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A comparative study of tree community structure and natural regeneration status in Bontang urban forest and conservation forest of the LNG Industrial Plant Area, East Kalimantan, Indonesia

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Abstract. *Sudrajat S, Dwiputro M. 2019. A comparative study of tree community structure and natural regeneration status in Bontang urban forest and conservation forest of the LNG Industrial Plant Area, East Kalimantan, Indonesia. Biodiversitas 20: 2841-2847.* The objective of this study was to describe and compare the community structure and natural regeneration status of tree species in urban forests within industrial estates. This study was conducted in two types of forests, Bontang urban forests within industrial area and conservation forests in the Industrial buffer zone area. At each forest location, a transect was made, and along the transect, a plot of size 20 x 20 meters was made with a distance between plots of 100 meters. In each plot, several subplots were made with size of 5m x 5m for sapling level, and 2m x 2m for seedling level. The results of this study showed that in urban forest areas there were 32 tree-level species, 21 sapling species and 15 seedling species, belonging of 49 genera and 39 families. The number of species, species richness, species diversity, evenness of sapling and tree-level species was more in urban forests than in conservation forest, and the condition was vice versa for seedling level. The value of species dominance index in conservation forest was greater than urban forest, and conversely, the value of individual density/ha for tree-level was 562.50 individuals/ha, sapling level was 7,933 ind./Ha and for seeding level 80,625 ind./ha. Of the 53 urban forest species, 28 species (52.83%) were in no regeneration category, 3 species (5.66%) were in poor regeneration category, and 22 species (41.50%) were in the new species category. In contrast, among 76 species of the conservation forests, 8 species (10.52%) showed good regeneration status, 13 species (17.10%) showed poor status and 55 species (72.36%) showed no regeneration status. From the results, it can be concluded that the Bontang urban forest in the industrial area shows no regeneration status and the emergence of new species. In the context of conservation, it is recommended to implement special silvicultural techniques to maintain the biodiversity of this urban forest.

Keywords: Industrial estate, natural regeneration, tropical rainforest, urban forest

INTRODUCTION

The Bontang urban forestry, which is located in the industrial area of a liquefied natural gas refinery, is considered as an ecosystem that has rich and unique flora and fauna, and many commercially and historically valuable tree species, as the rest of the lowland tropical forest ecosystems of East Kalimantan. This forest is the result of fragmentation since 1972 from its main habitat, Kutai National Park. The urban forest is currently very well-protected and keeps showing a picture of the lowland type of Dipterocarpaceae primary forest. This condition is due to the the very tight security provided by the company's security forces for this region.

Based on the estimated age of trees carried out by Zuhud et al. (1995), there exists several species of trees older than 100 years, such as *Canarium caudatum*., *Litsea* spp., *Bischofia* spp., *Eugenia* spp., *Lophopetalum* spp., *Ficus spp.* etc. The estimated age of a *Canarium caudatum* tree is 535 years. There are 18 protected species located in this area, namely: *Alstonia scholaris, Aquilaria malaccensis, Diospyros buxifolia, Diospyros coriacea, Diospyros rigidus, Diospyros sumatrana, Diospyros toposioides, Drybalanops sp., Duabanga moluccana, Dyera costulata, Eurycoma longifolia, Eusideroxylon zwageri, Fagraea fragrans, Flacourtia rukam, Ganua motleyana, Lophopetalum beccarianum, Shorea leprosula,* and *Styrax macrocarpa*. From the inventory, theoretically, there are potential areas for other planting activities in this urban forest area.

Mishra et al. (2013) has stated that the assessment of the structure and composition of forest communities is very important to understand the condition of tree populations, their regeneration capabilities.. Natural regeneration is one of the factors that can change the stand structure of tree species growing, the number of trees, the location and composition of trees over time (Kusmana and Susanti 2015). Therefore, understanding the status of regeneration and how it influences the abiotic and biotic factors is important for ecological studies. The natural ability of forests to regenerate species is the key to the ecosystem to be able to continue carrying out its functions. The process of regenerating a species is largely determined by the seed production process and its spread, germination power, and its growth power from seed to adulthood. Regeneration is a recovery process that occurs in the forest where trees that have died naturally or due to wind exposure, flooding, logging will be replaced by new individuals. Dead trees that have seed banks, will be replaced by seedlings of the same plant species. Light tolerant species regenerate quickly and survive into adulthood. But the seedlings of light intolerant species will experience dormancy and regeneration will occur only under shaded conditions.

Maintenance of forest stands with sufficient regeneration is the main target in conservation ecology. The existence of strict protection by industrial companies for fragments of the urban forest is very helpful for ensuring their sustainability, but because of their isolation from original forest, reproductive capacity may be affected resulting in a typical regeneration status. Information about the structure and composition of the community as well as the regeneration status of this forest type has never been reported. It is also very interesting to study how the community constituents of isolated forest fragments and the regeneration ability of each species in them. The results of this study are expected to be helpful inputs for determining management strategies and policies of Bontang urban forest areas in order to ensure their sustainability.

MATERIALS AND METHODS

Location and characteristics of study areas

Geographically, Bontang City is located between 117°23' and 117°38' East and between 0°01' and 0°12' North. The location of Bontang Urban Forest is in the area of PT Badak Natural Gas Liquefaction covering ± 7.4 hectares, and located in geographical coordinate points of N 0°06'5" and E 117° 30' (Figure 1). This area was designated as Bontang City forest on 31 May 2012 based on the Bontang Government Decree No. 259/2012 on Determination of Natural Forests of PT. Badak NGL as Green Open Space or Urban Forest.

The soil type is dominated by yellow, alluvial and latosol complex red pod solid. This soil has topsoil that is thin and sensitive to erosion and nutrient-poor. Based on the Schmidt and Ferguson classification, this region has type B climate with Q values ranging from 14.3 to 33.3%. From the data at the observation station in the Bontang area, the average annual rainfall is 1543.6 mm and the average temperature is 26°C (ranging from 24 to 33°C) with a relative humidity of 67-98%.

Sampling method

Sampling is carried out in the Bontang urban forest (Location A) which is in the Liquefied Natural Gas plant environment and the conservation forest managed by the company in the buffer zone between the company area and the outside environment (Location B). Field data collection is carried out with a plot transect system to make a path along the field contour. The lines are made of 6 transects (2 transects at Location A and 4 transects at location B) with a length of 500 m or more and 20 m wide, with a distance of 200 m in between. In the transect, observation plots are made intermittently with a distance of 100 m between each plot. In each plot, several subplots are made, namely a 20m x 20m plot for tree-level samples, 5m x 5m for the sapling level, and 2m x 2m for seedling levels.

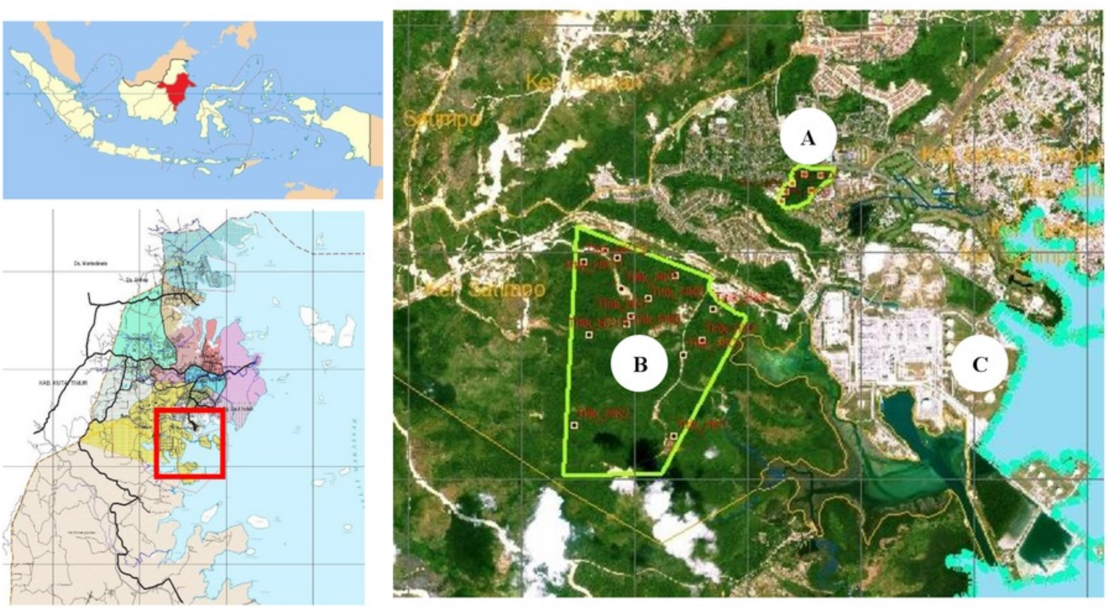

Figure 1. Study plots at Urban Forests in the liquefied natural gas industry area in Bontang, East Kalimantan, Indonesia. A. Natural forest isolated in the area of LNG plant, B. Company conservation forest area, C. Operational area ofl natural gas liquefaction plant

Along the paths in the plot, the types found from the lower plants to the large and small trees are recorded. Plants are divided into seedlings, saplings and trees (Pudyatmoko et al. 1997; Sing et al. 1986; Dhar et al. 1997; Kusmana 1997; Ngo et al. 2017). The size class categories are "seedling level", i.e. the regeneration of tree species (dbh <2 cm and height <150 cm); "Sapling level", i.e. above 150 cm high and chest height> 2cm to <10cm, and "tree level", i.e. diameter at breast height >10 cm. The species of plants that cannot be identified in the fields, are identified using herbarium, in the laboratory of the Dendrology Faculty of Forestry University Mulawarman Samarinda.

Data analysis

The value of density, frequency and important values are analyzed based on the formula of Cox (1976). The diversity of tree species is calculated based on (i) diversity index of Shannon (H'), and (ii) evenness index (Mueller-Dombois and Ellenberg 1974). Species importance level in each location is calculated by adding relative values of frequency, density and dominance. Data used for the analysis of tree species regeneration status consists of family, species name, number of trees, the population of sapling and seedling levels of each species. Criteria used for assessing species regeneration status was according to Malik and Bhatt (2016) which is as follows: tree species are declared as having "good" regeneration status, if seedling level population> tree>, "fair" if seedling level population> or ≤ stake ≤ tree, "poor" if there is only sapling level individuals, no seedlings (seedlings <,> or = tree), "no regeneration" if there is only tree level, saplings and seedlings are not found, and "newcomer species " if there are no trees but only saplings and or seedlings .

RESULTS AND DISCUSSION

Forest community composition and structure

Analysis of species composition in the sampling plots of two remnant forest fragments studied (Locations A and B), revealed that the number of tree species ranged between 10 and 32, number of sapling level species ranged between 3 and 21, and sapling level ranged between 7 and 34. The values of density, relative density, relative frequency, species richness, important values of species, species diversity index, dominance index, and evenness index are presented in Table 1. Based on the data in Table 1, forest fragments in buffer zones of industrial forest conservation companies had an average density of 491 trees/ha, 3,725 saplings/ha and 69,218 seedlings/ha, , and 562 trees/ha, 7,933 saplings/ha, and 80,625 seedlings/ha, in Bontang urban forest.

Table 1. Structure and composition of trees in the Bontang Urban Forest of the Industrial and Conservation Forest of the buffer zone of the Liquid Natural Gas Industry area, East Kalimantan, Indonesia

Parameter	Location							
	Conservation Forest in Buffer Zone					Bontang Urban Forest		
	1	2	3	4	Average	1	2	Average
Total Species								
Seedling	34	15	26	7	20.50	15	14	14.50
Sapling	20	15	15	3	13.25	17	21	19.00
Tree	20	32	39	10	25.25	32	27	29.50
Important species index values (%)								
Seedling	200	200	200	200	200	200	200	200
Sapling	200	200	200	200	200	200	200	200
Tree	100	300	300	300	250	300	300	300
Density (Ind/Ha)								
Seedling	100,625	92.500	35,000	48,750	69,218	50.000	111.250	80,625
Sapling	4,500	5,200	4,400	800	3,725	7,467	8,400	7,933.50
Tree	444	525	550	488	491,75	625	500	562.50
Species Richness Index (R)								
Seedling	6.49	2.97	6.21	1.64	4.32	3.42	2.90	3.16
Sapling	4.99	3.82	3.70	1.44	3.48	3.97	5.35	4.66
Tree	4.66	7.48	8.49	2.46	5.77	7.18	7.32	7.25
Species diversity index(H')								
Seedling	2.95	2.01	2,.8	1.64	2.39	2.33	1.64	1.98
Sapling	2.70	2.45	2.35	1.04	2.13	2.42	2.74	2.58
Tree	2.38	2.99	3.31	2.01	2.67	3.12	3.23	3.17
Dominance Index C)								
Seedling	0.09	0.21	0.07	0.23	0.15	0.13	0.30	0.21
Sapling	0.09	0.11	0.13	0.38	0.17	0.13	0.09	0.11
Tree	0.15	0.08	0.05	0.16	0.11	0.06	0.04	0.05
Species evenness index (e)								
Seedling	0.84	0.74	0.92	0.84	0.83	0.86	0,62	0.74
Sapling	0.90	0.90	0.87	0.95	0.90	0.85	0.90	0.87
Tree	0.80	0.86	0.90	0.87	0.85	0.90	0.97	0.93

Note: 1,2,3: Numbers of observation transects

Table 2. Regeneration status of tree species of Bontang Urban Forest in the Industrial Area of the Liquid Natural Gas Industry, East Kalimantan, Indonesia

No	Family	Species	Density (ind/ha)			Status regeneration
			Tree	Sapling	Seedling	
1	Lecythidaceae	*Planchonia grandis* Ridl	75			No
2	Apocynaceae	*Alstonia scholaris* (L.) R. Br	33			No
3	Hypericaceae	*Cratoxylum formosum* (Jack) Benth. & Hook.f. ex Dyer.	83	267		poor
	Dipterocarpaceae	*Vatica umbonata* (Hook.f.) Burck.	25			No
	Dipterocarpaceae	*Shorea smithiana* Sym.	17			No
	Dipterocarpaceae	*Shorea leprosula* Miq.	17			No
	Dipterocarpaceae	*Anisoptera costata* Korth.	8			No
	Dipterocarpaceae	*Shorea ovalis* Blume	8			No
	Dipterocarpaceae	*Shorea elliptica* Burck.			833	New
5	Theaceae	*Schima wallichii* (DC.) Korth	33			No
6	Chrysobalanaceae	*Licania splendens* (Korth.) Prance & Kosterm	25			No
7	Rubiaceae	*Breonia chinensis* (Lam.) Capuron	17			No
	Rubiaceae	*Tarenna costata* Merr.	8			No
8	Lauraceae	*Actinodaphne macrophylla* (Blume) Nees.	17			No
	Lauraceae	*Litsea elliptica* Blume		400		New
9	Centroplacaceae	*Bhesa paniculata* Arn.	17			No
10	Burceraceae	*Dacryodes rostrata* (Bl.) H.J. Lam	17			No
11	Clusiaceae	*Garcinia beccarii* Pierre.	8			No
12	Asteraceae	*Vernonia arborea* Buch.	8			No
13	Euphorbiaceae	*Macaranga recurvata* Gage	8			No
	Euphorbiaceae	*Endospermum diademum* (Miq.) Airy Shaw	8			No
	Euphorbiaceae	*Macaranga pruinosa* (Miq.) Mûll.Arg	8			No
	Euphorbiaceae	*Macaranga gigantea* (Reichb.f. & Zoll.) Mull.Arg.	17			No
	Moraceae	*Artocarpus* sp.	8			No
14	Fabaceae	*Fordia brachybotrys* Merr		1.200	5.000	New
	Fabaceae	*Spatholobus ferrugineus* (Zoll & Moritzi) Benth.			2.500	New
	Fagaceae	*Lithocarpus lucidus* (Roxb.) Rehder	8	133		poor
15	Celastraceae	*Siphonodon celastrineus* Griff	8			No
16	Annonaceae	*Hydnocarpus polypetala* (Sloot.) Sleum.	8			No
17	Chrysobalanaceae	*Maranthes corymbosa* Bl	8			No
18	Lecythidaceae	*Barringtonia macrostachya* (Jack) Kurz.	8			No
19	Malvaceae	*Sterculia rubiginosa* Zoll.	8			No
20	Cannabaceae	*Gironniera nervosa* Planch.	8	267		New
21	Combretaceae	*Terminalia foetidissima* Griff	8		83	poor
22	Vitaceae	*Leea indica* (Burm.f.) Merr.		2.13	3.333	New
23	Myrtaceae	*Syzygium palawanense* (C.B.Rob.) Merr. & Perry.		667	1.667	New
	Myrtaceae	*Rhodamnia cinerea* Jack.		267		New
24	Dilleniaceae	*Dillenia reticulata* King.		267		New
25	Celastraceae	*Siphonodon celastrineus* Griff.		400		New
26	Celastraceae	*Bhesa paniculata* Arn.		133		New
27	Sterculiaceae	*Leptonychia caudata* (Wall. ex G.Don) Burret		267		New
28	Myristicaceae	*Myristica elliptica* Wall. ex Hook.f. & Thomson		267		New
29	Sapotaceae	*Palaquium dasyphyllum* Pierre ex Dubard		267		New
30	Olacaceae	*Strombosia javanica* Blume		245	1.667	New
31	Moraceae	*Artocarpus* sp.		133		No
32	Salicaceae	*Flacourtia rukam* Zoll. & Mor.		140		No
33	Marantaceae	*Stachyphrynium repens* (Körn.) Suksathan & Borchs.			12.500	New
34	Passifloraceae	*Adenia macrophylla* (Blume) Koord			5.000	New
35	Araceae	*Epipremnum amplissimum* (Schott) Engl.			3.333	New
36	Lygodiaceae	*Lygodium circinatum* (Burm.) Sw.			2.500	New
37	Poaceae	*Cyrtococcum patens* (L.)			833	New
38	Dioscoreaceae	*Dioscorea* sp.			833	New
39	Sapindaceae	*Lepisanthes amoena* (Hassk.) Leenh			833	New

Table 3. Regeneration status of trees in the conservation forest of the buffer zone of the Liquid Natural Gas Industry area, East Kalimantan

No	Family	Species	Density (Ind/ha)			Status
			Tree	Sapling	Seedling	regeneration
1	Dipterocarpaceae	*Shorea johorensis* Foxw	42	92	7,692	good
	Dipterocarpaceae	*Shorea smithiana* Sym	38	-	-	No
	Dipterocarpaceae	*Shorea ovalis* (Korth.) Bl	17	-	-	No
	Dipterocarpaceae	*Shorea grandiflora* Brandis	6	-	-	No
	Dipterocarpaceae	*Shorea* sp.	2	92	192	good
	Dipterocarpaceae	*Dryobalanops lanceolata* Burck	2	-	-	No
2	Euphorbiaceae	*Macaranga gigantea* (Reichb.f. & Zoll.) Mull.Arg	44	-	-	No
	Euphorbiaceae	*Croton griffithii* Hook	4	62	1,346	good
	Euphorbiaceae	*Blumeodendron tokbrai* (Bl.) Kurz	4	-	-	No
	Euphorbiaceae	*Macaranga tanarius* (L.) Mull.Arg	2	215?	-	poor
3	Lamiaceae	*Vitex pinnata* L	40	62	2,308	good
4	Moraceae	*Artocarpus elasticus* Reinw. ex Blume	19	92	-	poor
	Moraceae	*Ficus variegata* Blume	2	62?	577	good
	Moraceae	*Artocarpus lakoocha* Roxb	2	92?	-	poor
	Moraceae	*Artocarpus tamaran* Becc	2	-	-	No
	Moraceae	*Ficus stricta* (Miq.) Miq	2	-	-	No
	Lauraceae	*Phoebe* sp.	6	-	-	No
5	Fagaceae	*Lithocarpus sundaicus* (Blume) Rehd.	10	-	192??	No
	Fagaceae	*Lithocarpus blumeanus* (Korth.) Rehd	6	-	-	No
6	Malvaceae	*Sterculia rubiginosa* Zoll. ex Miq	12	-	-	No
	Malvaceae	*Pterospermum javanicum* Jungh	8	-	-	No
	Malvaceae	*Pentace triptera* Mast	2	-	-	No
7	Lecythidaceae	*Barringtonia macrostachya* (Jack) Kurz	12	-	-	No
	Lecythidaceae	*Planchonia grandis* Ridl	15	-	-	No
8	Fabaceae	*Acacia auriculiformis* A.Cunn. ex Benth	13	-	-	No
	Fabaceae	*Archidendron jiringa* (Jack) Nielsen	6	62	192	good
	Fabaceae	*Dialium indum* L	6	-	-	No
	Fabaceae	*Cassia siamea* Lam	4	-	-	No
	Fabaceae	*Adenanthera borneensis* Brace ex Prain	2	-	-	No
9	Myrtaceae	*Syzygium* sp.	8	277	962	good
	Myrtaceae	*Syzygium hirtum* (Korth.) Merr. & Perry	4	62	-	poor
	Myrtaceae	*Vernonia arborea* Buch.-Ham. ex Buch.-Ham	4	-	-	No
	Myrtaceae	*Syzygium palawanense* (C.B.Rob.) Merr. & Perry	2	31	-	poor
	Myrtaceae	*Syzygium tenuicaudatum* Merr. & Perry	2	-	-	No
10	Burseraceae	*Dacryodes rostrata* (Bl.) H.J. Lam	10	92	-	poor
	Burseraceae	*Santiria grandiflora* Kalkman	6	-	-	No
11	Annonaceae	*Polyalthia rumphii* (Bl.) Merr	8	-	-	No
	Annonaceae	*Polyalthia* sp.	4	-	-	No
12	Rubiaceae	*Nauclea officinalis* (Pierre ex Pitard) Merr. & Chun	4	31	192	good
	Rubiaceae	*Gardenia tubifera* Wall	2	-	-	No
13	Cannabaceae	*Gironniera subaequalis* Planch	4	-	3,462	**No**
14	Sapotaceae	*Palaquium dasyphyllum* Pierre ex Dubard, Bull	6	92	-	poor
15	Ebenaceae	*Diospyros borneensis* Hiern	6	92	-	poor
16	Anacardiaceae	*Campnosperma coriaceum* (Jack) Hall.f	4	-	-	No
	Anacardiaceae	*Buchanania arborescens* (Blume) Blume	4	-	-	No
	Anacardiaceae	*Gluta* sp	2	-	-	No
	Anacardiaceae	*Dracontomelon costatum* Bl	2	-	-	No
	Anacardiaceae	*Semecarpus* sp.	2	-	-	No
17	Oxalidaceae	*Sarcotheca macrophylla* Blume	4	92	-	poor
18	Irvingiaceae	*Irvingia malayana* Oliv	2	-	-	No
19	Hypericaceae	*Cratoxylum formosum* (Jack) Benth. & Hook	4	-	-	No
20	Thymelaeaceae	*Aquilaria malaccensis* Lamk	2	-	-	No
21	Apocynaceae	*Cerbera manghas* L	4	-	-	No
22	Celastraceae	*Lophopetalum beccarianum Pierre* & Ridl	2	-	-	No
23	Meliaceae	*Swietenia macrophylla* King	4	-	-	No
	Meliaceae	*Aglaia crassinervia* Kurz ex Hiern	2	-	192	**No**
	Meliaceae	*Walsura pachycaulon* T.P.Clarck	2	-	-	No
	Meliaceae	*Carapa guianensis* Aubl	2	-	-	No
24	Theaceae	*Schima wallichii* (DC) Korth	2	-	-	No
25	Hypericaceae	*Cratoxylum sumatranum* (Jack) Blume	4	-	-	No
26	Myristicaceae	*Myristica smythiesii* J.Sinclair, Gard	2	-	-	No
	Myristicaceae	*Knema hirtella* W.J.deWilde	2	62	-	poor

27	Dilleniaceae	*Dillenia borneensis* Hoogl	2	-	385	
28	Annonaceae	*Cyathocalyx deltoideus* (Airy Shaw) R.J. Wang & R.M.K. Saunders	2	62	-	Poor
	Annonaceae	*Miliusa macropoda* Miq	2	-	-	No
	Annonaceae	*Cyathocalyx magnifructus* R.J.Wang & R.M.K.Saunders	2	-	-	No
	Annonaceae	*Cyathocalyx virgatus* (Bl.) King	2	-	-	No
29	Rubiaceae	*Neonauclea calycina* (DC) Merr	2	-	-	No
	Rubiaceae	*Diplospora malaccensis* Hook	2	31		Poor
30	Lauraceae	*Cinnamomum parthenoxylon* (Jack) Meisn	2	-	-	No
	Lauraceae	*Cinnamomum iners* Reinw. ex Blume	2	-	-	No
	Lauraceae	*Litsea* sp.	2	31	-	Poor
	Lauraceae	*Cryptocarya impressa* Miq	2	-	-	No
31	Rosaceae	*Prunus beccarii* (Ridl.) Kalkman	2	-	-	No
32	Phyllanthaceae	*Baccaurea tetrandra* (Baill.) Mull.Arg	2	-	-	No
33	Chrysobalanaceae	*Licania splendens* (Korth.) Prance	2	-	-	No

The average Margallef (R) richness index values for the level of trees, saplings and seedlings in conservation forests in the buffer zone ranged between 3.48 and 5.77 (medium to high). In Bontang urban forest, the species value (R) for the tree level was 7.25 (high), for sapling level was 4.66 (medium) and for seedling level was 3.16 (low). This condition illustrates that in urban forests there were more species richness of trees than seedlings and saplings. The Bontang urban forest in the company area had more tree species than conservation forests in the Industrial buffer zone.

The tree-level biodiversity (H') index value in each sample plot was classified as moderate to high with a value of 1.5. > 3, seedlings and saplings were classified as moderate with H' values between 2 to 3. Dominance index values (C) for all growth stages were low with values of 0 <C <0.5. Evenness index value (e) of all growth stages were found to be almost even with e values between 0.76 and 0.96. This may be due to the relatively similar number of specify species of forest fragments, so that competition between species was relatively low.

Regeneration status

According to the regeneration status based categories proposed by Malik and Bhatt (2016), among 76 species of trees recorded from the conservation forest of the buffer zone area, 8 species (10.52%) showed good regeneration status, 13 species (17.10%) showed poor status and 55 species (72.36%) showed no regeneration status. Tree species that showed good regeneration included *Shorea johorensis, Shorea* sp., *Croton griffithii, Vitex pinnata, Ficus variegata, Archidendron jiringa, Syzygium* sp. and *Nauclea officinalis.* Among the seven Dipterocarpaceae species, only two species, namely *Shorea* sp. and *Shorea johorensis,* had good regeneration status.

Among the 53 tree species found in Bontang urban forest, none showed good regeneration status, 28 species (52.83%) showed no regeneration status, 3 species (5,669%) showed poor regeneration and 22 species (41.50%) belonged to generation of new species. All the 7 Dipterocarpaceae species recorded including *Vatica umbonata, Shorea leprosula, S.ovalis, S.johorensis, S.smithiana, S.elliptica* and *Anisoptera costata* showed no regeneration status (Table 2, Table 3).

The problem of lack of regeneration, especially for Dipterocarpaceae plants, is in line with Yasman (1994) and Smits (1986) stating that Dipterocarpaceae seeds are recalcitrant so they cannot be stored for a long time, while erratic flowering and fertilization ranges from 4-5 years once or every 5-13 years. Due to this condition, seeds are not available every year. Therefore, it was difficult to find seedlings of Dipterocarpaceae species. Inability to find any mother trees that was flowering or bearing fruit is an indicator that the trees are facing difficulties in flowering in urban forests, and also in conservation forest areas of the buffer zone. Among the seven species of Dipterocarpaceae, only two seedling species were found, namely *Shorea* sp. and *Shorea johorensis.*

Discussion

Understanding the ecology of the old forest and maintaining its distinctive biological diversity requires a very long and extensive study of its various aspects. The process of natural regeneration of forest ecosystems is a parameter that plays an important role in the sustainability of the structure and composition of its plant species. The long history of the formation of forest fragments in Bontang City has included the environment of the liquefied natural gas refinery industry since the 1970s. Without being disturbed by the company, this forest exists as representative of lowland tropical forest in East Kalimantan. Tree density is 562 Ind./ha, sapling density is 7,933 Ind./ha and seedlings and understorey density is 80,625 Ind./ha. The average species richness of trees in the urban forest is high (R> 5), but the sapling is in a moderate status (R = 4.66) and the seedling level is low (R <3.16). The average tree diversity index value is in high category (H' > 3) and the sapling and seedling diversity conditions are in moderate status (H' between 2-3). The average value of evenness is quite even (e between 0.76 - 0.96), but the dominance index is low for all tree stratification, sapling and seedlings (C values <C <0.5).

Some tree species show lack of regeneration in the Bontang urban forest area which is in the liquefied natural gas refinery industry, namely *Planchonia grandis* Ridl, *Alstonia scholaris* (L.) R.Br, *Cratoxylum formosum* (Jack) Benth. & Hook.f. ex Dyer., *Vatica umbonata* (Hook. f.) Burck, *Shorea smithiana* Sym, *Shorea leprosula* Miq, *Anisoptera costata* North. *Shorea ovalis* Blume, *Schima wallichii* (DC.) Korth, *Licania splendens* (Korth.) Prance & Kosterm, *Breonia chinensis* (Lam.) Capuron, *Tarenna costata* Merr, *Actinodaphne macrophylla* (Blume) Nees.*Bhesa paniculata* Arn.*Dacryodes rostrata* (Bl.) HJ Lam,*Garcinia beccarii* Pierre. *Vernonia arborea* Buch. *Macaranga recurvata* Gage, *Endospermum diadenum* (Miq.) Airy Shaw, Macaranga pruinosa (Miq.) Műll. Arg, *Macaranga gigantea* (Reichb.f. & Zoll.) Mull. Arg., *Artocarpus* sp. *Siphonodon celastrineus* Griff, *Polypetala hydnocarpus* (Sloot.) Sleum., *Maranthes corymbosa* Bl, *Barringtonia macrostachya* (Jack) Kurz., *Sterculia rubiginosa* Zoll.

The aforementioned conditions illustrate that the regeneration process of native tree species is hampered by various factors including the availability of seeds, seed predation, seed dispersal, and seed formation (Shono et al. 2006). Floristic and structural composition of forests will change from one community state to another community state simultaneously with the ability to compete with the existing seedlings to become their next-generation (Barker and Kirkpatrick 1994). Natural regeneration can take place through the formation of seeds and shoots from stumps to produce high-quality forests with high biodiversity (Yang et al. 2014). Factors that effectively determine the success of regeneration include seed availability, soil cover, seed growth status, tree stand cover, tree canopy average, organic matter content in the soil, soil reaction, rainfall and variation in growth requirements (Özel et al. 2010; Smith et al. 2016). Meanwhile, Khaine et al. (2018) reported that in Myanmar's tropical rainforest the average annual rainfall (abiotic) factors, as well as ecosystem complexity, density, species richness, and overstory were found to be the most influential factors for density and diversity of natural forest regeneration.

From the description above, to make older forests to regenerate, there must be enough seeds that can grow into seedlings. This condition requires seed spreading agents that can move from one forest fragment to other forest fragments. Besides, the availability of seedlings is often incidental and depends on the condition of the soil, remaining standing density, the composition of stand species that produce their seeds, and climatic conditions when seeds are available and growing, light intensity, and shade tolerance. The condition of isolated urban forests from their parent habitat makes these agents may not be available in sufficient quantities. It is considered to cause the unavailability of seedlings and saplings of the same species as the parent tree.

In general, the study has shown that Bontang urban forest located within the area of the liquefied natural gas refinery company is in very poor or low natural regeneration status. The low level of natural regeneration of certain species, theoretically shows that the population of these species is in a phase of degradation and can threaten the sustainability of species in the future. The density of seedlings and saplings of each species varies, resulting in different regeneration patterns. Based on these data, it can be concluded that natural regeneration alone may not be sufficient to maintain the desired stock of each species to be maintained, and immediate restoration steps must be taken to assist the natural regeneration process.

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