

## POPULATION STUDY AND REASSESSMENT OF CONSERVATION STATUS OF AN ENDEMIC DIPTEROCARP, *Hopea bilitonensis*

Siti Roosita ARIATI<sup>1\*</sup>, Iyan ROBIANSYAH<sup>2</sup>, Didik WIDYATMOKO<sup>2</sup>,  
Sri Ulie RAKHMAWATI<sup>3</sup>, Ade Yusup YUSWANDI<sup>4</sup>, HARTO<sup>4</sup>

<sup>1</sup> Research Center for Biosystematics and Evolution – National Research and Innovation Agency (BRIN) – Jl. Raya Jakarta Bogor KM 46, Cibinong, West Java, INDONESIA 16911

<sup>2</sup> Research Center for Ecology and Ethnobiology – National Research and Innovation Agency (BRIN) – Jl. Raya Jakarta Bogor KM 46, Cibinong, West Java, INDONESIA 16911

<sup>3</sup> Independence Scholar – Pasir Mulya, Bogor, West Java, INDONESIA 16118

<sup>4</sup> Directorate of Scientific Collection Management – National Research and Innovation Agency (BRIN) – Jl. Raya Jakarta Bogor KM 46, Cibinong, West Java, INDONESIA 16911

### Abstract

*Hopea bilitonensis* is a rare, endemic Dipterocarp species in the Malesian Region. It has a disjunct distribution pattern, where main populations occur on the sandy soils of Bangka Belitung Islands of Indonesia and some on limestone forest in Perak, Peninsular Malaysia. Current global status of this species based on the IUCN Red List is Critically Endangered (CR) A1c+2c, B1+2c (1998) whilst in Malaysia it is assessed as CR A4c, B1ab(iii) (2010). A reassessment of the conservation status of this species is needed to provide the most current population status and its extinction risk, especially in Indonesia using the IUCN Red List Categories and Criteria version 3.1. This study was conducted to survey and assess the current populations of this species in Belitung Island where most population occurred and subsequently to recommend its current conservation status. The species is in fact still common in the island, stretching along the main roads and surrounding forests. Using the purposive sampling method, we developed a total of 16 plots of 20x20m each in 10 different locations across the Belitung Island. A total of 730 individuals were found with stem diameter at breast height ranged from 2cm to more than 30cm. For global reassessment, based on the current distribution and herbarium records, the calculated extent of occurrence (EOO) is 108,128.642km<sup>2</sup>, whilst the area of occupancy (AOO) is 84 km<sup>2</sup>. However, the species clearly has a restricted distribution and is facing high threats due to frequent timber harvesting and continuing decline of the EOO and AOO. The species extinction risk was then assessed by using five quantitative criteria of the IUCN. Therefore, we propose *H. bilitonensis* category is considered to be Endangered (EN) based on A2c, B2ab(i,ii,iii,iv,v) and C2a(i) criteria.

**Keywords:** *Hopea bilitonensis*; Population study; Reassessment; Conservation status; Belitung Island

### Introduction

The Dipterocarps are well known tropical plants due to their high commercial value. Most of the dipterocarps are tall trees forming emergent formations in tropical forests. Based on the data from the Plant of the World Online [1], there are 539 accepted species that confined to 16 genera belonging to three sub families, i.e. Monotoideae of Africa and South America, Pakaraimoideae which is a monotypic genus in South America and Dipterocarpoideae of tropical Asia to New Guinea [2].

\* Corresponding author: siti.roosita.ariati@brin.go.id; sita\_ariati@hotmail.com

The family Dipterocarpaceae is currently threatened mostly by unsustainable harvest, habitat conversion and mining. The dipterocarps are an important and valuable plant family that is commonly traded in international market. They are highly valued particularly for their quality timber but also for their valuable champor, nuts and resins [3]. In Indonesia, the dipterocarps are the main target of logging, contributing more than 85% of the timber exports [3]. Furthermore, most of dipterocarps are found in lowland areas, where habitat degradation and conversion to settlements and agriculture has mostly occurred. In Indonesia, this type of forest area had declined by 9.79Mha (c.11%) from 2001 to 2019 which mainly due to plantations expansion [4]. The other threats following logging and agricultural expansion are roads construction, mining, droughts and forest fires [5-7].

Due to aforementioned threats, a total of 361 species (73.5%) of the Dipterocarps listed in the 2021 IUCN Red List are threatened with extinction (i.e. Vulnerable, Endangered and Critically Endangered) [8]. The most threatened species of the Dipterocarps are from the genus *Shorea* comprising 126 species, followed by *Hopea* with 77 species. *Hopea* is a wide ranged genera consisting of 102 species with 82% of which being represented in Malaysia. *Hopea* is usually small or medium-sized tree, occasionally large tree, mainly as canopy or understorey of lowland forests, rarely emergent [2]. The major product of *Hopea* is lightweight to medium-heavy hardwood such as *Hopea beccariana*, *H. dryobalanoides*, *H. mengarawan*, *H. odorata* and *H. sangal* [9]. In addition, *Hopea* is one of the important genera in Southeast Asia for producing resin (e.g. *Hopea celebica* and *H. dryobalanoides*) and tannin (e.g. *H. odorata* and *H. parviflora*) [10].

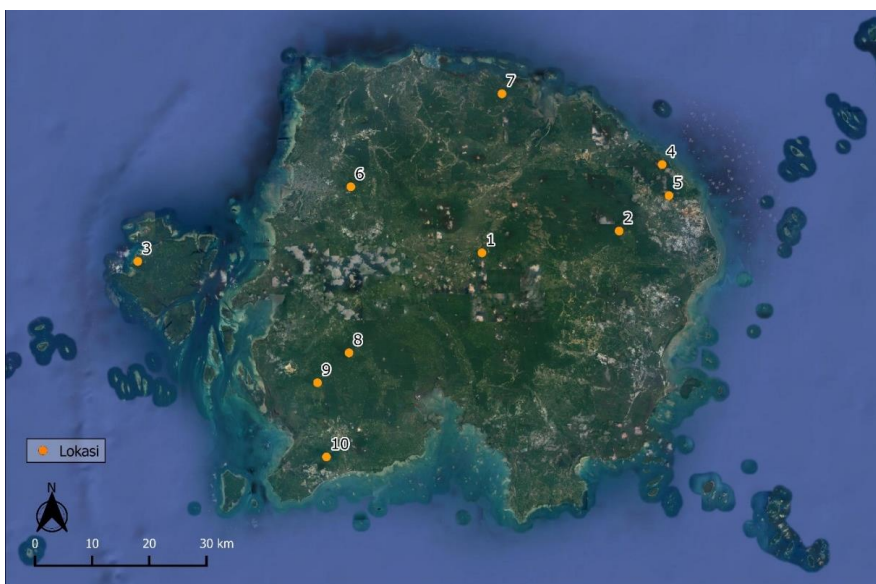
One of the *Hopea* species that is threatened with extinction is *Hopea billitonensis* [2]. The species has a disjunct distribution and can only be found in Belitung Island of Indonesia and Perak of Malaysian Peninsular [11]. Current global status of the species based on the IUCN Redlist is Critically Endangered (CR) A1c+2c, B1+2c, which is based on the past population size reduction (criterion A) and a restricted geographic range (criterion B) [12]. In Malaysia, the species is also assessed as CR under the criteria of B1ab(iii)+2ab(iii) and is threatened due to habitat loss arising from quarrying activities [13]. Therefore, the current population status of the species needs to be studied in order to determine its current conservation status regarding all threats faced by this species.

In the present study, we aimed to conduct the population survey of *H. bilitonensis* in Belitung Island. The specific objectives of this study were: i) to outline spatial distribution and population structure of the species in Belitung Island, ii) to identify and analyse potential threats to the species and iii) to assess and update the global extinction risk of the species using the IUCN Red List Categories and Criteria version 3.1.

## Methodology

### *Study site*

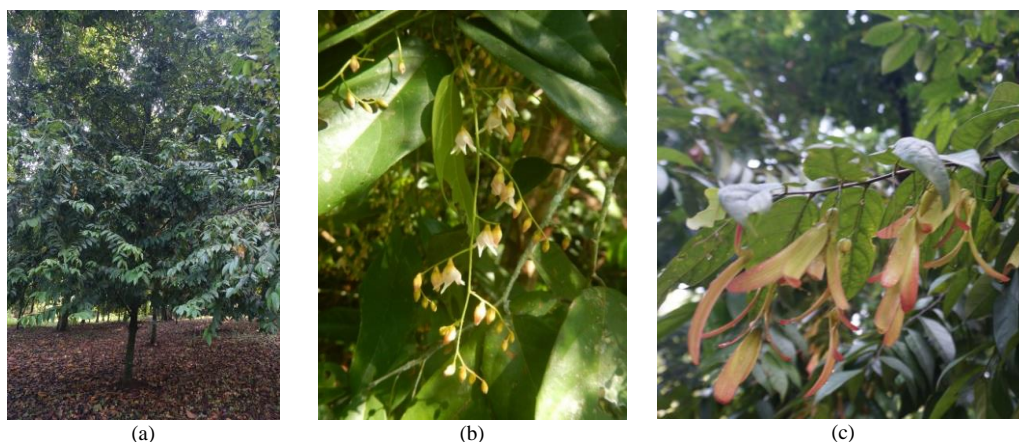
The study was conducted in lowland forests across Belitung Island and the adjacent area during October 2018. Belitung Island is located between 107°30' – 108°30' E and 2°50' - 3°30' S, covering an area of approximately 4,900km<sup>2</sup> (Fig. 1). The topography of the island is undulating with an average altitude of 10m above sea level (asl) and the highest peak is 510m asl of Mount Tajam. The soil condition is dominated by sand and quartz, alluvial and granite rocks, acid (pH less than 5), with a high level of Aluminum content and tin (Stannum). The average temperature is 27.3°C, with a minimum temperature of 22.5°C and maximum of 34.29°C. The annual precipitation is 2,073.33mm with 196 days of rainy day [14, 15].



**Fig. 1.** Locations of *Hopea biltonensis* population samplings conducted in Belitung Island, Indonesia, located between  $107^{\circ}30' - 108^{\circ}30' E$  and  $2^{\circ}50' - 3^{\circ}30' S$

### **Species information**

*Hopea biltonensis* P.S.Ashton was first collected in 1875, first published in the Gardens' Bulletin Singapore 31: 35 (1978) and described as new species by P.S. Ashton [11]. The species is a small smooth-barked tree with stilt roots, predominantly selfing dipterocarp; Leaves ovate-lanceolate, more or less chartaceous, 7.5-16 by 3.5-6cm in size; Sepals fimbriate; Flowers in panicle to c.18cm long, slender, axillary, solitary, pendant; Ovary small, ovoid; Stamens 15, shorter than style at anthesis; Small fruits with 2 longer calyx lobes and 3 shorter lobes (Fig. 2). The species has a disjunct distribution, apparently since the Pleistocene, one being locally common in lowland forest, on the sandy soils of Bangka Belitung Islands while the other is from limestone site in Northwest Malaya. The generation length of *H. biltonensis* is estimated at around 80 years, similar to the other members of *Hopea* i.e. *Hopea tenuivervula* and *H. andersonii* [16, 17].



**Fig. 2.** Morphological features of *Hopea biltonensis* (a) tree, (b) flowers, (c) fruits

### ***Population survey***

Population samplings were conducted using a purposive sampling method to estimate the population size and geographic distribution of *H. bilitonensis*. A total of 16 plots of each 20x20m were established, comprising nine different locations in Belitung Island and one location in Mendanau Island, an adjacent island to the west (Figure 1). Within each plot, the data recorded for *H. bilitonensis* included the number of individuals, reproductive stage (mature/immature) of each individual, diameter at breast height (dbh) and estimated tree height. The geographic position of each individual was recorded based on simple terrestrial mapping method using a GPS receiver, compass and roll meter. In addition, environmental variables were measured for each plot, including air temperature, relative air humidity, elevation, slope, aspect and canopy cover. Other data and relevant information of *H. bilitonensis* population outside the sampling sites were obtained from published papers, fieldwork reports and herbarium records.

Assessment of threats to the species from habitat conversion, land cover and forest change was estimated based on the tree cover loss using the Global Forest Watch [18].

### ***Reassessment of conservation status***

The extinction risk assessment of *H. bilitonensis* was conducted based on the IUCN Red List Categories and Criteria version 3.1 [19]. There are five quantitative criteria to be used for this assessment, which are (A) Population size reduction (past, present and/or projected); (B) Geographic range size and fragmentation, few locations, decline or fluctuations; (C) Small and declining population size and fragmentation, fluctuations, or few subpopulations; (D) Very small population or very restricted distribution and (E) Quantitative analysis of extinction risk (e.g. Population Viability Analysis). The geographic range in criterion B is in the form of either the extent of occurrence (EOO) and/or the area of occupancy (AOO). The EOO and AOO were estimated using Geospatial Conservation Assessment Tool (GeoCAT), which available online at <https://geocat.kew.org/> [20]. The taxa should be assessed against as many criteria as possible based on the availability of the data. The result of this assessment is then used to determine the species to which belongs to one of the nine determined categories, i.e. Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD) or Not Evaluated [21].

## **Results and discussion**

### ***Population status***

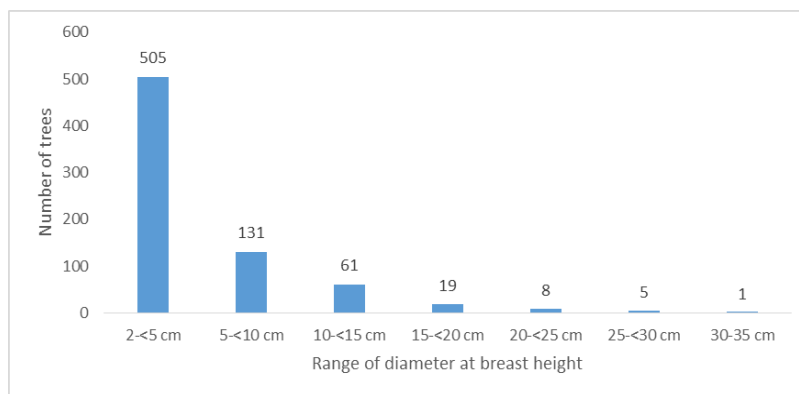
Populations of *Hopea bilitonensis* were sampled from 16 plots from 10 locations in Belitung Island and the adjacent area, which were (1) Genting Apit, (2) Kelubi, (3) Gunung Saer (P. Mendanau), (4) Air Kelik, (5) Mempayak, (6) Prawas, (7) Hutan Lindung (HL/Protected Forest) Batu Pulas, (8) HL Gunung Kubing, (9) Air Perlak and (10) Membalong. The elevation ranges between 15 to 95 m asl. with the slope ranges from 0.5° to 31°. The canopy gap ranges between 2.44% and 37.90%, which mostly constitute open secondary forests. The temperature at the study sites ranges between 26.70° to 31.90°C and humidity of 63.4 to 96% (Table 1).

A total of 730 individuals were recorded from 16 plots of 10 locations, with a total extent of 0.64ha. The highest density of this species population was found in Plot 14 (Air Perlak), whilst the least was in Plot 11 (HL Batu Pulas). The distribution of diameter class was shown in figure 3. The population structure was dominated by individuals with diameter class less than 20cm (95.47%), whilst a total of 94 trees were mature individuals (12.88%). This composition is somewhat similar to *Hopea subulata*, a rare and endemic Dipterocarp in Malaysia, comprising 98.05% and 16.70% respectively [21]. When the population data were extrapolated, the mature trees comprised 146 individuals per ha. The largest tree was recorded at a diameter of 32.2cm which was found in Mt. Saer, Mendanau Island. During the observation

in the fields, *H. bilitonensis* was quite common and easily found along the main roads, as well as in the protected forests, however, in some areas the species was absent. Seedlings were mostly abundant within or near the sampling plots.

**Table 1.** Population samplings of *Hopea bilitonensis* and the habitat conditions. Temperature, RH and HL are Air Temperature, Relative Humidity and Hutan Lindung (protected forest), respectively

| Location                | Plot | No. Individual  | Elevation (m asl) | Slope (°)       | Canopy gap (%) | Aspect    | Temp. (°C)     | RH (%)         |
|-------------------------|------|-----------------|-------------------|-----------------|----------------|-----------|----------------|----------------|
| Genting Apit            | 1    | 27              | 62                | 14              | 21.70          | North     | 31.9           | 65.90          |
| Genting Apit            | 2    | 27              | 51                | 1               | 7.17           | East      | 28.8           | 83.10          |
| Kelubi                  | 3    | 17              | 29                | 4               | 5.05           | South     | 31.9           | 63.40          |
| Mt. Saer (Mendanau Is.) | 4    | 33              | 28                | 3               | 23.58          | East      | 30.5           | 79.20          |
| Mt. Saer (Mendanau Is.) | 5    | 34              | 46                | 10              | 9.08           | West      | 30.7           | 75.90          |
| Air Kelik               | 6    | 100             | 15                | 1               | 4.58           | Southwest | 31.6           | 73.00          |
| Mempayak                | 7    | 16              | 76                | 27              | 7.93           | North     | 27.6           | 88.90          |
| Mempayak                | 8    | 57              | 95                | 31              | 2.44           | West      | 27.0           | 88.58          |
| Prawas                  | 9    | 54              | 55                | 4               | 11.20          | South     | 29.2           | 73.70          |
| HL Batu Pulas           | 10   | 37              | 22                | 0.5             | 3.48           | West      | 27.2           | 88.70          |
| HL Batu Pulas           | 11   | 5               | 27                | 1               | 3.78           | Southwest | 26.7           | 96.00          |
| HL Mt. Kubing           | 12   | 68              | 33                | 25              | 7.90           | North     | 29.1           | 87.00          |
| HL Mt. Kubing           | 13   | 53              | 70                | 23              | 8.05           | Southeast | 28.8           | 79.10          |
| Air Perlak              | 14   | 113             | 51                | 3               | 2.49           | South     | 28.1           | 92.70          |
| Membalong               | 15   | 36              | 81                | 28              | 37.90          | West      | 31.1           | 65.70          |
| Membalong               | 16   | 53              | 90                | 24              | 12.60          | South     | 29.1           | 77.70          |
| Range                   |      | 5-113           | 15-90             | 0.5-31          | 2.44-37.90     |           | 26.7-31.9      | 63.40-96       |
| Mean                    |      | 45.63<br>±29.22 | 52.01<br>±25.22   | 12.47<br>±11.74 | 10.56<br>±9.57 |           | 29.33<br>±1.77 | 79.91<br>±9.98 |



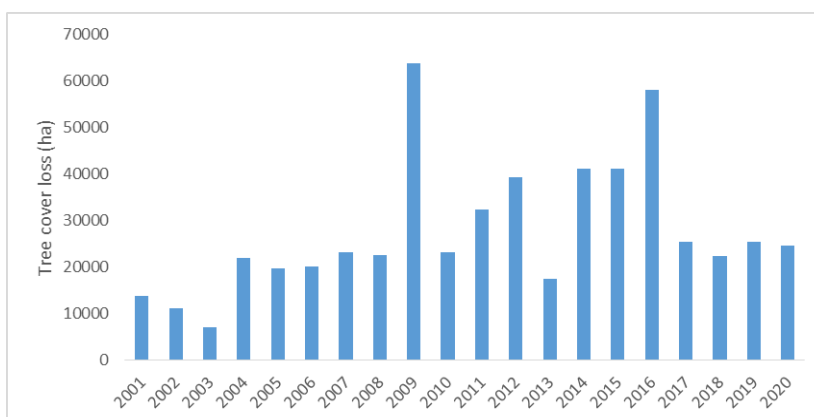
**Fig 3.** Distribution by diameter (dbh) class of *Hopea bilitonensis* from 10 locations in Belitung Island

Population threat is mainly due to habitat conversion (i.e. plantations, residential areas/settlement and tin mining) and timber harvesting (Fig. 4). It is common for local people in Belitung Island to use timber of *H. bilitonensis* as plant truss for pepper plantations and this is traditionally managed.

According to Global Forest Watch, Bangka Belitung Islands lost 556,000ha of tree cover, equivalent to a 42% decrease in tree cover, from 2001 to 2020. The highest tree cover loss occurred in 2009, whilst the lowest was in 2003, with the figure of 63,895 and 7,123ha respectively (Fig. 5). In addition, Bangka Belitung lost 69,800ha of humid primary forest, making up 13% of its total tree cover loss in the same time period, or decreasing by 32% of total area of humid primary forest in the Islands [18].



**Fig. 4.** Threats of *Hopea biltonensis* including timber harvest and habitat conversion for pepper (a) and oil palm plantations (b).



**Fig. 5.** Tree cover loss in Bangka Belitung Islands from 2001 to 2020 based on the Global Forest Watch Analysis

### ***Reassessment of conservation status***

The conservation status of *H. biltonensis* was reassessed using five quantitative criteria of the IUCN Red List and the results are as follows:

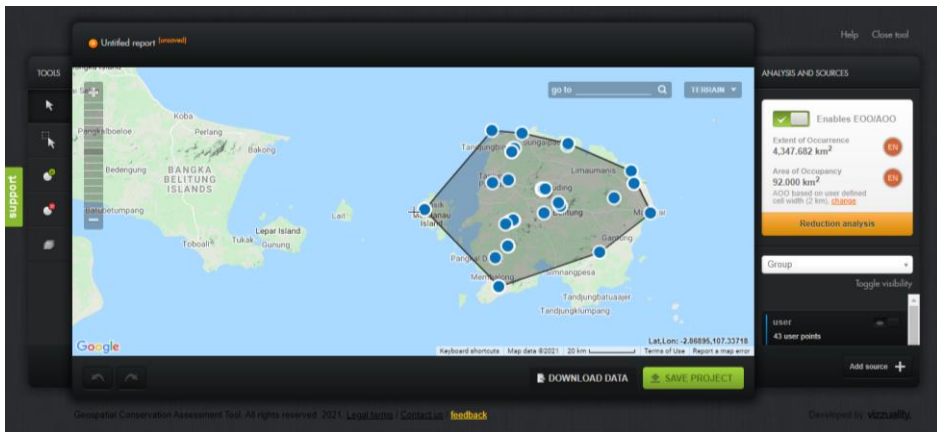
#### ***Assessing the species using criterion A (Population size reduction)***

Global Forest Watch estimated that the forests in Bangka Belitung Province have declined by 42% between 2001 and 2020, which was very likely to influence the population of *H. biltonensis*. It is suspected that habitat loss and degradation would have reduced the population of this species in Belitung by more than 50% over the past three generations of the species (i.e. 240 years). Therefore, *H. biltonensis* is assessed as Endangered (EN) under criteria A2c.

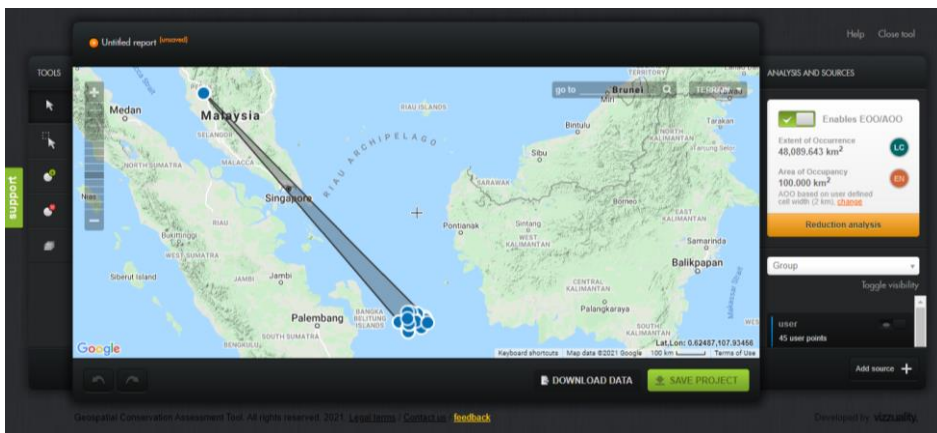
#### ***Assessing the species using criterion B (Geographic Range)***

Geographic data were obtained from the protologue [11], herbarium vouchers (BO and GBIF) and fieldworks, from which there are 45 points recorded. Based on these data, the EOO and AOO were estimated using the GeoCAT both for national and global levels. In Indonesia, *Hopea biltonensis* is confined to Belitung Island. Recent studies showed that the species was not found in the adjacent island, such as Bangka [22]. Therefore, the number of locations for the species in Indonesia is considered to be only one. The AOO and EOO of the species in Belitung Island are 92 and 4,347.682km<sup>2</sup>, respectively (Fig. 6). It is also inferred that the EOO, AOO, habitat quality, number of locations or sub population and/or number of mature individuals continue to decline. Therefore, the species is categorised as Endangered (EN) B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v).

At global level, the EOO is 48,089.643km<sup>2</sup> and AOO is 100km<sup>2</sup> (Fig. 7). The EOO crosses several areas such as part of Batam Island, Bintan Island, part of Singapore Islands, part of Johor and part of Pahang (Malaysia). Up to present, there is no information on the existence of this species in those areas. In Malaysia, *H. biltonensis* was found in Gua Tempurung and Gunung Gajah, Perak, where it occupies a total area of 1.18ha with 320 individuals of one cm in dbh or above [23]. Based on this information, number of locations for the species in the global level is considered to be two. Therefore, the species can be assessed as EN B2ab(i,ii,iii,iv,v).



**Fig. 6.** The extent of occurrence (EOO) and area of occupancy (AOO) of *Hopea biltonensis* calculated using Geocat in Belitung Island are 4,347.682 and 92km<sup>2</sup> respectively



**Fig. 7.** The extent of occurrence (EOO) and area of occupancy (AOO) of *Hopea biltonensis* calculated using Geocat showing its allopatric distribution.

#### *Assessing the species using criterion C (Small population size and decline)*

Based on the information of population study above, from 10 locations covering an area of 0.64ha, it showed that the number of mature individuals was 94 trees. In addition, Astuti et al. (unpublished, 2017) conducted population samplings in Mount Tajam, Mount Bantan and Hutan Belanda/Balangeran covering an area of 0.8ha and found 258 individuals of dbh more than 2cm, with the total of mature trees were 83 individuals. Therefore, there was at least 177 reproductively mature trees found in Belitung Island. Population structure of the species is presented in figure 8. All locations were dominated by individuals at the sapling stage which has diameter (dbh) class less than 10cm. The highest number of mature trees was found in Mount Tajam comprising 63 trees, whilst other locations showed less than 50 trees. When those

two data are extrapolated, the number of mature trees is estimated to be 146 and 103 individuals respectively. During fieldwork, we also observed that mature trees occurred in several areas e.g. HL (Hutan Lindung/protected forest) Bringsing Papuyu, HL Gunung Duren and Bukit Peramun. However, we did not conduct population samplings in those areas due to time constraint. It is believed that the overall number of mature trees is more than 250 individuals but not more than 2,500. Therefore, the species is considered to be Endangered (EN) under criterion C2a(i), which is observed that the number of mature individuals in each location/subpopulation is less than 250.

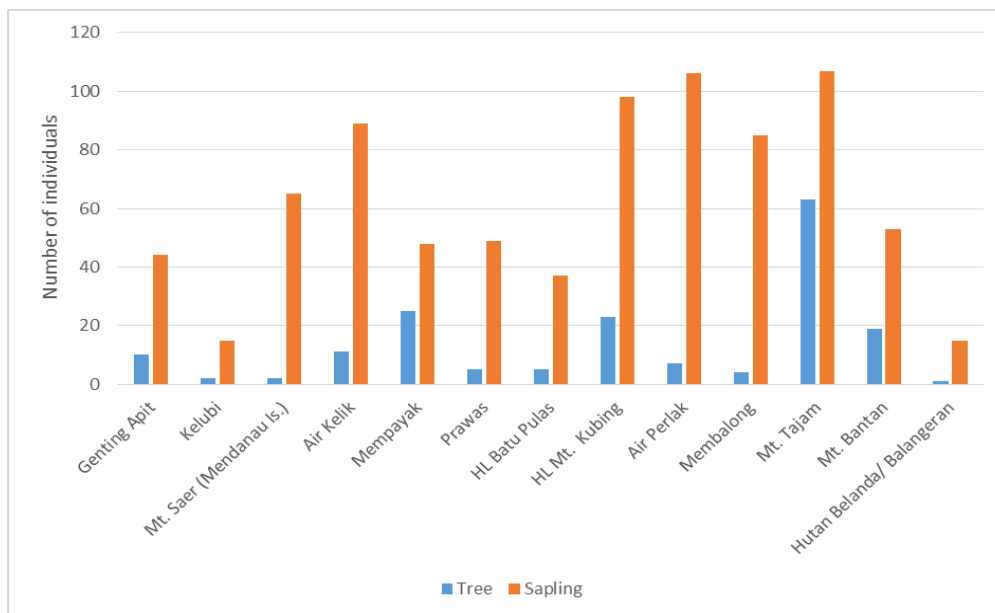


Fig. 8. Population structure of *Hopea bilitonensis* in Belitung Island showing the dominance of the saplings in all localities

*Assessing the species using criterion D (Very small or restricted population)*

This criterion is applied for a taxon with very small population or confined to restricted area. A taxon qualifies for this criterion if either has very small number of mature individuals (the limit depends on the category) or a restricted area of occupancy which is approximately less than 20km<sup>2</sup> [8]. The population study of *H. bilitonensis* was based on purposive sampling using plots of 20 x 20m each, which consequently did not indicate the total number of mature trees in its geographic range. The total number of mature trees was estimated between 250 and 2,500 individuals. Under this population estimates, *H. bilitonensis* qualifies for Near Threatened (NT).

*Assessing the species using criterion E (Quantitative analysis)*

Criterion E usually requires a comprehensive data especially on the population dynamics. This current population study of *Hopea bilitonensis* is conducted to sample population across its geographic range. It is therefore lack of information on its population dynamics, because no time series’ study was conducted. The species is therefore designated as Data Deficient (DD).

**Conservation implication**

During fieldworks observation, seedlings were abundant. There were approximately 2,200 seedlings recorded from 16 plots of 2 x 2m each. We managed to bring some seedlings from across population and there are now over 180 individuals in Bogor Botanic Gardens Nursery in which 17.5% is ready to be planted. The seedling survival rate seems to be moderate (c. 45%). There are also two specimens collected from Mt. Tajam, Belitung Island in 2007, that



have been grown in the garden collection. We suggest that living plants of *H. bilitonensis* should be made available at regional botanic gardens in Indonesia, especially those located in lowland areas of Sumatra (i.e. similar ecoregion), including Batam Botanic Garden (Riau Is, Sumatra), ITERA BG (Lampung, Sumatra), Sriwijaya BG (South Sumatra) and Samosir BG (North Sumatra). Seeds of this species do not tolerate neither desiccation nor low temperature, which then may not survive for long term storage. Therefore, further study is required to preserve this species seeds e.g. using cryopreservation techniques. Other conservation actions such as reintroduction or translocation may also be conducted with careful planning, in order to re-establish a viable population, or to extent its distribution for improving its conservation status.

## Conclusions

This population study of *Hopea bilitonensis* shows that the species is in fact still common in Belitung Island which is mainly dominated by individuals at the sapling stage. This indicates that the population will grow in the future, however, proper monitoring and management is required to ensure its long-term sustainability. There were 730 recorded individuals in which 12.87% is reproductively mature trees. According to the IUCN Guidelines only the criteria for the highest category of threat that the taxon qualifies for should be listed. Based on all available data and information above, we propose *Hopea bilitonensis* is categorised as Endangered (EN) A2c, B2ab(i,ii,iii,iv,v), C2a(i). Under the criterion A2c, more than 50% of the population size reduced over the past three generations, B2ab(i,ii,iii,iv,v) in which the AOO is < 500km<sup>2</sup> and continuing to decline and C2a(i) which is the number of mature individuals is < 2,500 trees and each population may not exceed 250 mature trees.

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