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Tree Diversity and Timber Resources Assessment in Secondary Forests of Quirino Forest Landscape Project, Philippines

ELIZABETH T. CARIG
ORCID NO. 0000-0002-7949-8483
elizabeth.carig@qsu.edu.ph
Research and Development Office, Quirino State University
Diffun, Quirino, Philippines

RYAN P. MANUEL
ORCID NO. 0000-0003-0519-4441
nayrleunam@gmail.com
College of Forestry, Nueva Vizcaya State University
Nueva Vizcaya, Philippines

ABSTRACT

This study is a part of baseline data gathering for a short-term project in 12 barangays referred to as Quirino Forest Landscape (QFL). The study assessed trees' diversity, biophysical attributes, utilization values, and ecological importance. Quadrat sampling was performed to gather abundance and biometric data of trees with a diameter at breast height of 15 cm and greater. Data analysis employed alpha diversity indices, distance and similarity measures, carbon-based allometric equations, stand-stock table, and other tools. Secondary information and first-hand accounts were used to gather ecological and utilization values. Diversity was very high, highly heterogeneous, and very complex. Diffun was found to have the most contiguous tree assemblage; Cabarroguis and Aglipay share more species than Maddela and Diffun. Analysis of photographed canopies revealed mean canopy closure is 77.41%. Close to half of individual trees fall under 40 cm and 50 cm dbh classes, implying QFL as a secondary forest. Trees have aboveground stored Carbon of 642.87 tons/ha or 1.26 tons/tree. The area host five premium timbers, 10 Philippine Mahogany timbers, Rosewoods, 15 Furniture/Construction, and 95 underutilized species. Slightly more than a third (33.60%) of sampled canopy trees (43 species total) require conservation effort; White Lauan (Shorea contorta) is the most critical. To control further damage,

measures to prevent further forest cover loss must be instituted to understand and sustain ecosystem functions.

Keywords: Secondary Forest, biodiversity, importance value, carbon storage, cabarroguis, Quirino Forest Landscape

INTRODUCTION

The Quirino Forest Landscape (QFL) is a collection of semi-contiguous closed and open forests that runs along with four out of 6 municipalities of Quirino Province. About 33,317.00 hectares that comprise the QFL (not to be confused with Quirino Protected Landscape, a declared protected area in the same province), was subject to a short-term forestry-based development project, which is the latest among the many local and foreign-funded interventions in Quirino.

Forest resources in QFL areas are confronted by problems like undocumented harvesting, land conversion, fires, squatting, and many other weak and unsustainable resource uses. These issues, however, are seen as central to the livelihood of upland barangays that are dependent upon Quirino's forests. It is ironic to note that the environmental resources and services that these communities enjoy are known to degrade if unsustainable practices are left unabated. There must be an in-depth understanding of the core resources that make up the forest landscape itself - the trees. By knowing various tree attributes in local situations (e.g., diversity, utilization value), managers can address persistent issues that contribute to forest cover decline. Attaining substantial data on forest trees as a collective resource can shed light on why other socio-economic and political challenges that intensify forest cover loss occur. Following the arguments of Gonzales et al. (2009), Nguyen et al. (2012), and Gardner et al. (2009), uncovering the values of trees encourage direct beneficiaries and stakeholders, the barangay residents, to embrace their role in protection, conservation, rehabilitation, and proper utilization of forest resources surrounding them.

A pioneer for a short-term forestry development project in the QFL, the execution of this study was based on two premises. First, to serve as a basis for conceptualizing forest-based livelihood options. Second, to raise objectively designed policies that would harmonize conservation, protection, and rehabilitation efforts of all area stakeholders.

OBJECTIVES OF THE STUDY

The researchers investigated the biological diversity and timber values of mature trees in 12 barangays/communities that comprise the Quirino Forest Landscape. The researchers determined the trees' alpha (community) and beta (comparative) diversities, assessed their biometric attributes, and observed their known usage to carry out this aim. The researchers also measured and described the ecological importance of the QFL trees.

MATERIALS AND METHODS

Composition of the Assessment Team

This study used a modified version of the Biodiversity Monitoring System (BMS; NORDECO-BMB-DENR 2001). Ideally, the BMS recommends a 2-km transect for establishing quadrats, but due to terrain and safety reasons, the most feasible transect length for the studied QFL sites was 150 m. Following such modification, the assessment team established one transect per site in each of the 12 barangays. A sampling quadrat measuring 20 m x 20 m was laid out at each end of the transect. Within these quadrats, the team identified and measured canopy (>15 cm dbh) and undergrowth tree species. As such, diameters at breast height were measured. Notable epiphytes and plants were also recorded. Skyward-looking digital photographs were also acquired to check the canopy closure of each site. Quadrats' area totaled 9,600 m2.

The researchers were assisted by the project's Bantay-Kalikasan (forest ranger) members, Forestry student-interns, representatives of MENRO of Cabbaroguis, and Maddela towns, as well as elders from various Peoples' Organizations in the QFL barangays. These assisting persons served as field guides, enumerators and Key Informants.

Raw data from the forest inventory were used to produce the following: Stand-Stock Table, Diversity (alpha) indices, and Species Importance Values, as well as pixel percentages (histogram) using binary conversion (RGB to B/W) of canopy photographs. Results were used to explain other characteristics of the forests/forest resources such as species conservation and use-values, distribution, biomass and timber stocking, and carbon fixation. The Stand-Stock Table, generally used as a timber volume estimation tool, was employed in this study to support the presentation of the timber biomass in the QFL sites and respective utilization values.

Table 1

The Barangay-Beneficiaries of the Quirino Forest Landscape Project. Closed Forest Data from the National Mapping Resource Information Authority (NAMRIA)

Site (Barangay)	Land Area (ha)	Closed Forest Cover (ha) 2015
Municipality of Aglipay		
Diodol	1,162.31	0.00
San Manuel	2,077.32	36.25
Victoria	2,489.42	0.00
Municipality of Cabarroguis		
Calaocan	1,260.12	0.00
Dibibi	2,586.12	0.00
Dingasan	3,285.54	60.49
Eden	1,421.40	0.00
Municipality of Diffun		
Baguio Village	2,049.81	0.00
Don Mariano Perez	1,730.33	0.00
Ifugao Village	1,396.05	0.00
Municipality of Maddela		
Balligui	941.44	0.00
Jose Ancheta	1,2916.96	4001.89

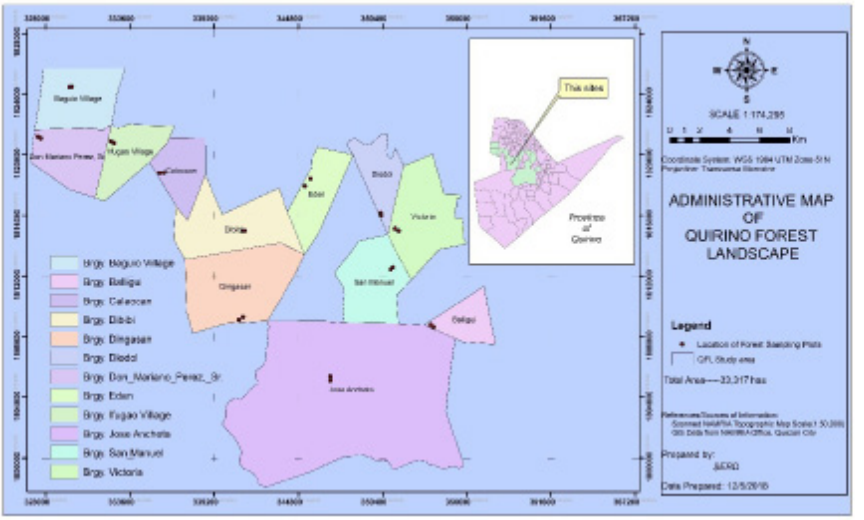

Figure 1. Location of Study Sites within the Quirino Forest Landscape. Credits: RLPascua, NAMRIA.

RESULTS AND DISCUSSION

Diversity Values

General Biodiversity. The assessment team identified 125 tree species within sampled plots in twelve QFL barangays. Diversity is very high (Shannon *H"* = 3.90) and highly heterogeneous (Shannon *E* = 0.81). Dominance is shared by about 16% of total species (Simpson's Reciprocal Index = 20.03). Given the tree assemblage within the plots, possible maximum diversity in the surrounding areas exceed normal Shannon-Weiner Index values (>4.50, per Magurran 1988, implying very complex tree diversity (H'_{max} = 4.83).

The forest along the QFL can generally be termed as "Tropical Evergreen Lowland Forest," or "Dipterocarp Forest" following classifications by Fernando et al. (2004) and Tamesis (1948). Site visits to various QFL barangays impressed upon the researchers that certain trees tend to dominate certain portions of the forest landscape. For example, Dungon (*Heritiera sylvatica*) was more prominent in low-lying open forests of Eden and Dibibi, whereas Magabuyo (*Celtis philippinensis*) and Banato (*Mallotus philippinensis*) were widespread in closed ridges of Ifugao Village. In upper slopes like in Dingasan, stands of Binuang (*Octomeles sumatrana*) were found prevalent. Similar observations in other parts of Barangay Eden and Dibibi (Cabarroguis town) were reported by Manuel et al. (2019).

Three out of 5 most frequent species in the sampled sites (Table 2) are dipterocarps: White lauan (*Shorea contorta*), Tanguile (*Shorea polysperma*), and Mayapis (*Shorea palosapis*). The other two most abundant species are Narra (*Pterocarpus indicus*) and Magabuyo (*Celtis philippinensis*). These can be considered "climax" trees since mature individuals dictate the canopy, structure, recruitment, and general functioning of the forest. Other notable trees sighted and reported by locales in the QFL sites are Red Lauan (*Shorea negrosensis*), Hagakhak (*Dipterocarpus validus*), Binuang (*Octomeles sumatrana*), Balobo (*Diplodiscus paniculatus*), Nato (*Palaquium luzoniense*), Tuai (*Bischofia javanica*), Lamio (*Dracontomelon edule*) and Mountain Tapinag (*Sterculia montana*).

Ecological Importance

The Species Importance Values, as a function of density, frequency, abundance, and dominance average, of trees in the sampled areas in QFL, are also presented in Table 2. Average IV per species is 0.80% (SD=1.59%). Only 19 species (15.20%) of encountered species have IVs more than 1.00% and above,

indicating that most individuals of the majority of the tree species inventoried are few, infrequent, and small in stature. Conversely, 27 species have IV of 0.16% to 0.29%. Basic interpretation of species IV dictates that most of the trees encountered call for conservation-protection measures if local populations are to be preserved.

Highest IV (S) in both sites belongs to *Shorea contorta*, a Philippine endemic. As described previously, *S. contorta* is one of the most abundant climaxes and ecologically dominant trees in the assemblage. Said species at this moment are identified as most contributory to ecological functions of the QFL forest, such as light attenuation, microclimate stabilization, faunal recruitment, and succession. Other ecologically dominant tree species in the QFL are Tanguile (*Shorea astylosa*), Mayapis (*S. philippinensis*), Narra (*Pterocarpus indicus*), Balobo (*Diplodiscus paniculatus*), Tangisang bayawak (*Ficus variegata*), Magabuyo (*Celtis luzonica*), Pagsahingin (*Canarium luzonicum*), Manaring (*Lithocarpus* sp), and Hagimit (*F. minahassae*).

Except for the naturalized fruit tree Nangka (*Artocarpus heterophyllus*), the least abundant species are also endemic/indigenous canopy trees. These are Makaasim (*Syzygium*), Balakat gubat (*Balakata luzonica*), Dapdap (*Erthryina orientalis*), and Anongo (*Turpinia ovalifolia*). Their abundance and dominance in the area (please see succeeding sections) reflect the composition of the old-growth forest that once stood in such parts of QFL.

Table 2

No.	Species		Average IV	Abundance
	Common Name	Binomen		
1	White Lauan[CR]	*Shorea contorta*	15.84	82
2	Tanguile	*Shorea polysperma*	6.35	49
3	Mayapis	*Shorea palosapis*	5.10	40
4	Narra[VU, CR]	*Pterocarpus indicus*	3.44	13
5	Balobo[VU, DD]	*Diplodiscus panculatus*	3.27	16
6	Tangisang bayawak	*Ficus variegata*	2.27	8
7	Magabuyo[VU]	*Celtis luzonica*	2.17	13
8	Pagsahingin	*Canarium ovatum*	1.77	10
9	Manaring	*Lithocarpus solortana*	1.56	9
10	Hagimit[VU]	*Ficus minahassae*	1.54	9
11	Tibig	*Ficus nota*	1.51	5
12	Kangko[LC]	*Aphanamixis polystachya*	1.49	5
13	Red Lauan	*Shorea negrosensis*	1.47	8
14	Bolong eta	*Diospyros philosanthera*	1.40	8
15	Piling Liitan[LC, OTS]	*Canarium luzonicum*	1.33	3
16	Guijo[CR]	*Shorea guiso*	1.17	5
17	Bagtikan	*Parashorea malaanonan*	1.10	7
18	Katmon[VU]	*Dillenia philippinensis*	1.05	5

Table 2 continued.

No.	Species		Average IV	Abundance
	Common Name	Binomen		
19	Baling Uwai	*Flagellaria indica*	1.00	7
20	Karaksan[DD]	*Linociera ramiflora*	0.99	5
21	Anabiong[LC]	*Trema orientalis*	0.91	4
22	Anang[LC]	*Diospyros pyrrhocarpa*	0.90	3
23	Dangloi	-	0.82	6
24	Antipolo[VU]	*Artocarpus blancoi*	0.78	2
25	Aplas	*Ficus tritana*	0.78	4
26	Dalinsi	*Terminalia citrina*	0.76	4
27	Kamagong	*Diospyros blancoi*	0.72	4
28	Malakatmon[VU]	*Dillenia luzoniensis*	0.72	5
29	Binuang[LC]	*Octomeles sumatrana*	0.71	2
30	Dao	*Dracontomelon dao*	0.71	2
31	Panglomboien	*Syzygium samarangense*	0.70	5
32	Rain tree	*Samanea saman*	0.70	1
33	Banato	*Mallotus philippinensis*	0.69	2
34	Panau	*Dipterocarpus gracilis*	0.68	4
35	Dungon	*Heritiera sylvatica*	0.63	2
36	Kapulasan	*Nephelium ramboutan-ake*	0.63	4
37	Lukban	*Citrus máxima*	0.61	4
38	Palonapoi	*Lithocarpus casiellarianus*	0.59	4
39	Takip Asin[VU]	*Macaranga grandiflora*	0.59	2
40	Binunga	*Macaranga tanarius*	0.57	2
41	Batikuling	*Litsea leytensis*	0.55	3
42	Gatasan	*Garcinia venulosa*	0.55	2
43	Kalantas[DD]	*Toona calantas*	0.54	2
44	Apitong	*Dipterocarpus grandiflorus*	0.53	3
45	Kalumpit	*Terminalia microcarpa*	0.53	2
46	Pagsahinging Liitan	*Discocalyx micrantha*	0.52	3
47	Kalingag[VU]	*Cinnamomum mercadoi*	0.52	3
48	White Nato[VU]	*Palaquium macranthe*	0.52	2
49	Mahogany	*Swietenia macrophylla*	0.51	3
50	Taluto	*Pterocymbium tinctorium*	0.51	1
51	Manggachapui	*Vatica mangachapoi*	0.49	3
52	Dangula	*Teijsmanniodendron ahernianum*	0.48	2
53	Mangga[DD]	*Mangifera indica*	0.48	2
54	Lanceteng gubat	*Kibatalia gitingensis*	0.47	2
55	Apo oak	*Lithocarpus apoensis*	0.46	2
56	Alim	*Mallotus multiglandulosa*	0.44	2
57	Kalubkob	*Syzygium calubcob*	0.44	2
58	Pahutan[VU]	*Mangifera altissima*	0.42	2
59	Malaikmo[LC]	*Celtis philippinensis*	0.42	2
60	Wild makopa	*Nephelium ramboutanake*	0.42	2
61	Bagarilau	*Cryptocarya ampla*	0.41	2
62	Palosapis	*Anisoptera thurifera*	0.41	2
63	Nato[VU]	*Palaquium luzonensis*	0.41	2
64	Gubas	*Endospermum peltatum*	0.40	2
65	Kaatoang Matching[LC]	*Chisocheton pentandrus*	0.40	2
66	Malabuho	*Sterculia foetida*	0.39	2
67	Magilik	*Premna cumingiana*	0.39	2
68	Tangisang Layugan	*Ficus variegata*	0.38	1
69	Paronapin	*Lithocarpus sp*	0.35	1
70	Pomegranate	*Punica granatum*	0.35	1
71	Aplas	*Ficus odorata*	0.34	1
72	MalakMalak[VU]	*Palaquium philippinensis*	0.33	1
73	Igyo	*Dysoxylum gaudichaudianum*	0.33	1
74	Lamio	*Dracontomelon edule*	0.32	1
75	Katap	*Trigonostemon philippinensis*	0.32	1
76	Duguan[VU]	*Myristica philippinensis*	0.32	1

Table 2 continued.

No.	Species		Average IV	Abundance
	Common Name	Binomen		
77	Tiagkot	*Aberema clypearia*	0.32	1
78	Upling gubat	*Ficus ampelas*	0.32	1
79	Dita[LC]	*Alstonia scholaris*	0.32	1
80	Sapote	*Diospyros digyna*	0.32	1
81	Panan	-	0.31	1
82	Terminalia sp.	-	0.31	1
83	Palindan	*Orania palindan*	0.31	1
84	Pangnan	*Lithocarpus bennettii*	0.31	1
85	Bayanti[LC, NT]	*Aglaia rimosa*	0.31	1
86	Caimito	*Chrysophyllum cainito*	0.31	1
87	Tabgun	*Ficus ruficaulis*	0.31	1
88	Amugis	*Koordersiodendron pinnatum*	0.31	1
89	Dangloi buntotan	*Pseuduvaria philippinensis*	0.30	1
90	Kuling Baboy	*Dysoxylum altissimum*	0.30	1
91	Kalomata	*Clausena brevistyla*	0.30	1
92	Bangkal	*Nauclea orientalis*	0.30	1
93	Hamindang[VU]	*Macaranga bicolor*	0.30	1
94	Kalimutain	*Dysoxylum arborescens*	0.30	1
95	Kanapay	*Ficus magnolifolia*	0.30	1
96	Tinaang-pantay	*Drypetes magulingensis*	0.30	1
97	Dalingdingan	*Hopea foxworthyi*	0.30	1
98	Pakiling	*Ficus odorata*	0.30	1
99	Apanang[LC]	*Mallotus cumingii*	0.29	1
100	Kaburo	*Phoebe sterculioides*	0.29	1
101	Ngarusangis	*Cryptocaria cagayanensis*	0.29	1
102	Bayok-bayokan[LC]	*Pterospermum obliquum*	0.29	1
103	Ligas	*Semecarpus cuneiformis*	0.29	1
104	Lunas	*Lunasia amara*	0.29	1
105	Bayok	*Pterospermum diversifolium*	0.29	1
106	Kape	*Coffea* sp	0.29	1
107	Matang-hipon	*Breynia rhamnoides*	0.29	1
108	Kubi	*Ficus nitida*	0.29	1
109	Kulatingan	*Pterospermum*	0.29	1
110	Malugai liitan	*Pometia pinnata var. Repanda*	0.29	1
111	Kamulang	*Microcos stylocarpa*	0.29	1
112	Salaki	*Aglaia elliptica*	0.29	1
113	Ambalag	*Pedicellia fuscescens*	0.29	1
114	Babulo	-	0.29	1
115	Hauli	*Ficus séptica*	0.29	1
116	Tambalau[LC]	*Knema glomerata*	0.29	1
117	Pagsahingin bulog[VU]	*Canarium calophylum*	0.29	1
118	Bagna[LC]	*Glochidion triandrum*	0.29	1
119	Taklang Anak	*Garcinia dulcis*	0.29	1
120	Anitap	*Macaranga cumingii*	0.29	1
121	Makaasim	*Syzygium nitidum*	0.29	1
122	Balakat gubat	*Balakata luzonica*	0.28	1
123	Dapdap	*Erythrina orientalis*	0.28	1
124	Anongo	*Turpinia ovalifolia*	0.20	1
125	Nangka	*Artocarpus heterophyllus*	0.16	1

Average IV of species derived from computed relative abundance, dominance, frequency and density. Species in **RED** are Philippine endemics. Legend for Conservation Status (IUCN, DENR) of species: **CR**=Critically Endangered; **VU**=Vulnerable, **LC**=Least Concern; **DD**=Data Deficient; **NT**=Not Threatened; **OTS**=Other Threatened Species.

Comparison of Forest Diversity among QFL Barangays

Using cluster analysis (Figure 2), Diffun was found to have the most contiguous tree assemblage across the QFL barangays. Cabarroguis and Aglipay share more species than the other two towns. Dissimilarity matrix (Euclidean

nearest neighbor method; Table 3) of tree composition of the 12 barangays further showed that there are areas that are perfectly unrelated and similar. Jose Ancheta and Calaocan were 100% dissimilar in terms of species content. On the other hand, Victoria and Dingasan were 100% similar to each other brought by absolute 0 value in Euclidean absolute value. In terms of biodiversity management, there can be a "relaxed" treatment on populations or individuals of species expected to be lost during conversion of areas having complementary sites (i.e., with similar species composition). This is so because they can still be found in such complementary sites. Conversely, managers must provide a critical view of those uncommon species as these will be most affected by changes in land use in the different QFL barangays.

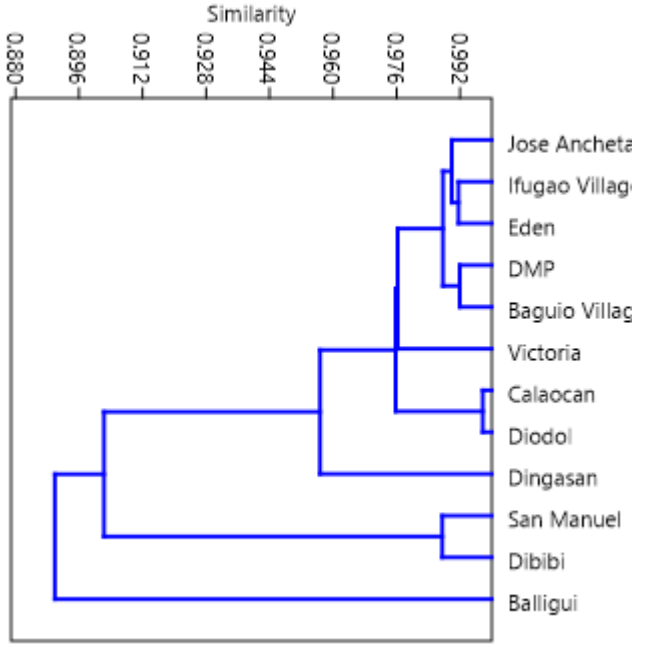

Figure 2. Cluster Analysis (Bray-Curtis method, single link) of plant diversities of the 12 QFL barangays. Performed using PAST 3 Software.

Table 3

Dissimilarity Matrix (Euclidean Distance method) of plant communities in the QFL Performed using SPSS software

Barangay	Eden	Dibibi	Baguio Village	Ifugao Village	Don Mariano Perez	Diodol	Victoria	San Manuel	Balluigi	Jose Ancheta	Calaoocan	Dingasan
Eden	0											
Dibibi	0.11	0										
Baguio Village	0.12	0.29	0									
Ifugao Village	0.37	0.34	0.51	0								
Don Mariano Perez	0.65	0.70	0.75	0.48	0							
Diodol	0.03	0.16	0.21	0.36	0.66	0						
Victoria	0.06	0.20	0.11	0.38	0.68	0.09	0					
San Manuel	0.09	0.27	0.17	0.54	0.74	0.19	0.18	0				
Balluigi	0.23	0.37	0.35	0.44	0.38	0.30	0.31	0.33	0			
Jose Ancheta	0.69	0.76	0.76	0.7	0.40	0.69	0.72	0.75	0.23	0		
Calaoocan	0.66	0.64	0.80	0.29	0.64	0.61	0.66	0.82	0.80	1	0	
Dingasan	0.04	0.18	0.04	0.39	0.66	0.07	0	0.14	0.26	0.67	0.68	0

Interpretation: **0**=perfect similarity; **1**=perfect dissimilarity.

Biophysical Attributes of Forest Trees in QFL

Canopy Structure. Once a major logging hotspot, the Province of Quirino forests nowadays are predominantly secondary. However, certain stands and tree individuals in sampled QFL sites are undoubtedly remnants of the old-growth forest that once covered the area. The presence of oversized individuals of Dao (*Dracontomelon dao*), Tuai (*Bischofia javanica*), Binuang (*Octomeles sumatrana*), Nato (*Palaquium* sp), Banato (*Mallotus* philippinensis), and dipterocarps (*Shorea, Dipetrocarpus*) along roads and accessible slopes are signs that QFL forests still retain its primary nature.

If a forest canopy is taken as a proxy measure for the quality of forest cover, the QFL is above average. Based on photographic analysis of 24 canopies (2 per Barangay), the mean canopy closure is 77.41% (SD=11.16). Densest canopies are found in Diodol, Calaocan, and Baguio Village. On the other hand, more open sites were in San Manuel, Dibibi, and Balligui, which implies that more understorey species are present in these parts of the QFL forests.

Figure 3. Example of binary-processed skyward-looking digital photographs used to estimate forest canopy cover. (Barangay Dingasan2; Closure = 74.82%).

Table 4

Canopy closure (histogram measurements) of sampled QFL sites

Site (Barangay)	Town	Open (%)	Shade (%)
1. Diodol	Aglipay	11.94	88.06
2. Calaocan	Cabarroguis	12.17	87.83
3. Baguio Village	Diffun	14.59	85.41
4. Don Mariano Perez	Diffun	15.40	84.60
5. Eden	Cabarroguis	16.63	83.37
6. Ifugao Village	Diffun	17.47	82.53
7. Jose Ancheta	Maddela	18.48	81.52
8. Victoria	Aglipay	20.85	79.15
9. Dingasan	Cabarroguis	25.18	74.82
10. San Manuel	Aglipay	34.95	65.05
11. Dibibi	Cabarroguis	36.20	63.80
12. Balligui	Maddela	47.21	52.79

Increment in Forest. Analysis of the stand-stock table of sampled trees in QFL (total volume = 568.17m3) revealed that 41.56% of tree individuals fall under 40cm and 50cm dbh classes, which indicates that QFL is indeed secondary forest. In comparison, Adame et al. (2014) calculated that trees in the Puerto Rican secondary forests have an average diameter Mean Annual Increment of

0.37cm/yr. If this projection with a conservative limit of 60% is to be used as a benchmark for determining the increment-ages of sampled trees in QFL, then the largest trees such as Dao and Banato are at least 162 years; age estimates for Binuang (*Octomeles sumatrana*), a known fast-growing tree) can be much younger, at around 30 years. Rosli and Gang (2013) calculated specifically that Meranti (*Shorea)* trees in Selangor, Malaysia have an annual increment of 0.62cm/yr, respectively. Based on this, the majority of the dipterocarps in the QFL (falling under 40cm dbh class) must be around 64.52 years. Given the history of logging in the QFL area, these individuals have survived the selection process during the 1970s and '80s.

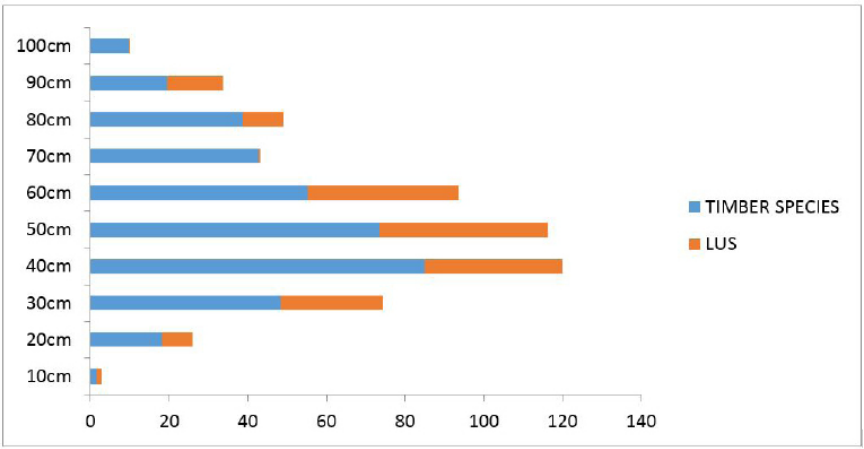

Figure 4. Summary of the diameters at breast height-timber classes of Stand-Stock Inventory performed in the 12 Quirino Forest Landscape barangays.

General Carbon Capture Estimates. The researchers utilized three models (two from Brown (1997) and another by Banaticla (2007)) to estimate the average biomass of trees in the sampled sites. Trees in sampled QFL sites have aboveground stored Carbon (C) average of 642.87tons/ha or 1.26tons/tree. It is estimated that canopy trees in sampled areas in QFL have AGB of 1,346.88 tons/ha. This figure is 259% times higher than Philippine estimates by Brown (1997) for moist old-growth and logged dipterocarp forests (370-520t/ha and 300-370t/ha). In comparison, the prior carbon sequestration estimates by Manuel et al. (2019) for Barangays Eden and Dibibi (Cabarroguis) are 359.85t/ha (Density=250trees/ha) and 1,319.32t/ha (Density=375trees/ha).

At the species level, *Shorea contorta* and *Pterocarpus indicus* individuals account for 46.87% of total Carbon fixed in all sampled plots (1,060.47 tons). However, on a "pound-for-pound" basis, Raintree (*Samanea saman*) was the most efficient Carbon Dioxide fixer among all listed species plots, with 31.90 tons of captured C per standing tree. Of all species, however, Binuang is thought to have the highest Carbon sequestration potential, given its rapid growth and maximum possible height (the tallest tree species in the collection).

With C_{AGB} to CO2 ratio of 3.664, the inventoried canopy trees would have fixed 2,262.66 tons of Carbon Dioxide. Extrapolating such figures to QFL's forest cover, the landscape has sequestered at least 219.74 Megatons of CO2 in closed forests; 82.03 Megatons in open forests. These figures, however, are less than what was reported by Brown (1997) for similar type of Forest in Monsson tropics.

Table 5

Total Estimates for Aboveground Biomass (AGB), stored Carbon and Carbon sequestered in the 12 Barangays of Quirino Forest Landscape

Parameter (Tons)	Total in Sample	per Tree	per Species	per ha
AGB	1,293.01	2.63	10.34	1,346.88
AGB+Root	1,551.61	3.16	12.41	1,616.26
Carbon in AGB	617.15	1.26	4.94	642.87
CO_2 Fixed	2,262.66	4.61	18.10	2,356.94
CO_2 Fixed by individuals of each Species	337.89	0.69	2.70	351.96

Utilization Values

Referring to various literature and websites (e.g., Fernando et al. 2004; Stuartexchange.net) and timber quality listings used by DENR (DAO, 2000-63, DAO, 2001-07), the researchers compiled important uses of some of the listed species in QFL barangays. The forested areas host five premium timbers, 10 Philippine Mahogany timbers, Rosewoods (Nato), 15 Furniture/Construction, and 95 underutilized species. The premium species in QFL represent one-fourths of listed Philippine species for said timber grouping. These are Narra, Bolong eta, Kamagong, Kalantas, and Dao.

The Philippine Mahogany group is composed of dipterocarps. Various groupings are being used by the DENR for *Dipterocarpaceae* as various species differ in strength and usefulness. Among the species encountered in QFL, the rarest were the endemic Red Lauan (*Shorea negrosensis*) and Dalingdingan (*Vatica*

mangachapoi).

A special group comprises the Nato trees (*Palaquium*). The DENR recognizes the genus' importance in the forestry industry as it is the main source of Gutta-Percha, a dense latex used for caulking and construction. The wood of Nato species (Nato, White Nato and Red Nato) is an excellent choice for furniture and paneling purposes.

The furniture or construction group is best represented in the QFL by Oaks (*Lithocarpus*) and Dungon (*Heritiera sylvatica*). These species produce very strong wood that may rival common timber species like Narra, Gmelina, and Large-Leafed Mahogany. Batikuling is a favorite in the wood carving industry and popular in the making of religious idols.

Lesser-used and lesser-known species in the QFL have potential cottage industry values. *Canarium luzonicum* (Piling-liitan) and may also open the market for its nutrient-rich nuts. Sapote (*Diospyros digyna*), Native Rambutan (*Nephelium ramboutanake*), Balinghasai (*Buchanania arborescens*), and Ligas (*Semecarpus cuneiformis*) are also some of the underutilized fruit-bearing species in the country. The usually ignored *Ficus variegata* and *F. nota* have syconia (fused fruit) that are a potential base for wine-making. Also, *F. nota* leaves are consumed as vegetables in other parts of the country.

Bamboos like Bolo, Kawayan-Kiling, and Bikal (*Dinochloa acutiflora*) are also widely-known furniture and construction materials found in abundant groves in Baguio Village, Ifugao Village, and many others.

Conservation Values

As per IUCN Red List (various versions) and DENR Administrative Order 2007-01, slightly more than a third (33.60%) of sampled canopy trees (43 species total) in the Quirino Forest Landscape Project require conservation effort. Species listed as Critically Endangered (Red List) are Guijo (*Shorea guiso*), White and Red Lauans (*Shorea contorta*, *S. negrosensis*), and Narra (*Pterocarpus indicus*). In consideration of endemism and level of endangerment, the assessment team forwards White Lauan (*Shorea contorta*) as the most critical species in the QFL.

For DAO (2007-01), other critically endangered species encountered in the QFL area are Kamagong (*Diospyros blancoi*), Malinoag (*D. brideliifolia*), and Dalingdingan (*Hopea foxworthyi*). Moreover, Vulnerable species under the DENR listing include Dao, Molave, Tanguile, Apo Oak, Balakat-Gubat White Launan, Kalingag, Red Nato, and Malak-Malak. Other Threatened Species found in QFL

are Bitongol (*Flacourtia rukam*) and Malakatmon.

Certain species have different national and worldwide conservation listings. White Lauan (IUCN = CR) is categorized as a step lower by DENR (Endangered). Pili (*Canarium luzonicum*), listed on the Red List as "vulnerable" species, is considered in DAO (2007-01) only as "Other Threatened Species." Bayanti (*Aglaia rimosa*) is listed in the IUCN Red List as "Not Threatened" but "Vulnerable" in DAO (2007-01).

While Mango (*Mangifera indica*) is included in the IUCN Red List as "Data Deficient," such species is deemed not threatened because it is a commercial fruit source. However, the sighted local mango species such as Paho (*Mangifera altissima*) and Balinghasai (*Buchanania arborescens*) are hardly known to the locales. Hence, there is the plausibility of community folk eliminating them in accessible parts of the forest.

In relation to the above, the endemism of certain species can also be used as a basis for conservation value (see Table 5). Some of the notable trees found only in the Philippines are Bagtikan (*Parashorea malaanonan*), Kamagong (*Diospyros blancoi*), Panau (*Dipterocarpus gracilis*), and Batikuling (*Litsea leytensis*). Species with the lowest IVs are likewise interpreted as species having critical populations or distributions in the QFL. These trees can be given local conservation value aside from those species with inter/national listings.

Conservation values of epiphytes are herein given highlight due to their dependence on certain species/environments, rarity, and other values. Notable species encountered in the QFL area were Pakpak-Lawin (*Asplenium nidus*), *Strongylodon elmeri*, *Telosma*, Gac (*Momordica cochicinensis*).

Asplenium nidus, a vulnerable fern under DENR (2001-01), grows in moist, humid, and closed forests. It is commonly sold ornamental in garden shops and highway stalls, especially along the Nueva Vizcaya - Nueva Vizcaya boundary. Bindanugan (*Strongylodon elmeri*; Figure 5), another vulnerable liana, is similar in color and habit to Tayabak or Jade Vine (*S. macrobotrys*), popular in the gardening world for its cyan-turquoise inflorescence. Sabidukong (*Telosma*) is a rather small vine that produces edible inflorescence. Such is a delicacy among the Ilocano people. Meanwhile, Gac Fruit, a relative of bitter gourd (Ampalaya, *Momordica charantia*), is gaining popularity in the wellness world as it is said to possess many therapeutic properties. Lastly, *Tetrastigma* is the only known host genus of the parasitic plant *Rafflesia* (Corpse Flower). *T. harmandii* was reported by Pelser et al. (2016) to host the corpse flower *Rafflesia speciosa* specifically. It is plausible that the corpse flower can thrive in the province. In Quirino, these epiphytic plants were found perched on crowns/branches of mature trees in forest peripheries.

Table 6

Summary of conservation values of identified trees in Quirino Forest Landscape barangays

Parameter	IUCN Red List		DENR AO 2007-01	
	Total in Sample	Relative Abundance (%)	Total in Sample	Relative Abundance (%)
Critically Endangered	3	2.40	2	1.60
Endangered				
Vulnerable	19	15.20		
Least Concern	13	10.40		
Data Deficient	4	3.20		
Other Threatened Species			1	0.80
Not Threatened	1	0.80		
TOTAL	40	32.00	3	2.40

CONCLUSIONS

This study attempted to provide Quirino Forest Landscape stakeholders, planners, policy-makers, and project managers with a concise but in-depth look into the various attributes of trees/timber resources critical to the continuity of forest functions. Results convey that forest landscape holds a plethora of ecologically - and economically important species. However, the relative openness and secondary nature (i.e., once logged-over areas) of most sites may imply that such forested portions of QFL are still prone to land-uses that can disrupt natural processes, following the argument by Brown and Gurevitch (2004). It is common knowledge nowadays that healthy diversity also promotes healthy ecosystem processes, but specific functions in the forests affected by species loss are yet to be understood (Nadrowski et al., 2010). in the context of QFL, further loss of forest cover and diversity may also drive the removal of beneficial processes before they can even be fully understood and utilized. The researchers adhere that preventive measures like forest protection, designation of multiple-use and strictly production zones, and forest cover enhancement should be implemented pending the conduct of more long-term and specific studies in QFL. While this paper is acknowledged as preliminary in nature, it is hoped that results will instill the much-needed appreciation of responsibility to Quirino's peoples as stewards of the rich natural resources they ought to enjoy for generations to come.

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