Parameter research for the tropical rain forest growth model

FORMIX4

Peter Köhler

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Report

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Report No. 204

by

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Preface

This project has been undertaken at the Malaysian-German Sustainable Forest Management Project at the Forestry Department in Sandakan, Sabah, Malaysia. It was sponsored by the German Research Foundation (DFG) in a project of the Center for Enviromental Systems Research, Universtity of Kassel, Germany, called *'Growth modelling of tropical rain forests with respect to wide disturbances'* or short *FORMIX4.* The study was carried out during a 3 months stay (16.08.-15.11.1997) within the GTZ group at the Sabah Forests Department, HQ in Sandakan.

I would like to thank all the people, who helped me in and on my way to Malaysia, especially Dr. Michael Kleine for his kind support during the stay, Robert C. Ong for data, his advises and some cans of beer, Encik Masirum Rundi for his expertise on light demand, Dr. Andreas Huth and Thomas Ditzer for the ongoing remote support via email, and all the people of the GTZ project. Special thanks to 'Lei Hoh' Glauner for his introduction to the people and the system and to my college, Peter Lagan for funny lunch times, Hubert-'we're onto something'-Perol for a good time and interesting books, Zainol, the WWF man of the Kinabatangan area, for a lot of fun during most of the time and fellow reseacher during my stay, Mr. Klaus Werner. And a very warm thank to all the persons I met during my stay in Sandakan and who gave me the feeling of being at home all the time.

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CONTENT

Chapter 1: Introduction

Management of rain forests is nowadays a challenge for people involved, because the area covered by rain forest is decreasing at a fast rate. Destructive logging and fires destroy huge forest areas which require very long period for recovering. Therefore a proper management can prevent lots of the damages done by logging operations. For these management plans a lookout of further forest productivity might help in deciding the amount of allowed annual timber extracting in terms of cutting regimes, felling intensites, felling cycles and possibilities of forest recovery.

For these purposes the simulation model FORMIX3 was developed and tested for various forest conditions around Malaysia (Huth et al., 1996). Improvements of the model as well as further developments from a stand size of one hectare to the size of a management unit of several tens of thousands of hectares are the objectives of the FORMIX4 project, sponsored by the German Research Foundation (DFG). Within this project the author visited the Forestry Department of Sabah for three months to improve the input data of the model and recalculate parameters on the basis of permanent sample lots (PSP) and inventory data taken by the Forestry Department staff in the last couple of years.

The objectives of the present sub project are:

- Elaborate new species grouping for the FORMIX4 model based on expert knowledge of light demand of tree species and potential maximum heights.
- Calculate regeneration rates for different functional groups as a function of stand quality and the number of mother trees. Data from forest management inventory should be used for this analysis.
- Calculate mortality rate for different functional groups as a function of diameter or diameter increment. The data of permanent sampling plots should be used for this purpose.

In the following section the reason for these investigations are discussed briefly, whereas the later chapter contain the results achieved in this work.

1. **Grouping** (chapter 2): For practical reasons species richness has to be aggregated in functional groups, which means tree species with similar growth behaviour are grouped together. The grouping in FORMIX3 was based on research by Ong and Kleine (1995), where species grouping was undertaken according to diameter increment pattern, with additional information about height growth and light demand. It turns out that these two different classifications of tree species do not fit together very well, so it is desirable to redo it from the very beginning. Additional information about light demand, which is hardly to be found in literature is sought from local forest experts. The independent information (potential maximum height and light demand) are added together to form up to 13 functional groups. Further investigations undertaken in the following tops 2 and 3 should be based on both the grouping used in FORMIX3 and the new grouping for FORMIX4 .

2. **Regeneration** (chapter 3): In FORMIX3 the input of seedlings into the model is performed with a fixed rate of 700-6000 seedlings per group and year and patch of 400 m^2. This approach assumes that the simulated patch is surrounded by intact forest which can provide a sufficient amount of seeds. This situation does not allow calculations of badly damaged forests and extinction of species can not be performed in the simulations. It is well known, that regeneration rate influences the future development of the forest a lot, so a more precise formulation of regeneration is necessary. Additionally to the data research undertaken by myself a fellow researcher, Mr. K. Werner, is doing field research on this subject. Therefore the results in this subject have to be combined with his achievements.

3. **Mortality** (chapter 4): In FORMIX3 mortality is a function of diameter increment, tree species and size. The input for the mortality parameters is based mainly on one research study (Swaine, 1989) undertaken in Peninsular Malaysia. Therefore it is necessary to confirm that this approach is suitable for Sabah rain forests as well. It might be that the functional context is different in this area.

Chapter 2: FORMIX4 Grouping

A new grouping is performed, which is based on two independent classifications. The species are grouped in five height groups according to the height layers in the FORMIX model with different boundaries in the lowest layer. These are 5m and below, 5m-15m, 15m-25m, 25m-36m and above 36m. The second classification is done due to the light demand of the species. We distinguish three light demands: pioneer species, non-pioneer species with intermediate light demand and non-pioneer species which are shade tolerant.

A more detailed description of the grouping process including tests for mortality and regeneration rates is found in the publication:

Köhler, P., Huth, A.; Ditzer, T. (1998). *Concepts for the aggregation of tropical tree species into functional types and the application on Sabah's dipterocarp lowland rain forests.* Submitted to Forest Ecology and Management.

2.1 Height grouping

The grouping of the species in 5 height groups was done by the following procedure. Mr. R. Glauner grouped the species in 15 groups according to old groupings of the Canadian inventory (Sabah Forestry Department, 1973) and other available expert knowledge. These grouping is referred as SPC_GRP in Appendix A and is the basis for further development. For these 15 groups Mr. Glauner developed height-to-diameter-curves, which represent the tree height to the top of the crown, for 4 different slopes (variable RELI_1=1-4, which refers to 'valley, 'upper slope', ''middle slope', 'lower slope' respectively). For all four slopes hd-curves are required, but however for further grouping the slope 'middle slope' is seen as representative. Maximum heights for the hd-curves are calculated and the 15 groups are aggregated to the well known 5 FORMIX3 height layers (layer 1: $h \preceq 5m$; layer 2: $5m < h \preceq 15m$; layer 3: $15m < h \preceq 25m$; layer 4: $25m < h \preceq 36m$; layer 5: $h > 36m$). It figures out, that the calculated maximum heights for the 15 groups are all above 25 m, which means the lower layers are unpopulated. Therefore we rely on literature data for all groups with a lower maximum height. Out of an literature inquiry we get maximum height or maximum diameter for most of the tree species. The diameter is transformed into a maximum height using the hd-curve of the related classification of Mr. Glauner. Where literature data for maximum height and calculated maximum height do not correspond, we prefer the literature data for maximum height. Qualitative statements like 'small' are considered as well (bushes: layer 1; small: layer 2; small-medium: layer 3; medium: layer 3; small-large: layer 3). Some features of the performed height grouping are documented in Table 2.1. The height group (or layer) 1 is assumed to represent climbers, shrubs, lianas, herbs and other small plants. Therefore it is obvious that only 2 of the tree species belong to this height group. We do not need a special hd-curve for this group.

Out of the height grouping and the existing height-to-diameter-curves of the Canadian inventory new curves for the five FORMIX4 height groups has to be developed. Because the grouping process was rather complicated it can be expected that derivation of the hd-curves is not an easy target. However the hd-curves are not an objective of this project. Some preliminary efforts show, that new curves can not be derived easily. These results are not mentioned here, but are included in the file collection which is part of this final report (see Appendix I for files).

Table 2.1: Aggregation of Sabahs lowland tree species into height groups. A: number of species per group. B: Percentage of trees in forest management inventory for four forest reserves in Sabah (Deramakot, Lingkabau, Kalabakan, Ulu Segama).

Height group	Maximum potential height [m]	A	B[%]
1	0-5: shrub species	15	5.7
2	5-15: understorey species	97	13.5
3	15-25: lower maincanopy species	119	32.9
4	25-36: upper main canopy species	117	21.9
5	36+: emergent species	120	26.0
Sum		468	100

2.2 Light grouping

Relying on expert knowledge and verbal communication (Mr. Masirom Rundi) most of the species were classified in one of three light demand groups. They are in detail:

- Pioneers as very light demanding species
- Non-pioneers species with intermediate light demands
- Non-pioneer species which are shade tolerant

However the light demand of a lot of the species was unknown. In this case we tried to classify them according to their maximum height, where we assume, that trees of the understorey (h<=15m) might be shade tolerant, whereas the tree growing higher than 15m might have intermediate light demand.

Table 2.2: Aggregation of Sabahs lowland tree species into light demand groups. A: number of species per group. B: Percentage of trees in forest management inventory for four forest reserves in Sabah (Deramakot, Lingkabau, Kalabakan, Ulu Segama).

Light demand group	Light demand	A	B[%]
1	pioneers	31	24.8
2	non-pioneers, intermediate demand	317	63.4
3	non-pioneers, shade-tolerant	120	11.9
Sum		468	100

It might be expected that shade tolerant species are growing slower than light demanding pioneers and therefore produces wood with a higher density. A statistical analysis of the parameter wood density in the three different light demanding groups is shown in Table 2.3. For this analysis only species with known wood density are taken into account (which are 241 out of 468). However, the analysis shows that the average wood density shows no significant derivation within the different groups. This might have various reasons. It could be that the parameter wood density is not properly investigated, that our light demand grouping is not performed on enough expert knowledge or the assumption about the relationship between light demand and wood density is wrong. However some corelations between timber group and light demand group can be found as shown in the publication Köhler et al (1998).

Table 2.3: Wood density in different light demanding groups

Light demand	Number of species	Wood density [kg/m^3]
Pioneer	14	701 ± 148
Intermediate	154	704 ± 145
Shade tolerant	73	698 ± 195
average	241	702 ± 177

2.3 Resulting grouping.

The two groupings are now performed independent on all species leading to 3x5=15 groups. In height group 1 (h $\leq$ 5m) it seems not reasonable to distinguish different light demands, therefore we end up with 13 groups only. Table 2.4 shows the resulting grouping, and the number of related species. The classification for all species is found in the species list in Appendix A.

PFT	Height	Light	A	B2[%]
1	1	2	15	5.7
2	2	1	5	0.4
3	2	2	28	4.7
4	2	3	65	8.3
5	3	1	14	19.0
6	3	2	92	13.6
7	3	3	13	0.3
8	4	1	10	4.1
9	4	2	89	16.0
10	4	3	18	1.8
11	5	1	3	1.2
12	5	2	93	23.3
13	5	3	24	1.5
Sum			468	100

Table 2.4: Final characteristics of resolved PFTs. Height: related height group (Table 2.1). Light: related light demand group (Table 2.2). A: number of species per group. B: Percentage of trees in forest management inventory for four forest reserves in Sabah (Deramakot, Lingkabau, Kalabakan, Ulu Segama).

Chapter 3: Regeneration

The aim of this investigation was to find out the regeneration rate in Sabahs tropical forests. Regeneration rate in this context means the amount of seedlings, which are established per time and area depending on the stand situation and existing mother trees, distinguished in functional groups, esp. the FORMIX3 groups and the new FORMIX4 groups.

Two different types of research were performed.

1. Data from inventories taken in different forest reserves were analyzed.
2. Various literature about regeneration was studied.

3.1 Data from inventory

In a management planning inventory data were taken and are available for four forest reserves, which are Deramakot, Ulu Segama, Kalabakan and Lingkabau. The three reserves mentioned first are very similar in terms of elevation, soils and structure. The diameter distribution (see Table 3.1) is fairly similar. It seems that the stem numbers in Deramakot are slightly higher and in Lingkabau lower than the average (the later especially in the lower diameter classes). Because of the similar stand structure their data were partly analyzed together in further analysis.

The inventory data were taken of various field sampling units (SU) (Deramakot 487 SU; Kalabakan: 577 SU; Lingkabau: 508 SU and Ulu Segama: 523 SU). The sampling unit have a L-shape structure, each side 72.5 m long and 20 m width (=0.25 ha). On the whole area trees with dbh≥40 cm were recorded, where smaller trees were only counted in parts of the area. The so called ‘regeneration’ was only recorded in a 5m × 5m square in the corner of the SU. These were trees with h>1.5m and d<10cm. For further information on the technical details of the inventory see Chai et al. (1991).

The objective of the inventory was forest management. Therefore the data do not suit perfectly for our purpose, e.g. regeneration in context of FORMIX are trees smaller than 1.3 m in height. The design of the SU is chosen for practical reasons and a correlation between the recorded regeneration in the small subplot and the whole SU is more than questionable. However we try to figure out some trends and rough orders of magnitude for the regeneration rate as a function of stand parameters like basal area, number of mother trees and general stocking of the forest.

Table 3.1: Diameter distribution in four forest reserves in Sabah

diameter class [cm]	Kalabakan [1/ha]	Deramakot [1/ha]	Ulu Segama [1/ha]	Lingkabau [1/ha]
h>1.5m-010	3701.00	4710.00	3809.00	3232.00
010-015	192.55	186.65	213.00	175.20
015-020	119.06	106.78	104.02	99.61
020-025	43.37	50.21	48.37	34.99
025-030	26.95	29.98	24.38	22.98
030-035	15.03	23.31	12.48	16.83
035-040	8.80	17.40	9.37	9.15
040-045	4.34	7.38	4.85	3.80
045-050	2.97	5.71	2.53	2.94
050-055	2.81	4.41	2.55	2.47
055-060	1.86	3.15	1.48	1.53
060-065	1.73	2.80	1.46	1.48
065-070	1.07	1.74	0.91	0.69
070-075	0.80	1.58	0.76	0.45
075-080	0.52	1.00	0.53	0.42
080-085	0.58	0.83	0.41	0.38
085-090	0.29	0.66	0.30	0.15
090-095	0.29	0.45	0.21	0.08
095-100	0.19	0.24	0.11	0.10
100-105	0.15	0.29	0.10	0.09
105-110	0.04	0.15	0.05	0.04
110-115	0.07	0.26	0.05	0.04
115-120	0.01	0.03	0.06	0.00
120-125	0.08	0.21	0.12	0.04
125-130	0.01	0.08	0.03	0.01
130-135	0.02	0.09	0.04	0.01
135-140	0.01	0.04	0.02	0.01
140-145	0.03	0.05	0.02	0.00
145-150	0.00	0.02	0.00	0.00
150-300	0.01	0.11	0.05	0.01
Total d≥10cm	423.65	445.60	428.24	373.49

3.1.1 Deramakot Data for FORMIX3 grouping

Because of the later implementation of FORMIX4 on the whole of Deramakot this data was considered as more important. I tried to find various correlations between regeneration and basal area of the stand, regeneration and basal area of trees of the same group, regeneration and number of emergent trees, regeneration and the number of mother trees of the same group. In this context emergent trees and mother trees are trees with a diameter of at least 50 cm. This first analysis should show, where a relation could be expected, and where further investigation with other data should be done. I tried to find linear relations and relations with a polynom of second order.

The analysis for the FORMIX3 grouping is found in the Appendix B. There the correlation coefficient (correlation, if the coefficient is high) of linear regression and the P-value (second order correlation is suitable, if P-value is low < 0.1) of second order polynomial regression are listed. I filtered the data in three different variables to find correlation depending on stand quality:

- Stratum91, which is the aerial photo interpretation on 25ha basis (1,2,3,4, where 4 indicates a good stratum)
- Basal area of the whole stand (0-20 m^2/ha, 20-30 m^2/ha, 30-40 m^2/ha, 40+ m^2/ha)
- Mother trees with a diameter ≥ 50 cm (0-10 1/ha, 10-20 1/ha, 20-30 1/ha, 30-40 1/ha, 40+ 1/ha)

General impression:

There seems to be no or very few relation between the regeneration and the stand, independent which variable I try to analyze. Very few second order regression show a P-value which indicates a relation of this order. In the linear case, the correlation coefficient is only four times (out of 252) higher than 0.5, only 66 times higher than 0.2.
In statistic terms, this means, there is only a very weak correlation in some selected cases.

In detail:

- Group 1: Filtering between different basal areas seems to be the worst description of stand quality, because there seems to be no correlation at all. Filtering the number of mother trees achieves reasonable results, if regeneration is a function of basal area. If you choose Stratum91 as a criteria, the results are good, if regeneration depends on basal area or basal area of the same group, especially in Stratum91=4 (good quality).
- Group 2: Again for Stratum91=4 some fairly acceptable results can be achieved, filtering for mother trees seems to be effective in some cases.
- Group 3: There seems to be no correlation what so ever!
- Group 4: Similar results to group 1 and 2. Filtering in mother trees and Straum91 seems fairly good.
- All groups: No relation if filtered in basal area.

For further investigation I would recommend not to find some mathematical correlation’s in strong statistical meaning, because the correlation will always be very questionable. The cases where from an ecological point of view I might expect some correlation (distinguish basal area for different stand quality) achieve the worst results. Therefore further investigations are only done ‘visually’ to show, where trends can be expected. To visualize this the results mentioned above are shown in Appendix C. For group 1 results for every filter variable is shown, where for the following groups I concentrate on the question, which should involve the most logical answer, which is: Regeneration as a function of basal area of the same groups, filtering SU with different basal areas for different stand quality. To visualize which additional information is gained with the filtering the regeneration as a function of basal area without filtering is shown first.

The average regeneration incl. standard deviation is shown in Table 3.2.

It is quiete an interesting question, in which dimension the regeneration varies. Therefore Figure 3.1 contains the frequency distribution for the single groups as well as for all species. The groups have quiet different pattern. Where group 1 and all species have their main peak between 3001 and 4000 1/ha, in group 2, 3 and 4 plots dominate without any regeneration, indicating, that special environmental circumstances like huge gaps are necessary to establish any seedlings. These circumstances

Table 3.2: Regeneration data

FORMIX3 group	regeneration [1/ha] Deramakot h>=1.5m, d<10cm	regeneration [1/ha] 4 forest reserves h>=1.5m, d<10cm
all	4709 ∓ 3151	3960 ∓2374
1	3690 ∓ 2449	2969 ∓1931
2	649 ∓ 992	634 ∓881
3	30 ∓ 113	45 ∓188
4	340 ∓560	311 ∓501

might be a important condition in FORMIX3, which can not be figured out in these data. The information we can get is the range over which regeneration can vary.

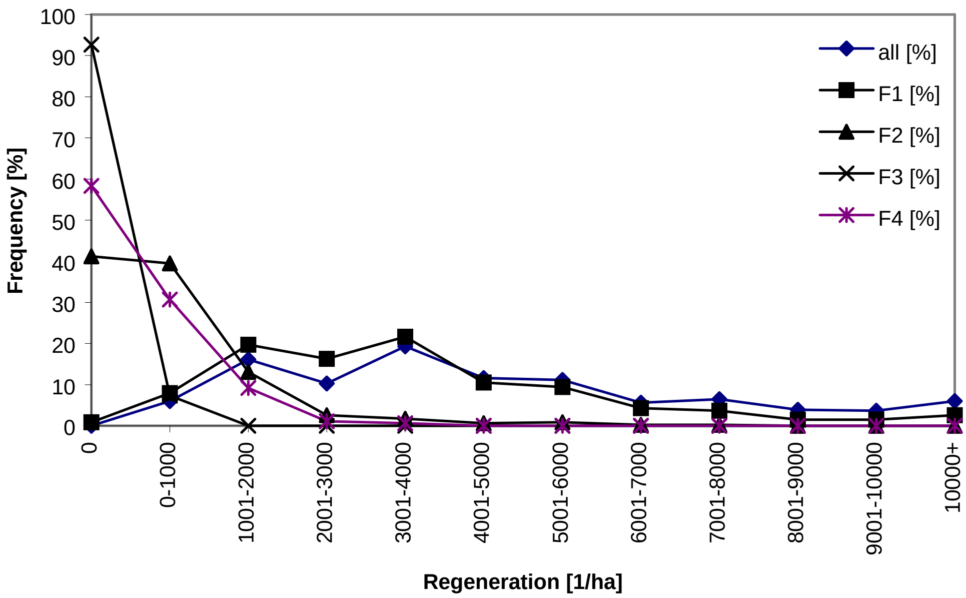

Figure 3.1: Frequency distribution of regeneration rates

3.1.2 Data from other forest reserve for FORMIX3 grouping

For better understanding of the forest structure the different basal areas are compared in Table 3.3. It can be seen, that Kalabakan and Ulu Segama are very similar forest reserves, while in Deramakot and Lingkabau the average stand conditions are slightly better, respectively worse.

Table 3.3: Basal area in different forest reserves

	Deramakot	Kalabakan	Lingkabau	Ulu Segama
average BA [m^2/ha]	20.86	15.41	12.95	14.26
stdev [m^2/ha]	9.23	6.38	5.57	6.96
max. [m^2/ha]	57.80	42.80	33.04	44.70
min [m^2/ha]	1.33	0.79	0.55	0.79

Doing the same analysis than with the Deramakot data we achieve similar results, which means the forest reserves are indeed comparable, but the analysis does not lead us to further interesting relation. The frequency distribution of the regeneration rate can be seen in Figure 3.2. It is in most features identical to the one in chapter 3.1.1. Regeneration for all species has its maximum at 3001-4000 1/ha, while group 2, 3 and 4 tend only to regenerate under certain conditions (maximum at 0 1/ha). Only within group 1 the maximum is at 1001-2000 slightly different from the previous one.

The same detailed regression analysis can be done, but would not achieve any new information. The same trends for Deramakot shown in Appendix C would be the result. The regeneration for the single groups represent the same trends than the Deramakot data. The only difference are obvious in group 3, where regeneration gets up to 1600/ha, once even up to 3200, were it has been 400/ha or below in Deramakot. Therefore we do not investigate any further in that direction.

Because the regeneration data in these inventories do not represent the size class we are interested in and as a consequence of the results achieved with the FORMIX3 grouping it is very unlikely that investigations with the new grouping for FORMIX4 will lead to any new results which can be more than rough orders of magnitude and trends.

Therefore analysis for the FORMIX4 grouping are not carried out.

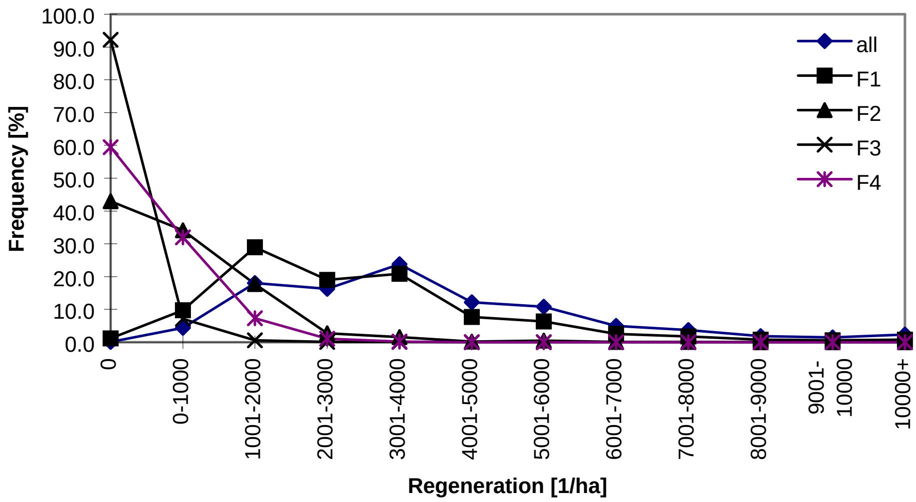

Figure 3.2: Frequency distribution of regeneration rates for all 4 forest reserves

3.2. Literature studies

Various Ph.D. thesis and publications were studied for appropriate information about regeneration. Of course the objective of the studies were different from ours, so information suitable for the parametrisation of the FORMIX model were rare.

3.2.1 Kennedy (1991)

Kennedy observed the soil seed bank and counted seeds in canopy gaps of different size. There is no evidence, that seed number depend on the size of a canopy gap - unless the gap is not bigger than 30 % canopy opening (measured with an 180 degree photograph interpretation) corresponding to 1202 m^2 felled area.
He found (34∓37) seeds/(m^2 * a), from which 41-60% are tree species. As a rough figure for the maximum amount of seedlings we can therefore get:

- 14 - 20 seeds/(m^2 * a) or
- 5600 - 8000 seeds/(plot * a), where plot is an area of 20m x 20m or
- 140 000 - 200 000 seeds/(ha * a).

In this calculation annual fluctuations due to mass fruiting are not taken into account. But it is known that the past four years before his study was performed no mass fruiting occurred in Danum Valley.

3.2.2 Brown (1990)

No information about numbers of seedlings. Ecological study of seedlings growth. There are shade tolerant seedlings, which grow worse in better light conditions! This is something which is not happening in FORMIX3.

3.2.3 Moad (1992)

Moad counts seedlings systematically around selected mother trees. He gets 24200 seedlings/(ha * a), which lies in a range Fox (1972) mentioned (6200 - 180 000 seedling/(ha * a)).

He found the following functional dependencies for the number of seedlings NS:

- NS = f(distance d to mother tree) = a-b*ln(d), maximal distance = 60m

- NS ≠ f(slope)
- NS = f(number of mother trees)
- no density depending mortality.

Seedlings growth depends strongly on the occurrence and duration of sunflecks. Their is a linear relation between the relative growth RG [1/a] of seedlings and the average daily duration of sunflecks DSF [min/day] depending on the species.
RG = -0.32 + 0.012 * DSF.
Furthermore, his study includes photosynthesis rate for 12 different seedling species, from whom only the maximum photosynthesis P_{max} is available. These species all belong to FORMIX3 group 1 and 2 or FORMIX4 group 12 and 13.

3.2.4 Fox (1972)

Fox counts seedlings as a function of distance to the mother tree. For 19 dipterocarp tree species in different forest reserves in Sabah and Peninsula Malaysia he gets:

- average seedlings: 1293 1/(plot * mother tree)
- standard derivation: 1170 1/(plot * mother tree)
- maximum: 3450 1/(plot * mother tree)
- minimum: 13 1/(plot * mother tree)

where plot are 400 m^2.

Very seldom the seedlings occur further away than 40 m from the mother tree. In fact 45% (88 %) of the seedlings occur within 10 m (30 m) distance to the mother tree.

3.2.5 Chim and On (1973)

Various investigations:

- Number of seedlings varies with soil type

average seedlings:	2046	1/plot
standard derivation:	1387	1/plot
maximum:	3588	1/plot
minimum:	131	1/plot

  where plot are 400 m^2.

- Density dependent seedling mortality with MN = 0.178723 + 0.000119099* N, where [N]: 1/plot (Figure 3.3)

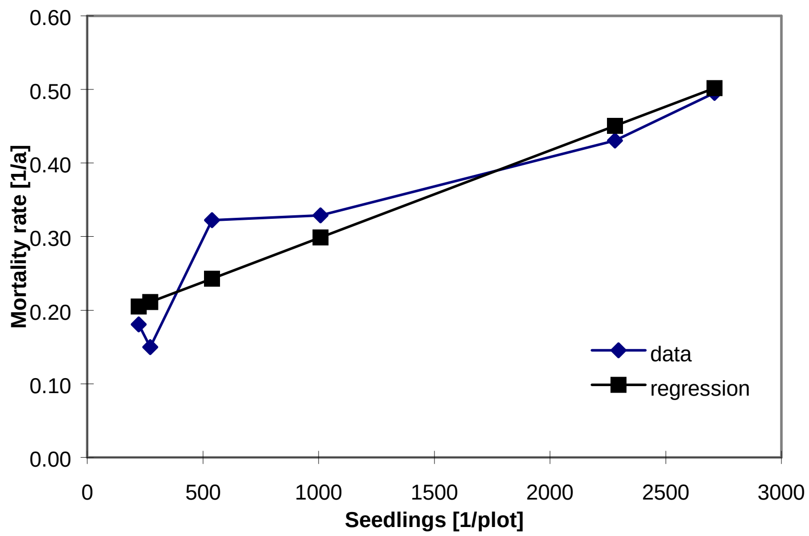

Figure 3.3: Density dependent seedling mortality (from Chim and On)

- Percentage of seedling as function from the distance to mother tree:

10m	20m	30m	40m	50m	60m
38.5%	71.0%	85.3%	93.0%	96.8%	100.0%

3.2.6 Putz (1979)

This paper contains a four year analysis of fruiting, flowering and leave production. The forest studied lies in Sungai Buloh Forest Reserve, Peninsula Malaysia is populated but is not dominated by dipterocarps. So 90% of the species of canopy trees have animal-dispersed propagules, which should not be the case in dipterocarp forests. However 30% of the matured trees were permanently fruiting all over the year, while other 30% had a fruit peak every 2 years.

3.2.7. Manokaran and Swaine (1994)

In a 0.08ha plot in Sungei Menyala Forest Reserve, Peninsula Malaysia, the number of poles in 4 sizes (h > 1.5m, d < 2.5cm; 2.5cm≤ d <5cm; 5cm ≤ d <7.5cm; 7.5cm≤d <10cm) classes were measured. They found an average of 7529 poles/ha with an average diameter of 2.8cm. The distribution of the poles within the diameter range is exponential as seen in Figure 3.4. With this relation it might be possible to extrapolate the amount of seedlings (h<=1.5m) out of the diameter distribution of the Sabah inventories (chapter 3.1). It is well known that diameter distribution in virgin forests are fairly exponential, but especially the lower diameter classes tend not to behave as predicated (UNESCO 1978). Unfortunately there are no measurements for the adult trees in this plot, which provide a broader basis for further assumptions. The subplot belongs to a 2ha plot with long-term observations and poles measurement was done in 1950 and 1982. It is possible to connect to pole data (in 5cm diameter classes) with the inventory in 1985, which leads to Figure 3.5. The increase in stem number above 55cm happens because all bigger trees are summed up. The behavior is obvious exponential, but the data below 5cm do not fit in any regression, which means a further extrapolation to the amount of seedlings might not be very accurate and is not considered any further.

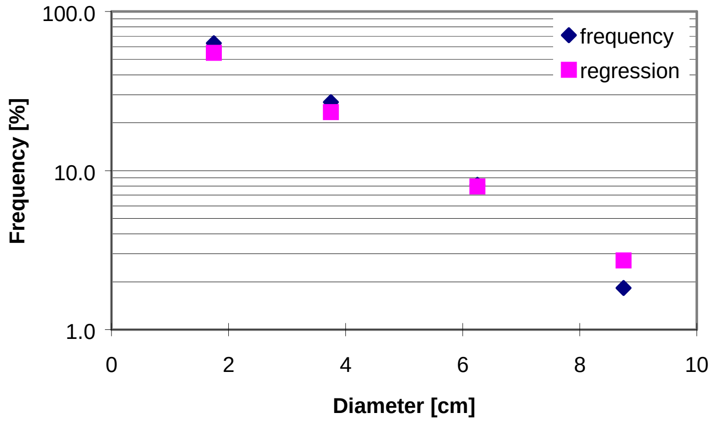

Figure 3.4: Diameter distribution of poles in 0.08ha sampling plot, Sungei Menyala Forest Reserve**.**

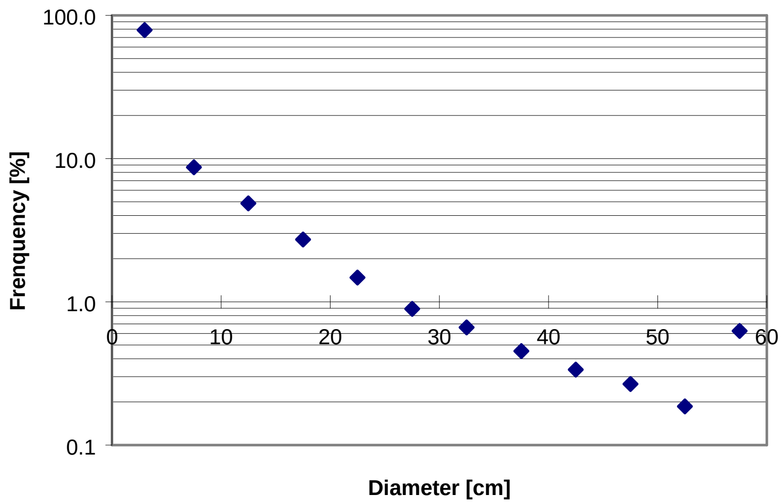

Figure 3.5: Diameter distribution in Sungei Menyala Forest Reserve, Peninsula Malaysia

3.3 Recommendations for FORMIX4

Detailed seedling numbers as parameter data for FORMIX4 should be based on appropriate field measurements. Within this chapter it was shown that it is difficult to get these data out of inventory which were undertaken with a totally different objective in mind as well as in an extensive literature study.

Nevertheless useful comments about the so called state of the art of regeneration in FORMIX3 and some improvements can be done. These are concentrated on climax species due to a lack of data for the pioneers.

- At the moment FORMIX3 has a regeneration rate of 13900 seedlings 1/(a x plot), from which 7900 belong to the non pioneer species. [347500 / 197500 1/(ha x a)]. These seems to be far to high. In the data of Fox (1972) and Kennedy (1991) who counted directly under seed trees the upper limit was 180000 to 200000 1/(ha x a).

- I would recommend an upper limit of 8000 to 10000 per plot for high peak season after mass fruiting. But this level again should be calculated out of field measurements.

- Seedling input should be a function of the number of mother trees, which means number of trees of a certain diameter. For emergent trees d_{mother}=50cm seems suitable. For the other groups, expert knowledge may serve as basis.

- For each mother tree a basis amount NG of seedlings plus a variation NV might cover the whole available range incl. mass fruiting which can be triggered for the whole stand with a random variable $r \in [-1,+1]$. Regeneration NS would be:

$$NS = NG + r \cdot NV \qquad (3.1)$$

- r might be weighted with a normal distribution. A time interval between mass fruitings might be assumed and trigger the variable r.

- The main amount of seedlings (40%) establishes in the plot of the mother tree, another 40% establishes in the eight neighboring plots (5% each) and the remaining 20% are equally distributed over the rest of the 1 ha stand (1.25% each plot).

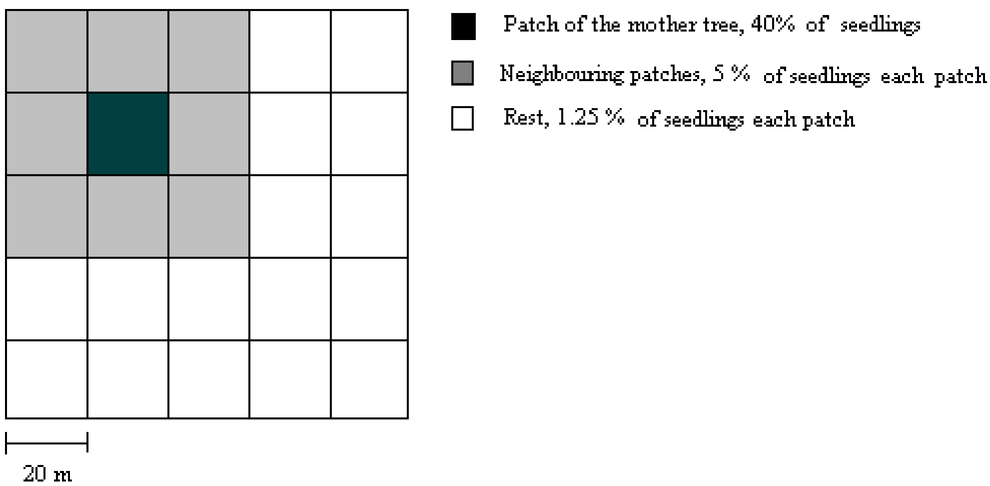

Figure 3.6: Distribution of seedlings around a mother tree in a 1 ha simulation area

- Seedling mortality (all trees with h<=1.3m) should be density dependent according to Figure 3.3.

- The range of stem numbers (d<=10cm) in the inventory data (main peak at 3000-4000 1/ha, range up to 10000 1/ha) should be used as a target to which the seedling input can be adjusted.

Chapter 4: Mortality

In this chapter it is attemped to improve the knowledge about tree mortality in rain forests, especially in Sabah. The objective of investigations is, whether there are any relationships between mortality rate and functional groups, tree size or tree growth. Until now in the FORMIX3 model mortality is mainly performed as a function of diameter increment and tree size based on a study by Swaine (1989) in West Malaysia.

Again I analyze data which were available at the Forestry Department and studied some publications about mortality to come up with some useful recommendations for FORMIX4.

4.1 Data from permanent sampling plots

The data available for analysis are from four different forest reserves. In each reserve the number of records and the time between two recordings varies widely. Therefore it is not possible to analyze the data set as a whole, we have to concentrate on single case studies for the different forest reserves and try to derive a general trend at the end.

The data set has the following characteristics:

Table 4.1: Technical information about the data set

Forest reserve	size [ha]	A	B	C	D	E	F	G
Garinono	2	871	1973-1982	9	10	1	45	284; 285
Gunung Rara	11	4978	1981-1990	9	7	1-2	11-12	691-695; 702-707
Segaliud Lokan1	7	4258	1982-1992	10	3	5	25	571; 573; 575; 577-579; 5710
Segaliud Lokan2	1	365	1972-1985	13	8	1-2	8	601
Sepilok	4	2218	1973-1993	20	5	5	19	541; 542; 544; 545

Legend:
A: number of trees at first enumeration
B: time of observation
C: length of observation [a]
D: number of recordings
E: time between two recordings [a]
F: time between last logging and first inventory [a]
G: name of plots

It can be seen, that the data were all taken in logged over forest with a wide range of time (8-45 a) past after logging and before the first inventory was taken. This has to be taken into consideration when the data are interpreted, mortality in virgin forest might differ significantly from the logged over forest which is analyzed here. There is no information about the intensity of logging and the forest structure right after the impact.

4.1.1 Stand structure of the forest reserves

In Figure 4.1 the diameter distribution of the different sample sites are shown. The sites have quiet different structure which can also be seen in the total stem number and basal area (Table 4.2). Total stem number varies from 365 1/ha in Segaliud Lokan2 to 608 1/ha in Segaliud Lokan1, the range of basal area goes from 12 m²/ha to 31.3 m²/ha in the same two forest reserves. Apart from Gunung Rara they are all in the lowland areas with elevation under 300 m.

Table 4.2: Stem number and basal area at the beginning of observation for trees with d>=10cm for different forest reserves

Forest reserve	N [1/ha]	BA [m²/ha]
Garinono	435.5	28.3
Gunung Rara	450.4	17.4
Segaliud Lokan1	608.3	31.3
Segaliud Lokan2	365.0	12.0
Sepilok	554.5	24.6

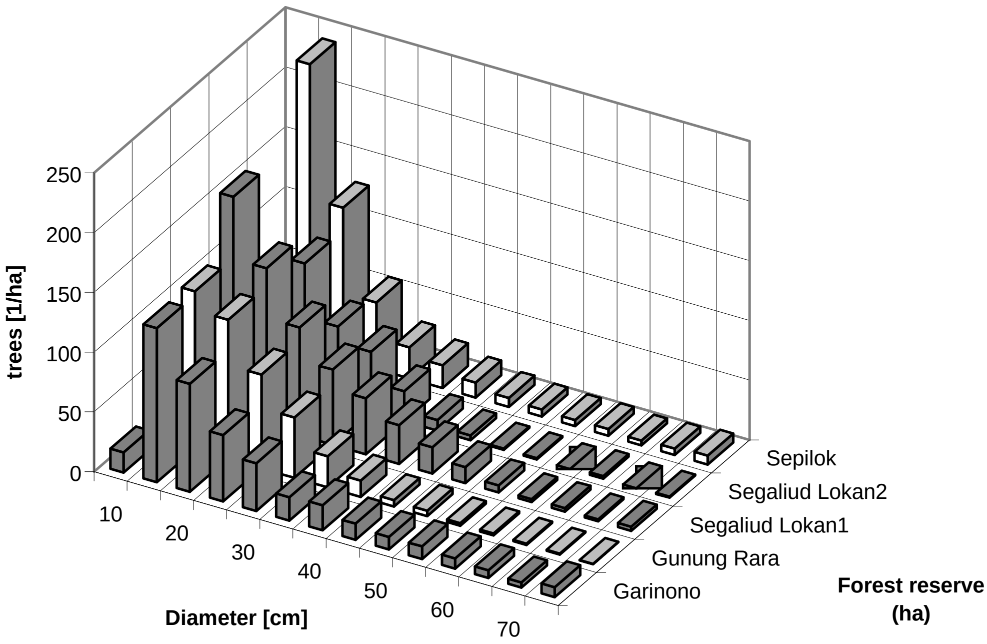

Figure 4.1: Diameter distribution of different forest reserves

The following Figures 4.2 and 4.3 show the distribution of the trees in different functional groups. We show both the old FORMIX3 and the new FORMIX4 grouping. In the old grouping the huge amount of pioneers especially in Garinono, Gunung Rara and Segaliud Lokan2 are worth noticing. In the more detailed FORMIX4 grouping four groups (5, 9, 11, 12) seems to dominate the stands.

A detailed listing of the different stands divided in diameter classes and functional groups is found in Appendix D.

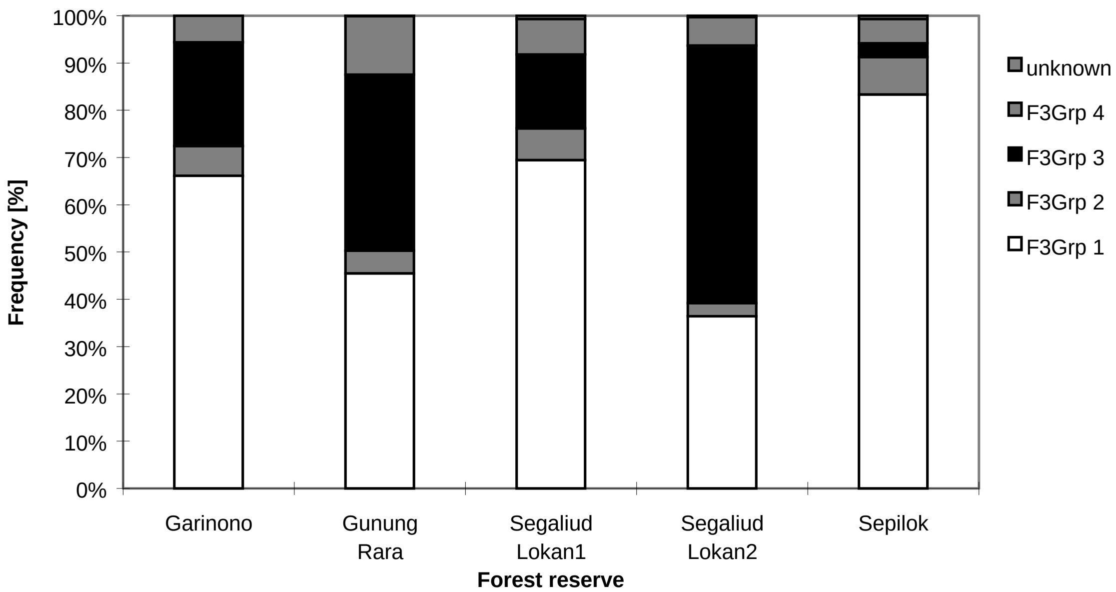

Figure 4.2: Tree distribution in FORMIX3 groups

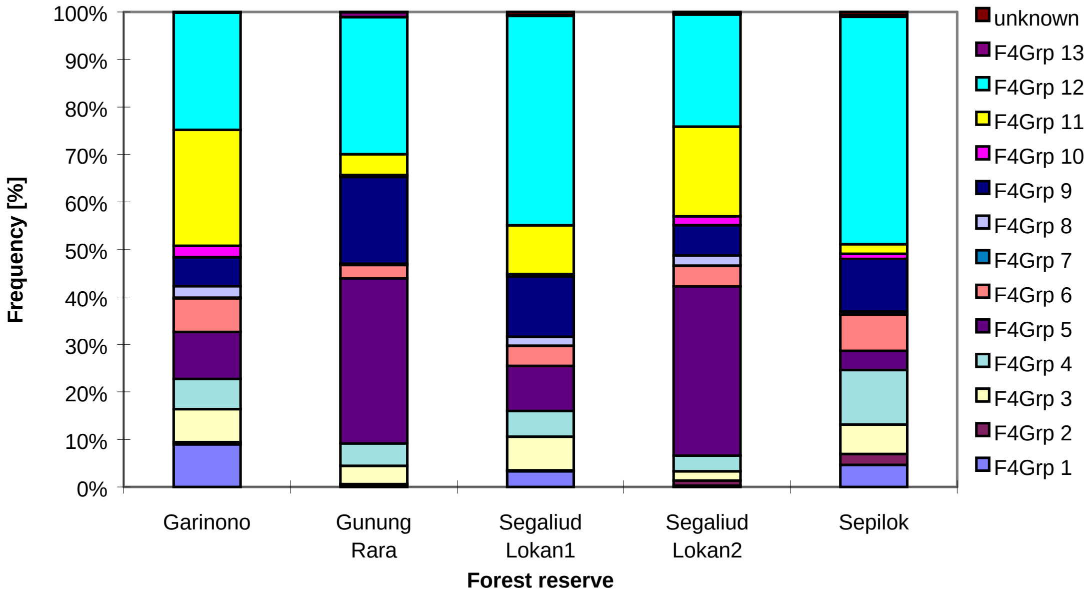

Figure 4.3: Tree distribution in FORMIX4 groups

4.1.2 Theoretical calculations for deriving the mortality rate

One has to calculate the mortality rate carefully. Because field measurements as well as computer simulation with a time step Δt need a discrete consideration, while normally a theoretic approach would assume an infinite time step δt, which can be regarded as continual. We try to calculate now, how mortality rate can be achieved from the field data.

In FORMIX3 the losses of trees δN according to mortality M is calculated in Huth et al (1996) with Eq (1) and (16) to:

$$\frac{\partial N}{\partial t} = -M \cdot N(t)\,, \tag{4.1}$$

with N is the number of trees, δt the infinite time step. Solving the differential equation leads to

$$N(t) = N(t_0) \cdot \exp(-M \cdot t)\,. \tag{4.2}$$

This is the logarithmically approach used in literature. M is the relative mortality rate (unit: [1/a]). In practice however the time step Δt is to large to be considered as infinite, so that we have to have a look at the discrete formulation:

$$\frac{N_{j+1} - N_j}{\Delta t} = -M \cdot N_j\,, \tag{4.3}$$

or

$$N_{j+1} = N_j \cdot (1 - M \cdot \Delta t)\,, \tag{4.4}$$

where N_j is the tree number at time t_j, N_{j+1} the tree number at time t_{j+1} and Δt the time step between two discrete times. It has to be mentioned that no regeneration, which might increase the initial number of trees, is considered. Following tree numbers can be calculated iteratively from the origin number N_0 at t_0.

$$N_j = N_0 \cdot (1 - M \cdot \Delta t)^j\,. \tag{4.5}$$

With m as the relative part of N_j which is dying in the time Δt the equation becomes to:

$$N_j = N_0 \cdot (1 - m)^j\,. \tag{4.6}$$

If we have two inventories j and j+1 with a time step of Δt between them, mortality m is calculated from the data as:

$$m = \frac{N_j - N_{j+1}}{N_j}. \quad \textbf{(4.7)}$$

Because generally the time step Δt is too big, discreting can not be done easily by M = m / Δt. A parameter for the exponential function has to be found which represents the discrete points in time. Let it be:

$$M' = \ln(1-m) \quad \text{or} \quad \exp(M') = 1-m. \quad \textbf{(4.8)}$$

Eq. (4.6) and eq (4.8) lead to

$$N_j = N_0 \cdot \exp(M' \cdot j). \quad \textbf{(4.9)}$$

The transition to the continuum equation derives:

$$N(j \cdot \Delta t) = N_0 \cdot \exp\left(\frac{M'}{\Delta t} \cdot j \cdot \Delta t\right). \quad \textbf{(4.10)}$$

The discrete data are interpolated with the continuum equation of the type of eq. (4.2) with

$$M = -\frac{M'}{\Delta t} = -\frac{\ln(1-m)}{\Delta t}. \quad \textbf{(4.11)}$$

Only for Δt<<1 with m<<1 it is ln(1-m) δ m, but not generally, which leads to the expected M = m / Δt. The mortality rate M we are interested in therefore is derived with the following equation:

$$M = -\frac{\ln\left(1 - \frac{N_j - N_{j+1}}{N_j}\right)}{\Delta t}. \quad \textbf{(4.12)}$$

4.1.3 Average mortality rate

Average annual mortality rate M independent on tree size and growth is calculated using eq (4.12). The results are summarized in Table 4.3. The mortality rate M varies widely from 0.24% to 6.34%. Literature studies show, that the expected average mortality rate should be between 1% and 3% (see chapter 4.2). Therefore the data seems to present rain forest stand which show different mortality behaviour than expected. If the time past after the last logging is taken into consideration, the forest in Garinono had the longest period of 45 years for regeneration and present the most intact forest within these sample. Its average mortality rate of 2.59% seems the most realistic one. The higher mortality in Segaliud Lokan and Sepilok might be an effect of the logging, which happened 8 to 25 years ago. One has to consider the high part of pioneers with a higher mortality rate than climax species within some forest reserves (Gunung Rara and Segaliud Lokan2). Higher mortality can also occur due to a drought in 1982/83 with nearly no rainfall at all for eight months, which effected parts of the forest reserve Segaliud Lokan. There seems to be no suitable reason for the very low mortality rate in Gunung Rara, where logging was performed 11 to 12 years before data were taken.

Table 4.3: Average mortality rate M

Forest reserve	Trees at first census	Death in time of observation	Δt [a]	M [%/a]
Garinono	871	181	9	2.59
Gunung Rara	4978	108	9	0.24
Segaliud Lokan1	4755	1700	10	5.10
Segaliud Lokan2	365	205	13	6.34
Sepilok	2218	1416	20	5.09

To investigate the influence of the drought further the mortality as a function of time is visualized in the following figures. It can be seen that in Garinono and Segaliud Lokan1 the mortality is fairly constant, varying from 0.9%/a to 5.0%/a. and 5.0%/a to 5.2%/a respectively, while in Segaliud Lokan2 and Sepilok there are sharp increases in mortality. In Segaliud Lokan2 after eight years of no dying trees at all, mortality rises after 1982 up to 36.7%/a. In Sepilok M rises from moderate 2.8%/a after 1983 to 9.6%/a in 1993. This might be correlated with the drought as well.

However for the analysis of data we take all inventories into consideration to rely on a data set as large as possible. Keeping in mind the effects of the drought it seems that the forest reserves Garinono and Segaliud Lokan1 might lead to the most reasonable results, Sepilok with some deficiency according to the drought.

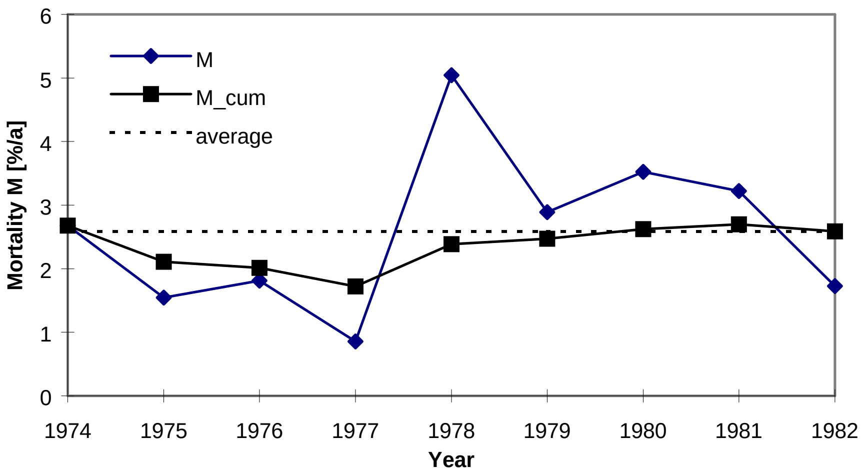

Figure 4.4: Mortality over time in **Garinono**. *M* is the mortality for the previous time step, *M_cum* the cumulative mortality of the past years.

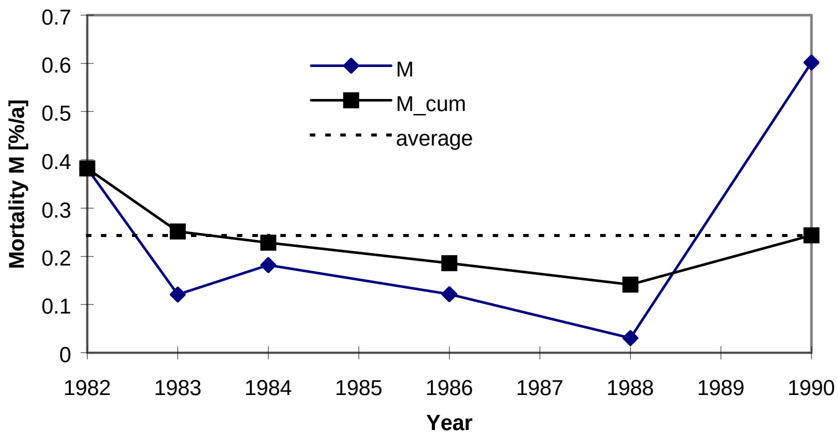

Figure 4.5: Mortality over time in **Gunung Rara**. *M* is the mortality for the previous time step, *M_cum* the cumulative mortality of the past years.

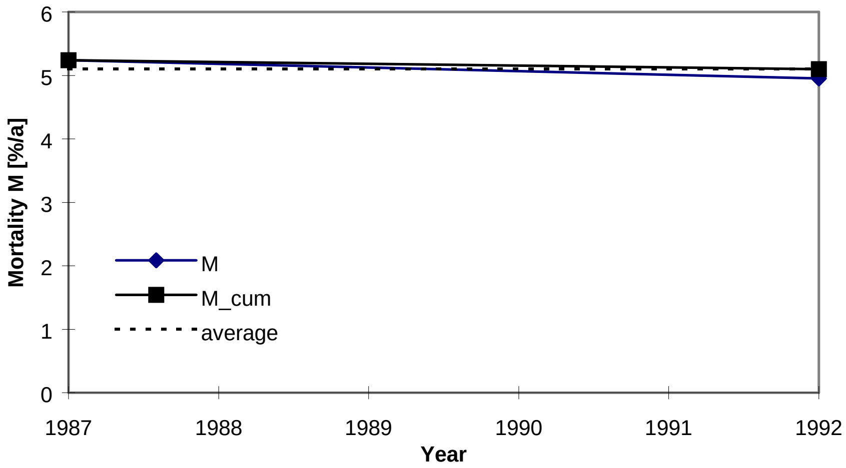

Figure 4.6: Mortality over time in **Segaliud Lokan1**. *M* is the mortality for the previous time step, *M_cum* the cumulative mortality of the past years.

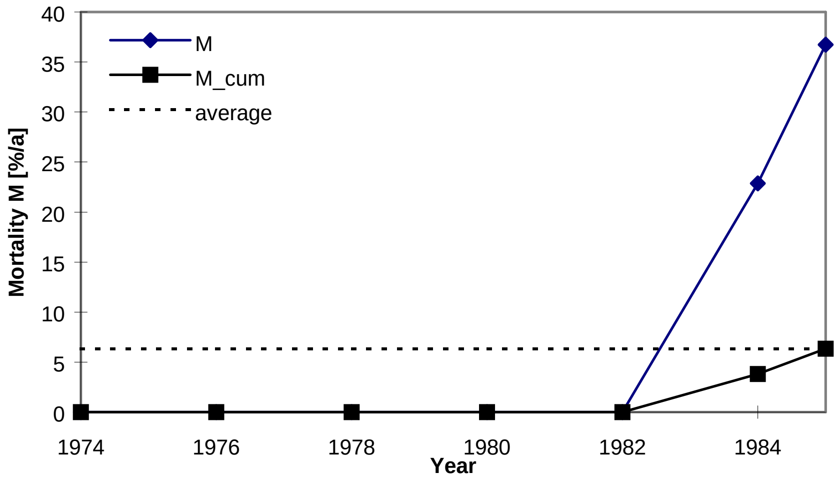

Figure 4.7: Mortality over time in **Segaliud Lokan2**. *M* is the mortality for the previous time step, *M_cum* the cumulative mortality of the past years.

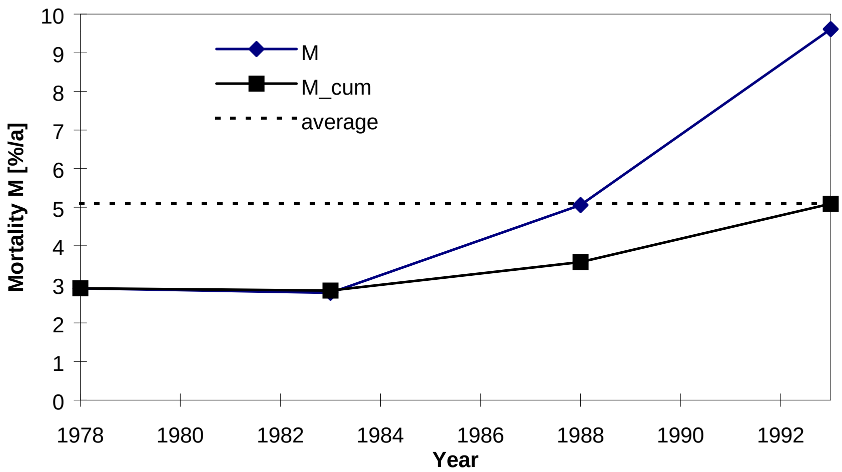

Figure 4.8: Mortality over time in **Sepilok**. *M* is the mortality for the previous time step, *M_cum* the cumulative mortality of the past years.

4.1.4 Mortality as a function of species group

FORMIX3 grouping

The mortality rate for the different FORMIX3 groups are shown in Figure 4.9. It is quiet obvious, that the rate for forest reserve Gunung Rara differs significantly from the rest. Therefore Gunung Rara is not taken into account for further statistical analysis. A multi sample comparison shows significant difference between group 3 and the other three groups. The average annual mortality rates vary from 2.5 % (group 2) to 3.8 % (group 1) except group 3 which has 8.1%. They are illustrated in Figure 4.10.

A detailed listing of the number of dead trees and the corresponding χ^2-test for significant differences from the average mortality are found in Appendix E. These additional tests show, that most of the functional groups have a mortality rate significantly different from the average rate. In Table 4.4 the distribution of the probabilities that the mortality does not vary with functional group is documented. It is obvious that in all forest reserves apart from Gunung Rara two or more groups have a probability $P<0.1$. Only in Garinono and Gunung Rara there are two and three groups respectively with $P>0.1$ (one/two groups even with $P>0.5$), which indicates, that in these forest reserves the mortality rate does not differ too much in different groups. However a χ^2 test for the whole data set (P_{all} in Table 4.4) indicates, that not in a single reserve the mortality rate stays constant in different functional groups.

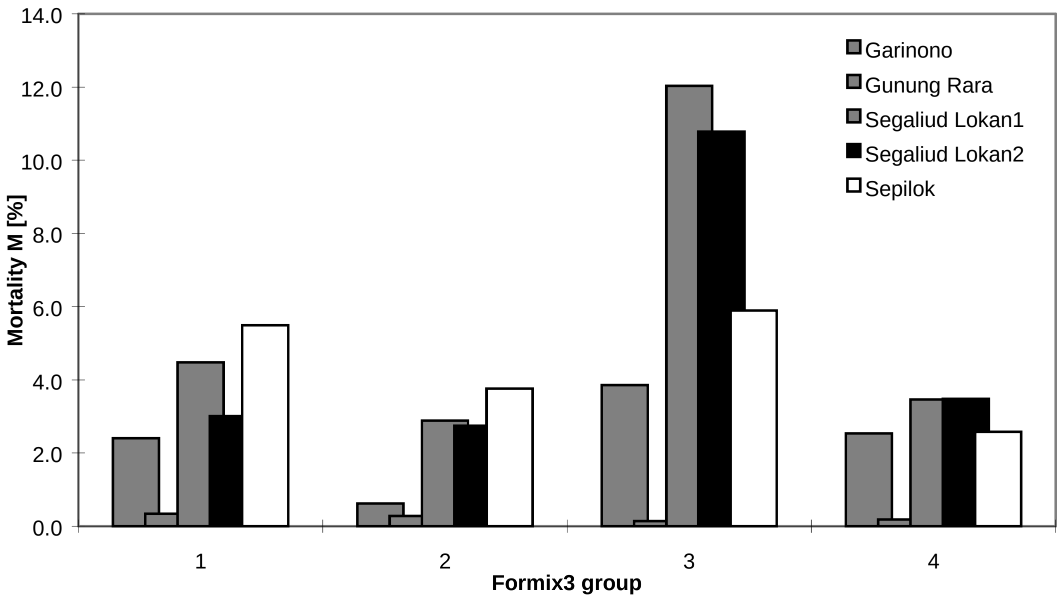

Figure 4.9: Mortality M in different forest reserves for the FORMIX3 groups

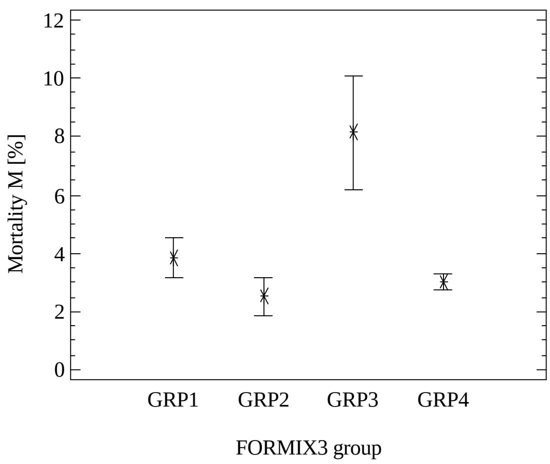

Figure 4.10: Average mortality M incl. standard derivation in FORMIX3 groups

Forest reserve	P>0.5	P>0.1	P<0.1	P<0.05	P<0.001	P_{all}
Garinono	1	1			2	<0.001
Gunung Rara	2	1	1		1	0.002
Segaliud Lokan1					4	<0.001
Segaliud Lokan2			2		2	<0.001
Sepilok		1		1	2	<0.001

Table 4.4: Distribution of probability P for χ^2-analysis of mortality in different FORMIX3 groups. Statistical details are found in Appendix E. A high probability indicate that the mortality of the single functional group does not vary significantly from the average mortality. P_{all} is the probability for the whole data set.

Conclusions have to be drawn from the two different results. A multi sample analysis for all reserves indicates only a difference between mortality in group 3 and the other groups, while χ^2-analysis for the single forest reserves indicates that most groups have significant different mortality rates. Normally one might expect that mortality does not vary a lot in different samples. However the different reserves have a different history and it is therefore not automatically justified to analyze average data from the reserves. Nevertheless the aim of this investigation is to derive average values for Sabah's lowland dipterocarp rain forest. For that reason I tend to prefer the results of the multi sample analysis. If data for a lot more reserves would be available one might decide in single cases to rely on the data of a specific forest reserve.

FORMIX4 grouping

Annual mortality M as a function of functional groups for the FORMIX4 grouping is shown in Figure 4.11. Results from the Gunung Rara forest reserve again have a significant lower mortality, so that they are taken out of further analysis. A multi sample comparison show a significant difference between group 5 and all the other groups. For the groups 2, 7 and 13 only in some forest reserve trees exist in a small number, so these data are too few to make any statistical statement. In Figure 4.12 the annual mortality rate M averaged over the forest reserves and the standard derivation is drawn. M varies (excluding group 2, 7 and 13) from 2.0% (group 3) to 6.3% (group 1) for all groups except group 5, which has a M=15.2%.

Again a detailed listing including statistically analysis (χ^2-test) are found in Appendix E. The tests prove the significant difference in mortality rate of most functional groups from the average mortality. In Garinono, Gunung Rara and Segaliud Lokan2 more than half of the functional groups have a probability P>0.1, for 5, 5 and 1 groups respectively P>0.5, indicating no significant variation from the average mortality. In the other reserves at least half of the groups have a probability P<0.1 indicating significant differences from the average value. A statistic for the whole data set leads to probabilities P_{all}<0.001 even for the forest reserves Garinono and Segaliud Lokan2, only Gunung Rara has a slightly higher P-value of P_{all}=0.035. These indicates that the mortality for different groups varies significantly from the average value.

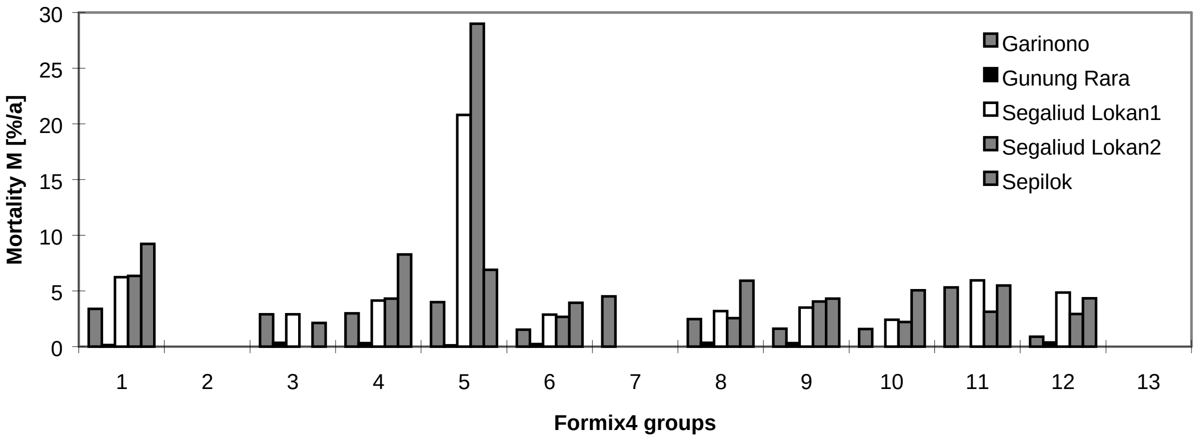

Figure 4.11: Mortality M in different forest reserves for the FORMIX4 groups

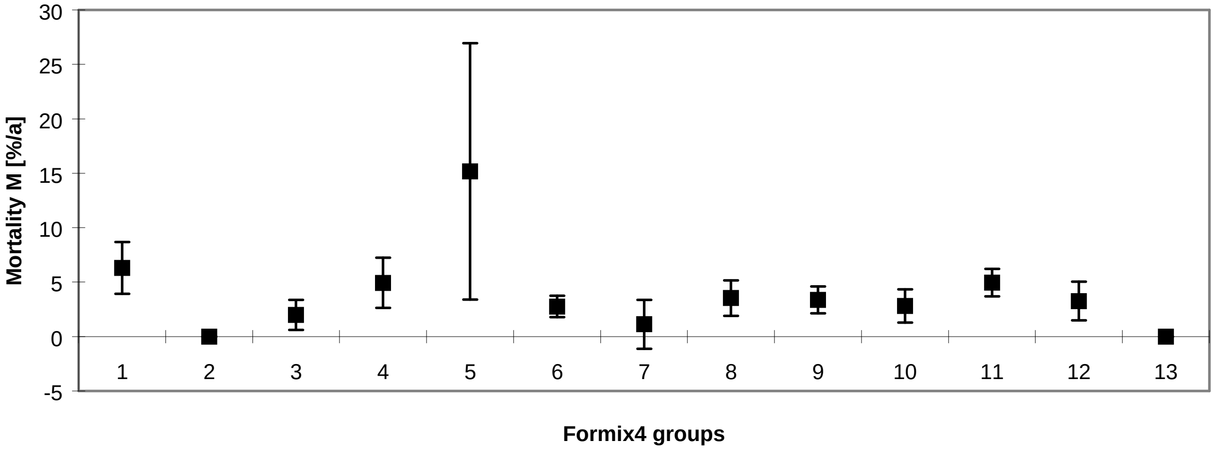

Figure 4.12: Average mortality M incl. standard derivation in FORMIX4 groups

Forest reserve	P>0.5	P>0.1	P<0.1	P<0.05	P<0.01	P_{all}
Garinono	5	4	1		2	<0.001
Gunung Rara	5	6		1	1	0.035
Segaliud Lokan1		3		2	7	<0.001
Segaliud Lokan2	1	6			4	<0.001
Sepilok	2	2		2	8	<0.001

Table 4.5: Distribution of probability P for χ^2-analysis of mortality in different FORMIX4 groups. Statistical details are found in Appendix E. A high probability indicate that the mortality of the single functional group does not vary significantly from the average mortality. P_{all} is the probability for the whole data set.

Following the same arguments than in the previous section the results of the multi sample analysis should be regarded as more important than the χ^2-analysis for the single forest reserves.

Light demand grouping

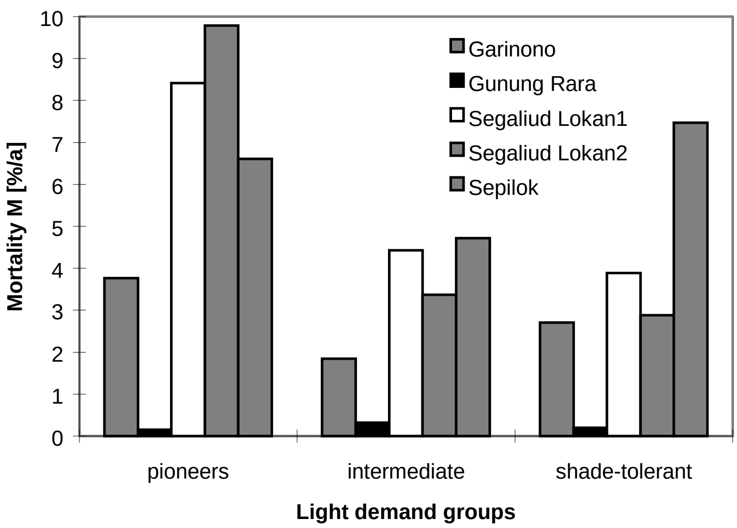

Figure 4.13a: Mortality M in different forest reserves for the light demand groups

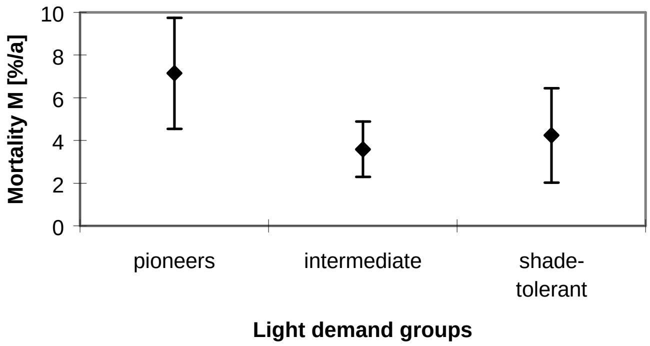

Figure 4.14b: Average mortality M incl. standard derivation in light demand groups

Following the ideas from the previous section the mortality rate depending on light demand groups can be analyzed (Fig. 4.12a & 4.12b). Again Gunung Rara has a unexpected low mortality rate and is taken out of further analysis. The χ^2-test shows as well as the average vales (Fig. 4.12b), that mortality varies signifigantly for different light demand groups as seen in Tab. 4.6a, where again the P-values are listed. For all forest reserves P-values are very low, even the P_{all} for the whole sample. Mortality rate for pioneers is significantly higher (7.1%) than the rates for shade-tolerant (4.2%) or intermediate species (3.6%).

Forest reserve	P>0.5	P>0.1	P<0.1	P<0.05	P<0.01	P_{all}
Garinono	1				2	<0.001
Gunung Rara	2			2		0.010
Segaliud Lokan1					4	<0.001
Segaliud Lokan2		1		1	3	<0.001
Sepilok				1	3	<0.001

Table 4.6a: Distribution of probability P for χ^2-analysis of mortality in different Light demand groups. Statistical details are found in Appendix E. A high probability indicate that the mortality of the single functional group does not vary significantly from the average mortality. P_{all} is the probability for the whole data set.

Height grouping

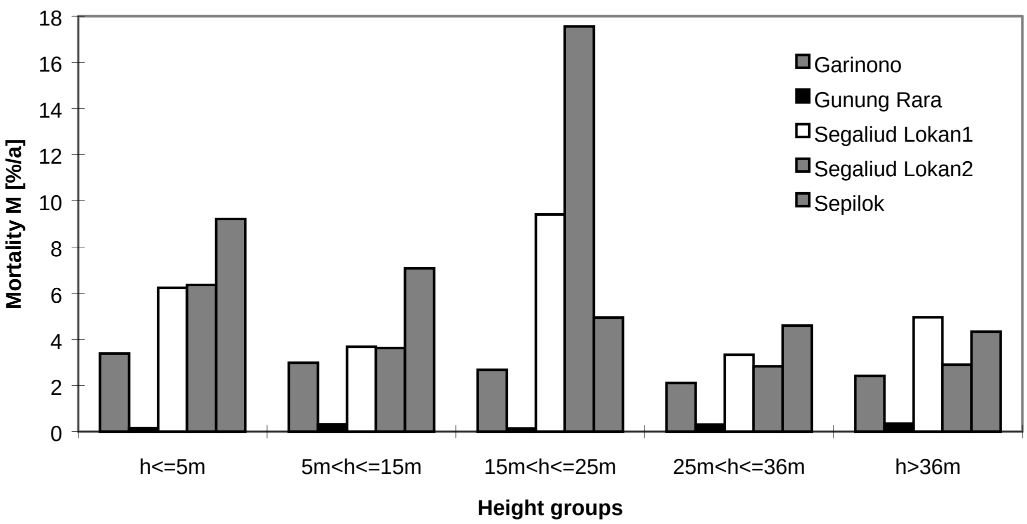

Figure 4.15c: Mortality M in different forest reserves for the height groups

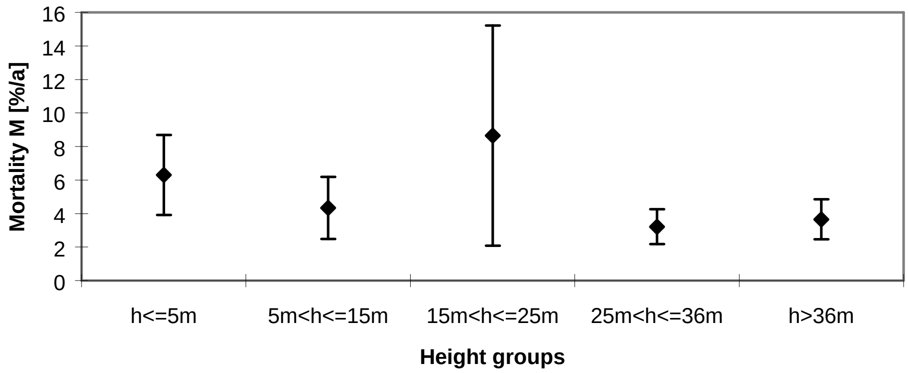

Figure 4.16d: Average mortality M incl. standard derivation in light demand groups

Forest reserve	P>0.5	P>0.1	P<0.1	P<0.05	P<0.01	P_{all}
Garinono	3	2				0.326
Gunung Rara	1	3		1	1	0.068
Segaliud Lokan1		1		1	4	<0.001
Segaliud Lokan2	1	2			3	<0.001
Sepilok	1	1			4	<0.001

Table 4.7b: Distribution of probability P for χ^2-analysis of mortality in different height groups. Statistical details are found in Appendix E. A high probability indicate that the mortality of the single functional group does not vary significantly from the average mortality. P_{all} is the probability for the whole data set.

The same analysis as for the light demand groups can be performed for the height groups. Again Fig.4.12c shows mortality rates for different forest reserves, Fig. 4.12d the average mortality without data Gunung Rara. In Tab. 4.7c the P-values derived from the χ^2-test are shown. This time in Garinono and Gunung Rara there is no significant difference for different height groups, where for the other three reserves significant difference is obvious (P_{all} < 0.001, more than half of the P-values <0.05). Apart from height group (15m-25m) (M=8.6%), where most of the pioneers are grouped in, there is a slight trend of lower mortality rate for species with higher potential maximum height (M is 6.3% and 4.3% in the smaller growing groups and 3.2% / 3.7% in the higher growing groups).

4.1.5 Mortality as a function a tree size

In determining the mortality as a function of tree size we choose the tree diameter at breast height as size characteristic. Doing so the dying trees are normally grouped in the diameter class they had at the first inventory. By the time they are dying it is very likely, that they have a different diameter. However it is not possible to analyze data for the current diameter, if not a huge area with a very frequent census is the source of the data.

5cm diameter classes

In this first approach we choose diameter classes of 5 cm width. In the following figures 4.13-4.17 the annual mortality rate M as a function of diameter is shown for the different forest reserves. The second drawing in the graphs is always the average mortality in this particular reserve.

In Garinono the mortality does not vary a lot with the tree size. In the Gunung Rara reserve their seems to be an increase in mortality to bigger size classes. In diameters below 40cm mortality reaches not even 1%, where it rises up to 4% for trees with 60cm in diameter. Gunung Rara again shows very untypical behavior strengthen the suspicious about any mistakes in the data set. All the other three forest reserves show a trend, that mortality does decrease in bigger size classes. However it has to be considered that there are only very few big trees in the sample plots which might lead to misinterpretations of mortality in this short periods of census. Mortality in Segaliud Lokan1 & 2 is below average in small size classes (d<=15cm). The high peak of more than 12% mortality in Segaliud Lokan2 might happen due to the big number of pioneer species in this site. In Segaliud Lokan1 and Sepilok the amount of pioneers is relatively smaller, so the species group might not be the main reason for these mortality pattern.

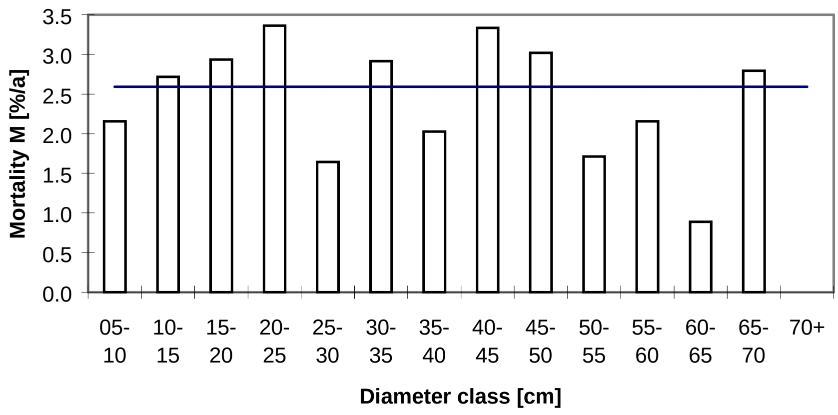

Figure 4.17: Mortality rate of trees (d>=5cm) in 5cm size classes in **Garinono**

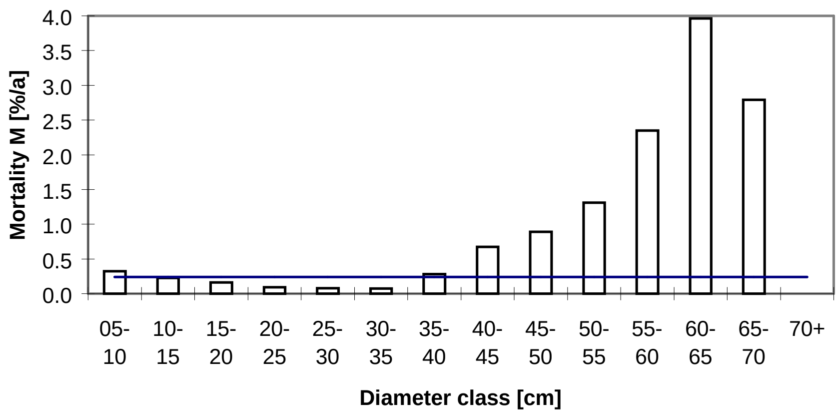

Figure 4.18: Mortality rate of trees (d>=5cm) in 5cm size classes in **Gunung Rara**

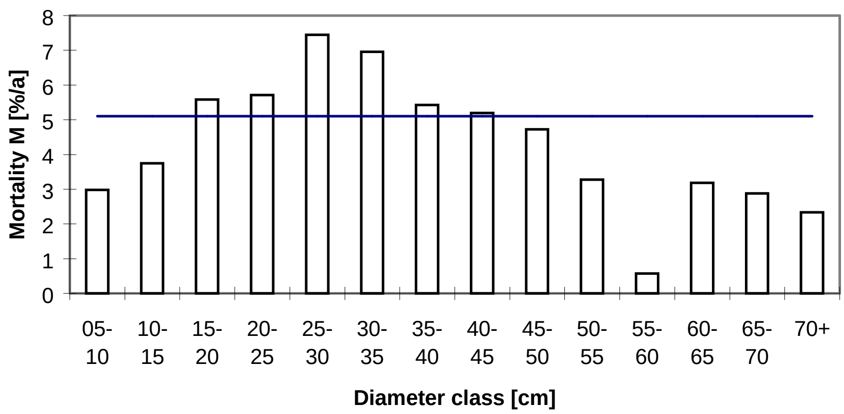

Figure 4.19: Mortality rate of trees (d>=5cm) in 5cm size classes in **Segaliud Lokan1**

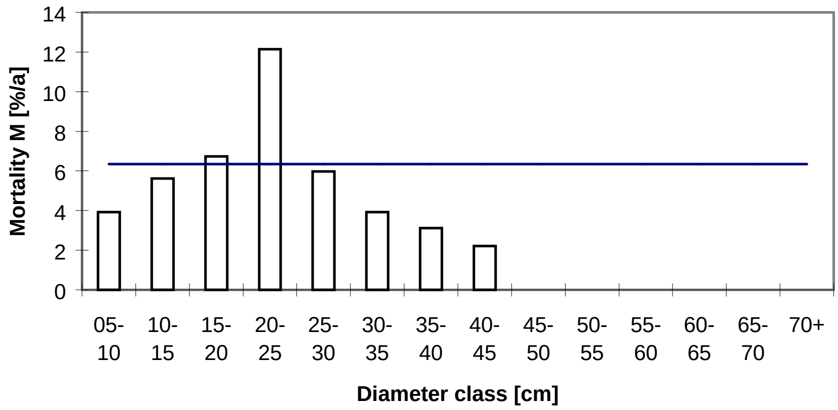

Figure 4.20: Mortality rate of trees (d>=5cm) in 5cm size classes in **Segaliud Lokan2**

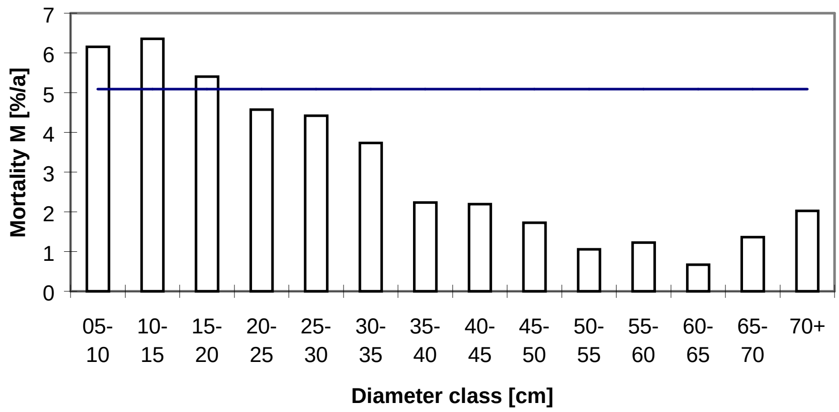

Figure 4.21: Mortality rate of trees (d>=5cm) in 5cm size classes in **Sepilok**

A detailed listing of the number of dead trees and the corresponding χ^2-test for significant differences from the average mortality are found in Appendix F. These additional tests show very different results for the individual forest reserves. In Table 4.6 the distribution of the probabilities P that mortality does not vary with tree size are shown. In Garinono and Segaliud Lokan2 all but one size class have a P-value >0.1, in the first reserve even 10 classes gain P>0.5, indicating, that mortality does not vary with size class. It has to be considered that in Segaliud Lokan2 all size classes above 40cm are poorly inhabit. In the three other reserves more than half of the size classes have P-value P<0.1, indicating significant differences in mortality from the average rate.

Forest reserve	P>0.5	P>0.1	P<0.1	P<0.05	P<0.01	P_{all}
Garinono	10	4		1		0.52
Gunung Rara	2	3		5	5	<0.001
Segaliud Lokan1	3	3	3	1	4	0
Segaliud Lokan2	2	9			1	0.002
Sepilok		3	1	1	9	<0.001

Table 4.8: Distribution of probability P for χ^2-analysis of mortality in different tree size classes (5cm diameter width). Statistical details are found in Appendix F. A high probability indicate that the mortality of the single functional group does not vary significantly from the average mortality. P_{all} is the probability for the whole data set.

The probabilities P_{all} for the whole data set are very low (P_{all}<0.005) for all but Garinono which has a P-value >0.5. Again this indicates constant mortality in all size classes in Garinono and a functional coherence between mortality and size class in the other reserves. However there seems not to be a relation which describes the coherence generally, it is very different in different sites. Therefor it is difficult to derive a general formalism for the FORMIX4 model.

20cm diameter classes

In most cases the data set is so small that in a distribution in 5cm classes there are often classes with very few or no trees. For better statistical analysis we therefore apply a distribution in diameter classes of 20 cm width and do the same analysis than in the previous section.

Trends seen in the previous section are confirmed in this analysis. In Garinono and even in Segaliud Lokan2 the mortality rate of the different size classes does not differ much from the average annual mortality, while in Segaliud Lokan1 and Sepilok there is the clear trend for lower mortality in higher size classes. Gunung Rara again shows the abnormal trend of higher mortality in big trees. The only astonishing result is an increase of mortality in middle sized trees in Segaliud Lokan2 compared to the 5cm classes. This might be due to only one tree per size class in the 5cm distribution, from which it is not possible to derive a mortality rate and therefore M is assumed to be zero.

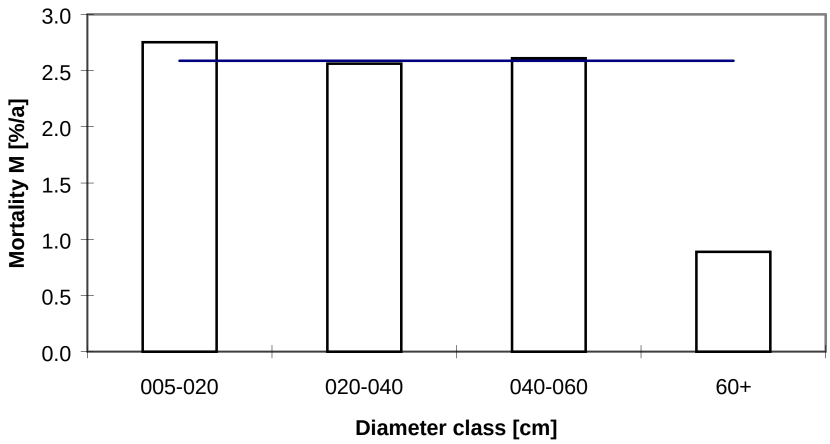

Figure 4.22: Mortality rate of trees (d>=5cm) in 20cm size classes in **Garinono**

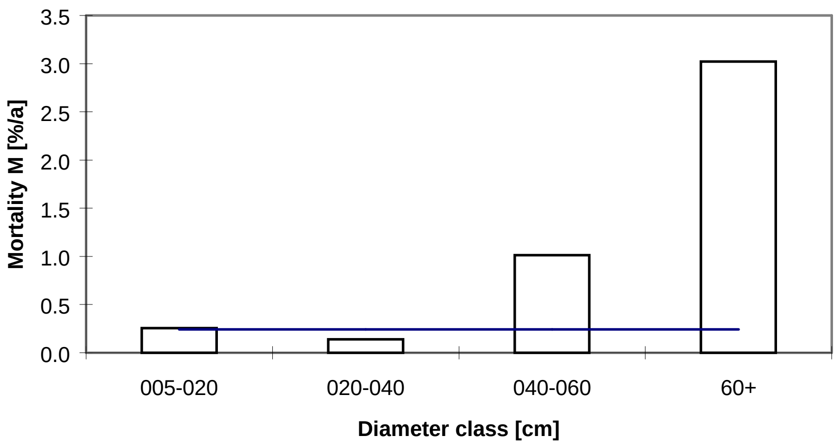

Figure 4.23: Mortality rate of trees (d>=5cm) in 20cm size classes in **Gunung Rara**

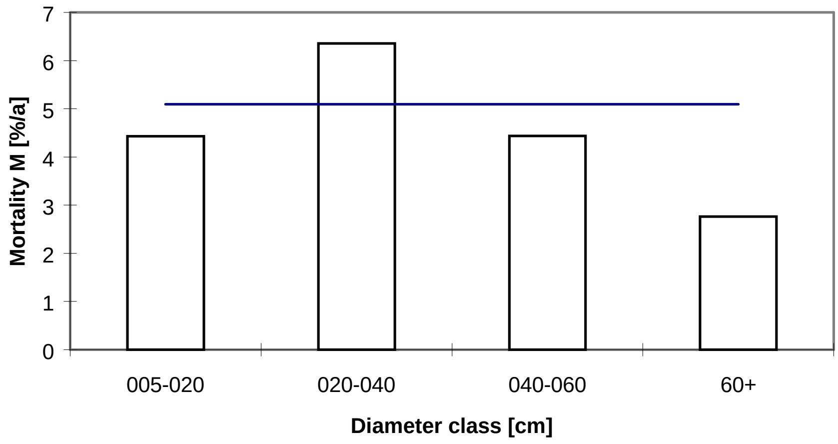

Figure 4.24: Mortality rate of trees (d>=5cm) in 20cm size classes in **Segaliud Lokan1**

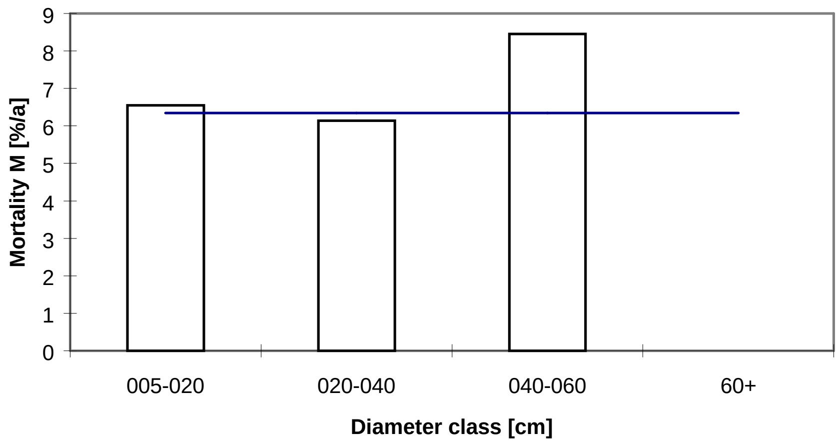

Figure 4.25: Mortality rate of trees (d>=5cm) in 20cm size classes in **Segaliud Lokan2**

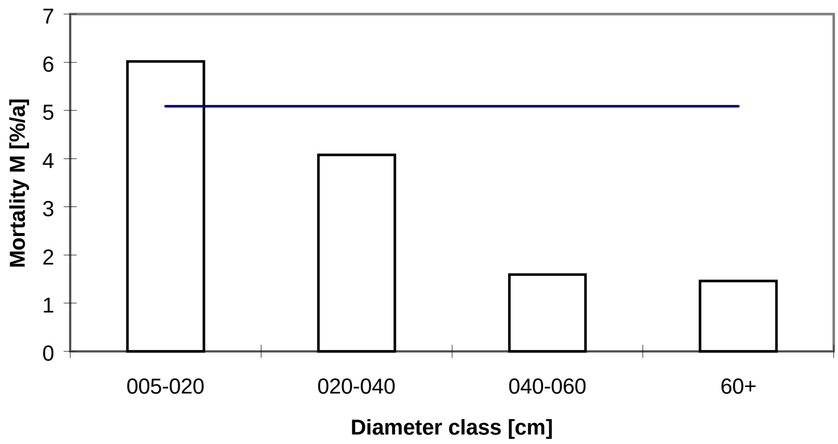

Figure 4.26: Mortality rate of trees (d>=5cm) in 20cm size classes in **Sepilok**

Forest reserve	P>0.5	P>0.1	P<0.1	P<0.05	P<0.01	P_{all}
Garinono	3			1		0.217
Gunung Rara	1				3	<0.001
Segaliud Lokan1		1		1	2	<0.001
Segaliud Lokan2	3		1			0.243
Sepilok					4	<0.001

Table 4.9: Distribution of probability P for χ^2-analysis of mortality in different tree size classes (20cm diameter width). Statistical details are found in Appendix F. A high probability indicate that the mortality of the single functional group does not vary significantly from the average mortality. P_{all} is the probability for the whole data set.

By analyzing the probability distribution (Table 4.7) only in the forest reserves Garinono and Segaliud Lokan2 more than half of the size classes have a P-value>0.5, indicating no variation of mortality with tree size. The same result is achieved by interpretation of the P_{all}-value, which is >0.2 for the two mentioned reserves. In the other three forest mortality differ significantly from the average value. However there does not seem to be a simple functional context between mortality and tree size.

4.1.6 Mortality as a function of tree size and species group

This analysis applies the two filters (species group and tree size) which were used in the two previous section independently.

Using the knowledge from the previous section we only investigate mortality as a function of species group for FORMIX3 grouping and tree size for 20cm class width. The other possible combinations (FORMIX4 grouping and 5cm class width) will lead to classes with very few or no trees inside, where it is not possible to derive a mortality rate. Even with this classification it is not possible to apply a ξ^2-test, because various classes are not occupied leading to a data sample which will not pass the ξ^2 equations (division by zero).

The detailed listings of mortality rates and dying trees for the different forest reserves with the used classifications is found in Appendix G.

Trends in the mortality are the following:

- In Garinono groups 1 and 4 have a fairly constant mortality over all tree sizes, while in group 3 mortality decreases with increasing tree size. For group 2 only one reading at the lowest diameter class does not give information about size distribution.
- In Gunung Rara forest reserve especially group 2 shows a significant increase in mortality from below 1% for small tree up to 12% for trees with d>60cm. In all other groups M tend to increase only slightly to bigger trees size.
- Segaliud Lokan1: Again in group 3 mortality M tends decrease significantly for bigger tree size, while the other groups have a fairly constant mortality rate for different size classes.
- Segaliud Lokan2: In group 3 there might be an decrease in mortality to bigger tree size, unfortunately there are no recordings for trees with d>40cm. For all the other groups it seems that M is not varying much with different size.
- In Sepilok forest reserve we do not achieve the same decrease of mortality M in group 3. M is constantly high in this group, while a decrease of mortality to bigger size classes can be found in group 1. For the other two groups no distinct pattern in mortality rate can be found.

Summarizing the analysis it seems that mortality as a function of species group and tree size might be weaker than the dependency on the individual stand site conditions. Some pattern are found repeatedly in more than one reserve (decrease of mortality rate to bigger tree size in group 3; constant mortality rate over tree size in group 1, 2 and 4), but there are always examples which do not confirm this results.

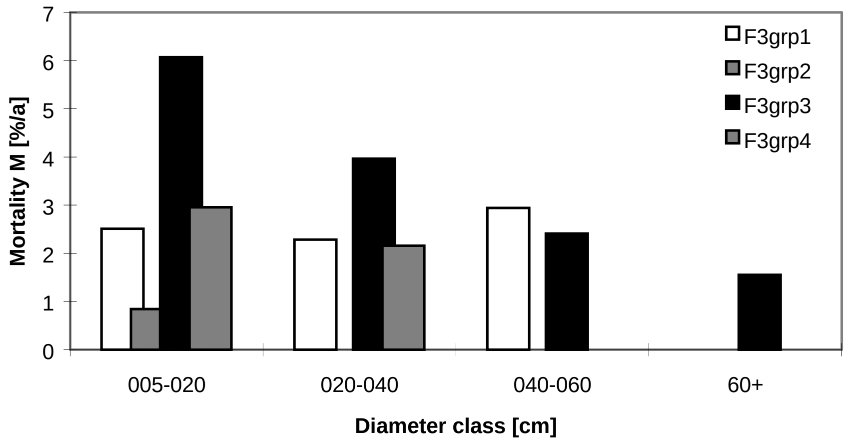

Figure 4.27: Mortality rate of trees in 20cm size classes and functional groups in **Garinono**

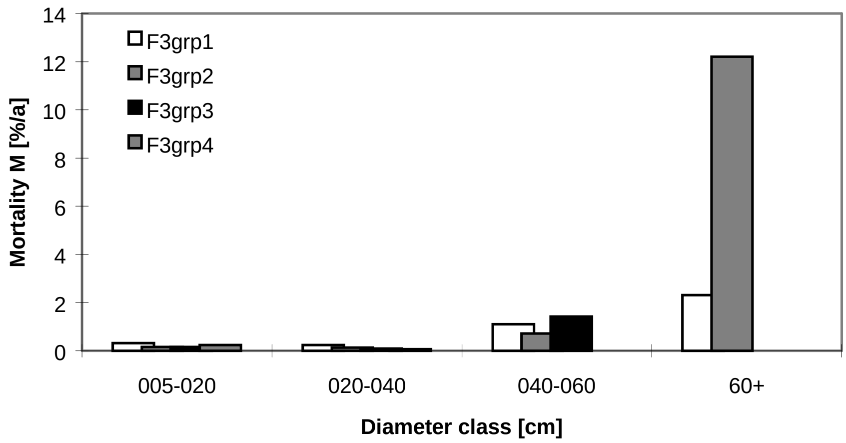

Figure 4.28: Mortality rate of trees in 20cm size classes and functional groups in **Gunung Rara**

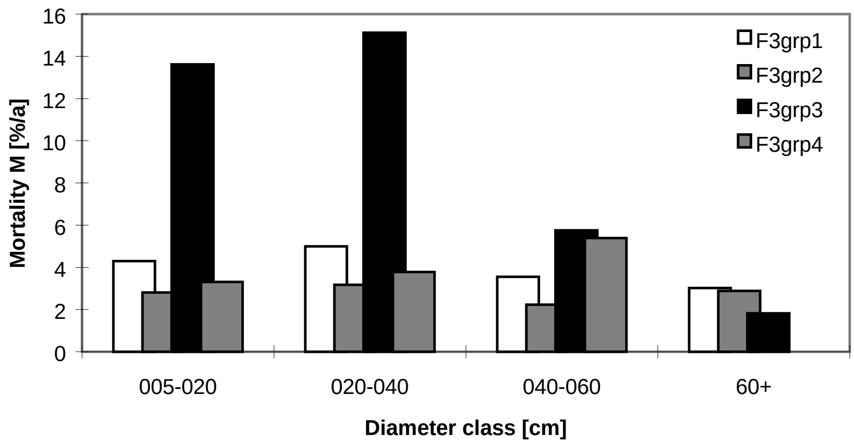

Figure 4.29: Mortality rate of trees in 20cm size classes and functional groups in **Segaliud Lokan1**

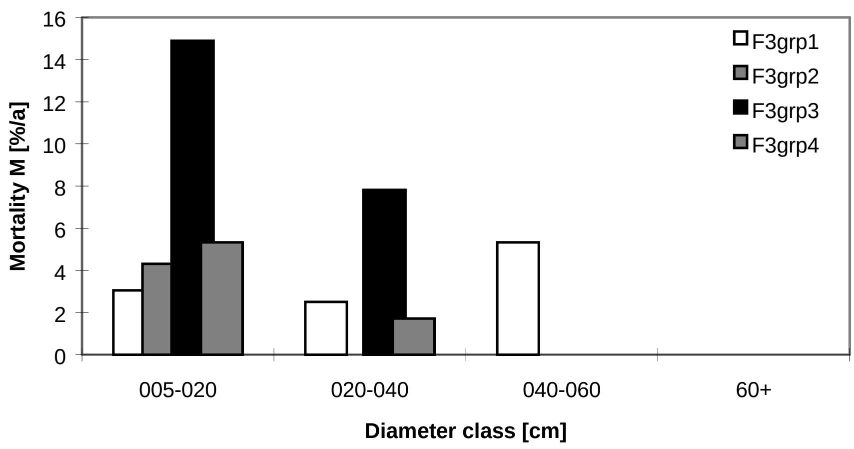

Figure 4.30: Mortality rate of trees in 20cm size classes and functional groups in **Segaliud Lokan2**

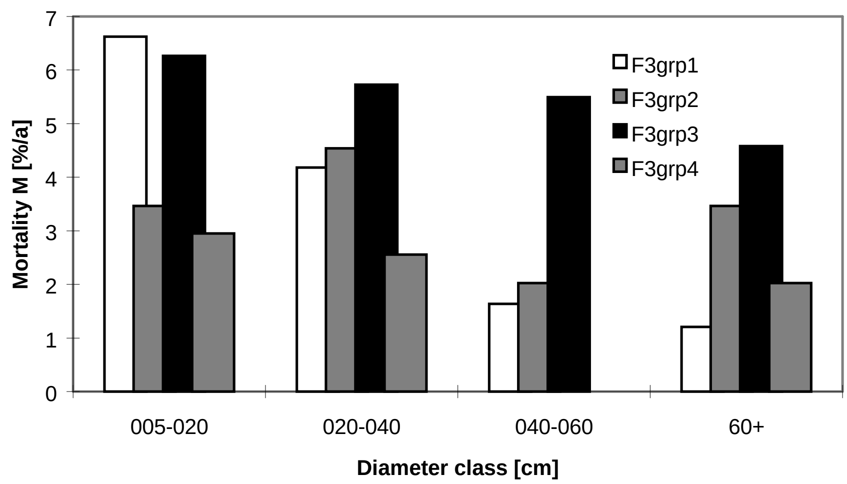

Figure 4.31: Mortality rate of trees in 20cm size classes and functional groups in **Sepilok**

4.1.7 Mortality as a function of diameter increment

In this section the correlation between growth in terms of diameter increment and annual mortality is analyzed. The detailed listing of mortality rates depending on tree growth is found in Appendix H.

Because not for every tree which was counted in the first enumeration a growth measurement is available the sample size is reduced again, especially in the forest reserve Segaliud Lokan1, where only 3 measurement are available. Only trees which exit in the first inventory and do not die before the second inventory produce data which can be analyzed. Therefore in some forest reserves (e. g. Segaliud Lokan1) it seems that the distribution of mortality rate over the increment classes might have a different average mortality than the one shown in the Figures 4.28-4.32. For the average mortality the trees, for which no increment data were available were considered as well.

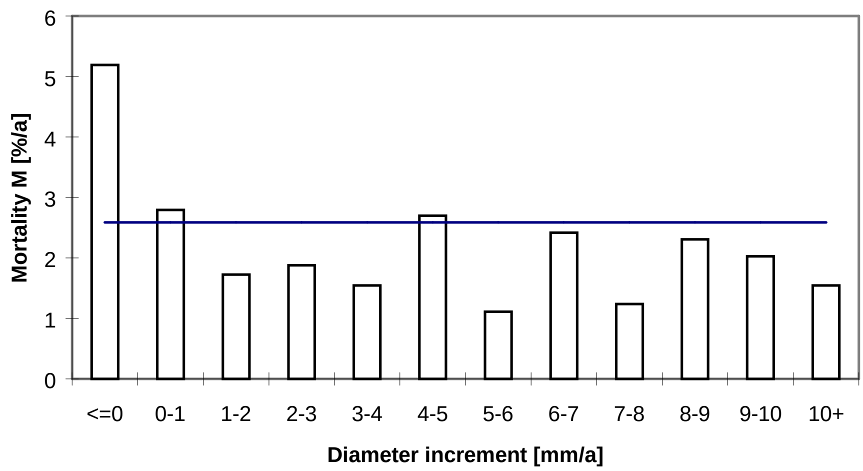

Figure 4.32: Mortality rate as a function of diameter increment in **Garinono**

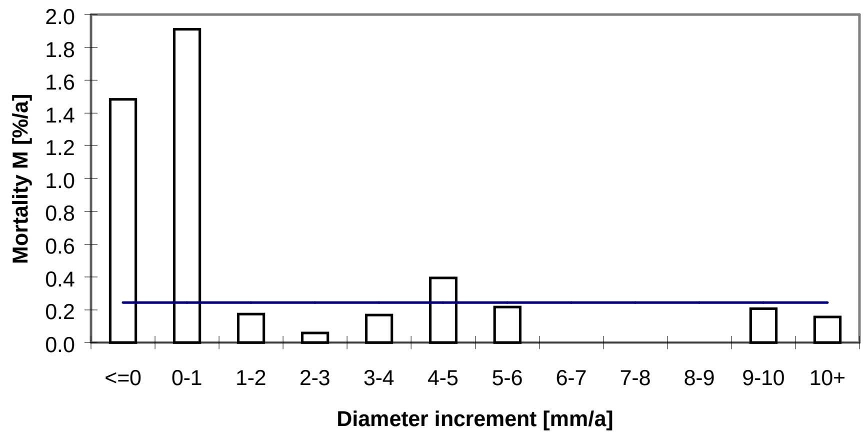

Figure 4.33: Mortality rate as a function of diameter increment in **Gunung Rara**

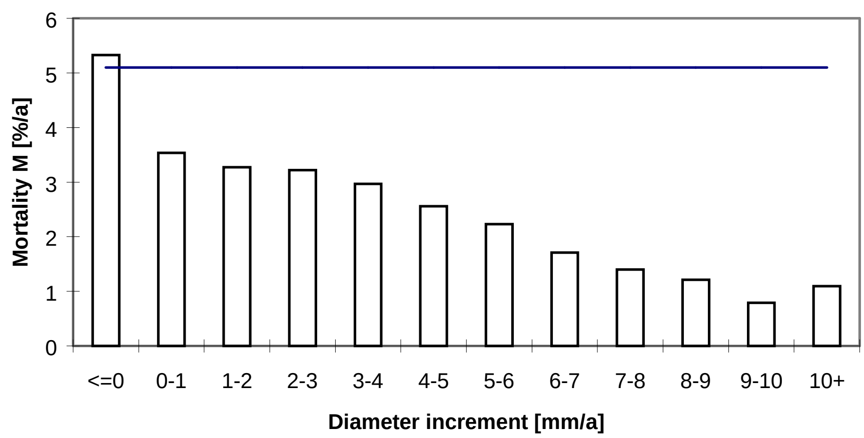

Figure 4.34: Mortality rate as a function of diameter increment in **Segaliud Lokan1**

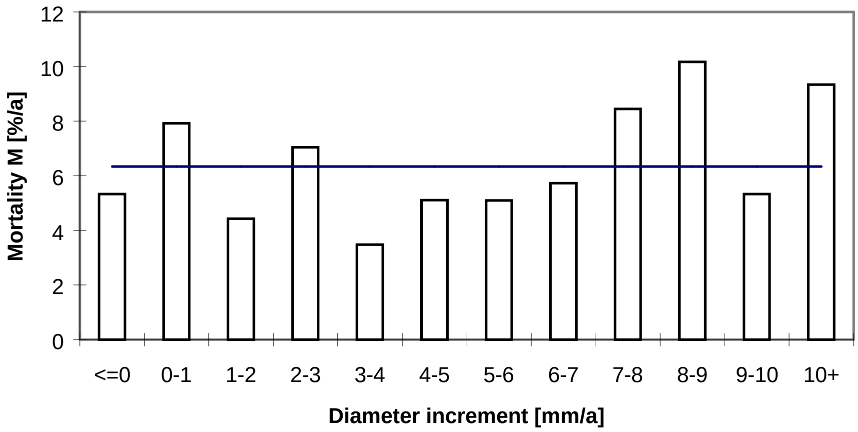

Figure 4.35: Mortality rate as a function of diameter increment in **Segaliud Lokan2**

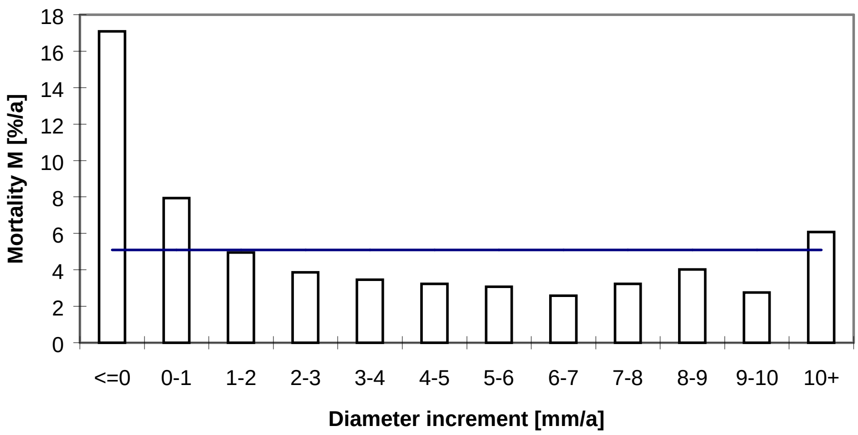

Figure 4.36: Mortality rate as a function of diameter increment in **Sepilok**

Forest reserve	P>0.5	P>0.1	P<0.1	P<0.05	P<0.01	P_{all}
Garinono	7	3			2	<0.001
Gunung Rara	2	6		1	3	<0.001
Segaliud Lokan1	1			1	10	<0.001
Segaliud Lokan2	4	6		2		0.069
Sepilok	1	2			9	<0.001

Table 4.10: Distribution of probability P for χ^2-analysis of mortality in different diameter increment classes. Statistical details are found in Appendix H. A high probability indicate that the mortality of the single functional group does not vary significantly from the average mortality. P_{all} is the probability for the whole data set.

The trend of the relationship between mortality rate and diameter increment is quiet different in the various forest reserves. In all but Segaliud Lokan2 no or a negative increment has a significant higher mortality, in Gunung Rara the mortality of the class with small increment (0-1 mm/a) is even higher than the class with negative increment. In Segaliud Lokan1 the mortality decreases with annual diameter increment, while it stays fairly constant over the increment range in the other forest reserve.

This pattern can be seen again in the distribution of probability P of the χ^2-test. Segaliud Lokan1 and Sepilok are the only reserve with more than half the increment classes with a P-value<0.1, indicating a significant difference from the average mortality rate. In the other forest reserves more than half the increment classes have a probability P>0.1 indicating no significant difference from the average mortality rate.

Because of the small data set I do not try to find relationships between mortality rate and diameter increment in different functional groups. For this analysis a much larger data set is necessary.

It is a well known problem in the FORMIX3 model, that a mortality rate as a function of diameter increment tend to effect large trees a lot. Trees which reach their maximum size in the model do grow only very little each year. A mortality function which would increase mortality in trees with little annual growth might increase mortality in matured trees more than observed in nature. For that reason it would be interesting to analyze mortality as a function of diameter and diameter increment. Unfortunately the data set is too small for this purpose. Their are seldom trees with d≥80cm becuase most of the PSP are logged, regenerating forests. However a brief analysis of big trees show, that their diameter increment is spread over the whole range from no increase up to 10mm/a (in Sepilok forest reserve). The mortality rate in the very little cases where the increment classes are occupied do not indicate a higher mortality in larger diameter and low increment classes.

4.2 Literature data

4.2.1 Manokaran and Kochummen (1987)

The data source for this paper were long term investigations (1947-1981) on a 2 ha plot in Sungei Menyala Forest Reserve, Peninsula Malaysia. It is an dipterocarp forest, dominated by ‘red meranti timber’, which are the species Dipterocarpus and Shorea. It is a mature to over-mature forest as near to virgin as possible.

Basal area (d❍10cm) varies between 30.05 and 33.3 m²/ha. Tree density (d❍10cm) is in the range 537.5 to 461.5 1/ha.

Annual mortality rate M is calculated with the log-model explained in section 4.1.2.

Annual mortality is 2.02% with no variation in different diameter classes.

Mortality rate however varies within different species groups. The author distinguish the following five groups:

- Emergents (E) 1.43 % mortality per year
- Main canopy (MC) 1.82 % mortality per year
- Understorey (U) 2.58% mortality per year
- Pioneers (P) not enough data
- Late seral (LS) 3.29% mortality per year
- P + LS 3.77% mortality per year

where ‘Late Seral’ are light demanding but relatively shade tolerant species during late stage of succession. They can form parts of a matured forest.

The paper further presents a diameter increment analysis, but without relation to mortality.

4.2.2 Manokaran and Swaine (1994)

This book contains research results from three forest reserves (A: Bukit Lagong, B: Sungei Menyala, C: Pasoh) in Peninsular Malaysia, from which one is the study site in chapter 4.2.1. The length of observation varies from 13 to 38 years.

Again the mortality rate is calculated with the log model.

Results are:

- Average mortality rate varies from 1.39% (A), 2.03% (B) to 2.07% (C).

- Mortality as a function of diameter: There seems to be no variation of mortality rate with diameter in two study areas (B, C), where in A the mortality in the bigger diameter classes (50-60 cm) rises to nearly twice the average value .

- Mortality as a function of diameter increment: In study site A and B there is a significant higher mortality in trees with negative or poor increment and a drop of mortality to larger increment rates. In study site C the data set is poor for further interpretation. Only one increment measurement over seven years is correlated with a mortality estimation of following five year. In these data the mortality of tree with negative growth is surprisingly low and the overall variation is smaller compared with data set A and B.

- Mortality as a function of functional group: Similar results than in 4.2.1 can be seen here. The mortality rate is lower in species groups with a higher potential maximum size. They are in detail:

Table 4.11: Mortality rate for different species groups. A, B, C refer to different forest reserves

Species group	A [%]	B [%]	C [%]
Emergents	1.11	1.44	1.65
Main canopy	1.33	1.8	1.90
Unterstorey	1.45	2.58	2.35
Pioneer	-	-	-
Late-seral	2.74	3.26	2.65
Pioneer + Late-seral	3.60	3.69	3.12
average	1.39	2.03	2.07

4.3 Recommendations for FORMIX4

Mortality seems to be very sensitive for different circumstances. Environmental factors like droughts and site quality as well as logging seems to effect mortality on a long scale. It is therefore not easy to derive principles or functional relationship s between mortality and various other features. For a general modeling approach which tries to cover most possible situations, a very simple formalism seems to be the most appropriate, while special feature like depending on diameter increment might be a good approach for selected sites with a good data base available.

For a final statement I like to concentrate mainly on results from the forest reserves Garinono, Segaliud Lokan1 and Sepilok. Gunung Rara is the largest data set, but all the features in this reserve tend to represent opposite characteristics of the other reserve. And mortality seems far too low to take it as a long term average rate. Segaliud Lokan2 data is only based on a 1ha sample site, which is to small for most of the statistical tests.

Adding all available information together the following topics might be the best approach in the FORMIX4 model, whose target is modeling large areas of different site quality. In general I will figure out trend whereas absolute parameter values are difficult to define. Larger study areas (50ha plot in Pasoh, Peninsular Malaysia and 50ha plot in Lambir, Sarawak which are all primary forest) might be the appropriate sources for further investigations.

- Mortality rate M might vary with time due to water stress in unusual long dry seasons. In single cases M might rise up to 30%/a for a short period of time.

- Mortality does vary with functional group. Pioneers have a significant higher mortality (especially FORMIX3 group 3 and FORMIX4 group 5). For the other groups differences in average mortality are small and fall within the range of the standard deviation.

- Mortality seems not to vary with tree size. In Sepilok reserve M might be smaller with larger trees, which can be a feature for a selected case study.

- In the permanent sample plot there are no information about seedling mortality. I like to refer to results archived in chapter 3 for small trees.

- If one distinguishes species group and tree size for mortality pattern there are selected cases, where M decreases for bigger trees in emergent or pioneer species. However this seems not to be a general pattern.

- Mortality is significant higher in trees with no or negative increment. However near matured trees do tend to have the whole range of increment, which does not allow them a higher average mortality, as it would happen if a increment dependent mortality is applied in the FORMIX model.

- Over the range of diameter increment in most cases mortality in constant. In selected cases it might decrease for larger diameter increment.

Finally I would like to recommend to keep mortality rate and functional dependencies as simple as possible. Various relationship do tend to appear in nature, but the only general features which can be applied for all study sites seems to be a higher mortality rate in pioneer species and within very small trees.

Chapter 5: Summary

Within this project three different objectives have been the target of investigations.

1. Species grouping. Based on expert knowledge a grouping of 436 tree species occurring in Sabah rain forests was undertaken in 5 height groups (criteria 1) and 3 light demand groups (criteria 2). An independent performance of both groupings results in max. 15 final groups, from which three (lowest height layer) are considered as identical. Ending up with the resulting 13 groups this new species grouping should be the basis for a further development of the FORMIX4 model. Height-to-diameter-curves still have to be improved for this new grouping.

2. Regeneration: Data from inventories in four different forest reserves in Sabah were analyzed for regeneration of tree species. Because the field data did not content the tree size we are interested in ($h \leq 1.3m$) we can only end up with some orders of magnitude and general features about regeneration. Additionally interesting publication and Ph.D. thesis' were analyzed. As a result it seems that the number of seedlings varies widely and depends on the distance to the mother trees, the number of mother trees and a biological phenomenon called 'mass fruiting' which occurs every 4-6 years. Some functional relationships between number of seedlings and their occurrence in the FORMIX4 model can be mentioned, however the defined numbers of seedlings are better taken out of the research undertaken parallel to this study by Mr. Klaus Werner. His results combined with the expected range for small trees might give a good basis for site quality dependent regeneration pattern.

3. Mortality: Data from permanent sample plots in four different forest reserves over different lengths of time were analyzed for relationships between annual mortality rate and functional group, tree size, tree growth and various combinations of the latter. Some of the data sets were strongly influenced by a drought in 1982/83 which makes it impossible to present reliable figures for the mortality. Therefore again only trends can be worked out. Mortality seems to be significant higher in pioneer species, for trees with no or negative increment and seedlings depending on their tree density. All other relations are not confirmed over the whole range of the data set, but might be used in single case studies. They are:
   - Decreasing mortality rate in big trees, especially for single functional groups (pioneer and emergent).
   - Decreasing mortality rate in trees with large annual diameter increment.
   - Increasing mortality over a short period due to environmental circumstances (e. g. droughts, 'El Niño').

As general it can be said that there are very few principle pattern in regeneration and mortality which can be applied for simulation of rain forest. A worthwhile investigation might be the analysis of a data set of a huge area over a long period of time like the established 50ha plots in Lambir, Sarawak and Pasoh, Peninsular Malaysia. Unfortunately these data set were not available for this study.

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Appendix A: Species list with all available information

The following table contains all available information about the species, including the grouping for FORMIX4 with all the previous sub steps. It also contains information collected by Andreas Huths working group about maximum height and wood density.

The table is two pages wide and 11 pages long!

The legend below describes the columns in detail.

Legend:

SP_NAME	full botanical name
SP_LOCAL	full local name
SPC_CODE	Forest Research Center code
SPCD_HQ	Headquarters code, used in inventories
SP_TGRP	timber code, see Ong and Kleine (1995), p.20
SP_GRP	unknown grouping
SP_IN	increment grouping according to Ong and Kleine (1995)
F3	grouping in FORMIX3
SP_VO	grouping for volume in Canadian inventory
SP_HT	grouping for height in Canadian inventory
SPC_GRP	Reinhold's grouping, mixture of SP_GRP, SP_VOL_EQ and expert knowledge
HMAX1	maximum height [m] due to literature studies
H4_1	height grouping of HMAX1 with Busch(1), klein(2), mittel(3), klein-mittel(2), klein-gross(3)
GIRTH	maximum girth [m] due to literature studies
DIA	calculated max. diameter [cm] from GIRTH
HMAX2	maximum height calculated from max. diameter and Reinhold's preliminary hd-curves
H4_2	height grouping of HMAX2
DIFF_H4	difference in HMAX1 and HMAX2
DENSITY	wood density [kg/m³] due to literature studies. This should be air dried wood.
HF4_N	height grouping of SPC_GRP due to max. height of hd-curve and FORMIX layers
LF4_MR	light demanding grouping of Masirum Rundi
LF4	final light demanding grouping, where unknown in LF4_MR grouped according to height (h<=15m (3), h>15m(2))
HF4	final height grouping where HF4_N is corrected for small (h<=25m) growing trees with H4_1 and H4_2 (first one dominates)
F4	final FORMIX4 grouping
C_SPHQ	counts the number of species in SPCD_HQ
DERA	tree number of this SPCD_HQ in Deramakot inventory
DERA_W	Deramakot inventory weighted with COUNT_SPHQ
DERA_%	relative species share at Deramakot inventory
D_MIN	minimum diameter of trees occuring in Deramakot inventory
D_MAX	maximum diameter of trees occuring in Deramakot inventory
FREQ	frequency of occurrence due to literature studies with: often(3), medium(2), rare(1)
SOURCE	literature source with: 1=Tree Flora of Malaya 2=Timbers of Sabah 3=Dipterocarps of Sabah 4=Trees of Sabah 5=Preferred Check-list 6=Horn et al (1993) 7=PROSEA 5,2 (1994) 8=Keating et al (1982) 9=PROSEA 5,1 (1994)

SP_NAME	SP_LOCAL	SPC_CODE	SPCD_HQ	SP_TGRP	SP_GRP	SP_IN	F3	SP_VO	SP_HT	SPC_GRP	HMAX1	H4_1	GIRTH
Acronychia sp.	Limau hutan	ACRO	OTH	OTHR	13	14	1	15	15	15		0	1.4
Actinodaphne glomerata	Medang serai	ACGL	MDS	NDLH	11	19	1	9	9	9	18	3	
Adenanthera pavonia	Saga	SAGA	OTH	OTHR	13	14	1	15	15	15	30.5	0	
Adina trichotoma	Mengkeniab	ADTR	MGB	NDLH	13	14	1	15	15	15	20	3	
Adinandra dumosa	Bawing	BAWI	BW	NDLH	13	16	2	15	15	15	20	3	
Afzelia borneensis	Ipil darat	IDRT	IPD	NDMH	13	19	1	8	8	15	25	3	2.4
Agathis dammara	Mengilan	AGDA	MGL	NDLH	11	15	1	14	14	14	48.8	0	5.2
Aglaia argentea	Koping-koping	AGAR	KOP	NDLH	13	14	1	8	8	15	30	0	1.1
Aglaia cordata	Kalambio	AGCO	OTH	OTHR	13	14	1	15	15	15	10	2	0.3
Aglaia elliptica	Lantupak jambu	AGEL	OTH	OTHR	13	14	1	15	15	15	20	3	0.15
Aglaia sp.	Langsat-langsat	AGOD	LLS	NDLH	13	14	1	15	15	15	klein	2	0.7
Ailanthus integrifolia	Tree of heaven	AIIN	TOH	OTHR	13	14	1	15	15	15	24	3	
Alangium sp.	Kondolon	KOND	KON	NDLH	13	14	1	15	15	15	12.2	2	1.2
Albizzia sp.	Batai	BTAI	BTI	NDLH	11	15	1	15	15	15	klein-mittel	2	0,9 - 2,4
Aleurites moluccana	Kamiri	KMRI	KMR	NDLH	13	14	1	15	15	15	1.2	2	
Alphitonia incana	Pakudita	PAKU	PAK	OTHR	13	14	1	15	15	15	mitte l	3	
Alstonia macrophylla	Pulai daun besar	ALMA	OTH	NDLH	13	13	3	15	15	8	30	0	2.1
Alstonia sp.	Pulai	PULA	PUL	NDLH	11	13	3	8	8	8		0	2.4
Amoora rubiginosa	Lantupak paya	AMRU	OTH	OTHR	13	14	1	15	15	15	35	0	
Anacardiaceae family	Rengas	RENG	RGS	NDMH	11	19	1	8	8	8		0	0,6+
Angelesia splendens	Tampaluan	TAMP	OTH	OTHR	13	14	1	15	15	15	15	2	
Anisophyllea disticha	Payung-payung	ANDI	OTH	OTHR	13	14	1	15	15	15	7	2	
Anisoptera costata	Pengiran kesat	PKST	PS	DLH	10	2	1	2	2	2	60	0	4.5
Anisoptera grossivenia	Pengiran kunyit	PKUN	PY	DLH	10	2	1	2	2	2	45	0	
Anisoptera laevis	Pengiran durian	PDUR	PD	DLH	10	2	1	2	2	2	60	0	
Anisoptera marginata	Pengiran kerangas	PKER	PK	DLH	10	2	1	2	2	2	30-50	0	
Anisoptera reticulata	Pengiran gajah	PGAJ	PJ	DLH	10	2	1	2	2	2	groß	0	
Anisoptera sp.	Pengiran	PENG	PG	DLH	10	2	1	2	2	2	groß	0	
Anonaceae family	Karai	PGPG	KRY	NDLH	11	14	1	8	8	8	30	0	1.8
Anonaceae family	Pisang-pisang	PGPG	PIS	NDMH	11	14	1	8	8	8	?	0	
Anthocephalus chinensis	Laran	LARA	LRN	PION	12	13	3	14	14	14		0	1.5
Anthoshorea group of Shorea	Melapi	MELA	MP	DLH	3	2	1	2	2	2	50-60	0	3
Antidesma ghasemblica	Tandoropis	ANGH	OTH	NDLH	13	14	1	15	15	15	6	2	0.9
Antidesma sp.	Gerusih	ANTI	OTH	OTHR	13	14	1	15	15	15	6	2	
Apocynaneae family	Jelutong	JELU	JLT	NDLH	11	15	1	8	8	8	1,5 bis 30	0	bis 3
Aporusa grandistipulata	Galang-galang	APGR	GLG	OTHR	13	14	1	15	15	15	klein	2	
Aporusa nitida	Bagil	APOL	BGL	OTHR	13	14	1	15	15	15	7	2	
Aporusa sp.	Penatan	APEL	PTN	OTHR	13	14	1	15	15	15	20	3	
Aquilaria malaccensis	Gaharu	GAHA	GH	NDLH	11	12	4	15	15	15	36	0	1.8
Archidendron	Patai keryong	PATA	PATA	OTHR	13	14	1	15	15	15	?	0	
Ardisia sp.	Serusop	ARDI	OTH	OTHR	13	14	1	15	15	15	8	2	1
Aromadendron sp.	Kepayang ambok	ARNU	KAP	DMH	13	14	1	15	15	15	20	3	
Artocarpus anisophyllus	Terap ikal	ARAN	TRI	OTHR	11	14	1	15	15	15	30	0	1.8
Artocarpus elasticus	Terap togop	AREL	TRO	NDLH	11	15	1	15	15	15	45	0	2.1
Artocarpus sp.	Terap	TRAP	TRP	NDLH	11	15	1	15	15	15	24	3	1.5

SP_NAME	DIA	HMAX2	H4_2	DIFF_H4	DENSITY	HF4_CAN	HF4_N	LF4_MR	LF4	HF4	F4	C_SPHQ	DERA	DERA_W	DERA_%	D_MIN	D_MAX	FREQ	SOURCE
Acronychia sp.	44.56	20.75	3	0		2	4	4	2	3	6	89	21805	245	0.1131	10	145		1
Actinodaphne glomerata	0.00	0.00	0	0		2	4	4	2	3	6	2	0	0	0.0000	0	0		1
Adenanthera pavonia	0.00	0.00	0	0	960	2	4	4	2	4	9	89	21805	245	0.1131	10	145		1,2
Adina trichotoma	0.00	0.00	0	0	897.1	2	4	4	2	3	6	1	0	0	0.0000	0	0		1,2
Adinandra dumosa	0.00	0.00	0	0	610	2	4	1	1	3	5	1	3350	3350	1.5459	11	34	3	1,6
Afzelia borneensis	76.39	26.06	0	0	880	2	4	3	3	3	7	1	0	0	0.0000	0	0	2	2,4
Agathis dammara	165.52	0.00	0	0	465	4	5	4	2	5	12	2	4	2	0.0009	51	51	2	1,6
Aglaia argentea	35.01	18.26	3	0	853	2	4	4	2	3	6	1	0	0	0.0000	0	0	3	1,8
Aglaia cordata	9.55	9.59	2	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		1
Aglaia elliptica	4.77	7.64	2	1		2	4	4	2	2	3	89	21805	245	0.1131	10	145		1
Aglaia sp.	22.28	14.30	2	0	800	2	4	4	2	2	3	1	300	300	0.1384	10	13		2
Ailanthus integrifolia	0.00	0.00	0	0	370	2	4	4	2	3	6	1	0	0	0.0000	0	0		1,7
Alangium sp.	38.20	19.14	3	1	752.9	2	4	4	2	2	3	1	329	329	0.1518	10	37	1	2
Albizzia sp.		0.00	0	0	480	2	4	4	2	2	3	1	37	37	0.0171	32	88		2
Aleurites moluccana	0.00	0.00	0	0	309.9	2	4	4	2	1	1	2	29	15	0.0067	30	51	3	2
Alphitonia incana	0.00	0.00	0	0		2	4	4	2	3	6	1	0	0	0.0000	0	0		5
Alstonia macrophylla	66.85	38.23	0	0		4	5	1	1	4	8	89	21805	245	0.1131	10	145	3	1
Alstonia sp.	76.39	40.31	0	0	432.5	4	5	2	2	5	12	1	632	632	0.2916	13	107	2	2
Amoora rubiginosa	0.00	0.00	0	0	928	2	4	4	2	4	9	89	21805	245	0.1131	10	145		1,2
Anacardiaceae family		0.00	0	0	801	4	5	2	2	5	12	1	2263	2263	1.0443	10	130	1	2
Angelesia splendens	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145	3	1
Anisophyllea disticha	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145	3	1
Anisoptera costata	143.24	0.00	0	0	624	3	5	2	2	5	12	1	8	8	0.0037	70	82	2	2,3
Anisoptera grossivenia	0.00	0.00	0	0	729	3	5	2	2	5	12	1	0	0	0.0000	0	0		2,3
Anisoptera laevis	0.00	0.00	0	0	600	3	5	2	2	5	12	1	0	0	0.0000	0	0		2,3
Anisoptera marginata	0.00	0.00	0	0	639	3	5	2	2	5	12	1	0	0	0.0000	0	0	1	2,3
Anisoptera reticulata	0.00	0.00	0	0		3	5	2	2	5	12	1	0	0	0.0000	0	0		5
Anisoptera sp.	0.00	0.00	0	0		3	5	2	2	5	12	1	8	8	0.0037	81	94		5
Anonaceae family	57.30	35.39	0	0	400-800	4	5	1	1	4	8	1	233	233	0.1075	11	39	3	1,2
Anonaceae family	0.00	0.00	0	0		4	5	1	1	4	8	1	2852	2852	1.3161	10	67		1
Anthocephalus chinensis	47.75	35.49	0	0	416	4	5	1	1	4	8	1	3410	3410	1.5736	11	77	3	2
Anthoshorea group of Shorea	95.49	36.51	0	0		3	5	2	2	5	12	1	1156	1156	0.5335	10	95	3	3
Antidesma ghasemblica	28.65	16.37	3	1	672	2	4	4	2	2	3	89	21805	245	0.1131	10	145	3	1,2
Antidesma sp.	0.00	0.00	0	0	600	2	4	4	3	2	4	89	21805	245	0.1131	10	145		1
Apocynaneae family		0.00	0	0	400-480	4	5	1	1	5	11	1	8	8	0.0037	43	59	3	1,2
Aporusa grandistipulata	0.00	0.00	0	0		2	4	4	3	2	4	1	0	0	0.0000	0	0		5
Aporusa nitida	0.00	0.00	0	0		2	4	4	3	2	4	1	300	300	0.1384	11	22		1
Aporusa sp.	0.00	0.00	0	0		2	4	2	2	3	6	1	479	479	0.2210	10	49		1
Aquilaria malaccensis	57.30	23.43	3	0		2	4	4	2	3	6	1	112	112	0.0517	22	45	3	1
Archidendron	0.00	0.00	0	0		2	4	4	2	4	9	1	0	0	0.0000	0	0		1
Ardisia sp.	31.83	17.34	3	1		2	4	4	3	2	4	89	21805	245	0.1131	10	145		1
Aromadendron sp.	0.00	0.00	0	0		2	4	4	2	3	6	1	4	4	0.0018	52	52		1
Artocarpus anisophyllus	57.30	23.43	3	0	739	2	4	4	2	3	6	1	25	25	0.0115	18	21	1	1,2
Artocarpus elasticus	66.85	24.95	3	0	490	2	4	1	1	3	5	1	29	29	0.0134	24	66	3	1,7
Artocarpus sp.	47.75	21.49	3	0	612	2	4	1	1	3	5	1	964	964	0.4449	10	86		1,8

SP_NAME	SP_LOCAL	SPC_CODE	SPCD_HQ	SP_TGRP	SP_GRP	SP_IN	F3	SP_VO	SP_HT	SPC_GRP	HMAX1	H4_1	GIRTH
Artocarpus sp.	Terap timadang	AROD	TRT	NDLH	11	15	1	15	15	15	15	2	0.3
Artocarpus tamaran	Timbangan	ARTA	TIMD	NDLH	11	15	1	15	15	15	mittel	3	
Azadirachta excelsa	Limpaga	LIMP	LM	NDLH	11	17	1	8	8	8	50	0	4
Baccaurea angulata	Belimbing hutan	BAAN	BBH	OTHR	13	14	1	15	15	15	15	2	0.45
Baccaurea lanceolata	Limpaung	BALA	OTH	OTHR	13	14	1	15	15	15	7	2	
Baccaurea sp.	Kunau-kunau	BACC	KNU	NDLH	13	14	1	15	15	15	klein-mittel	2	
Baccaurea sp.	Tampoi	BACC	TMP	NDLH	13	14	1	15	15	15	?	2	
Barringtonia sp.	Tampalang	TMPL	TNG	NDLH	13	14	1	15	15	15	7	2	
Berrya cordifolia	Mengkapang darat	BECO	OTH	OTHR	13	14	1	15	15	15	7	2	
Bischofia javanica	Tungou	TUAI	TUN	NDMH	13	19	1	15	15	15	45	0	4.5
Blumeodendron tokbrai	Gangulang	BLUM	CG	NDLH	13	14	1	15	15	15	21	3	0.9
Borneodendron enigmaticum	Bangkau-bangkau	BKAU	BB	NDMH	13	19	1	15	15	15	27	0	1.8
Breynia patens	Kubamban-kubamban	BRPA	OTH	OTHR	13	14	1	15	15	15	klein	2	
Bridelia glauca	Manik-manik/kutang	BRGL	OTH	OTHR	13	14	1	15	15	15	klein	2	
Bridelia stipularis	Balatotan	BRST	OTH	OTHR	13	14	1	15	15	15	6	2	
Brownlowia peltata	Pingau-pingau	BRPE	OTH	OTHR	13	14	1	15	15	15	mittel	3	
Bruinsmia stracoides	Tingo-tingo	BRST	OTH	OTHR	13	14	1	15	15	15	mittel	3	
Buchanania sp.	Kepala tundang	BUSE	KET	NDLH	13	14	1	9	9	15	27	0	1.2
Buchanania sp.	Kepala tundang t. pendek	BUAR	KPLT	NDLH	13	16	2	9	9	15	27	0	1.2
Burseraceae family	Kedondong	KDDG	KD	NDLH	11	16	2	10	10	10	25	3	
Callophyllum sp.	Bintangor	BINT	BIN	NDLH	11	13	3	8	8	9	32	0	1.2
Calophyllum inophyllum	Penaga laut	CAIN	PGI	NDMH	13	18	4	9	9	15	35	0	2
Campnosperma auriculta	Terentang	TERA	TRG	NDLH	11	15	1	15	15	15	33	0	1.2
Cananga odorata	Bunga gadong	CADD	BUG	OTHR	13	14	1	15	15	15	31	0	
Canarium decumanum	Pomotodon	POMO	POT	NDLH	11	15	1	10	10	15	55	0	4.6
Canarium odontophyllum	Kembayu	KBYU	KMY	NDLH	13	18	4	10	10	15	25	3	1.8
Carallia sp.	Meransi	MRSI	MRSI	NDLH	13	14	1	15	15	15	30	0	2.1
Cassia nodosa	Busuk-busuk	CANO	BSK	NDLH	13	14	1	15	15	15	25	3	1.8
Castanopsis	Berangan	BERA	BER	NDMH	11	20	1	9	9	9	25	3	1.6
Casuarina equisetifolia	Aru	ARUX	ARU	NDHH	13	19	1	14	14	14	50	0	3
Celastraceae family	Perupok	PERU	PEP	NDLH	11	20	1	9	9	8	27	0	1.5
Cerbera odollom	Burung gagak	CEOD	OTH	OTHR	13	14	1	15	15	15	7	2	
Chaetocarpus castanocarpus	Kayu dusun	CHAE	KAY	NDMH	13	20	1	15	15	15	12	2	0.6
Chisocheton beccarianus	Lisi-lisi	CHBE	OTH	OTHR	13	14	1	15	15	15		0	0.9
Chisocheton glomeratus	Berindu	CHGL	BDU	OTHR	13	14	1	15	15	15		0	0.9
Cleistanthus paxii	Garu-garu	CLPA	OTH	OTHR	13	14	1	15	15	15	klein	2	
Cleistanthus sp.	Baubo	CLEI	BBO	OTHR	13	14	1	15	15	15	?	0	
Combretocarpus rotundatus	Perapat paya	CORO	PPP	NDMH	13	18	4	15	15	15	25	3	2.4
Cordia dichotoma	Guma	CODI	OTH	OTHR	13	14	1	15	15	15	13	2	1.9
Cordia subcordata	Agutud	COSU	OTH	OTHR	13	14	1	15	15	15	15	2	1.5
Cotylelobium melanoxylon	Resak temporong	RETP	RBG	DHH	9	7	2	3	3	3	38	0	
Crateva religiosa	Pangos	CRRE	OTH	OTHR	13	14	1	15	15	15	6	2	
Cratoxylon arborescens	Serungan	SERU	SERU	NDLH	12	13	3	15	15	9	42	0	0.2
Cratoxylon sp.	Geronggang	GERO	SG	NDLH	11	18	4	9	9	9	10	2	
Croton caudatus	Angguk-angguk	CRCA	OTH	OTHR	13	14	1	15	15	15	9	2	

SP_NAME	DIA	HMAX2	H4_2	DIFF_H4	DENSITY	HF4_CAN	HF4_N	LF4_MR	LF4	HF4	F4	C_SPHQ	DERA	DERA_W	DERA_%	D_MIN	D_MAX	FREQ	SOURCE
Artocarpus sp.	9.55	9.59	2	0		2	4	4	2	2	3	1	0	0	0.0000	0	0		1
Artocarpus tamaran	0.00	0.00	0	0		2	4	4	2	3	6	1	0	0	0.0000	0	0		5
Azadirachta excelsa	127.32	0.00	0	0	600	4	5	2	2	5	12	1	4	4	0.0018	79	82		1,2
Baccaurea angulata	14.32	11.44	2	0		2	4	4	3	2	4	1	150	150	0.0692	10	31		2
Baccaurea lanceolata	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145	3	1,2
Baccaurea sp.	0.00	0.00	0	0		2	4	3	3	2	4	1	750	750	0.3461	10	31		1,2
Baccaurea sp.	0.00	0.00	0	0		2	4	3	3	2	4	1	1165	1165	0.5376	12	59		1
Barringtonia sp.	0.00	0.00	0	0	480-720	2	4	2	2	2	3	1	1466	1466	0.6765	12	50		1,2
Berrya cordifolia	0.00	0.00	0	0	960	2	4	4	3	2	4	89	21805	245	0.1131	10	145	1	1,8
Bischofia javanica	143.24	0.00	0	0	768	2	4	4	2	4	9	1	0	0	0.0000	0	0	3	1
Blumeodendron tokbrai	28.65	16.37	3	0	678	2	4	4	2	3	6	1	4	4	0.0018	48	48	3	1
Borneodendron enigmaticum	57.30	23.43	3	0	860	2	4	4	2	3	6	1	0	0	0.0000	0	0	3	2
Breynia patens	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		5
Bridelia glauca	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		5
Bridelia stipularis	0.00	0.00	0	0		2	4	4	2	3	6	89	21805	245	0.1131	10	145	2	1
Brownlowia peltata	0.00	0.00	0	0		2	4	4	2	3	6	89	21805	245	0.1131	10	145		5
Bruinsmia stracoides	0.00	0.00	0	0		2	4	4	2	3	6	89	21805	245	0.1131	10	145		5
Buchanania sp.	38.20	19.14	3	0	559	2	4	4	2	3	6	1	0	0	0.0000	0	0	3	1,2
Buchanania sp.	38.20	19.14	3	0	559	2	4	4	2	3	6	1	100	100	0.0461	11	11	3	1,2
Burseraceae family	0.00	0.00	0	0		3	4	2	2	3	6	1	2511	2511	1.1587	10	114	3	1
Callophyllum sp.	38.20	19.31	3	0	682	2	4	1	1	3	5	1	1214	1214	0.5602	10	68	3	1,8
Calophyllum inophyllum	63.66	24.49	3	0	690	2	4	4	2	3	6	1	0	0	0.0000	0	0	2	1
Campnosperma auriculta	38.20	19.14	3	0	432	2	4	1	1	3	5	1	104	104	0.0480	15	84	3	1,2
Cananga odorata	0.00	0.00	0	0	382	2	4	4	2	4	9	1	0	0	0.0000	0	0	3	1,8
Canarium decumanum	146.42	0.00	0	0	512	2	4	4	2	4	9	1	25	25	0.0115	29	26	1	1,2
Canarium odontophyllum	57.30	23.43	3	0	608	2	4	4	2	3	6	1	0	0	0.0000	0	0		2
Carallia sp.	66.85	24.95	3	0	848	2	4	4	2	3	6	1	12	12	0.0055	47	55	2	1
Cassia nodosa	57.30	23.43	3	0		2	4	4	2	3	6	1	4	4	0.0018	49	49	3	1
Castanopsis	50.93	22.82	3	0	688	2	4	4	2	3	6	1	290	290	0.1338	15	59		1
Casuarina equisetifolia	95.49	0.00	0	0	1010	4	5	4	3	5	13	1	0	0	0.0000	0	0	3	1,2
Celastraceae family	47.75	31.80	0	0	801	4	5	2	2	4	9	1	678	678	0.3129	15	61	3	1,2
Cerbera odollom	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		1
Chaetocarpus castanocarpus	19.10	13.19	2	0	1000	2	4	4	3	2	4	1	0	0	0.0000	0	0	3	1
Chisocheton beccarianus	28.65	16.37	3	0	560	2	4	4	2	3	6	89	21805	245	0.1131	10	145		2
Chisocheton glomeratus	28.65	16.37	3	0	560	2	4	4	2	3	6	1	100	100	0.0461	13	13		2
Cleistanthus paxii	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		5
Cleistanthus sp.	0.00	0.00	0	0		2	4	4	2	4	9	1	54	54	0.0249	21	40		1
Combretocarpus rotundatus	76.39	26.06	0	0	750	2	4	4	2	3	6	1	54	54	0.0249	24	52	1.2	1
Cordia dichotoma	60.48	23.98	3	1	479	2	4	4	3	2	4	89	21805	245	0.1131	10	145	1	1,2
Cordia subcordata	47.75	21.49	3	1	560	2	4	4	3	2	4	89	21805	245	0.1131	10	145	2	1,2
Cotylelobium melanoxylon	0.00	0.00	0	0	987	5	5	4	3	5	13	1	0	0	0.0000	0	0	3	2
Crateva religiosa	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145	1	1
Cratoxylon arborescens	6.37	7.88	2	0	469	2	4	1	1	2	2	1	0	0	0.0000	0	0	3	1,2
Cratoxylon sp.	0.00	0.00	0	0	480	2	4	4	2	2	3	1	125	125	0.0577	18	22		2,8
Croton caudatus	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145	2	1

SP_NAME	SP_LOCAL	SPC_CODE	SPCD_HQ	SP_TGRP	SP_GRP	SP_IN	F3	SP_VO	SP_HT	SPC_GRP	HMAX1	H4_1	GIRTH
Croton heterocarpus	Bendak	CRHE	OTH	OTHR	13	14	1	15	15	15	12	2	
Croton oblongus	Lokon	CROT	OTH	OTHR	13	14	1	15	15	15	klein	2	
Croton sp.	Croton	CROT	OTH	OTHR	13	14	1	15	15	15	klein	2	
Crudia reticulata	Anggar-anggar	CRUD	OTH	NDLH	13	14	1	9	9	15	klein	2	
Crypteronia griffithii	Rambai-rambai	CRGR	KAM	DMH	13	14	1	15	15	15	45	0	2.7
Crypteronia griffithii	Rambai-rambai	CRGR	RAM	OTHR	13	14	1	15	15	15	45	0	2.7
Ctenolophon parvifolius	Besi-besi	CTPA	BSI	NDLH	13	14	1	15	15	15	klein-groß	3	
Cynometra sp.	Katong-katong	KATO	KAT	NDHH	11	14	1	8	8	8	klein-mittel	2	
Dacrydium elatum	Sempilor	SPLR	SPL	NDMH	11	14	1	14	14	14	37	0	2.4
Dactylocladus stenostachys	Jongkong	JONG	J	NDLH	11	18	4	15	15	15		0	3.7
Dehassia incrassata	Medang sisek	DEIN	MDK	NDLH	11	19	1	9	9	9	24	3	0.15
Dialium sp.	Keranji	KRNJ	KJ	NDHH	11	10	1	9	9	9	groß	0	
Dillenia borneensis	Simpor gajah	SIMG	SIG	NDMH	11	19	1	15	15	15	36.5	0	2.1
Dillenia sp.	Simpor	SIMP	SIM	NDLH	11	19	1	15	15	15	20-38	0	1-2,8
Dimocarpus longan	Mata kuching	MKUC	MAT	DMH	13	14	1	15	15	9	mittel	3	
Dimorphocalyx muriana	Obah puteh	DIMU	DIMU	OTHR	13	14	1	15	15	9	12	2	
Diospyros durionoides	Sabah ebony	SEBY	SEB	NDHH	11	19	1	8	8	15		0	2.7
Diospyros sp.	Kayu malam	KMLM	KMM	NDMH	11	19	1	8	8	8	klein-mittel	2	klein-mittel
Dipterocarpus applanatus	Keruing daun besar	KDBR	KDB	DMH	6	4	1	5	5	5	31	0	
Dipterocarpus caudatus	Keruing gasing	KGAS	KGS	DMH	6	4	1	5	5	5	groß	0	
Dipterocarpus confertus	Keruing kobis	KKOB	KKO	DMH	6	4	1	5	5	5	46	0	5.5
Dipterocarpus conformis	Keruing beludu kuning	KBKU	KBK	DMH	6	4	1	5	5	5	groß	0	
Dipterocarpus costulatus	Keruing kipas	KKIP	KEK	DMH	6	4	1	5	5	5	37	0	
Dipterocarpus coudiferus	Keruing putih	KPUT	KPT	DMH	6	4	1	5	5	5	groß	0	
Dipterocarpus crinitus	Keruing mempelas	KMEM	KMP	DMH	6	4	1	5	5	5	groß	0	
Dipterocarpus exalatus	Keruing rapak	KRAP	KRP	DMH	6	4	1	5	5	5	37	0	2.8
Dipterocarpus geniculatus	Keruing tangkai panjang	KTPJ	KTP	DMH	6	4	1	5	5	5	mittel	3	
Dipterocarpus globosus	Keruing buah bulat	KBBT	KBB	DMH	6	4	1	5	5	5	37	0	
Dipterocarpus gracilis	Keruing kesat	KKES	KKS	DMH	6	4	1	5	5	5	groß	0	
Dipterocarpus grandiflorus	Keruing belimbing	KBEL	KB	DMH	6	4	1	5	5	5	42	0	4.3
Dipterocarpus hasseltii	Keruing kerukap kecil	KKKL	KKK	DMH	6	4	1	5	5	5	groß	0	
Dipterocarpus humeratus	Keruing kerukup	KKUK	KKU	DMH	6	4	1	5	5	5	46	0	2.75
Dipterocarpus kerri	Keruing gondol	KGON	KGD	DMH	6	4	1	5	5	5	groß	0	
Dipterocarpus lamellatus	Keruing jarang	KJAR	KEJ	DMH	6	4	1	5	5	5	55	0	
Dipterocarpus lowii	Keruing shol	KSHO	KS	DMH	6	4	1	5	5	5	55	0	3.1
Dipterocarpus oblongifolius	Keruing neram	KNER	KN	DMH	6	4	1	5	5	5	klein	2	dünn
Dipterocarpus ochranceus	Keruing ranau	KRAN	KRN	DMH	6	4	1	5	5	5	mittel	3	
Dipterocarpus palembanicus	Keruing palembang	KPAL	KPD	DMH	6	4	1	5	5	5	42	0	
Dipterocarpus sp	Keruing	KERU	KR	DMH	6	4	1	5	5	5	mittel-groß	0	
Dipterocarpus stellatus	Keruing bulu	KBUL	KBU	DMH	6	4	1	5	5	5	groß	0	
Dipterocarpus tempehes	Keruing asam	KASM	KA	DMH	6	4	1	5	5	5	36	0	
Dipterocarpus verrucosus	Keruing merah	KMRH	KMR	DMH	6	4	1	5	5	5	61	0	3.7
Dipterocarpus warburgii	Keruing kasugoi	KKAS	KK	DMH	6	4	1	5	5	5	31	0	
Dolichandrone spathacea	Tui	TUIX	OTH	OTHR	13	14	1	15	15	15	24	3	
Dracrontomelon sp.	Sengkuang/soronsob	SENG	SGK	NDLH	13	18	4	15	15	15	36	0	1.5

SP_NAME	DIA	HMAX2	H4_2	DIFF_H4	DENSITY	HF4_CAN	HF4_N	LF4_MR	LF4	HF4	F4	C_SPHQ	DERA	DERA_W	DERA_%	D_MIN	D_MAX	FREQ	SOURCE
Croton heterocarpus	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145	2	1
Croton oblongus	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		5
Croton sp.	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		5
Crudia reticulata	0.00	0.00	0	0		2	4	4	2	2	3	89	21805	245	0.1131	10	145		5
Crypteronia griffithii	85.94	26.75	0	0		2	4	4	2	4	9	1	4	4	0.0018	64	64	2	1
Crypteronia griffithii	85.94	26.75	0	0		2	4	4	2	4	9	1	0	0	0.0000	0	0	2	1
Ctenolophon parvifolius	0.00	0.00	0	0		2	4	4	2	3	6	1	0	0	0.0000	0	0		1
Cynometra sp.	0.00	0.00	0	0	1075	4	5	3	3	2	4	1	187	187	0.0863	12	67		5,8
Dacrydium elatum	76.39	42.68	0	0	570	4	5	4	2	5	12	1	0	0	0.0000	0	0	3	1,2
Dactylocladus stenostachys	117.77	0.00	0	0	528	2	4	1	1	4	8	1	0	0	0.0000	0	0	1	2
Dehassia incrassata	4.77	7.21	2	1	612	2	4	4	2	2	3	1	0	0	0.0000	0	0	2	1,8
Dialium sp.	0.00	0.00	0	0	1020	2	4	4	3	4	10	1	380	380	0.1754	17	82		5,8
Dillenia borneensis	66.85	24.95	3	0		2	4	1	1	3	5	1	108	108	0.0498	10	50		1
Dillenia sp.		0.00	0	0	590-860	2	4	2	2	4	9	1	1528	1528	0.7051	10	53	3	2
Dimocarpus longan	0.00	0.00	0	0	960	2	4	2	2	3	6	1	483	483	0.2229	12	42		1,8
Dimorphocalyx muriana	0.00	0.00	0	0		2	4	4	3	2	4	1	0	0	0.0000	0	0		1
Diospyros durionoides	85.94	26.75	0	0	958	2	4	4	3	4	10	1	4	4	0.0018	47	47	3	2
Diospyros sp.		0.00	0	0	540-960	4	5	2	2	2	3	1	4256	4256	1.9640	10	107	1 bis 3	2
Dipterocarpus applanatus	0.00	0.00	0	0	675	4	5	2	2	4	9	1	344	344	0.1587	10	92	3	2
Dipterocarpus caudatus	0.00	0.00	0	0		4	5	4	2	5	12	1	0	0	0.0000	0	0		5
Dipterocarpus confertus	175.07	0.00	0	0	802	4	5	2	2	5	12	1	132	132	0.0609	24	112	3	2
Dipterocarpus conformis	0.00	0.00	0	0		4	5	2	2	5	12	1	100	100	0.0461	11	11	1	2
Dipterocarpus costulatus	0.00	0.00	0	0		4	5	2	2	5	12	1	4	4	0.0018	49	49		3
Dipterocarpus coudiferus	0.00	0.00	0	0	670	4	5	2	2	5	12	1	1343	1343	0.6197	10	142	3	2
Dipterocarpus crinitus	0.00	0.00	0	0	925	4	5	2	2	5	12	1	0	0	0.0000	0	0	2	2,6
Dipterocarpus exalatus	89.13	41.20	0	0	666	4	5	2	2	5	12	1	8	8	0.0037	75	77	3	2
Dipterocarpus geniculatus	0.00	0.00	0	0	758	4	5	2	2	3	6	1	0	0	0.0000	0	0	3	2
Dipterocarpus globosus	0.00	0.00	0	0	872	4	5	2	2	5	12	1	100	100	0.0461	17	20	1	2
Dipterocarpus gracilis	0.00	0.00	0	0	755	4	5	4	2	5	12	1	36	36	0.0166	41	87	2	2
Dipterocarpus grandiflorus	136.87	0.00	0	0	790	4	5	2	2	5	12	1	57	57	0.0263	25	80		2
Dipterocarpus hasseltii	0.00	0.00	0	0	790	4	5	2	2	5	12	1	0	0	0.0000	0	0	2	3,9
Dipterocarpus humeratus	87.54	41.14	0	0	765	4	5	4	2	5	12	1	74	74	0.0341	32	72	3	2
Dipterocarpus kerri	0.00	0.00	0	0	735	4	5	4	2	5	12	1	89	89	0.0411	24	83	1	2,6
Dipterocarpus lamellatus	0.00	0.00	0	0	925	4	5	2	2	5	12	1	0	0	0.0000	0	0	1	2
Dipterocarpus lowii	98.68	0.00	0	0	866	4	5	2	2	5	12	1	0	0	0.0000	0	0	3	2
Dipterocarpus oblongifolius		0.00	0	0	654	4	5	2	2	2	3	1	0	0	0.0000	0	0	3	2
Dipterocarpus ochranceus	0.00	0.00	0	0	766	4	5	2	2	3	6	1	25	25	0.0115	33	36	3	2
Dipterocarpus palembanicus	0.00	0.00	0	0	678	4	5	2	2	5	12	1	4	4	0.0018	54	54	2	2
Dipterocarpus sp	0.00	0.00	0	0	815	4	5	2	2	5	12	1	2571	2571	1.1864	10	140		2,8
Dipterocarpus stellatus	0.00	0.00	0	0	817	4	5	2	2	5	12	1	112	112	0.0517	11	87	2	2
Dipterocarpus tempehes	0.00	0.00	0	0	642	4	5	2	2	4	9	1	8	8	0.0037	61	67	2	2
Dipterocarpus verrucosus	117.77	0.00	0	0	731	4	5	4	2	5	12	2	29	15	0.0067	30	51	2	2
Dipterocarpus warburgii	0.00	0.00	0	0	658	4	5	2	2	4	9	1	0	0	0.0000	0	0	2	2
Dolichandrone spathacea	0.00	0.00	0	0		2	4	4	2	3	6	89	21805	245	0.1131	10	145		1
Dracrontomelon sp.	47.75	21.49	3	0	600	2	4	4	2	3	6	1	0	0	0.0000	0	0	3	1,2

SP_NAME	SP_LOCAL	SPC_CODE	SPCD_HQ	SP_TGRP	SP_GRP	SP_IN	F3	SP_VO	SP_HT	SPC_GRP	HMAX1	H4_1	GIRTH
Dryobalaonops beccarii	Kapur merah (minyak)	KPMH	KPM	DMH	5	5	1	4	4	4	61	0	3
Dryobalaonops keithii	Kapur gumpait	KPGM	KG	DMH	5	5	1	4	4	4	36.6	0	2.1
Dryobalaonops lanceolata	Kapur paji	KPJI	KPG	DMH	5	5	1	4	4	4	76	0	4.6
Dryobalaonops rapa	Kapur paya	KPYA	KY	DMH	5	5	1	4	4	4	37	0	2.1
Drypetes microphylla	Odopan putih	DRMA	ODP	NDLH	13	14	1	15	15	15	klein-mittel	2	
Duabanga moluccana	Magas	MAGA	MAG	PION	12	13	3	15	15	14		0	2.1
Durio graveolens	Durian merah	DUGR	DUGR	NDLH	11	17	1	8	8	8	46	0	3.1
Durio sp.	Durian	DURI	DRN	NDLH	11	17	1	8	8	8	21 bis 46	0	1.1-2.7
Dyera costulata	Jelutong bukit	DYCO	JLB	NDLH	11	15	1	8	8	8	60	0	7.8
Dyera polyphylla	Jelutong paya	DYPO	JLP	NDLH	11	15	1	8	8	8	mittel	3	
Elaeocarpus sp.	Tonop	ELST	KUK	NDLH	11	16	2	15	15	15	?	0	
Elaeocarpus sp.	Kungkurad	ELAE	KUL	NDMH	11	16	2	15	15	15	klein-mittel	2	klein
Elaeocarpus sp.	Kulibobok	ELAE	TNP	NDLH	12	14	1	15	15	15	?	2	
Elateriospermum tapos	Perah ikan	ELAT	PEI	NDLH	11	14	1	15	15	15		0	1.8
Endospermum sp.	Sendok-sendok	SEND	SSB	NDLH	11	16	2	15	15	15	40	0	
Ervatamia sp.	Burut-burut	ERMA	OTH	NDLH	13	14	1	15	15	15		0	
Erythrina variegata	Dadap	ERVA	DDP	NDLH	13	14	1	15	15	15	15	2	
Erythroxylum cuneatum	Perepat burung	PEBR	PB	NDMH	11	19	1	15	15	15	46	0	1.6
Eugenia sp.	Obah	OBAH	OB	NDMH	11	12	4	9	9	9	27	0	1.2 -1.8
Euodia sp.	Pau-pau	OTHR	PAU	OTHR	13	14	1	15	15	15	31	0	1.8
Eurycoma longifolia	Pahit-pahit (tongkat ali)	EULO	OTH	OTHR	13	14	1	15	15	15	10	2	
Eusideroxilon zwageri	Belian	BELI	B	NDHH	11	12	4	13	13	13		0	3.7
Eusideroxylon malagangai	Malangangai	MGAI	MA	NDHH	11	12	4	15	15	13	mittel-groß	0	1.8
Fagraea racemosa	Tadapon puak	FARA	OTH	OTHR	13	14	1	15	15	15	klein	2	
Fagraea sp.	Tadapon putih	TEMB	TM	NDHH	11	14	1	15	15	15	klein	3	
Fagraea sp.	Tambusu	TEMB	TPP	NDHH	13	14	1	15	15	15	mittel	3	
Ficus fulva	Togung korop	TAND	OTH	OTHR	13	14	1	15	15	15	18	3	
Ficus sp.	Jiwit	KRAH	ARA	OTHR	13	14	1	15	15	15	mittel-groß	0	
Ficus sp.	Ara	JIWT	OTH	OTHR	13	14	1	15	15	15	groß	0	
Flacourtia rukam	Rukam	RUKA	OTH	OTHR	13	14	1	15	15	15	12	2	
Ganua motleyana	Nyatoh katiau	GAMO	GAMO	OTHR	13	14	1	15	15	9	40	0	2.6
Garcinia forbesii	Bebata	GAFO	BBA	NDMH	13	19	1	15	15	15	18	3	0.3
Garcinia mangostana	Manggis	GAMA	GAMA	NDMH	11	19	1	15	20	15	klein	2	
Garcinia nervosa	Kandis daun besar	GARC	KAN	NDMH	11	20	1	15	15	15	21	3	0.3
Garcinia parvifolia	Kandis	KNDS	KNDS	NDMH	11	20	1	15	15	15	30	0	0.7
Geunsia pentandra	Tambung	TAMB	TAMB	OTHR	12	14	1	15	15	15	18	3	
Gironniera sp.	Ampas tebu	GINE	OTH	OTHR	13	14	1	15	15	15	klein	2	
Glochidion litorale	Saka-saka	GLLI	OTH	OTHR	13	14	1	15	15	15	Busch	1	
Glochidion sp.	Oba nasi	OBNA	ONA	NDLH	13	14	1	15	15	15	Büsche	1	
Glochidion superbum	Gerumong jantan	GLSU	OTH	OTHR	13	14	1	15	15	15	18	3	1.2
Gonystylus bancanus	Ramin	RAMN	R	NDLH	11	18	4	15	15	15	27	0	2.1
Gordonia sp.	Melulok	GORD	OTH	OTHR	13	14	1	15	15	15	bush & tree	1	
Guioa sp.	Tanggir manuk	GUIO	OTH	OTHR	13	14	1	15	15	15	klein	2	
Gymnacranthera contracta	Lunau	GYCO	OTH	OTHR	13	14	1	15	15	15	18	3	0.8
Helicia sp.	Kurunggu	KGGU	KRGU	NDLH	13	14	1	15	15	15	bush & tree	1	

SP_NAME	DIA	HMAX2	H4_2	DIFF_H4	DENSITY	HF4_CAN	HF4_N	LF4_MR	LF4	HF4	F4	C_SPHQ	DERA	DERA_W	DERA_%	D_MIN	D_MAX	FREQ	SOURCE
Dryobalaonops beccarii	95.49	49.29	0	0	731	5	5	4	2	5	12	1	1467	1467	0.6770	11	165	1	2
Dryobalaonops keithii	66.85	43.74	0	0	778	5	5	2	2	5	12	1	767	767	0.3539	11	114	1	2
Dryobalaonops lanceolata	146.42	0.00	0	0	736	5	5	2	2	5	12	2	2561	1281	0.5909	10	131	2	2
Dryobalaonops rapa	66.85	43.74	0	0	752	5	5	2	2	5	12	1	0	0	0.0000	0	0	1	2
Drypetes microphylla	0.00	0.00	0	0		2	4	2	2	2	3	1	454	454	0.2095	11	38	1	1
Duabanga moluccana	66.85	41.73	0	0	400	4	5	1	1	5	11	1	623	623	0.2875	11	107		2
Durio graveolens	98.68	0.00	0	0		4	5	2	2	5	12	1	0	0	0.0000	0	0		1
Durio sp.		0.00	0	0	640	4	5	2	2	5	12	1	347	347	0.1601	15	82	1	1,2
Dyera costulata	248.28	0.00	0	0	465	4	5	4	2	5	12	1	4	4	0.0018	80	80	2	1,2
Dyera polyphylla	0.00	0.00	0	0		4	5	4	2	3	6	1	0	0	0.0000	0	0		5
Elaeocarpus sp.	0.00	0.00	0	0		2	4	4	2	4	9	1	308	308	0.1421	16	44		1
Elaeocarpus sp.		0.00	0	0	530-720	2	4	4	2	2	3	1	200	200	0.0923	11	13	1	1
Elaeocarpus sp.	0.00	0.00	0	0	382	2	4	4	2	2	3	1	0	0	0.0000	0	0		1,8
Elateriospermum tapos	57.30	23.43	3	0	840	2	4	4	2	3	6	1	0	0	0.0000	0	0	1	2
Endospermum sp.	0.00	0.00	0	0		2	4	1	1	4	8	1	1177	1177	0.5431	12	82	3	1
Ervatamia sp.	0.00	0.00	0	0		2	4	4	2	4	9	89	21805	245	0.1131	10	145	1	1
Erythrina variegata	0.00	0.00	0	0		2	4	4	2	2	3	1	0	0	0.0000	0	0	3	1
Erythroxylum cuneatum	50.93	22.18	3	0	848	2	4	4	2	3	6	1	0	0	0.0000	0	0		2
Eugenia sp.		0.00	0	0	600-1000	2	4	4	2	4	9	1	6081	6081	2.8062	10	128	3	1,2
Euodia sp.	57.30	23.43	3	0		2	4	4	2	3	6	1	1957	1957	0.9031	10	62	2	1
Eurycoma longifolia	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		1
Eusideroxilon zwageri	117.77	0.00	0	0	1038	2	4	3	3	4	10	1	985	985	0.4545	11	107	3	2
Eusideroxylon malagangai	57.30	24.21	3	0	685	2	4	4	3	3	7	1	0	0	0.0000	0	0		2
Fagraea racemosa	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145	3	1
Fagraea sp.	0.00	0.00	0	0		2	4	4	3	3	7	1	0	0	0.0000	0	0		5
Fagraea sp.	0.00	0.00	0	0		2	4	4	3	3	7	1	4	4	0.0018	67	67		5
Ficus fulva	0.00	0.00	0	0		2	4	4	2	3	6	89	21805	245	0.1131	10	145	3	1
Ficus sp.	0.00	0.00	0	0		2	4	2	2	4	9	1	0	0	0.0000	0	0		1
Ficus sp.	0.00	0.00	0	0		2	4	4	2	4	9	89	21805	245	0.1131	10	145		5
Flacourtia rukam	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145	2	2
Ganua motleyana	82.76	28.96	0	0	560	2	4	2	2	4	9	1	0	0	0.0000	0	0	3	1,2
Garcinia forbesii	9.55	9.59	2	1		2	4	4	2	2	3	1	0	0	0.0000	0	0	2	1,2
Garcinia mangostana	0.00	0.00	0	0	998	2	4	4	3	2	4	1	0	0	0.0000	0	0		1,2
Garcinia nervosa	9.55	9.59	2	1	960	2	4	4	2	3	6	1	0	0	0.0000	0	0	2	1,2
Garcinia parvifolia	22.28	14.30	2	0	688	2	4	2	2	2	3	1	325	325	0.1500	11	21	3	1,2
Geunsia pentandra	0.00	0.00	0	0		2	4	1	1	3	5	1	1016	1016	0.4688	10	44		1
Gironniera sp.	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		1
Glochidion litorale	0.00	0.00	0	0		2	4	4	2	1	1	89	21805	245	0.1131	10	145	2	1
Glochidion sp.	0.00	0.00	0	0		2	4	4	2	1	1	1	2649	2649	1.2224	10	82	2	1
Glochidion superbum	38.20	19.14	3	0		2	4	4	2	3	6	89	21805	245	0.1131	10	145	3	1
Gonystylus bancanus	66.85	24.95	3	0	675	2	4	4	2	3	6	1	220	220	0.1015	15	67	3	1,2,6
Gordonia sp.	0.00	0.00	0	0		2	4	4	2	1	1	89	21805	245	0.1131	10	145		1
Guioa sp.	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		1
Gymnacranthera contracta	25.46	15.36	3	0		2	4	4	2	3	6	89	21805	245	0.1131	10	145	1	1,2
Helicia sp.	0.00	0.00	0	0		2	4	4	2	1	1	1	8	8	0.0037	40	44	2	1

SP_NAME	SP_LOCAL	SPC_CODE	SPCD_HQ	SP_TGRP	SP_GRP	SP_IN	F3	SP_VO	SP_HT	SPC_GRP	HMAX1	H4_1	GIRTH
Heritiera littoralis	Dungun	HELI	DUGN	NDHH	13	19	1	15	15	9	15	2	2.4
Heritiera simplicifolia	Kembang/ mengkulang	KEMB	KM	NDMH	11	19	1	9	9	9	45	0	4.2
Hibiscus tiliceus	Baru	HITI	BRU	OTHR	13	14	1	15	15	15	12	2	0.6
Homalium caryophyllaceum	Takaliu	TLIU	TKU	NDHH	13	14	1	15	15	15	6	3	1
Homalium sp.	Takaliu	TLIU	TKU	OTHR	13	14	1	15	15	15	klein-groß	3	
Hopea aequalis	Selangan sama	SSAM	SLS	DMH	7	7	2	2	2	2	?	0	
Hopea argentea	Selangan urat	SURT	SLT	DMH	7	7	2	2	2	2	mittel	3	mittel
Hopea beccariana	Selangan penak	SPEN	SLE	DMH	7	7	2	2	2	2	37	0	3
Hopea dryobalanoides	Selangan daun kapur	SDKP	SLK	DMH	7	7	2	2	2	2	klein	2	klein
Hopea dyeri	Selangan daun halus	SDHS	SDH	DMH	7	7	2	2	2	2	klein	2	klein
Hopea ferruginea	Selangan mata kucing	SMKC	SMC	DMH	7	7	2	2	2	2	mittel	3	mittel
Hopea latifolia	Selangan jongkong	SJON	SJK	DMH	7	7	2	2	2	2	?	0	
Hopea mengerawan	Selangan hitam	SHTM	SH	DMH	7	7	2	2	2	2	?	0	
Hopea micrantha	Selangan lunas	SLUN	SLN	DMH	7	7	2	2	2	2		0	
Hopea montana	Selangan bukit	SBUK	SUK	DMH	7	7	2	2	2	2		0	
Hopea myrtifolia	Selangan beludu	SBDU	SU	DMH	7	7	2	2	2	2	?	0	
Hopea nervosa	Selangan jangkang	SJKG	SJ	DMH	7	7	2	2	2	2	31	0	1.5
Hopea nutans	Giam	GIAM	G	DHH	7	7	2	2	2	15	groß	0	
Hopea pentanervia	Selangan lima urat	SLUR	SLU	DHH	7	7	2	2	2	2	30	0	1.8
Hopea sangal	Gagil	GAGL	GL	DMH	7	7	2	4	4	4	46	0	3.7
Hopea semicuneata	Giam kulit merah	HOSE	GK	DHH	7	7	2	2	2	15		0	3.4
Hopea sp.	Selangan	SELA	S	DMH	7	7	2	2	2	2	mittel-groß	0	
Hopea tenuinervula	Selangan daun serong	SDSG	SDS	DMH	7	7	2	2	2	2	?	0	
Hopea vaccinifolia	Selangan ribu	SRIB	SLR	DMH	7	7	2	2	2	2	klein	2	
Hopea wyatt-smithii	Selangan daun bulat	SDBL	SLB	DMH	7	7	2	2	2	2	mittel	3	
Hydnocarpus sp.	Karpus	KARP	KAR	NDMH	13	18	4	15	15	15	15-30	0	1.8
Ilex cissoidea.	Morogis	MORO	MGS	OTHR	12	14	1	15	15	15	mittel	3	
Ilex cymosa	Bangkulatan	BKLT	BGN	OTHR	13	14	1	15	15	15	klein-mittel	2	
Intsia bijuga	Ipil laut	ILAT	IPL	NDHH	13	14	1	8	8	15	24	3	1.8
Intsia palembanica	Merbau	MERB	MER	NDHH	11	12	4	9	9	9	55	0	4.6
Irvingia malayana	Pauh kijang	PAUH	PKI	NDHH	11	10	1	15	15	15	40	0	4.6
Itea macrophylla	Marapid/kaintuhan	ITMA	OTH	OTHR	13	14	1	15	15	15	klein	2	
Ixonanthes reticulata	Inggir burung	IXON	IB	NDMH	13	14	1	15	15	15	klein	2	
Jackia ornata	Selumar	JAOR	SLR	NDHH	13	20	1	15	15	15	35	0	1.8
Kleinhovia hospita	Timahar	KLHO	OTH	OTHR	13	14	1	15	15	15	20	3	0.9
Koilodepus sp.	Kilas	KILA	KLS	NDHH	13	14	1	15	15	15	7	2	0.3
Koompassia excelsa	Mengaris	MENG	MEN	NDMH	11	10	1	12	12	12	80	0	7
Koompassia malaccensis	Kempas	IMPS	IMP	NDHH	11	10	1	12	12	12	55	0	3
Koordersiodendron pinnatum	Ranggu	RGGU	RGU	NDMH	11	18	4	8	8	8	30	0	1.5
Lagerstroemia speciosa	Bungor	OTHR	OTH	OTHR	13	14	1	15	15	15	30.5	0	1.5
Lansium domesticum	Langsat	LADO	LADO	OTHR	13	14	1	15	15	15	15	2	0.6
Lapisanthes sp.	Lapisanthes	LAPI	OTH	OTHR	13	14	1	15	15	15	?	0	
Lasianthus sp.	Kopi-kopi	KOPI	OTH	OTHR	13	14	1	15	15	15	bush & tree	1	
Lauraceae family	Medang	MEDA	MD	NDLH	11	19	1	9	9	9	bush & tree	1	
Leea sp.	Mali-mali	LEEA	OTH	OTHR	13	14	1	15	15	15	bush & tree	1	

SP_NAME	DIA	HMAX2	H4_2	DIFF_H4	DENSITY	HF4_CAN	HF4_N	LF4_MR	LF4	HF4	F4	C_SPHQ	DERA	DERA_W	DERA_%	D_MIN	D_MAX	FREQ	SOURCE
Heritiera littoralis	76.39	28.03	0	0	795	2	4	3	3	2	4	1	100	100	0.0461	16	19	2	1,2,8
Heritiera simplicifolia	133.69	0.00	0	0	749	2	4	2	2	4	9	1	410	410	0.1892	10	131	3	1,2
Hibiscus tiliceus	19.10	13.19	2	0		2	4	4	3	2	4	1	4	4	0.0018	41	41	3	1
Homalium caryophyllaceum	31.83	17.34	3	0	928	2	4	3	3	3	7	2	533	267	0.1230	11	79	3	1,2
Homalium sp.	0.00	0.00	0	0	hoch	2	4	3	3	3	7	2	533	267	0.1230	11	79		1
Hopea aequalis	0.00	0.00	0	0		3	5	3	3	5	13	1	0	0	0.0000	0	0		2
Hopea argentea		0.00	0	0		3	5	2	2	3	6	1	0	0	0.0000	0	0	2	2
Hopea beccariana	95.49	36.51	0	0	786	3	5	3	3	5	13	1	29	29	0.0134	25	55	2	2
Hopea dryobalanoides		0.00	0	0	718	3	5	3	3	2	4	1	0	0	0.0000	0	0		2
Hopea dyeri		0.00	0	0	766	3	5	3	3	2	4	1	33	33	0.0152	32	97	1	2
Hopea ferruginea		0.00	0	0	699	3	5	3	3	3	7	1	0	0	0.0000	0	0	2	2
Hopea latifolia	0.00	0.00	0	0		3	5	3	3	5	13	1	316	316	0.1458	11	114		1,2
Hopea mengerawan	0.00	0.00	0	0	715	3	5	3	3	5	13	1	0	0	0.0000	0	0		1,2,8
Hopea micrantha	0.00	0.00	0	0	787	3	5	3	3	5	13	1	0	0	0.0000	0	0	1	2
Hopea montana	0.00	0.00	0	0	851	3	5	3	3	5	13	1	0	0	0.0000	0	0	1	2
Hopea myrtifolia	0.00	0.00	0	0		3	5	3	3	5	13	2	0	0	0.0000	0	0		1,2
Hopea nervosa	47.75	26.20	0	0	704	3	5	2	2	4	9	1	1210	1210	0.5584	11	114	3	2
Hopea nutans	0.00	0.00	0	0	1056	2	4	3	3	4	10	1	8	8	0.0037	54	78	3	2,3
Hopea pentanervia	57.30	29.17	0	0	1104	3	5	3	3	4	10	1	114	114	0.0526	24	63		2
Hopea sangal	117.77	0.00	0	0	699	5	5	3	3	5	13	1	8	8	0.0037	55	58	3	2
Hopea semicuneata	108.23	0.00	0	0	1008	2	4	3	3	4	10	1	0	0	0.0000	0	0	2	2
Hopea sp.	0.00	0.00	0	0	1080	3	5	3	3	5	13	1	182	182	0.0840	17	63		5,8
Hopea tenuinervula	0.00	0.00	0	0		3	5	3	3	5	13	1	0	0	0.0000	0	0		1,2
Hopea vaccinifolia	0.00	0.00	0	0		3	5	3	3	2	4	2	0	0	0.0000	0	0		1,2
Hopea wyatt-smithii	0.00	0.00	0	0		3	5	4	2	3	6	1	0	0	0.0000	0	0		1,2
Hydnocarpus sp.	57.30	23.43	3	0	700	2	4	2	2	3	6	1	2417	2417	1.1154	10	82		2
Ilex cissoidea.	0.00	0.00	0	0		2	4	4	2	3	6	2	8	4	0.0018	44	45		5
Ilex cymosa	0.00	0.00	0	0		2	4	3	3	2	4	1	0	0	0.0000	0	0	3	1
Intsia bijuga	57.30	23.43	3	0	838	2	4	4	3	3	7	1	0	0	0.0000	0	0	3	1,2
Intsia palembanica	146.42	0.00	0	0	793	2	4	3	3	4	10	1	165	165	0.0761	11	122	2	1,2
Irvingia malayana	146.42	0.00	0	0	992	2	4	4	3	4	10	1	118	118	0.0545	27	114	3	1,2
Itea macrophylla	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145	1	1
Ixonanthes reticulata	0.00	0.00	0	0		2	4	4	3	2	4	1	100	100	0.0461	14	14		5
Jackia ornata	57.30	23.43	3	0	912	2	4	3	3	3	7	2	0	0	0.0000	0	0	2	1,2
Kleinhovia hospita	28.65	16.37	3	0	480	2	4	4	2	3	6	89	21805	245	0.1131	10	145	2	1,2
Koilodepus sp.	9.55	9.59	2	0		2	4	3	3	2	4	1	525	525	0.2423	10	19	1	1
Koompassia excelsa	222.82	0.00	0	0	827	4	5	2	2	5	12	1	273	273	0.1260	12	160	2	1,2
Koompassia malaccensis	95.49	38.70	0	0	1114	4	5	3	3	5	13	1	153	153	0.0706	21	105	2	1,2
Koordersiodendron pinnatum	47.75	31.80	0	0	801	4	5	2	2	4	9	1	607	607	0.2801	10	108	2	2
Lagerstroemia speciosa	47.75	21.49	3	0	674	2	4	4	2	3	6	89	21805	245	0.1131	10	145	3	1,2
Lansium domesticum	19.10	13.19	2	0		2	4	4	3	2	4	1	0	0	0.0000	0	0	3	1
Lapisanthes sp.	0.00	0.00	0	0		2	4	4	2	4	9	89	21805	245	0.1131	10	145		1
Lasianthus sp.	0.00	0.00	0	0		2	4	4	2	1	1	89	21805	245	0.1131	10	145		1
Lauraceae family	0.00	0.00	0	0	350 - 880	2	4	2	2	1	1	1	7394	7394	3.4121	10	114	2	1
Leea sp.	0.00	0.00	0	0		2	4	4	2	1	1	89	21805	245	0.1131	10	145	3	1

SP_NAME	SP_LOCAL	SPC_CODE	SPCD_HQ	SP_TGRP	SP_GRP	SP_IN	F3	SP_VO	SP_HT	SPC_GRP	HMAX1	H4_1	GIRTH
Leptospermum sp.	Gelam bukit	LEPT	OTH	OTHR	13	14	1	15	15	15	12	2	
Linociera sp.	Bangkulat	LIPL	BGT	OTHR	13	14	1	15	15	15	oft mittel	3	
Lithocarpus sp.	Mempening	MEMP	MEM	NDMH	11	20	1	9	9	2		0	
Litsea cubeba	Lindos/railos	LICB	LDS	NDLH	13	19	1	15	15	15	?	0	
Litsea graciea	Pengulobon	LIGA	PGN	NDLH	12	19	1	9	9	9	mittel	3	1.2
Litsea odorifera	Medang pawas	LIOD	MDP	NDLH	11	19	1	9	9	9	mittel	3	1.5
Litsea odorifera	Medang pawas	LIOD	TWD	NDLH	13	19	1	9	9	9	mittel	0	1.5
Macaranga conifera	Ludai	LUDA	LUDA	NDLH	13	13	3	15	15	14	24	3	1.5
Macaranga hosei	Lopokon	MAHO	OTH	OTHR	13	14	1	15	15	15	?	0	
Macaranga sp.	Kubin	MAGI	OTH	MACA	13	13	3	15	15	14	klein-mittel	3	
Macaranga sp.	Sedaman	MACA	SEDA	MACA	13	13	3	15	15	14	klein-mittel	3	
Macaranga sp.	Sedaman	SEDA	SEDA	MACA	13	14	1	15	15	14	klein-mittel	3	
Macaranga tanarius	Lingkabong	MATA	OTH	OTHR	13	14	1	15	15	15	21	3	
Magnoliaceae family	Cempaka	MAGN	CP	NDMH	11	20	1	15	15	15	bush & tree	1	
Mallotus mollissimus	Dahu	MAMO	OTH	OTHR	13	14	1	15	15	15	klein	2	
Mallotus muticus	Mallotus paya	MAMU	MAMU	OTHR	13	14	1	15	15	15	24	3	1.4
Mallotus philipinensis	Mallotus philipine	MAPH	OTH	OTHR	13	14	1	15	15	15	10	2	0.3
Mallotus sp.	Melutos	MALL	MTS	NDLH	13	14	1	15	15	15	klein-mittel	2	
Mangifera pajang	Bambangan	MGPA	BBG	NDLH	11	17	1	15	15	15	?	0	
Mangifera sp.	Bachang	ASAM	BC	NDLH	11	19	1	15	15	15	klein-groß	3	
Mangifera sp.	Dumpiring	ASAM	DUM	NDLH	11	19	1	15	15	15	klein-groß	3	
Mangifera sp.	Pahu	ASAM	PHU	NDLH	11	19	1	9	9	15	klein-groß	3	
Mangitera sp.	Assam	ASAM	ASS	NDLH	11	19	1	9	9	15	klein-groß	3	
Mangostana sp.	Manggis	GARC	MGS	NDMH	11	19	1	15	15	15	?	3	
Meliaceae family	Lantupak	LANT	LA	OTHR	13	14	1	8	8	8	mittel	3	
Meliosma sumatrana	Gapas-gapas	GPAS	GP	NDMH	13	14	1	15	15	15	mittel	3	
Memecylon sp.	Nipis kulit	MLAE	OTH	OTHR	13	14	1	15	15	15	bush & tree	1	
Mesua macrantha	Bintangor batu	MEMA	BIB	NDMH	11	19	1	9	9	9	klein	2	
Microcos sp.	Korodong	KRDG	DAMA	OTHR	11	15	1	15	15	15	bush & tree	1	
Microcos sp.	Korodong/damak-damak	KRDG	KDG	OTHR	13	14	1	15	15	15	bush & tree	1	
Milletia sp.	Taroi-taroi	MILL	OTH	OTHR	13	14	1	15	15	15	klein-mittel	2	
Myristicaceae family	Darah-darah	DARA	DRA	NDLH	11	16	2	15	15	15	klein-groß	3	klein-groß
Nauclea sp.	Bangkal	BKAL	BKL	NDLH	12	14	1	15	15	15	mittel-groß	0	mittel
Neesia sp.	Durian monyet	DMYT	DRM	NDLH	11	17	1	8	8	8	mittel-groß	0	
Nephelium glabrum	Satu inchi	NEGL	NEGL	OTHR	13	14	1	15	15	15	klein-mittel	2	
Nephelium maingayi	Kelamondoi	NEPH	KDI	OTHR	13	14	1	15	15	15	35	0	1.6
Nephelium mutabile	Maritam	MERI	MTM	NDLH	13	14	1	15	15	15	35	0	0.6
Nephelium sp.	Meritam	MERI	MTM	NDLH	13	14	1	15	15	15	45	0	4
Nephelium sp.	Rambutan	RBTN	RBTN	OTHR	13	14	1	15	15	15	45	0	4
Notaphoebe obovata	Lamau-lamau	NOOB	LMU	NDLH	11	18	4	15	15	15	mittel	0	
Ochanostachys amentacea	Petaling	TGGL	PET	NDMH	11	19	1	8	8	15	30	0	1.8
Octomeles sumatrana	Binuang	BINU	BN	PION	12	13	3	15	15	11	55	0	6.1
Omalanthus sp.	Ludai	LUDA	LUDA	NDLH	13	16	2	15	15	15	oft klein	3	
Osbornia octodonta	Gelam laut	OSOC	OTH	OTHR	13	14	1	15	15	15	?	0	
Ostodes sp.	Pait-pait	PAIT	PAIT	OTHR	13	14	1	15	15	15	mittel	3	

SP_NAME	DIA	HMAX2	H4_2	DIFF_H4	DENSITY	HF4_CAN	HF4_N	LF4_MR	LF4	HF4	F4	C_SPHQ	DERA	DERA_W	DERA_%	D_MIN	D_MAX	FREQ	SOURCE
Leptospermum sp.	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		1
Linociera sp.	0.00	0.00	0	0		2	4	4	2	3	6	1	154	154	0.0711	13	55		5
Lithocarpus sp.	0.00	0.00	0	0		3	5	2	2	5	12	1	2672	2672	1.2330	11	78	3	2
Litsea cubeba	0.00	0.00	0	0		2	4	4	2	4	9	1	0	0	0.0000	0	0		1
Litsea graciea	38.20	19.31	3	0		2	4	4	2	3	6	1	0	0	0.0000	0	0	1	2,5
Litsea odorifera	47.75	22.00	3	0	509	2	4	4	2	3	6	1	0	0	0.0000	0	0		2,5
Litsea odorifera	47.75	22.00	3	0	509	2	4	4	2	3	6	1	0	0	0.0000	0	0		2,5
Macaranga conifera	47.75	35.49	0	0	niedrig	4	5	1	1	3	5	2	2066	1033	0.4767	10	68	1	1,2
Macaranga hosei	0.00	0.00	0	0		2	4	4	1	4	8	89	21805	245	0.1131	10	145		1
Macaranga sp.	0.00	0.00	0	0	niedrig	4	5	1	1	3	5	89	21805	245	0.1131	10	145		1
Macaranga sp.	0.00	0.00	0	0	niedrig	4	5	1	1	3	5	2	37111	18556	8.5627	10	73		1
Macaranga sp.	0.00	0.00	0	0	niedrig	4	5	1	1	3	5	2	37111	18556	8.5627	10	73		1
Macaranga tanarius	0.00	0.00	0	0	500	2	4	4	1	3	5	89	21805	245	0.1131	10	145		2
Magnoliaceae family	0.00	0.00	0	0		2	4	2	2	1	1	1	629	629	0.2903	12	47		1
Mallotus mollissimus	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145	3	5
Mallotus muticus	44.56	20.75	3	0	432	2	4	4	2	3	6	1	0	0	0.0000	0	0	3	1,2
Mallotus philipinensis	9.55	9.59	2	0	749	2	4	4	3	2	4	89	21805	245	0.1131	10	145	2	1,2
Mallotus sp.	0.00	0.00	0	0		2	4	3	3	2	4	1	3970	3970	1.8320	10	52		1,2
Mangifera pajang	0.00	0.00	0	0		2	4	4	2	4	9	1	4	4	0.0018	46	46		1
Mangifera sp.	0.00	0.00	0	0	mittel	2	4	4	2	3	6	1	429	429	0.1980	10	49		1
Mangifera sp.	0.00	0.00	0	0	mittel	2	4	4	2	3	6	1	0	0	0.0000	0	0		1
Mangifera sp.	0.00	0.00	0	0	mittel	2	4	4	2	3	6	1	0	0	0.0000	0	0		1
Mangitera sp.	0.00	0.00	0	0	mittel	2	4	4	2	3	6	1	258	258	0.1191	10	64		1
Mangostana sp.	0.00	0.00	0	0		2	4	4	2	3	6	2	8	4	0.0018	45	44		1
Meliaceae family	0.00	0.00	0	0		4	5	2	2	3	6	1	7473	7473	3.4485	10	114	3	1
Meliosma sumatrana	0.00	0.00	0	0		2	4	4	2	3	6	1	0	0	0.0000	0	0		5
Memecylon sp.	0.00	0.00	0	0		2	4	4	2	1	1	89	21805	245	0.1131	10	145		1
Mesua macrantha	0.00	0.00	0	0		2	4	4	3	2	4	1	158	158	0.0729	15	43		5
Microcos sp.	0.00	0.00	0	0	mittel	2	4	1	2	1	1	1	875	875	0.4038	10	28		1
Microcos sp.	0.00	0.00	0	0	mittel	2	4	1	2	1	1	1	741	741	0.3419	10	69		1
Milletia sp.	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145	3	1
Myristicaceae family		0.00	0	0	590	2	4	2	2	3	6	1	3985	3985	1.8389	10	71	3	1,2,8
Nauclea sp.		0.00	0	0	560-880	2	4	1	1	4	8	1	3027	3027	1.3968	10	190		1,2
Neesia sp.	0.00	0.00	0	0		4	5	4	2	5	12	1	312	312	0.1440	11	77	2	1
Nephelium glabrum	0.00	0.00	0	0		2	4	4	3	2	4	1	0	0	0.0000	0	0		1
Nephelium maingayi	50.93	22.18	3	0		2	4	4	2	3	6	1	0	0	0.0000	0	0		1
Nephelium mutabile	19.10	13.19	2	0		2	4	2	2	4	9	2	773	387	0.1784	11	62		1
Nephelium sp.	127.32	0.00	0	0		2	4	2	2	4	9	2	773	387	0.1784	11	62		1
Nephelium sp.	127.32	0.00	0	0		2	4	4	2	4	9	1	158	158	0.0729	17	67		1
Notaphoebe obovata	0.00	0.00	0	0		2	4	4	2	4	9	1	0	0	0.0000	0	0		5
Ochanostachys amentacea	57.30	23.43	3	0	880	2	4	3	3	3	7	1	381	381	0.1758	13	88	2	1,2
Octomeles sumatrana	194.17	0.00	0	0	400	4	5	1	1	5	11	1	259	259	0.1195	28	99	3	2
Omalanthus sp.	0.00	0.00	0	0		2	4	1	1	3	5	2	2066	1033	0.4767	10	68		5
Osbornia octodonta	0.00	0.00	0	0		2	4	4	2	4	9	89	21805	245	0.1131	10	145		1
Ostodes sp.	0.00	0.00	0	0		2	4	4	2	3	6	1	0	0	0.0000	0	0		5

SP_NAME	SP_LOCAL	SPC_CODE	SPCD_HQ	SP_TGRP	SP_GRP	SP_IN	F3	SP_VO	SP_HT	SPC_GRP	HMAX1	H4_1	GIRTH
Otophora fruticosa	Balingasan	OTFR	OTH	OTHR	13	14	1	15	15	15	6	2	
Pangium edule	Pangi	KEPA	PAN	NDLH	13	14	1	15	15	15	38	0	2.7
Paranephelium sp.	Membuakat	MEMB	OTH	OTHR	13	14	1	15	15	15	klein-mittel	2	
Parashorea malaanonan	Urat mata daun licin	UMDL	UML	DLH	2	1	1	3	3	3	61	0	6.1
Parashorea parvifolia	Urat mata daun kecil	UMDK	UMK	DLH	2	5	1	3	3	3	43	0	2.7
Parashorea smythiesii	Urat mata batu	UMBT	UMB	DMH	2	5	1	3	3	3	43	0	6.1
Parashorea sp.	Urat mata	WHSY	WS	DLH	2	1	1	3	3	3	groß	0	
Parashorea tomentella	Urat mata beludu	UMBL	UMU	DLH	2	1	1	3	3	3	61	0	6.1
Parastemon urophyllum	Mandailas	PAUR	MDS	NDLH	13	18	4	15	15	15	36	0	
Parinari	Bangkawang	BKWG	NAN	NDLH	11	12	4	15	15	15	48	0	mittel
Parinari oblongifolia	Merbatu	PAOD	MEB	NDMH	11	12	4	15	15	15	40	0	2.6
Parishia insignis	Layang-layang	LAYA	LAY	NDMH	13	20	1	15	15	15	60	0	1.9
Parishia sp.	Layang-layang	LAYA	LAY	OTHR	13	20	1	15	15	15	60	0	3.3
Parkia javanica	Kupang	KUPA	KNG	NDLH	13	14	1	8	8	8	30	0	
Parkia sp.	Petai	PTAI	PTI	NDMH	11	14	1	8	8	8	30	0	2.5
Peltophorum racemosum	Timbarayong	TIMB	OTH	OTHR	13	14	1	15	15	15	groß	0	groß
Pentace adenophora	Takalis daun bulat	PEAD	PEAD	NDHH	11	17	1	9	9	9	30	0	2.1
Pentace laxiflora	Takalis daun halus	PELA	TKH	NDLH	11	16	2	9	9	9	klein	2	9.9
Pentace sp.	Takalis	TAKA	TKS	NDLH	11	17	1	9	9	9	mittel-groß	0	mittel
Pentaspodon motleyii	Pelajau	PELJ	PEL	NDLH	13	19	1	15	15	15	36	0	1.32
Pericopsis mooniana	Ipil air	IAYR	IPA	NDMH	13	19	1	8	8	15	30	0	1.5
Phaleria perrottetetiana	Alig pagi	ALIG	OTH	OTHR	13	14	1	15	15	15	klein	2	
Phyllanthus emblica	Laka	PYEM	OTH	OTHR	13	14	1	15	15	15	36	0	1.5
Pithecellobium sp.	Jering	JARG	OTH	OTHR	13	14	1	15	15	15	bush & tree	1	
Planchonia valida	Putat paya	PUTP	PUT	NDLH	11	18	4	8	8	8	30	0	3
Plectronia confertum	Grubai	PLCO	OTH	OTHR	13	14	1	15	15	15	klein	2	
Pleiocarpidia sandakanensis	Buloh-buloh	PLSA	BLH	NDLH	13	14	1	15	15	15	klein	2	
Podocarpus blumeii	Lampias	POBL	LPS	NDLH	13	17	1	15	15	14	37	0	3
Podocarpus imbricatus	Lompoyou	POIM	LOM	NDLH	13	17	1	14	14	14	35	0	2.4
Podocarpus rumphii	Kayu china	PORU	KCN	NDMH	11	17	1	14	14	14	mittel	3	
Polyosma integrifolia	Bedaru	BEDA	BED	OTHR	13	14	1	15	15	15	14	2	
Pometia pinnata	Kasai	KASA	KAS	NDMH	11	19	1	15	15	15	40	0	2.4
Pongomia pinnata	Marabahai	MHAI	MHI	NDMH	13	18	4	15	15	15		0	1.5
Prunus javanica	Kelanus	PRJA	KNS	NDLH	13	14	1	15	15	15	30	0	2.1
Pternandra coerulescens	Sirih-sirih	SIRE	OTH	OTHR	13	14	1	15	15	15	20	3	2.7
Pterocarpus indicus	Angsana	ANGS	ANG	NDLH	13	17	1	8	8	8	31	0	2.4
Pterocymbium tinctorium	Teluto	TELU	TTO	NDMH	11	14	1	15	15	9		0	1.8
Pterospermum sp.	Bayor	BAYO	BY	NDLH	12	14	1	15	15	9	mittel	3	
Quassia borneensis	Manunggal	QUBO	MGL	OTHR	13	14	1	15	15	15	mittel	3	
Randia anisophylla	Bembalor	RAAN	OTH	OTHR	13	14	1	15	15	15	12	2	
Ryparosa sp.	Giwie	GIEW	GWI	OTHR	13	14	1	15	15	15	21	3	
Sandoricum maingayi	Sentul hutan	SAMA	STH	NDLH	13	19	1	15	15	15	45	0	2.4
Sandoricum mangyi	Sentol hutan	SAMA	STL	NDLH	13	15	1	15	15	15	45	0	2.4
Sapium indicum	Apid-apid	APID	OTH	OTHR	13	14	1	15	15	15	18	3	1.2
Sapotaceae family	Nyatoh	NYAT	NT	NDMH	11	21	2	9	9	9	klein - groß	0	

SP_NAME	DIA	HMAX2	H4_2	DIFF_H4	DENSITY	HF4_CAN	HF4_N	LF4_MR	LF4	HF4	F4	C_SPHQ	DERA	DERA_W	DERA_%	D_MIN	D_MAX	FREQ	SOURCE
Otophora fruticosa	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		1
Pangium edule	85.94	26.75	0	0	660	2	4	4	2	4	9	1	0	0	0.0000	0	0		2
Paranephelium sp.	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		1
Parashorea malaanonan	194.17	0.00	0	0	531	5	5	2	2	5	12	1	1432	1432	0.6608	11	126	3	2
Parashorea parvifolia	85.94	46.43	0	0	665	5	5	2	2	5	12	1	0	0	0.0000	0	0	1	2
Parashorea smythiesii	194.17	0.00	0	0	678	5	5	2	2	5	12	1	1123	1123	0.5182	11	100	2	2
Parashorea sp.	0.00	0.00	0	0		5	5	2	2	5	12	1	94	94	0.0434	21	106		5
Parashorea tomentella	194.17	0.00	0	0	506	5	5	2	2	5	12	1	4859	4859	2.2422	10	150	2	2
Parastemon urophyllum	0.00	0.00	0	0	1075	2	4	4	2	4	9	2	0	0	0.0000	0	0	3	1,6
Parinari		0.00	0	0	720-900	2	4	2	2	4	9	1	0	0	0.0000	0	0	3	1,2
Parinari oblongifolia	82.76	26.56	0	0	739	2	4	2	2	4	9	1	543	543	0.2506	12	107	3	1,2
Parishia insignis	60.48	23.98	3	0	560	2	4	4	2	4	9	2	0	0	0.0000	0	0	2	1,2
Parishia sp.	105.04	0.00	0	0		2	4	4	2	4	9	2	0	0	0.0000	0	0	3	1
Parkia javanica	0.00	0.00	0	0		4	5	4	2	4	9	1	100	100	0.0461	10	10	3	1
Parkia sp.	79.58	40.84	0	0	mittel	4	5	2	2	4	9	1	315	315	0.1454	12	114	3	1
Peltophorum racemosum		0.00	0	0	640	2	4	4	2	4	9	89	21805	245	0.1131	10	145		2
Pentace adenophora	66.85	26.36	0	0		2	4	4	3	4	10	1	0	0	0.0000	0	0		1
Pentace laxiflora	315.13	0.00	0	0	360	2	4	2	2	2	3	1	1274	1274	0.5879	10	67	3	2
Pentace sp.		0.00	0	0	750	2	4	2	2	4	9	1	2663	2663	1.2289	10	124	2	1,2
Pentaspodon motleyii	42.02	20.13	3	0	722	2	4	4	2	3	6	1	0	0	0.0000	0	0	1	1,2
Pericopsis mooniana	47.75	21.49	3	0	800	2	4	4	2	3	6	1	0	0	0.0000	0	0	2	1,2
Phaleria perrottetetiana	0.00	0.00	0	0		2	4	1	1	2	2	89	21805	245	0.1131	10	145		5
Phyllanthus emblica	47.75	21.49	3	0	mittel	2	4	4	2	3	6	89	21805	245	0.1131	10	145	2	1
Pithecellobium sp.	0.00	0.00	0	0		2	4	4	2	1	1	89	21805	245	0.1131	10	145		1
Planchonia valida	95.49	42.20	0	0	792	4	5	4	2	4	9	1	66	66	0.0305	26	87	1	1,2
Plectronia confertum	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		5
Pleiocarpidia sandakanensis	0.00	0.00	0	0		2	4	4	2	2	3	1	0	0	0.0000	0	0		5
Podocarpus blumeii	95.49	0.00	0	0	619	4	5	4	2	5	12	1	0	0	0.0000	0	0	2	1,2
Podocarpus imbricatus	76.39	42.68	0	0	520	4	5	4	2	4	9	1	0	0	0.0000	0	0	2	4,2
Podocarpus rumphii	0.00	0.00	0	0		4	5	4	2	3	6	1	0	0	0.0000	0	0		4
Polyosma integrifolia	0.00	0.00	0	0		2	4	4	3	2	4	1	0	0	0.0000	0	0		1
Pometia pinnata	76.39	26.06	0	0	832	2	4	2	2	4	9	1	33	33	0.0152	25	57	3	1,2
Pongomia pinnata	47.75	21.49	3	0	800	2	4	4	2	3	6	1	0	0	0.0000	0	0		2
Prunus javanica	66.85	24.95	3	0		2	4	4	2	3	6	1	0	0	0.0000	0	0	1	1
Pternandra coerulescens	85.94	26.75	0	0	hoch	2	4	4	2	3	6	89	21805	245	0.1131	10	145	3	1
Pterocarpus indicus	76.39	40.31	0	0	624	4	5	4	2	4	9	1	0	0	0.0000	0	0		2
Pterocymbium tinctorium	57.30	24.35	3	0	672	2	4	4	2	3	6	1	0	0	0.0000	0	0	1	2
Pterospermum sp.	0.00	0.00	0	0	niedrig	2	4	1	1	3	5	1	1990	1990	0.9183	10	59	3	1
Quassia borneensis	0.00	0.00	0	0		2	4	4	2	3	6	2	4	2	0.0009	51	51		5
Randia anisophylla	0.00	0.00	0	0	mittel	2	4	4	3	2	4	89	21805	245	0.1131	10	145	2	1
Ryparosa sp.	0.00	0.00	0	0		2	4	2	2	3	6	1	650	650	0.3000	10	23		2
Sandoricum maingayi	76.39	26.06	0	0		2	4	4	2	4	9	1	0	0	0.0000	0	0	2	1
Sandoricum mangyi	76.39	26.06	0	0		2	4	4	2	4	9	1	0	0	0.0000	0	0	2	1
Sapium indicum	38.20	19.14	3	0	448	2	4	4	2	3	6	89	21805	245	0.1131	10	145	2	2
Sapotaceae family	0.00	0.00	0	0		2	4	2	2	4	9	1	4217	4217	1.9460	10	77	2	1

SP_NAME	SP_LOCAL	SPC_CODE	SPCD_HQ	SP_TGRP	SP_GRP	SP_IN	F3	SP_VO	SP_HT	SPC_GRP	HMAX1	H4_1	GIRTH
Saracca sp.	Gapis	GAPI	GAPI	NDLH	13	14	1	8	8	15	14	2	
Sarcotheca diversifolia	Tabarus	SADI	OTH	OTHR	13	14	1	15	15	15	klein	2	
Saurauia sp.	Sokong-sokong	SAUR	OTH	OTHR	13	14	1	15	15	15	klein	2	
Scaphium affine	Kembang semangkok	KSMK	KEM	NDLH	11	17	1	15	15	15	45	0	2.4
Schima wallichii	Gatal-gatal	GTAL	GT	NDLH	13	14	1	15	15	15	45	0	2.4
Scorodocarpus borneensis	Bawang hutan	BWHN	BWH	NDMH	11	19	1	8	8	8	36	0	2.4
Serialbizzia splendens	Kungkur	KKUR	KUR	NDLH	11	20	1	15	15	15	30	0	3
Serianthes dilmyi	Batai laut	SEDI	BLT	NDLH	13	14	1	8	8	15	klein-mittel	2	
Shorea acuminatissima	Seraya kuning runcing	SKRG	SPC	DLH	4	6	2	6	6	6	groß	0	
Shorea agami	Melapi agama	MEAG	MPA	DLH	3	2	1	2	2	2	60	0	4.5
Shorea almon	Seraya kerukup	SKER	SKE	DLH	1	2	1	2	2	2	61	0	3.7
Shorea andulensis	Seraya daun merah	SDME	SDR	DLH	1	3	1	2	2	2	38	0	
Shorea angentifolia	Seraya daun mas	SDMS	SDM	DLH	1	8	1	2	2	2	53	0	3.7
Shorea angustifolia	Seraya kuning bukit	SKBT	SKT	DLH	4	6	2	6	6	6	15	2	1
Shorea atrinervosaq	Selangan batu hitam	SBHM	SBX	DHH	8	10	1	7	7	7	60	0	4
Shorea beccariana	Seraya langgai	SLGG	SLG	DLH	1	11	1	2	2	2	55	0	3.1
Shorea biawak	Selangan batu biawak	SBBK	SBW	DHH	8	10	1	7	7	7	31	0	
Shorea bracteolata	Malapi pang	MEPG	MPP	DLH	3	2	1	2	2	2	mit.-groß	0	
Shorea coriacea	Seraya tangkai panjang	STKP	STP	DLH	1	7	2	2	2	2	43	0	
Shorea cristata	Kawang daun merah	KWDM	KWM	DLH	1	11	1	2	2	2		0	
Shorea curtissii	Seraya betul	SBET	SRU	DLH	1	8	1	2	2	2	61	0	4.6
Shorea dasyphylla	Seraya batu	SBAT	SRB	DLH	1	9	1	2	2	2	groß	0	groß
Shorea domatiosa	Selangan batu mata-mata	SBMM	SMM	DHH	8	10	1	7	7	7	60	0	4.5
Shorea exeliptica	Selangan batu tembaga	SBTM	SBZ	DHH	8	10	1	7	7	7	60	0	4.5
Shorea faguetiana	Seraya kuning siput	SKSP	SSP	DLH	4	6	2	6	6	6	63	0	4.6
Shorea falciferoides	Selangan batu laut	SBLT	SBP	DMH	8	10	1	7	7	7	?	0	
Shorea fallax	Seraya daun kasar	SEDK	SDK	DLH	1	3	1	2	2	2	7	2	klein
Shorea ferruginea	Seraya melantai kecil	SMKL	SMK	DLH	1	11	1	2	2	2		0	
Shorea flaviflora	Seraya daun besar	SDBR	SDB	DLH	1	11	1	2	2	2	mittel	3	
Shorea foxworthyii	Selangan batu bersisek	SBBS	SBB	DHH	8	10	1	7	7	7	60	0	4.5
Shorea gibbosa	Seraya kuning gajah	SKGH	SGT	DLH	4	6	2	6	6	6	70	0	4.6
Shorea glaucescens	Selangan batu laut	SBLX	SBL	DMH	8	10	1	7	7	7	35	0	2.5
Shorea gratissima	Melapi laut	MELT	MPU	DLH	3	2	1	2	2	2	53	0	3.1
Shorea havilandii	Selangan batu pinang	SBPG	SPG	DHH	8	10	1	7	7	7	15	2	1
Shorea hopeifolia	Seraya kuning jantan	SKJN	SJT	DLH	4	6	2	6	6	6	61	0	3.1
Shorea hypoleuca	Selangan batu kelabu	SBKB	SBG	DHH	8	10	1	7	7	7	35	0	2.5
Shorea johorensis	Seraya majau	SMAJ	SM	DLH	1	2	1	1	1	1	69	0	3.7
Shorea kudatensis	Seraya kuning kudat	SKKU	SDD	DLH	4	6	2	6	6	6	46	0	
Shorea kunstleri	Seraya sirap	SSIR	SSR	DHH	1	10	1	2	2	2	55	0	2.4
Shorea lamentella	Melapi lapis	MELP	MPL	DLH	3	2	1	2	2	2	46	0	
Shorea laxa	Seraya kuning keladi	SKKL	SLI	DLH	4	6	2	6	6	6	klein	2	
Shorea leprosula	Seraya tembaga	STEM	ST	DLH	1	3	1	2	2	2	61	0	3.1
Shorea leptoderma	Selangan batu biabas	SBBI	SBI	DHH	8	10	1	7	7	7	31	0	
Shorea macrophylla	Kawang jantung	KWJT	KWJ	DLH	1	11	1	2	2	2	46	0	3.1
Shorea macroptera	Seraya melantai	SMEL	SML	DLH	1	11	1	2	2	2	61	0	3.1

SP_NAME	DIA	HMAX2	H4_2	DIFF_H4	DENSITY	HF4_CAN	HF4_N	LF4_MR	LF4	HF4	F4	C_SPHQ	DERA	DERA_W	DERA_%	D_MIN	D_MAX	FREQ	SOURCE
Saracca sp.	0.00	0.00	0	0		2	4	4	2	2	3	1	137	137	0.0632	17	62	2	1
Sarcotheca diversifolia	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		5
Saurauia sp.	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		5
Scaphium affine	76.39	26.06	0	0	560	2	4	4	2	4	9	1	1250	1250	0.5768	11	87	3	1,2
Schima wallichii	76.39	26.06	0	0	672	2	4	4	2	4	9	1	0	0	0.0000	0	0	3	1,2
Scorodocarpus borneensis	76.39	40.31	0	0	905	4	5	2	2	4	9	1	445	445	0.2054	19	64	2	1,2
Serialbizzia splendens	95.49	27.03	0	0	720	2	4	4	2	4	9	1	4	4	0.0018	85	85	2	1,2
Serianthes dilmyi	0.00	0.00	0	0		2	4	4	2	2	3	1	0	0	0.0000	0	0	2	1
Shorea acuminatissima	0.00	0.00	0	0		5	5	2	2	5	12	1	638	638	0.2944	10	151		5
Shorea agami	143.24	0.00	0	0	665	3	5	2	2	5	12	1	33	33	0.0152	34	52	2	2
Shorea almon	117.77	0.00	0	0	527	3	5	2	2	5	12	1	98	98	0.0452	22	89	2	2
Shorea andulensis	0.00	0.00	0	0		3	5	2	2	5	12	1	0	0	0.0000	0	0	1	2
Shorea angentifolia	117.77	0.00	0	0	829	3	5	2	2	5	12	1	709	709	0.3272	10	99	2	2
Shorea angustifolia	31.83	21.42	3	1	853	5	5	2	2	2	3	1	0	0	0.0000	0	0	1	2
Shorea atrinervosaq	127.32	0.00	0	0	997	5	5	4	3	5	13	1	0	0	0.0000	0	0	2	2
Shorea beccariana	98.68	36.80	0	0	597	3	5	2	2	5	12	1	278	278	0.1283	15	100	3	2
Shorea biawak	0.00	0.00	0	0	930	5	5	4	3	4	10	1	0	0	0.0000	0	0	3	2
Shorea bracteolata	0.00	0.00	0	0	647	3	5	2	2	5	12	1	4	4	0.0018	95	95	1	2
Shorea coriacea	0.00	0.00	0	0	699	3	5	2	2	5	12	1	0	0	0.0000	0	0	1	2
Shorea cristata	0.00	0.00	0	0	828	3	5	4	2	5	12	1	0	0	0.0000	0	0	1	2
Shorea curtissii	146.42	0.00	0	0	656	3	5	2	2	5	12	1	0	0	0.0000	0	0	1	2
Shorea dasyphylla		0.00	0	0	520	3	5	2	2	5	12	1	0	0	0.0000	0	0	2	2
Shorea domatiosa	143.24	0.00	0	0	1022	5	5	4	3	5	13	1	0	0	0.0000	0	0	1	2
Shorea exeliptica	143.24	0.00	0	0	944	5	5	4	3	5	13	1	0	0	0.0000	0	0	3	2
Shorea faguetiana	146.42	45.71	0	0	634	5	5	2	2	5	12	1	1050	1050	0.4845	11	97	2	2
Shorea falciferoides	0.00	0.00	0	0		5	5	4	2	5	12	1	86	86	0.0397	27	109		1
Shorea fallax		0.00	0	0		3	5	2	2	2	3	1	0	0	0.0000	0	0	1	2
Shorea ferruginea	0.00	0.00	0	0		3	5	2	2	5	12	1	0	0	0.0000	0	0	2	2
Shorea flaviflora	0.00	0.00	0	0		3	5	2	2	3	6	1	0	0	0.0000	0	0		5
Shorea foxworthyii	143.24	0.00	0	0	992	5	5	3	3	5	13	1	8	8	0.0037	50	50	2	2
Shorea gibbosa	146.42	45.71	0	0	509	5	5	2	2	5	12	1	20	20	0.0092	42	114	2	2,5
Shorea glaucescens	79.58	45.86	0	0	838	5	5	3	3	4	10	1	70	70	0.0323	26	143		2
Shorea gratissima	98.68	36.80	0	0	620	3	5	4	2	5	12	1	0	0	0.0000	0	0	2	2
Shorea havilandii	31.83	26.06	0	0	1088	5	5	4	3	2	4	1	0	0	0.0000	0	0	1	2
Shorea hopeifolia	98.68	40.71	0	0	570	5	5	2	2	5	12	1	0	0	0.0000	0	0	1	2
Shorea hypoleuca	79.58	45.86	0	0	938	5	5	3	3	4	10	1	124	124	0.0572	10	94	2	2
Shorea johorensis	117.77	0.00	0	0	499	4	5	2	2	5	12	1	2244	2244	1.0355	10	126	3	2
Shorea kudatensis	0.00	0.00	0	0	638	5	5	2	2	5	12	1	0	0	0.0000	0	0	2	2
Shorea kunstleri	76.39	33.74	0	0	848	3	5	2	2	4	9	1	0	0	0.0000	0	0	1	2
Shorea lamentella	0.00	0.00	0	0	728	3	5	4	2	5	12	1	0	0	0.0000	0	0	1	2
Shorea laxa	0.00	0.00	0	0		5	5	2	2	2	3	1	0	0	0.0000	0	0	1	2,5
Shorea leprosula	98.68	36.80	0	0	575	3	5	2	2	5	12	1	917	917	0.4232	10	120	3	2,5,6
Shorea leptoderma	0.00	0.00	0	0	930	5	5	3	3	4	10	1	70	70	0.0323	23	75	2	2
Shorea macrophylla	98.68	36.80	0	0	350	3	5	2	2	5	12	1	464	464	0.2141	11	110	2	2,6
Shorea macroptera	98.68	36.80	0	0	540	3	5	2	2	5	12	1	3519	3519	1.6239	10	95	2	2

SP_NAME	SP_LOCAL	SPC_CODE	SPCD_HQ	SP_TGRP	SP_GRP	SP_IN	F3	SP_VO	SP_HT	SPC_GRP	HMAX1	H4_1	GIRTH
Shorea mecistopteryx	Kawang burung	KWBR	KWR	DLH	1	11	1	2	2	2	39	0	2.4
Shorea multiflora	Banjutan	BANJ	BJ	DMH	4	7	2	6	6	6	15	2	2.4
Shorea myrionerva	Seraya urat banyak	SUBK	SBK	DLH	1	11	1	2	2	2	38	0	2.7
Shorea nebulosa	Seraya kabut	SKAB	SKB	DLH	1	9	1	2	2	2	55	0	4
Shorea obscura	Selangan batu tanduk	SBTA	SBT	DHH	8	10	1	7	7	7	35	0	2.5
Shorea ochracea	Melapi daun besar	MEDB	MPB	DLH	3	2	1	2	2	2	groß	0	
Shorea oleosa	Seraya minyak	SMIN	SMY	DLH	1	3	1	2	2	2	61	0	
Shorea ovalis	Seraya kepong	SKEP	SKP	DLH	1	11	1	2	2	2	61	0	3.7
Shorea ovata	Seraya punai bukit	SPBT	SNB	DLH	1	7	2	2	2	2	mittel	3	mittel
Shorea parvifolia	Seraya punai	SPUN	SNI	DLH	1	3	1	2	2	2	61	0	3.1
Shorea parvistipulata	Seraya lupah	SLUP	SLA	DLH	1	8	1	2	2	2	35	0	2
Shorea patoiensis	Seraya kuning pinang	SKPG	PN	DLH	4	6	2	6	6	6	38	0	
Shorea pauciflora	Oba suluk	OSUL	OS	DLH	1	5	1	2	2	2	69	0	4.6
Shorea pilosa	Kawang bulu	KWBL	KWB	DLH	1	11	1	2	2	2		0	
Shorea pinanga	Kawang pinang	KWPG	KWP	DLH	1	11	1	2	2	2	30	0	2.5
Shorea platycarpa	Seraya paya	SPAY	SYA	DLH	1	7	2	2	2	2	46	0	1.8
Shorea platyclodos	Seraya bukit	SBKT	SRI	DLH	1	5	1	2	2	2	55	0	5.5
Shorea polyandra	Seraya kuning quion	SKQN	SPQ	DLH	4	6	2	6	6	6		0	
Shorea quandrinervis	Seraya sudu	SSUD	SSU	DLH	1	9	1	2	2	2	38	0	
Shorea quiso	Selangan batu merah	SBMH	SBM	DHH	8	10	1	7	7	7	?	0	
Shorea retusa	Seraya daun tumpul	SDTU	SDU	DLH	1	3	1	2	2	2	30	0	1.7
Shorea revoluta	Seraya daun tajam	SBTA	SRT	DLH	1	7	2	2	2	2	32	0	2
Shorea rubra	Seraya bingkai	SBIN	SRK	DLH	1	8	1	2	2	2	groß	0	
Shorea rugosa	Seraya buaya hantu	SBHA	SRH	DLH	1	7	2	2	2	2		0	
Shorea scaberrima	Seraya mempelas	SMMP	SMP	DLH	1	11	1	2	2	2	35	0	2
Shorea scabrida	Seraya lop	SLOP	SLP	DLH	1	3	1	2	2	2	31	0	1.5
Shorea scrobiculata	Selangan batu kurap	SBKP	SBS	DHH	8	10	1	7	7	7	?	0	
Shorea seminis	Selangan batu terandak	SBTK	SBY	DHH	8	10	1	7	7	7	55	0	3.7
Shorea slooteni	Seraya kepong kasar	SKEK	SKG	DLH	1	11	1	2	2	2	40	0	2.5
Shorea smithiana	Seraya timbau	STIM	SBU	DLH	1	1	1	2	2	2	53	0	4.6
Shorea sp.	Kawang	KWNG	KW	DLH	1	11	1	2	2	2	mittel-groß	0	
Shorea sp. (Eushorea group)	Selangan batu	SBTU	SB	DHH	8	10	1	7	7	7	mittel-groß	0	
Shorea sp. (Richetia group)	Seraya kuning s.d. besar	SKUN	DLH	DLH	4	6	2	6	6	6	?	0	
Shorea sp. (Rubroshorea group)	Seraya	SRYA	SR	DLH	1	3	1	2	2	2	groß	0	
Shorea superba	Selangan b. daun halus	SBDH	SBH	DHH	8	10	1	7	7	7	63	0	4.6
Shorea symingtonii	Melapi kuning (bunga)	MEBG	MPK	DLH	3	2	1	2	2	2	61	0	4.6
Shorea teysmanniana	Seraya bunga	SBGA	SRG	DLH	1	7	2	2	2	2	groß	0	2.5
Shorea venulosa	Seraya kerangas	SKGS	SKA	DLH	1	5	1	2	2	2	60	0	
Shorea virescens	Melapi sulang salig	MSSG	MPS	DLH	3	2	1	2	2	2	64	0	5.5
Shorea waltonii	Seraya kelabu	SKBU	SKK	DLH	1	9	1	2	2	2	60	0	
Shorea xanthophylla	Seraya kuning barun	SKBA	SKU	DLH	4	6	2	6	6	6	26	0	
Sindora irpicina	Sepetir	SEPT	SPT	NDLH	11	14	1	9	9	9	30	0	2.5
Stemonurus corniculata	Samala	STCO	OTH	OTHR	13	14	1	15	15	15	39	0	1.8
Stemonurus scorpioides	Katok	KTOK	KTK	OTHR	13	14	1	15	15	15	33	0	1.5
Sterculia macrophylla	Kelumpang	KLPG	KPG	NDMH	13	16	2	9	9	9	36	0	1.5

SP_NAME	DIA	HMAX2	H4_2	DIFF_H4	DENSITY	HF4_CAN	HF4_N	LF4_MR	LF4	HF4	F4	C_SPHQ	DERA	DERA_W	DERA_%	D_MIN	D_MAX	FREQ	SOURCE
Shorea mecistopteryx	76.39	33.74	0	0	550	3	5	2	2	4	9	1	942	942	0.4347	11	114	1	2
Shorea multiflora	76.39	35.87	0	0	659	5	5	2	2	2	3	1	122	122	0.0563	22	90	2	2
Shorea myrionerva	85.94	35.36	0	0	610	3	5	2	2	4	9	1	0	0	0.0000	0	0	1	2
Shorea nebulosa	127.32	0.00	0	0	604	3	5	2	2	5	12	1	174	174	0.0803	14	114	2	2
Shorea obscura	79.58	45.86	0	0	922	5	5	2	2	4	9	1	137	137	0.0632	23	55		2
Shorea ochracea	0.00	0.00	0	0	539	3	5	2	2	5	12	1	100	100	0.0461	12	12	2	2
Shorea oleosa	0.00	0.00	0	0	478	3	5	2	2	5	12	1	1951	1951	0.9003	10	98		2
Shorea ovalis	117.77	0.00	0	0	509	3	5	2	2	5	12	1	840	840	0.3876	10	124	3	2
Shorea ovata		0.00	0	0	784	3	5	2	2	3	6	1	0	0	0.0000	0	0	2	2
Shorea parvifolia	98.68	36.80	0	0	468	3	5	2	2	5	12	1	3385	3385	1.5621	10	114	3	2
Shorea parvistipulata	63.66	30.89	0	0	499	3	5	2	2	4	9	1	0	0	0.0000	0	0	2	2
Shorea patoiensis	0.00	0.00	0	0		5	5	4	2	5	12	1	0	0	0.0000	0	0	1	2
Shorea pauciflora	146.42	0.00	0	0	675	3	5	2	2	5	12	1	358	358	0.1652	12	114	3	2,6
Shorea pilosa	0.00	0.00	0	0	409	3	5	2	2	5	12	1	609	609	0.2810	11	100	1	2
Shorea pinanga	79.58	34.33	0	0	419	3	5	2	2	4	9	1	1635	1635	0.7545	10	112	2	2
Shorea platycarpa	57.30	29.17	0	0	709	3	5	2	2	4	9	1	0	0	0.0000	0	0		2
Shorea platyclodos	175.07	0.00	0	0	736	3	5	2	2	5	12	1	25	25	0.0115	23	20	2	2
Shorea polyandra	0.00	0.00	0	0		5	5	2	2	5	12	1	0	0	0.0000	0	0	1	5
Shorea quandrinervis	0.00	0.00	0	0	569	3	5	2	2	5	12	1	0	0	0.0000	0	0	2	2
Shorea quiso	0.00	0.00	0	0		5	5	3	3	5	13	1	33	33	0.0152	29	97		1
Shorea retusa	54.11	28.23	0	0		3	5	2	2	4	9	1	0	0	0.0000	0	0	1	2
Shorea revoluta	63.66	30.89	0	0		3	5	2	2	4	9	1	0	0	0.0000	0	0	1	2
Shorea rubra	0.00	0.00	0	0	668	3	5	2	2	5	12	1	25	25	0.0115	37	34	1	2,5
Shorea rugosa	0.00	0.00	0	0	649	3	5	2	2	5	12	1	0	0	0.0000	0	0	1	2
Shorea scaberrima	63.66	30.89	0	0	549	3	5	2	2	4	9	1	0	0	0.0000	0	0	2	2
Shorea scabrida	47.75	26.20	0	0	558	3	5	2	2	4	9	1	0	0	0.0000	0	0	2	2
Shorea scrobiculata	0.00	0.00	0	0		5	5	4	3	5	13	1	0	0	0.0000	0	0		1
Shorea seminis	117.77	0.00	0	0	921	5	5	4	3	5	13	1	16	16	0.0074	40	67	2	2
Shorea slooteni	79.58	34.33	0	0		3	5	2	2	4	9	1	125	125	0.0577	14	17	1	2
Shorea smithiana	146.42	0.00	0	0	499	3	5	2	2	5	12	1	1532	1532	0.7070	11	126	3	2
Shorea sp.	0.00	0.00	0	0		3	5	2	2	5	12	1	702	702	0.3239	11	114		5
Shorea sp. (Eushorea group)	0.00	0.00	0	0		5	5	3	3	5	13	1	1454	1454	0.6710	10	147		5
Shorea sp. (Richetia group)	0.00	0.00	0	0		5	5	4	2	5	12	1	0	0	0.0000	0	0		1
Shorea sp. (Rubroshorea group)	0.00	0.00	0	0		3	5	2	2	5	12	1	792	792	0.3655	11	82	1	5
Shorea superba	146.42	0.00	0	0	581	5	5	3	3	5	13	1	194	194	0.0895	12	143	2	2
Shorea symingtonii	146.42	0.00	0	0	520	3	5	2	2	5	12	1	4	4	0.0018	58	58	2	2
Shorea teysmanniana	79.58	34.33	0	0	589	3	5	2	2	4	9	1	0	0	0.0000	0	0	2	2,5
Shorea venulosa	0.00	0.00	0	0	803	3	5	2	2	5	12	1	0	0	0.0000	0	0		2
Shorea virescens	175.07	0.00	0	0	499	3	5	4	2	5	12	1	8	8	0.0037	60	67	2	2
Shorea waltonii	0.00	0.00	0	0	428	3	5	2	2	5	12	1	262	262	0.1209	15	128		2
Shorea xanthophylla	0.00	0.00	0	0	654	5	5	2	2	4	9	1	1274	1274	0.5879	10	114	2	2
Sindora irpicina	79.58	28.52	0	0	598	2	4	4	2	4	9	1	369	369	0.1703	11	115	1	2
Stemonurus corniculata	57.30	23.43	3	0	1130	2	4	4	2	3	6	89	21805	245	0.1131	10	145	2	1,2
Stemonurus scorpioides	47.75	21.49	3	0	<1130	2	4	2	2	3	6	1	450	450	0.2077	11	17		1,2
Sterculia macrophylla	47.75	22.00	3	0	560	2	4	2	2	3	6	2	2561	1281	0.5909	10	131		1,2

SP_NAME	SP_LOCAL	SPC_CODE	SPCD_HQ	SP_TGRP	SP_GRP	SP_IN	F3	SP_VO	SP_HT	SPC_GRP	HMAX1	H4_1	GIRTH
Sympetalandra borneensis	Merbau lalat	MLAL	MBL	NDMH	11	19	1	15	15	15	22	3	2.4
Symplocos fasciculata	Jiak	JIAK	JAK	OTHR	13	14	1	15	15	15	15	2	0.4
Symplocos lateviridis	Poroi untu	SYMP	OTH	OTHR	13	14	1	15	15	15	21	3	
Symplocos polyandra	Mogkulat	SYMP	OTH	OTHR	13	14	1	15	15	15	?	0	
Symplocos sp.	Kemenyan	LOBO	LOBO	OTHR	13	14	1	15	15	15	bush & tree	1	
Symplocos sp.	Lobo	KEME	OTH	OTHR	13	14	1	15	15	15	bush & tree	1	
Tectona grandis	Jati	JATI	JTI	NDMH	11	18	4	15	15	15	groß	0	
Teijsmanniodendron sp.	Buak-buak	BUAK	BU	NDMH	13	16	2	15	15	15	klein	2	
Teijsmanniodendron sp.	Buak-buak jarietek	TEPT	BUJ	NDMH	13	16	2	15	15	15	klein	2	
Terminalia copelandii	Talisai paya	TECO	TLP	NDLH	11	15	1	15	15	8	groß	0	2.5
Terminalia sp.	Talisai	TALI	TLI	NDMH	11	18	4	15	15	8	groß	0	3
Tetramerista glabra	Tuyut	TUYT	TUY	NDLH	13	16	2	15	15	15		0	1.8
Thespesia populnea	Baru laut	THPO	BRL	OTHR	13	14	1	15	15	15	18	3	
Timonius flavescens	Tapai-tapai	TIFL	OTH	OTHR	13	14	1	15	15	15	10	2	
Toona sp.	Surian	TOON	SU	NDLH	11	18	4	15	15	15	30	0	2.1
Trema orientalis	Randagong	RAND	RAND	OTHR	13	14	1	15	15	14	27	0	2.1
Trigonopleura malayana	Gambir hutan	TRMA	GRH	NDLH	13	14	1	15	15	15	27	0	1.2
Tristania clementis	Pelawan-pelawan	PLWN	PP	NDMH	13	19	1	15	15	15	mittel	3	1.2
Unknown	Unknown	UNKN	OTH	OTHR	13	14	1	15	15	15		0	
Upuna borneensis	Upun	UPUN	UP	DLH	10	2	1	2	2	3	46	0	
Vatica albiramis	Resak putih	REPU	RBT	DHH	9	7	2	3	3	3	8	2	0.8
Vatica bancana	Resak banka	REBA	REBA	DHH	9	7	2	3	3	3	24	3	
Vatica dulitensis	Resak bukit	REBU	RBK	DHH	9	7	2	3	3	3	27	0	1.2
Vatica maritima	Resak laut	RELT	RBU	DHH	9	7	2	3	3	3	19	3	
Vatica oblongifolia	Resak daun panjang	REDP	RBP	DHH	9	7	2	3	3	3	31	0	
Vatica odorata	Resak biabas	REBI	RBS	DHH	9	7	2	3	3	3		0	1.6
Vatica sarawakensis	Resak sarawak	RESK	RBW	DHH	9	7	2	3	3	3	15.3	3	
Vatica sp.	Resak degong	RESA	RBD	DHH	9	7	2	3	3	3	klein-groß	3	
Vatica/cotylelobium sp.	Resak	RESA	RB	DHH	9	7	2	3	3	3	?	0	
Viburnum amplificatum	Ranuk	VIAM	OTH	OTHR	13	14	1	15	15	15	klein	2	
Vitex pubescens	Kulimpapa	KULI	KULI	NDHH	13	14	1	15	15	15	9.5	2	klein
Weinmannia blumei	Sumu-silan	WEBL	OTH	OTHR	13	14	1	15	15	15	12.2	2	0.6
Wendlandia dasythyrsa	Malitap bukit	WEDA	OTH	OTHR	13	14	1	15	15	15	klein	2	
Wetria macrophylla	Rambai hutan	WEMA	OTH	OTHR	13	14	1	15	15	15	klein	2	
Wikstroemia tenuiramis	Tindot	TIND	OTH	OTHR	13	14	1	15	15	15	klein	2	
Xanthophyllum sp.	Minyak beruk	XANT	MNY	NDMH	13	20	1	15	15	15	klein-groß	3	
Xanthophyllum sp.	Minyak beruk	XAEL	XAEL	OTHR	13	14	1	15	15	15	klein-groß	3	
Xerospermum sp.	Gurulau	OTHR	GU	NDMH	13	14	1	15	15	15	klein-mittel	3	
Xylosma sumatrana	Linau	XYSU	OTH	OTHR	13	14	1	15	15	15	18	3	
Zizyphus angustifolius	Monsit	MSIT	MST	NDLH	13	14	1	15	15	15	klein	2	
	Buah-buah	OTHR	BHN	OTHR	13	14	1	15	15	15		3	
		CEMP	CEMP	OTHR	13	14	1	15	15	15		0	
		DHHX	DHHX	DHH	8	10	1	7	7	15		0	
		DLHX	DLHX	DLH	1	3	1	2	2	15		0	
		DMHX	DMHX	DMH	5	5	1	4	4	15		0	

SP_NAME	DIA	HMAX2	H4_2	DIFF_H4	DENSITY	HF4_CAN	HF4_N	LF4_MR	LF4	HF4	F4	C_SPHQ	DERA	DERA_W	DERA_%	D_MIN	D_MAX	FREQ	SOURCE
Sympetalandra borneensis	76.39	26.06	0	0	680	2	4	2	2	3	6	1	412	412	0.1901	11	49	2	1,2
Symplocos fasciculata	12.73	10.84	2	0		2	4	1	1	2	2	1	600	600	0.2769	10	21	3	1
Symplocos lateviridis	0.00	0.00	0	0		2	4	4	2	3	6	89	21805	245	0.1131	10	145	1	1
Symplocos polyandra	0.00	0.00	0	0		2	4	4	2	3	6	89	21805	245	0.1131	10	145		1
Symplocos sp.	0.00	0.00	0	0		2	4	4	2	1	1	1	0	0	0.0000	0	0	3	1
Symplocos sp.	0.00	0.00	0	0		2	4	4	2	1	1	89	21805	245	0.1131	10	145	3	1
Tectona grandis	0.00	0.00	0	0	625	2	4	4	2	4	9	1	0	0	0.0000	0	0		5,6
Teijsmanniodendron sp.	0.00	0.00	0	0		2	4	2	2	2	3	1	791	791	0.3650	10	57	1	1
Teijsmanniodendron sp.	0.00	0.00	0	0		2	4	4	3	2	4	1	0	0	0.0000	0	0	1	1
Terminalia copelandii	79.58	40.84	0	0	430	4	5	4	2	5	12	1	0	0	0.0000	0	0	3	2,5
Terminalia sp.	95.49	42.20	0	0	730	4	5	4	2	5	12	1	174	174	0.0803	14	126	2	2,5
Tetramerista glabra	57.30	23.43	3	0	720	2	4	4	2	3	6	1	0	0	0.0000	0	0	2	2
Thespesia populnea	0.00	0.00	0	0		2	4	4	2	3	6	1	0	0	0.0000	0	0		1
Timonius flavescens	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145	1	1
Toona sp.	66.85	24.95	3	0	368	2	4	4	2	3	6	2	0	0	0.0000	0	0	3	1,2
Trema orientalis	66.85	41.73	0	0		4	5	4	2	4	9	1	4	4	0.0018	48	48	2	1
Trigonopleura malayana	38.20	19.14	3	0	mittel	2	4	4	2	3	6	1	0	0	0.0000	0	0		1
Tristania clementis	38.20	19.14	3	0		2	4	4	2	3	6	1	191	191	0.0881	11	65		2,5
Unknown	0.00	0.00	0	0		2	4	4	2	4	9	89	21805	245	0.1131	10	145		
Upuna borneensis	0.00	0.00	0	0	995	5	5	3	3	5	13	1	0	0	0.0000	0	0	1	2
Vatica albiramis	25.46	22.66	3	1	893	5	5	3	3	2	4	1	25	25	0.0115	24	27		2
Vatica bancana	0.00	0.00	0	0	768	5	5	3	3	3	7	1	0	0	0.0000	0	0	2	2
Vatica dulitensis	38.20	30.09	0	0	824	5	5	3	3	4	10	1	0	0	0.0000	0	0	2	2
Vatica maritima	0.00	0.00	0	0		5	5	3	3	3	7	1	0	0	0.0000	0	0	1	2
Vatica oblongifolia	0.00	0.00	0	0	858	5	5	3	3	4	10	1	4	4	0.0018	42	42	2	2
Vatica odorata	50.93	36.22	0	0		5	5	3	3	5	13	1	0	0	0.0000	0	0	1	2
Vatica sarawakensis	0.00	0.00	0	0		5	5	3	3	3	7	1	0	0	0.0000	0	0	1	2
Vatica sp.	0.00	0.00	0	0		5	5	3	3	4	10	1	0	0	0.0000	0	0		5
Vatica/cotylelobium sp.	0.00	0.00	0	0		5	5	3	3	4	10	1	2060	2060	0.9506	10	51		1
Viburnum amplificatum	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		5
Vitex pubescens		0.00	0	0	800	2	4	1	1	2	2	1	1448	1448	0.6682	10	114	3	2
Weinmannia blumei	19.10	13.19	2	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		1
Wendlandia dasythyrsa	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		5
Wetria macrophylla	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		5
Wikstroemia tenuiramis	0.00	0.00	0	0		2	4	4	3	2	4	89	21805	245	0.1131	10	145		5
Xanthophyllum sp.	0.00	0.00	0	0		2	4	2	2	3	6	1	1424	1424	0.6571	11	56		1
Xanthophyllum sp.	0.00	0.00	0	0		2	4	4	2	3	6	1	0	0	0.0000	0	0		1
Xerospermum sp.	0.00	0.00	0	0		2	4	4	2	3	6	1	0	0	0.0000	0	0		1
Xylosma sumatrana	0.00	0.00	0	0		2	4	4	2	3	6	89	21805	245	0.1131	10	145		2
Zizyphus angustifolius	0.00	0.00	0	0		2	4	4	2	2	3	1	0	0	0.0000	0	0		1
OTHR						2	4	4	2	3	6	1	125	125	0.0577	15	24		
CEMP						2	4	4	2	4	9	1	0	0	0.0000	0	0		
DHHX						2	4	4	3	4	10	1	0	0	0.0000	0	0		
DLHX						2	4	4	2	4	9	1	0	0	0.0000	0	0		
DMHX						2	4	4	2	4	9	1	0	0	0.0000	0	0		

SP_NAME	SP_LOCAL	SPC_CODE	SPCD_HQ	SP_TGRP	SP_GRP	SP_IN	F3	SP_VO	SP_HT	SPC_GRP	HMAX1	H4_1	GIRTH
		DURM	DURM	OTHR	13	14	1	15	15	15		0	
		EURO	EURO	OTHR	13	14	1	15	15	15		0	
		KARA	KARA	OTHR	13	14	1	15	15	15		0	
		KTUN	KTUN	OTHR	13	14	1	15	15	15		0	
		KURI	KURI	OTHR	13	14	1	15	15	15		0	
		MACX	MACX	MACA	13	14	1	15	15	15		0	
		MEDP	MEDP	OTHR	13	14	1	15	15	15		0	
		NDX	NDX	NDLH	11	14	1	15	15	15		0	
	Adarah	ADAR	OTH	OTHR	13	14	1	15	15	15		0	
		ANJA	OTH	OTHR	13	14	1	15	15	15		0	
		BNKL	OTH	OTHR	13	14	1	15	15	15		0	
		BRUN	OTH	OTHR	13	14	1	15	15	15		0	
		DARU	OTH	OTHR	13	14	1	15	15	15		0	
	Dryepetes	DRYP	OTH	OTHR	13	14	1	15	15	15		0	
		KUWG	OTH	OTHR	13	14	1	15	15	15		0	
		LPDA	OTH	OTHR	13	14	1	15	15	15		0	
		OTHX	OTHX	OTHR	13	14	1	15	15	15		0	
		PIOX	PIOX	PION	12	14	1	15	15	15		0	

SP_NAME	DIA	HMAX2	H4_2	DIFF_H4	DENSITY	HF4_CAN	HF4_N	LF4_MR	LF4	HF4	F4	C_SPHQ	DERA	DERA_W	DERA_%	D_MIN	D_MAX	FREQ	SOURCE
DURM						2	4	4	2	4	9	1	0	0	0.0000	0	0		
EURO						2	4	4	2	4	9	1	0	0	0.0000	0	0		
KARA						2	4	4	2	4	9	1	0	0	0.0000	0	0		
KTUN						2	4	4	2	4	9	1	0	0	0.0000	0	0		
KURI						2	4	4	2	4	9	1	0	0	0.0000	0	0		
MACX						2	4	1	1	4	8	1	0	0	0.0000	0	0		
MEDP						2	4	4	2	4	9	1	0	0	0.0000	0	0		
NDX						2	4	4	2	4	9	1	0	0	0.0000	0	0		
ADAR						2	4	4	2	4	9	89	21805	245	0.1131	10	145		
ANJA						2	4	4	2	4	9	89	21805	245	0.1131	10	145		
BNKL						2	4	4	2	4	9	89	21805	245	0.1131	10	145		
BRUN						2	4	4	2	4	9	89	21805	245	0.1131	10	145		
DARU						2	4	4	2	4	9	89	21805	245	0.1131	10	145		
DRYP						2	4	4	2	4	9	89	21805	245	0.1131	10	145		
KUWG						2	4	4	2	4	9	89	21805	245	0.1131	10	145		
LPDA						2	4	4	2	4	9	89	21805	245	0.1131	10	145		
OTHX						2	4	4	2	4	9	1	0	0	0.0000	0	0		
PIOX						2	4	1	1	4	8	1	0	0	0.0000	0	0		
														216702	100.00				

Appendix B: Correlation of regeneration and stand structure, grouping for FORMIX3 using the Deramakot inventory data

Legend:

FR	forest reserve (DERA: Deramakot; KALA: Kalabakan; LING: Lingkabau; ULU: Ulu Segama)
Reg_Grp	FORMIX3 group, for which regeneration is analyzed

selected filter variable: filters data out of the whole pool

Strat91	interpretation of aerial photographs (1: bad to 4: good site quality on 25ha basis)
BA_ALL	basal area of all tree (d❍10cm) [m^2/ha]
F_ALL	number of potential mother trees (d❍50cm) [1/ha]

linear correlation coefficient:

f(BA_GRP)	regeneration as function of basal area of the same group
f(F_GRP)	regeneration as function of mother trees of the same group
f(BA_ALL)	regeneration as function of whole basal area
f(F_ALL)	regeneration as function of all mother trees

second order: P-value: This order of regression is suitable, if P-value is <0.1.

q(BA_GRP)	regeneration as function of basal area of the same group
q(F_GRP)	regeneration as function of mother trees of the same group
q(BA_ALL)	regeneration as function of whole basal area
q(F_ALL)	regeneration as function of all mother trees

	selected filter variable				linear: correlation coefficient				square: P-value of second order			
FR	Reg_Grp	Strat91	BA_ALL	F_ALL	f(BA_GRP)	f(F_GRP)	f(BA_ALL)	f(F_ALL)	q(BA_GRP)	q(F_GRP)	q(BA_ALL)	q(F_ALL)
DERA	1	-	-	-	0.23	0.15	0.27	0.13	0.18	0.84	0.09	0.62
DERA	1	1	-	-	0.23	0.11	0.27	0.11	0.38	0.27	0.29	0.64
DERA	1	2	-	-	0.08	0.04	0.13	0.05	0.27	0.65	0.34	0.96
DERA	1	3	-	-	0.21	0.11	0.22	0.07	0.24	0.63	0.48	0.17
DERA	1	4	-	-	0.53	0.45	0.47	0.34	0.39	0.87	0.003	0.6
DERA	1	-	0-20	-	0.13	0.1	0.19	0.04	0.12	0.07	0.5	0.1
DERA	1	-	20-30	-	-0.04	-0.04	0.09	-0.08	0.31	0.17	0.05	0.3
DERA	1	-	30-40	-	0.11	0.14	0.13	0.07	0.6	0.93	0.61	0.04

FR	Reg_Grp	Strat91	BA_ALL	F_ALL	f(BA_GRP)	f(F_GRP)	f(BA_ALL)	f(F_ALL)	q(BA_GRP)	q(F_GRP)	q(BA_ALL)	q(F_ALL)
DERA	1	-	40+	-	0.06	-0.14	-0.17	-0.07	0.39	0.43	0.94	0.5
DERA	1	-	-	0-10	0.25	0.17	0.35	0.18	0.91	0.29	0.66	0.81
DERA	1	-	-	10-20	0.16	0.1	0.26	0.04	0.02	0.28	0.01	1
DERA	1	-	-	20-30	0.18	0.11	0.21	0.13	0.75	0.52	0.56	0.38
DERA	1	-	-	30-40	0.19	-0.12	0.39	0.36	0.42	0.68	0.24	1
DERA	1	-	-	40+	0.07	0.28	0.35	0.29	0.65	0.66	0.24	0.61
DERA	2	-	-	-	0.23	0.1	0.26	0.21	0.96	0.16	0.45	0.31
DERA	2	1	-	-	0.2	0.08	0.27	0.2	0.2	0.27	0.16	0.27
DERA	2	2	-	-	0.13	0.008	0.16	0.19	1	0.22	0.96	0.82
DERA	2	3	-	-	0.12	-0.02	0.13	-0.01	0.4	0.19	0.2	0.35
DERA	2	4	-	-	0.41	0.2	0.45	0.3	0.83	0.5	0.51	0.68
DERA	2	-	0-20	-	0.16	0.04	0.13	0.06	0.12	0.46	0.4	0.03
DERA	2	-	20-30	-	0.09	0.007	0.15	0.18	0.87	0.1	0.52	0.19
DERA	2	-	30-40	-	0.18	0.12	0.24	-0.01	0.42	0.58	0.52	0.14
DERA	2	-	40+	-	0.17	-0.29	-0.04	0.12	0.89	0.65	0.11	0.44
DERA	2	-	-	0-10	0.25	0.13	0.24	0.23	0.15	0.48	0.15	0.59
DERA	2	-	-	10-20	0.06	-0.04	0.14	0.03	0.17	0.44	0.38	1
DERA	2	-	-	20-30	0.02	-0.09	0.14	-0.001	0.41	0.16	0.1	0.02
DERA	2	-	-	30-40	0.51	0.29	0.28	0.13	0.03	0.94	0.29	1
DERA	2	-	-	40+	0.03	-0.27	0.05	-0.001	0.29	0.88	0.02	0.13
DERA	3	-	-	-	-0.04	0.02	-0.03	0.02	0.52	0.66	0.48	0.16
DERA	3	1	-	-	-0.05	-0.01	0.02	0.09	0.93	0.47	0.13	0.07
DERA	3	2	-	-	-0.03	0.06	-0.1	-0.13	0.39	0.09	0.98	0.82
DERA	3	3	-	-	0.03	0.03	-0.23	-0.12	0.36	0.33	0.13	0.74
DERA	3	4	-	-	-0.07	-0.04	-0.11	0.04	0.71	1	0.98	0.34
DERA	3	-	0-20	-	-0.05	0.005	0.04	0.09	0.97	0.44	0.5	0.21
DERA	3	-	20-30	-	-0.03	0.07	0.007	-0.001	0.36	0.13	0.19	0.36
DERA	3	-	30-40	-	-0.04	-0.02	-0.07	0.13	0.48	0.78	0.31	0.37
DERA	3	-	40+	-	0	0	0	0	1	1	1	1
DERA	3	-	-	0-10	-0.01	0.17	-0.03	0.11	0.97	1	0.51	0.98
DERA	3	-	-	10-20	-0.06	0.06	-0.13	0.05	0.49	0.83	0.9	1
DERA	3	-	-	20-30	-0.03	-0.05	-0.01	0.09	0.56	0.94	0.43	0.83
DERA	3	-	-	30-40	-0.06	-0.03	0.07	0.11	0.65	0.78	0.55	1
DERA	3	-	-	40+	-0.15	-0.1	-0.13	-0.11	0.65	0.85	0.44	0.96

FR	Reg_Grp	Strat91	BA_ALL	F_ALL	f(BA_GRP)	f(F_GRP)	f(BA_ALL)	f(F_ALL)	q(BA_GRP)	q(F_GRP)	q(BA_ALL)	q(F_ALL)
DERA	4	-	-	-	0.19	0.13	0.2	0.1	0.92	0.004	0.03	0.33
DERA	4	1	-	-	0.17	0.08	0.19	0.08	0.75	0.17	0.08	0.006
DERA	4	2	-	-	0.31	0.25	0.19	0.1	0.42	0.0005	0.03	0.27
DERA	4	3	-	-	0.14	0.13	0.27	0.11	0.66	0.28	0.85	0.75
DERA	4	4	-	-	0.32	0.38	0.58	0.44	0.86	0.99	0.64	0.75
DERA	4	-	0-20	-	0.06	-0.07	0.15	0.07	0.8	0.93	0.57	0.16
DERA	4	-	20-30	-	0.21	0.16	-0.04	-0.07	0.47	0.002	0.43	0.23
DERA	4	-	30-40	-	0.12	0	-0.08	-0.06	0.86	0.16	0.5	0.77
DERA	4	-	40+	-	0.12	0.47	-0.11	-0.15	0.27	0.8	0.11	0.96
DERA	4	-	-	0-10	0.06	-0.07	0.32	0.15	0.75	0.49	0.14	0.67
DERA	4	-	-	10-20	0.24	-0.1	0.23	-0.08	0.92	0.98	0.01	1
DERA	4	-	-	20-30	0.05	0.07	0.09	-0.01	0.63	0.26	0.38	0.43
DERA	4	-	-	30-40	0.42	0.49	0.34	0.31	0.12	0.79	0.72	1
DERA	4	-	-	40+	0.38	0.41	-0.22	0.07	0.85	0.22	0.03	0.96
DERA	all	-	-	-			0.33	0.19			0.04	0.88
DERA	all	1	-	-			0.33	0.15			0.1	0.21
DERA	all	2	-	-			0.18	0.11			0.28	0.93
DERA	all	3	-	-			0.24	0.07			0.33	0.49
DERA	all	4	-	-			0.62	0.45			0.05	0.48
DERA	all	-	0-20	-			0.21	0.06			0.48	0.03
DERA	all	-	20-30	-			0.11	-0.03			0.05	0.14
DERA	all	-	30-40	-			0.18	0.06			0.92	0.3
DERA	all	-	40+	-			-0.16	-0.03			0.3	0.86
DERA	all	-	-	0-10			0.4	0.23			0.86	0.91
DERA	all	-	-	10-20			0.28	0.03			0.01	1
DERA	all	-	-	20-30			0.22	0.09			0.57	0.14
DERA	all	-	-	30-40			0.45	0.37			0.16	1
DERA	all	-	-	40+			0.02	0.24			0.55	0.75

Appendix C: Regeneration (h≥1.5m, d<10cm) for FORMIX3 groups in Deramakot Forest Reserve

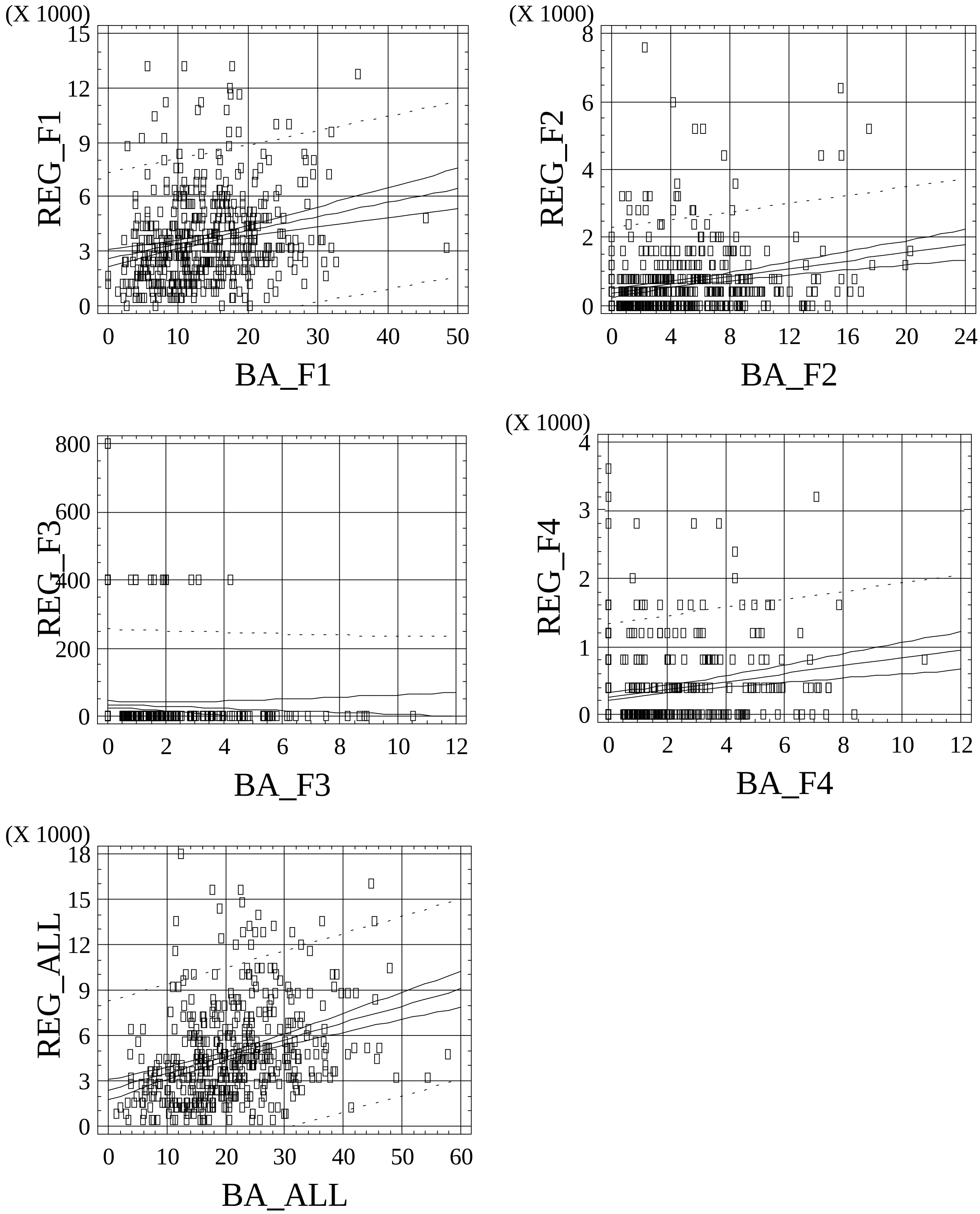

Figure C.1: Regeneration [1/ha] for different groups, incl. linear regression:

a: group1 as a function of basal area of group 1 [m^2/ha]
b: group2 as a function of basal area of group 2 [m^2/ha]
c: group3 as a function of basal area of group 3 [m^2/ha]
d: group4 as a function of basal area of group 4 [m^2/ha]
e: all groups as a function of total basal area [m^2/ha]

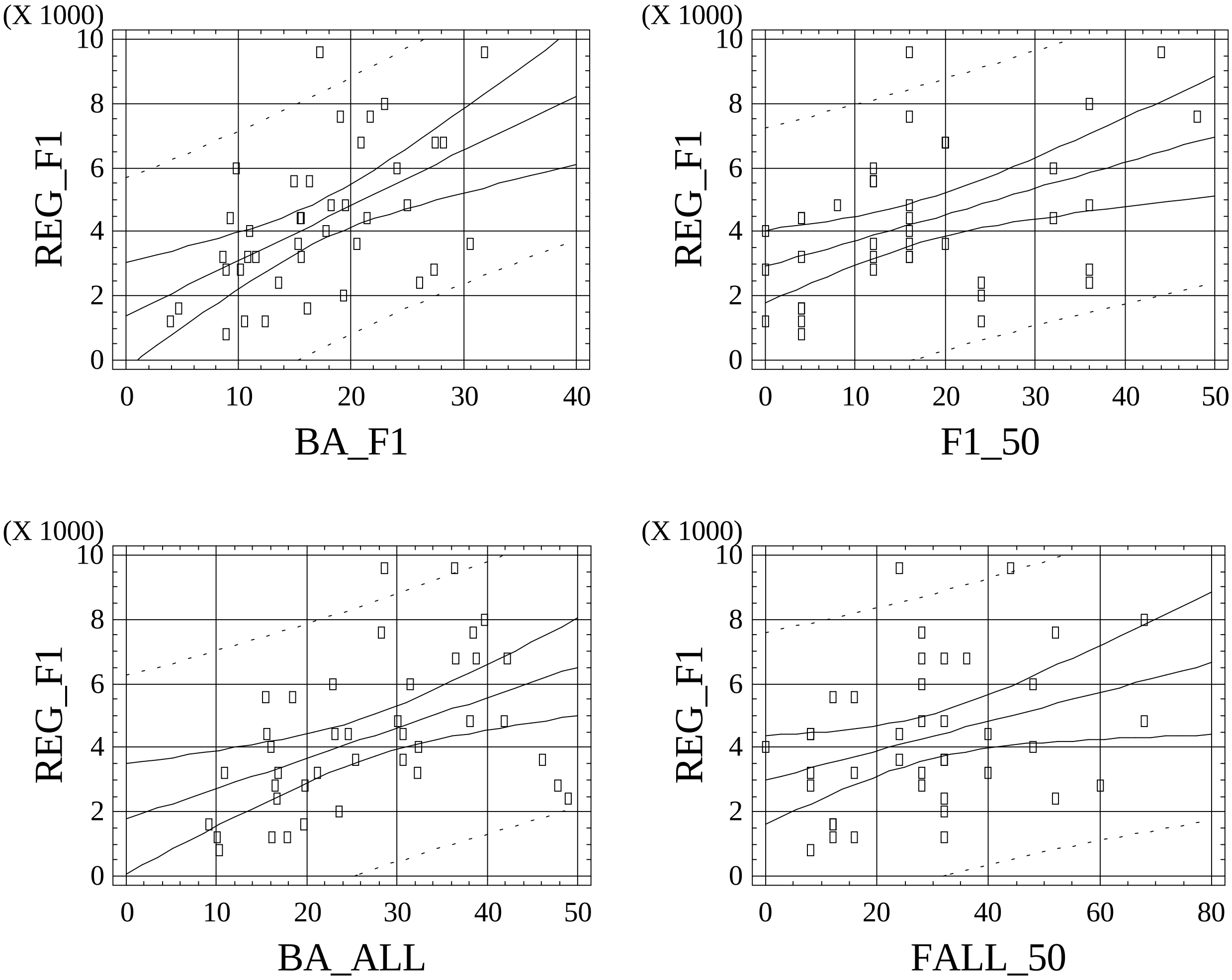

Figure C.2: Regeneration [1/ha] of group 1 incl. linear regression for Stratum91=4 (good quality) as a function of

a: basal area of group 1 [m²/ha]

b: number of mother trees (d>=50cm) of group 1 [1/ha]

c: total basal area [m²/ha]

d: total number of emergent trees (d>=50cm) [1/ha]

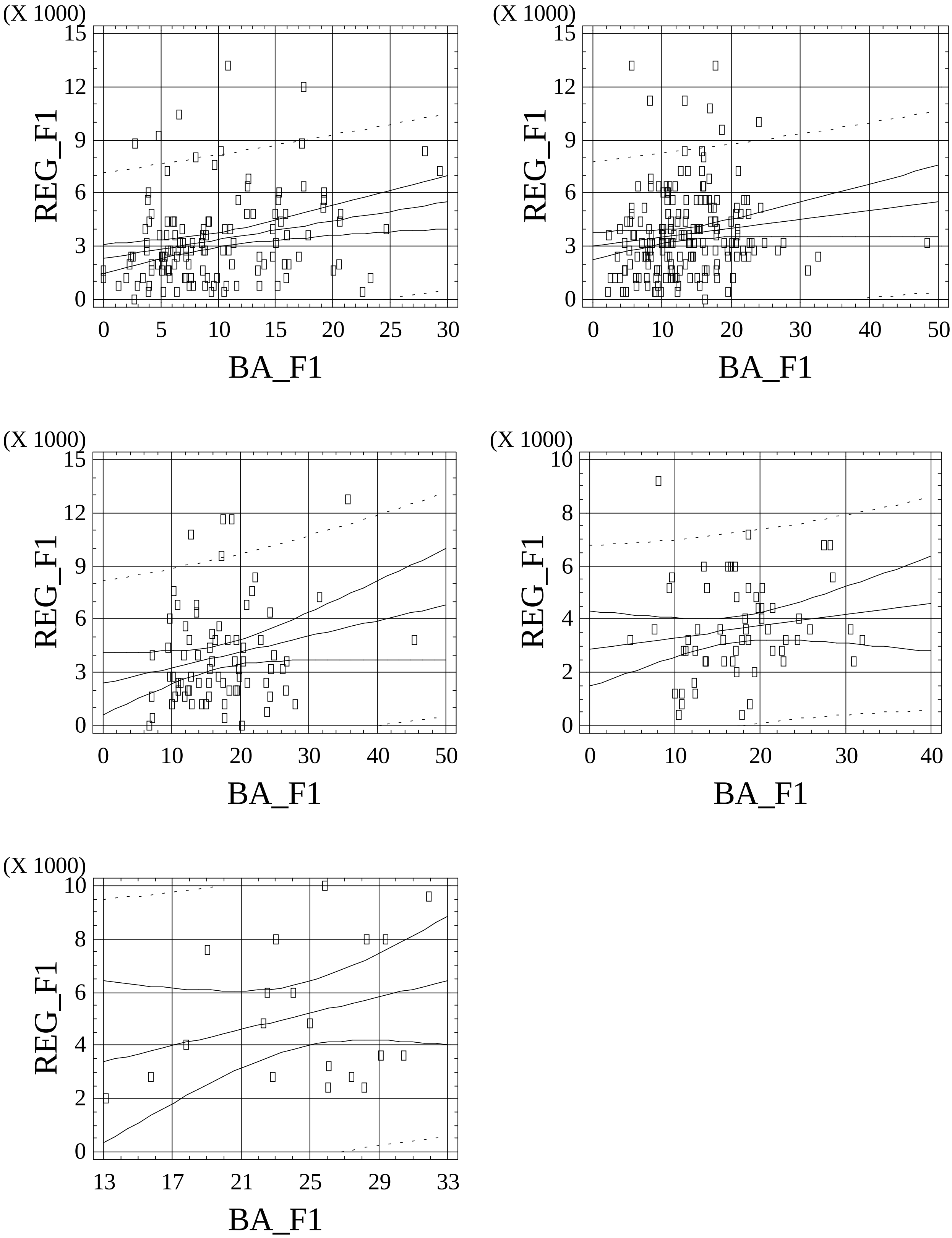

Figure C.3: Regeneration [1/ha] of group 1 as a function of basal area [m²/ha] of group 1, incl. linear regressnio, data filtered as:

a: number of emergent trees 0-10 1/ha
b: number of emergent trees 11-20 1/ha
c: number of emergent trees 21-30 1/ha
d: number of emergent trees 31-40 1/ha
e: number of emergent trees 41+ 1/ha

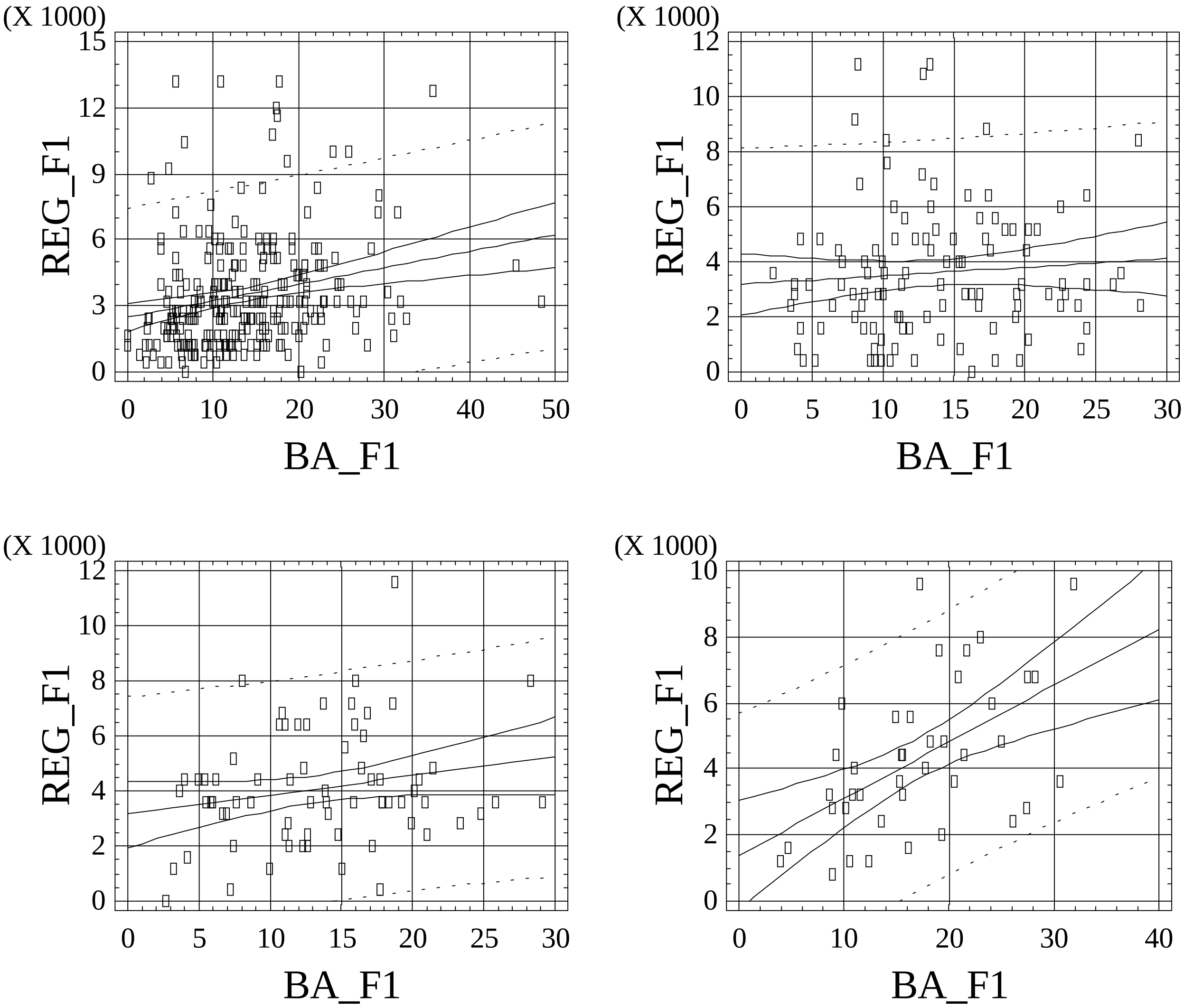

Figure C.4: Regeneration [1/ha] of group 1 as a function of basal area [m²/ha] of group 1, incl. linear regression, data filtered as:

a: Stratum91=1 (0-4 emergents per ha)
b: Stratum91=2 (5-7 emergents per ha)
c: Stratum91=3 (8-15 emergents per ha)
d: Stratum91=4 (16+ emergents per ha)

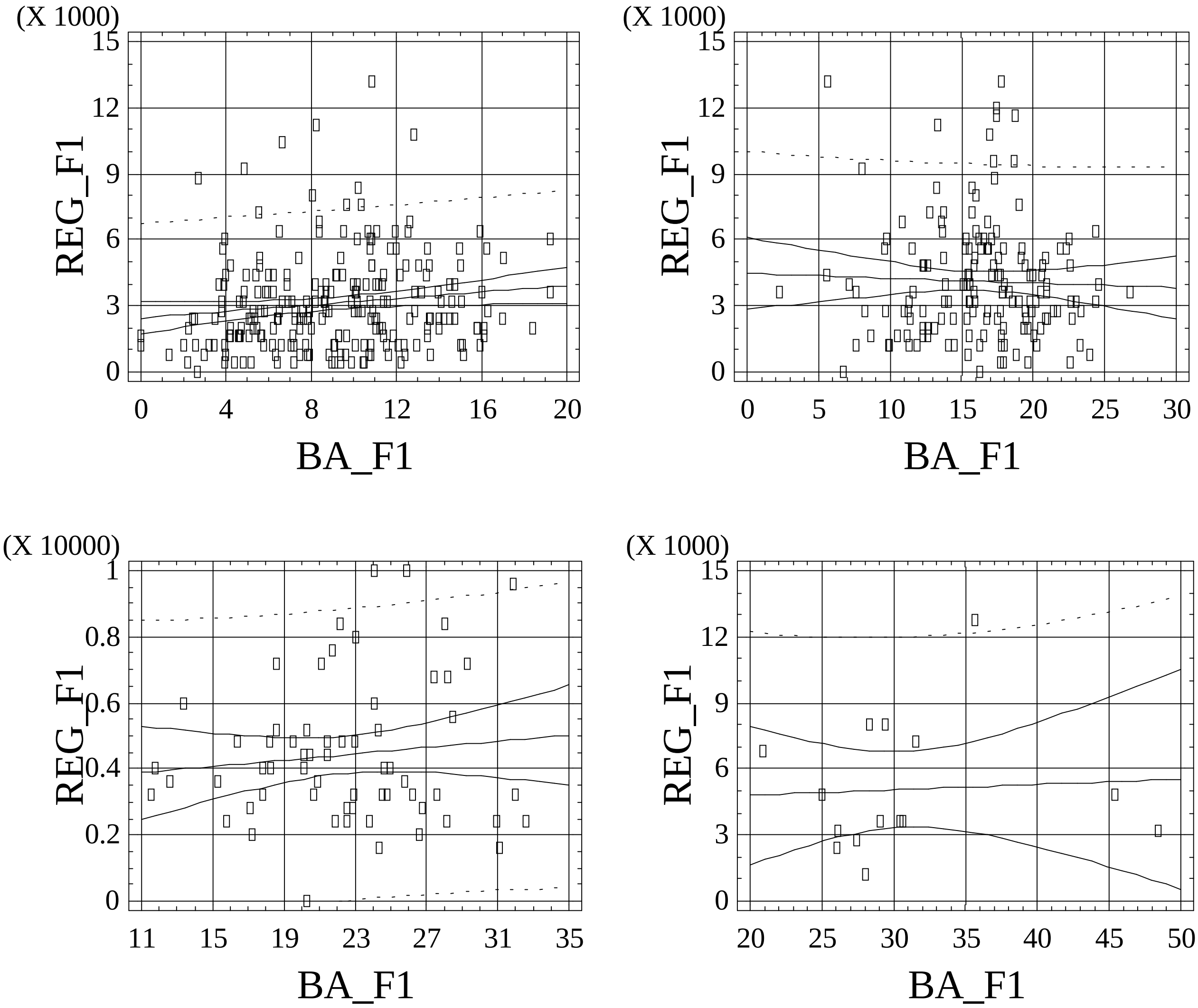

Figure C.5: Regeneration [1/ha] of group 1 as a function of basal area [m²/ha] of group 1, incl. linear regression, data filtered as:

a: total basal area [m²/ha] ∈ [0,20] m²/ha
b: total basal area [m²/ha] ∈ (20,30] m²/ha
c: total basal area [m²/ha] ∈ (30,40] m²/ha
d: total basal area [m²/ha] ∈ (40+) m²/ha

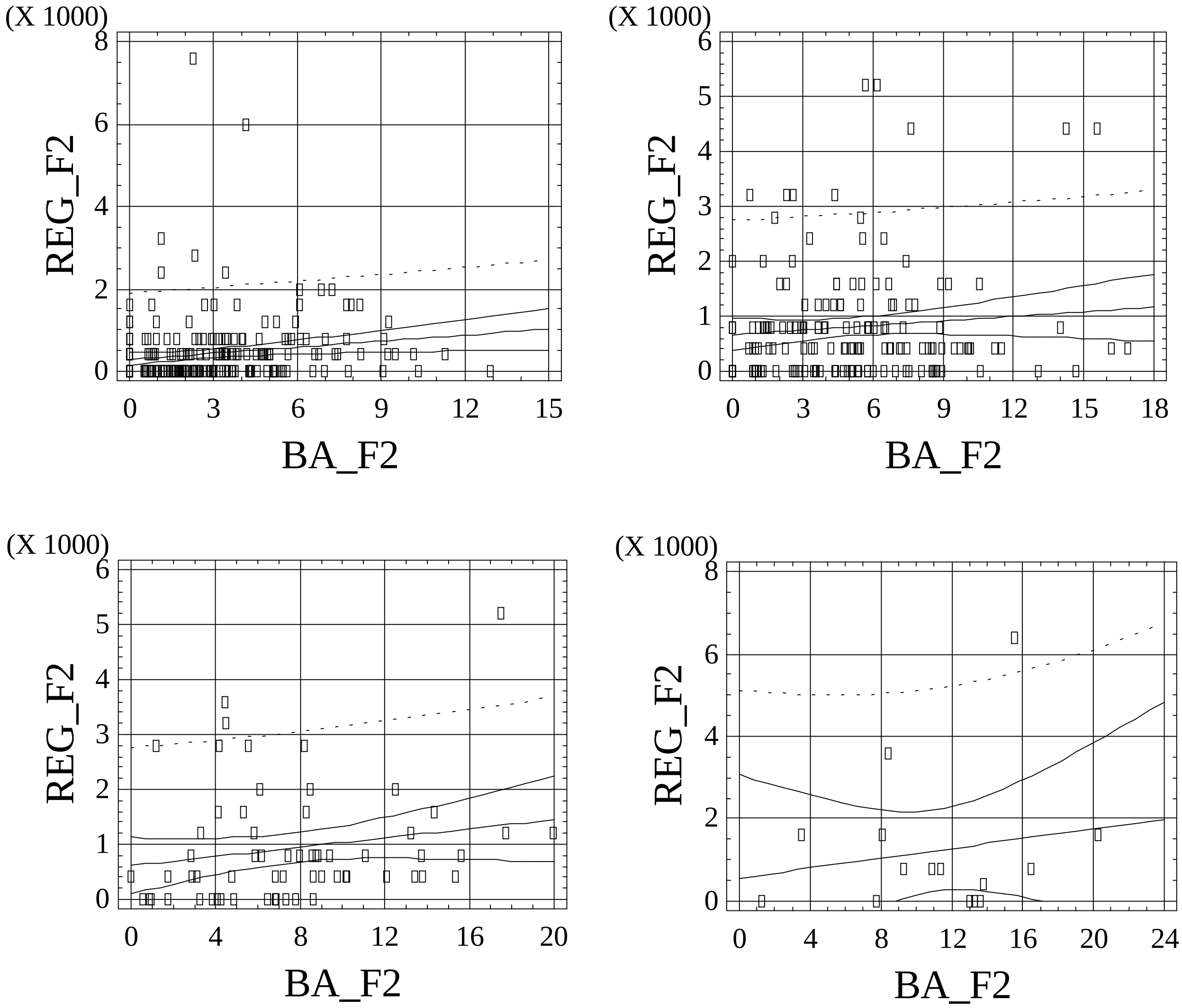

Figure C.6: Regeneration [1/ha] of group 2 as a function of basal area [m²/ha] of group 2, incl. linear regression, data filtered as:

a: total basal area [m²/ha] ∈ [0,20] m²/ha

b: total basal area [m²/ha] ∈ (20,30] m²/ha

c: total basal area [m²/ha] ∈ (30,40] m²/ha

d: total basal area [m²/ha] ∈ (40+) m²/ha

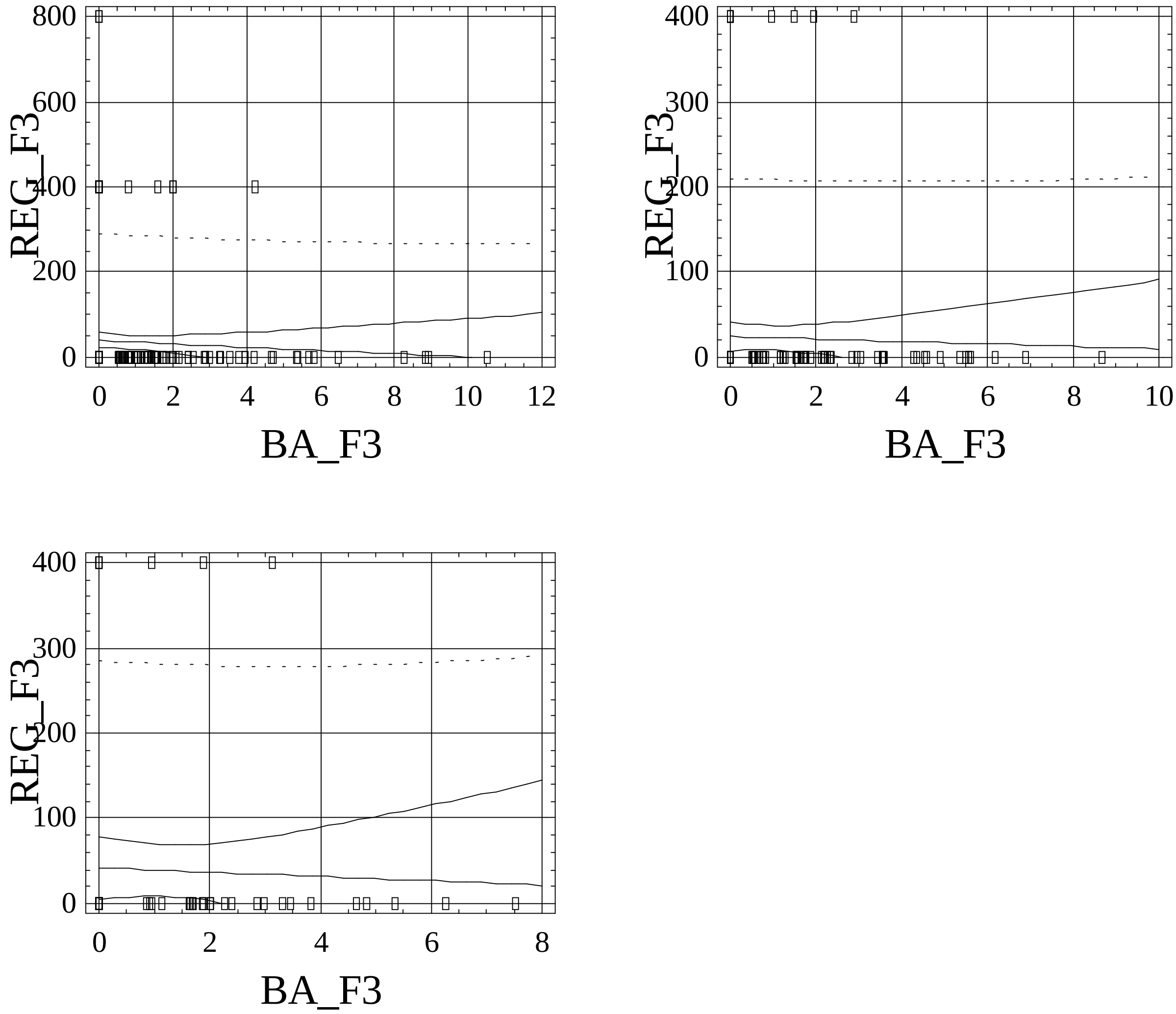

Figure C.7: Regeneration [1/ha] of group 3 as a function of basal area [m²/ha] of group 3, incl. linear regression, data filtered as:

a: total basal area [m²/ha] ∈ [0,20] m²/ha

b: total basal area [m²/ha] ∈ (20,30] m²/ha

c: total basal area [m²/ha] ∈ (30,40] m²/ha

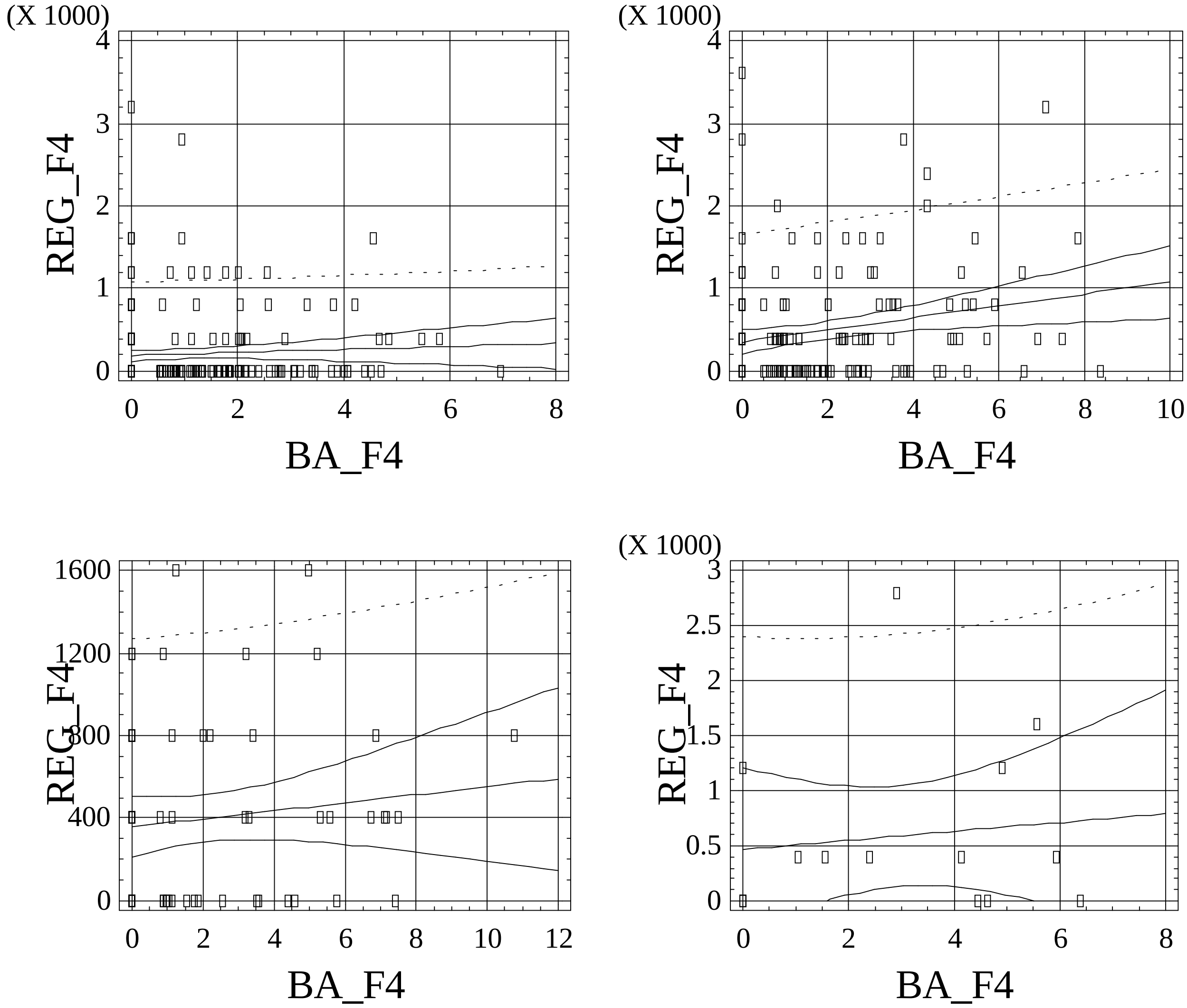

Figure C.8: Regeneration [1/ha] of group 4 as a function of basal area [m²/ha] of group 4, incl. linear regression, data filtered as:

a: total basal area [m²/ha] ∈ [0,20] m²/ha
b: total basal area [m²/ha] ∈ (20,30] m²/ha
c: total basal area [m²/ha] ∈ (30,40] m²/ha
d: total basal area [m²/ha] ∈ (40+) m²/ha

Appendix D: Stem diameter distributions for PSP

In the following tables the stem diameter distribution for different functional groups (FORMIX3 and FORMIX4 grouping) for the first year of inventory are documented. ‘Unknown’ refers to trees, which appear with a species code which is not included in the species list (Appendix A).

Garinono

	FORMIX3 groups				FORMIX4 groups													
Diameter class [cm]	1	2	3	4	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
000-005	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
005-010	30	0	0	4	0	0	0	3	0	2	0	0	0	3	0	26	0	34
010-015	193	30	16	19	16	2	23	30	12	29	1	6	25	10	29	75	0	258
015-020	122	11	41	7	24	1	21	14	8	12	0	3	12	2	47	37	0	181
020-025	72	5	26	8	17	0	7	3	11	8	0	8	7	3	28	19	0	111
025-030	53	6	18	3	13	1	9	5	5	5	0	1	6	0	19	16	0	80
030-035	25	1	10	3	6	0	1	0	9	2	0	0	1	1	10	8	1	39
035-040	22	1	16	3	1	0	0	0	10	1	0	3	1	1	16	9	0	42
040-045	10	0	16	1	0	0	0	0	4	2	0	0	0	0	16	5	0	27
045-050	11	0	10	0	0	0	0	0	6	0	0	0	0	0	10	5	0	21
050-055	15	1	5	0	1	0	0	0	11	1	0	0	1	0	5	2	0	21
055-060	7	0	10	0	0	0	0	0	6	0	0	0	0	0	10	1	0	17
060-065	6	0	6	1	0	0	0	0	2	0	0	0	0	1	6	4	0	13
065-070	3	0	6	0	0	0	0	0	0	0	0	0	0	0	6	3	0	9
70+	6	0	11	0	0	0	0	0	2	0	0	0	0	0	11	4	0	17
Total	576	55	191	49	78	4	61	55	86	62	1	21	53	21	213	215	1	871

Gunung Rara

	FORMIX3 groups					FORMIX4 groups														
Diameter class [cm]	1	2	3	4	unknown	1	2	3	4	5	6	7	8	9	10	11	12	13	unknown	Total
000-005	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	6
005-010	206	2	1	4	0	0	0	1	4	1	0	0	0	6	0	0	199	2	0	213
010-015	847	78	293	235	1	15	0	86	123	294	61	0	5	326	10	41	482	10	1	1454
015-020	546	58	485	188	1	8	5	55	63	473	41	0	6	264	7	43	298	14	1	1278
020-025	259	28	476	98	1	0	0	23	29	449	10	0	2	145	2	33	159	9	1	862
025-030	150	26	344	36	0	0	0	12	10	308	12	0	3	66	0	42	97	6	0	556
030-035	84	20	159	23	1	0	0	5	3	135	7	0	0	48	0	27	59	2	1	287
035-040	56	7	71	18	0	0	0	4	5	58	1	0	0	25	0	14	42	3	0	152
040-045	35	6	14	4	0	0	1	2	0	9	4	0	0	10	0	7	24	2	0	59
045-050	32	5	7	6	0	0	1	1	0	2	2	0	0	11	0	6	26	1	0	50
050-055	17	1	4	1	0	0	0	1	0	0	1	0	0	4	0	4	12	1	0	23
055-060	11	4	0	2	0	0	0	0	0	0	0	0	0	3	0	0	14	0	0	17
060-065	8	2	1	0	0	0	0	0	0	0	0	0	0	0	0	1	9	1	0	11
065-070	5	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	6	0	0	7
70+	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3
Total	2265	238	1855	616	4	23	7	190	237	1729	139	0	16	909	19	218	1436	51	4	4978

Segaliud Lokan1

	FORMIX3 groups					FORMIX4 groups														
Diameter class [cm]	1	2	3	4	unknown	1	2	3	4	5	6	7	8	9	10	11	12	13	unknown	Total
05-10	53	5	1	3	0	0	0	5	4	0	2	0	0	4	1	2	44	0	0	62
10-15	921	108	82	152	21	18	6	144	102	17	86	0	35	230	18	147	458	2	21	1284
15-20	683	79	77	79	3	31	1	86	83	59	58	0	24	134	2	64	375	1	3	921
20-25	463	42	80	42	3	42	0	36	26	65	24	0	8	74	1	26	325	0	3	630
25-30	286	21	115	17	1	28	0	15	8	98	6	0	6	36	0	31	211	0	1	440
30-35	216	11	95	7	0	15	0	7	5	70	2	0	1	21	0	33	175	0	0	329
35-40	132	7	82	4	2	5	0	3	1	49	0	0	3	13	0	38	113	0	2	227
40-45	80	4	64	5	0	2	0	2	1	26	2	0	2	10	0	42	66	0	0	153
45-50	47	3	41	2	0	0	0	2	0	14	0	0	0	8	0	29	40	0	0	93
50-55	21	1	18	3	0	0	0	0	0	6	0	0	0	4	0	15	18	0	0	43
55-60	9	2	5	2	0	0	0	0	0	0	0	0	2	2	0	5	9	0	0	18
60-65	19	1	1	1	0	0	0	2	0	1	0	0	0	2	0	1	15	1	0	22
65-70	9	0	3	0	0	0	0	0	0	0	0	0	0	1	0	3	8	0	0	12
70+	18	3	2	1	0	0	0	1	0	0	0	0	0	1	0	2	20	0	0	24
Total	2957	287	666	318	30	141	7	303	230	405	180	0	81	540	22	438	1877	4	30	4258

Segaliud Lokan2

	FORMIX3 groups						FORMIX4 groups														
Diameter class [cm]	1	2	3	4	unknown		1	2	3	4	5	6	7	8	9	10	11	12	13	unknown	Total
005-010	20	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	19	1	0	20
010-015	39	6	26	10	0		0	2	4	4	22	8	0	1	10	1	4	25	0	0	81
015-020	48	1	54	4	1		1	2	1	4	40	3	0	6	5	1	14	30	0	1	108
020-025	11	1	49	2	0		0	0	1	3	32	0	0	0	5	1	17	4	0	0	63
025-030	9	0	39	2	0		0	0	1	0	24	2	0	0	2	0	15	6	0	0	50
030-035	2	1	22	0	0		0	0	0	1	8	0	0	0	1	0	14	1	0	0	25
035-040	0	0	8	1	0		0	0	0	0	3	0	0	0	0	1	5	0	0	0	9
040-045	2	1	1	0	0		0	0	0	0	1	2	0	1	0	0	0	0	0	0	4
045-050	1	0	0	0	0		0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
050-055	1	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
055-060	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
060-065	0	0	0	2	0		0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
065-070	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
70+	0	0	0	1	0		0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Total	133	10	199	22	1		1	4	7	12	130	16	0	8	23	7	69	86	1	1	365

Sepilok

	FORMIX3 groups					FORMIX4 groups														
Diameter class [cm]	1	2	3	4	unknown	1	2	3	4	5	6	7	8	9	10	11	12	13	unknown	Total
005-010	123	8	0	5	1	3	3	4	20	0	7	0	0	8	1	2	87	1	1	137
010-015	831	68	20	35	2	56	16	68	154	31	67	1	6	86	11	16	439	3	2	956
015-020	415	38	15	34	5	27	9	38	60	23	45	0	3	73	8	5	210	1	5	507
020-025	178	19	7	15	3	11	10	13	12	12	23	0	2	30	1	4	100	1	3	222
025-030	74	17	5	7	1	4	8	5	0	8	10	0	0	19	0	3	45	1	1	104
030-035	52	14	7	2	1	1	5	5	3	7	6	0	2	10	0	5	31	0	1	76
035-040	33	7	3	6	1	1	0	3	2	4	6	0	0	5	1	2	24	1	1	50
040-045	26	2	1	2	0	0	0	1	1	2	3	0	0	6	0	1	17	0	0	31
045-050	20	1	1	2	0	0	0	0	0	1	1	0	1	1	1	1	18	0	0	24
050-055	19	0	1	1	0	0	0	0	1	0	1	0	0	1	0	1	17	0	0	21
055-060	21	0	0	2	0	0	0	0	1	1	0	0	0	2	0	0	19	0	0	23
060-065	13	0	0	3	0	0	0	0	0	0	1	0	0	1	1	0	13	0	0	16
065-070	16	1	4	0	0	0	0	1	0	0	0	0	0	2	0	3	15	0	0	21
70+	27	1	1	0	1	0	0	0	0	0	0	0	0	1	0	1	27	0	1	30
Total	1848	176	65	114	15	103	51	138	254	89	170	1	14	245	24	44	1062	8	15	2218

Appendix E: Detailed listing of mortality rates as a function of species groups

Comparision of tree mortality in different species groups. χ^2-tests are based on expected values from the total mortality of all species pooled.

Garinono

FORMIX3 group	Trees in 1973	Death in 1982	Mortality rate [%/a]	χ^2	P
1	576	112	2.40	0.625	>0.1
2	55	3	0.62	7.848	<0.01
3	191	56	3.86	8.459	<0.005
4	49	10	2.54	0.004	>0.9
unknown	-	-	-	-	-
Total	871	181	2.59		

FORMIX4 group	Trees in 1973	Death in 1982	Mortality rate [%/a]	χ^2	P
1	137	36	3.3873	2.514	>0.1
2	0	0	-	-	-
3	13	3	2.9152	0.042	>0.5
4	55	13	2.9963	0.272	>0.5
5	86	26	4	4.667	>0.1
6	93	12	1.535	3.506	<0.1
7	3	1	4.5052	0.287	>0.5
8	126	25	2.4573	0.068	>0.5
9	67	9	1.6028	2.197	>0.1
10	15	2	1.59	0.505	>0.1
11	108	41	5.3049	19.33	<0.001
12	167	13	0.9005	17.12	<0.001
13	1	0	0	0.262	>0.5
unknown	-	-	-	-	-
Total	871	181	2.59		

Light group	Trees in 1973	Death in 1982	Mortality rate [%/a]	χ^2	P
1	320	92	3.77	12.34	<0.001
2	477	73	1.85	8.691	<0.001
3	74	16	2.70	0.032	>0.5
unknown	-	-	-	-	-
Total	871	181	2.59		

Height group	Trees in 1973	Death in 1982	Mortality rate [%/a]	χ^2	P
1	137	36	3.38	2.514	>0.1
2	68	16	2.98	0.312	>0.5
3	182	39	2.68	0.046	>0.5
4	208	36	2.11	1.524	>0.1
5	276	54	2.42	0.248	>0.5
unknown	-	-	-	-	-
Total	871	181	2.59		

Gunung Rara

FORMIX3 group	Trees in 1981	Death in 1990	Mortality rate [%/a]	χ^2	P
1	2265	69	0.31	8.204	<0.005
2	238	6	0.26	0.139	>0.5
3	1855	23	0.12	7.553	<0.01
4	616	10	0.16	0.866	>0.1
unknown	4	0	0.00	0.089	>0.5
Total	4978	108	0.22		

FORMIX4 group	Trees in 1981	Death in 1990	Mortality rate [%/a]	χ^2	P
1	228	3	0.15	0.783	>0.1
2	0	0	-	-	-
3	34	1	0.33	0.0954	>0.5
4	208	6	0.33	0.5011	>0.1
5	1734	20	0.13	8.4355	<0.005
6	192	4	0.23	0.0067	>0.9
7	7	0	0	0.1552	>0.5
8	222	7	0.36	1.0119	>0.1
9	1066	30	0.32	2.0876	>0.1
10	73	0	0	1.6189	>0.1
11	12	0	0	0.2661	>0.5
12	1147	37	0.36	6.0292	<0.05
13	51	0	0	1.131	>0.1
unknown	4	0	0.00	0.0887	>0.5
Total	4978	108	0.22		

Light group	Trees in 1981	Death in 1990	Mortality rate [%/a]	χ^2	P
1	1968	27	0.15	5.8986	>0.01
2	2667	75	0.32	5.1888	>0.01
3	339	6	0.20	0.2551	>0.5
unknown	4	0	0	0.0887	>0.5
Total	4978	108	0.2437		

Height group	Trees in 1981	Death in 1990	Mortality rate [%/a]	χ^2	P
1	228	3	0.15	0.783	>0.1
2	242	7	0.33	0.596	>0.1
3	1933	24	0.14	7.8423	<0.01
4	1361	37	0.31	1.933	>0.1
5	1210	37	0.35	4.4985	<0.05
unknown	4	0	0	0.0887	>0.5
Total	4978	108	0.24		

Segaliud Lokan1

FORMIX3 group	Trees in 1982	Death in 1992	Mortality rate [%/a]	χ^2	P
1	2957	1068	4.48	17.846	<0.001
2	287	72	2.89	26.344	<0.001
3	666	466	12.03	250.659	<0.001
4	318	93	3.46	15.12	<0.001
unknown	30	1	0.34	16.744	<0.001
Total	4258	1700	5.10		

FORMIX4 group	Trees in 1982	Death in 1992	Mortality rate [%/a]	χ^2	P
1	343	159	6.23	5.9141	>0.01
2	0	0		-	-
3	131	33	2.90	11.857	<0.001
4	227	77	4.14	3.4118	<0.01
5	409	358	20.82	386.46	<0.0001
6	301	75	2.87	28.266	<0.0001
7	0	0	-	-	-
8	356	97	3.18	23.856	<0.0001
9	570	168	3.49	25.958	<0.0001
10	42	9	2.41	5.9907	>0.01
11	163	73	5.94	1.6055	>0.1
12	1685	649	4.86	1.3938	>0.1
13	1	1		1.5047	>0.1
unknown	30	1	0.34	16.747	<0.0001
Total	4258	1700	5.10		

Light group	Trees in 1982	Death in 1992	Mortality rate [%/a]	χ^2	P
1	928	528	8.42	111.45	<0.0001
2	3030	1084	4.43	21.749	<0.0001
3	270	87	3.89	6.6789	<0.01
unknown	30	1	0.34	16.747	<0.0001
Total	4258	1700	5.10		

Height group	Trees in 1982	Death in 1992	Mortality rate [%/a]	χ^2	P
1	343	159	6.23	5.9141	>0.01
2	358	110	3.67	12.63	<0.0005
3	710	433	9.41	131.3	<0.0001
4	968	274	3.33	54.485	<0.0001
5	1849	723	4.96	0.5217	>0.1
unknown	30	1	0.34	16.747	<0.0001
Total	4258	1700	5.10		

Segaliud Lokan2

FORMIX3 group	Trees in 1972	Death in 1985	Mortality rate [%/a]	χ^2	P
1	133	43	3.00	30.6861	<0.001
2	10	3	2.74	2.78056	<0.1
3	199	150	10.78	29.8355	<0.001
4	22	8	3.48	3.50346	<0.1
unknown	1	1	-	0.78049	>0.1
Total	365	205	6.34		

FORMIX4 group	Trees in 1972	Death in 1985	Mortality rate [%/a]	χ^2	P
1	16	9	6.36	0.0001	>0.9
2	0	0	-	-	-
3	1	0	0.00	1.281	>0.1
4	7	3	4.30	0.504	>0.1
5	130	127	28.99	91.06	<0.001
6	17	5	2.68	4.942	<0.01
7	0	0	-	-	-
8	74	21	2.57	23.21	<0.001
9	22	9	4.05	2.080	>0.1
10	8	2	2.21	3.156	<0.1
11	3	1	3.12	0.635	>0.1
12	85	27	2.94	20.55	<0.001
13	1	0	0.00	1.281	>0.1
unknown	1	1	-	0.781	>0.1
Total	365	205	6.34		

Light group	Trees in 1972	Death in 1985	Mortality rate [%/a]	χ^2	P
1	207	149	9.79	21.033	<0.001
2	141	50	3.37	24.548	<0.001
3	16	5	2.88	4.034	<0.05
unknown	1	1	-	0.7805	>0.1
Total	365	205	6.34		

Height group	Trees in 1972	Death in 1985	Mortality rate [%/a]	χ^2	P
1	16	9	6.36	0.0001	>0.9
2	8	3	3.62	1.132	>0.1
3	147	132	17.56	67.534	<0.001
4	104	32	2.83	27.242	<0.001
5	89	28	2.91	22.061	<0.001
unknown	1	1	-	0.7805	>0.1
Total	365	205	6.34		

Sepilok

FORMIX3 group	Trees in 1973	Death in 1993	Mortality rate [%/a]	χ^2	P
1	1848	1232	5.49	6.3905	<0.05
2	176	93	3.76	9.226	<0.005
3	65	45	5.89	0.8179	>0.1
4	114	46	2.58	27.25	<0.001
unknown	15	0	0.00	26.484	<0.001
Total	2218	1416	5.09		

FORMIX4 group	Trees in 1973	Death in 1993	Mortality rate [%/a]	χ^2	P
1	259	218	9.22	46.366	<0.0001
2	2	2	-	1.1328	>0.1
3	29	10	2.11	10.828	<0.001
4	220	178	8.28	27.763	<0.0001
5	135	101	6.89	7.0422	<0.01
6	233	127	3.9	8.7954	<0.005
7	8	8	-	4.5311	>0.01
8	49	34	5.92	0.653	>0.1
9	299	173	4.32	4.6346	>0.01
10	55	35	5.10	0.001	>0.9
11	9	6	5.49	0.0311	>0.5
12	903	524	4.34	13.216	<0.0005
13	2	0	0	3.5312	>0.05
unknown	15	0	0	26.484	<0.0001
Total	2218	1416	5.09		

Light group	Trees in 1973	Death in 1993	Mortality rate [%/a]	χ^2	P
1	195	143	6.61	7.6109	<0.01
2	1723	1052	4.72	5.7892	>0.01
3	285	221	7.47	23.181	<0.0001
unknown	15	0	0	26.484	<0.0001
Total	2218	1416	5.09		

Height group	Trees in 1973	Death in 1993	Mortality rate [%/a]	χ^2	P
1	259	218	9.22	46.366	<0.0001
2	251	190	7.07	15.284	<0.0001
3	376	236	4.94	0.1884	>0.5
4	403	242	4.59	2.5099	>0.1
5	914	530	4.34	13.571	<0.0005
unknown	15	0	0	26.484	<0.0001
Total	2218	1416	5.09		

Appendix F: Detailed listing of mortality rates as a function of tree size

Comparision of tree mortality in different size groups. χ^2-tests are based on expected values from the total mortality of all diameter classes pooled.

The upper diameter of each diameter class belongs always to the same class, while the lower diameter belongs to the class below (e. g. 010-015 can be read as (10,15].).

The two classification in different diameter classes (5cm width and 20cm width) are shown.

Garinono

Diameter class [cm]	Trees in 1973	Death in 1982	Mortality rate M [%/a]	χ^2	P
000-005	1	0	0.00	0.262	>0.5
005-010	34	6	2.16	0.203	>0.5
010-015	258	56	2.72	0.134	>0.5
015-020	181	42	2.93	0.646	>0.5
020-025	111	29	3.36	1.927	>0.1
025-030	80	11	1.64	2.402	>0.1
030-035	39	9	2.92	0.125	>0.5
035-040	42	7	2.03	0.432	>0.5
040-045	27	7	3.33	0.434	>0.5
045-050	21	5	3.02	0.117	>0.5
050-055	21	3	1.71	0.538	>0.1
055-060	17	3	2.16	0.101	>0.5
060-065	13	1	0.89	1.353	>0.1
065-070	9	2	2.79	0.011	>0.9
70+	17	0	0.00	4.459	<0.05
Total	871	181	2.59		

Diameter class [cm]	Trees in 1973	Death in 1982	Mortality rate M [%/a]	χ^2	P
005-020	474	104	2.75	4.453	>0.5
020-040	272	56	2.56	4.066	>0.5
040-060	86	18	2.61	4.059	>0.5
60+	39	3	0.89	4.058	<0.05
Total	871	181	2.59		

Gunung Rara

Diameter class [cm]	Trees in 1973	Death in 1982	Mortality rate M [%/a]	χ^2	P
000-005	6	1	2.03	5.941	<0.05
005-010	213	9	0.48	4.241	<0.05
010-015	1454	33	0.26	0.069	>0.5
015-020	1278	24	0.21	0.512	>0.1
020-025	862	9	0.12	5.144	<0.05
025-030	556	4	0.08	5.509	<0.05
030-035	287	3	0.12	1.709	>0.1
035-040	152	7	0.52	4.249	<0.05
040-045	59	3	0.58	2.362	>0.1
045-050	50	4	0.93	8.008	<0.01
050-055	23	4	2.12	25.108	<0.001
055-060	17	2	1.39	7.374	<0.01
060-065	11	3	3.54	32.659	<0.001
065-070	7	2	3.74	22.989	<0.001
70+	3	0	0.00	0.067	>0.5
Total	4978	108	0.24		

Diameter class [cm]	Trees in 1973	Death in 1982	Mortality rate M [%/a]	χ^2	P
005-020	2951	67	0.26	0.141	>0.5
020-040	1857	23	0.14	7.583	<0.01
040-060	149	13	1.01	30.167	<0.001
60+	21	5	3.02	46.333	<0.001
Total	4978	108	0.24		

Segaliud Lokan1

Diameter class [cm]	Trees in 1982	Death in 1992	Mortality rate M [%/a]	χ^2	P
005-010	62	16	2.98	5.153	<0.05
010-015	1284	401	3.74	40.467	<0.001
015-020	921	394	5.58	3.129	<0.1
020-025	630	274	5.71	3.342	<0.1
025-030	440	231	7.44	29.010	<0.001
030-035	329	165	6.96	14.347	<0.001
035-040	227	95	5.42	0.351	>0.5
040-045	153	62	5.20	0.023	>0.5
045-050	93	35	4.72	0.203	>0.5
050-055	43	12	3.27	2.589	>0.1
055-060	18	1	0.57	8.865	<0.005
060-065	22	6	3.18	1.468	>0.1
065-070	12	3	2.88	1.114	>0.1
70+	24	5	2.34	3.647	<0.1
Total	4258	1700	5.10		

Diameter class [cm]	Trees in 1982	Death in 1992	Mortality rate M [%/a]	χ^2	P
005-020	2267	811	4.43	16.284	<0.001
020-040	1626	765	6.36	34.397	<0.001
040-060	307	110	4.44	2.146	>0.1
60+	58	14	2.76	6.027	<0.05
	4258	1700	5.10		

Segaliud Lokan2

Diameter class [cm]	Trees in 1972	Death in 1985	Mortality rate M [%/a]	χ^2	P
005-010	20	8	3.9294	2.123	>0.1
010-015	81	42	5.6222	0.612	>0.1
015-020	108	63	6.7344	0.206	>0.5
020-025	63	50	12.1399	13.772	<0.001
025-030	50	27	5.9733	0.095	>0.5
030-035	25	10	3.9294	2.653	>0.1
035-040	9	3	3.1190	1.905	>0.1
040-045	4	1	2.2129	1.578	>0.1
045-050	1	1	0.0000	0.780	>0.1
050-055	1	0	0.0000	1.281	>0.1
055-060	0	0	-	-	-
060-065	2	0	0.0000	2.562	>0.1
065-070	0	0	-	-	-
70+	1	0	0.0000	1.281	>0.1
Total	365	205	6.34		

Diameter class [cm]	Trees in 1972	Death in 1985	Mortality rate M [%/a]	χ^2	P
005-020	239	137	6.55	0.130	>0.5
020-040	120	66	6.14	0.066	>0.5
040-060	3	2	8.45	0.134	>0.5
60+	3	0	0.00	3.844	<0.1
Total	365	205	6.34		

Sepilok

Diameter class [cm]	Trees in 1973	Death in 1992	Mortality rate M [%/a]	χ^2	P
005-010	137	97	6.16	2.876	<0.1
010-015	956	688	6.36	27.341	<0.001
015-020	507	335	5.41	1.096	>0.1
020-025	222	133	4.57	1.486	>0.1
025-030	104	61	4.42	1.212	>0.1
030-035	76	40	3.74	4.137	<0.05
035-040	50	18	2.23	16.787	<0.001
040-045	31	11	2.19	10.798	<0.005
045-050	24	7	1.72	12.499	<0.001
050-055	21	4	1.06	18.236	<0.001
055-060	23	5	1.23	17.665	<0.001
060-065	16	2	0.67	18.294	<0.001
065-070	21	5	1.36	14.578	<0.001
70+	30	10	2.03	12.095	<0.005
Total	2218	1416	5.09		

Diameter class [cm]	Trees in 1973	Death in 1992	Mortality rate M [%/a]	χ^2	P
005-020	1600	1120	6.02	26.290	<0.001
020-040	452	252	4.08	12.812	<0.001
040-060	99	27	1.59	57.350	<0.001
60+	67	17	1.46	42.950	<0.001
Total	2218	1416	5.09		

Appendix G: Detailed listing of mortality rates as a function of tree size and species group

Only FORMIX3 grouping and a classification in 20cm diameter classes is used in this analysis. Grouping in FORMIX4 groups and/or 20cm diameter classes does not lead to reasonable mortality rates because the data set is not big enough. ξ^2-test was not performed for single size class and functional group because the data set is to small for that purpose.

Garinono

	Trees in 1973				Death in 1982				Mortality rate M [%/a]			
Diameter class [cm]	F3grp 1	F3grp 2	F3grp 3	F3grp 4	F3grp 1	F3grp 2	F3grp 3	F3grp 4	F3grp 1	F3grp 2	F3grp 3	F3grp 4
005-020	346	41	57	30	70	3	24	7	2.51	0.84	6.07	2.95
020-040	172	13	70	17	32	0	21	3	2.29	0	3.96	2.16
040-060	43	1	41	1	10	0	8	0	2.94	0	2.41	0
60+	15	0	23	1	0	0	3	0	0	-	1.55	0
Total	576	55	191	49	112	3	56	10	2.40	0.62	3.86	2.54

Gunung Rara

	Trees in 1981				Death in 1990				Mortality rate M [%/a]			
Diameter class [cm]	F3grp 1	F3grp 2	F3grp 3	F3grp 4	F3grp 1	F3grp 2	F3grp 3	F3grp 4	F3grp 1	F3grp 2	F3grp 3	F3grp 4
005-020	1605	138	779	427	45	2	11	9	0.32	0.16	0.16	0.24
020-040	549	81	1050	175	12	1	9	1	0.25	0.14	0.10	0.06
040-060	95	16	25	13	9	1	3	0	1.11	0.72	1.42	0
60+	16	3	1	1	3	2	0	0	2.31	12.21	0	0
Total	2265	238	1855	616		144	9	23	0.31	0.26	0.12	0.16

Segaliud Lokan1

	Trees in 1982				Death in 1992				Mortality rate M [%/a]			
Diameter class [cm]	F3grp 1	F3grp 2	F3grp 3	F3grp 4	F3grp 1	F3grp 2	F3grp 3	F3grp 4	F3grp 1	F3grp 2	F3grp 3	F3grp 4
005-020	1657	192	160	234	578	47	119	66	4.29	2.81	13.62	3.31
020-040	1097	81	372	70	431	22	290	22	4.99	3.17	15.12	3.77
040-060	157	10	128	12	47	2	56	5	3.56	2.23	5.75	5.39
60+	46	4	6	2	12	1	1	0	3.02	2.88	1.82	0.00
Total	2957	287	666	318	1068	72	466	93	4.48	2.89	12.03	3.46

Segaliud Lokan2

	Trees in 1972				Death in 1985				Mortality rate M [%/a]			
Diameter class [cm]	F3grp 1	F3grp 2	F3grp 3	F3grp 4	F3grp 1	F3grp 2	F3grp 3	F3grp 4	F3grp 1	F3grp 2	F3grp 3	F3grp 4
005-020	113	7	104	14	37	3	89	7	3.05	4.30	14.89	5.33
020-040	18	3	94	5	5	0	60	1	2.50	0.00	7.82	1.72
040-060	2	0	1	0	1	0	1	0	5.33	-	-	-
60+	0	0	0	3	0	0	0	0	-	-	-	0.00
Total	133	10	199	22	43	3	150	8	3.00	2.74	10.78	3.48

Sepilok

	Trees in 1973				Death in 1993				Mortality rate M [%/a]			
Diameter class [cm]	F3grp 1	F3grp 2	F3grp 3	F3grp 4	F3grp 1	F3grp 2	F3grp 3	F3grp 4	F3grp 1	F3grp 2	F3grp 3	F3grp 4
005-020	1369	114	35	74	1005	57	25	33	6.62	3.47	6.26	2.95
020-040	337	57	22	30	191	34	15	12	4.18	4.54	5.73	2.55
040-060	86	3	3	7	24	1	2	0	1.64	2.03	5.49	0.00
60+	56	2	5	3	12	1	3	1	1.21	3.47	4.58	2.03
Total	1848	176	65	114	1232	93	45	46	5.49	3.76	5.89	2.58

Appendix H: Detailed listing of mortality rate as a function of diamenter increment

Comparison of tree mortality in different diameter increment classes. χ^2-tests are based on expected values from the total mortality of all increment classes pooled.

The upper diameter increment of each increment class belongs always to the same class, while the lower diameter increment belongs to the class below (e. g. 1-2 can be read as (1, 2].).

Garinono

Diameter increment [mm]	Trees in 1973	Death in 1982	Mortality rate [%/a]	χ^2	P
no d_{inc} data	23	23			
<=0	75	28	5.19	33.823	<0.001
0-1	198	44	2.79	11.055	<0.001
1-2	139	20	1.73	0.016	>0.5
2-3	90	14	1.88	0.176	>0.5
3-4	100	13	1.55	0.086	>0.5
4-5	51	11	2.70	2.412	>0.1
5-6	42	4	1.11	0.704	>0.1
6-7	46	9	2.42	1.174	>0.1
7-8	19	2	1.24	0.192	>0.5
8-9	16	3	2.31	0.297	>0.5
9-10	18	3	2.03	0.105	>0.5
10+	54	7	1.54	0.050	>0.5
Total	871	181	2.59		

Gunung Rara

Diameter increment [mm]	Trees in 1982	Death in 1992	Mortality rate [%/a]	χ^2	P
no d_{inc} data	19	19			
<=0	48	6	1.48	24.134	<0.001
0-1	133	21	1.91	116.241	<0.001
1-2	2569	40	0.17	4.541	<0.05
2-3	1157	6	0.06	14.858	<0.001
3-4	468	7	0.17	1.001	>0.1
4-5	115	4	0.39	0.928	>0.1
5-6	52	1	0.22	0.015	>0.9
6-7	47	0	0.00	1.042	>0.1
7-8	45	0	0.00	0.998	>0.1
8-9	55	0	0.00	1.220	>0.1
9-10	54	1	0.21	0.026	>0.5
10+	216	3	0.16	0.620	>0.1
Total	4978	108	0.24		

Segaliud Lokan1

Diameter increment [mm]	Trees in 1982	Death in 1993	Mortality rate [%/a]	χ^2	P
no d_{inc} data	982	975			
<=0	46	19	5.33	0.036	>0.5
0-1	94	28	3.54	4.028	<0.05
1-2	369	103	3.27	22.197	<0.001
2-3	534	147	3.22	34.215	<0.001
3-4	572	147	2.97	48.261	<0.001
4-5	509	115	2.56	63.746	<0.001
5-6	325	65	2.23	53.794	<0.001
6-7	229	36	1.71	55.935	<0.001
7-8	161	21	1.40	48.505	<0.001
8-9	114	13	1.21	38.664	<0.001
9-10	92	7	0.79	40.058	<0.001
10+	232	24	1.09	84.634	<0.001
Total	4258	1700	5.10		

Segaliud Lokan2

Diameter increment [mm]	Trees in 1982	Death in 1992	Mortality rate [%/a]	χ^2	P
<=0	2	1	5.33	0.031	>0.5
0-1	28	18	7.92	0.750	>0.1
1-2	32	14	4.43	2.003	>0.1
2-3	40	24	7.05	0.239	>0.5
3-4	33	12	3.48	5.255	<0.05
4-5	35	17	5.12	0.820	>0.1
5-6	33	16	5.10	0.790	>0.1
6-7	40	21	5.73	0.218	>0.5
7-8	27	18	8.45	1.210	>0.1
8-9	15	11	10.17	1.796	>0.1
9-10	16	8	5.33	0.247	>0.5
10+	64	45	9.34	5.203	<0.05
Total	365	205	6.34		

Sepilok

Diameter increment [mm]	Trees in 1982	Death in 1992	Mortality rate [%/a]	χ^2	P
no d_{inc} data	299	299	-	-	-
<=0	61	59	17.09	25.568	<0.001
0-1	284	226	7.94	30.465	<0.001
1-2	339	213	4.95	0.150	>0.5
2-3	305	164	3.86	13.398	<0.001
3-4	264	132	3.47	21.791	<0.001
4-5	181	86	3.22	20.847	<0.001
5-6	150	69	3.08	20.675	<0.001
6-7	109	44	2.58	28.229	<0.001
7-8	82	39	3.23	9.415	<0.005
8-9	47	26	4.03	1.479	>0.1
9-10	33	14	2.76	6.557	<0.01
10+	64	45	6.07	1.161	>0.1
	2218	1416	5.09		

Appendix I: Listing of files and their contents

All files are zipped with WINZIP 6.2.

They are:

ZIP name	Name of files	contents
report.zip	AppendixA.doc	Appendix A of the final report
	AppendixA.xls	large table out ouf Appendix A of the final report
	AppendixB.doc	Appendix B of the final report
	AppendixC.doc	Appendix C of the final report
	AppendixD.doc	Appendix D of the final report
	AppendixE.doc	Appendix E of the final report
	AppendixF.doc	Appendix F of the final report
	AppendixG.doc	Appendix G of the final report
	AppendixH.doc	Appendix H of the final report
	AppendixI.doc	Appendix I of the final report
	F4Grouping2.doc	Chapter 2 ‘FORMIX4 Grouiping’ of the final report
	intro.doc	Chapter 1 ‘Introduction’ of the final report
	Literature.doc	Chapter ‘Literature’ of the final report
	Mortality.doc	Chapter 4 ‘Mortality’ of the final report
	Regeneration.doc	Chapter 3 ‘Regeneration’ of the final report
	Summary.doc	Chapter 5 ‘Summary of the final report
sepilok.zip	sepilok.xls	Permanent sampling plot (PSP) data incl. analysis for Sepilok
segaliud.zip	segaliu1.xls	PSP data incl. analysis for Segaliud Lokan2
	segaliud_1.xls	PSP data incl. analysis for Segaliud Lokan1
garinono.zip	gar2.xls	PSP data incl. analysis for Garinono
gunrara.zip	gra.xls	PSP data incl. analysis for Gunung Rara
mndata.zip	GRP.xls	PSP analysis, species distribution in functional groups
	MNdinc.xls	PSP analysis, mortality=f(diameter increment)
	MNF3.xls	PSP analysis, mortality=f(FORMIX3 grouping)
	MNF4.xls	PSP analysis, mortality=f(FORMIX4 grouping)
	MNsize.xls	PSP analysis, mortality=f(diameter)
	MNsizegrp.xls	PSP analysis, mortality=f(diameter, FORMIX3 group)
	MNsizegrp2.xls	PSP analysis, mortality=f(diameter, FORMIX3 group)
	nd.xls	PSP analysis, stem-diameter-distribution
deramakot.zip	hdreinhold.xls	all information about hd-curves
	pkcorelation.xls	corelation between regeneration and stand for Deramakot pk stands for PETER KÖHLER
	pkrec2.dbf	processed data of regeneration (d<10cm)
	pkrec235.dbf	processed data of stand (d❍10cm)
	pkregen3.xls	processed data of relationship between regeneration and stand
	Record1.dbf	raw data, general information
	Record2.dbf	raw data, regeneration (d<10cm)
	Record31.dbf	raw data, trees (10cm≤d<20cm)
	Record4.dbf	raw data, trees (20cm≤d<40cm)
	Record5.dbf	raw data trees (d❍40cm)
linkabau.zip	pkrec2.dbf	processed data of regeneration (d<10cm)
	pkrec345.dbf	processed data of stand (d≥10cm)
	pkregen1.xls	processed data of relationship between regeneration and stand
	Record1.dbf	raw data, general information
	Record2.dbf	raw data, regeneration (d<10cm)
	Record31.dbf	raw data, trees (10cm≤d<20cm)
	Record4.dbf	raw data, trees (20cm≤d<40cm)
	Record5.dbf	raw data trees (d≥40cm)

ZIP name	Name of files	contents
kalabakan.zip	pkrec2.dbf	processed data of regeneration (d<10cm)
	pkrec345.dbf	processed data of stand (d≥10cm)
	pkregen1.xls	processed data of relationship between regeneration and stand
	Record1.dbf	raw data, general information
	Record2.dbf	raw data, regeneration (d<10cm)
	Record31.dbf	raw data, trees (10cm≤d<20cm)
	Record4.dbf	raw data, trees (20cm≤d<40cm)
	Record5.dbf	raw data trees (d≥40cm)
segama.zip	pkrec2.dbf	processed data of regeneration (d<10cm)
	pkrec345.dbf	processed data of stand (d≥10cm)
	pkregen1.xls	processed data of relationship between regeneration and stand
	Record1.dbf	raw data, general information
	Record2.dbf	raw data, regeneration (d<10cm)
	Record31.dbf	raw data, trees (10cm≤d<20cm)
	Record4.dbf	raw data, trees (20cm≤d<40cm)
	Record5.dbf	raw data trees (d≥40cm)
sabah.zip	diadistr.xls	Diameter distribution forall 4 forest reserves
	pkregf4.xls	Summaring file for regeneration for all 4 reserves
data.zip	pkspecies.xls	detailed information of grouping for all species
	fox.xls	data analysis of Fox (1972)
	kennedy.xls	data analysis of Kennedy (1991)
	manok.xls	data analysis of Manokaran and Kochumnen (1987)
	mn_chim.xls	data analysis of Chim and On (1973)