Chapter 5
CONCLUSIONS AND RECOMMENDATIONS

Based on the overall morphological similarity, the Sumatran representative *Cyrtostachys renda* and the Bornean native *C. lakka* were determined to be one species (synonymous), as there were no significant differences found within "those formerly regarded two species". Thus the hypothesis developed is accepted. *However, since most of the data obtained were of vegetative characters, more floral morphological data may be required for further analyses.*

Cyrtostachys renda requires specific ecological and habitat requirements, and is determined to be an indicator species of the Southeast Asian lowland peat swamp forest. **In order to conserve this species effectively, its suitable habitat must be properly managed. The suitable habitat characteristics are well-drained habitat with a high sand content, a thin peat layer, and a low C/N value; less acidic soil and water; and soil and water of low major nutrient contents but with relatively high organic substances (forms).**

The well-drained area in the reserve becomes **the palm favourable habitat** which is needed by the species to survive and develop evolutionary lines. By protecting this habitat type, most populations can be reserved for a long term. ***The hypothesis constructed is accepted.*** Such information can be used to set criteria for protecting representative suitable sites of the targetted species, both within and outside Kerumutan Wildlife Sanctuary. In a wider perspective, such method can be applied to develop habitat evaluation (suitability) procedures for any other plant species.

Populations at Galoga border and Kempas Creek were the most significant populations to be conserved and prioritised, based on the population status, demographic, and abundance parameters. *However, further studies to investigate the relationship between the size of a suitable habitat (particularly well-drained area) and the palm's ability to colonise it needs to be conducted.*

The overall population of *Cyrtostachys renda* within Kerumutan Wildlife Sanctuary was growing, consisting of dominant young plants with lower numbers of the older stages, though the population sizes and structures varied spatially. Although regeneration and recruitment continue, habitat loss and other human disturbances occurred threatening the sustainability of the distinctive species. **Near Threatened** category is proposed for the palm's conservation status and should be included in the IUCN Red List.

Population structure (in terms of height and diameter classes) appears to vary amongst sites, but younger plants tend to dominate. Sucker stages comprised 89.0% of the total population while the older stages (juveniles and adults) only made 11.0%. In most sites, the numbers of adult stems were much lower than those of suckers. This figure suggests that a wise harvesting of adult individuals should be applied if we are to prevent the palm population decline in the near future. Overall, there was a dominance of individuals with stem heights between 0.0 and 4.0 m (47.5%), stem diameters between 4.0 and 10.0 cm (82.0%), and leaf scar numbers between 0 and 60 (69.2%).

Demographic attributes, reproductive behaviour, and individual variations of the three stage classes (sucker, juvenile, and adult) varied considerably. A curvilinear relationship between age and stem height was resulted, $Y = 7.77 \ln(X) - 21.93$, where Y = height and X = age. Wild plants reach reproductive maturity and start to produce seeds at between 25 and 30 years of age and the individuals can survive more than 80 years. However, cultivated plants appear to flower and reproduce earlier than wild representatives, and a number of modifications (variations) occurred under cultivation. Cultivated plants appear to flower more frequently and produce more seeds. Seeds of cultivated plants gave 74.0% germination, while wild seeds only gave 11.0% indicating a lower quality (apparently abortive seeds). This is supported by the fact that in the wild *Cyrtostachys renda* tends to regenerate through the suckers, rather than through the seedlings.

A high mortality was experienced by sucker stages, while adults were stable. Therefore, *in situ* management strategy should be prioritised for the early stages to enable the suckers to establish more successfully. Sucker development appears to be more strategic to cope with waterlogged conditions, as sucker has a more rapid growth than seedling. While the density of sucker reached 84.82 / ha on average, the percentage of known flowering or fruiting plants was only 5.14% of the total population. Individual growth was plant size dependent, with adult stage became the most productive class.

Gluta renghas, *Eleiodoxa conferta*, *Korthalsia flagellaris*, *Shorea parvifolia*, and *Pandanus terrestris* became the top five species which were closely associated with *Cyrtostachys renda*, indicating similar ecological and habitat preferences among these species. The largest populations occurred in the forest associations of Anacardiaceae dominant, Dipterocarpaceae dominant, and Pandanaceae dominant. Thus, to conserve the well-drained sites of the sanctuary where these three forest associations occurred is essential to sustain the main populations.

There were no serious pests or diseases observed during the study, but the grasshopper *Valanga nigricornis sumatrensis* appears to be a potential threat for young leaves. On the other hand, habitat loss and forest degradation have become the most serious threats to the palm sustainability. Although a slight disturbance appears to stimulate this palm to establish, high habitat disturbances have led the palm populations to drop dramatically.

Population abundances varied considerably among sites and were determined by a combination of interrelated environmental quality parameters and habitat characteristics, including drainage quality, edaphic factors, nutrient contents, peat depth, habitat types, and interspecific and forest associations. The percentage of fine sand was most influential, both to densities and sizes, and both to frequency and basal area. Individual palm growth was plant size and habitat type–dependent.

There are at least five different uses of lipstick palm applicable for the local communities, including bagan construction, horticultural purpose, vegetable, logging rail construction, and supernatural connections. Horticultural means have been the only widely recognised indirect uses of this palm. The average value of community knowledge of the uses of *Cyrtostachys renda* in Kerumutan and the adjacent areas was 1.2, indicating different use values. Number of different plant uses appears to decrease as locations are farther from the palm natural habitat. The palm stem is frequently used to construct bagan's floor and there are at least five tree species most preferred by the local communities for developing such purpose. The highest rank was assigned to the endangered timber *Shorea rugosa* (meranti bakau) with the average rank 1.45 and *Cyrtostachys renda* (with the average rank 2.00). *Shorea rugosa* becomes the most preferred species might be due to its durability, strength, and resistance to termite and moth attack, while *C. renda* is preferred because it is easily managed and the stem is straight and smooth, though it is not as durable as the dipterocarp species.

Based on the overall considerations, the conservation of *Cyrtostachys renda* within its natural ecosystem is strongly suggested. The palm is totally confined to the Southeast Asian lowland peat swamp ecosystem, becoming an indicator species of this ecosystem, requiring specific ecological preferences, associations and habitat requirements, and suggesting the existence of a complex interconnectedness between this species and its natural environment, both biologically and physically. This palm is not only taxonomically distinctive (which can be used as a 'flag species" to promote conservation of peat swamp forests), but also providing a number of potential benefits for local communities. A proper protection and management, in combination with wise uses, would be a desirable way in managing and conserving this species sustainably.

An integrated approach combining eco-biological, physical, and socio-economic components would be an effective conservation strategy for achieving sustainable management of the rare species. The approach model suggested is

$$Y_{ACMi} = f\ (\text{Physical Components, Eco-Biological Components, Socio-Economic Components}) + E_{nod}$$

$$= f\ (P, Q, R) + E_{nod}$$

$$= f\ (P_1, P_2, P_3, P_4, P_5, Q_1, Q_2, Q_3, Q_4, Q_5, R_1, R_2) + E_{nod}$$

Where:
Y_{ACMi} = Autecology and conservation management of species i (as an integrated species-based conservation strategy model), f = A nonlinear function, P = Physical components (state variables), Q = Eco-biological components (explanatory variables), R = Socio-economic components (measured input disturbances), P_1 =

Physiography (particularly the size/extent of suitable habitat: well-drained area, topography, local conditions), P_2 = Accessions (number of accesses, practicality), P_3 = Hydrological system (pattern, water movement), P_4 = Administrative management (boundary, law enforcement), P_5 = Soil and water quality (soil texture/sand content, major mineral and organic form contents), Q_1 = Population structure and status, Q_2 = Forest and interspecific associations, Q_3 = Plant growth (growth rate), Q_4 = Plant survivorship, Q_5 = Reproductive behaviour, R_1 = Plant uses (use values and preferences), R2 = Population pressure (indirect impacts), E_{nod} = Disturbances of variable dynamics that are not observable (the system noises), such as logging, land conversion, plantation, and competition post disturbances.

The **major determinants** of the survival of *Cyrtostachys renda* within Kerumutan Wildlife Sanctuary include the size of particularly well-drained area (drainage quality), pristine hydrological system, soil and water quality of less major mineral contents but with relatively high organic substances, soils of a thin peat layer and low C/N value but with a high sand content, interspecific and forest associations, along with the critical sucker stage survivorship and appropriate *in situ* management strategy and protection. Thus, the habitat preference model constructed is $Y_{HPi} = f\ (P_1, P_3, P_5, Q_2) + E_{nod}$ (where Y_{HPi} = Habitat preference/suitability of species i).

Since the model includes multidimentional aspects, it is not realistic to construct a unidimensional equation. Sites which possess only a single environmental quality attribute can be measured in a quantitative manner, but those possessing multiple attributes, the attributes should be treated as separate variables. It may be better understood when the model is broken into manageable components (in practical applications). The critical assumption is that there are *complexities*, *uncertainties*, and *interconnectedness* among components involved, e.g. between physical and eco-biological components. Thus, multiple attributes potentially create a multi-collinearity problem (suppressor variables) leading to an invalid or inappropriate model. In this study, multicollinear variables may include physiography (particularly the size of well-drained area), hydrological pattern, soil and water quality, and interspecific and forest associations.