Chapter 3
APPROACH AND METHODOLOGY

Approach

The research approach was a mixture of autecological, bio-physical, morphological (variations), and quantitative ethnobotanical studies, which were integrated in the context of plant conservation management, with special reference to the rare lipstick palm *Cyrtostachys renda* Blume. The research works involved herbarium and living specimen investigations, field studies and site visits, glasshouse germination and growth trials (laboratory works), literature studies, and the application of a Geographic Information System.

The autecological research and biological components focused on the studies of specific ecological and habitat requirements, reproductive biology (vegetative and generative development), germination requirements, population structure, demography, growth rates, and associated species analysis. Taxonomic study emphasized on the investigation of variations occurred within the species (geographic variation and variation under cultivation), while ethnobotanical aspect (socio-economic components) focused on the potential use values of *Cyrtostachys renda* and the preferences of the local communities in the uses of the palm species for a specific purpose (i.e. bagan construction), in conjunction with the limited availability of the palm stock in the sanctuary. All of these information was then synthesized with the results of the investigations and analyses of the physical components (physiography, habitat types, edaphic factors, hydrology, forest and vegetation types, accessions, and administrative management and border), threats and disturbance, and the application of the categories and concepts of rarity (the 1994 and 2000 IUCN Systems) to perform a comprehensive species based conservation management strategy.

A number of methods of analysis were used to process and analyse the data collected, including cluster and ordination analysis (to show similarity/dissimilarity among variables), correlation and regression analysis (to
show relationships among variables), association tests (to test hypothesis and show possible associations between variables), and log-nonlinear and -linear modellings. Both quantitative and qualitative data were used in the analyses. The computer packages operated were NTSys – pc Program and Microsoft Excel, while the statistical formulas operated were correlation statistics and regressions. The software ArcView GIS Version 3.1 was used to analyse the maps and visualize the current situations of the study area. Questionnaires were designed and made to interview and collect the data and information needed from relevant respondents.

3.2 Methodology

3.2.1 Study Sites

Fifteen sites (localities) were chosen inside the study area and one site at the adjacent sanctuary (rubber plantation) to cover a wide range of vegetation association, forest and habitat types, altitudes, and densities and sizes of populations, spanning the four aspects of the reserve (Fig. 3.1). To narrow down the study area, a preliminary survey exploring the reserve was conducted before deciding the selected sites. A series of 1542 transects of 100 m x 10 m each covering a total forest area of 154.2 ha (0.13% of the total area of the reserve) were established in those chosen sites (Fig. 3.1). Study sites and the existing reserve were performed and analysed using three data (map) sources: 1) LAPAN’S Landsat Imageries (maps): Path/Row 126 – 60, Acq. 23 – 02 – 2000, with a Format Programme ERDAS – LAN (processed by ArcView GIS Version 3.1) and the printed edition Landsat 5 TM, Band 542, Acq. 19 June 1996, Path/Row 126 – 60 (used for comparison), 2) the topographic maps: Peta Rupa Bumi Indonesia Lembar 0916 Siak Sri Indrapura and Lembar 0915 Rengat, Scale 1 : 250.000, first edition 1986, and 3) the situation map: Boundary Reconstruction Map of Kerumutan Wildlife Sanctuary, 1993/1994, scale 1 : 250.000. Each locality where transects were established was located by a Global Positioning System MAP 175 GARMIN.
To determine specific habitat requirements of *Cyrtostachys renda*, the 16 sites chosen were classified into three types of distinct habitats (Fig. 3.2). These habitat types typically constituted the physiognomy of Kerumutan forest and they were determined and differentiated on the basis of water drainage quality and ground surface characteristics. **First,** *permanently waterlogged (swamp) forest* comprised Sarang Unggas Creek, Kelantan Creek, Bebak Creek, Peteloran Creek, Mengkuang River, and Gaung River left branch. Although the level of inundation varies considerably between dry and wet seasons (from only several centimetres to several metres), this habitat is waterlogged all year-round, thus very poorly drained. **Second,** *seasonally flooded forest*, which is poorly drained, consists of Merbau River estuary, Gaung River right branch, Galoga’s rubber plantation, Terusan Siam Stream, and Lintang Creek. These localities are flooded during the rainy season but relatively dry during the dry seasons. **Third,** *well-drained forest* includes Galoga border, Kempas Creek, Buluh Creek, Ketopatan Creek, and Merbau River upstream. In this type of habitat, water drains very well, even during the wet season (though water flowed slowly), indicating the existence of slopes and higher sites (Fig. 3.2).

To complement the classification of the habitat types, three other forest types based on the forest integrity (disturbance level) were covered: *natural forest, disturbed forest* (slightly and highly disturbed), and *totally converted forest* (traditional rubber plantation). Based on the forest associations (above ground characteristics), the detail types (patterns) of association at each location were described. The association types resulted were then divided (grouped) into floristically and structurally distinct association types (Fig. 3.2).

Today Kerumutan Wildlife Sanctuary contains one of the substantial (extant) populations of *Cyrtostachys renda* in which natural regeneration is occurring and a complete range of age and size classes can be found. Some successful recruitment also occurs in several sites, e.g. along Kerumutan and Merbau watercourses. In extant populations elsewhere, sucker stages in particular and juveniles are abundant.
Figure 3.2. Sampling methodology of the study area (habitat and forest classification). T = Transects.
3.2.2 Phenetic Analysis

In order to give more support to the taxonomic account of the ‘two species’ based on the similarities of their morphological characters, a numerical/phenetic analysis was performed using NTSys-pc program (Rohlf, 1993). The phenetic analysis was to determine groups of individuals or taxa based on the overall similarity (Sneath and Sokal, 1973). The method took into account various different characters and treat them as equal weightings. Results were presented as dendrograms (phenograms) which did not infer phylogenetic relationship. The relationship between taxa (OTUs) was based on taxonomic distance. Clustering method was based on the sequential, agglomerative, non-overlap method (SAHN) (Sneath and Sokal, 1973). An Unweighted Pairs Group Method of Averaging (UPGMA) was used to give proportional weights to the data attributes. The ordination method used was Multidimensional Scaling (MDS). Seventeen continuous data from 21 specimens of *Cyrtostachys renda* and *C. lakka* were used in this analysis (Fig. 3.3).

3.2.3 Population Structure and Status

To assess the population structure and status of the species, a systematic parallel line method was used. Parallel line techniques are by far the most reliable survey technique to ensure that all parts of the study area have been covered and therefore the target species have been recorded (Krebs, 1989; Cropper, 1993). The selected study sites were divided into easily recognised blocks (1 ha each: 100 m x 10 m x 10). All of the blocks were systematically investigated by moving across the shortest distance (100 m long each) in a series of parallel lines (transects, Appendix 1a). All individuals of *Cyrtostachys renda* (see the definition below), both suckers, juveniles and adults, were recorded and measured as they were encountered (Fig. 3.4.1). Each of the straight lines for the 100 m transect was derived from a selected compass bearing. To develop a full population structure and status, each lipstick palm sucker, juvenile and tree (with a visible stem) within 5 m either side of each transect was measured and...
counted. The accuracy of this method was improved by developing the transects closer together, with an interval 10 m (Fig. 3.4.2). To avoid any problems of overlapping and consequently double counting (measurement), all individuals within their clumps that have been recorded were tagged or signed.

Measurements include the numbers of discrete clumps (from which palm frequencies and densities were determined), the numbers of individual plants within each clump to determine clump sizes and tree densities (Appendix 1b), the numbers of leaves (for suckers, juveniles and adults), stem diameter at breast height (dbh) for adults to determine the basal area (Appendix 1c), height of the visible stem to the base of the leaf sheath of the lowest leaf (for juveniles and adults), leaf size (length average) of the two oldest live leaves (for suckers only, Appendix 1d), and number of leaf scars on each stemmed individuals (juveniles and adults) (Fig. 3.4.1). Stem height was measured by a hagameter for tall plants while shorter individuals (< 5m) by a tape with an extension, and stem at breast height by a diameter tape. Another species (abundance) parameter recorded was canopy cover (area) to estimate size and compactness of individual tree crowns. All of these measurement attributes were then analysed to perform their relationships. Damaged or dead plants were not included because their height and diameter would be affected, whereas each stem and sucker within a clump was counted individually. Nine suckers (vegetative shoots) of very early stage (with one or two scale leaves) were tagged to investigate their growth rate (compared with that of seed).

3.2.4 Demography, Age Estimation, and Germination

To perform life tables, demographic parameters comprising survivorship, growth, reproduction, and age were investigated based on marked individuals in the eight known sites (Fig. 3.5; Appendix 1e). Information on survivorship came from censuses conducted every 6 months for suckers and annually for juveniles and matures. The census period was between November 1996 and June 2000. Individual growth (including stem-height increment) was determined by
Counting the number of new leaves produced per year (Ratsirarson et al., 1996). The youngest leaf of each individual was tagged at the beginning of the research, and all new leaves produced were recorded at each census. Each new leaf produced by individuals with a visible stem represented a stem-height increment of 11.98 cm on average (but the rate does not the same throughout the life span), and the total height growth of the stem over time was estimated from the number of new leaves produced (based on Ratsirarson et al., 1996).

To construct a stage-structured model (to project population growth or predict future population), eight different stage classes were defined within the populations depending on the size (length) of the leaves for suckers (stem invisible) and the height of the stem for juveniles and adults (stem visible). The categories defined were sucker $S_1$, leaf length $< 100$ cm; sucker $S_2$, leaf length $100 - 200$ cm; sucker $S_3$, leaf length $> 200$ cm; juvenile $J_1$, stem visible (leaf scars conspicuous), crown shafts developed, and the stem height $< 100$ cm; juvenile $J_2$, immature individual with stem height $100 - 200$ cm; adult $A_1$, mature individual with stem height $> 200 - 500$ cm (based on the flowering and fruiting evidences of wild individuals and those of Cyrostachys renda’s collections (data) in Bogor Botanic Gardens; adult $A_2$, mature individual with stem height $> 500 - 800$ cm; and adult $A_3$, mature individual with stem height $> 800$ cm.

Age ($A$) of stemmed individuals was estimated from the total number of leaf scars ($N$) left on the stem, the number of live leaves present ($n$), the leaf production rate ($l$) of an individual, and the time ($a$) required for a new sucker or seedling to produce a visible stem (establishment phase). The value of the establishment phase (the time taken for individuals to produce stems) is 15 years on average based on the plantation data of Cyrostachys renda at Bogor Botanic Gardens (Registration Section). Individual growth was significantly variable. Based on Corner’s (1966) formula $A = [(N + n) / l] + a$, the age of each individual with a visible stem was determined. As the number of leaf scars cannot provide an absolute age for any individual, an approximate age was
estimated on the basis of leaf production average among individuals observed. Quantitative relationships among variables and prediction were analysed using regression analysis (Tomlinson, 1990).

*For plants, the use of stage-structured models to project population growth is preferable to age-structured models, because reliable information on the age of immature individuals is very limited.* In addition, the indeterminate growth (growth plasticity) of plants often make the age-structure a poor predictor of future population (Lefkovitch, 1965 in Ratsirarson et al., 1996). Multiple regression is used to determine the potential state variables contributing to the population growth. Height has been found to be a better predictor of palm fecundity than age (Ratsirarson et al., 1996). Following these authors, height is chosen as a state variable for projecting future population growth in this study.

To perform the sequence of seed germination and seedling establishment, germination trials were conducted at the glass house of Bogor Botanic Gardens (Pembibitan I, Appendix I). *First*, the trial conducted from 27 June 2000 to 6 February 2001 was to observe and monitor the sequence of seed germination, until the germinating seeds reached the autotrophic stage (the first eophyll splitting completely). The total seed germinated was 150 and divided into three replications and the average value were used. Seeds were collected from the study area (Galoga border population). The germination media was pure river sand. Germinated seeds were watered daily and monitoring conducted daily.

*Second*, the earlier germination trial (monitoring) conducted from 11 August 1998 to 6 February 2001 was used to complement the results of the latter trial, performing further seedling establishment. In this trial, 150 seeds were collected from a collection plant of Bogor Botanic Gardens (Vak II J 22).
TAXONOMIC STATUS
(*Cyrtostachys renda* and *C. lakka*)

**NUMERICAL / PHENETIC ANALYSIS**
- Overall similarity among characters

- 17 Continuous data (generative and vegetative characters)
- 21 Specimens

**RESULTS**

**DENDROGRAM**
- Taxonomic distance (Quantitative)
- Clustering method (SAHN)
- UPGMA

**ORDINATION**
- Multidimensional Scaling

**Fig. 3.3 Determination of the taxonomic status of *Cyrtostachys renda* and *C. lakka.***
Fig. 3.4.1 Attributes measured to perform population structure and status of *Cyrtostachys renda* in Kerumutan Wildlife Sanctuary.
Fig. 3.4.2 The systematic parallel line method used in the study area. Numbers 1 – 20 indicate the square plots of interspecific association tests (5 m x 5 m each), from which soils were sampled for each location (site). Solid lines show the transect lines developed (100 m x 10 m each, the total number = 1542 transects) and dotted lines indicate imaginary lines to assist measurements and counting.
DEMOGRAPHY

SITES

Demographic Parameters

Marked individuals

Reproductive measurement attributes

- Sucker establishment
- Seed production

Age-structured model

\[ A = \frac{[1 + a]}{[1 + a]} \]

Leaf length increase/year

Stem length increment

No. new leaves/year

Counting

Individual Growth

Survivorship

Censuses (transects)

Marked individuals

Demographic Parameters

Reproduction

Age Estimation

Quantitative Relationships

(Regressions)

Prediction

Correlations among variables

Related Measurement Attributes

LIFE TABLES

Demographic study of Cyrtostachys renda in Kerumutan Wildlife Sanctuary, Riau.

Fig. 3.5 Methodology of demographic study of Cyrtostachys renda in Kerumutan Wildlife Sanctuary, Riau.
3.2.5 Definition and Counting of Clumps and Individuals of *Cyrtostachys renda*

Problems associated with the definition of plant individuals are often encountered, especially for clustering plants (clumps) like *Cyrtostachys renda*. The above-ground parts of the palm clump usually consist of a wide range of plant age and size classes, comprising different stages of suckers, juveniles, and adults. Juveniles or small (young) trees next to an adult plant may actually be still root suckers. Therefore such plants (i.e. at distances equal to or less than that of the radius of the clump) were regarded as suckers rather than seedlings, but single juvenile and adult stems not associated with large clumps were counted as separate individuals (regarded as ‘solitary clumps’). However, it should be noticed that each plant may represent a genet (a plant derived from seed) or a ramet (such as a separate shoot). Cropper (1993) suggested that if plant individuals are not easily distinguished, the number of above-ground parts should be taken as an index for population numbers, while Soegianto (1994) and Begon *et al.* (1986) suggested that plants within a clump should be treated as an individual. Clearly, IUCN (1994) suggested that reproducing units within a clone (clump) should be counted as individuals, except where such units are unable to survive alone. In this case, the suitable measurement can be either basal coverage (basal area) or aerial coverage (canopy circle area). Density could thus represent both clump density and individual plant density (adult, juvenile, and sucker or seedling). These criteria do meet the nature and life-form of the lipstick palm. Bradshaw (1981) argued that the choice of the basic unit (i.e. what we call with an individual) depends on the purpose of the study and the nature of the plant. The basic unit should therefore be clearly defined based on the nature of the species studied, i.e. species by species approach. Due to the local use (i.e. for bagan construction material), the stem numbers of *C. renda* were counted to estimate the availability (based on the clump sizes: stems / clump). In this case, the use of index or clump-based counting (i.e. aerial
may not be an appropriate method. From local importance point of view, basal coverage (stem diameter) together with the stem height can be more useful information for the conservation (sustainable use strategy) of this palm.

For *Cyrtostachys renda*, however, each plant within a clump almost always has its own roots, and it can therefore be an independent individual. By splitting the clumps into several smaller clumps (groups) or cutting the young plants within the clumps gradually, the splitting and cutting plants were successful to grow to be healthy individuals (Widyatmoko, 1989). This indicates that plants within a clump are actually independent individuals. Therefore, to construct a full population status, all discrete clumps and the size of each clump in terms of the numbers of suckers, juveniles, and adults were counted in this study. Density means the number of clumps per hectare and tree density refers to the number of stems (trees) per hectare. Basal coverage (dominance) and aerial coverage (based on the crown projections) were also calculated. This study also showed that *C. renda* can be found solitary in several populations, e.g. in Merbau River and Lintang Creek. In this case, each solitary plant was regarded both as a clump and an individual tree.

### 3.2.6 Interspecific Association

To analyse the possible association patterns between *Cyrtostachys renda* and the other coexisting palm and plant species in Kerumutan forests, pairs of species were chosen to test with *C. renda*. The selection of species that would be tested with *C. renda* was based on their co-occurrence (binary data): the paired species have occurred in at least one plot of the total plot collection observed (Ludwig and Reynolds, 1988). This study involves two distinct procedures. The first step is a statistical test of the hypothesis that two species are associated or not at some predetermined probability level. The second step is a measure of the degree of strength of the association. Three measures of interspecific association are presented to provide some comparisons: Ochiai Index, Dice Index, and Jaccard Index (Fig. 3.6).
Fig. 3.6 Diagram (procedure) of interspecific association.
3.2.6.1 Test of association

The interspecific association study is based on the presence and absence of selected species within the transects developed (artificial sampling units). A total of 160 square plots (of 5 m x 5 m each, derived from the 100 m x 10 m transects), involving eight known sites of *Cyrtostachys renda* within Kerumutan Sanctuary (thus 20 sampling units for each locality) were observed (Fig. 3.6). At number of sampling units) = 20, the Dice Index will be powerful to estimate true population values (Ludwig and Reynolds, 1988). A known site in Galoga’s traditional rubber plantation was excluded and regarded as an unnatural forest area (the surrounding/existing plants were planted). The establishment of the large number of sampling units was to lessen size dependence, as size can influence the outcome of plant association, while the inclusion of all known population of *C. renda* was to reduce the dependence of spatial distribution of the species. The shape of the sampling units was made similar (square plots) in order to avoid bias, while the placement and selection of each plot within each transect where *C. renda* occurs were made randomly.

Binary data were presented: presence was counted with a 1 and absence with a 0. The data were then summarized in the form of a 2 x 2 table of contingency (Table 3.1).

### Table 3.1 The 2 x 2 contingency table for species association.

<table>
<thead>
<tr>
<th></th>
<th>Present</th>
<th>Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cyrtostachys renda</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td>Absent</td>
<td>c</td>
<td>d</td>
</tr>
<tr>
<td>a + c</td>
<td>b + d</td>
<td>N = a + b + c + d</td>
</tr>
</tbody>
</table>

**Notes:**

- a: the number of plots where both species (*Cyrtostachys renda* and the paired species) occur (joint occurrence).
- b: the number of plots where *C. renda* occurs, but not the paired species.
- c: the number of plots where the paired species occurs, but not *C. renda.*
The number of plots where neither *C. renda* nor the paired species are found (joint absence). 

The total number of plots \( (N = a + b + c + d) \).

The null hypothesis (Ho) constructed is that *Cyrtostachys renda* is an independent species; there is no association with other species. To test the null hypothesis of independence (in the 2 x 2 table), the chi-square test statistic \( (\chi_d) \) was used:

\[
\chi^2 = \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}}
\]

While the expected values for cells a, b, c, and d are respectively:

\[
E(a) = \frac{(a + b)(a + c)}{N},
\]

\[
E(b) = \frac{(a + b)(b + d)}{N},
\]

\[
E(c) = \frac{(a + c)(c + d)}{N}, \text{ and}
\]

\[
E(d) = \frac{(b + d)(c + d)}{N}
\]

Based on these formulas, the chi-square test statistic is then given as:

\[
\chi^2 = \left[ \frac{a - E(a)}{E(a)} \right]^2 + ... + \left[ \frac{d - E(d)}{E(d)} \right]^2
\]

The significance of the chi-square test statistic is determined by comparing it to the theoretical chi-square distribution \( (\chi_d, 1 \text{ df at the } 5\% \text{ probability level}) \). If \( \chi^2 > \chi_d \), the null hypothesis is rejected. It means that the co-occurrence of *Cyrtostachys renda* and the paired species is dependent; they are associated. Types of associations were determined (whether positive or negative) by comparing the value of observed a to that of expected a. If observed a > E(a), it indicates a positive association (the pair of species occurred more often than expected if independent), and if observed a < E(a), it
indicates a negative association (the pair of species occurred together less often than expected if independent).

### 3.2.6.2 Measures of the degree of association

Three measures of association recommended by Hubalek (1982) and Janson & Vegelius (1981) were used to analyse and compare the degree of association. These are Ochiai Index (O1), Dice Index (DI), and Jaccard Index (JI), which are respectively given as:

\[
O1 = \frac{a}{\sqrt{a + b} \sqrt{a + c}}
\]
\[
D1 = \frac{2a}{2a + b + c}
\]
\[
J1 = \frac{a}{a + b + c}
\]

These three indices are equal to 0 at “no association” and 1 at “maximum association”.

### 3.2.7 Water Quality Analyses

To assess the possible effects of water quality on the palm occurrences and requirements (densities and sizes), water was sampled from three types of habitats studied (permanently waterlogged, seasonally flooded, and well-drained habitats) in February 1999 (Fig. 3.7). Water pH was measured by a calibrated pH meter (at a temperature of 30.1°C), electrical conductivity was measured by a conductometer Metrohm (at 30.0°C), water turbidity was determined by turbidimeter (ppm SiO₂), while colour intensity was determined with unit of colour. Four major nutrients (Ca, Mg, K, and Na) were determined by the titer procedures (titracy) using the titrant ethylenediamine tetraacetic acid (EDTA) solution 0.01 M and EBT indicator. Iron (Fe) content was determined by saturated K₂S₂O₇, saturated sulphidic acid (H₂SO₃), and KSCN 3N solutions, using the spectrophotometer Spectronic 20D for measuring transmittances (T),
Thus determining absorbances (A), with the formula $A = - \log \frac{T}{100}$, through the construction of a calibrated curve. Mn level was determined by (NH$_4$)$_2$S$_2$O$_8$, catalyst AgNO$_3$, HNO$_3$, Mn$^{2+}$ standard solution (10 ppm), and Spectronic 20D. Zn, Pb, and Cu were all also determined by the spectrophotometry procedures.

NH$_4$ - N content was determined by the standard solution of ammonium chloride 5 ppm N, Nessler reactor, and Spectronic 20D; NO$_2$ - N content determined by sulphanilic amide solution, N - (1 - naphthyl) - ethylenediamine dihydrochloride, the NO$_2$ - N standard solution 5 ppm, and Spectronic 20D; while NO$_3$ - N determined by the NO$_3$ - N standard solution 1 ppm, sulphanilic acid, NaCl 30% solution, H$_2$SO$_4$ 75%, natrium arsenic solution, and Spectronic 20D. The orthophosphate PO$_4^{3-}$ was determined by ammonium molybdate sulphidic acid, SnCl$_2$ (stano chloride), phosphate standard solution containing 5 ppm P, and Spectronic 20D. Sulphate (SO$_4^{2-}$) content was determined by the turbidity method (using the conditioning reagent, BaCl$_2$ crystals 20 - 30 meash, standard sulphate (H$_2$SO$_4$ 0.02 N), and Spectronic 20D.

Measurements were conducted at Laboratorium Kimia Lingkungan, Bogor Agricultural University and Pusat Penelitian Tanah dan Agroklimat, Bogor.

---

**Fig. 3.7 Water quality analysis of three habitat types of Kerumutan Wildlife Sanctuary.**
3.2.8 Soil Analyses

To assess possible influences or interactions between edaphic factors and the palm occurrences (abundances) and preferences, soils were sampled from each locality (in which transects developed). The precise site of each soil pit was chosen within the transects developed for the interspecific association tests. Soil samples were taken from two depths: surface and subsurface, ranging from 2 to 75 cm (mainly O and A horizons), and were analysed separately to give mean profile values. Surface soil levels appear to be more important than the whole (deeper) soil profile since the feeding roots of *Cyrtostachys renda* are close to the soil surface. Chemical and physical analyses were carried out on air-dried samples (105°C) in Pusat Penelitian Tanah dan Agroklimat, Bogor. Soil pH was measured on a 1:2.5 soil - distilled water mix, exchangeable bases were extracted with NH4-Acetate 1 N, pH 7, and total N was determined by the Kjeldahl method. The physical structure of the soils was determined by removal of clay using ultrasonics and sedimentation, while sand content was measured by sieving and washing (Fig. 3.8). Correlation statistics were applied to assess the influences of edaphic parameters on the densities and sizes of *C. renda*.

3.2.9 Interactions Between Species and Physical Environment Quality

To elucidate possible interactions between the palm and the physical components, parameters of species measured in all locations were correlated with those of the environmental quality, using their R² values. Scores ranging from 0 to 4 were made based on the R² values resulted (0 indicates a poor correlation and 4 indicates a high correlation). The data matrix resulted was then analysed using NTSys - pc Program and results were presented in the forms of cluster and ordination (Fig. 3.9).

3.2.10 Deciding Priority Sites To Be Conserved

To decide the sites of high priority for conservation, all known locations (populations) were compared and analysed based on the goodness of their species parameters measured (population structure, demography, and...
Scoring was applied between each location (habitat type) and each species parameter, ranging from 0 (the smallest score, means bad conditions/values/planes) to 3 (the highest score, means best conditions/values/planes). The input (data) matrix was then processed using NTSys-pc Program and the results were performed in the forms of cluster and ordination (Fig 3.10).

SOIL QUALITY ANALYSIS

16 Sites

2 Depths
  - Surface (2 – 5 cm)
  - Subsurface (>5 – 75 cm)

Mean profile values

pH, moisture, exch. bases (Ca, Mg, K), %C, %N, C/N, soil texture (% sand, % silt, % clay)

Influences of edaphic parameters on C. renda’s abundance
  - Correlation statistics

Fig. 3.8 Soil quality analysis of three habitat types of Kerumutan Wildlife Sanctuary.
Fig. 3. Methodology for measuring species and environmental quality interactions.
Fig. 3.10 Methodology for deciding sites of high priority (need to be conserved).
3.2.11 Estimation of Use Value and Species Preference

To estimate the use value of *Cyrtostachys renda* in different locations, data were collected from 13 locations (nine near/within and four outside the sanctuary), by interviewing a total of 69 respondents. The respondents were selected (representing men, adults and youngs) and chosen from the dominant community (Melayu Rengat) occupying Kerumutan and the adjacent areas (Fig. 3.11). Male interviewees were chosen because they were the group (gender) who particularly used the forest (plant) resources (e.g. collecting forest products, cutting trees, constructing bagan, and conducting logging), while females were mainly conducting fishing.

![Diagram of Use Value Estimate]

**Fig. 3.11 Methodology of use value estimate of *Cyrtostachys renda* in Kerumutan and the adjacent area.**
Questions asked included the uses of *Cyrtostachys renda* (local name: Linau) in their daily lives (horticulture, bagan construction, food source, logging and supernatural connections), parts of the palm to be used (trunk, stem, stem apex, and leaf), amount of material collected, and gathering intensity (ranging from 0 indicating never; 1 - very rarely, one to several times within 5 year; 2 - rarely, one to several times within one year; 3 - often, one to several times within one month; 4 - very often, one to several times within one week). Estimation of the use value of Linau for each respondent $i$ ($UV_i$) was estimated following the formulas introduced by Philip in Martin (1998):

$$UV_i = \frac{\sum C_{Ui}}{n}$$

Where $\sum C_{Ui}$ is number of uses of *C. renda* mentioned by respondent $i$ in each occasion (interview), and $n_i$ is number of interview for *C. renda* for respondent $i$ in this study only one occasion for each respondent, thus $n_i = 1)$. Then, estimation of the average use value of *Cyrtostachys renda* ($UV_s$) is:

$$UV_s = \frac{\sum UV_i}{n}$$

Where $UV_s$ is the average value of community knowledge of the uses of *C. renda*, $\sum UV_i$ is the total estimate of the use value of *C. renda*, and $n$ is the number of respondents interviewed for *C. renda*. One occasion is defined as one time interview (discussion) between a respondent and the researcher discussing the uses of *C. renda*. The palm is a useful and popular species in Kerumutan and the adjacent areas.

In order to assess species preference among the respondents, five tree species commonly used for constructing bagan’s floor were selected and the 20 respondents were asked to state and rank their preferences among the five selected species, started from the most preferred species (ranked with 1) to the less preferred (ranked with 5). However, more than one species belonging to the same rank were possible according to the responses of each interviewee. Thus, the rank was not always complete from 1 to 5 for each respondent. The basic data matrix was standardized by dividing the matrix elements by the standard