*	7	PE
7	Liusin	*Maranthes corymbosa*	5	PE
8	White lauan	*Shorea contorta*	5	PE
9	Wisak	*Neonauclea media*	3	NE
10	Red nato	*Palaquium luzoniense*	3	PE

PE – Philippine Endemic; NE – Native but non-endemic.

Conclusions

The study has provided an intensive checklist of tree diversity within an operational mining area. Results of the study revealed that the established semi-permanent monitoring plots in Carrascal Nickel Corporation, Inc. harbor a noteworthy species of trees in spite fertility limitations of the ultramafic substrate. It also showed very high species endemism and harbored a significant number of ecologically threatened trees. The data generated in this study ought to fill in as a benchmark for nickel mining sites, which is of basic significance for the future research undertakings in the area. As human-caused changes in environment particularly mining are likely to cause significant loss of plant diversity in the near future, the data produced herein could be an imperative setting for planning conservation and rehabilitation endeavours and therefore should be properly disseminated.

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References

Bonifacio E, Zanini E, Boero V, Franchini-Angela M. 1997. Pedogenesis in a soil catena on serpentine in North-Western Italy. Geoderma **75**, 33-51.

Ent van der A. 2011. The ecology of ultramafic areas in Sabah: Threats and conservation needs. Garden's Bulletin Singapore **63(1 & 2),** 385-393.

Fernando ES, Co LL, Lagunzad DA, Gruezo WS, Barcelona JF, Madulid DA, Baja-Lapis A, Texon GI, Manila AC, Zamora PM. 2008.Threatened plants of the Philippines: A preliminary assessment. Asia Life Sciences, Supplement **3,** 1-52.

Garnier J, Quantin C, Guimaraes E, Garg VK, Martins ES, Becquer T. 2009. Understanding the genesis of ultramafic soils and catena dynamics in Niquelandia, Brazil. Geoderma **151,** 204-214.

Lantican CB. 2015. Philippine Native Trees – What to Plant in Different Provinces. Unpublished Terminal Report to DOST-PCARRD.

Serapio M. Jr. 2016. New Philippine minister says open-pit mining is "madness". Retrieved from www.reuters.com/article/philippines-mining-idUSL4N19E1RF.

The IUCN. 2016. The IUCN Red List of Threatened Species **2016-3,** Downloaded on 05 March 2017.

Tilman D, Lehman C. 2001. Human-caused environmental change: Impacts on plant diversity and evolution. Paper presented to the National Academy of Sciences colloquium, "The future of Evolution", Arnold and Mabel Beckham Center in Irvine, CA. Retrieved from: www.pnas.org/content/98/10/5433.full

Transparency Market Research. 2017. Nickel Mining Market - Global Industry Analysis, Market Size, Share, Growth Trends and Forecast 2015-2023. www.transparencymarketresearch.com/nickel-mining-market.html

Whittaker RH, Walker RB, Kruckerberg AR. 1954. The ecology of serpentine soils: A symposium. Ecology **35,** 258-288.