# CONSERVATION STATUS OF *HOPEA SUBALATA* (DIPTEROCARPACEAE) IN PENINSULAR MALAYSIA

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*Received July 2003*

**CHUA, L. S. L., NURULHUDA, H., HAMIDAH, M. & SAW, L. G. 2004. Conservation status of *Hopea subalata* (Dipterocarpaceae) in Peninsular Malaysia.** *Hopea subalata* (Dipterocarpaceae) is a rare and endemic species of Peninsular Malaysia. It is known to occur only in Kanching Forest Reserve, Selangor. The spatial distribution of the individuals is clumped. Some adult individuals have no regenerating stands surrounding them. While the majority of the individuals lies within the forest reserve boundary, there are at least 10 trees present outside the boundary. The conservation status of *H. subalata* and possible threats to its population are described. Conservation measures for populations existing in the forest reserve and the population outside the reserve are prescribed.

Key words: Spatial distribution – Kanching Forest Reserve – threats to population – size class distribution

**CHUA, L. S. L., NURULHUDA, H., HAMIDAH, M. & SAW, L. G. 2004. Status pemuliharaan *Hopea subalata* (Dipterocarpaceae) di Semenanjung Malaysia.** *Hopea subalata* (Dipterocarpaceae) merupakan salah satu spesies endemik di Semenanjung Malaysia. Spesies ini amat langka dan hanya wujud di Hutan Simpan Kanching, Selangor. Populasi spesies memperlihatkan taburan secara berkelompok. Kajian menunjukkan bahawa tidak terdapat pertumbuhan semula di sekeliling sesetengah pokok induk. Walaupun kebanyakan pokok tumbuh di dalam kawasan hutan simpan ini, terdapat kira-kira 10 pokok yang berada di luar sempadannya. Status pemuliharaan dan ancaman kepada populasi *H. subalata* dihuraikan. Langkah-langkah pemuliharaan bagi populasi di dalam dan di luar hutan simpan disarankan.

## Introduction

*Hopea subalata* Symington (Dipterocarpaceae) is endemic to Peninsular Malaysia (Ashton 1982). It is very rare and known to occur only in Kanching Forest Reserve in the state of Selangor. In view of its rarity and the fact that Selangor faces a severe conflict between conservation of biodiversity and socio-economic development, a study was undertaken to locate and enumerate populations of *H. subalata* and determine its conservation status. Apart from the taxonomic accounts published by Ashton (1982) and Symington (1943), and collections lodged at the Forest Research Institute Malaysia (FRIM)'s Herbarium (KEP), there is hardly any documentation available to indicate the status of the species in its natural habitat.

This paper outlines geographical distribution, current stocking, diameter size

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class distribution and perceived threats to the species. In this paper, the authors provide recommendations that are aimed at improving current conservation measures. Area of population that is located outside the forest reserve was estimated and conservation measures for this population are also suggested.

## Materials and methods

Collections lodged at KEP indicated that the species existed in compartments 1, 2, 5D and 14 of Kanching Forest Reserve. Current forestry records show that compartments 1, 2 and 14 are still extant. Compartment 5D has been subdivided into compartments 4, 16 and 17. The State and District Forest Offices kindly supplied detailed inventory records such as logging cycles and logging prescriptions of all the compartments.

A botanical team was responsible for locating the populations of *H. subalata* in this study. Habitat preferences were used as a guide to outline the possible extent of the species distribution. Major topographical features, such as ridges, slopes, riverbanks, and undulating land in compartments 2, 4, 17, 16, 15 and 14 were inspected. Once the population was located, a careful search was made to identify the outliers; these outliers were used as a guide for the demarcation of the population. This search method enabled the team to cover a larger area but inadvertently some trees could have been missed in the survey. Standard methods of tagging and diameter at breast height (dbh) measurements were used (Manokaran *et al.* 1990). Traditional ecological methodology was modified to examine the conservation status of the species. Population boundary was demarcated. Impulse 200, a laser instrument which measures distances, heights, inclination and azimuth, was used to map population boundary and tree position on the ground while GPS instrument (Garmin Etrex Summit) was used to determine coordinates for population boundary. The accuracy for the GPS instrument was about 30 m. Ground station points (STNs) were used to create an imaginary boundary around populations. The STNs were marked on the ground. Distances between STNs varied depending on the longest clear line of sight available. Tree position was mapped from the selected STNs. Both tree-to-tree and array mapping methods were employed during the tree mapping exercise. The STNs, tree-to-tree and array data were entered into Roadeng software (Version 3.1), which then generated a tree position map. This Roadeng-generated map was converted to .dxf format. Population boundary was then tied to GPS coordinates using Autocad Map 2000i software.

To ascertain whether populations in compartments 2 and 14 were randomly dispersed, i.e. follow a Poisson distribution, the populations were subjected to a Chi-square test ($\chi^2$). The spatial distribution of trees was calculated using the variance-to-mean ratio or index of dispersion (ID) (Elliott 1973, Brower *et al.* 1997). Calculation of ID was based on the area of occupancy defined by the population boundary. The area of occupancy was subdivided into $5 \times 5$ m subplots. The index of dispersion calculation is given below.

$$ID = s^2 / \bar{x}$$

where

$\bar{x}$ = mean of individuals in a subplot = $x/n$,

$s^2$ = variance of individuals in a subplot = $\frac{\sum x^2 - (\sum x)^2 / n}{n-1}$

$x$ = number of individuals in a subplot

$n$ = number of subplots

$\chi^2$ was calculated using the following equation:

$$\sum_{i=1}^{N} \chi^2 = ID\ (n-1)$$

Since $n > 30$, $\chi^2$ was corrected using the equation:

$$d = \sqrt{2\chi^2} - \sqrt{2\ (n-1) - 1}$$

where

$d$ = correction factor

If

$d >$ 1.96, population is clumped

$d <$ 1.96, population is random

$d <$ - 1.96, population is regular or uniform

GPS points, population boundary and tree positions were plotted using Arc View 3.3. The tree position map generated was then overlaid onto topographic and forest reserve maps and Landsat TM images (30 m). A digital copy of the area's topographic map was acquired from the Survey Department in March 2003. Editing and map display were done using Autocad Map 2000i software. The GIS data on the Forest Reserve boundary, including its compartment boundaries, were acquired from the Forest Department of Peninsular Malaysia in November 2002. The Landsat image (30 m) was acquired for 18 March 2001, courtesy of the Remote Sensing and GIS Unit, FRIM. The spatial data was incorporated using Arc View 3.3 software.

## *Plant description*

Detailed botanical descriptions are given in Symington (1943) and Ashton (1982). *Hopea subalata* is a small tree, with maximum height of 12 m and 35 cm dbh. The outer bark is smooth, brownish-grey, while its inner bark is a very pale pinkish brown turning yellowish brown upon exposure. By and large, trees found naturally have a poor bole form or a very short clear bole. *Hopea subalata* in FRIM's dipterocarp arboretum attained 13.06 cm dbh at around 40 years of age (Ng & Tang 1974); there was no girth increment in the subsequent measurement taken at 44 years (Wong, K. M., pers. comm.).

## Geographical distribution

Although herbarium records indicated that *H. subalata* occurred in compartments 1, 2, 5D and 14, Kanching Forest Reserve, recent ground survey showed that the species was present only in compartments 2 and 14 (Figure 1). No individual was detected in compartment 1 and compartments 4, 16 and 17, i.e. the former compartment 5D. Trees in compartment 2 formed a population together with other species outside the forest reserve.

## Ecology

*Hopea subalata* is found on undulating land up to 140 m above sea level. It has a preference for low ridges and gentle hill slopes (Figures 2 and 3) but is also found along stream banks. It grows on granite derived soils. On the hill slopes and ridge tops, it occurs together with the gregarious *Dryobalanops aromatica*. It is interesting to note that Kanching Forest Reserve has a small quartz ridge. It is one of the many small quartz ridges that border the largest outcrop, i.e. the Klang Gates Ridge. Quartz ridges are renowned for their high plant endemism. In Kanching Forest Reserve, this geological aggregation may give rise to a complex series of soils that possibly determine the ability of a particular species to colonise specific sites. This perhaps explains why the populations of *H. subalata* in the reserve are rather discreet.

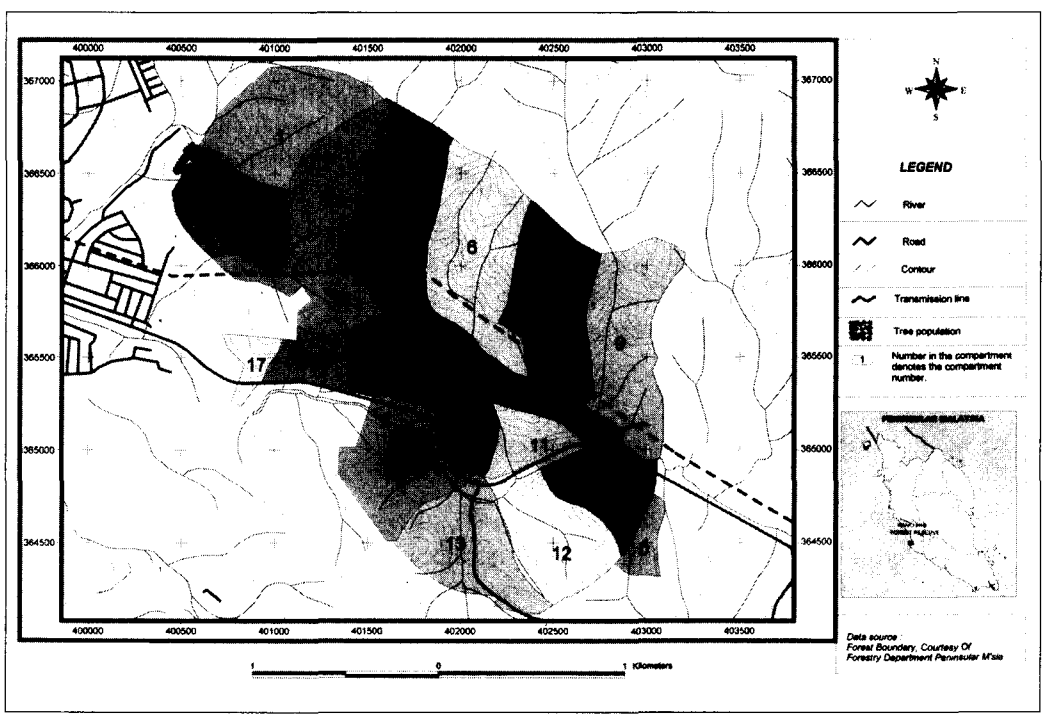


**Figure 1** Distribution of *Hopea subalata* in Kanching Forest Reserve, Selangor, Peninsular Malaysia

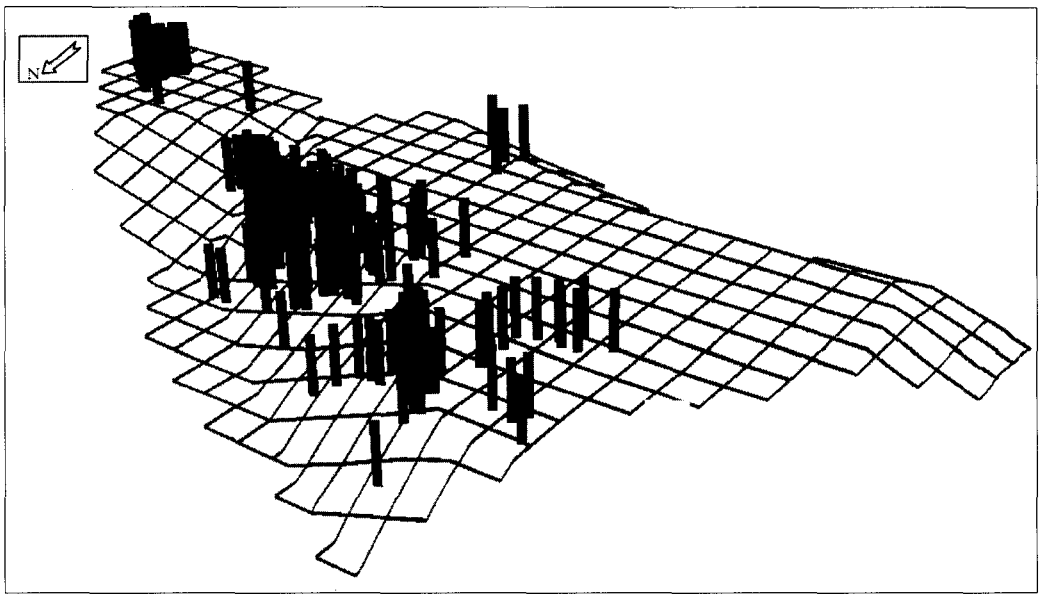


**Figure 2** 3-D view of *Hopea subalata* on a 10 × 10 m grid in compartment 2, Kanching Forest Reserve

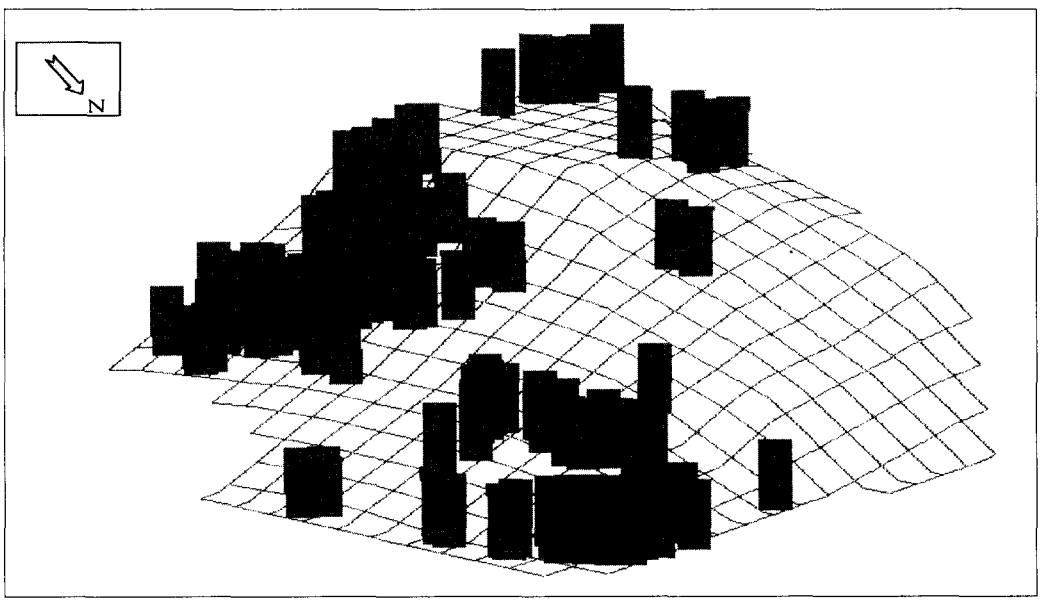


**Figure 3** 3-D view of *Hopea subalata* on a 10 × 10 m grid in compartment 14, Kanching Forest Reserve

## Flowering and fruiting

The *H. subalata* population at Kanching Forest Reserve fruited in 1921, 1927, 1933 and 1976. The large gap between the observed fruiting years does not indicate non-flowering and fruiting, merely that in the intervening period, no collection was made. A tree at FRIM's dipterocarp arboretum (No. 149) fruited in 1955, 1958

and 1963. A planted tree near the cafeteria flowered in 1980 while another individual in the dipterocarp arboretum fruited in 1985. The above information was acquired from the herbarium specimens at FRIM.

During the mast-fruiting year of 2002, observed trees in the Kanching population did not flower. However, trees no. 725 (FRI 41780) and 774 at FRIM's dipterocarp arboretum flowered but did not set mature fruits. The non-synchronous flowering and fruiting behaviour between two fairly near populations—FRIM is less than 10 km away from Kanching Forest Reserve—cannot be explained at present because its flowering behaviour is hardly known.

Planting records of tree no. 149 in the dipterocarp arboretum indicated that it had a dbh of 13.74 cm when it flowered in 1955. Although data was only available from one tree, we speculate that *H. subalata* becomes reproductively mature at around this dbh size.

## Conservation notes

### *Population in compartment 2*

Figure 4 shows the tree distribution in compartment 2. The corrected $\chi^2$ value (d) of the index of dispersion was 28.15, indicating a distinct clumping pattern (Table 1). The larger trees (> 20 cm dbh), namely nos. 259, 262, 257 and 260 were located at the periphery of the population and were not surrounded by other individuals. In other words, there were no regenerating stands surrounding these reproductively mature individuals. This is of concern for it may indicate that these adult trees (trees with dbh > 13.74 cm) do not produce viable progenies. Alternatively, this may be because site conditions have influenced the distribution of regeneration. It can be seen from Figure 4 that other adult trees (nos. 42 and 173) were surrounded by juveniles of several diameter size classes.

During the enumeration, 266 trees of ≥ 1 cm dbh were detected. Due to the limitations of the survey method, the population is expected to be higher as some individuals may have been missed out during the search. The distribution of *H. subalata* by dbh size classes is given in Figure 5. Typically, density, based on diameter size class, decreased with increasing size class. As much as 97.8% of the population was below 20 cm dbh. The largest diameter was 34.0 cm (tree no. 42). The absence of larger dbh size class indicated that *H. subalata* is a small-size dipterocarp. A total of 49 trees (18.35% of the population) can be considered as breeding individuals, based on the assumption that the species becomes reproductively mature when dbh reaches 13.74 cm.

Figure 1 shows that part of the population lies outside the boundary of the forest reserve. At least 10 trees are outliers (nos. 1–10), all < 20 cm dbh. The estimated area of occupancy was 0.17 ha. District Land Office records indicate that this land has been categorised and granted the category 'Lot Kediaman' (residence lot) (Gombak District Land Office records: File No. PTG 2/161/87 (L)) but the land has yet to be purchased. Landsat TM images for March 2001 (Figure 6) and recent ground survey indicated that this area is forested.

**Table 1** $\chi^2$ test of significant departures of index of dispersion (ID) of *Hopea subalata* from the Poisson distribution

| Compartment | $\Sigma x$ | $n$ | $\Sigma x^2$ | $s^2$ | $\bar{x}$ | ID | $\chi^2$ | $d$ |
|---|---|---|---|---|---|---|---|---|
| 2 | 266 | 800 | 976 | 1.11 | 0.33 | 3.36 | 2684.64 | 28.15 |
| 14 | 177 | 1019 | 357 | 0.32 | 0.17 | 1.88 | 1913.84 | 16.76 |

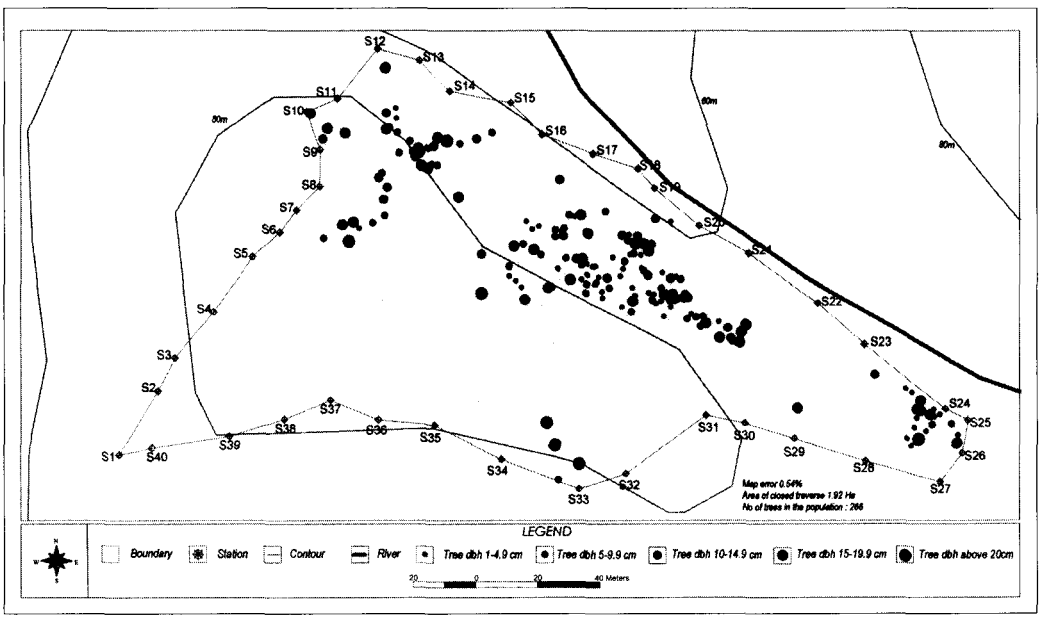


**Figure 4** Distribution of *Hopea subalata* in compartment 2, Kanching Forest Reserve

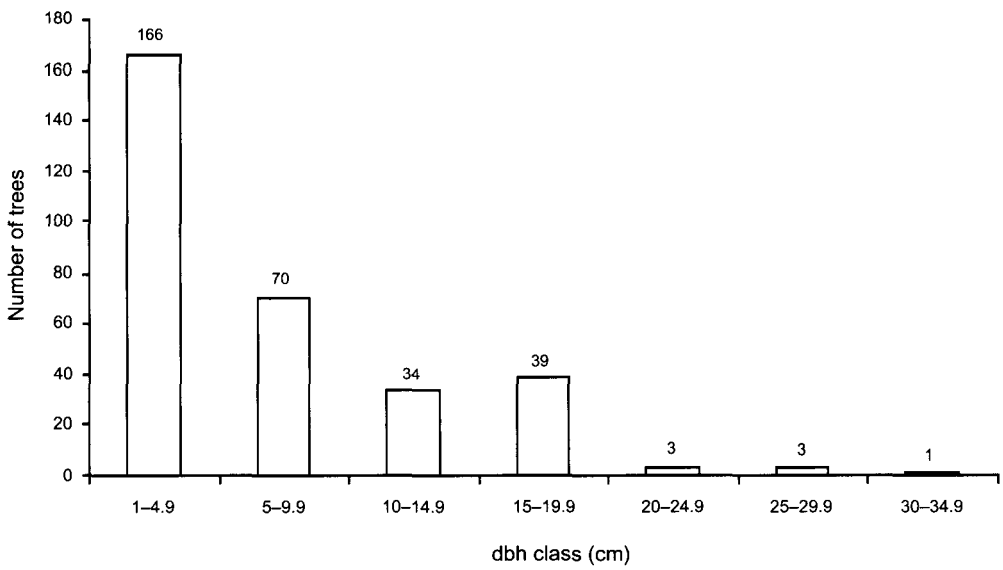


**Figure 5** Distribution by diameter (dbh) size classes of *Hopea subalata* trees ≥ 1 cm in compartment 2, Kanching Forest Reserve

### *Population in compartment 14*

Figure 7 shows the tree distribution in compartment 14. The corrected $\chi^2$ value (d) based on the ID was 16.76, indicating a clumping pattern (Table 1). The larger trees (> 20 cm dbh), namely, no. 7, 8 and 131 were located at the periphery of the population and had regenerating stands.

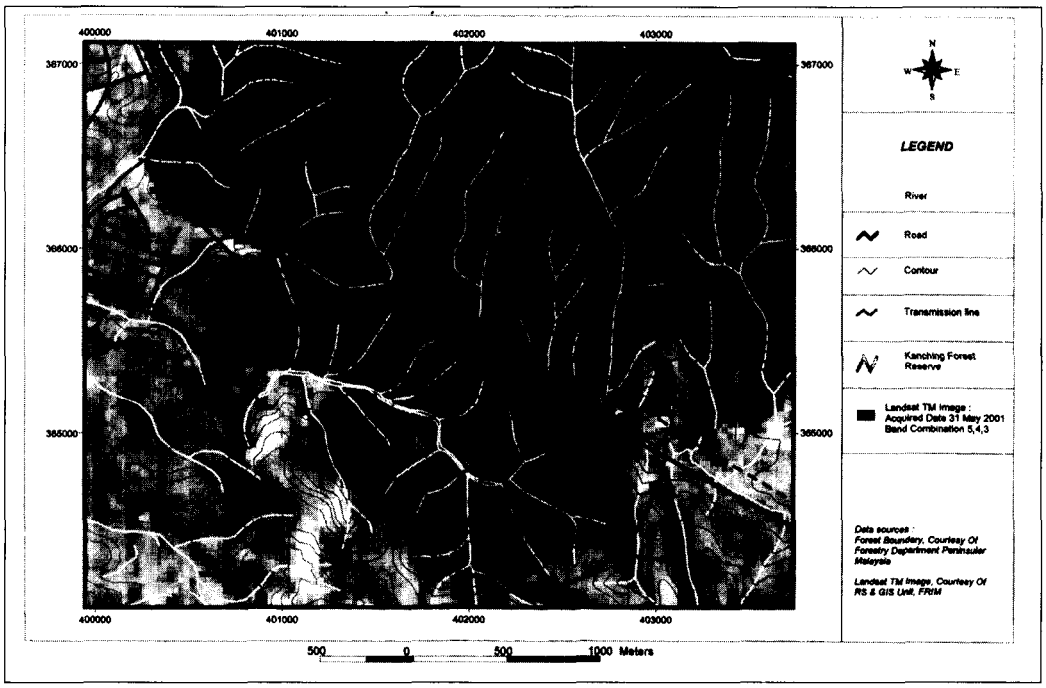


**Figure 6** Landsat TM (2001) for Kanching Forest Reserve, Selangor

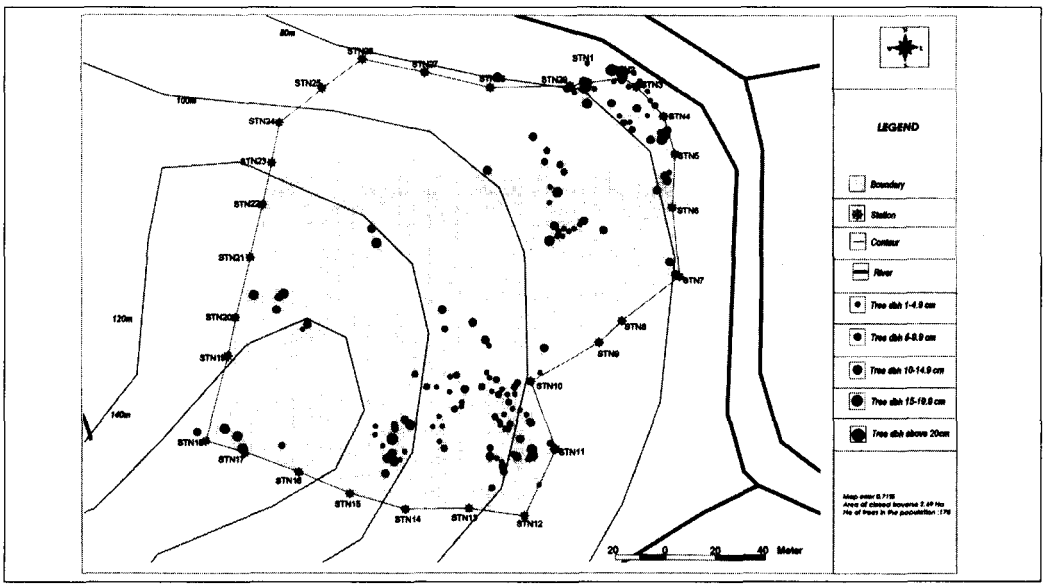


**Figure 7** Distribution of *Hopea subalata* in compartment 14, Kanching Forest Reserve

A total of 177 trees of ≥ 1 cm dbh were enumerated in this compartment. Their distribution by dbh size classes is given in Figure 8. As much as 98.3% of the population was < 20 cm dbh. The largest diameter was 25.0 cm. A total of 25 trees (14.12%) were reproductively mature.

## IUCN (2001) category

In view of the above results, *H. subalata* should be given the 2001 IUCN category of CR A4cB2. Following the IUCN (2001) Red List categories, a species may be categorised as 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 (NE). *Hopea subalata* is given an A4 because there is an inferred or suspected population size reduction of ≥ 80% over a period of three generations (up to a maximum of 100 years in the future); this period includes both the past and the future. The IUCN CR criteria further state that population reduction or its causes may not have ceased or may not be understood or may not be reversible, based on any of the following: (a) direct observation, (b) an index of abundance appropriate to the taxon, (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat, (d) actual or potential levels of exploitation, and/or (e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites. In the case of *H. subalata*, its absence from compartments 1, 4, 16 and 17 indicates that there has been a decline in area of occupancy and extent of occurrence; hence, it is given a 'c'. In addition, because its geographic range, in the form of the extent of occurrence and area of occupancy, is estimated to be less than 10 km$^2$, it is given a B2.

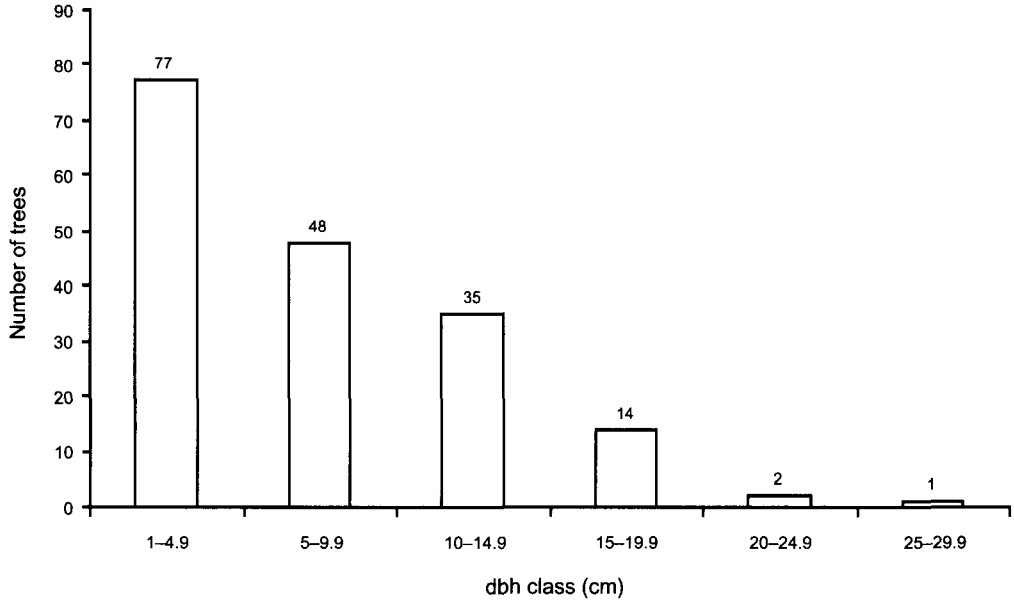


**Figure 8** Distribution by diameter (dbh) size classes of *Hopea subalata* trees ≥ 1 cm in compartment 14, Kanching Forest Reserve

## Discussion

*Hopea subalata* is confined to certain parts of the forest reserve and has very low adult population densities. These reasons alone necessitate the need for conservation. Studies with local endemic dipterocarps have shown that many species exhibit low densities (Bawa & Ashton 1991, Bawa 1998). *Hopea subalata* is a triploid (2n = 21, also 2n = 20 and 22) (Kaur *et al.* 1978, Somego 1978) and is closely allied phylogenetically to *H. rudiformis*, *H. sphaerocarpa* and *H. mesuoides* of the subsection Sphaerocarpae (Ashton, P. S., pers. comm.). Due to insufficient information on its breeding systems, genetic diversity and demographic patterns, it is difficult to speculate whether its populations, at their present sizes, are sufficiently viable to sustain the species over the long term. We noticed that while, in general, the population structure is viable, the total number of adults is small and some of the adult trees have no regenerating stands surrounding them. Presumably, some of these trees fruited in the past, but the loss of individuals from subsequent generation(s) could indicate that these trees cannot produce sufficiently vigorous plants to withstand selection. Genetic diversity and demographic studies are required to find out how this affects species survival in face of pressures from natural selection and man-made threats. Research work on the genetic diversity of two other locally endemic dipterocarps, namely, *Shorea lumutensis* and *H. bilitonensis* is nearing completion (Lee, S. C., pers. comm.). The data will provide crucial insights into the genetic composition of local rare populations. For *H. subalata*, efforts are currently underway to outline its genetic diversity and understand its breeding system.

Forest fragmentation, deforestation, even minor changes in landuse and selective harvesting may have long-term deleterious effects on the genetic diversity of *H. subalata*. In the 1920s, when the species was discovered in Kanching, there were large tracts of primary forests in Selangor. Fragmentation has since taken place; in Kanching Forest Reserve, forestry records indicate that most of the compartments, including compartments 2 and 14, had not been logged but were destroyed or damaged during the Japanese occupation and many parts had been rehabilitated with *D. aromatica* (Dipterocarpaceae) (Wan Mamat Saufi, pers. comm.). The rehabilitation must have played an important role in sustaining the populations in these two compartments.

The apparent absence of *H. subalata* from compartments 1, 4, 16 and 17 is of concern. Two scenarios are speculated. Lower collecting intensities in these compartments could indicate that the populations are more dispersed with individuals being more scattered and hence more difficult to detect. The apparent absence of *H. subalata* could simply reflect a failure to detect the species in the current survey. The second scenario involves the road and the transmission power line that now divides Kanching Forest Reserve (Figure 1). The presence of road and transmission line effectively creates forest fragmentation over the long term. The physical barriers, in addition to the accompanying forest clearance activities, either permitted or illegal within the vicinity, and the edge effects that invariably arise from fragmentation are likely to hamper the natural exchange of gene flow and affect its population viability in the long term.

Compartments 2 and 14 were originally identified in the forestry records as being productive (Wan Mamat Saufi, pers. comm.). In 1985, however, the entire forest reserve was converted from a productive status (where logging would be permitted) to a protected status and placed under the functional class of recreation forest.

Selective harvesting *per se*, although quoted above as a potential factor for genetic reduction, is not applicable to *H. subalata*. It is a small size dipterocarp and, by Malaysian forestry standards, has no commercial viability since stocking of trees > 30 cm dbh was poor.

## Conservation recommendations

Part of the overall population in compartment 2 lies outside of the forest reserve. From a conservation viewpoint, this forested zone, which separates the forest reserve boundary from the residential/industrial estates, is too narrow. Since a land grant has already been issued, this area will be purchased and converted into non-forest landuse in the future. As a short-term conservation measure, it is strongly recommended that the State Forest Department and the District Forest Office make an appeal to the Selangor Government, via the District Land Office, to prevent purchase of the land parcel. It is recommended that the grant File No. PTG 2/161/87 (L), 'Lot Kediaman' Kampung Batu 16, Rawang, Selangor be cancelled, thus rendering the site not available for conversion. For the long-term, it would be prudent if the relevant authorities (District Land Office, Forest Department and the Selangor Government) gazette this relatively small site as an addition to the rorest reserve. The annexed land then falls under the jurisdiction, management and legal mechanism of the Permanent Forest Estates, under which it should be placed in the protection forest category. Strict adherence to the regulations will ensure the conservation of the population. Further protection can be decreed by designation of a virgin jungle reserve status or recognising restricted zones in the overall designation of recreation forest status for the Kanching Forest Reserve.

In addition, since both populations are situated relatively close to the forest reserve boundary, it is strongly recommended that the District Forest Office regularly monitor pertinent sections of the boundary to ensure its integrity and prevent future conflicts.

## Acknowledgements

We wish to express our gratitude to W. M. Y. Wan Mamat Saufi, Raja Muzaffar Shah and the foresters and rangers of the Hulu Selangor District Forest Office for the permission granted and full field assistance provided. We are grateful to A. Roslan (Selangor State Forest Department), Mokhtar, Mat Shah and Rosli (Gombak District Land Office), the GIS Units of Forestry Department Headquarters and FRIM for providing the necessary information. Special thanks are due to the Forest Engineering Team (Natural Forest Division, FRIM) for their technical assistance. Thanks are also due to S. L. Lee and Muhammad Farid (FRIM), Abd. Latiff Mohd.

and M. Shukor (Universiti Kebangsaan Malaysia) for their constructive comments and to S. Damahuri, Y. C. Chan, D. Mustapa and K. Ayau, the botanical team who undertook the field data collection. Support for research came from the Flora Malaysiana Centre Fund, Ministry of Primary Industries, Malaysia under Project 6: Conservation Monitoring System for Threatened Plants.

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