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Biodiversity Assessment and Functions of Secondary Forest Ecosystems in Eden and Dibibi, Quirino, Philippines

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ABSTRACT

This paper is preliminary part of a long-term and comprehensive monitoring of forest resources in Eden and Dibibi, Quirino Province. The general aim was to present various biodiversity values and functions of trees. Pilot quadrat sampling was used to yield preliminary data on canopy composition and undergrowth tree species. For purposes of the long-term assessment, canopy trees are those individuals having 20cm dbh and higher; undergrowth having <20cm dbh. Various indices were utilized to measure and compare forest strata, diversity, morphology and physiognomy. Species Importance Values and Carbon sequestration formulas were used to glean the functionality of canopy trees. Both forest sites resemble Tropical Lowland Evergreen- and Semi-Evergreen Rainforest formations. General diversity is moderate (H'Eden=2.65; H'Dibibi=2.26) and species composition is heterogeneous (βcc=0.745). At least 18.75% of canopy and undergrowth species are found endemic to the Philippines. Jaccard and Sorenson Indices on forests (collectively and individually) denote that canopy and undergrowth layers are dissimilar. Estimates of AGB and Carbon storage fall below the per-hectare figures given in authoritative literatures. The forests, have ecological and economic potentials. However, only species that abundant in number can be expected to be resilient to disturbances. Other observations can be used as bases for community-based rehabilitation and conservation.

Keywords*:* Secondary Forest, Biodiversity, Importance Value, Carbon Storage, Cabarroguis, QFL

INTRODUCTION

Biodiversity studies reveal that the Philippines is "one of the most important biodiversity hotspots in the world" (Langenberger et al., 2006). Because many Filipino communities are situated nearby or within forestlands, timber extraction, land conversion and many other uses render once-pristine forests into degraded (secondary forest) state. Studies over the last 20 years like that of Lasco et al. (2001), Chokkalingam and De Jong (2001) further argue that secondary forests in the Philippines are now the largest and most critical ecosystem in the country. The 2006 country-wide report by Lasco and Pulhin summarizes the degraded state of forest biodiversity: estimated 8 Million ha of degraded forestland, and deforestation rate of 100,000 ha annually.

In the advent of innumerable sustainable development efforts, the so-called future of forest biodiversity (including forestlands in the Philippines) would depend upon scientific management of artificial and/or modified landscapes (Gardner et al., 2009). Justification for science-based forest management include ecosystem values and functions such as biophysical characteristics (Kalacska et al., 2004); biodiversity and resiliency (Mukul et al., 2016; Townes, 2010; Gonzales et al., 2009;) carbon capture (Han et al., 2010; Sheeran, 2006), land productivity (Nguyen et al., 2012; Shively & Pagiola, 2004) water regimes (Lasco et al., 2005) among others. This opens more opportunities to re-investigate "degraded" forestlands in the country in hopes of streamlining government thrusts with peoples' needs.

With combined land area of 4,493.11 ha, barangays Dibibi and Eden are the second- and 5th-largest communities in Cabarroguis, capital town of Quirino province said barangays are part of the Quirino Forest Landscape, a government-recognized biodiversity sub-corridor in Sierra Madre Mountain Range, Philippines. The communities are highly dependent on land and water resources for agriculture, tree farming and livestock production. Being significant parcels of four subwatersheds in Cabarroguis, these barangays were once renowned for their vast biophysical resources. But increased human activities have visibly rendered the landscape limited of forest cover (LGU Cabarroguis 2016).

In recent years, only a handful of studies have been made in the provinces' forests, let alone in Eden and Dibibi, to warrant sustainable use. These, coupled with inadequate information can aggravate not only the degradation of forest, but also the ecosystem functions and services inherent to the environment (FAO 2006). Without the neutrality of scientific information, future policies may also become "biased", being mainly influenced by pressures from either "pro-protection" or "pro-use" groups (Grainger & Malayang, 2006).

In simplest applications of "Precautionary Principle" (Beder, 2013), there is a pressing need to raise scientific information on the values and functions inherent in the remaining secondary forests of Eden and Dibibi. Reasons for such include: refinement of definition of "open access" for the community folk's understanding; streamlining of policies and refunding related to management of the areas; delineate priority zones for full protection versus utilization; and identification of land-use alternatives for better version of sustainability thereat.

Thus, there is a need to "objectify" the management of forests of Eden and Dibibi in order to have a more harmonious management thereat. It is in this light that this study is mainly predicated upon.

OBJECTIVES OF THE STUDY

This paper assessed the diversity and functions of the secondary forests of Eden and Dibibi as basis for management and protection. To carry out the same, the following were performed: 1. Physiognomy (structure) evaluation of the forests in the two areas; 2. Biological diversity measurement (alpha and beta diversity) of canopy trees and undergrowth species, and; 3. Functions descriptions of the forests and the species, which includes: Importance Values and Carbon Storage/ sequestration estimates

METHODOLOGY

It must be noted that this paper presents initial findings that would prompt more intensive sampling in the future. A 6-man team carried out rapid inventory of forest trees species in upland forests of Eden and Dibibi May 2016. Purposive sampling utilized paired quadrat method, with elevation and safety as primary considerations. Such became the primary factors for using basic quadrat sampling after it was revealed in prior reconnaissance visits that still-intact forests in the two barangays are fairly inaccessible. Since the landscape was visually impacted by human activities (e.g., farming), quadrat locations were also selected based on where the forest/tree stands are at its densest. Thus, the team set up two (2) pilot quadrats for each barangay: one (1) quadrat was placed at the lowest accessible part of the forest; another at the mountain peak (~700masl). Quadrats (Figure 1) each measures 20m x 20m. Eden Quadrat 1 is located at 16°26'43.28"N and 121°32'18.26"N, while Quadrat 2 at 16°26'49.35"N and 121°32'39.67"N. In Dibibi, Quadrat 1 is situated at 16°24'39.34"N and 121°30'42.52"E and Quadrat 2 at 16°24'39.50"N and 121°30'46.16"E.

Basic biometry was done to all trees having 20cm diameter at breast height (dbh) and above. These trees represent the species forming the forest canopy. Only individual count was performed for smaller trees, herein categorized as understory species. Epiphytes, fauna and notable species were recorded as well. Initial identification of tree species was performed by team's dendrologists and local guides. When identification was doubtful, photographs of essential parts (e.g., leaves and fruits) substituted for voucher specimens. Identifications and salient characteristics were verified in the laboratory using literatures (Fernando, 2005; Fernando et al., 2004; other internet sources).

Information on biomorphology as well as distribution (exotic, endemic, indigenous) were likewise collated to further the general description of the area. By biomorphology means the described potential height, phyllotaxy, laminar form and leaf size. In the case of species distributions, "indigenous" includes those which have been naturalized species or those introduced since prehistory (Baguinon et al., 2003). Pertinent formulas used herein are further described in Appendix of this paper.

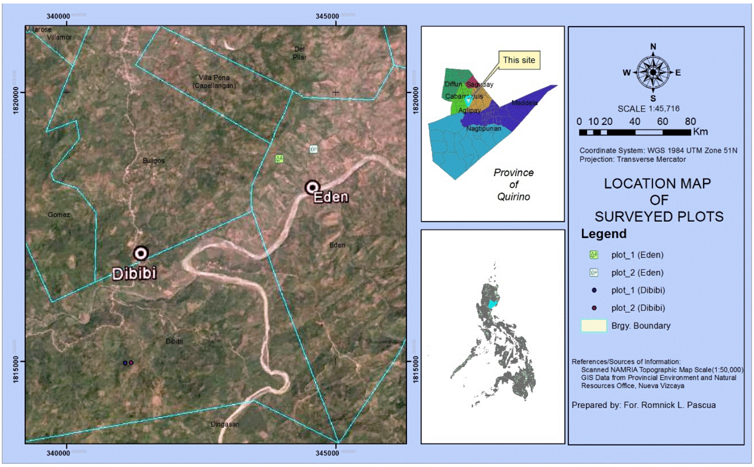

Figure 1. Location of study sites in Eden and Dibibi, Cabarroguis, Quirino Province. GIS Imagery by For. RL Pascua, Nueva Vizcaya State University College of Forestry

Basic alpha diversity indices (Magurran, 2004) were employed to gain insights on species richness, dominance and evenness of mature and understory trees. Alpha, or community diversity summarizes the richness, variety and proportion of various diversity features (in this case, trees) being measured. However, since no single index is capable of capturing such elements "equally", the authors paired

Shannon-Weiner (H’), Simpson’s Reciprocal Index (1/D) and Pielou’s Evenness (E) to have a better observation of floral diversity. Hmax, or potential maximum community diversity was computed for canopy trees as well.

Diversity comparisons usually answer which site or community has better species composition. In other cases, it answers how similar two or more communities are. But another interesting diversity point is raised in this paper by the authors: just how closely related are the forest trees in the landscape? Here, basic Taxonomic distinctness (Clarke & Warwick, 1988; Magurran, 2004) is given emphasis on the assumption that similar species (i.e., belonging to same higher-level taxa) also share habitat preferences. And so, species dissimilarity in an area may be attributed to its conduciveness for more organisms. In short, higher taxonomic distinctness means better ecological conditions. Diversity therefore is not based on number of species (S) per se, but on the variety of higher taxa (i.e, Family, Order) that the observed S represents. This aspect of biodiversity is very important to be incorporated with other values such as endemism, species use and conservation status.

For gradient, or beta diversity, various methods were employed: similarity using Jaccard and Sorenson (Qualitative) Indices, Taxonomic Dissimilarity by Calderón-Patrón et al. (2016), Taxonomic Distinctness by Clarke and Warwick (1988) in Magurran (2004) (Clarke & Warwick, 1999), and phylogenetic grouping as a multivariate (supraspecific taxa) approach to analysing gradient diversity (Plazzi et al., 2010). Jaccard and Sorenson Indices are two of the simplest similarity/homogeneity measures, whereby diversity is based on shared species of two sites, in relation to individual richness of each site. Dissimilarity is the “inverse” of the aforesaid, as it focuses on the heterogeneity (exclusivity) of two sites (in either species or higher taxa) versus the species or taxa shared by them. Taxonomic distinctness measures the relatedness of any. Lastly, instead of the usual ordination /Bray-Curtis clustering, this paper used phylogenetic database v.2015.1 of National Center for Biotechnology Information (NCBI, 2016) to map lineages and taxonomic associations (starting at Genus level of sampled individuals) thru PhyloT (Phylogenetic Tree generator) and iTOL (interactive Tree of Life) online applications (Letunic & Bork, 2016).

Table 1. Biological diversity indices used in this study

Alpha (community diversity)		
Shannon-Weiner, *H'*	General richness	Abundance or encounter
Simpson's Reciprocal Index, 1/*D*	Dominance	Abundance or encounter; Simpson's D computed first (Appendix 1)
Pielou's Evenness, E (aka Shannon *J*)	Proportion of individuals of species	Abundance, *H'*
H_{max}	Highest possible number of species, expressed in natural log	Abundance, *H'*
Beta (comparison of two alphas)		
Jaccard	Homogeneity; species shared by two sites	Encounter
Sorenson (Qualitative)		
Taxonomic Dissimilarity, βcc	Heterogeneity	Encounter data vs number of taxa unique to and shared by two sites
Taxonomic Distinctness, Δ^+		Taxonomic distance between any two species (pair-wise)
Phylogenetic Tree	Relatedness of genera	Supraspecific taxa

Biometric data were employed to compute ecological Importance Values (aka Importance Value Index, IV), as well as Above-Ground Biomass (AGB) Carbon storage, and sequestered carbon dioxide in the atmosphere by the canopy species. For IV, three parameters per-individual-to-per-tree were analysed first: species abundance, physical dominance, and species density. Relative values (%) were then averaged to get the "importance" of a species. As common knowledge in ecology, the interpretation of IV depends on the objective of paper; here, higher average IVs denote higher resiliency of tree species toward ecological disturbances.

For AGB and C estimation, three allometric mainstream AGB models (see Appendix) were used. The first two, herein labelled FAO1 and FAO2 were generic models forwarded by Brown (1997) for tropical moist forests. The third is a modification by Banaticla et al. (2007) after scrutiny of equations proposed by Tandug (1986) and Kawahara et al. (1981). Inserting the dbh measurements, total and average AGBs for each species were obtained. After which, the biomass were multiplied by 0.4773, as average of Carbon storage estimates by IPCC (1996 and 2006) and Birdsey et al. (1992) (45%, 47% and 50% respectively). This value is also close to that is proposed by Condit = 48.00% (2008). At this point, potential Carbon sequestered could be easily computed using the molecular weight ratio of CO2 to C = 3.3663. Because Carbon stock and AGB figures in this paper are treated as baseline estimates, palm species (i.e. *Caryota rumphiana* Matt.) was loosely treated as a "tree" and so same equations were applied to the same.

RESULTS AND DISCUSSION

Landscapes of Eden and Dibibi contain low mountains of about 600-700masl with steep slopes and ridges. These natural features facilitate water drainage to meandering sections of Addalam River System in Eden and Addalam Rivers (Dibibi). The landscape exhibits significant human alterations, i.e. slopes are utilized for farming, wherever feasible (supported by personal communications). Dotted by residences, the corn fields, livestock farms and exotic timber plantations (*Gmelina arborea* Roxb., *Swietenia macrophylla* King) are the major land-uses in the two barangays. In open or idle lands, grass and weeds are the dominant features. There were frequent sightings of *Pterocarpus indicus* and *Diospyros pyrrhocarpa* Miq. In sampled areas' forest edges, various epiphytes like orchids, passionfruit (*Passiflora* sp) and lianas were encountered.

Physiognomy of Canopy Trees

Sampling of canopy and undergrowth species across the two barangays yielded 51 species. From the assemblage of trees and the areas' environmental characteristics, Eden and Dibibi's forests are akin to Tropical Lowland Evergreen- and Semi-Evergreen Rainforests as per descriptions by Fernando et al. (2008). The most speciose families are *Moraceae* and *Euphorbiacae* with 7 and 6 encountered species (Fig. 2 and Fig. 4). These are mostly nurse and early successional species. Estimated number of individuals per unit area (excluding undergrowth) for Eden and Dibibi are 250trees/ha and 375 trees/ha respectively. Non-contiguousness of tree cover is the most pressing indicator that the forests are logged-over or residual. Dominance of *Euphorpbiaceae* in secondary forests in Indonesia were noted by Langenberger et al. (2006) and Kessler et al. (2005), indicating decline in climax species composition. Proximity of human settlements and other land-uses to the forests fits description by Lasco et al. (2001) that condition of Eden and Dibibi springs from poor local economy, and population pressure. Verburg et al. (2004) also stressed that accessibility to forestlands determines land-use of such areas. And so the condition of forests in the two barangays are indeed attributable to the adjacent settlements.

Sfair et al. (2016) as well as Turner and Corlett (1996) argued that fragmented lowland forests, while highly susceptible to various degradation mechanisms (e.g., restricted organismal population, altered microclimate at edges), nonetheless provide good conservation values. In an older paper, Kartawinata (1994) forwarded that secondary forest species can be utilized for rehabilitation of forestlands. Reasons relatable to Eden-Dibibi forests are: 1) these forests still allow certain fauna and flora and to thrive, like dipterocarps, and; 2) such fragments can become foci of recruitment and "coalescence" with other tree stands. Given that *Moraceae* and *Euphorbiaceae* trees can be considered nurse trees for slow-growing species in the two barangays, current forest composition further indicates that Eden-Dibibi forests are undergoing early secondary succession.

In terms of composition and structure of canopy trees (Table 2), 71.88% of species are simple-leaved. About ¾ of these individuals is meso- to megaphylls, or plants having leaf/leaflet length of at least 7.50cm. Most frequent species are *Shorea contorta*, *Trema orientalis* and *Diplodiscus paniculatus*. The biggest individuals by merchantable volume (as best estimation of cylindrical volume) in Dibibi are *Samanea saman* (Jacq.) Merr. (28.09m3), and *Ficus variegata* (12.10m3). On the other hand, three *S. contorta* have more than 3.00m3 in Eden. Based on morphological descriptions, biggest species for both areas can attain potential maximum dbh=71.80cm and height=24.93m. *S. contorta* and *S. guiso* (estimated final height of 40.00m++) are expected to eventually emerge from the canopy layer of both forests. It has long been considered that tree leaf size, affect forest temperature, humidity, soil moisture, light attenuation, even species recruitment, as with investigations by Chaturvedi & Raghubanshi (2018), Dupuy & Chazdon (2008), Kalacska et al. (2004), Bruhl et al. (2001) and Rijkers (2000). In the case of both Eden and Dibibi, canopy trees (being mostly meso- to megaphylls) can induce optimal forest conditions. However, openness and lack of large individuals make for faster evaporation (increasing ambient temperature) and light penetration (recruitment of weeds and invasive plants). The present condition of gaps along these forests may arrest growth and development of other forest species.

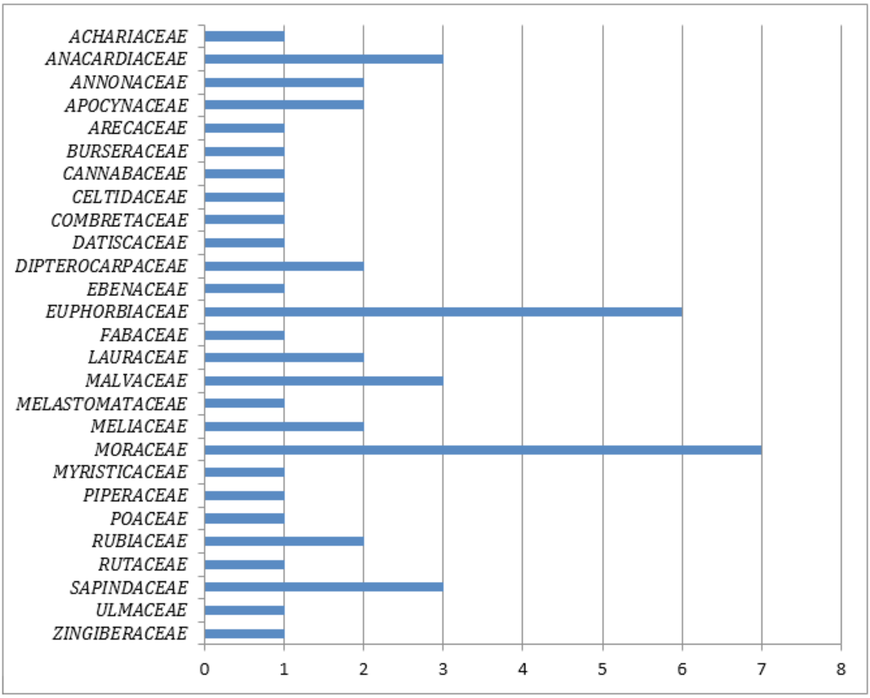

Figure 2. Summary of canopy and undergrowth diversity of plants in Eden and Dibibi (by family).

Table 2. Summary of measurements, distributions and utilizations of canopy trees in Eden and Dibibi.

[redacted]					
Distribution					
Indigenous, including naturalized	12	75.00	12	75.00	75.00
endemic	2	12.50	4	25.00	18.75
Phyllotaxy					
Simple vs compound	11	68.75	12	75.00	71.88
Evergreen (vs deciduous)	10	62.5	10	62.50	62.5
Blade class					
Microphyll	2	12.50	1	6.25	9.38
Notophyll	3	18.75	2	12.50	15.66
Mesophyll-Megaphyll	11	68.75	13	81.25	75.00
Use					
Timber	5	31.25	7	43.75	37.50
Food	3	18.75	10	62.50	40.63

Diversity and Phylogeny Analyses

In terms of community diversity, Eden and Dibibi each contain 16 and 12 species (S) of canopy trees. Albeit having lesser S, Dibibi has more individuals (33 trees). While H' for Eden and Dibibi is moderately high (Table 3), results can be misleading since only 2 species (Ficus minahassae and *S. contorta*, in Dibibi) occur in more than 5 individuals. Thus, diversity must also be inferred from the calculated dominance (1/D) and evenness. As such, there appears no distinct numerically dominant species since individuals are distributed among, or "shared" by most species. Further, the canopy layer of the two areas is dissimilar; only *Octomeles sumatrana* Miq., *S. contorta* and *Ficus variegata*, *sensu lato*, are the canopy species being shared by the two sites. In connection, only few of the recorded trees are reiterated in the undergrowth. The quadrats were found to be sparsely vegetated and highly heterogenous. This is supported by calculated Jaccard (=0.077) and Sorensen-qualitative indices (=0.14) (Table 4a).

Table 3. Alpha diversity of Eden and Dibibi's canopy trees.

[redacted]	[redacted]	[redacted]
Shannon-Weiner, H'	2.65[a]	2.26[a]
Simpson's Reciprocal Index, 1/*D*	27.14	10.35
Pielou's Evenness, *J*	0.956	0.91
$H_{\max}$ (natural log)	3.00	3.50

[a] Qualitative scales for *H'* Fernando (1988) are as follows: Very High >3.5; High 3.0-3.49; Moderate 2.5-2.99; Low 2.0-2.49; Very Low <1.99. *H'* values rarely register <1.50, and extremely rarely >4.50 (Magurran, 1988).

Table 4a. Beta (similarity) diversity of plants in the 2 forest strata of Eden and Dibibi.

[redacted]	[redacted]	[redacted]	[redacted]
Jaccard	0.077	0.344	0.255
Sorenson	0.143	0.512	0.406

The understorey stratum are more diverse, and relatively more similar than their canopy counterparts (13 shared S). Beta diversity analysis of the canopy layer plus their respective undergrowth provides a better view of relationship among species. The observed accumulation of shared species between the two sites suggests that the previous communities along the area gradient/landscape – prior to human perturbations – were once fairly analogous. This discrepancy in species richness between the two strata matches the positions of Ali & Yan (2017) and Dupuy & Chazdon (2008) that canopy openness allows recruitment of other (tree) species.

Phylogenetic visualization of floral samples (Figure 3a, 3b) reveals that canopy species are more taxonomically associated (Wheeler et al., 2006) at the Order levels and greater. When undergrowth species were included, the plants appear to be more dispersed and more connected at the family level and adjacent subtaxa. This is supported by the higher taxonomic dissimilarity compared to the trees' species dissimilarity (Table 4b).

Despite the low representation of species at individual level, the forests exhibit better heterogeneity in supraspecific taxa, thereby relatively moderate diversity. Computed Taxonomic Distinctness (i.e., taxonomic distance between any two species) for two sites' canopy and undergrowth flora up to Order level are above moderate by itself and in comparison to one another (Eden $\Delta+ = 3.835$; Dibibi $\Delta+ = 3.828$) because individuals belong to few families but diverse Orders. The most represented Orders (Fig. 4) in the two sites are *Rosales* and *Sapindales* (11 species each), *Malpighiales* (6 Families), *Malvales* (5) and *Magnoliales* and *Gentianales* (3 each).

Cladistics (Figs. 3a, 3b) further reveals that ancestry of all sampled individuals belong to Mesangiospermae, the broadest of the four angiosperm groups. Combined taxa (51 species) samples yielded 42 phylogeny leaves that branch out to 4 clades 33 phylogeny leaves were observed in Eden, making it the more, albeit slightly, taxonomically and phylogenetically diverse site. Sfair et al. (2016) found that in fragmented tropical forests have lower taxonomic distinctness than robust stands. In Uganda, Gwali et al. (2010) attribute low taxonomic distinctness to anthropogenic factors. Given that there is high taxonomic dissimilarity in Eden-Dibibi, despite proximity of various land uses, it can be construed that diversity of secondary forests in said barangays is still in a "healthy" state.

Table 4b. Beta diversity (dissimilarity, bcc) of plants in the 2 forest strata of Eden and Dibibi.

Taxa shared by both sites (Ta)	13	52
Taxa exclusive to Eden (Tb)	38	100
Tax exclusive to Dibibi (Tc)	26	52
Dissimilarity (beta diversity)	**(Species) 0.745**	**(Taxonomic) 0.831**

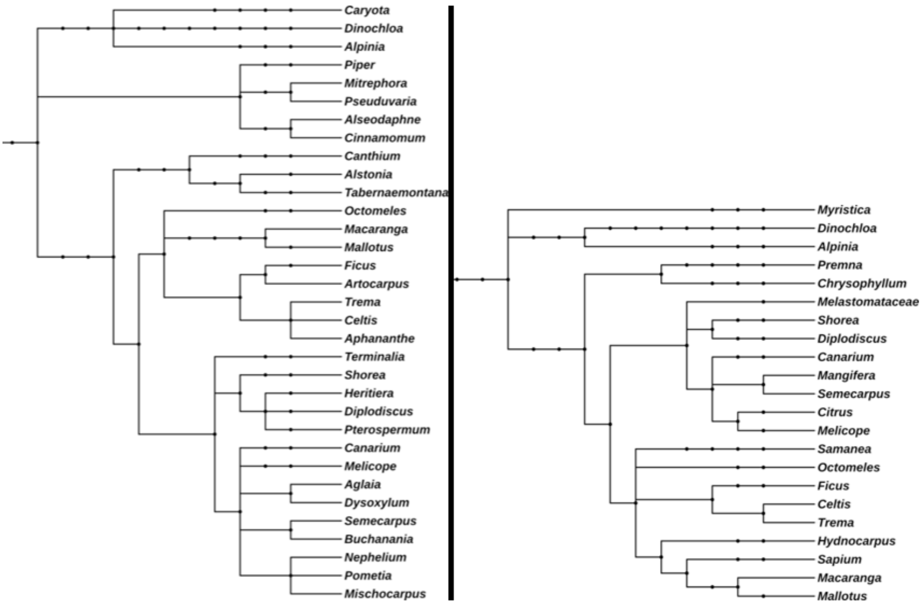

Figure 3a. Phylogeny trees of Eden (left) and Dibibi (right) flora. Nodes refer to supraspecific taxa (Genus, Family, Order, etc) while dots to other subtaxa (e.g, Tribe, Subfamily). Individual species disregarded to put more emphasis on higher ranks. Morphotypes, or plants not identified to Species level (Terminalia and Melastomataceae spp) were included using the best lowest rank.
Image Credits: http://phylot.biobyte.de/ and iTOL (Letunic and Bork 2016).

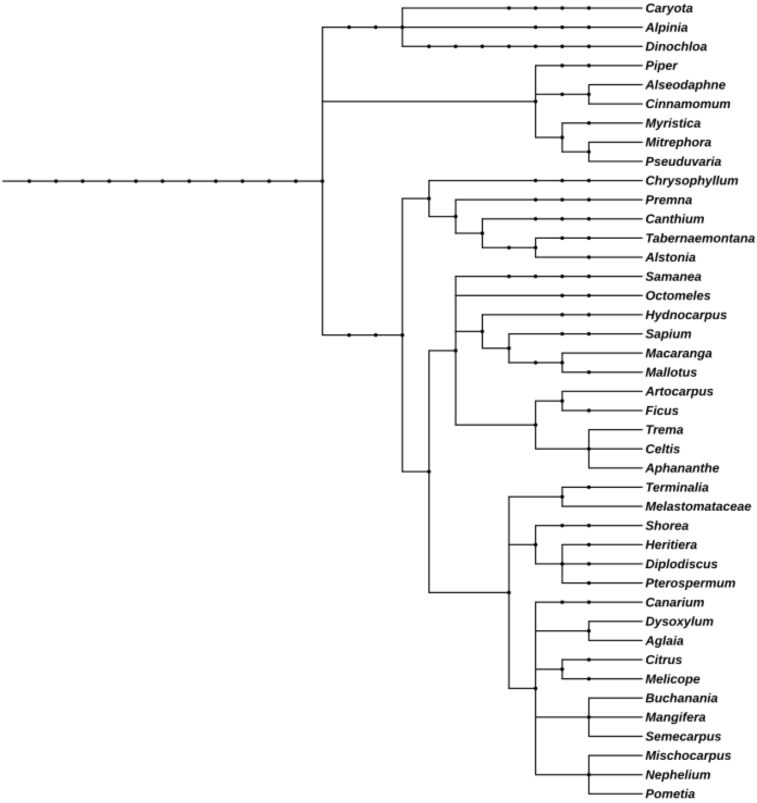

Figure 3b. Phylogeny tree of plant genera Eden and Dibibi flora. Nodes refer to supraspecific taxa (Genus, Family, Order, etc) while dots to other subtaxa (e.g, Tribe, Subfamily). Individual species disregarded to put more emphasis on higher ranks. Morphotypes, or plants not identified to Species level (Terminalia and Melastomataceae spp) were included using the best lowest rank. Image Credits: http://phylot.biobyte.de/ and iTOL (Letunic and Bork 2016).

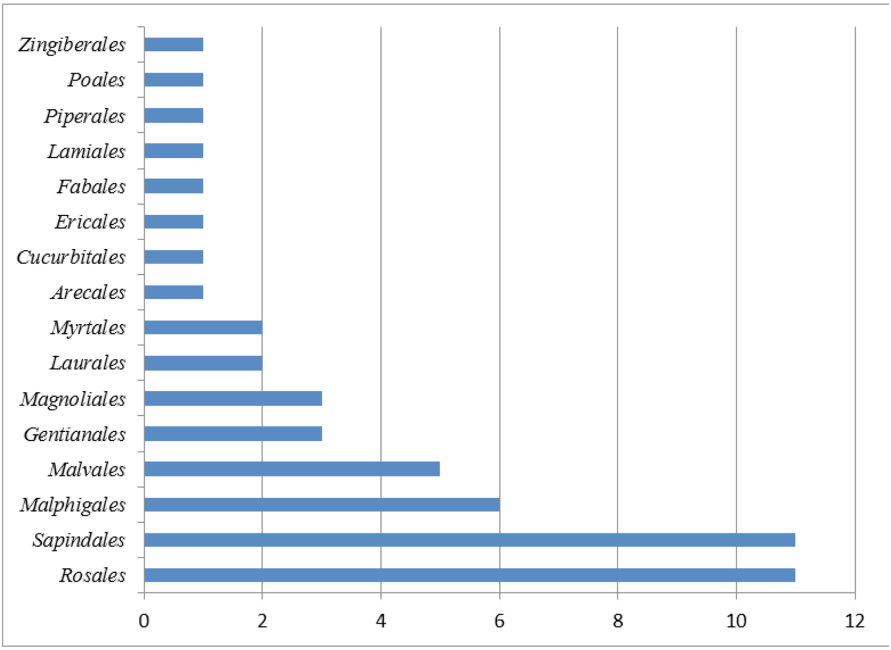

Figure 4. Summary of Eden and Dibibi Flora using higher taxa (Order).

Ecological Importance and Conservation Values

Importance values, as function of density, abundance and dominance average are presented in Tables 5a and 5b. Highest IV (S) in both sites belongs to *Shorea contorta*. A Philippine endemic, S. contorta emerged as the more ecologically dominant species given its high relative abundances and densities and cumulative basal areas. Still, the sparseness of the trees (hence the small IVs) found thereat convey that all of the species are important in ecological functions such as light attenuation, microclimate stabilization, faunal recruitment and succession.

As per IUCN ver. 2.3 and national listings (DENR AO 2007-01), 43.75% of identified canopy trees require conservation effort. These are *Artocarpus blancoi* (Elmer) Merr., *Diplodiscus paniculatus* Turcz., *Ficus minahassae*, *Macaranga bicolor* Müll.Arg., *Pterocarpus indicus*, *Canarium luzonicum* (all vulnerable, VU) as well as *Shorea guiso* and *S. contorta* (both Critically Endangered, CR1cd). Low Risk/ Least Concern species are *Octomeles sumatrana*. and *Alstonia scholaris* (L.) R. Br. While Mangifera indica L. is likewise included in IUCN Red List (data deficient, DD), this species is deemed not vulnerable as it is a common fruit source. In the undergrowth, *Cinnamomum mercadoi* Vidal, *Sapium luzonicum* (Vidal) Merr., *Diplodiscus paniculatus* Turcz.,and *Celtis luzonica* Warb. are also listed as VU in the Red List. Only *S. contorta*, *Pterocarpus indicus* (Critically Endangered), *Sapium luzonicum* (Vulnerable) and *C. luzonicum* (Other Threatened Species) are listed in the DENR's Philippine list of Threatened plants (DENR AO 2007-01; Fernando et al., 2008). The two sites also contain endemic species, which can also be seen as another conservation value. In Dibibi, these are *Ficus minahassae*, *Premna cumingiana* Schauer, *Canarium luzonicum* and *Shorea contorta*.

Cross-referencing of species descriptions yielded important uses. Of the 16 canopy trees in Eden, 5 and 3 can be utilized as timber and food. Likewise, 7 and 10 in Dibibi's equivalent are appropriate for said uses. For example, dungon (*Heritiera sylvatica*) produces very strong wood hence a good alternative to usual timber species. Undergrowth plants like bikal (*Dinochloa acutiflora*) can be substituted to *P. indicus* and *S. contorta* for light construction and furniture. The usually-ignored *Ficus variegata* and *F. nota* have syconia (fused fruit) that are potential base for wine-making. In addition, *F. nota* leaves are eaten as vegetable in other parts of the country. *Canarium luzonicum* (piling-liitan) and bagarbas (*Hydnocarpus sumatrana*) may also open market for its nutrient-rich nuts. Native rambutan (*Nephelium ramboutan-ake*), balinghasai, (*Buchanania arborescens* (Blume) Blume) and ligas (*Semecarpus cuneiformis* Blanco) are also some of underutilized fruit-bearing species in the country.

Table 5a. Importance Values (averaged) of Canopy trees found in Eden forest

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1	*Shorea contorta*	4	20	54.79	20	31.60
2	*Ficus irisana*	2	10	6.76	10	8.92
3	*Shorea guiso*	1	5	9.55	5	6.52
4	*Artocarpus blancoi*	1	5	6.07	5	5.36
5	*Diplodiscus paniculatus*	1	5	4.06	5	4.69
6	*Octomeles sumatrana*	1	5	3.54	5	4.51
7	*Trema orientalis*	1	5	3.05	5	4.35
8	*Alstonia scholaris*	1	5	2.90	5	4.30
9	*Terminalia sp.*	1	5	2.46	5	4.15
10	*Heritiera sylvatica*	1	5	2.32	5	4.11
11	*Pseudovaria caudata*	1	5	1.80	5	3.93
12	*Caryota rumphiana var. philippinesis*	1	5	0.65	5	3.55
13	*Pomelia pinnata forma repanda*	1	5	0.58	5	3.53
14	*Pterospermum obliquum*	1	5	0.58	5	3.53
15	*Alseodaphne longipes*	1	5	0.45	5	3.48
16	*Ficus variegata var. garciae*	1	5	0.45	5	3.48
TOTAL for Eden		20	100.00	100.00	100.00	100.00

Table 5b. Importance Values (averaged) of Canopy trees found in Dibibi forest.

[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
1	*Shorea contorta*	7	21.21	13.05	21.21	18.49
2	*Ficus variegata*	3	9.09	31.29	9.09	16.49
3	*Ficus minahassae*	6	18.18	3.21	18.18	13.19
4	*Samanea saman*	1	3.03	25.50	3.03	10.52
5	*Citrus grandis*	4	12.12	4.48	12.12	9.57
6	*Ficus nota*	3	9.09	3.03	9.09	7.07
7	*Mangifera indica*	2	6.06	4.29	6.06	5.47
8	*Octomeles sumatrana*	1	3.03	7.98	3.03	4.68
9	*Macaranga bicolor*	2	6.06	0.77	6.06	4.30
10	*Premna cumingiana*	2	6.06	0.67	6.06	4.26
11	*Canarium luzonicum*	1	3.03	4.20	3.03	3.42
12	*Chrysophyllum cainito*	1	3.03	1.53	3.03	2.53
TOTAL		33	100.00	100.00	100.00	100.00

Carbon Estimates using Existing Models

Implementation of ANOVA to the above-ground biomass carbon storage values of canopy species yielded from three allometric models (FAO1, FAO2, Power-fit) obtained p-values of 0.6522 in Eden dataset and 0.3939 in Dibibi (alpha=0.05). This reflects that there is no significant difference between sampled medians. Kruskal-Wallis as post hoc test reinforce this observation in Eden [$H(chi^2)$=3.159; *p* (same)= 0.206] and Dibibi [$H(chi^2)$=1.875; p (same)= 0.3915]. Of the three models, the power-fit function gives lower estimates (roughly 42%) compared to the FAO_1 and FAO_2 equations.

Eden has average aboveground stored Carbon (C) of 263.67metric tons/ha, or 1.63tons/tree. This means that a hectare of Eden forest having a community of 250 trees has sequestered at least 966.685 metric tons of Carbon Dioxide in the air. Dibibi's carbon stock and sequestration potential per-hectare basis (average of 3 models=359.85tons/ha) is higher because there are more individuals in the site. Aboveground carbon storage per tree is estimated at 1.35tons/tree. In turn about 1319.32tons of CO2 per hectare in the air is fixed in Dibibi.

Allometric estimates herein for AGB and Carbon storage fall below the per-hectare figures given by FAO (Brown, 1997), Sales et al. (2001) and Lasco et al. (2004). Nonetheless, another 20% of the computed values are potentially stored in the roots and in the soil, following the position of Lasco et al. (2001).

CONCLUSION

The forests of Eden and Dibibi, holds considerable potentials for both ecological and economic use. In terms of diversity, structure and function, the two forests studied herein are in the early stages of self-restoration; and contain diversified assemblage of early successional and climax species. The density of canopy and the undergrowth layers also provide a fully-stocked and diverse forest in the future. Many of the plants found thereat have ecological and other potentials. By projections, its good canopy cover may also function as a potential major carbon sink in the Province of Quirino.

However, since almost all of the sampled species (canopy and undergrowth species) have very few individuals, rarefaction plays an important role in latent ecological processes, functions and services such as biodiversity recruitment, species dominance, and natural regeneration. Only few species (e.g., *S. contorta*) can be expected to "endure" individual extirpation because of its abundance in the two sites. On the land-use, the mix of economically viable and lesser-used/lesser known species may lead to two "lose-lose" scenarios if proper management/mitigation schemes are not implemented:

a) People will replace economically unimportant species with "money trees", like exotic timbers, and;

b) People will become more aggressive in harvesting economically-important individuals to "edge out" their competitors over the land resources.

Thus viewed, observations made in this paper are some of numerous bases for rehabilitation, conservation and restoration, but only when the scientific information is translated to a language that local folk understand that such science can be used in observance of future policies.

RECOMMENDATIONS

To ensure that Eden and Dibibi's forests will continue to provide wide range of ecosystem services in the future, the following recommendations are suggested:

1. The two local government units may consider passing local ordinance declaring the remaining forests in their respective areas as community watersheds. Such ordinance should cover prohibited activities and corresponding penalty for any acts committed thereat; and

2. Local communities may also be mobilized to conduct forest protection activities to control destructive human activities like timber poaching, burning and expansion of swidden farms. Enrichment planting may be undertaken to increase current tree population as well as resilience to disturbance and change.

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