

## High Species Diversity of the Family Dipterocarpaceae in Mursala Island, Indonesia

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**Abstract**— Known to have a long history of timber extraction, Mursala Island on the west coast of North Sumatra Province is a small island home to the endemic tree *Dipterocarpus cinereus* and many other *Dipterocarpaceae* species. In the present study, distance sampling using line-transect was used to assess the species diversity and population status of *Dipterocarpaceae* species on the Island. A total of 26 *Dipterocarpaceae* species from 6 genera was identified from Mursala Island. The genus that was represented by the highest number of species was *Shorea* (13 species), followed by *Vatica* (5), *Dipterocarpus* (4), *Hopea* (2), *Cotylelobium* (1) and *Dryobalanops* (1). Among these, two Mursala Island endemic were identified: *D. cinereus* and *H. bancana*. Furthermore, according to IUCN Red List category, 11 species (42.3%) were classified as critically endangered, four species (15.4%) were of endangered, 5 species (15.2%) were of vulnerable, one species was of near threatened, 2 species were of least concern and 3 species were not assessed yet. Based on distance analysis, the species with the highest individual density was *S. multiflora* ( $21.72 \pm 10.96$  individual/ha), whereas species with the lowest density was *S. johorensis* ( $0.06 \pm 0.01$  individual/ha). Two main threats for *Dipterocarpaceae* species in Mursala Island were observed during the survey: illegal logging and habitat conversion. Increasing the protection level of the island was recommended to conserve all the species of *Dipterocarpaceae*. Besides, providing alternative sources of living for the illegal logger through commercialization of non-timber forest products, ecotourism, and the sustainable fishery was recommended so that they could stop illegal logging activity.

**Keywords**— *Dipterocarpaceae*; *Dipterocarpus cinereus*; distance sampling; endemic tree; *Hopea bancana*; Mursala Island.

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### I. INTRODUCTION

*Dipterocarpaceae* is one of the biggest tree family with >500 species in the world [1]-[3]. It is a pantropical family, distributed in the lowlands and hills of the tropics below 1800 m [3]. The family includes three subfamilies: *Monotoideae* in Africa and South America, *Pakaraimoideae* in South America, and *Dipterocarpoideae* in Asia [2]. The species from the last subfamily were mainly found in the Malesian region (ca. 386 species) [1].

In Indonesia, there were 238 species of *Dipterocarpaceae* or 62% of the Malesian species, with Kalimantan (200 species) and Sumatra (111 species) being the center of the diversity [1]. Most of these species are in lowland forests below 1500 m, an area with a high rate of tree cutting and forest conversion. Consequently, a total of 151 species

(63.4%) of Indonesian *Dipterocarpaceae* are included as threatened species by IUCN Red List [4].

Known to have a long history of timber extraction, Mursala Island on the west coast of North Sumatra Province is home to the endemic *Dipterocarpus cinereus* and many other *Dipterocarpaceae* species. Due to this extensive timber extraction, Ashton [5] declared that *D. cinereus* was extinct in the wild in 1998. A team from Bogor Botanic Gardens – LIPI, however, reported the rediscovery of the species in 2013 [6]. Additional explorations at the end of 2013 [7] and 2017 [8] have been conducted on the island confirming the present of the species. Besides, these explorations reported the presence of other 22 species of *Dipterocarpaceae*. This high richness of *Dipterocarpaceae* has made the island one of the hotspots for *Dipterocarpaceae* biodiversity.

As previous studies only covered small areas of the west part of Mursala Island, further studies that cover wider areas

are needed to reveal the current status of *D. cinereus* and to assess *Dipterocarpaceae* diversity of the island. This information is crucial for conservation planning and actions of all these species as illegal cutting and timber extraction on the island are still ongoing at an alarming rate. Thus, in the present study, distance sampling using line-transect will be used to assess the *Dipterocarpaceae* population in Mursala Island. The objectives are to i) assess the diversity and distribution of *Dipterocarpaceae* in the island, ii) assess the population structure of all the species, iii) estimate the density of all the species based on distance sampling applied, and iv) identify all threats that may threaten all the *Dipterocarpaceae* species and their habitat.

## II. THE MATERIALS AND METHOD

### A. Study Area

Covered a total area of 8000 ha, Mursala Island is the largest island in the District of Central Tapanuli. It is located

at the west coast of the province of North Sumatera (01°35'15" - 2°22'0" N and 98°38' - 37°12' E), between Nias Island and the town of Sibolga (Fig. 1). Hilly areas dominate the island with the highest point of 500 m above sea level. The average temperature and humidity are 26.7°C and 75%, respectively [8]. The average precipitation between 2009-2016 is 12.96 mm/year, with the average number of rainy days is 261 days/year [9].

### B. Field Survey

To assess the population structure and estimate the population density of all *Dipterocarpaceae* species in Mursala Island, distance sampling using line-transect (Buckland et al. 2000) was used. A total of 8 line transects were purposively laid in the Island (Fig. 1) with the selection of the first point for each transect was merely based on the availability of a safe place for boot landing on the beach.

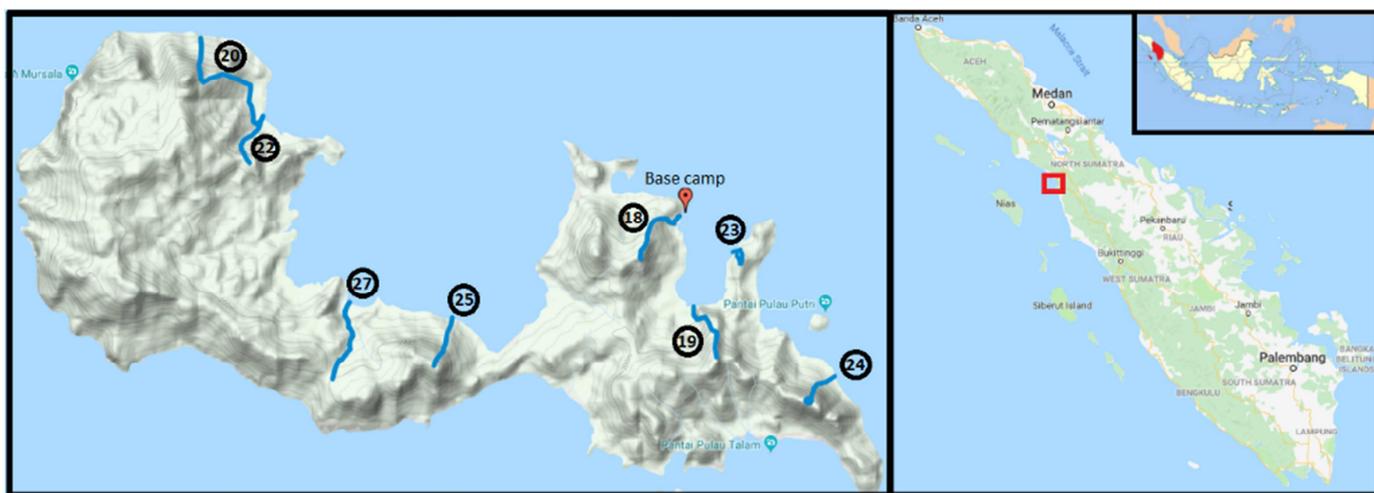


Fig. 1 Location of Mursala Island in District of Central Tapanuli, North Sumatera Province. Blue lines and its numbers are line transects used in the study

The length and elevation range of each transect were presented in Table 1.

TABLE I  
PROFILE OF LINE TRANSECTS USED IN MURSALA ISLAND

No	Transect	Length (km)	Elevation
1	18	1.68	0-300
2	19	1.46	0-360
3	20	3.21	0-320
4	22	1.07	10-260
5	23	0.76	0-100
6	24	1.13	0-360
7	25	1.12	0-330
8	27	1.89	0-200

Along each transect, *Dipterocarpaceae* species were searched for by one assigned observer moving along the transect line. The perpendicular distance from the transect to each tree sighted was recorded using Laser Distance (Leica

Disto D2 NEW), and diameter at breast height (dbh) measurements were taken at 1.3 m above the ground using a diameter tape. Furthermore, the following environmental factors were also measured: elevation, slope, aspect, and terrain features (valley, slope, and ridge). For endemic species (*D. cinereus* and *Hopea bancana*), soil samples near the tree were collected to characterize the soil pH, C, N dan P content.

### C. Data Analysis

The density of each species was estimated using Distance 7.1 Release 1 software [10]. Four model types (half-normal, hazard-rate, uniform, and negative-exponential), each with cosine, simple *polynomial*, and *Hermite polynomial* adjustments, were fitted to each population. The selection of the most appropriate detection function was based on the minimum Akaike Information Criterion (AIC) [11], [12].

## III. RESULTS AND DISCUSSION

### A. Species Richness and Distribution

Using a total of 8 line transects, 26 species of *Dipterocarpaceae* in Mursala Island were able to be identified. Genus that was represented by the highest number of species was *Shorea* (13 species), followed by *Vatica* (5), *Dipterocarpus* (4), *Hopea* (2), *Cotylelobium* (1), and *Dryobalanops* (1). Among these, two Mursala Island endemic species were identified: *D. cinereus* (Fig. 2) and *H. bancana* (Fig. 3). Furthermore, according to IUCN Red List Category, 11 species (42.3%) were classified as critically endangered, four species (15.4%) were of endangered, five species (15.2%) were of vulnerable, one species was of near threatened, two species were of least concern and three species were not assessed yet.



Fig. 2 Trunk, leaves and fruit morphology of *Dipterocarpus cinereus*.



Fig. 3 Trunk, leaves and fruit morphology of *Hopea bancana*

The number of species identified in the present study was higher compared to of 22 species found by previous studies [6]–[8]. It was also higher compared to the number of 24 species recorded at the *Herbarium Bogoriense*. In addition, the *Dipterocarpaceae* diversity of the Island was much higher compared with other small islands around the mainland Sumatra. Siberut Island, for example, held 20 species of *Dipterocarpaceae* [13] and Enggano Island with only 5 species [14]. Furthermore, Lingga, Singkep, Batam, Bintan, and Bunguran of Riau Islands respectively had 13, 2, 7, 10, and 21 species [15].

Each species had its pattern of distribution on the island (Table 2). *Shorea atrinervosa* was species with the most widespread distribution. It was found at all eight line-transects used in the present study. The next species with widespread distribution were *D. cinereus*, *S. acuminata*, and *S. multiflora*, which were found at seven transects. On the

contrary, there were species that have very narrow distribution on the island and were found only in one transect: *S. johorensis*, *S. ochrophloia*, *S. palembanica*, and *Vatica perakensis*. Population Structure

TABLE II  
SPECIES OF DIPTEROCARPACEAE IDENTIFIED IN MURSALA ISLAND WITH ITS IUCN RED LIST STATUS, NUMBER OF OBSERVED INDIVIDUAL AND DISTRIBUTION IN THE LINE TRANSECTS. NUMBERS OF THE LINE TRANSECT INSIDE THE BRACKETS REFERRED TO NUMBERS IN FIGURE 1

No	Species	Category of IUCN Red List	Number of observed Individual (mature individual)	Line transect
1	<i>Cotylelobium melanoxylon</i>	Endangered	16 (1)	3 (20,22,24)
2	<i>Dipterocarpus cinereus</i>	Critically Endangered	163 (30)	7 (18,19,20,22,24,25,27)
3	<i>Dipterocarpus cornutus</i>	Critically Endangered	65 (24)	5 (20,23,24,25,27)
4	<i>Dipterocarpus gracilis</i>	Vulnerable	11 (1)	2 (22,27)
5	<i>Dipterocarpus kunstleri</i>	Critically Endangered	63 (4)	4 (19,20,23,27)
6	<i>Dryobalanops sumatrensis</i>	Vulnerable	52 (14)	6 (18,20,22,25,27)
7	<i>Hopea bancana</i>	Critically Endangered	36 (9)	3 (19,23,27)
8	<i>Hopea mengerawan</i>	-	4 (1)	2 (22,25)
9	<i>Shorea acuminata</i>	Critically Endangered	101 (60)	7 (18,19,22,23,24,25,27)
10	<i>Shorea atrinervosa</i>	Vulnerable	160 (52)	8 (18,19,20,22,23,24,25,27)
11	<i>Shorea bracteolata</i>	Endangered	11 (0)	5 (18,19,20,22,25)
12	<i>Shorea furfuracea</i>	-	15 (4)	3 (9,25,27)
13	<i>Shorea johorensis</i>	Critically Endangered	5 (4)	1 (20)
14	<i>Shorea lepidota</i>	Critically Endangered	84 (40)	4 (20,22,25,27)
15	<i>Shorea leprosula</i>	Near Threatened	58 (37)	5 (19,20,22,25,27)
16	<i>Shorea multiflora</i>	Least Concern	228 (62)	7 (19,18,22,23,24,25,27)
17	<i>Shorea ochrophloia</i>	Critically Endangered	4 (0)	1 (27)
18	<i>Shorea ovata</i>	Endangered	36 (20)	5 (20,22,24,25,27)
19	<i>Shorea palembanica</i>	Critically Endangered	2 (1)	1 (27)
20	<i>Shorea parvifolia</i>	Least Concern	20 (8)	5 (18,20,22,25,27)
21	<i>Shorea retinodes</i>	-	16 (10)	4 (20,22,25,27)
22	<i>Vatica pauciflora</i>	Vulnerable	5 (0)	2 (20,27)
23	<i>Vatica perakensis</i>	Endangered	2 (1)	1 (22)
24	<i>Vatica soepadmoi</i>	Critically Endangered	5 (0)	4 (18,19,25,27)
25	<i>Vatica stapfiana</i>	Vulnerable	5 (1)	2 (20,23)
26	<i>Vatica venulosa</i> ssp. <i>Simalurensis</i>	Critically Endangered	120 (4)	5 (18,19,22,23,24)

During the survey, a total of 1,289 individual trees of *Dipterocarpaceae* were observed (Table 2). Species with the highest number of observed individuals was *S. multiflora* (228 individuals), followed by *D. cinereus* (163), *S.*

*atrinervosa* (160), and *Vatica venulosa ssp. simalurensis* (120), whereas species with the lowest number of observed individuals were *S. palembanica* and *V. perakensis* with only two individuals each.

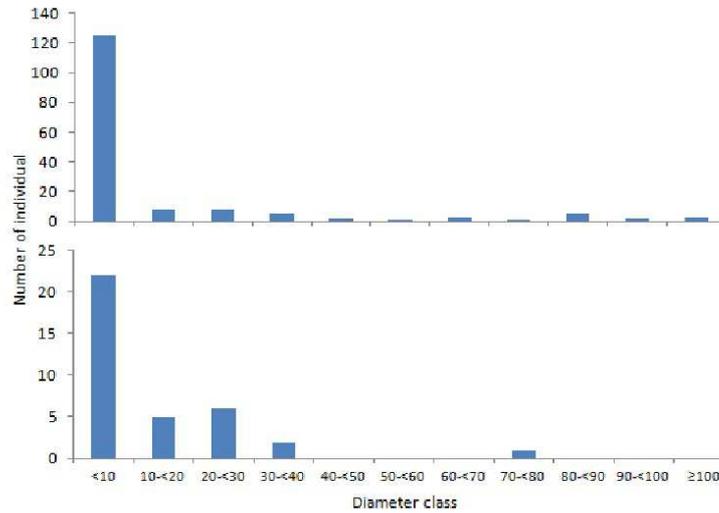


Fig. 4 Population structures of endemic *Dipterocarpus cinereus* (top) and *Hopea bancana* (bottom) based on diameter classes.

Based on dbh distribution, population structures of all species were dominantly characterized by the absence or a deficient number of large-diameter individuals. They thus were deviated from the standard inverted-J type curves commonly found in tropical forests. This pattern of dbh distribution suggested an unhealthy population condition. The pattern was similar for endemic (Fig. 4) and non-endemic species (Fig. 5). The most likely reason behind this

was the observed illegal logging activities in the island. As the logger targeted mature Dipterocarpaceae individuals, their number in the population became very low or even vanish. Similar deviation of dbh distribution from normal reverse-J shape due to selective illegal logging was also observed in the Kibauni Hill Forest, Kenya [16], the forest of Tripura, India [17], forest of Bago Yoma, Myanmar [18], and Ndege Forest Reserve, Tanzania [19].

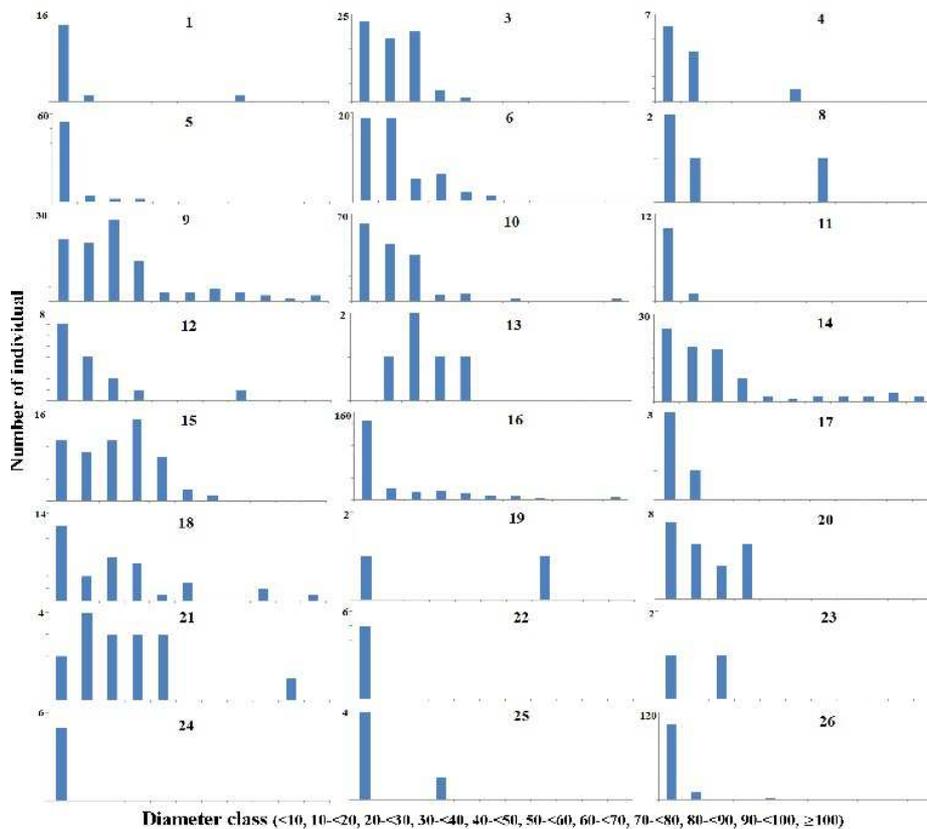


Fig. 5 Population structures of *Dipterocarpaceae* species in Mursala Island based on diameter classes. Number on each graph referred to the species number in Table 2

### B. Species Density

Based on distance analysis, the Hazard-rate model (with Hermite series adjustment) was found most suitable for most populations, as judged by low AIC (Table 3). The species with the highest individual density was *S. multiflora*

(21.72±10.96 individual/ha), whereas the species with the lowest individual density was *S. johorensis* (0.06±0.01 individual/ha). The density of endemic tree *D. cinereus* and *H. bancana* were 8.4±3.79 individual/ha and 3.48±2.78 individual/ha, respectively.

TABLE III  
DENSITY ESTIMATES OF DIPTEROCARPACEAE SPECIES IN MURSALA ISLAND BASED ON SELECTED DISTANCE MODELS

No	Species	Density estimate (individuals/ha)	Model/Series	Akaike Information Criterion	95% Confidence interval
1	<i>Cotylelobium melanoxyton</i>	1.18±1.12	Hazard Rate/Cosine	78.29	0.20-6.96
2	<i>Dipterocarpus cinereus</i>	8.4±3.79	Hazard Rate/Cosine	848.03	3.08-22.94
3	<i>Dipterocarpus cornutus</i>	2.77±1.27	Hazard Rate/Polynomial	397.88	1.03-7.41
4	<i>Dipterocarpus gracilis</i>	0.59±0.48	Negative Exponential/Hermite	63.26	0.12-2.86
5	<i>Dipterocarpus kunstleri</i>	4.12±3.78	Hazard rate/Hermite	289.29	0.68-25.7
6	<i>Dryobalanops sumatrensis</i>	2.23±0.94	Negative Exponential/Hermite	301.28	0.92-5.44
7	<i>Hopea bancana</i>	3.48±2.78	Hazard rate/Hermite	149.1	0.7-17.24
8	<i>Hopea mengerawan</i>	0.19±0.15	Uniform/Hermite	17.21	0.03-1.04
9	<i>Shorea acuminata</i>	3.89±1.55	Hazard rate/Hermite	551.13	1.59-9.53
10	<i>Shorea atrinervosa</i>	9.43±4.55	Hazard rate/Hermite	897.39	3.27-27.17
11	<i>Shorea bracteolata</i>	1.2±0.69	Hazard rate/Hermite	45.49	0.38-3.79
12	<i>Shorea furfuracea</i>	1.26±0.89	Hazard Rate/Polynomial	76.92	0.33-4.84
13	<i>Shorea johorensis</i>	0.06±0.01	Uniform/Cosine	28.9	0.03-0.09
14	<i>Shorea lepidota</i>	4.31±1.89	Hazard Rate/Cosine	470.25	1.64-11.34
15	<i>Shorea leprosula</i>	2.11±1.04	Hazard rate/Hermite	356.48	0.73-6.16
16	<i>Shorea multiflora</i>	21.72±10.96	Hazard Rate/Cosine	966.68	7.47-63.15
17	<i>Shorea ochrophloia</i>	0.14±0.06	Uniform/Hermite	16.64	0.06-0.33
18	<i>Shorea ovata</i>	0.33±0.04	Uniform/Cosine	198.39	0.26-0.42
19	<i>Shorea palembanica</i>	0.22±0.14	Uniform/Polynomial	4.65	0.06-0.85
20	<i>Shorea parvifolia</i>	1.88±1.33	Hazard rate/Hermite	97.39	0.59-6
21	<i>Shorea retinodes</i>	0.68±0.35	Uniform/Cosine	93.44	0.24-1.92
22	<i>Vatica pauciflora</i>	0.47±0.11	Uniform/Hermite	9.56	0.28-0.78
23	<i>Vatica perakensis</i>	0.14±0.13	Uniform/Hermite	7.17	0.02-1.05
24	<i>Vatica soepadmoi</i>	0.41±0.17	Uniform/Cosine	16.09	0.15-1.1
25	<i>Vatica stapfiana</i>	0.38±0.13	Uniform/Polynomial	13.86	0.17-0.79
26	<i>Vatica venulosa ssp. Simalurensis</i>	9.01±5.65	Hazard Rate/Polynomial	501.88	2.36-34.37

Distance sampling has many advantages than other methods, including more economical, statistically defensible, and more practical in quantitating plant species characteristics [20]. The present study showed that distance sampling using line-transect could be effectively used to survey the population status and estimate the species density of *Dipterocarpaceae* species in Mursala Island. The method, for instance, could detect 30 mature individuals of the endemic tree *D. cinereus*. This number was much higher compared to 3 mature individuals observed by previous studies. From these observed individuals, the density of *D. cinereus* was estimated to be 8.4±3.79 individuals/ha. This density estimate (and the estimate of the other species), however, had to be used carefully when applying it to other

un-surveyed areas on the island. Habitat specificity as well as the high rate of tree cutting and land conversion, might make the density estimate in other areas become unreliable.

### C. Habitat Characteristics

*Dipterocarpaceae* species were found throughout the island from near sea level at an elevation of 5 m to the highest peak at 500 m above sea level. However, most of the individuals were found on ridge and slope terrains at a higher elevation, including the endemic *D. cinereus* that was dominantly located at the top of hills. There were only a few species found on valleys of the Island, such as *D. cornutus*, *Dryobalanops sumatrensis*, and *S. johorensis* (Table 4).

TABLE IV  
HABITAT CHARACTERISTICS OF DIPTEROCARPACEAE SPECIES IN MURSALA ISLAND

No	Species	Slope		Elevation		Aspect		Terrain	
		Mode	Range	Mode	Range	Mode	Range	Mode	Range
1	<i>Cotylelobium melanoxyton</i>	21	4-30	258	250-335	West	Northeast, West	Ridge	Slope-Ridge
2	<i>Dipterocarpus cinereus</i>	30	10-36	340	19-371	Northeast	North-Southeast, Southwest-West	Slope	Slope-Ridge
3	<i>Dipterocarpus cornutus</i>	10	0-35	55	12-185	Northeast	West-Northeast, flat	Valley	Valley-slope-ridge
4	<i>Dipterocarpus gracilis</i>	14	10-24	98	49-164	East	Northeast-East	Ridge	Slope-Ridge
5	<i>Dipterocarpus kunstleri</i>	12	4-32	97	26-162	Northeast	West-Southeast	Slope	Slope-Ridge
6	<i>Dryobalanops sumatrensis</i>	21	0-35	6	5-258	North	North-East, South, West, Flat	Valley	Valley-slope-ridge
7	<i>Hopea bancana</i>	2	2-35	13	12-190	Northwest	West-East	Slope	Slope-Ridge
8	<i>Hopea mengerawan</i>	12	12-15	169	150-169	Northwest	Northwest, Flat	Ridge	Ridge
9	<i>Shorea acuminata</i>	12	4-55	317	57-370	Northeast	North-West, Flat	Slope	Slope-Ridge
10	<i>Shorea atrinervosa</i>	21	4-57	259	20-344	West	North-East, Southwest, Northwest, Flat	Ridge	Valley-slope-ridge
11	<i>Shorea bracteolata</i>	28	5-32	180	41-264	North	North-East, West, Flat	Ridge	Valley-slope-ridge
12	<i>Shorea furfuracea</i>	33	10-35	295	22-342	North	West-East	Slope	Valley-slope-ridge
13	<i>Shorea johorensis</i>	0	0-31	19	18-120	Flat	East, Flat	Valley	Valley-Slope
14	<i>Shorea lepidota</i>	10	4-36	140	61-365	North	West-East, Flat	Slope	Slope-Ridge
15	<i>Shorea leprosula</i>	30	0-32	75	12-312	East	Northwest-Southeast, Flat	Ridge	Valley-slope-ridge
16	<i>Shorea multiflora</i>	28	4-57	108	53-338	North	All	Ridge	Slope-Ridge
17	<i>Shorea ochrophloia</i>	6	6-35	67	57-160	Northwest	West-Northeast, East	Slope	Slope
18	<i>Shorea ovata</i>	31	4-55	160	29-370	Northeast	North-Northeast, West, Flat	Slope	Slope-Ridge
19	<i>Shorea palembanica</i>	-	24-15	-	167-170	-	East	-	Slope
20	<i>Shorea parvifolia</i>	31	6-33	353	95-353	Northeast	North-East, Northwest	Ridge	Slope-Ridge
21	<i>Shorea retinodes</i>	6	6-28	66	12-172	Northwest	North-East, Northwest, Flat	Slope	Valley-slope-ridge
22	<i>Vatica pauciflora</i>	-	12-21	-	10-294	-	North-East	Slope	Valley-Slope
23	<i>Vatica perakensis</i>	-	20-27	-	127-200	-	Northeast, Northwest	-	Ridge
24	<i>Vatica soepadmoi</i>	12	5-18	-	108-341	North	North-Northeast	Ridge	Slope-Ridge
25	<i>Vatica stapfiana</i>	4	4-30	120	5-312	-	East-Southeast, West	Ridge	Valley-slope-ridge
26	<i>Vatica venulosa ssp. Simalurensis</i>	55	4-55	273	70-338	North	Southeast-Northeast	Ridge	Slope-Ridge

Furthermore, the North aspect slope (including Northeast and Northwest) was observed to be the most favorable habitat for the *Dipterocarpaceae* species. For the endemic *D. cinereus*, its soil was characterized by pH, organic carbon, nitrogen and phosphorus content of, respectively,  $4.72 \pm 0.15$ ,  $5.92 \pm 1.48$  %,  $0.34 \pm 0.02$  %, and  $6.67 \pm 1.69$  ppm, whereas soil pH, organic carbon, nitrogen and phosphorus content of *H. bancana* was  $5.37 \pm 0.27$ ,  $2.84 \pm 0.13$  %,  $0.2 \pm 0.02$  %, and  $9.33 \pm 5.84$  ppm, respectively.

#### D. Threats and Conservation Actions

Two main threats for *Dipterocarpaceae* species in Mursala Island were identified during the field survey:

heavy illegal logging and forest conversion. For the first threat, there are two to four sources of chainsaw sound that were heard by the team every day during the data collection. Local people did the logging activities, and they targeted mainly big trees from *Dipterocarpaceae* species, including the endemic tree *D. cinereus*. In addition, many logging sites (Fig. 6a-c) were found, including tracks to transport the processed timber from the logging site to the beach (Fig. 6d). After reaching the beach, the processed timbers were covered by twig and branch of trees (Fig. 6e-f) in order to hide the woods from the marine police patrol. In addition to trading in the main island of Sumatra, the timbers were also

used by local people for making houses (Fig. 6g) and boat

(Fig. 6h).



Fig. 6 Illegal logging activities found in Mursala Island: a-c) logging sites, d) tract for transporting processed timber in the forest, e-f) processed timber in the beach ready for transporting, g) house made of timber cut from the forest, h) boat made of timber from the forest.

The second threat to the *Dipterocarpaceae* was habitat conversion. Local people cut the forest along the coastal areas and plant the rubber tree, cassava, sweet potato, and others. These plantations were distributed mainly along the northern beach of the Island and could stretch up to more than 100 m into the forest areas.

Mursala Island could be considered as one of the important areas for *Dipterocarpaceae* conservation. Among 26 recorded species, 20 (76.9%) of them were threatened species according to the IUCN Red List category and criteria.

Furthermore, Mursala Island was the only habitat for *D. cinereus*, the previously reported extinct tree species. Moreover, for *H. bancana*, although it was believed to be endemic to Sumatra [21], the present study and the collections records of Bogor Botanic Gardens revealed that Mursala Island was the only remaining habitat for the species. Thus, comprehensive conservation actions are needed to protect the *Dipterocarpaceae* diversity in the Island. Increasing the protection level of the island and providing alternative sources of living for the illegal logger

through commercialization of non-timber forest products, ecotourism, and sustainable fishery are some of the recommended actions. These actions must be implemented immediately as the present study showed timber extraction activities are still undergoing on the island at an alarming rate.

#### IV. CONCLUSION

Despite extensive wood extraction that has been undergoing for a long time, Mursala Island still possesses a high species diversity of *Dipterocarpaceae*. This high species diversity has made the island one of the hotspots for *Dipterocarpaceae* biodiversity. Immediate comprehensive conservation actions need to be implemented to conserve the species and their habitat.

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