Ecological Species Grouping for Forest Management in East Kalimantan.

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Executive Summary

An ecological species grouping has been developed through statistical analysis of growth data from the STREK permenant sample plots in the Labanan concession of PT Inhutani I. This new grouping was intended to supplement existing species groupings developed by Inhutani in conjunction with the BFMP project linked to the development of the Yield Scheduling System (Rombouts, 1998b) and Inventory (Kuru, 1999).

The ecological species grouping was initially developed to meet a need for use in the development of the SYMFOR growth and yield model and the statistical analysis of data from the STREK plots. The new grouping has been shown to be a significant improvement on existing groupings for these applications and as such complements previous work.

The ecological species grouping contains ten groups. There are four groups describing the main dipterocarp species, two pioneer groups and three additional groups describing small trees which tend to be non-commercial. The last group contains all individuals that have not been identified to the level of at least taxonomic family.

The ecological species grouping has been used to analyse the results from the STREK thinning trial (van Gardingen, 1999b) and will be used for similar analysis of the STEEK logging trial. Preliminary results from analysis of the thinning trial using the ecological grouping have demonstrated significant differences in the response of specific groups to the method and intensity of logging which are not apparent when using the alternative BFMP groupings. The most significant result has been the observation that there is a highly significant increase in the number of individuals of trees in the two pioneer species groups and their growth rates when plots are subjected to high intensity logging. This may form the basis for the development of a suitable ecological indicator of good forest management.

Abbreviations.

BFMP	Berau Forest Management Project
DFID	Department For International Development (UK)
PSP	Permanent Sample Plot
STREK	Silvicultural Treatments for Regeneration of logged over forest in East Kalimantan.
SYMFOR	Sustainable Yield Management for Tropical Forests. (DFID, Growth model)
TPTI	Indonesian Selective Logging and Replanting System

1 Introduction

1.1.1 The BFMP project has previously developed a species grouping based on commercial characteristics from the STREK sample plots that was subsequently used to develop the BFMP Yield Scheduling Systems (YSS) (Rombouts, 1998b). This grouping has also been used in initial analysis of inventory results. A more detailed analysis of commercial timber utilisation (Kuru, 1999). These two systems for species grouping have been shown to be essential tools in developing management plans and support tools for the Labanan concession of Inhutani I.

1.1.2 Data from the STREK plots are being analysed to support the development of a management plan for the Labanan concession. A review of the data has illustrated their potential to be used in support of management decisions (van Gardingen, 1999a). Further work has applied these data to analyse the observed benefits of thinning as applied in the STREK trials (van Gardingen, 1999b). Both of these studies found that existing species groupings developed by the BFMP (Rombouts, 1998b) (Kuru, 1999)or previously by the STREK project (Sist & Abdurachman, 1998) were not able to fully describe the observed growth responses of the forest to applied silvicultural treatments. It was apparent that a separate grouping based on growth and ecological characteristics was required for this application.

1.1.3 The STREK data are also being applied in the development of an improved model to predict growth and yield based on Permanent Sample Plot (PSP) data. The SYMFOR programme is being developed by a Department for International Development (DFID) project in co-operation with BFMP and PT Inuhutani I. The development of SYMFOR has also required the development of species groups based on growth and ecological characteristics as derived from the PSP data.

1.1.4 It was recognised that it would be desirable to develop one ecological species grouping that could be used for both modelling and statistical applications. This report describes the development of a system that is the result of collaborative work between the BFMP and DFID projects.

2 Background

2.1.1 Forest managers, forest scientists and forest policy makers all rely on accumulated knowledge of the forest in order to make decisions. This knowledge may be based on their own experience or that of others, but will have originated from information collected from the forest. A quantitative understanding of the forest requires quantitative data to support it, and a suitable analysis to reduce the raw data to a meaningful form.

2.1.2 In the case of mixed tropical forests, an important element of the raw data is the taxonomic description of tree species. The botanical composition of a forest, may affect decisions related to forest management (logging operations or silvicultural planning), forest policy (annual allowable cut and perhaps the minimum logging cycle) or conservation (biodiversity and wildlife habitats). The large number of tree species found even within very localised areas of mixed tropical forests mean that any raw data is difficult to summarise in a form that can be used for scientific investigations or to support management decisions.

2.1.3 One hectare of forest may contain between 80 and 200 different identified species of tree (Newman, Burgess & Whitmore, 1996a; Newman, Burgess & Whitmore, 1996b; Bertault & Kadir, 1998) with a diameter at breast height (DBH) greater than 10 cm. This leaves the analyst with three choices:

(1) Average data quantities for each species separately;
(2) Average data quantities over all species; or
(3) Group the species in some meaningful way as a compromise between the detail of (1) and the brevity and readability of (2).

2.1.4 For biodiversity applications an appropriate, meaningful grouping may be made by using a taxonomic approach at the level of family or genus. For a commercial analysis of a timber company's logging operation a meaningful grouping may simply be a question of which commercial timber group the tree belongs to. However, for a general description of the state of the forest or a more detailed application such as growth and yield modelling, a more complex approach to grouping the tree species is required.

2.1.5 The development of the SYMFOR growth and yield model for mixed tropical forest in Kalimantan, Indonesia, prompted the requirement for a suitable tree species grouping. The primary reason for this was that the growth response function of trees was found to be significantly different for trees of different species. This necessitated the modelling of growth separately for these species. The large number of tree species in the available data and the extremely low occurrence frequency of many species meant that separate modelling for each individual species was impossible. In addition, as pointed out by (Vanclay, 1994) the grouping of species can reduce the number of equations required by modelling to a manageable number. Other requirements were also placed on the grouping:

(1) That it should be usable in all the sub-models and not solely in the growth part of the model. This included recruitment of saplings into the model and the representation of mortality.
(2) That it should be usable outside the model as a tool for describing the state of the forest, primarily for statistical analysis with a view to silvicultural management. This is desirable of any grouping, but essential in this instance because of the need to use model-output to support forest management decisions.

2.2 Existing species groupings.

2.2.1 Several pre-existing species groupings were considered for use. Grouping by taxonomic classification at genus level was found to be inappropriate for modelling growth. For example, the genus *Shorea* in the Dipterocarpaceae family contains species which have a large range of maximum diameters and growth rates (measured under the same conditions). The variance of the growth model would not be reduced by using a group "*Shorea*" compared to grouping all trees in the forest together.

2.2.2 Grouping by commercial status (combined with taxonomic information from the BFMP YSS, (Rombouts, 1998b)) was found to be inadequate for modelling growth, partly due to the variety of growth characteristics found in topical forest tree species, and partly because the definition of which species are and are not commercial may vary between areas, companies and from year to year.

2.2.3 A grouping based on functional attributes (for example, light demand or potential height (Kohler & Huth, 1998)) was not appropriate for the current applications since the primary reason for the grouping was to develop aggregated growth equations for an empirical model. The empirical model was to be calibrated from the data, so a consitstent approach was required for the species grouping.

2.2.4 The grouping developed for the DIPSIM model (Ong & Kleine, 1995) was developed in Sabah, Malaysia, in forests with different species composition, density, climate and forest usage than for the forests in Kalimantan. They aggregated species to 22 groups, which was considered too many to summarise the state of the forest and to render the model equations manageable.

2.2.5 The grouping developed by for the use of DIPSIM for forest in East Kalimantan (Rombouts, 1998a) used dependant variables for the growth equations that were very different to those used in the individual-based model under development, which could lead to a different grouping structure. In addition, Rombouts found 19 groups, which was considered too many, as with Ong and Kleine's grouping. None of the existing groupings were suitable for an individual-based model of forest growth in Kalimantan and thus a new grouping was required.

3 Methods.

3.1 Permanent sample plot Data.

3.1.1 Data from the STREK permanent sample plots (van Gardingen, 1999a) were used to develop the species grouping. Data were stored as tables in a relational database based upon the Growth and Yield Data System (Rombouts, 1997) stored as individual databse tables (Visual Foxpro version 5. Microsoft Corporation, USA). Statistical analysis of the data was completed using SAS (Version 6.12, SAS Institute Inc). Data up to and including those from measurement campaign 4 (1997) were used for the development of the groups.

3.2 Methodologies for development of a species grouping.

3.2.1 (Vanclay, 1991) developed a methodology for isolating species groups based on “founding” species that were shown to be significantly different to each other. The groups were then completed using pair-wise F-tests on the growth equation parameters. This method was used to group 237 taxa into 41 species groups using data from rainforest in north Queensland. This method is suitable where it is possible to develop meaningful equations for a large proportion of the number of species, which in turn depends on the choice of equation and the data available.

3.2.2 (Schwarzwäller, 1997), working in Peninsular Malaysia, decided to not use this method due to the low proportion of species with sufficient observations to satisfy this requirement. In the current study, at species level, the growth equations could explain only 20%, on average, of the variation in observed growth rates and so only species with a large number of observations were considered suitable for forming the equations. This constituted 64 species out of a total of 575, rendering Vanclay’s method inappropriate. In addition, the total number of groups was limited due to the data requirements for recruitment calibration and that the number of groups should be minimised in order to effectively summarise the data.

3.2.3 (Schwarzwäller, 1997), used a clustering method for grouping species, having also found Vanclay’s approach unsuitable. This method grouped observations statistically, based on their relative positions within parameter space and was only appropriate for species with well-defined parameter values. For most tropical forest species it is not possible to estimate model parameters with any degree of accuracy due to the low number of observations. Schwarzwäller approached this problem by approximating any missing parameters for species with sufficient data for only a partial regression to be possible. The clustering approach was suitable for the current study, but only for those species with well-defined parameter values and a new method was necessary in order to accommodate the remaining species.

3.3 Grouping species

3.3.1 No assumption was made that a single species should form the basis for a species group. However, the species for which there is more data clearly have their characteristics better defined by the data, and so these were used to form the grouping structure. Other species, with intermediate amounts of data, were assigned to the existing groups by analytical methods. All remaining species were assigned to the groups either by using the maximum DBH, as documented elsewhere (Newman, Burgess & Whitmore, 1996a; Newman, Burgess & Whitmore, 1996b; Argent *et al.*, 1997a; Argent *et al.*, 1997b) or, lacking this information, by genus, if a species of the same genus had already been grouped. Species for which there was no previous basis for grouping were allocated to default groups.

3.4 Cluster Analysis.

3.4.1 The species for which there was sufficient data for reliable parameter estimation were used to form the groups using cluster analysis. The clustering analysis requires a set of variable values for each species to be grouped. Variables describing the growth, recruitment and mortality processes were selected for the clustering process.

3.4.2 Growth of a species was characterised using mean growth rates at defined values of tree size and competition. These were calculated using a model of annual growth rate:

$$\Delta D = ((b_0 + b_1 D).e^{\frac{-D^2}{b_2}} + b_3 \text{-} b_0).(1 + b_4 S).((1 + b_5 S').e^{\frac{-S'^2}{b_6}})$$

3.4.3 where D = (DBH –10) (cm), S is a competition factor evaluated within a range of 5 m, S' is a similar factor evaluated within 30 m and b_0 to b_6 are the parameters estimated by the regression (SAS procedure "nlin") (SAS Institute Inc., 1989b, pp. 1135-1195). The competition factor, S, is given by:

$$S = \sum_{i=1}^{n} \frac{D_i}{xD_t}$$

3.4.4 where D_i is the DBH of a neighbouring tree (cm), where a neighbouring tree is defined as one within a given range (for example 5 m) of the object tree, D_t is the DBH of the object tree (cm), and x is the distance between the two trees (m).

3.4.5 The parameter value estimates were then used to calculate predicted growth rates at 4 combinations of values of D, S and S': (0, 8.0, 0.5), (0, 24.0, 6.0), (40, 2.0, 0.1) and (40, 5.0, 3.0). This was necessary because the non-linear spread of the parameter values would lead to a distorted grouping, had the parameter values themselves been used to group the species. Using actual values of predicted growth gave a direct correspondence between difference in growth rate and the separation of species groups.

3.4.6 To describe recruitment, the value of S' for trees recorded in one measurement survey that had not been in the previous survey was averaged for all trees of the same species. This variable gives an indication of whether saplings of a given species grow successfully in relatively light or dark conditions.

3.4.7 To describe mortality, an additional predicted growth point was used, (70, 2.0, 0.5), although the predicted growth rate at this point was set to –10.0 cm/yr if the fifth largest tree of that species had $D < 70$ cm. This final point corresponds to a simple measurement of maximum diameter, which is related to mortality rate via the growth functions.

3.4.8 The clustering analysis routine provided by SAS, "proc cluster" was used to cluster the species into groups (Appendix I). Clustering analyses are significantly affected by the distribution of observations for each parameter; this implies that if the distribution of values of a particular parameter is non-uniform then the clustering procedure may not perform well. For this reason the output of the clustering process could not be taken as final, and some subjective adjustment was made to the grouping at this stage. The adjustment was based on graphical examination of the growth data, but changes were suggested by phylogenetic information. The number of groups was chosen from the clustering analysis such that the number of changes, or the number of apparent conflicts within a group, was minimised.

3.5 Adding to the groups - discriminant analysis.

3.5.1 Other species, that had sufficient data for some parameter estimation to be made, were then added to the existing groups using a discriminant analysis. The routine used was the SAS routine "discrim" (Appendix I). Discriminant analysis attempts to identify the areas of variable-space occupied by groups, and can then assign a new observation, or set of observations, to an existing groups. Discriminant analysis is subject to the same weakness as clustering methods for parameters which do not have a uniform distribution.

3.5.2 The same variables as used for clustering were evaluated for the unassigned species. For the growth rate regressions, only species with 30 or more growth observations were considered to be adequate and for recruitment variable evaluation only species with 5 or more new recruits recorded in the data were used. Following the discriminant analysis, a subjective adjustment of the enlarged contents of the groups was made, for the same reasons as following the clustering analysis.

3.6 Assigning the remaining species.

3.6.1 The remaining ungrouped taxonomic classifications observed in the data were then grouped based on their documented maximum diameter (Newman, Burgess & Whitmore, 1996a; Newman, Burgess & Whitmore, 1996b; Argent *et al.*, 1997a; Argent *et al.*, 1997b) or using taxonomic information if this was not available. This method is partly subjective, however it was necessary in order to obtain a consistent grouping that included less-frequent species that form the majority of species but the minority of individuals in a stand. This ensured that the importance that a given species had in the grouping structure corresponded to the amount of data available to describe it.

3.6.2 Any less-frequent species that exhibited extreme behaviour could at this stage be identified to form more species groups. This avoided the inclusion of the extreme growth characteristics in other groups, and allowed models and descriptions to include any particularly dramatic species-dependant effects within a forest.

4 Results

4.1 Clustering

4.1.1 64 species had at least 100 growth observations, and these were used in the clustering analysis. The parameters in the model of growth were estimated by regression for each species, and these were used to calculate the five predicted growth variables. The recruitment variable was also calculated for these species. These 6 variables were used by the clustering analysis.

4.1.2 10 groups were output from the clustering process, which led to the formation of 7 statistically distinct species groups. From within these, however, two more groups were identified that should be separated. The characteristically smaller-sized, and therefore less important, Dipterocarpaceae species had been shown by the clustering analysis to be statistically compatible with other existing groups, however the increased importance of the Dipterocarpaceae compared to other families for forest data description purposes led to the decision to separate them.

4.1.3 The second group to be created subjectively was that of the "unknown" species. Due to the enormous diversity of species in tropical forests, experts will often fail to identify the species of up to 30 % of trees. The resulting growth, recruitment and mortality behaviour of such trees observed in the data is likely to be a combination of characteristics from all contributing species. Thus this "species" is not expected to fit into any one group and would indeed distort the overall behaviour of that group, so was separated to form a separate group.

4.1.4 Following examination of the clustering variable values, four individual species were moved from small, anomalous groups to larger groups with a more defined species composition. The original grouping of these four species was assumed to be due to poor performance of the clustering procedure, so the resulting grouping is considered to be more robust than the original.

4.1.5 The process of clustering highlighted some of the instabilities associated with this approach. The use of alternative models for growth, changing the value of the diameter limit for the mortality variable or using an alternative clustering algorithm each produced a slightly different grouping. However, the basis of each grouping is similar, and the main differences were observed in the less populated groups.

4.1.6 Slight changes were made to the variables and algorithms used, in combination with visual examination of the data, in a subjective approach to obtain a robust grouping that will be largely independent of the details of the method used.

4.2 Discriminant analysis.

4.2.1 The remaining 511 species then had to be assigned to groups. Two of the existing 9 groups could not be used in the automation of this process, as they were not statistically distinct; the process used to assign new species to existing groups would mis-assign species to the two non-statistically generated groups. The species already assigned to the 7 statistical groups and their variable values used for clustering were entered to a discriminant analysis procedure as the training data set.

4.2.2 Only species with 30 or more growth observations were considered to be useable, and for recruitment variable evaluation only species with 5 or more new recruits recorded in the data were used. This reduced the number of species available for assignment to a group by discriminant analysis to 72 species. The variables used in the clustering analysis were calculated for these species, and then were entered to the discriminant analysis as the test data set. Following this analysis, 19 species were re-assigned to groups manually in order to place increased significance on the recruitment variable compared to the predicted growth data. The purpose of this was to emphasise the effect of the regeneration characteristics of the species groups that dominates tropical forest dynamics. These species were almost all from non-Dipterocarpaceae families, and therefore of less significance to model results and forest data descriptions. The two non-statistical groups ("small Dipterocarps" and "unknown") were then recreated. In total, 136 species were grouped by either clustering or discriminant analysis with some subjective adjustment into 9 groups.

4.3 The remaining species.

4.3.1 Species that could not be grouped by analytical methods were assigned to a group based on phylogenetic information or the maximum DBH observed, as recorded in the relevant forest manuals (Newman, Burgess & Whitmore, 1996a; Newman, Burgess & Whitmore, 1996b; Argent *et al.*, 1997a; Argent *et al.*, 1997b). All remaining 439 species were assigned in this way. One species, *Anthocephalus chinensis*, in the Rubiaceae family, was observed and is known to grow fast but only in heavily disturbed forests, and was placed in a new group, giving a total of 10 groups.

5 The resulting species groups.

5.1.1 Table 1 describes the ten species groups.. A full listing of the species in each group is given in Appendix II.

Group	Name (reference)	Characteristics	Dominant members
1	Fast growing shorea	Large trees, light demanding, very fast growing	*Shorea johorensis*, *S. leprosula*
2	Dipterocarpus	Large trees, shade tolerant, slow growing	*Dipterocarpus*, some *Shorea*
3	Other large dipterocarps	Large trees, shade tolerant, fast growing	*Shorea*, *Parashorea*, *Dryobalanops*
4	Small dipterocarps	Default group for Dipterocarpaceae species	*Hopea*, *Vatica*, some *Shorea, Dipterocarpus*
5	Anthocephalus	Small trees, fast growing, highly disturbed forest	*Anthocephalus chinensis*
6	Macaranga	Small trees, light demanding, very fast growing	*Macaranga*
7	Gap small trees	Small trees, recruit in light areas	*Aglaia, Knema, Artocarpus*
8	Other small trees	Small trees, default group for non-Dipterocarpaceae species	*Diospyros, Dacryodes, Polyalthia*
9	Shade small trees	Small trees, recruit in shady areas	*Macaranga lowii, Gonystylus, Madhuca, Kayea*
10	Unknown	"Unknown" species, genus or family identity	Unknown

Table 1. The characteristics and content summary of each species group.

5.1.2 The method of development of the groups ensured that they were suitable for use in the modelling process. The other requirement of the grouping, that they should be suitable for summarising the state of the forest, was also met: the number of groups is small, and the groups can be described by both some phylogenetic description and also their ecological characteristics.

5.1.3 Although 439 species (76 %) are assigned to groups using maximum height data taken from the literature and phylogenetic information, this corresponds to only 21 % of the number of trees present in the forest. Thus the effect of the subjective part of the grouping method is substantially smaller than as first appears. The dominating effect leading to the nature of the groups is from the species used in the clustering analysis.

5.2 Comparisons with other groupings.

5.2.1 Unlike in the approach of (Vanclay, 1991) some subjectivity was used in order to be able to use the grouping to describe the state of the forest. This was also necessary in order to group the less frequent species, where growth and recruitment data was not available. This has allowed concise and readily understandable descriptions of each group to be created, which would almost certainly not be possible from an automated grouping process. The descriptions afford the user an insight into the grouping structure that encourages the use of the grouping and an increased comprehension of results from the usage. This is an important aspect to any model or analysis tool.

5.2.2 (Rombouts, 1998a) claimed that only species groupings based on local species names could be of any use in forest management, since identifiers with an advanced knowledge of botanical identifications was not widely available in Kalimantan. However, if the forest can be described by a grouping that is also used in modelling then the only requirement on species identification is that the identification of the species group of a tree is correct. The descriptive comments about each group allow a mapping to local species names to be created even without resort to botanical identification. Vanclay (1994, pp. 127-128) notes that this feature of a species grouping can bypass sources of potentially serious error in species identification.

5.2.3 The grouping produced is clearly dependent on the choice of equation and dependant variables used to model growth. However, there are some underlying trends which are likely to separate some species regardless of the choice of model; these can be summarised as: maximum growth rate, maximum diameter and preferred light conditions. These quantities lead to the separation of many species in the Dipterocarpaceae family, and often the *Macaranga* genus, from many other species. These are common features in the grouping developed in this study and the groupings of (Rombouts, 1998a) and the DIPSIM model for Sabah (Ong & Kleine, 1995)

5.2.4 (Vanclay, 1991)and (Rombouts, 1998a) who used the same method, arrive at 41 and 19 species groups respectively. (Ong & Kleine, 1995) obtain 22 groups. This is in contrast to the 10 groups presented here. The contrast is due in part to the requirement that the grouping here should be used as a means of summarising the state of the forest, which necessarily limits the number of groups. In addition, the method used allows the developer to choose the number of groups. This allows some subjectiveness in the grouping and a compromise between an unmanageable complexity and over-simplicity to be established.

6 Applications of the Ecological Species Grouping.

6.1.1 The grouping has been used to describe the status of areas of forest in East Kalimantan. The ecological grouping was an important tool is the analysis of the STREK thinning trial (van Gardingen, 1999b) and will be used to analyse the assocoated logging trials.

6.1.2 The ecological grouping allows a statement of the standing basal area to be made for the large tree groups, and comparison to be made for the different pioneer groups, in particular for heavily logged-over forest where many *Anthocephalus chinensis* are found. It has been found possible to elecit some elements of the history of a stand by analysis of the species content using this species grouping, such as time since logging and the level of logging. This will allow the development of practical indicators of good forest management.

6.1.3 This grouping is currently being used in the development of the SYMFOR growth and yield model which will be applied for yield regulation in the Labanan Concession. The details of this model will be published elsewhere, however preliminary results indicate that the grouping enables a significant increase of the coefficient of determination of the growth model relative to that using either a previous BFMP grouping (Rombouts, 1998b) or no grouping. This is the case particularly for the groups that dominate the forest dynamics following logging: the pioneer groups *Anthocephalus chinensis* and the *Macaranga* (groups 5 and 6) and the fast-growing, light-demanding *Shorea* (group 1). Other groups that are important for silvicultural planning (the large Dipterocarpaceae, groups 2 and 3) are also better modelled than the smaller, non-commercial species.

7 Adding New Species to the Ecological Groups

7.1.1 It will be necessary to add new species to the existing grouping, as additional data are collected from plots in the Labanan concession, or the grouping is applied to other localities. For a species grouping to be useful in a general context, it is important to specify to future users the method by which a new species may be added to one of the groups. This is particularly the case for forests of high species diversity, for which it is not uncommon to observe trees of a species not observed elsewhere. This section describes the general procedure to be followed to add new species to the ecological grouping.

7.1.2 For species not mentioned in appendix II, the procedure for adding them to the grouping would be as follows:

- Given sufficient data, evaluate the variables described previously for the ungrouped species and the grouped species alike. Ignoring groups 4 and 10, use the grouped species as a training set, and use the ungrouped species as the test data set in a discriminant analysis. This would assign each species to a group statistically. If the species is in the Dipterocarpaceae family and it is placed in group 5, 6, 7, 8, or 9, then change it to group 4 ("Small Dipterocarpaceae").
- If there are insufficient data to perform the above analysis, then attempt to group the species by its characteristics as described in Table 1.
- If there are insufficient data and knowledge of the species' characteristics to perform either of the above steps, match the genus of the unassigned species to a genus already present in the table, and place the two species in the same group. For Dipterocarpaceae, check the documented maximum diameter in suitable forestry manuals e.g. (Newman, Burgess & Whitmore, 1996a; Newman, Burgess & Whitmore, 1996b). If this is less than 1m, place the species in group 4. If it is greater than 1m and a heavy hardwood then choose group 2, otherwise choose group 3.
- If all else fails, choose group 4 for Dipterocarpaceae species and group 8 for all other species.

7.1.3 Care must be taken in performing an addition of this kind that the proportion of the forest made up by the unassigned species is small. If it is not, a complete re-grouping should be considered since the addition of the new species could alter the distribution of the groups in variable-space, and hence alter the species composition of the groups.

7.1.4 It should be noted that for the Labanan concession it is likely than any new species will consist of only a limited number of individuals and as such the will be insufficient data available for the statistical approach. It will the be necessary to assign the species using the taxonomic approach.

8 Summary.

8.1.1 A species grouping has been produced that is:

- primarily derived from forest data, rather than being created from descriptive characteristics of each species.
- based on a clustering of the predicted growth rates calculated with an equation for growth rate for an individual-based growth and yield model, a measure of maximum diameter to represent mortality and the average competition environment of small (DBH=10 cm) trees.
- designed to satisfy both modelling requirements and also general data analysis requirements. This has the effect that the grouping is explainable to and usable by a wider section of the forest community, as the grouping can be used to summarise the state of a forest.

8.1.2 The grouping was derived using a multi-stage approach: a clustering method for highly frequent species; a discriminant method for less frequent species; and a more subjective method based on documentation and botanical species identification for the very infrequent species. This method was found to be suitable for producing an adaptable and useful grouping of species in an environment of very high species diversity. Comparisons with previous approaches indicate that more specific groupings, containing more groups, are less appropriate for summarising the state of the forest although they may be more highly trained to the requirements of the model. These other approaches were designed to satisfy the requirements of the model only, whereas the new grouping is appropriate for general statements of forest condition.

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10 Appendix I. Statistical Analysis Programmes

10.1 These programmes are listed in the sequence in which they were used.

<u>Programme 1 – model the growth data for each main species.</u>

```
/* Fit the desired functions to the growth rate vs diameter and
Competition Index data */

proc printto;
run;

/* Make the local data file */
data work.calib (keep=plot_id ru_id tree_id cdnfi Dbh Grrate shade5
shade30);
        set bfmp.calib100;
        dbh = avdiam - 10;              /* adjust the dbh here to
make the equations simpler */
        /*if plot_id ge "BFMPBER 4 1" and*/
        if (plot_id ne "BFMPBER 4 1" or RU_ID ne 4);
run;

/* Sort the calib data by species */
proc sort data=work.calib;
        by cdnfi;
run;

proc printto log="c:\temp\hypoth5c.log";
run;
proc printto print="c:\temp\hypoth5c.output";
run;

/* Do the non-linear regression */
proc nlin data=work.calib outest=work.parm method=newton;
        by cdnfi;

        parms b0=0.0 1
                b1=-0.1 0.1 0.5
                b3=10 250
                b4=0.3 1.0
                b5=0.1
                b8=-0.1 to 0.1 by 0.1
                b9=300 1000;
/*                b7= 50 300*/
        bounds 1<b3<10000, 0<=b4<=5, -1<b0<=2, b1>-1, b5>-1, b8>-1,
1<b9<10000; /* 1<b7<100000, */

        /* Create temporary variables to simplify the calculation for
SAS */
        dbh1 = b1 * dbh;
        dbh3 = exp( -(dbh**2)/b3 );
        dbht = (b0 + dbh1) * dbh3 + b4 - b0;

        shd55 = b5 * shade5;
/*        shd57 = exp( -(shade5**2)/b7 );*/
        shd5t = (1  + shd55);           /* * shd57;*/
```

```
        shd305 = b8 * shade30;
        shd307 = exp( -(shade30**2)/b9 );
        shd30t = (1  + shd305) * shd307;

        model grrate = dbht * shd5t * shd30t;

        output out=nlino sse=sse;
run;

proc printto;
run;


/* Get the corrected sum of squares for the original data */
proc means data=work.calib noprint css;
        by cdnfi;
        var grrate dbh;
        output out=meano css=css max(dbh) = maxdbh;
run;

/* Get just the Sum of Squares of Errors (residuals) for each species
*/
data sum (keep=cdnfi sse);
        set nlino;
        by cdnfi notsorted;
        if first.cdnfi = 1;
run;

/* Combine the SSE and CSS tables to obtain the R-square estimator */
data arsq (keep=cdnfi _FREQ_ sse css Rsq maxdbh);
        merge meano sum;
        by cdnfi;
        if css gt 0 then Rsq = 1 - SSE/CSS;
        else rsq = -1.;
run;

/* Summarize the Parameters information */
data parsum (keep=cdnfi b0 b1 b3 b4 b5 b8 b9);
        set work.parm;
        by cdnfi;
        if _type_ eq "FINAL";
run;

/* Combine the parameters and the R-square information */
data total (keep=cdnfi _freq_ sse css Rsq b0 b1 b3 b4 b5 b8 b9
maxdbh);
        merge arsq parsum;
        by cdnfi;
run;

/* Summarize the results for analysis */
proc means data=total noprint;
        output out=summ
                sum    (_freq_) = N
                mean   (Rsq) = mRsquare
                mean   (sse) = mSSE
                mean   (css) = mCSS
                mean   (b0) = mb0
                mean   (b1) = mb1
                mean   (b3) = mb3
```

```
                mean    (b4) = mb4
                mean    (b5) = mb5
                mean    (b8) = mb8
                mean    (b9) = mb9;
run;

data bfmp.RKL4h6b;
        set work.total;
run;
```

10.1.1

Programme 2 – calculate growth variables for each species.

```
/* use the >100 data set to calibrate the discriminant function
        use the discriminant function to classify the >10 data set
        output the classified >10 data set to clas10 */

/* First have to run hypoth6b, to model the remaining cdnfi.
        Then run CalcCharacsRkl42 to create normalised predicted
growth points,
        and recruit103 to calculate average shade30 value of new
recruits.
        Use these to assign the new cdnfi to the old groups. */

/* Start by adding the newly calculated group info to the old set of
characteristics */

proc sort data=bfmp.clusgrps; by cdnfi; run;
proc sort data=rec5; by cdnfi; run;
data doneset (keep=cdnfi group dlclsl dlchsh dhclsl dhchsh declsa
mshade30);
        merge bfmp.clusgrps rec5;
        by cdnfi;
        if group ne 5 and group ne 6;
run;

/* Then add a blank "group" column to the new larger set of
characteristics */
data newset (keep=cdnfi group dlclsl dlchsh dhclsl dhchsh declsa
mshade30);
        set charac10;
        group = .;
run;

/* Now do the discriminant analysis */

proc discrim data=doneset testdata=newset out=groupout
testout=cha30out
        method=normal;
        class group;
        var dlclsl dlchsh dhclsl dhchsh declsa mshade30; /* First
attempt */
run;

proc sort data=species.allcdnfi; by cdnfi; run;
data tempspec (keep=cdnfi family genus species);
        set species.allcdnfi;
run;

proc sort data=cha30out; by cdnfi; run;
data cha30mod;
        merge cha30out tempspec;
        by cdnfi;
        if _into_ ne .;
run;
```

Programme 3 – calculate recruitment variables for each species.

```
/* Select the cases of ingrowth */

data rec1 (keep=plot_id ru_id tree_id cdnfi xposn xgrid yposn ygrid
diam survey shade5 shade30);
        set bfmp.itree_52;
        /* Need to look at all surveys for the unlogged plots */
        if diam1 eq 0 and diam2 ne 0 then
        do;
                survey = 2;
                diam = diam2;
                shade5 = shade52;
                shade30 = shade302;
        end;
        else if diam2 eq 0 and diam3 ne 0 then
        do;
                survey = 3;
                diam = diam3;
                shade5 = shade53;
                shade30 = shade303;
        end;
        else if diam3 eq 0 and diam4 ne 0 then
        do;
                survey = 4;
                diam = diam4;
                shade5 = shade54;
                shade30 = shade304;
        end;
        if shade30 ne . then do;
                if xposn eq 0 and yposn eq 0 and shade30 eq 0 then
shade30 = -1;
        end;

        /* Adjust the erroneous diameters */

        if xposn lt 0.0 then xposn + 100.0;
        if yposn lt 0.0 then yposn + 100.0;
        if xposn eq 100.0 then xposn = 99.9;
        if yposn eq 100.0 then yposn = 99.9;

        /* Calculate the relevant grid id */

        xgrid = int ((xposn + 10.0)/10.0);
        ygrid = int ((yposn + 10.0)/10.0);
        if diam ne . and cdnfi ne 0;
run;

/* Now do the gridsquares table */

data grid1;
        set bfmp.grid10;
        xgrid = int ((xcentre + 10.0)/10.0);
        ygrid = int ((ycentre + 10.0)/10.0);
run;

/* For three cases, calculate the probability of an ingrowth tree
occurring in a gridsquare as
        a function of shade30 */
```

```
/* 1. Calculate the number of trees ingrowing per year, per shade30
band, per plot type, per
        species group */

proc sort data=species.allgrps; by cdnfi; run;
proc sort data=work.rec1; by cdnfi; run;
data rec2 (keep=group plot_id ru_id tree_id xposn yposn shade30
sh30band plottype);
        merge rec1 species.allgrps;
        by cdnfi;
        if plot_id eq "BFMPBER 4 1" or
           plot_id eq "BFMPBER 4 4" or
           plot_id eq "BFMPBER 410" then plottype = "unlogged";
        else if plot_id = "BFMPBER 1 4" or
                plot_id = "BFMPBER 1 5" then plottype = "logged83";
        else if plot_id = "BFMPBER 4 2" or
                plot_id = "BFMPBER 4 3" or
                plot_id = "BFMPBER 4 5" or
                plot_id = "BFMPBER 4 6" or
                plot_id = "BFMPBER 4 7" or
                plot_id = "BFMPBER 412" then plottype = "RILthn91";
        else if plot_id = "BFMPBER 4 8" or
                plot_id = "BFMPBER 4 9" or
                plot_id = "BFMPBER 411" then plottype = "conthn91";
        else if plot_id = "BFMPBER 1 1" or
                plot_id = "BFMPBER 1 2" or
                plot_id = "BFMPBER 1 3" or
                plot_id = "BFMPBER 1 6" then plottype = "log83thn";
        if      shade30 lt  0 then sh30band =  .;
        else if shade30 lt  5 then sh30band =  2.5;
        else if shade30 lt 10 then sh30band =  7.5;
        else if shade30 lt 15 then sh30band = 12.5;
        else if shade30 lt 20 then sh30band = 17.5;
        else if shade30 lt 25 then sh30band = 22.5;
        else if shade30 lt 30 then sh30band = 27.5;
        else if shade30 lt 35 then sh30band = 32.5;
        else if shade30 lt 40 then sh30band = 37.5;
        else                       sh30band = 42.5;
        if xposn ne .;
run;

/* Do the same for gridsquares */

data grid2 (keep=plot_id ru_id xgrid ygrid plottype shade30
sh30band);
        set grid1;
        shade30 = gshd304;
        if plot_id eq "BFMPBER 4 1" or
           plot_id eq "BFMPBER 4 4" or
           plot_id eq "BFMPBER 410" then plottype = "unlogged";
        else if plot_id = "BFMPBER 1 4" or
                plot_id = "BFMPBER 1 5" then plottype = "logged83";
        else if plot_id = "BFMPBER 4 2" or
                plot_id = "BFMPBER 4 3" or
                plot_id = "BFMPBER 4 5" or
                plot_id = "BFMPBER 4 6" or
                plot_id = "BFMPBER 4 7" or
                plot_id = "BFMPBER 412" then plottype = "RILthn91";
        else if plot_id = "BFMPBER 4 8" or
                plot_id = "BFMPBER 4 9" or
                plot_id = "BFMPBER 411" then plottype = "conthn91";
```

```
        else if plot_id = "BFMPBER 1 1" or
                plot_id = "BFMPBER 1 2" or
                plot_id = "BFMPBER 1 3" or
                plot_id = "BFMPBER 1 6" then plottype = "log83thn";
        if      shade30 lt  0 then sh30band =  .;
        else if shade30 lt  5 then sh30band =  2.5;
        else if shade30 lt 10 then sh30band =  7.5;
        else if shade30 lt 15 then sh30band = 12.5;
        else if shade30 lt 20 then sh30band = 17.5;
        else if shade30 lt 25 then sh30band = 22.5;
        else if shade30 lt 30 then sh30band = 27.5;
        else if shade30 lt 35 then sh30band = 32.5;
        else if shade30 lt 40 then sh30band = 37.5;
        else                       sh30band = 42.5;
run;

/* Count how many instances there are of each sh30band */
proc sort data=grid2; by plottype sh30band; run;
proc means data=grid2 noprint;
        by plottype sh30band;
        output out=grid3
                mean (shade30) = mshade30;
run;

data grid4 (keep=plottype sh30band Ngrids group);
        set grid3;
        Ngrids = _freq_;
        if Ngrids = 0 then Ngrids = 1.5;
        do group = 1 to 10;
                output;
        end;
run;

proc sort data=rec2; by plottype sh30band group; run;
proc means data=rec2 noprint;
        by plottype sh30band group;
        output out=rec3
                mean (shade30) = mshade30;
run;

/* Combine the gridsquare and tree data tables to obtain
probabilities */
data gridrec1 (drop=_type_);
        merge rec3 grid4;
        by plottype sh30band group;
        prob = _freq_ * 100 / (Ngrids * 6);             /* / 6 years
*/
        if prob eq . then prob = -1;
run;

proc sort data=gridrec1; by group sh30band; run;
proc transpose data=gridrec1 out=gridrec2;
        by group sh30band;
        id plottype;
        var prob _freq_;
run;

data gridrec3 (drop=log83thn rilthn91 conthn91 unlogged logged83);
        set gridrec2;
        unlog = unlogged;
        log83 = logged83;
```

```
        log91 = conthn91;
run;

proc sort data=rec1; by cdnfi; run;
/*proc sort data=groups1; by cdnfi; run;*/
proc sort data=charac5; by cdnfi; run;

proc means data=rec1 noprint;
        by cdnfi;
        output out=rec4
                mean (shade30) = mshade30
                stderr (shade30) = eshade30
                mean (shade5 ) = mshade5
                stderr (shade5) = eshade5;
run;

data rec5;
        merge rec4 charac5;
        by cdnfi;
        if dlclsl ne .;
run;
```

Programme 4 – clustering analysis.

```
/* program to try to cluster characteristic growth data together */
/*      Have dbh: low medium high, c.i.:low high                  */
/*      Try to group species by growth data from these 6 values  */

/* Input from output of calccharacs.sas */

proc cluster data=rec5 method=ward outtree=tree noprint;
        var     dlclsl dlchsh
                dhclsl dhchsh
                declsa
                mshade30;
        id cdnfi;
run;
proc tree data=tree out=trward n=10 noprint;
        copy    dlclsl dlchsh
                dhclsl dhchsh
                declsa
                mshade30 cdnfi;
run;


/* reorganise the data and merge all clusterings for comparison */


/* method = ward */
data trwards (drop=_name_ cluster clusname);
        set trward;
        wardclus = cluster;
run;

proc sort data=trwards;
        by cdnfi;
run;


/* Combine the results from all the clusterings */
data trall;
        merge trwards species.allcdnfi;
        by cdnfi;
        if wardclus ne .;
run;

/* Summarise the best clustering in one groups table */
data clusward (keep=cdnfi newgroup family genus species);
        set trall;
        newgroup = wardclus;
        if wardclus ne .;
run;

proc sort data=clusward; by cdnfi; run;
proc sort data=species.allgrps3; by cdnfi; run;

data groups11;
        merge clusward species.allgrps3;
        by cdnfi;
        if newgroup ne .;
run;
```

Programme 5 – discriminant analysis.

```
/* use the >100 data set to calibrate the discriminant function
        use the discriminant function to classify the >10 data set
        output the classified >10 data set to clas10 */

/* First have to run hypoth6b, to model the remaining cdnfi.
        Then run CalcCharacsRkl42 to create normalised predicted
growth points,
        and recruit103 to calculate average shade30 value of new
recruits.
        Use these to assign the new cdnfi to the old groups. */

/* Start by adding the newly calculated group info to the old set of
characteristics */

proc sort data=bfmp.clusgrps; by cdnfi; run;
proc sort data=rec5; by cdnfi; run;
data doneset (keep=cdnfi group dlclsl dlchsh dhclsl dhchsh declsa
mshade30);
        merge bfmp.clusgrps rec5;
        by cdnfi;
        if group ne 5 and group ne 6;
run;

/* Then add a blank "group" column to the new larger set of
characteristics */
data newset (keep=cdnfi group dlclsl dlchsh dhclsl dhchsh declsa
mshade30);
        set charac10;
        group = .;
run;

/* Now do the discriminant analysis */

proc discrim data=doneset testdata=newset out=groupout
testout=cha30out
        method=normal;
        class group;
        var dlclsl dlchsh dhclsl dhchsh declsa mshade30; /* First
attempt */
run;

proc sort data=species.allcdnfi; by cdnfi; run;
data tempspec (keep=cdnfi family genus species);
        set species.allcdnfi;
run;

proc sort data=cha30out; by cdnfi; run;
data cha30mod;
        merge cha30out tempspec;
        by cdnfi;
        if _into_ ne .;
run;
```

11 Appendix II. List of Species

11.1.1 A table showing a detailed listing of the family, genus and species information of the contents of each group. Where a blank is present for a genus or species it can be assumed that any genus or species elsewhere unspecified are included.

Group	Family	Genus	Species
1	Dipterocarpaceae	*Shorea*	*Shorea leprosula* Miq.
1	Dipterocarpaceae	*Shorea*	*Shorea johorensis* Foxw.
1	Dipterocarpaceae	*Shorea*	*Shorea ovalis ssp ovalis*
2	Dipterocarpaceae	*Dipterocarpus*	*Dipterocarpus caudiferus* Merr.
2	Dipterocarpaceae	*Dipterocarpus*	*Dipterocarpus confertus* Sloot.
2	Dipterocarpaceae	*Dipterocarpus*	*Dipterocarpus costulatus* Sloot.
2	Dipterocarpaceae	*Dipterocarpus*	*Dipterocarpus gracilis* Blume
2	Dipterocarpaceae	*Dipterocarpus*	*Dipterocarpus grandiflorus* (Blanco) Blanco
2	Dipterocarpaceae	*Dipterocarpus*	*Dipterocarpus humeratus* Sloot.
2	Dipterocarpaceae	*Dipterocarpus*	*Dipterocarpus acutangulus*
2	Dipterocarpaceae	*Dipterocarpus*	*Dipterocarpus glabrigemmatus*
2	Dipterocarpaceae	*Dipterocarpus*	*Dipterocarpus pachyphyllus*
2	Dipterocarpaceae	*Dipterocarpus*	*Dipterocarpus palemb. ssp borneensis*
2	Dipterocarpaceae	*Dipterocarpus*	*Dipterocarpus stellatus ssp parvus*
2	Dipterocarpaceae	*Hopea*	*Hopea sangal* Korth.
2	Dipterocarpaceae	*Hopea*	*Hopea semicuneata* Sym.
2	Dipterocarpaceae	*Shorea*	*Shorea guiso* (Blanco) Blume
2	Dipterocarpaceae	*Shorea*	*Shorea hopeifolia* (Heim) Sym.
2	Dipterocarpaceae	*Shorea*	*Shorea inappendiculata* Burck
2	Dipterocarpaceae	*Shorea*	*Shorea laevis* Ridley
2	Dipterocarpaceae	*Shorea*	*Shorea maxwelliana* King
2	Dipterocarpaceae	*Shorea*	*Shorea scrobiculata* Burck
2	Dipterocarpaceae	*Shorea*	*Shorea seminis* (de Vriese) Sloot.
2	Dipterocarpaceae	*Shorea*	*Shorea exelliptica*

3	Dipterocarpaceae	*Anisoptera*	*Anisoptera costata* Korth.
3	Dipterocarpaceae	*Anisoptera*	*Anisoptera laevis* Ridley
3	Dipterocarpaceae	*Anisoptera*	Unknown
3	Dipterocarpaceae	*Dipterocarpus*	*Dipterocarpus verrucosus* Foxw. ex Sloot.
3	Dipterocarpaceae	*Dryobalanops*	*Dryobalanops beccarii* Dyer
3	Dipterocarpaceae	*Dryobalanops*	*Dryobalanops lanceolata* Burck
3	Dipterocarpaceae	*Dryobalanops*	Unknown
3	Dipterocarpaceae	*Parashorea*	*Parashorea malaanonan* (Blanco) Merr.
3	Dipterocarpaceae	*Parashorea*	*Parashorea smythiesii*
3	Dipterocarpaceae	*Parashorea*	Unknown
3	Dipterocarpaceae	*Shorea*	*Shorea faguetiana* Heim
3	Dipterocarpaceae	*Shorea*	*Shorea lamellata* Foxw.
3	Dipterocarpaceae	*Shorea*	*Shorea mecistopteryx* Ridley
3	Dipterocarpaceae	*Shorea*	*Shorea ochracea* Sym.
3	Dipterocarpaceae	*Shorea*	*Shorea parvifolia* Dyer
3	Dipterocarpaceae	*Shorea*	*Shorea pauciflora* King
3	Dipterocarpaceae	*Shorea*	*Shorea pinanga* Scheff.
3	Dipterocarpaceae	*Shorea*	*Shorea smithiana* Sym.
3	Dipterocarpaceae	*Shorea*	*Shorea virescens* Parijs
3	Dipterocarpaceae	*Shorea*	*Shorea parvistipulata* Heim
3	Dipterocarpaceae	*Shorea*	*Shorea agamii ssp agamii*
3	Dipterocarpaceae	*Shorea*	*Shorea almon*
3	Dipterocarpaceae	*Shorea*	*Shorea confusa*
3	Dipterocarpaceae	*Shorea*	*Shorea longisperma*
3	Dipterocarpaceae	*Shorea*	*Shorea macrophylla x pinanga*
3	Dipterocarpaceae	*Shorea*	*Shorea parvifolia ssp parvi.*
3	Dipterocarpaceae	*Shorea*	*Shorea parvifolia ssp velu.*
3	Dipterocarpaceae	*Shorea*	*Shorea parvistipulata ssp alb.*
3	Dipterocarpaceae	*Shorea*	*Shorea pinanga x macrophylla*
3	Dipterocarpaceae	*Shorea*	*Shorea superba*
3	Dipterocarpaceae	*Shorea*	*Shorea symingtonii*
3	Dipterocarpaceae	*Shorea*	Unknown

4	Dipterocarpaceae	*Cotylelobium*	*Cotylelobium melanoxylon* (Hook. f.) Pierre
4	Dipterocarpaceae	*Cotylelobium*	Unknown
4	Dipterocarpaceae	*Dipterocarpus*	*Dipterocarpus appendiculatus* S
4	Dipterocarpaceae	*Dipterocarpus*	*Dipterocarpus tempehes* Sloot.
4	Dipterocarpaceae	*Dipterocarpus*	*Dipterocarpus elongatus*
4	Dipterocarpaceae	*Dipterocarpus*	Unknown
4	Dipterocarpaceae	*Hopea*	*Hopea bracteata* Burck
4	Dipterocarpaceae	*Hopea*	*Hopea dryobalanoides* Miq.
4	Dipterocarpaceae	*Hopea*	*Hopea ferruginea* Parijs
4	Dipterocarpaceae	*Hopea*	*Hopea mengerawan* Miq.
4	Dipterocarpaceae	*Hopea*	*Hopea pachycarpa* (Heim) Sym.
4	Dipterocarpaceae	*Hopea*	*Hopea resinosa* Sym.
4	Dipterocarpaceae	*Hopea*	*Hopea nervosa* King
4	Dipterocarpaceae	*Hopea*	Unknown
4	Dipterocarpaceae	*Shorea*	*Shorea atrinervosa* Sym.
4	Dipterocarpaceae	*Shorea*	*Shorea beccariana* Burck
4	Dipterocarpaceae	*Shorea*	*Shorea bentongensis* Foxw.
4	Dipterocarpaceae	*Shorea*	*Shorea ochrophloia* Strugnell ex Sym.
4	Dipterocarpaceae	*Shorea*	*Shorea angustifolia*
4	Dipterocarpaceae	*Shorea*	*Shorea fallax*
4	Dipterocarpaceae	*Shorea*	*Shorea leptoderma*
4	Dipterocarpaceae	*Shorea*	*Shorea macroptera ssp sandak.*
4	Dipterocarpaceae	*Shorea*	*Shorea parvistipulata ssp parv.*
4	Dipterocarpaceae	*Shorea*	*Shorea patoiensis*
4	Dipterocarpaceae	*Shorea*	*Shorea semicunata*
4	Dipterocarpaceae	Unknown	Unknown
4	Dipterocarpaceae	*Vatica*	*Vatica micrantha* Sloot.
4	Dipterocarpaceae	*Vatica*	*Vatica rassak* (Korth.) Blume
4	Dipterocarpaceae	*Vatica*	*Vatica sarawakensis* Heim
4	Dipterocarpaceae	*Vatica*	*Vatica umbonata* (Hook. f.) Burck
4	Dipterocarpaceae	*Vatica*	*Vatica albiramis*
4	Dipterocarpaceae	*Vatica*	*Vatica nitens*
4	Dipterocarpaceae	*Vatica*	*Vatica oblongifolia ssp multi.*
4	Dipterocarpaceae	*Vatica*	*Vatica odorata ssp mindanensis*
4	Dipterocarpaceae	*Vatica*	*Vatica vinosa*
4	Dipterocarpaceae	*Vatica*	Unknown

5	Rubiaceae	*Anthocephalus*	*Anthocephalus chinensis* (Lam.) Walp.
6	Euphorbiaceae	*Glochidion*	*Glochidion sp.*
6	Euphorbiaceae	*Macaranga*	*Macaranga bancana* Muell. Agr.
6	Euphorbiaceae	*Macaranga*	*Macaranga gigantea* (Reichb. f. & Zoll.) Muell
6	Euphorbiaceae	*Macaranga*	*Macaranga hypoleuca* (Reichb. f. & Zoll.) Muel
6	Euphorbiaceae	*Macaranga*	*Macaranga pruinosa* (Miq.) Muell. Arg.
6	Euphorbiaceae	*Macaranga*	*Macaranga semilgobosa* J.J.S
6	Euphorbiaceae	*Macaranga*	*Macaranga triloba* (Blume) Muell.Arg.
6	Euphorbiaceae	*Macaranga*	Unknown
6	Fagaceae	*Lithocarpus*	Unknown
7	Anacardiaceae	*Mangifera*	*Mangifera foetida* Lour.
7	Anacardiaceae	*Mangifera*	*Mangifera macrocarpa*
7	Anacardiaceae	*Mangifera*	*Mangifera oblongifolia*
7	Anacardiaceae	*Mangifera*	*Mangifera quadrifida*
7	Anacardiaceae	*Mangifera*	Unknown
7	Burseraceae	Unknown	Unknown
7	Euphorbiaceae	*Antidesma*	*Antidesma leucopodum*
7	Euphorbiaceae	*Antidesma*	Unknown
7	Euphorbiaceae	*Koilodepas*	Unknown
7	Euphorbiaceae	*Mallotus*	*Mallotus echinatus* Elmer
7	Euphorbiaceae	*Mallotus*	*Mallotus muticus* (Muell.Arg.) Airy Shaw
7	Euphorbiaceae	*Mallotus*	Unknown
7	Fagaceae	Unknown	Unknown
7	Lauraceae	*Alseodaphne*	*Alseodaphne insignis* Gamble
7	Lauraceae	*Alseodaphne*	*Alseodaphne dewildei*
7	Lauraceae	*Alseodaphne*	*Alseodaphne elmeri*
7	Lauraceae	*Alseodaphne*	*Alseodaphne oblanceolata*
7	Lauraceae	*Alseodaphne*	*Alseodaphne ceratoxylon*
7	Lauraceae	*Alseodaphne*	Unknown
7	Lauraceae	*Eusideroxylon*	*Eusideroxylon zwageri* Teijsm. & Binn.
7	Lauraceae	Unknown	Unknown
7	Melastomaceae	*Pternandra*	Unknown
7	Meliaceae	*Aglaia*	*Aglaia odoratissima* Blume
7	Meliaceae	*Aglaia*	*Aglaia tomentosa* Teijsm. & Binn.
7	Meliaceae	*Aglaia*	*Aglaia eximia Miq.*
7	Meliaceae	*Aglaia*	*Aglaia trichostemon*
7	Meliaceae	*Aglaia*	*Aglaia polyandra*
7	Meliaceae	*Aglaia*	*Aglaia sapindina*
7	Meliaceae	*Aglaia*	*Aglaia shawiana*
7	Meliaceae	*Aglaia*	Unknown
7	Moraceae	*Artocarpus*	*Artocarpus anisophyllus* Miq.
7	Moraceae	*Artocarpus*	*Artocarpus dadah* Miq.
7	Moraceae	*Artocarpus*	*Artocarpus elasticus* Reinw.
7	Moraceae	*Artocarpus*	*Artocarpus glaucus* Bl.
7	Moraceae	*Artocarpus*	*Artocarpus integer* Merr.
7	Moraceae	*Artocarpus*	*Artocarpus kemando* Miq.
7	Moraceae	*Artocarpus*	*Artocarpus lanceifolius* Roxb.
7	Moraceae	*Artocarpus*	*Artocarpus odoratissimus* Blanc

7	Moraceae	*Artocarpus*	*Artocarpus nitidus Trec. ssp. griffithii*
7	Moraceae	*Artocarpus*	Unknown
7	Myristicaceae	*Horsfieldia*	*Horsfieldia brachiata*
7	Myristicaceae	*Horsfieldia*	*Horsfieldia brachiata var.sumatranum*
7	Myristicaceae	*Horsfieldia*	*Horsfieldia grandis*
7	Myristicaceae	*Horsfieldia*	*Horsfieldia macrocoma*
7	Myristicaceae	*Horsfieldia*	Unknown
7	Myristicaceae	*Knema*	*Knema laurina* (Blume) Warb.
7	Myristicaceae	*Knema*	*Knema cineria*
7	Myristicaceae	*Knema*	*Knema furfuracea*
7	Myristicaceae	*Knema*	*Knema hookeriana*
7	Myristicaceae	*Knema*	*Knema latericia Elmer*
7	Myristicaceae	*Knema*	*Knema conferta*
7	Myristicaceae	*Knema*	*Knema elmeri*
7	Myristicaceae	*Knema*	*Knema latifolia*
7	Myristicaceae	*Knema*	Unknown
7	Sapotaceae	*Palaquium*	*Palaquium calophyllum*
7	Sapotaceae	*Palaquium*	Unknown
7	Sterculiaceae	Unknown	Unknown
7	Tiliaceae	*Pentace*	*Pentace polyantha* Hassk.
7	Tiliaceae	*Pentace*	*Pentace triptera* Mast.
7	Tiliaceae	*Pentace*	*Pentace adenophora*
7	Tiliaceae	*Pentace*	*Pentace borneensis*
7	Tiliaceae	*Pentace*	*Pentace discolor*
7	Tiliaceae	*Pentace*	Unknown
7	Ulmaceae	*Gironniera*	*Gironniera nervosa* Planch.
7	Ulmaceae	*Gironniera*	Unknown
8	Guttiferae	*Mammea*	*Mammea malayana*
8	Annonaceae	*Mezzetia*	*Mezzetia umbellata*
8	Moraceae	*Parartocarpus*	*Parartocarpus venenosus*
8	Moraceae	*Paratocarpus*	Unknown
8	Aceraceae	*Acer*	*Acer niveum* Bl.
8	Alangiaceae	*Alangium*	*Alangium ridleyi* King
8	Alangiaceae	*Alangium*	Unknown
8	Anacardiaceae	*Bouea*	*Bouea oppositifolia* (Roxb.) Meissn.
8	Anacardiaceae	*Bouea*	*Bouea macrophylla*
8	Anacardiaceae	*Bouea*	Unknown
8	Anacardiaceae	*Buchanania*	*Buchanania insignis* Blume
8	Anacardiaceae	*Buchanania*	Unknown
8	Anacardiaceae	*Campnosperma*	*Campnosperma auriculata* (Blume) Hook. f.
8	Anacardiaceae	*Campnosperma*	Unknown
8	Anacardiaceae	*Dracontomelon*	*Dracontomelon costatum* Blume
8	Anacardiaceae	*Dracontomelon*	*Dracontomelon dao (Blanco)* Merr. & Rolfe
8	Anacardiaceae	*Dracontomelon*	Unknown
8	Anacardiaceae	*Gluta*	*Gluta renghas* L.
8	Anacardiaceae	*Gluta*	*Gluta wallichii* (Hook. f.) Ding Hou
8	Anacardiaceae	*Gluta*	Unknown
8	Anacardiaceae	*Koordersiodendr*	*Koordersiodendron pinnatum* (Blanco) Merr.
8	Anacardiaceae	*Melanochyla*	Unknown
8	Anacardiaceae	*Melanochylla*	*Melanochylla elmeri*
8	Anacardiaceae	*Parishia*	*Parishia maingayi* Hook. f.
8	Anacardiaceae	*Parishia*	Unknown
8	Anacardiaceae	*Swintonia*	*Swintonia schwenkii* (Teism. & Binn.)

			Teijsm.& Binn.
8	Anacardiaceae	*Swintonia*	Unknown
8	Anacardiaceae	Unknown	Unknown
8	Annonaceae	*Cyathocalyx*	*Cyathocalyx magnificus*
8	Annonaceae	*Cyathocalyx*	Unknown
8	Annonaceae	*Goniothalamus*	*Goniothalamus macrophyllus*
8	Annonaceae	*Goniothalamus*	Unknown
8	Annonaceae	*Mezzettia*	*Mezzettia leptopoda*
8	Annonaceae	*Mezzettia*	Unknown
8	Annonaceae	*Monocarpia*	*Monocarpia euneura* Miq.
8	Annonaceae	*Nauclea*	Unknown
8	Annonaceae	*Polyalthia*	*Polyalthia glauca* Boerl
8	Annonaceae	*Polyalthia*	*Polyalthia lateriflora* King
8	Annonaceae	*Polyalthia*	*Polyalthia rumphii* Merr.
8	Annonaceae	*Polyalthia*	*Polyalthia sumatrana*
8	Annonaceae	*Polyalthia*	*Polyalthia beccarii*
8	Annonaceae	*Polyalthia*	Unknown
8	Annonaceae	*Popowia*	Unknown
8	Annonaceae	*Saccopetalum*	*Saccopetalum horsfieldii* Benn.
8	Annonaceae	*Sagereaea*	*Sagereaea lanceolata*
8	Annonaceae	Unknown	Unknown
8	Annonaceae	*Xylopia*	*Xylopia malayana* Hook.f.
8	Annonaceae	*Xylopia*	*Xylopia fusca*
8	Annonaceae	*Xylopia*	Unknown
8	Apocynaceae	*Alstonia*	*Alstonia angustiloba* Miq
8	Apocynaceae	*Alstonia*	Unknown
8	Apocynaceae	*Dyera*	*Dyera costulata* (Miq.) Hook. f.
8	Apocynaceae	*Dyera*	Unknown
8	Apocynaceae	*Ervatamia*	Unknown
8	Apocynaceae	*Kickxia*	Unknown
8	Apocynaceae	*Kopsia*	Unknown
8	Apocynaceae	*Lepiniopsis*	Unknown
8	Apocynaceae	*Ochrosia*	Unknown
8	Apocynaceae	*Plumiera*	Unknown
8	Apocynaceae	*Rauwolfia*	Unknown
8	Apocynaceae	Unknown	Unknown
8	Aquifoliaceae	*Ilex*	*Ilex cymosa* Blume
8	Araucariaceae	*Agathis*	*Agathis borneensis* Warb.
8	Bombacaceae	*Coelostegia*	*Coelostegia borneensis* Becc.
8	Bombacaceae	*Durio*	*Durio carinatus* Mast.
8	Bombacaceae	*Durio*	*Durio acutifolius* (Mast.) Kosterm.
8	Bombacaceae	*Durio*	*Durio kutejensis* (Hassk.) Becc.
8	Bombacaceae	*Durio*	*Durio oxleyanus* Griff.
8	Bombacaceae	*Durio*	*Durio testudinarum* Becc.
8	Bombacaceae	*Durio*	*Durio graveolens* Becc.
8	Bombacaceae	*Durio*	Unknown
8	Bombacaceae	*Neesia*	Unknown
8	Burseraceae	*Canarium*	*Canarium apertum* H.J. Lam
8	Burseraceae	*Canarium*	*Canarium caudatum* King
8	Burseraceae	*Canarium*	*Canarium denticulatum* Blume
8	Burseraceae	*Canarium*	*Canarium littorale* Blume
8	Burseraceae	*Canarium*	*Canarium odontophyllum* Miq.
8	Burseraceae	*Canarium*	*Canarium megalanthum* Merr.
8	Burseraceae	*Canarium*	*Canarium elmeri*

8	Burseraceae	*Canarium*	*Canarium littorale f. tomentos*
8	Burseraceae	*Canarium*	Unknown
8	Burseraceae	*Dacryodes*	*Dacryodes costata* (A.W. Benn.) H.J. Lam
8	Burseraceae	*Dacryodes*	*Dacryodes laxa* (A.W. Benn.) H.J. Lam
8	Burseraceae	*Dacryodes*	*Dacryodes rostrata* (Blume) H.J. Lam
8	Burseraceae	*Dacryodes*	*Dacryodes rugosa* (Blume) H.J. Lam
8	Burseraceae	*Dacryodes*	*Dacryodes pachyphyllus*
8	Burseraceae	*Dacryodes*	*Dacryodes rostrata f. pallida*
8	Burseraceae	*Dacryodes*	*Dacryodes rostrata f. rost.*
8	Burseraceae	*Dacryodes*	Unknown
8	Burseraceae	*Santiria*	*Santiria griffithii* (Hook. f.) Engl.
8	Burseraceae	*Santiria*	*Santiria laevigata* Blume
8	Burseraceae	*Santiria*	*Santiria tomentosa* Blume
8	Burseraceae	*Santiria*	Unknown
8	Buxaceae	Unknown	Unknown
8	Caesalpinaceae	*Sindora*	*Sindora velutinata*
8	Caesalpiniaceae	*Cynometra*	*Cynometra ramiflora* L.
8	Caesalpiniaceae	*Koompassia*	*Koompassia excelsa* (Becc.) Taub.
8	Caesalpiniaceae	*Saraca*	*Saraca minor* Miq.
8	Caesalpiniaceae	*Sindora*	*Sindora coriacea* (Baker) Prain
8	Caesalpiniaceae	*Sindora*	*Sindora galedupa* Prain
8	Caesalpiniaceae	*Sindora*	*Sindora velutina* Baker
8	Capparidaceae	Unknown	Unknown
8	Casuariceae	Unknown	Unknown
8	Ceasalpinaceae	*Sindora*	Unknown
8	Celastraceae	*Bhesa*	*Bhesa paniculata* Arn.
8	Celastraceae	*Kokoona*	*Kokoona reflexa* (Laws.) Ding Hou
8	Celastraceae	*Kokoona*	*Kokoona ochracea*
8	Celastraceae	*Kokoona*	Unknown
8	Celastraceae	*Lophopetalum*	*Lophopetalum javanicum*
8	Celastraceae	*Lophopetalum*	Unknown
8	Celastraceae	Unknown	Unknown
8	Chrysobalanaceae	*Atuna*	*Atuna excelsa*
8	Chrysobalanaceae	*Atuna*	Unknown
8	Chrysobalanaceae	*Parinari*	*Parinari oblongifolia* Hook. f.
8	Combretaceae	*Terminalia*	Unknown
8	Connaraceae	*Ellipanthus*	*Ellipanthus sp.*
8	Cornaceae	*Mastixia*	*Mastixia bracteata* Clarke
8	Cunoniceae	*Winmannia*	*Winmannia fraxinea* Smith.
8	Datiscaceae	*Octomeles*	*Octomeles sumatrana* Miq.
8	Dilleniaceae	*Dillenia*	*Dillenia excelsa* (Jack) Gilg
8	Dilleniaceae	*Dillenia*	*Dillenia sumatrana* Miq.
8	Dilleniaceae	*Dillenia*	Unknown
8	Ebenaceae	*Diospyros*	*Diospyros bantamensis* Koord. & Val. ex Bakh.
8	Ebenaceae	*Diospyros*	*Diospyros borneensis* Hiern
8	Ebenaceae	*Diospyros*	*Diospyros curranii* Merr.
8	Ebenaceae	*Diospyros*	*Diospyros densa* Bakh.
8	Ebenaceae	*Diospyros*	*Diospyros ferruginea* Bakh.
8	Ebenaceae	*Diospyros*	*Diospyros frutescens*
8	Ebenaceae	*Diospyros*	Unknown
8	Ebenaceae	Unknown	Unknown
8	Elaeocarpaceae	*Elaeocarpus*	Unknown
8	Elaeocarpaceae	Unknown	Unknown

8	Euphorbiaceae	*Aporusa*	*Aporusa lunata* (Miq.) Kurz
8	Euphorbiaceae	*Aporusa*	*Aporusa grandistipulata*
8	Euphorbiaceae	*Aporusa*	*Aporusa nitida*
8	Euphorbiaceae	*Aporusa*	*Aporusa subcaudata*
8	Euphorbiaceae	*Aporusa*	*Aporusa elmeri*
8	Euphorbiaceae	*Aporusa*	Unknown
8	Euphorbiaceae	*Baccaurea*	*Baccaurea deflexa* Roxb.
8	Euphorbiaceae	*Baccaurea*	*Baccaurea sumatrana* (Miq.) Muell.Arg.
8	Euphorbiaceae	*Baccaurea*	*Baccaurea macrophylla* (Muell.Arg.) Muell.Arg.
8	Euphorbiaceae	*Baccaurea*	*Baccaurea minor* Hook. f.
8	Euphorbiaceae	*Blumeodendron*	*Blumeodendron tokbrai* (Blume) Kurz
8	Euphorbiaceae	*Blumeodendron*	Unknown
8	Euphorbiaceae	*Cephalomappa*	*Cephalomappa sp.*
8	Euphorbiaceae	*Cephalomappa*	*Cephalomappa beccariana*
8	Euphorbiaceae	*Cephalomappa*	*Cephalomappa malloticarpa*
8	Euphorbiaceae	*Chaetocarpus*	*Chaetocarpus castanocarpus* (Roxb.) Thwaites
8	Euphorbiaceae	*Cleistanthus*	*Cleistanthus laevis* Hook.f.
8	Euphorbiaceae	*Cleistanthus*	Unknown
8	Euphorbiaceae	*Croton*	*Croton argyratus* Blume
8	Euphorbiaceae	*Croton*	*Croton glabrescens* Miq.
8	Euphorbiaceae	*Elateriospermum*	*Elateriospermum tapos* Blume
8	Euphorbiaceae	*Elateriospermum*	Unknown
8	Euphorbiaceae	*Endospermum*	*Endospermum banghamii* Merr.
8	Euphorbiaceae	*Fahrenheitia*	*Fahrenheitia pendula* (Hassk.) Airy Shaw
8	Euphorbiaceae	*Galearia*	Unknown
8	Euphorbiaceae	*Mallotus*	*Mallotus penangensis* Muell.Arg.
8	Euphorbiaceae	*Moultonianthus*	*Moultonianthus leembruggianus* (Boerl. & Koord
8	Euphorbiaceae	*Neocortechinia*	Unknown
8	Euphorbiaceae	*Neoscortechinia*	*Neoscortechinia kingii* (Hook. f.) Pax & Hoffm
8	Euphorbiaceae	*Neoscortechinia*	*Neoscortechinia sp.*
8	Euphorbiaceae	*Neoscortechinia*	*Neoscortechinia sumatrensis*
8	Euphorbiaceae	*Trigonostemon*	*Trigonostemon laevigatus* Muell.Arg.
8	Euphorbiaceae	*Trigonostemon*	*Trigonostemon malaccanus*
8	Euphorbiaceae	Unknown	Unknown
8	Fagaceae	*Castanopsis*	*Castanopsis megacarpa*
8	Fagaceae	*Castanopsis*	Unknown
8	Fagaceae	*Quercus*	*Quercus subsericea* A. Camus
8	Fagaceae	*Quercus*	Unknown
8	Flacourtiaceae	*Flacourtia*	*Flacourtia rukam* Zoll. & Mor.
8	Flacourtiaceae	*Hydnocarpus*	*Hydnocarpus woodii* Merr.
8	Flacourtiaceae	*Hydnocarpus*	Unknown
8	Flacourtiaceae	*Ryparosa*	*Ryparosa fasciculata*
8	Flacourtiaceae	*Ryparosa*	Unknown
8	Flacourtiaceae	Unknown	Unknown
8	Gnetacea	*Gnetum*	Unknown
8	Guttiferae	*Calophyllum*	*Calophyllum inophyllum* L.
8	Guttiferae	*Calophyllum*	*Calophyllum depressinervosum* Henderson & Wyat
8	Guttiferae	*Calophyllum*	*Calophyllum alboromutum*
8	Guttiferae	*Calophyllum*	*Calophyllum austrocoriaceum*

8	Guttiferae	*Calophyllum*	*Calophyllum echinatum*
8	Guttiferae	*Calophyllum*	Unknown
8	Guttiferae	*Cratoxylum*	Unknown
8	Guttiferae	*Garcinia*	*Garcinia celebica* L.
8	Guttiferae	*Garcinia*	*Garcinia dioica* Bl.
8	Guttiferae	*Garcinia*	*Garcinia nervosa* Miq.
8	Guttiferae	*Garcinia*	*Garcinia bailloni*
8	Guttiferae	*Garcinia*	*Garcinia bancana*
8	Guttiferae	*Garcinia*	*Garcinia motleyana*
8	Guttiferae	*Garcinia*	*Garcinia rigida*
8	Guttiferae	*Garcinia*	Unknown
8	Guttiferae	*Mesua*	*Mesua borneensis*
8	Guttiferae	*Mesua*	Unknown
8	Guttiferae	Unknown	Unknown
8	Icacinaceae	*Gonocaryum*	*Gonocaryum calleryanum*
8	Icacinaceae	*Gonocaryum*	Unknown
8	Icacinaceae	*Stemonorus*	*Stemonorus apicalis*
8	Icacinaceae	*Stemonorus*	*Stemonorus grandifolius*
8	Icacinaceae	*Stemonurus*	Unknown
8	Icacinaceae	Unknown	Unknown
8	Juglandaceae	*Engelhardia*	*Engelhardia serrata* Blume
8	Lauraceae	*Beilschmiedia*	*Beilschmiedia gemmiflora* Koste
8	Lauraceae	*Beilschmiedia*	*Beilschmiedia dictyoneura* Kosterm.
8	Lauraceae	*Beilschmiedia*	*Beilschmiedia argentea*
8	Lauraceae	*Beilschmiedia*	*Beilschmiedia gigantocarpa*
8	Lauraceae	*Beilschmiedia*	*Beilschmiedia wieringae*
8	Lauraceae	*Beilschmiedia*	Unknown
8	Lauraceae	*Cinnamomum*	Unknown
8	Lauraceae	*Cryptocarya*	*Cryptocarya elliptica*
8	Lauraceae	*Cryptocarya*	Unknown
8	Lauraceae	*Dehaasia*	Unknown
8	Lauraceae	*Dehaassia*	*Dehaasa microcephala*
8	Lauraceae	*Dehaassia*	*Dehaasia tomentosa*
8	Lauraceae	*Litsea*	*Litsea elliptica*
8	Lauraceae	*Litsea*	*Litsea erectinervia*
8	Lauraceae	*Litsea*	Unknown
8	Lauraceae	*Myristica*	*Myristica cinnamonea*
8	Lauraceae	*Neolitsea*	Unknown
8	Lauraceae	*Nothaphoebe*	Unknown
8	Lecythidaceae	*Barringtonia*	*Barringtonia pendula* (Griff.) Kurz
8	Lecythidaceae	*Barringtonia*	*Barringtonia excelsa*
8	Lecythidaceae	*Barringtonia*	*Barringtonia macrostachya*
8	Lecythidaceae	*Barringtonia*	Unknown
8	Lecythidaceae	Unknown	Unknown
8	Leguminosae	*Archidendron*	*Archidendron globosum* (Blume) Nielsen
8	Leguminosae	*Crudia*	Unknown
8	Leguminosae	*Cynometra*	Unknown
8	Leguminosae	*Dialium*	Unknown
8	Leguminosae	*Fordia*	Unknown
8	Leguminosae	*Koompassia*	*Koompassia malaccensis* Maing. ex Benth.
8	Leguminosae	*Sindora*	*Sindora wallichii* Graham ex Benth.
8	Leguminosae	Unknown	Unknown
8	Loganiaceae	*Fagraea*	*Fagraea racemosa* Jack ex Wall.
8	Loganiaceae	*Fagraea*	Unknown

8	Magnoliaceae	*Magnolia*	*Magnolia lasia* Noot.
8	Magnoliaceae	*Magnolia*	*Magnolia candollii var. candollii*
8	Magnoliaceae	*Magnolia*	*Magnolia candollii var. singapurensis*
8	Magnoliaceae	*Magnolia*	*Magnolia gigantifolia*
8	Magnoliaceae	Unknown	Unknown
8	Melastomaceae	*Memecylon*	Unknown
8	Melastomaceae	Unknown	Unknown
8	Meliaceae	*Chisocheton*	*Chisocheton divergens* Bl.
8	Meliaceae	*Chisocheton*	Unknown
8	Meliaceae	*Dysoxylon*	*Dysoxylum cyrtobotryum*
8	Meliaceae	*Dysoxylon*	*Dysoxylum pachytracta*
8	Meliaceae	*Dysoxylum*	*Dysoxylum alliaceum* (Blume) Blume
8	Meliaceae	*Dysoxylum*	*Dysoxylum amooroides* Miq.
8	Meliaceae	*Dysoxylum*	Unknown
8	Meliaceae	*Sandoricum*	*Sandoricum borneensis*
8	Meliaceae	Unknown	Unknown
8	Meliaceae	*Walsura*	*Walsura sp.*
8	Mimosaceae	*Adenanthera*	*Adenanthera bicolor*
8	Mimosaceae	*Albizia*	*Pithecellobium splendens* Corn.
8	Mimosaceae	*Archidendron*	*Pithecellobium bubalinum* Benth
8	Mimosaceae	*Parkia*	*Parkia singularis* Miq.
8	Mimosaceae	*Parkia*	*Parkia speciosa* Hassk.
8	Mimosaceae	*Parkia*	Unknown
8	Mimosaceae	*Pithecellobium*	*Pithecellobium globosum*
8	Mimosaceae	*Pithecellobium*	Unknown
8	Moraceae	*Broussonetia*	Unknown
8	Moraceae	*Ficus*	Unknown
8	Moraceae	*Paratrophis*	*Paratrophis bracteatus*
8	Moraceae	Unknown	Unknown
8	Myristicaceae	*Gymnacranthera*	*Gymnacranthera forbesii* (King) Warb.
8	Myristicaceae	*Gymnacranthera*	Unknown
8	Myristicaceae	Unknown	Unknown
8	Myrsinaceae	*Aegiceras*	Unknown
8	Myrsinaceae	*Ardisia*	Unknown
8	Myrtaceae	*Eugenia*	Unknown
8	Myrtaceae	*Tristania*	*Tristania obovata* R.Br.
8	Myrtaceae	Unknown	Unknown
8	Nyctaginaceae	Unknown	Unknown
8	Ochnaceae	*Gomphia*	*Gomphia serrata* (Gaertn.) Kanis
8	Olacaceae	*Ochanostachys*	*Ochanostachys amentacea* Mast.
8	Olacaceae	*Scorodocarpus*	*Scorodocarpus borneensis* (Baill.) Becc.
8	Olacaceae	*Strombosia*	*Strombosia javanica* Blume
8	Olacaceae	*Strombosia*	*Strombosia ceylanica* Gardner
8	Oleaceae	*Chionanthus*	Unknown
8	Oleaceae	Unknown	Unknown
8	Oxalidaceae	*Sarcotheca*	*Sarcotheca acuminata* Hall. f.
8	Oxalidaceae	*Sarcotheca*	*Sarcotheca glauca* (Hook. f.) Hallier f.
8	Oxalidaceae	*Sarcotheca*	*Sarcotheca subtriplinervis* Hal
8	Papilionaceae	*Dalbergia*	*Dalbergia sissoides* Grab.
8	Papilionaceae	*Erythrina*	Unknown
8	Papilionaceae	*Ormosia*	*Ormosia sp.*
8	Polygalaceae	Unknown	Unknown
8	Proteaceae	Unknown	Unknown
8	Rhamnaceae	Unknown	Unknown

8	Rhamnaceae	*Zizyphus*	Unknown
8	Rhizophoraceae	Unknown	Unknown
8	Rosaceae	*Parinari*	*Parinari canariodes*
8	Rosaceae	*Prunus*	*Prunus javanica* (Teijsm. & Binn.) Miq.
8	Rubiaceae	*Ixora*	*Ixora blumei* Z.
8	Rubiaceae	*Pertusadina*	Unknown
8	Rubiaceae	*Tarenna*	*Tarenna costata*
8	Rubiaceae	Unknown	Unknown
8	Rutaceae	*Euodia*	*Euodia sp.*
8	Rutaceae	Unknown	Unknown
8	Sapindaceae	*Lepisanthes*	Unknown
8	Sapindaceae	*Nephelium*	*Nephelium mutabile* Bl.
8	Sapindaceae	*Nephelium*	*Nephelium cuspidatum*
8	Sapindaceae	*Nephelium*	*Nephelium maingayi*
8	Sapindaceae	*Nephelium*	Unknown
8	Sapindaceae	*Paranephelium*	*Paranephelium sp.*
8	Sapindaceae	*Paranephelium*	Unknown
8	Sapindaceae	*Pometia*	*Pometia pinnata* Forst.
8	Sapindaceae	*Pometia*	*Pometia maingayi*
8	Sapindaceae	*Pometia*	Unknown
8	Sapindaceae	Unknown	Unknown
8	Sapindaceae	*Xerospermum*	Unknown
8	Sapotaceae	*Chrysophyllum*	Unknown
8	Sapotaceae	*Ganua*	Unknown
8	Sapotaceae	*Madhuca*	*Madhuca magnifacia* K.
8	Sapotaceae	*Madhuca*	*Madhuca sericea* (Miq.) H.J. Lam
8	Sapotaceae	*Madhuca*	*Madhuca kingiana*
8	Sapotaceae	*Madhuca*	*Madhuca laurifolia*
8	Sapotaceae	*Madhuca*	*Madhuca lanateramula*
8	Sapotaceae	*Madhuca*	*Madhuca mindanaensis*
8	Sapotaceae	*Madhuca*	*Madhuca pubicalyx*
8	Sapotaceae	*Palaquium*	*Palaquium dasyphyllum* (de Vriese) Dubard
8	Sapotaceae	*Palaquium*	*Palaquium eriocalyx* H.J. Lam
8	Sapotaceae	*Palaquium*	*Palaquium ferox* H.J.L.
8	Sapotaceae	*Palaquium*	*Palaquium gutta* (Hook. f.) Baillon
8	Sapotaceae	*Palaquium*	*Palaquium hexandrum* (Griff.) Baill.
8	Sapotaceae	*Palaquium*	*Palaquium rostratum* (Miq.) Burck
8	Sapotaceae	*Palaquium*	*Palaquium dubardii*
8	Sapotaceae	*Payena*	*Payena acuminata* Pierre
8	Sapotaceae	*Payena*	*Payena lucida* (G. Don) DC.
8	Sapotaceae	*Payena*	Unknown
8	Sapotaceae	Unknown	Unknown
8	Sarcospermaceae	Unknown	Unknown
8	Simaroubaceae	*Irvingia*	*Irvingia malayana* Oliv. ex Bennett
8	Simaroubaceae	*Irvingia*	Unknown
8	Sonneratiaceae	*Duabanga*	*Duabanga moluccana* Blume
8	Sterculiaceae	*Heritiera*	*Heritiera javanica*
8	Sterculiaceae	*Heritiera*	*Heritiera simplicifolia* (Mast.) Kosterm.
8	Sterculiaceae	*Heritiera*	*Heritiera acuminata*
8	Sterculiaceae	*Heritiera*	*Heritiera sumatrana*
8	Sterculiaceae	*Heritiera*	Unknown
8	Sterculiaceae	*Pterospermum*	*Pterospermum javanicum* Jungh.
8	Sterculiaceae	*Pterospermum*	Unknown
8	Sterculiaceae	*Scaphium*	Unknown

8	Sterculiaceae	*Sterculia*	*Sterculia cordata*
8	Sterculiaceae	*Sterculia*	*Sterculia parviflora*
8	Sterculiaceae	*Sterculia*	Unknown
8	Symplocaceae	*Symplocos*	*Symplocos fasciculata* Zoll.
8	Symplocaceae	*Symplocos*	*Symplocos sp.*
8	Taxodiaceae	*Cryptomeria*	*Cryptomeria japonica* Don.
8	Theaceae	*Adinandra*	*Adinandra borneensis* Kobuski
8	Theaceae	*Schima*	*Schima wallichii* (DC.) Korth.
8	Theaceae	*Tetramerista*	*Tetramerista glabra* Miq.
8	Theaceae	*Tetramerista*	Unknown
8	Theaceae	Unknown	Unknown
8	Thymelaeaceae	*Aquilaria*	*Aquilaria malaccensis* Lam.
8	Thymeleaceae	Unknown	Unknown
8	Tiliaceae	*Elaeocarpus*	*Elaeocarpus stipularis* Bl.
8	Tiliaceae	*Elaeocarpus*	Unknown
8	Tiliaceae	*Grewia*	*Grewia celtidifolia* Juss.
8	Tiliaceae	*Grewia*	*Grewia fibrocarpa*
8	Tiliaceae	*Microcos*	*Microcos florida* Burr.
8	Tiliaceae	Unknown	Unknown
8	Trigoniaceae	Unknown	Unknown
8	Ulmaceae	Unknown	Unknown
8	Urticaceae	*Dendrocnide*	*Dendrocnide stimulans*
8	Urticaceae	*Dendrocnide*	Unknown
8	Verbenaceae	*Teijsmanniodend*	*Teijsmanniodendron simplicifol*
8	Verbenaceae	*Teijsmanniodend*	*Teijsmanniodendron glabrum*
8	Verbenaceae	*Teijsmanniodend*	Unknown
8	Verbenaceae	Unknown	Unknown
8	Verbenaceae	*Vitex*	*Vitex pubescens* Val.
8	Verbenaceae	*Vitex*	*Vitex vestita* Wall.
8	Verbenaceae	*Vitex*	Unknown

9	Anacardiaceae	*Semecarpus*	*Semecarpus heterophyllus* Blume
9	Anacardiaceae	*Semecarpus*	Unknown
9	Caesalpinaceae	*Dialium*	*Dialium procerum*
9	Caesalpiniaceae	*Dialium*	*Dialium indum* L.
9	Caesalpiniaceae	*Dialium*	*Dialium platysepalum* Baker
9	Caesalpiniaceae	*Dialium*	*Dialium wallichii* Prain
9	Ebenaceae	*Diospyros*	*Diospyros endertii*
9	Euphorbiaceae	*Baccaurea*	Unknown
9	Euphorbiaceae	*Drypetes*	*Drypetes longifolia* (Blume) Pax & Hoffm.
9	Euphorbiaceae	*Drypetes*	*Drypetes subsymetrica* J.J.S.
9	Euphorbiaceae	*Drypetes*	*Drypetes kikir* Airy Shaw
9	Euphorbiaceae	*Drypetes*	*Drypetes polyneura* Airy Shaw
9	Euphorbiaceae	*Drypetes*	Unknown
9	Euphorbiaceae	*Macaranga*	*Macaranga lowii* King ex Hook. f.
9	Guttiferae	*Kayea*	*Kayea sp.*
9	Guttiferae	*Kayea*	Unknown
9	Lauraceae	*Actinodaphne*	*Actinodaphne malaccensis*
9	Lauraceae	*Actinodaphne*	Unknown
9	Myristicaceae	*Myristica*	*Myristica iners* Bl.
9	Myristicaceae	*Myristica*	Unknown
9	Polygalaceae	*Xanthophyllum*	*Xanthophyllum obscurum* Benn.
9	Polygalaceae	*Xanthophyllum*	*Xanthophyllum stipitatum* Benn.
9	Polygalaceae	*Xanthophyllum*	*Xanthophyllum affine* Korth. ex Miq.
9	Polygalaceae	*Xanthophyllum*	*Xanthophyllum rufrum*
9	Polygalaceae	*Xanthophyllum*	Unknown
9	Sapotaceae	*Madhuca*	*Madhuca malaccensis*
9	Sapotaceae	*Madhuca*	*Madhuca sessilis*
9	Sapotaceae	*Madhuca*	Unknown
9	Sterculiaceae	*Scaphium*	*Scaphium macropodum* (Miq.) Beumee ex Heine
9	Sterculiaceae	*Scaphium*	*Scaphium borneensis*
9	Thymelaeaceae	*Gonystylus*	*Gonystylus bancanus* Kurz.
9	Thymelaeaceae	*Gonystylus*	*Gonystylus macrophyllus* Airy Shaw
9	Thymeleaceae	*Gonystylus*	Unknown
10	Unknown	Unknown	Unknown