Inventory Techniques and Assessment of Rattan and Bamboo in Tropical Forests

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Contents

Foreword

Despite the steadily increasing demand for bamboo and rattan, not enough attention has been paid to them in the national forest inventories carried out in Asia, resulting in a serious lack of information on the available and potential supply of these two important resources. An international meeting of experts was convened in 1995 to discuss ideas on suitable inventory techniques and exchange information on recent surveys and inventories relavant to bamboo and rattan in different countries.

The two-day International Meeting of Experts on Inventory Techniques and Assessment of Rattan and Bamboo in Tropical Forests was jointly organized and sponsored by the International Network for Bamboo and Rattan, ODA-UK/Oxford Forestry Institute and the Forest Research Institute Malaysia. This publication, which presents the proceedings of the well-attended international meeting of experts, is a significant step in drawing attention to the problems and prospects of bamboo and rattan inventories.

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Rattan
Assessment and Inventory

Status of Rattan and Rattan Inventory in India

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Abstract

The status of rattans and rattan inventory in India is discussed briefly. The Kerala Forest Research Institute, as part of a research program is funded by IDRC, Canada, is currently involved in developing appropriate inventory methods for rattans. Based on these studies, various constraints in the design and execution of rattan inventory are discussed. The potentials of modern inventory tools such as remote sensing, geographic information systems (GIS), global position systems (GPS), as well as different sampling designs in overcoming these constraints, especially. regarding data capture, data integration, preparation of inventory design, data processing and display of results arediscussed.

1.0 introduction

Rattan is one of the most important non-timber forest products in India. About two million people, especially from the poorer sections, are employed in the industry (Bhat 1993). Till a few decades ago, rattans were found in abundance in natural forests and therefore scientific management of the resource was not accorded much importance. But exploitation, large-scale forest clearance and unscientific management have resulted in heavy depletion of the rattan. However, with proper inputs, there is substantial scope for enhancing productivity of rattans from Indian forests. The increasing national and international markets for rattan products offer considerable scope for investments 'in the development of this resource.

Rattan resources in India are distributed in evergreen, semi-evergreen and moist deciduous forests of three regions, viz., Western Ghats, Northeast and the Andaman and Nicobar Islands (Basu 1995). In these regions, rattan areas are diverse in terms of their populations and habitat parameters.

Of the 51 species found in the country, 18 occur in each of these three regions in a mutually exclusive manner (Basu 1995). Even within each region, there are site specificities for most of the species (Renuka 1992).

Locality factors influence not only the distribution patterns of the species but also stocking and age class distributions. While in Kerala rattan occurs in small pockets, in Kamataka, Maharashtra, Assam and West Bengal the pocket sizes are much larger. In Andaman and Nicobar Islands, they are distributed throughout the forests.

2.0 inventory Methods

For scientific management, adequate information on distribution of the resource and estimation of the growing stock is essential. This information has to come through inventory. However, as in the case of many other countries, rattan inventory in India is yet to receive adequate attention. Although "Rattan Working Circles" were common in Forest Working Plans, no systematic effort to inventory the resource has so . far been reported.

Efforts at developing inventory methods were also rare. Chacko (1963) suggested the use of low intensity line plot sampling method for survey of bamboo and rattan. However, no report is available with regard to the resource survey of rattans employing this method. Taking into consideration the diverse nature of rattan habitats, this method can give only a rough estimate of the growing stock.

Recognizing the need for scientific management of the resource, the Kerala Forest Research Institute,, through an IDRC-supported research program, initiated a multidisciplinary study on various aspects of rattan management and utilization. As part of this, studies were initiated to develop appropriate inventory methods.

Nandakumar and Menon (1993) provided a brief account of the constraints and prospects of resource survey of rattans in Kerala. The resource distribution status, ownership pattern, habitat features, and problems in field surveys were discussed and two inventory models, one for the State level and the other for the forest division, were proposed.

During ground survey, the following factors were noted as constraints: nonavailability of maps of rattan areas; heterogeneity of rattan habitats in terms of populations and habitat parameters; and difficulties owing due to inaccessibility, undulating terrain, inhospitable climate, leeches and wild animals, there were difficulties in identifying rattan species as well as in taking measurements. The possibility of using methods such as remote sensing, geographic information systems (GIS), global position systems (GPS) and other sampling and inventory methods were contemplated to overcome these difficulties.

A method for preparation of maps of probable rattan areas was developed using remote sensing (Nandakumar and Menon 1993a; Menon 1993). This is of considerable value when used for map preparation of large areas. Also, with the help of multistage sampling techniques appropriately designed, cost-effective sampling methods were developed for State and Divisional level surveys. Efforts were also made to utilize available information on silvics of rattans for developing inventory designs (Silvics relates to the whole body of knowledge on life history and / or forests as a basis for silviculture).

3.0 Research on inventory Methods and Future Plans

The methods proposed were by and large stop-gap arrangements. For effective management, an inventory system should provide information about the resource on a continuous basis at any desired point of time. Recognizing this, studies are now being held to develop a continuous inventory system which will provide data and models to give information. In order to capture the heterogeneity of rattan habitats to the maximum extent possible, a network of sample plots was initiated. Efforts were also initiated to carry out repeated measurements in selected sample plots to get an idea about change at the levels of the stand and of the individual plant, and to standardize such procedures as well as develop stand and individual growth models.

Attempts are being made to develop a GIS for rattan habitats by pooling available data on different parameters, such as topography, roads, drainage, vegetation and human settlements, into an integrated database. Refinement in GIS is planned by the use of multi-temporal / multi-spectral data obtained from satellite imageries, data obtained from sample plots and other data gathered through GPS. By the integrated use of remote sensing, GIS, GPS and ground survey technologies, it is planned to establish a set of permanent sample plots which, when monitored with the help of appropriate partial replacement methods, will give desired information for rattan management on a continuous basis. The present studies are directed to achieve this task. Once standardized these methods can be extended to the whole of India and, in turn, integrated with inventories of other countries.

4.0 International Co-operation: a Research Agenda

The recent technological revolutions in GIS, GPS, remote sensing and laser technology have provided a wide range of opportunities in evolving cost-effective and efficient inventory systems suitable to the highly inhospitable rattan habitats of the tropics, thus providing information regarding the management of rattans. International co-operation and financial support is needed to make full use of these technologies to develop these inventory systems.

Acknowledgements

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FRIM/ODA Rattan Inventory Research Project

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Abstract

A study was carried out to compare the applicability of three sampling methods in the inventory of rattan. It was conducted in a lowland dipterocarp forest at Pasoh Forest Reserve (PFR) and the hill dipterocarp forest of Semangkok Forest Reserve (SFR). Three sampling methods, line or strip, grid and cluster samplings were compared. From the analyses, line sampling gave a better estimate, a better picture of rattan production of PFR. In SFR, data collected from cluster sampling is closer to the mean. In terms of efficiency, grid sampling has a greater edge over strip and cluster sampling in PFR. However in SFR, the inventory of rattan using cluster sampling is more efficient, even though more time consuming.

1.0 Intrduction

Rattan inventory has been carried out in some rattan-producing countries e.g. Indonesia (Siswanto 1991), Malaysia (Forestry Department 1988), the Philippine (Tandug 1984 and work in 1988), and India (Sharma and Bhatt 1982; Nandakumar and Menon 1992). The work on rattan sampling methods has been reviewed (Nur Supardi 1992) although no work had been done to test the effectiveness of different sampling designs.

In 1991, a proposal was drawn up to study the effectiveness of rattan inventory designs. The Forest Research Institute of Malaysia and the ODA-UK agreed to fund the study and it started in mid-1992.

The purpose of the study was to determine the most efficient rattan inventory design that could be adopted in different forest types in the country as rattan, being an important non-timber forest resource will require systematic management for its sustainable production (Nur Supardi 1992). Information on its distribution and availability is possible through census, but the methodology should be devised first.

The project has a secondary objective, which is to understand the distribution patterns and the ecological relationships between rattan species and the associated vegetation. This paper, however, only reports results from the inventory studies.

2.0 Methods

The study was implemented in three phases: (1) training of staff in inventory work and rattan identification, (2) 100% survey of all rattan within demarcated plots, and (3) implementation of three sampling designs within the plots. Phases 2 and 3 were carried out in two forest types: lowland dipterocarp and hill dipterocarp forests.

2.1 studysites

Lowland Dipterocarp Forest: The site is located at Pasoh Forest Reserve (PFR) which is 140 km SE of Kuala Lumpur. It is made up of 650 ha of primary lowland mixed dipterocarp forest surrounded by another 650 ha of partly regenerated and partly virgin forest. PFR is characterized by family dominance of Dipterocarpaceae, and by three tree layers (emergent, main-storey and understorey trees).

Within the PFR, a 50 ha demographic plot was established. The rattan inventory plot is located on the western end of the plot.

Hill Dipterocarp Forest: The site is at compt. 30 of the Semangkok Forest Reserve (SFR), which is 80 km NE of Kuala Lumpur. The area is a virgin jungle reserve with many emergent trees of *Shorea curtisii*. Part of the plots are within the FRIM-FFPRI/NIES dipterocarp plot (an outstanding species association).

2.2 Rattan enumeration and plotdesign

This part of the study was the most time-consuming. However, this sampling is important to get the true mean values of parameters observed. The census also forms a base for further ecological work in the plot.

In PFR, 100% sampling of rattan was carried out in an area measuring 500 x 100 m of block A. The plot was divided into 125 plots of 20 x 20 m (Fig. l), which were further divided into six sub-quadrats of 5x5m.

After understanding the workload in surveying all rattans that there is not much variation between plot size greater than 1 ha, it was decided to reduce the plot size to 1 ha (100 x 100 m) which was replicated twice. The plot was divided into 25 small equal-sized plots of 20 x 20 m. The plots were then divided into four subplots measuring 10 x 10 m (Fig. 2). PVC poles marked every 10 m points. The poles were painted aluminous orange. Two Ushikata compasses (which give both the bearing and the slope gradient) were placed two metres on the western position of the subplot (distance 10 m apart) to obtain the bearings (position) of the rattan measured.

2.3 Sampling design and plots layout

Three sampling methods were conducted in two 5-ha blocks (block A and B) of size 500 x 100 m. The sampling designs were:

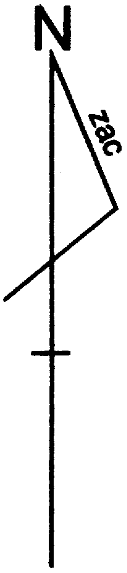
(1) Strip sampling of five lines (plots) measuring 100 x 10 m. There were four subplots of 25 x 10 m (Fig. 3).

(2) Grid sampling of five grids (plots), each within an area of 100 x 100 m. There were four subplots of 50 x 5 m (Fig. 4).

(3) Cluster sampling. There were three clusters (plots), each covering 100 x 76 m. Each plot had six subplots of 28 x 10 m (Fig. 5).

2.4 Sampling intensity

The sampling intensity was fixed at 10% as a control to compare the effect of different plot layout and sizes. Experiments on sampling intensities in Indonesia (Siswanto 1991) revealed that an intensity of 20% gave the best results in terms of information gathered, but costwise it proved expensive. Therefore, 10% was chosen to ensure that the cost of the census was kept low.



500m

024	124	224	324	432
023	123	223	323	423
022	122	222	322	422
021	121	221	321	421
020	120	220	320	420
019	119	219	319	419
018	118	218	318	418
017	117	217	317	417
016	116	216	316	416
015	115	215	315	415
014	114	214	314	414
013	113	213	313	413
012	112	212	312	412
011	111	211	311	411
010	110	210	310	410
009	109	209	309	409
008	108	208	308	408
007	107	207	307	407
006	106	206	306	406
005	105	205	305	405
004	104	204	304	404
003	103	203	303	403
002	102	202	302	402
001	101	201	301	401
000	100	200	300	400

20m

100m

Fig. 1: Plot designs for 100% sampling of rattans

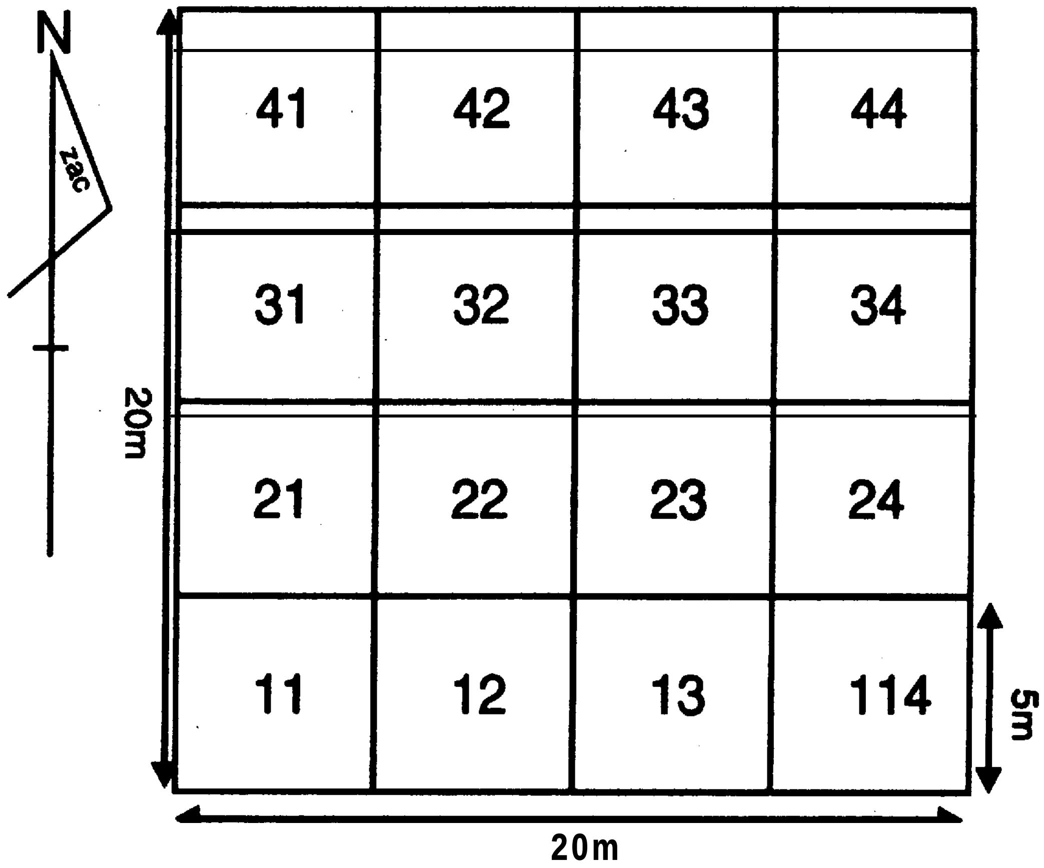


Fig. 2: Reduction of plot size for 100% sampling of rattan

2.5 Parameters observed

All rattans with stems of 1 foot (30 cm) or more were tagged and recorded for quadrat and subquadrat number, species, cluster number, stem number, stem length, diameter (if measurable) and other observations relevant to growth.

A white plastic tag was tied on every rattan stem. The lower length of the stem, which was sprawling on the ground and within reach, was measured using measuring tapes. The upper length of the stem was estimated visually by looking at the nodes. The uppermost portion, sometimes hidden by the tree canopy, was estimated using the height of the tree canopy as the indicator.

2.6 Labour usage

For all the samplings carried out in the study, a team of five persons was involved. Their tasks were apportioned as follows: one

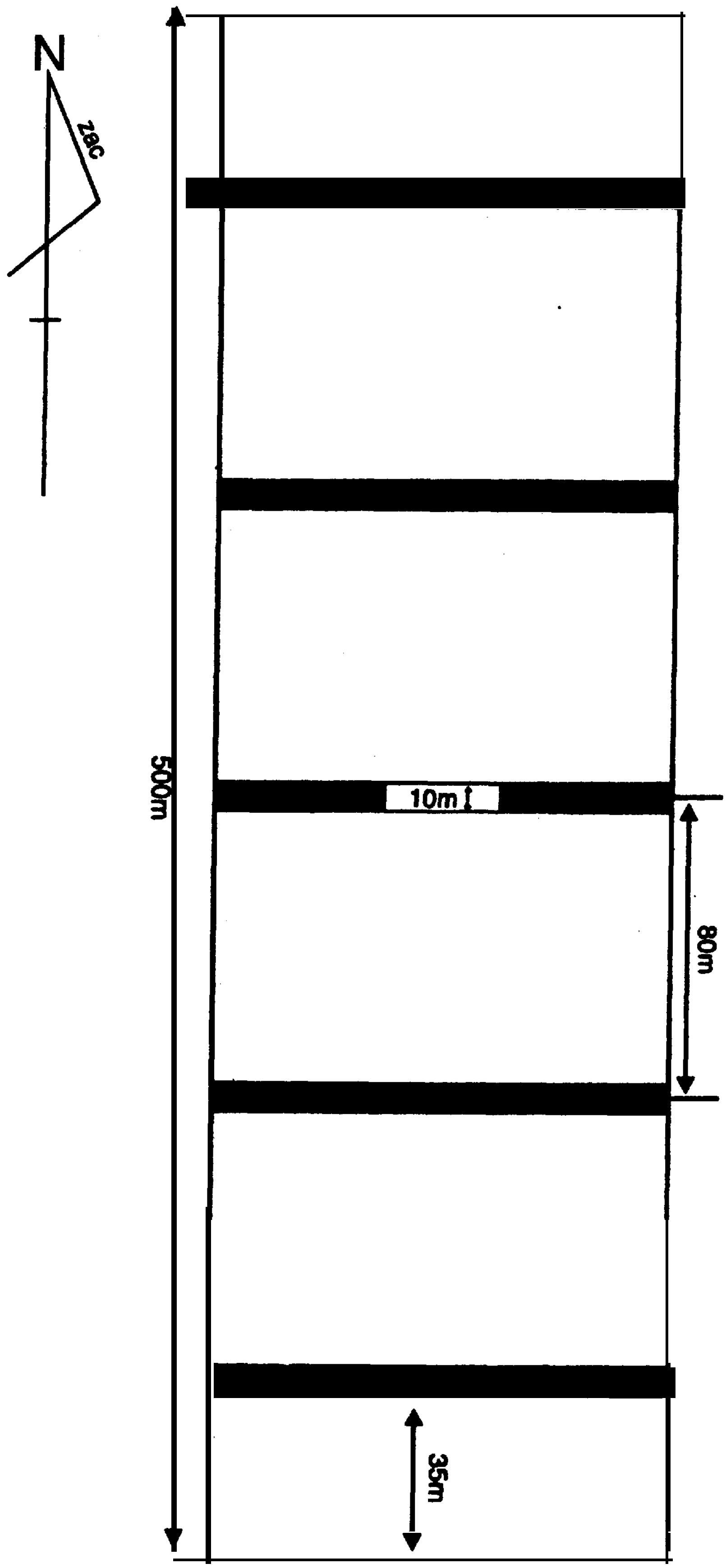


Fig. 3: Strip sampling plot design

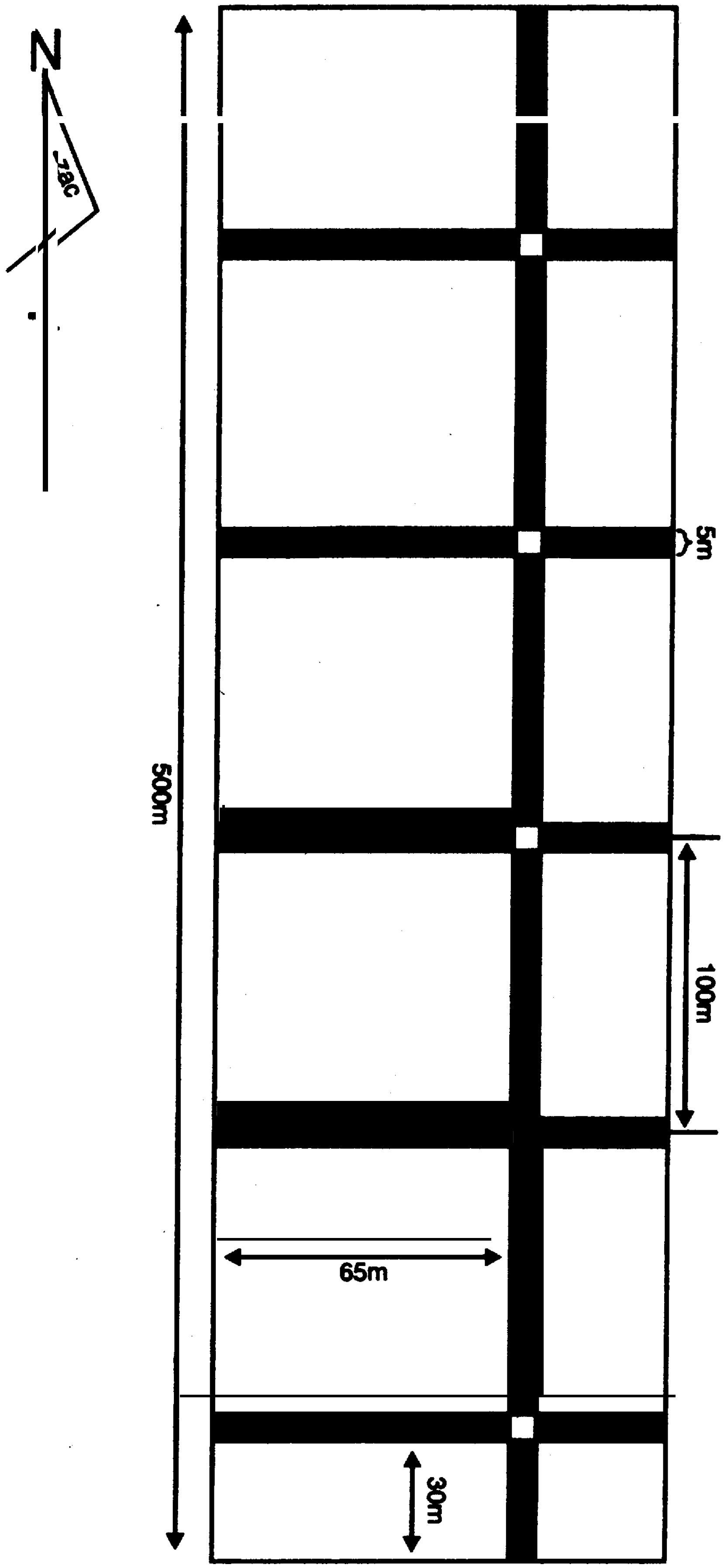


Fig. 4: Grid sampling plot design

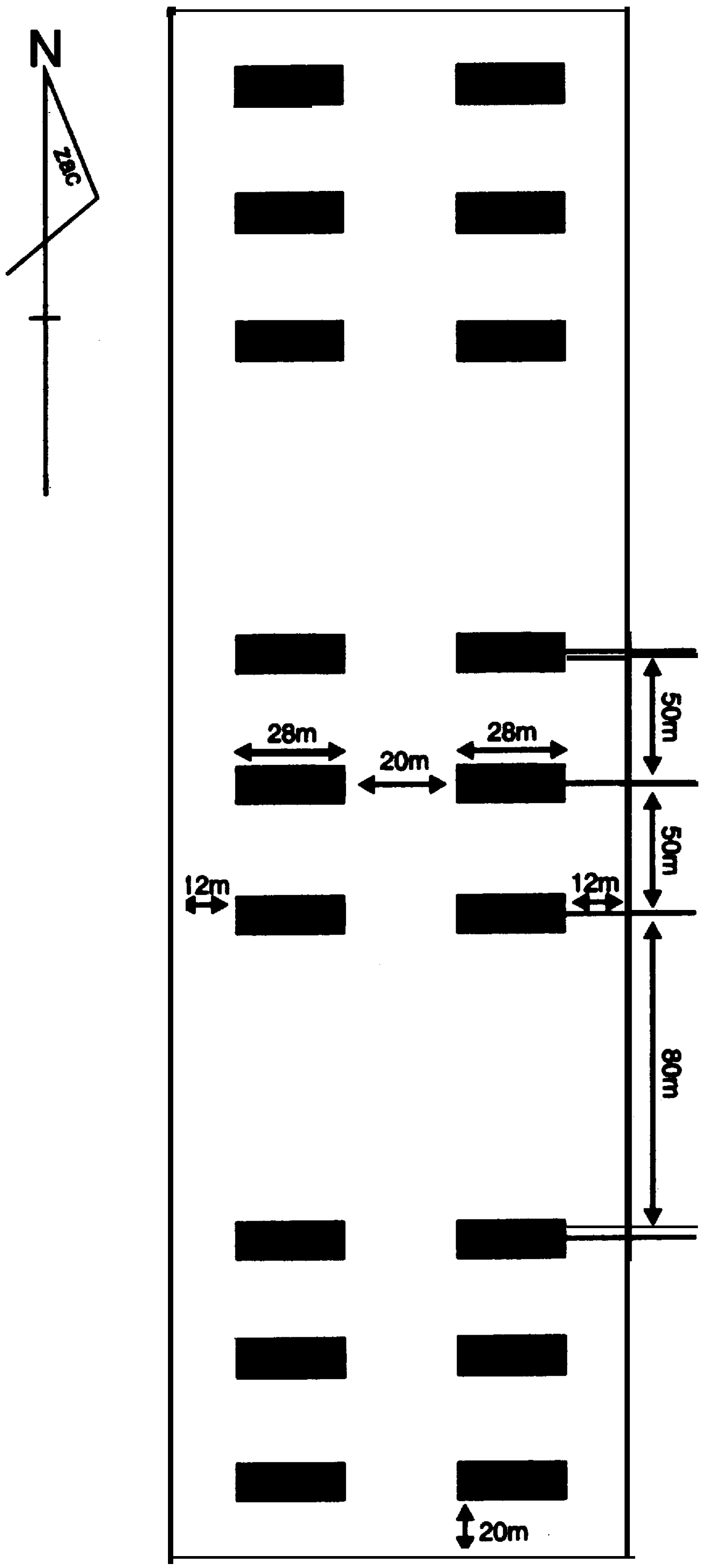


Fig. 5: Cluster sampling plot design

each for recording and species identification (team leader); bearing; and line clearing; and two distance measurement, rattan survey and tagging. The time taken to conduct the survey was used as a test of the efficiency of the methods studied.

3.0 Results and discussion

The statistical data of 100 percent enumeration for PFR and SFR are presented in Tables 1 and 2. The number of species recorded in the lowland dipterocarp forest of PFR is higher (29) than that in the hill forest of SFR (18). There were more rattan clumps and stems in PFR (371 clumps ha-l; 878 stems ha-l) as compared with SFR (341 clumps ha; 557.5-l stem ha l). There were higher numbers of rattans per clump at PFR. Less numbers of rattan were observed on ridges of SFR.

Table 1: Statistical results of the 5 ha plot at Pasoh forest Reserve (per ha)

	Mean	Std. dev.	Std. error	CV (%)	E (%)	Conf. Interval
No. of clump	371.4	**84.8**	37.9	22.8	21.8	80.9
No. of stem	878.4	197.2	88.2	22.4	21.4	188.0
Stem length (m)	9527.4	2648.2	1184.3	27.8	26.5	2524.9

Table 2: Statistical results of the two 1 ha plots at Semangkok Forest Reserve (per ha)

	Mean	Std dev.	Std error	CV (%)	CV (%)	Conf. Interval
No. of clump	341 .0	84.0	38.1	24.6	23.1	86.6
No. of stem	557.5	204.5	92.9	36.7	26.8	192.3
Stem length (m)	1887.7	460.52	224.3	24.4	24.2	438.4

The rattan stem in PFR (9 527 m ha^{-1}) was much longer than that at SFR (1 888 m ha^{-1}). This is attributed to the fact that there was an abundance of stemless or short-stemmed rattan species in SFR, (such as *Calamus casteneus* and *Daemonorops calicarpa*). Another factor is that rattan had been extracted from that area.

The results for the three sampling designs tested are presented in Tables 3 and 4. Comparisons with the "true" means were made for the variables tested. The ranking of estimates close to the “true” mean is presented in Table 5.

Table 3: The summary of results for various sampling methods at Pasoh Reserve (per ha)

	Strip sampling	Grid sampling	Cluster sampling	
No. of plot No. of subplot	5 20	5 20	3 18	
No. of clump	344.0 36.6 34.9	402.0 23.5 22.4	670.0 25.2 42.4	Mean Coeff. of Var. (CV) Sampling Error (%)
No. of rattan stem	908.0 47.6 45.4	1094.0 26.5 25.2	1623.3 49.0 82.7	Mean Coeff. of Var. (CV) Sampling Error (T)
Stem length (m)	12323.8 43.6 411.6	16231.8 23.1 22.1	16528.0 55.4 93.4	Mean Coeff. of Var. (CV) Sampling Error (T)

Table 4: The summary of results for variaous sampling methods at Semangkok Forest Reserve (per ha)

	Strip sampling	Grid sampling	Cluster sampling	
No. of plot No. of subplot	5 20	5 20	3 18	
No. of clump	406.0 50.8 80.8	236.0 22.9 36.5	357.4 28.7 25.3	Mean Coeff. of Var. (CV) Sampling Error(%)
No. of rattan stem	713.0 42.5 67.5	476.2 43.6 69.6	609.8 28.7 30.1	Mean Coeff. of Var(CV) Sampling Error (T)
Stem length (m)	2876.38 58.1 41.6	1763.2 69.4 110.4	2459.1 44.9 47.1	Mean coeff. of var. (CV) Sampling Error (T)

Table 5: Ranking of estimates close to the absolute

		Cluster / ha	Stem / ha	Total stem length (m / ha)	Sub total	Total
Strip sampling	PFR	1	1	1	3	11
	SFR	2	3	3	8	
Grid sampling	PFR	2	2	2	6	12
	SFR	3	2.	1	6	
Cluster sampling	PFR	3	3	3	9	13
	SFR	1	1	2	4	

Data collected from strip sampling seems to give the most reliable estimation for the number of clumps, number of stems and the steam length in the lowland dipterocarp forest. In hills of SFR, data collected from cluster sampling was the most reliable, probably because the sub-plots are widespread.

To test the efficiency of the sampling methods, through cost taken as time involvement, Grosenbaugh's criterion was used. In PFR, the time taken to accomplish the census was almost equivalent (83 minutes per plot) for all the three sampling designs; but smaller sampling errors (22- 25%) have ensured smaller Grosenbaugh's values, making it the most efficient sampling design.

In SFR, a longer time was spent to complete the inventory tasks. Most of the time was spent on demarcation of lines or plots as the terrain was rough and steep. Less time was used to complete a strip sampling plot (100 minutes).- A longer time was spent on grid sampling (162 minutes) which needed 1 km (100 x 10) of line alignment. Similarly, more time was taken to demarcate six subplots of the clusters (212 minutes per plot). However, cluster sampling was found to be the most efficient design in the hill dipterocarp forests for determining the number of rattan clusters and the stem number. This is attributed to the lower sampling error in this design. In determining the stem length, strip sampling was the most efficient sampling design.

3.1 Other observations

There are areas of high concentration of rattan clumps. There are small pockets also where rattan is found. Rattans in SFR are better distributed. In relating plot size to variability (Freese 1961), Stockdale and Wright (1993) found that the most efficient plot size for inventorying rattan in a dipterocarp forest in the Temburong District of Brunei ranged between 0.0025 ha and 0.025 ha.

The high coefficient of variation – e.g., 22.4% (grid sampling) to 93.4% (cluster sampling) – at PFR suggested that more plots are needed to obtain coefficient value of less than 20%. In the above example, grid sampling with subplot size of 0.05 ha gave a better estimate than cluster sampling (subplot size 0.028 ha).

The coefficient of variation between rattans (e.g. Calamus manan) of known age (planted) is high (Nur Supardi 1993). In the study, the coefficient of variation (CV %) for the stem length of various rattan species of wide range of ages varied from 23 to 69%.

4.0 Conclusions

The fact that different tests gave different results indicates the variety of choices in inventory work. In the case of lowland dipterocarp such as at Pasoh, strip sampling could be used to obtain general information on the rattan production in the area;. or grid sampling, which even though gives less precise data is more efficient and has less sampling error could be used.

In hill dipterocarp forest, cluster sampling gives a better estimation of the number of rattan clumps and stems, but not stem length. It is also the best in terms of efficiency in rattan inventory in the hill dipterocarp forest. .

Acknowledgements

The authors would like to thank the State Forest Departments of Negri Sembilan and Selangor, the District Officers of Kuala Pilah and Ulu Selangor, the Manager of Pasoh Field Station and the Leader of the Demographic Study Group for allowing us to conduct work in their jurisdiction.

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Table 6: The Grosenbaugh's criterion for the sampling methods with respect to sampling error and time (PFR)

	Strip sampling	Grid sampling	Cluster sampling
Mean time (min)	**81.7**	**84.0**	**83.0**
Sampling error (o/o)	**34.9** **45.4** **41.6**	**22.4** **25.2** **22.1**	**42.4 No. of clump** **82.7 No. of rattan stem** **93.4 Stem length (m)**
Grosenbagh's criterion*	**99511.4** **168396.8** **1411386.7**	**42147.8'.** **53343.4'** **41026.4'**	**149214.1 No. of clump** **567661.1 No. of rattan stem** **724055.5 Stem length (m)**

'Grosenbaugh's criterion = Sampling error^2 x Time
'Smallest value indicates best result

Table 7: The Grosenbaugh's criterion for the sampling methods, with respect to sampling error and time (SFR)

	Strip sampling	Grid sampling	Cluster sampling
Mean time per plot (min)	110.0	162.2	212.0
Sampling error (0/0)	80.8 67.5 41.6	36.5 69.6 110.4	25.3 No. of clump 30.1 No. of rattan stem 47.1 Stem length (m)
Grosenbagh's criterion*	718150.4 501187.5 190361.6	216090.9+ 785722.7 1976919.5	135699.1+ No. of clump 192074.1' No. of rattan stem 470302.9 Stem length (m)

Grosenbaugh's criterion = Sampling $error^2$ x Time
'Smallest value indicates best result

Current Rattan Assessment Techniques in Sarawak as Applied by the Forestry Department

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Abstract

Sarawak Forestry Department has established research plots and planting plots where a few rattan species are being tried. Currently the establishment of research plots is confined to assessment work only. For planting, the objective is to study the growth performance of C. *optimus* and C. caesius with four different types of fertilizer and on four different groups of Sarawak soils.

1.0 Introduction

Sarawak has recorded 106 species of rattan, and is considered one of the richest areas in rattan diversity in the world. A few localities with the most vulnerable species are Gunung Mulu National Park (Miri Div.), Sabal Tapang Forest Reserve (Samarahan Div.) and Sempadi (Kuching Div.). Rattan is included as an important minor forest product in Sarawak (Table **1).** Although export is insignificant (Table 1), the demand for local and international trade seems to be continuously increasing.

Rattans are widely used by the rural population, particularly for basketry, matting and tying. In addition, rattans are also sold to traders for obtaining much-needed cash. Currently, rattans are widely extracted from the natural forest, which could cause depletion of the resource and may affect species survival. To avoid shortage and damage from overexploitation, the Sarawak Government and the private sector have developed an interest in rattan silviculture and plantations (Table 2).

Table 1: Export of rattan from Sarawak for the period 1988-92 (Source: Sarawak Forest Department Annual Report)

	1988		1989		1990		1992		1992	
	Quantity (ton)	Value (RM $)	Quantity (ton)	Value (RM $)	Quantity (ton)	Value (RM $)	Quantity (ton)	Value (RM $)	Quantity (ton)	Value (RM$)
Whole rattan	2 285	6 921 715	2 760	7 271 575	1 836	4 593 978	1 642	4 511 910	2 046	5 515 547
Split rattan	27	44 258	120	488 729	217	686 450	216	646 504	140	665 575

Table 2: Rattan Plantation Project in Sarawak (Source: Utilization of Palms in Sarawak. Malayan Naturalist November 1989)

	Organization	Date set up	Objectives	Species	Location	Area (ha)	Notes
	a. Government Department or Agencies						
1	Botany Unit, Forest Dept., Sarawak	1982	To test growth Performance under natural	*Calamus optimus*	Landeh, Kuching Div.	0.034	Abandoned after 2 years
2	Botany Unit, Forest Dept., Sarawak	1984	Fertilizer trial	*C. optimus*	Ulu Landeh, Kuching Div.	4.9	Research plot 137
3	Botany Unit & Soil Unit Dept., Sarawak	1987	Growth	*C. caesius*	Sampadi	4.9	Resrarch plot
4	Reafforestation Unit Forest Dept., Sarawak	1986	Seed orchard	*C. caesius* *C. optimus* *C. ornatus* *C. scipionum* *Daemonorops sabut*	Semengoh Kuching Div.	25.2 available	
5	Reafforestation Unit Forest Dept., Sarawak	1990	To reforest and rehabilitate areas of PFE		Sabal, Sampadi	Increasing	Part of their Planting project
6	Rattan Plantation Project Unit, Sarawak Timber Industry Development Corporation (STIDC)	1988	Trial project for production of Commercial spp.	*C. caesius* *C. ornatus* *C. scipionum* *C. trachycoleus* '*wileya*' (unident)	Kota Samarah an, samarahan Div.	2 000 in stages	to include a seeding nursery
7	Agriculture Dept., Sarawak	1989	Seed garden cum experimental plot		Sg. Sebiew, Bintulu Div.	4.0	Planning stage
8	Agricultural Diversification Scheme, Agriculture Dept., Sarawak	1990				550 in	
	b. Private Organizations						
1	Linggi Jugah Group of Companies & the Commonwealth Development Corporation	1989 -	Commercial	*C. caesius* *C. manan* *C. trachycoleus*	Miri, Miri Div.	6 000	
2	KERESA	1990	Commercial	*C. caesius* *C. trachycoleus*	Tatau, Bintulu Div.	6 000 (in logged over forest)	Expected first harvested in 1999

2.0 History and Present Status of Rattan Inventory

Sarawak Forest Department established the first rattan silviculture plot in March 1982 within a plantation of *Shorea splendida,* an important species of dipterocarp. Survival after 1 year was 97.3%, but average height increment was poor (8.9 cm). The. seedlings were destroyed after 2 years, presumably by squirrels.

In 1984, the Research Branch established research plot 137 at Semengoh Forest Reserve, Kuching with the objective of studying the growth of *Calamus optimum* under four different types of fertilizer treatments (Treatment 1 - no fertilizer, control; Treatment 2 - 50 g of compound fertilizer, NPK 12, 12, 17, 2+TE; Treatment 3 - 50 g of triple superphosphate 46 P2 05 22P; and Treatment 4 - 50 g of each compound fertilizer + triple superphosphate). The plot of 175 x 280 m was divided into fivesub plots of size 35 x 70 m. The replicates consisted of four subplots for each treatment. Each subplot contained 10 planting lines, each with 10 planting pits.

In October 1987, research plot 145 entitled Rattan Project; Cultivation Trial was established. The project was carried out at Sempadi Forest Reserve, a primary forest located about 33 km from Kuching along the Kuching-Bau-Lundu Road. The objective was to investigate the growth performance of *Calamus caesius* assessed in terms of growth in cane length on four different types of Sarawak soils viz. alluvium (Block I), clay (Block II), red-yellow podzolic (Block III) and podzol {Block IV).

In 1990, the Reafforestation Unit began planting several species of rattan in the deforested areas of Bintulu (Bintulu Div.), Niah (Miri Dev.) and Sabal (Samarahan Div.). The objective was mainly to rehabilitate the areas.

The establishment of rattan research plots and planting in Sarawak is currently confined to experimental stages. They are not employed for inventory purposes, but confined to assessment work involving the measurement of cane length of the mother rattan. The assessment of research plot 137 and 145 is still going on.

2.1 Mensuration techniques

The assessment instruction for research plots 137 and 145 are as follows:

1. Measure length of the cane starting from the highest ground level to the base of the petiole of the youngest open leaf. Steel measuring tape may be used to measure the cane length and a l-inch diameter PVC pipe as measuring rod.
2. Count and record all suckers that are formed from each plant.
3. Examine the growth status of the plants and classify into three categories, namely 3 for good and healthy, 2 for moderate, 1 for poor and stunted, and x for dead.
4. Record the mortality or survival percentage and any other factors that may be observed.
5. Record the light intensity using a light meter (foot candle equipment)

The assessment work of research plots 137 and 145 is carried out once a year. The measurement of the cane length in every subplot is recorded on the assessment form (Table 3). All information recorded each year are filed but no analysis is done.

Table 3: Format of rattan trial planting assessment form

Locality:	Tally by:	RP:
Subplot no.:	Treatment:	Replicate:
Date est.:	Assessed	Age: yrs.

culm no.	Stem height (cm)	Existing leaves	Crown position	Total nos. of suckers	
1					
2					
3					
4					
5					
6					
etc.					

2.2 Interpretation of results

In research plot 137, assessment in 1994 showed the longest increment as 324.91 cm recorded in treatment 4, followed by treatment 3 (321.28 cm), treatment 2 (268.13 cm) and treatment 1 (212.95 cm) (Table 4). The longest increment recorded 335 cm found in a subplot of treatment 2.

In research plot 145, assessment in 1992 showed that C. caesius grows better in lowland areas than in upland areas. In lowland areas, the growth was better on clay soils than on alluvial soils. In upland areas, the growth was good only in valleys and depressions.

The survival percentage of rattans differs greatly among subplots, blocks and replicates. Generally, the survival percentage was very low despite the fact that the rattan produces suckers. The mother plants tended to die and the living ones were mostly suckers.

Table 4. Average reading of cane's normal length in each subplot (Research Plot 137, 1994)

Subplot	Treatment	Present reading (average cm)	Last reading (average cm)	Increment (cm)	Light intensity (%)	Survival (%)
01	T.4	1469.08	1132.00	337.08	9.11	12
05		1976.43	1609.73	366.70	17.47	49
07		2204.40	1846.36	358.04	40.92	
13		2230.88	1907.87	323.01	21.78	69
19		1448.81	1209.07	239.74	11.04	64
				324.91		
02	T.3	1951.75	1491.00	460.75	15.88	4
06		1231.74	962.12	269.62	13.31	38
10		1826.20	1593.12	233.08	32.33	40
14		2075.25	1738.84	336.41	14.12	69
18		1583.23	1276.68	306.55	19.43	65
				-321.28		
03	T.2	1482.79	1201.95	280.84	29.80	33
09		1467.35	1228.31	239.04	24.23	52
11		1338.47	1042.95	295.52	38.00	38
15		1386.39	1136.36	250.03	6.18	71
17		1693.07	1417.87	275.20	19.53	82
				268.13		
04	T.I	1512.90	1230.98	281.92	41.57	50
08		924.88	714.15	210.73	28.13	40
12		989.14	850.59	138.55	27.28	51
16		712.24	579.80	132.44	30.19	67
20		787.09	485.96	301.13	10.64	32
				212.95		

2.3 Problems in assessment work

1. Maintenance work is carried out before the assessment work starts and it is necessary to avoid harvesting the rattans.
2. If the rattan stem is high up on a tree or the measuring rod could not reach to the petiole of the last leaf, estimated measurement has to be taken.
3. The survival percentage decreased every year, as a result of squirrel attacks, pests and diseases.

2.4 Identification and classification

Despite the work in this field by Dr. John Dransfield and Dr. Paul Chai, there is a lack of well-trained, experienced and full-time identifiers.

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Rattan Inventory Techniques Currently Used in Sabah

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1.0 Rattan Resources in Sabah

Rattan occurs naturally in all forest types in Sabah. Harvesting of canes from the natural forest has always been carried out by villagers, who may have a rule of thumb for inventorying rattan. The authority responsible for management of the natural forest resource in the state, the Forestry Department, has never inventoried rattans in the natural forest. Thus, the rattan resource in the natural forest is known very poorly. The most recent documentation of the various rattan species is the qualitative description by Dransfield (1984), based on his field work in 1979. Since then rattan collection by villagers has intensified, prompted by the strong market demand. Based on the authors' experience of rattan seed collecting expeditions carried out since 1991, it can be concluded that commercially valuable rattans in all accessible forests have been depleted to the extent that many natural populations have disappeared. The few mature stems which remain are inadequate to form sustainable breeding populations, except in totally protected forests such as national parks.

The total area of rattan plantation is estimated at about 18 000 ha. Innoprise Corporation Sendirian Berhad (ICSB) accounts for most (51%) of the total area planted, followed by SAFODA (Sabah Forestry Development Authority) (31%), Jeroco Plantation (10%) and Sejati Plantation (8%). Details of the location, area and species in the plantations of these organizations are given in Table 1.

Table 1: Rattan plant; aitions in Sabah

Organization	Location	Area (ha)	Earliest planting date	Main species planted
SAFODA	Kinabatangan, Ulu Tungud	5600	1981	*Calamus tracbycoleus, C. caesius, C. manan*
Sejati Plantation	Telupid	1400	1982	*Calamus caesius, C. manan*
Innoprise Corporation Sdn. Bhd.	Luasong	9 100	1988	*Calamus caesius C. subinermis, C. manan, C. trachycoleus, C. merrillii*
Jeroco Plantation Sdn. Bhd.	Kuala Kinabatangan	1800	1982	*Calamus manan, C. caesius*
Forestry Department	Kolapis, Segaliud Lokan	50	1979	*Calamus caesius, C. manan, C. subinermis Daemonorops fissa*

2.0 History and Current Status of Rattan Inventory in Sabah

As stated above, rattan inventory in the natural forest has never been carried out in Sabah; but in plantations, two inventory systems-static and continuous-have been used.

2.1 Staticinventory

In plantation organizations which have started producing canes, i.e. SAFODA and Sejati Plantation, the estimation of stocking is static and carried out by destructive sampling. Only the harvestable blocks/ compartments are inventoried. Sampling is normally done randomly within each block or compartment, and systematic sampling is rarely used. Thus, the inventory method used by these organizations is stratified random sampling. Measuring methods used are empirical weighing and counting the number of canes of a given length (normally 3 m for large diameter and 6 m for small. diameter canes>.

2.2 Continuous/recurrent inventory

In the rattan plantation at Luasong, ICSB has set up pemanent sample plots for monitoring the growth of various species. The methods of measurement, plot layout and data analysis, however, have remained a commercial secret.

The Forest Research Centre of the Forestry Department, Sabah, has established two sets of plots of Calamus ***caesius*** in Sejati Plantation for monitoring the internode and sucker production in compartments ranging from l/2 to 10 years old. Preliminary results show that on similar sites and at similar light intensities, there is a significant trend of increase in internode production rate with clump size and age, but not with stem length. Sucker production rate increases with clump size and age.

3.0 Proposed Scheme for Planning a Rattan Inventory in Sabah

As the experience of rattan inventory in Sabah is limited, we propose the following scheme for planning a rattan inventory.

A. Identification of objectives of the inventory

Determination of stand density, site characteristics (including light, soil and climate), present stocking, potential yield, etc.

B. Compilation of background information

(i) Past enumeration, reports, maps, photographs

(ii) Characteristics of area to be inventoried

(a) Location

(b) Size

(c) Terrain, accessibility

(d) General features of rattan stand

(iii) Funds available

C. Deciding inventory design

(i) Estimation of area (from aerial photos, maps, existing plans or field measurements)

(ii) Mensuration techniques

(a) Destructive sampling; estimation of length with Stockdale and Power's methods (1994)

(b) Estimation of length, volume and weight with Lee's equations (1994)

(c) Estimation of cane diameter from measurement of diameter with leaf sheaths by regression as described by Lee and Swaine (1995)

(iii) Method for assessment of cane quality and extent of infestation by pests and diseases

(iv) Size and shape of sampling units

(v) Sampling designs (simple random sampling, stratified random sampling, multistage sampling, systematic sampling, cluster sampling, etc.)

(vi) Setting precision for inventory and determining sampling intensity

(vii) Time and cost for all phases of work

D. Formulation of procedure for field work

(i) Crew organization

(ii) Logistic support and transportation

(iii) Location and establishment of sampling units

(iv) Determination of current stand information, including instruction on measurement of stems and sample units

(v) Determination of growth, damage by insects and pathogens

(vi) Instruments

(vii) Recording of measurements and observations

(viii) Quality control

E. Formulation of procedure for data analysis and compilation

(i) Conversion of field measurements to commonly used expressions of quantity

(ii) Calculation of sampling errors and usable/net yield from gross yield for estimated wastage

(iii) Computer statistical packages or other software/hardware for data analysis

(iv) Description, with flow charts, of all stages of data analysis from handling of raw data to final results

F. Preparation of final report
- (i) Outline
- (ii) Information required in final report
  - (a) Tables, graphs, charts
  - (b) Maps, plans
  - (c) Narrative report
- (iii) Estimated time to prepare
- (iv) Personnel responsible for preparation
- (vi) Printing and distribution of report

G. Maintenance of records
- (i) Storage and retrieval of data
- (ii) Plans for updating inventory and remeasurement

H. Use of remote sensing techniques

Possibility of the use of aerial photography and satellite imagery, combined with ground truth, for rattan inventory.

4.0 Discussion and Conclusions

As proposed in the above scheme, the theory of rattan inventory does not differ from that for a typical timber-oriented forest inventory, in contrast to the view expressed by Rombe (1986) and Nur Supardi (1992). In 0ur opinion, the only difference between rattan inventory and timber-oriented forest inventory is the mensuration techniques used, some of which for rattan have been recently developed and cited in the preceeding section. Other aspects, such as the design and statistical analysis, are essentially the same. As such, classic works on forest inventory, like those by Loetsch and Haller (1973), Loetsch et al. (1973) and Philip (1994), are highly relevant,

Acknowledgements

We wish to thank various rattan plantation organizations, particularly ICSB, JERECO Plantation and SAFODA, for supplying useful information. This report was word-processed by Normah Uking.

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Current Rattan Inventory in Lao P.D.R.

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Abstract

This report summarizes the techniques and results of rattan inventory under the National Forest Inventory Project supported by Lao-Swedish Forestry Cooperation Program and methodologies of the rattan research done under a Bamboo and Rattan Research Project supported by International Development Research Centre (IDRC).

1.0 introduction

Rattan inventory as a part of the National Forest Inventory (NFI) was taken up in January 1991, and will be completed for the whole country by the end of 1998. The inventories carried out cover only accessible parts of Lao P.D.R. because field data collection is an expensive activity and time is limited. This means that:

- the area should not be more than 5 km from the road
- the area should not be unduly steep (mountainous areas)
- the area should be safe

The Research and Development of Rattan and Bamboo Project was organized at the beginning of 1992. The project carried out a taxonomic survey and resources survey and also looked at the growth and yield of natural rattan.

2.0 Objectivesand Methodology

The objectives of the inventory are:

- To further develop and test the method for national forest inventory that was proposed and test it from province to province in the field;
- To train personnel and further develop the organization of field work;

- To provide other information, in particular about standing volumes and resources of rattan; and
- To modify techniques when necessary.

The inventory of rattan (and bamboo) was done within NFI design, which is a two-phased, stratified, systematic cluster sampling. The sampling units consist of L-shaped tracts (clusters).

The stratification is done in order to make the NFI field work as efficient as possible with respect to statistical significance of results without spending more resources, efforts and time than necessary.

The stratification is based on Forest Type and Land Use Maps made from satellite Imagery, of 1987-90. According to accessibility for field work, areas in each province are divided into two groups; one group with accessible areas and the other with inaccessible areas.

In the first phase, a large number of possible tracts are laid out in the accessible areas delineated on the land use maps. The tracts are located systematically according to the map grid and classified according to land use. Based on this classification, the tracts are assigned to four different strata:

- Tracts dominated by “Current Forest”
- Tracts dominated by “Potential Forest”
- Tracts dominated by “Other area”
- Tracts with mixed land use

In the second phase, a certain ratio of the tracts, from different strata, are selected for field inventory.

2.1 Tracts

The clusters consist of L-shaped tracts with a side length of 1 000 m. Different types of sample plots are located along the tract sides. The tracts are drawn on a 1 : 100 000 scale topographic map’in preparation for the field work. The different sides of the tracts are located south and west.

2.2 Sample plots

There are three different types of sample plots (Fig. 1) in a tract:

Type A: Square plots of 20 x 20 m, located in the corners of the tract and in the middle of each tract side.

Type B: Rectangular plots of 20 x 40 m, located directly before and after each plot of type A.

Type C: Rectangular plots of 20 x 400 m, located between type B plots.

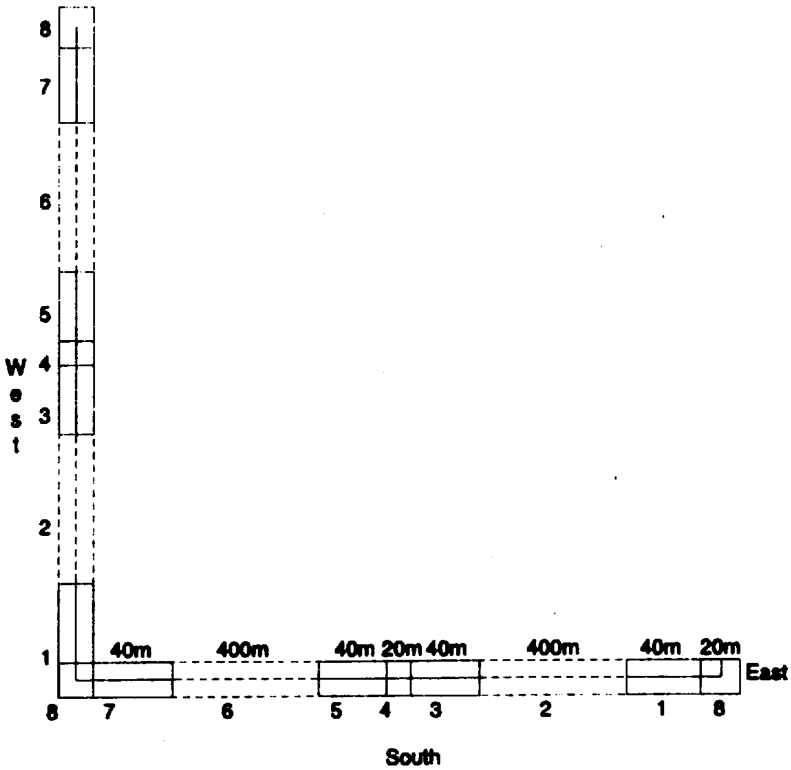

Fig. 1: An inventory tract with the different types of samples plots

3.0 Rattan Enumeration

Rattan plants both within and outside the sample plots were considered. In every sample plot, regardless of type, all rattan species were enumerated by the NFI teams and recorded on a Field Form. Outside the sample plots, simple observations on the occurrence of rattan species and their distribution were made by the soil mapping team and recorded on a special Rattan Observation Sheet.

Specimens of both identified and unidentified species were collected (Appendix 1). Each rattan species was coded and provided an identity, if known. If unknown '00' was used instead of a number and “unknown" written in place of name of the species (Appendix 2).

Following data were recorded:

Number of stems — Number of stems of each species

Stumps — Observation on stumps of rattan
1. No stump seen
2. Stumps occasionally seen
3. Stumps frequently seen

Clump/Solitary — Growing in has clump or a solitary stem
1. Clump
2. Solitary

Additional recordings include photo number, tract number, location, and abundance (scarce, fairly abundant and abundant).

4.0 Data Processing

When the field work had been completed, the data were entered 'and stored in a database. The data were entered twice to avoid recording errors, and then checked for errors.

Analysis is still going on and it is too early to give results. However, by experience and reported data from rattan factories it is seen that rattan resources exist in provinces where there are evergreen forests. The main area of rattan is mostly in the central part of the country. Interest about utilization is limited to a few commercial species:

Local name	Scientific name	Diameter (cm)
Wai Thoon	Calamus sp.	20-40
Wai Tabing	*Calamus rudentum*	20-40
Wai Deng	*Korthalsia laciniosa*	20-40
Wai Boon	*Daemonomros shmidtii*	10-40
Wai Taleuk	*Plectocomia pierreana*	20-40
Wai thok	*C.pandanosmus*	10-15
Wai Suum	*Calamus. sp.*	10-15
Wai Hang-noo	*C. javensis*	5-10

Further Reading

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Appendix 1: Specimen Collecting for Rattans

1. General

Identification of rattan species still remains a major problem for field staff. This, no doubt, affects the quality and accuracy of the collected data. The solution .to this problem is to get the staff intensively trained; but this is a long-term solution. The collecting of samples of different rattan species is, therefore, adopted in order to gradually improve the knowledge in this field.

The collecting of specimens. is performed in connection with the NFI field work and mainly concentrates on "unknown species". The collected specimens are consecutively numbered.

2. Methods of collection

a. Specimen:

The sample collected should consist of:

- Stem with leaf sheath, at least two internodes, flagellum or cirrus, if any
- Leaf
- Inflorescence with spathe, fruit, if any.

b. Marking:

Before being put in the press, each sample should be tagged with the following details:

- Date of collection
- Tract no.
- Side
- Plot no.
- Code

c. Descriptions:

Following notes will be made on rattan specimens and recorded:

- Habit: clump or solitary
- Stem appearance, size, length, colour, presence or absence of knee or ocrea

- Flagellum or cirrus present or absent
- Spines
- Leaf: shape, size, leaf tip, venation
- Leaf sheath
- Inflorescences and spathe
- Fruit and scales arrangement.

Appendix 2: Code List of Rattan

Vernacular name	Scientific name	Code
Wai Khio		01
Wai Khit		02
Wai Khom		03
Wai Sa-vang		04
Wai Sian		05
Wai Nam-lom		06
Wai Deng	*Kortbakia laciniasa*	07
Wai Tabong		08
Wai Taleuk	*Plectocomia pierreana*	09
Wai Tio-kheng		10
Wai Tia		11
Wai Tham		12
Wai Thoon	*Calamus* sp.	13
Wai Thok	*C. pandanosrmus*	14
Wai Nam		15
Wai Nouane		16
Wai Boon	*Daemonorops shmitii*	17
Wai Hang-noo	*C.. javensis*	18
Wai Horn		19
Wai Nam-hang		20

Current Rattan Inventory Techniques in the Philippines

Leuvina Micosa Tandug

Abstract

The critical situation of rattan supply and the absence of inventory of rattan resources underline the need for more accurate inventories of rattan resources in the country, not only at the local level but also at the national level. Several inventories have been conducted so far. But, these have proved to be inadequate owing to ineffective methods employed.

Economic planning as well as meaningful development programs for rattan can be undertaken only when the resource is accurately quantified. Availability of inventory data will provide the basis for developing better strategies for marketing rattan products, including further expansion and development of the industry.

1.0 Introduction

Rattan is one of the most important non-timber forest products in the Philippines. It is widely used in manufacture of furniture, handicrafts and other products which are in demand both locally and internationally. Rattan grows at low and medium elevations in old-growth and second-growth forests (logged-over forest) and is usually abundant and conspicuous, except where it has beenextensively cut for commercial purposes.

With the rapid growth and expansion of the rattan industry towards the end of the 1970s and the 1980s, rattan resources have dwindled very quickly, causing problems in cane supply. In the Philippines, some 40 to 50 years ago, it was thought that rattan resources were almost inexhaustible. However, defective harvesting methods and overexploitation led to diminishing availability, particularly in natural stands. This was felt by rattan industries in the 1980s.

Recent estimates (1991) show that only about 1.8 billion and 2.8 billion lineal metres (lm) of rattan in old-growth (804 900 ha) and residual forests (3 224 300 ha) respectively-r a combined total of about 4.6 billion lm- are left in philippine forests. In all 323 rattan cutting permits were granted throughout the country with an estimated allowable cut of 175 million lm.

The absence of rattan inventory information led to improper utilization practices. Harvesting, processing and marketing were unplanned. Hence, overexploitation led to a critical situation in rattan production.

One inventory did exist. In 1986, a local level inventory of the ‘8 080 ha forests in the towns of Ayungon and Bindoy in Negros Oriental included rattans. The inventory data served as basic information on the development, management and utilization of various forest resources there.

In the absence of nationwide inventory information, the government made it a point to include rattan in the national forest resources inventory (FRI) conducted by the Republic of the Philippines and the Federal Republic of Germany.

2.0 Inventory Results

The objective of this nationwide FRI was to provide land use statistics to policy makers as part of the country’s national land development plans programmed for five years. The project was successfully completed in 1988.

The project adopted a two-stage inventory design. It included aerial photography, satellite image interpretation and mapping as a basis for the field sampling (second stage). Using a stratified, restricted, random sampling design, field sampling was carried out only in the economically important forest strata, i.e. dipterocarp and pine forests. Six-point clusters (Fig. ‘1) were used in dipterocarp forest and three-point clusters (Fig. 2) in pine forests. The field sampling unit, called an inventory cluster, is triangular in shape, one comer being oriented to the south. There were six record units in the case of the 6-point cluster and three record units in the case of the 3-point cluster. Record units 1, 3 and 5 in the 6-point cluster and all record units in the 3-point cluster encompassed each of the two concentric circular plots of 2 m and 5 m radius, respectively. Rattans were surveyed within the 5 m radius plot. A total of 2 627 sample clusters were measured in the course of FRI.

O relascope sample point
basal area factor k = 9 m^2/ha

O circular plot with r = 5 m rattan occurence, regeneration from 5-14.9 cm dbh

o circular plot with r = 2 m regeneration above 1.3 m height, less than 5 cm dbh

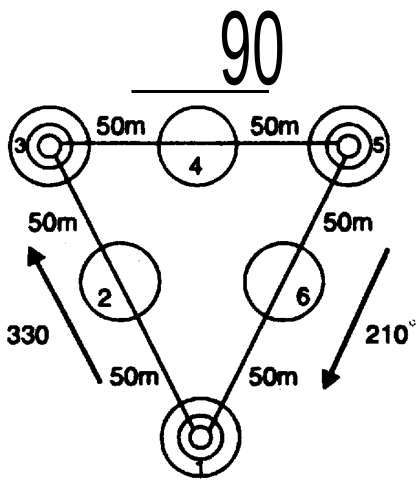

Fig. 1: Point cluster for dipterocarp forest

O relascope sample point
area factor k = 4m^2/ha

O circular plots for
o regeneration of rattan
(like 6-point cluster)

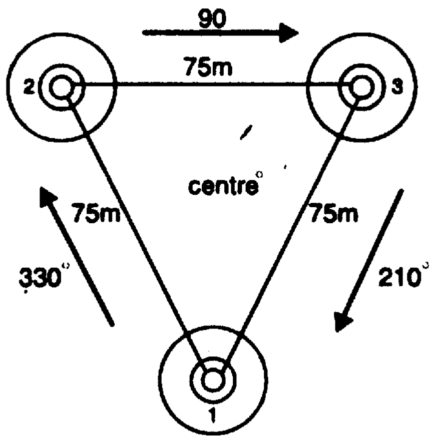

Fig. 2: Point cluster for pine forests

The inventory results disclosed that the total length of all rattan in the Philippine dipterocarp forests amount to 4.573 billion m. From the inventory, rattan species in the Philippine dipterocarp forests were identified (Table 1).

Table 1: Rattan species in dipterocarp forest

Species	D < 2 cm (million lm)	D > = 2 cm (million lm)	Total (million lni)
Apas	460.2	57.8	518.0
Ditaan (Daemonorops mollis	199.1	32.9	232.0
Limuran (Calamus ornatus	550.2	591.4	1,141.6
Palasan *(C. merrillii)*	645.2	730.6	1,3758
Sika (C. *caesius)*	68.6	7 9	76.5
Sumulid (D. *ochrolepis)*	68.2	16.5	74.7
Tandulang-gubat (C. *dimorphacanthus)*	340.7	69.7	410.4
Tumalim (C. *mindorensis)*	451.2	131.7	582.9
Others	92.3	68.3	160.6
Total	2,865.7	1,706.8	4,572.5

D = diameter of cane

Calamus ornatus, C. merrillii and *C. mindorensis* are the species most in demand by the furniture industry. Their 'combined length for poles above 2 cm diameter reaches 1 454 billion m. Owing to the shortage of the prime species, other rattans are now being used by the industry. All species together represent 1 707 billion lm of poles above 2 cm diameter.

Thinner rattan (less than 2 cm diameter) is normally spliced and used for chair backrests, baskets, etc. The total resources reach 2 866 billion lm for all species.

Lately, an assessment in Southern Philippines on an area of 5 108 ha was undertaken by the PICOP-NDC Rattan Management Project. The project area is a rattan plantation established within a timber concession of the Paper Industries Corporation of the Philippines

The inventory aimed to quantitatively assess the rattan, including naturally-growing rattan species found within the plantation.

It should be noted that in the Philippines, some say that rattan is fast diminishing and becoming scarce, while according to others, rattan is still abundant in the dipterocarp forests-its natural habitat. Both opinions may be true depending on whether one is referring to mature rattan plants with harvestable canes or the presence of wildlings. Results of a preliminary inventory conducted in four provinces of the country, - Palawan, Laguna, Agusan de1 Sur and Davao de1 Norte - show that the total number of mature plants per ha was only 4-16% of all rattan plants in these areas, as against 84-96% wildlings. Thus one can say that there is still rattan regeneration in forests. What must be done, however, is to properly manage and protect it to become the future resource. Thus, the application of silvicultural practices is very important.

At present, only meager information is available on inventory techniques to ascertain the number and quantity of various rattan species in the Philippines. To obtain reliable statistics on this, an accurate inventory of the various species. is necessary. From this information, the supply that really exists in the forests can be calculated.

3.0 Measuring Exent and Distribution of Rattans

One way to reliably estimate the extent and distribution of rattan is through the use of some sampling procedures which would minimize costs, reduce the need for labour and shorten the time of gathering vital information with an acceptable degree of reliability.

The first local attempt in this regard was the study by Tandug (1978) which determined the most appropriate size and shape of plot to be used for cruising rattan. The study found that the 10 x 10 m plot was the most efficient among nine different kinds of plots with various sizes and shapes (rectangles and squares), giving the smallest sampling error which is expressed in percent of the total .number of rattan.

However, it should be noted that accuracy and efficiency of cruises are independently affected by not only .the choice of plot size and shape, but also plot arrangement. In a sequel study (1984), Tandug determined the most efficient sampling design, making use of three basic characteristics, i.e. sample unit size, shape and distribution. Out of the three types of sampling methods (simple random sampling at 5% and 10% sampling intensities of SIs, strip method at l0%, 15% and 20% SIs, and line plot method at 5% and 10% SI utilizing fixed area plots) tested against 100% inventory, the strip (10 m wide) method at 10% sampling intensity involving fewer sampling units, less cruising time and efficient sampling design (in terms of accuracy, precision and length of time of crusing) was found to be the most appropriate for the inventory of Philippine rattan. In this study four sites/locations were included: namely, Palawan, laguna, Agusan de1 Sur and Davao de1 Norte, representing three climatic types.

A randomized complete block design with two blocks equal to 4 ha each, oriented according to the cardinal direction, and different sampling methods as the treatments was used in the study at each location. Each block was sub-divided into 400 10 x 10 m square plots and from within each plot, all rattan plants, either seedling or mature, were tallied, and the local name of each species was used. For clump-forming rattan species, the number of stems per plant was counted and recorded. For mature plants with utilizable rattan stems, diameters were measured (in centimetres) 1 m from the base using a vernier caliper, while total lengths in lineal metres were measured for each pulled stem using a plastic-chain tape. Rattan stems outside the plot with its base within the plot were included. Cruising time in terms of crew-hours spent was determined for each plot. Only the effective time involved in plot establishment and tallying was recorded.

Various sampling methods were tested for their efficiency in terms of the accuracy or closeness of the estimated means to the true values (actual means) as obtained from the standard 100% inventory procedure; precision of the estimates was measured in terms of the size of variance and the length of time for cruising. The efficiency index based on the product of the squared sampling error (%) and time spent in cruising, as suggested by Mesavage and Grosenbaugh (1956), was also considered.

The analysis of variance technique was used to test for significant differences among estimates of the various methods. The data for each method were taken from the 100% cruise accordingly. Average travel time per 10 m chain for each strip of 10 m wide within the 4 ha block was determined for use in locating sample plot boundaries; the rest periods were specifically excluded. For all the sampling methods, cruise compilations were done by calculating the merchantable length of mature stems in metres and the number of rattan plants on a per hectare basis.

4.0 Data Management

Data gathered in the course of rattan inventory in natural stands in the Philippines usually include the following:

1. Seedlings (wildlings) these are natural regenerations with no canes yet, having a height equal to or less than 5 m.
2. Immature plants those with canes less than 5 m in length which are not yet commercially usable.
3. Mature plants rattan with commercial canes of 5 m and above in length.
4. Mature cane length the estimated total mature/merchantable cane length in lm from mature rattan plants.
5. Immature cane length the total immature cane length in lm from' immature rattan plants.

The forested areas are first sub-divided into compartments or blocks using a base map and, correspondingly, on the ground. Sampling during the inventory is taken from each block. For example, in assessing PICOP-NDC's 5 000-ha Rattan Management Project in a timber concession in the Southern Phillippines, blocks of 25 ha each were delineated and from within each block, rattan data were gathered from sampling stripes using a tally sheet. The format of the tally sheet is shown in Table 2.

Raw data from tally sheets are then encoded by blocks in computers using a spreadsheet summarized in Table 3.

Table 2: Format of the tally sheet

Rattan Inventory Tally Sheet

Location:' Date:
Strip/Block no. : Recorder:
Plot no.:

SPECIES	SEEDLINGS/ WILDLINGS NO.	IMMATURE		MATURE		REMARKS
		NO.	CANE LENGTH	NO.	CANE LENGTH	

Table 3: Spreadsheet format (only partial data shown)

Information on naturally grown Rattan
(Palasan, limuran, ulisi, dilot, paang dalaga, kalapi, bugtongan)

Block no.	Plot no.	No. of seedings		Total no. immature		Total length immature		Total no. mature		Total length mature	
		Per plot	Per ha	Per plot	Per in	Per Plot	Per In	Per plot	Per In	Per plot	Per ha
8406	01	161.00	214.13	1.00	1.33	1.00	1.33	10.00	13.30	131 .00	174.23
8406	02	110.00	146.30	1.00	1.33	4.50	5.99	29.00	3857	409.50	544.64
8406	03	322.00	428.26	8.00	10.64	13.50	17.96	45.00	59.85	598.50	796.01
8406	04	410.00	545.30	2.00	2.66	8.50	11.31	54.00	71.82	952.00	1266.16
8415	03	238.00	316.54	0.00	0.00	0.00	0.00	38.00	50.54	530.50	705.57
8415	02	454.00	603.82	8.00	10.64	17.70	23.54	55.00	73.15	1033.00	1373.89
8415	01	301.50	401 .oo	15.00	19.95	33.00	43.89	37.00	49.21	806.00	1071.98
8415	04	310.00	412.30	0.00	0.00	0.00	0.00	47.00	62.51	567.50	754.78

With this system of blocking and sampling, we could map the distribution of rattan plants in the area under study. Hence, one could easily see the concentration of rattan in the area. This is important in planning the harvesting schedule of rattan. Essentially, the map is shaded for each rattan species according to the number of plants and length of canes.

5.0 Constraints

As in other inventory work, rattan inventory in the country also faces the following constraints:

1. Difficulty in the identification of rattan plants, especially in the seedling stage - the inventory crew should include rattan gatherers or someone who has a knoweldge of rattan taxonomy.

2. Difficulty in the estimation of cane length-as the canes are climbers, estimation can be done by segments only.

3. Dwindling supply of rattan - although not much is left in the forest because of illegal cutting and poaching, it is necessary to impose a strict protection of forested areas with remaining rattan regeneration. Once protected and maintained until harvest, wildlings and immature plants (which are still abundant in their natural habitats) could cushion the diminishing resource. In addition, government and private corporations should embark on major establishment of rattan plantations as early as possible.

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Rattan Resources in China

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Abstract

This paper presents the results of a resource inventory of rattan species in China conducted during 1985 to 1990. It is recognized that in China there are 40 species and 21 varieties belonging to 3 genera: 4 species of *Plectocomia* Mart; 36 species and 21 varieties of *Calamus* Linn. and 1 species of *Daemonorops* Blume. These are distributed over southern China, from the southeast coast to the southwest mountainous areas and Taiwan-China, Hainan and some islands. This paper not only deals with the geographic distribution of the species, their numbers and characteristics of the plant, but also briefly discusses the status of the resources and utilization of commercial rattan species.

1.0 Introduction

Rattans are interlayer plants in tropical and subtropical forests. Their stems are of high economic value and used for weaving and manufacturing furniture. Rattan is naturally distributed in 11 provinces in southern China. Hainan island and Shishuangbanna regions are the main wild rattan growing areas. However, rattan has been collected indiscriminately for a long time and as tropical and subtropical forests are shrinking, rattan natural resources are getting exhausted. In China, it is urgent and important to research on how to protect and utilize rattan resources sustainably, and also to develop rattan planting technology to develop large areas of plantations.

The main rattan-producing countries such as Indonesia and Malaysia have paid much attention to rattan resource survey and to cultivation research (Uhl and Dransfield 1987; Wong and Manokaran 1985; Manokaran 1990). In order to provide a basis for utilizing rattan resources and developing cultivation of commercial rattan species in China, taxonomic surveys have been conducted in Hainan, Guangdong, Guangxi, Fujian, Yunnan, Jiangxi and other provinces since 1985.

2.0 Rattan Genera, Species and Geographic Distribution

Rattan includes 600 species in 13 genera, 10 of which are distributed in South-East Asia and its neighbouring areas. The other 4 genera are distributed in the West African tropics. Most rattans grow in humid tropical forests. There are 40 species in 3 genera and 21 specific varieties. In China, they occur in four climatic areas from mid-tropical to mid-subtropical.

21 Rattan taxa

Daemonorops

Daemonorops includes 115 species in the world, of which only *D. margaritae* (Hance) Becc. is found in China. It is an important species of interlayer plants in tropical mountain forests and evergreen monsoon forests in east and mid-southern Hainan Island. It is sporadic in Guangdong and Southern Guangxi provinces. It occurs up to 1 100 m above sea level.

Calamus

Calamus includes about 370 species in the world. The widely distributed species in China are in 3 subgenera. Itanan Island and Xishuangbana are sites of diversity. Each species grows in its own area, which is different from another's. Attitudinal ranges are below *200* m.

Calamus subgenus *Procalamus*

Eight species and two varieties are found in China. They grow mainly in evergreen broad-leaved forest and evergreen monsoon broad-leaved forest and in mid-subtropical region and southern subtropical region. *C. dianbaiensis* and C. guangxiensis grow separately in Hewei mountain, Dianbai country in Guangdong province and Daqinshan at Pingxiang city in Guangxi province, which is the southwest distribution area of this subgenus.

Calamus subgenus ***Calamus***

Seventeen species and 8 varieties of this subgenus are found in China and distribution patterns vary widely. C. *rhabdocladus* is readily encountered in most tropical and southern subtropical areas, south to Zhangzhou (25°30') in Fujian province. The only C. *balansaenis* and C. *balansaeanus* var. *castaneotepis* growing in evergreen broad-leaved forests in limestone are in Guizhou, Guanxi province. C. gracilis normally grows in Xishuangbanna in Yunnan province and also in Hainan Island. C. *yunnanensis,* C. flagellum and C. *viminalis* var. *fasciculatus* grow only in South-West China; C. *multispicatus,* C. *pulchellus* and C. *tetradactyloides* mainly grow in east and central mountain areas of tropical mountain rainforest in Hainan Island. C. *formosanus* of South East Asia, is found only in Taiwan-China.

Calamus subgenus *Rhachicirrus*

Of this, 10 species and 11 varieties are found in China. These species are distributed in tropical evergreen monsoon rainforest and evergreen moist rainforest. C. *compostachys* is distributed in Dinghu mountains and Xinhui Guduo mountains in Guangdong province, which is the northern distribution of this subgenus.

Plectocomia

Four species in this genus grow in tropical evergreen monsoon rainforest or moist rainforest in China. *P. microstachys,* indigenous in China, is mainly seen in evergreen monsoon rainforest and mountain rainforest in middle and eastern areas of Hainan province. It can also be seen in the remaining moist broad-leaved rainforests in Funcheng, in Guangxi province. Three species of this genus are found in tropical rain forests around Xishuangbanna, of which *P. assamia* extends north-west to Mali lope. This genus grows 500-2 000 m in elevation. In Hainan island, its highest growing elevation is 1 100 m, but in Xishuangbanna, its highest elevation is 2 000 m.

2.2 Geographic characteristics

Most rattan species occur in centres of diversity in tropical and southern subtropical areas in China, the first centered on Hainan Island and the second centered around Xishuangbanna in Yunnan province. Rattan species growing in these two centres are so different that only 6 species are encountered in common.

Natural rattan population sizes and growth habits are closely related to climate and vegetation forms. The higher the elevation, the lower the temperature and the fewer the rattan species. Also, the plant's growth habit gradually changes from climbing type to vertical type (Table 1).

Table 1: Rattan distribution in typical areas

District	Longitude (N)	Numbers		Species	Vertical rattan species
		genera	species		
Jianfenling in Hainan province	**18°23'**	3	9	*D. margaritae* *P.* microstachys c. egregius c. tetradactylus *C. teradactyloides* *C.* simplicifolius *C. rhabdocladus* *C.* fabrerii	0
Dinghu mountain in Guangdong province	**23°06'**	2	4	C. faberii *D. margaritae* c. compsostachys C. macrorrhyncbus	1
Chebaling in Guangdong province	**24°43'**	1	1	*C. thysanolepis*	1

Based on Chinese vegetation types from north to south, natural rattans grow mainly in tropical rainforests and monsoon forests (Table 2). In the Jianfenling forest area, natural rattans can be encountered in most of the 25 vegetation forms in tropical mountainous rainforests and tropical evergreen seasonal rainforests. Some vegetation forms are even named by rattan species.

Table 2: Rattan species in different vegetation types in tropical and subtropical regions

Vegetation division	Subdivision	Zone/Subzone	Species	
Subtropical evergreen forest area	*East* subdivision	mid-subtropical *evergreen* broadleaved in southern part	*C. boplites* *C. oxycarpus* c. *balanseanus* var. *castaneolepis* C. *rbabdocladus*	*C. macrorrbynbus* *C. tbysanolepis*
	south-subtropical monsoon evergreen broadlcaved zone	*C. boplites* c. *balansaeanus* var. *castaneolepis* *C. compsostacbys* *C. oxycarpus* *C. orientalis* *D. margaritae* c. *balanseanus* C. *yangcbunensis*	c. *rbabdocladus* *C. melanocbrous* *C. formosanus* *C. tetradactylus* c. *guangxiensis* *C. dianbaiensis*	
Tropical monsoon rainforest zone	East subdivision	North-part tropical half evergreen monsoon forest, damp rainforest zone	*C. sipbonnospatbus* var. *sublaevis* *C. formosanus* *C. orientalis* *C. compsostacbys* *C. rbabdocladus* *C. rbabdocladus* var. *globulosus* *D. margaritae* *C. disticbus* var. *sbangsiensis* *C. austro-guangxiensis* *P. microstacbys*	*C. quiquesetinervius* *C. tetradactylus* *C. egregius* *C. faberii* *C. walkerii* *C. balanseanus*
		Tropical monsoon forest, damp rainforest zone	*C. rbabdocladus* var. *globulosus* *C. walkerii* c. *tetradactylus* *C. balansaeanus* var. *castanolepis* C. *bonianus* c. *simplicifolius* *C. faberii* *C. multispicatus* *D. margaritae*	c. *tetradactyloides* C. *rbabdocladus* *C. giganteus* *C. orientalis* *C. gracilis* *P. microstacbys*

		North-part tropical monsoor half evergreen forest zone	*C. platyacantbus* *C. yunnanensis* var. *intemedius* *C. palustris* var. *cocbincbinensis* *C. flagellum* *C. gracilis* *C. viminalis* var. *facsiculatus* *C. yunnanensis* *C. yuannanensis* var. *idensiflorus* *C. rbabdocladus* var. *globulosus* *C. palustris* *C. palustris* var. *longistacbys* *C. nambariensis* var. *alpinus* *C. nambariensis* var. *xisbuangbannaensis* *C. nambariensis* var. *imenglongensis* *C. nambariensis* var. *furfuraceus* *C. obovoideus* *C. platyacatbus* var. *mediostacbys* *C. giganteus* var. *robustus* *C. erectus* *C. erectus* var. *birmanicus* *C. nambariensis* var. *yingjiangensis* *C. feanus* var. *medogensis* *C. acantbospatbus*	*C. benryanus* *P. kerrana* *c. kariensis* *c. rbabdocladus* *c. wailong* *P. bimalayana* *P.* assamica

In different forest vegetation types, species numbers and density of natural rattans are different.

Table 3 : Rattan in same vegetation types

Place	Type of vegetation	Dominant tree species	Main rattan species	height (m)	Number of population (clumps/ha)	IV
Jianfeng-ling mountain	Tropical mountain rainforest	*Lithocarpus* spp. *Cryptocarya spp.* *Dacrydium pierei* *Podocarpus imbricatus* *Madhuca hainanesis* *Beilschmedia spp.* *Syzygium spp.* *Nephelium topengii* *Livingstonia saribus* *Quercus spp.*	*C.egregius* C. tetradactyloides *D. margaritae* *P. Kerrana* *C. simplicifolius* *C. rhabdocladus* *C. faberii*	3-8 3-5 3-8 10-20 3-8 5-10 3-5	40-700 2600-4000 10-900 40-110 17-500 33-2170 1-54	11-18 13-21 3-40 - 3-28 15-33
	Tropical evergreen monsoon forest	*Eleacocarpus spp.* Vatica spp. *Amesiodendron chinesis* *Litchi chinesis* var. *euspontanea* *Madhuca hainanesis* *Quercus Pateliformis* *Sindora glabra* *Ormosis spp.* *Syzygium spp.* *Ficus spp.*	*C. faberri* *D. margaritae* *C. rhabdocladus* *C. simplicifolius* *P. kerrana* *C. tetradactyloides*	3-5 5-10 5-10 3-8 10-30 3-5	150-800 517-1700 23--250 50-100 17-50 300	27-44 13-79 4-9 5-7 - 8.4
	Tropical half deciduous monsoon forest	*Aporosa chinensis* *Albizia* spp. Dimocarpus *Longan* *Syzygium cuminii* *Dalbergia spp.* *Lannea grandis* *Polyalthia spp.* *Gossampinus Malabarica*	*C. balansaceanus*	5-10	800	-
Dinghou-shan mountain	Subtropical evergreen broadleaved forest	*Cryptocarya spp.* *Castanopsis spp.* *Schima superba* *Sporosa Yunnanensis* *Lindera spp.*	*C. rhabdocladus* *C. macrorhynchus* *C. composistachys* *D. margaritae*	2-8	1300-2450	

3.0 Rattan Resources Utilization in China

In different degrees, all rattan species except Calamus subgenus Calamus and Plectocomia have been utilized in China. Most rattan species produce poor quality canes, and these are used to weave daily articles such as ropes, baskets etc. Some widespread species with good quality are made into furniture or woven into articles for market.

The annual raw rattan output in China is about 4 000-6 500 tons, mainly from the two centres of diversity.

As for important commercial rattans (Table 4) in China, key species in Hainan are D. margaritae, C. tetradactylus, C. faberli, C. egregius and C. rhabdocladus. Key species in Yunnan are C. gracilis, C. pulchellus, C. nambariensis, C. palustris and C. platyacanthus. We have found some rattan species with great potential for exploitation, although today they have narrow distribution and small production (Table 5).

Table 4: Important commercial rattan species in China

Commercial name	Scientific name	Diameter (cm)	Place of origin	Utilization
Hongteng	*D. margariate*	8-1.5	Hainan, Guangdong and South Guangxi	Weaving and making furniture
Baiteng	c. tetradactylus *C* .bonianus		Hainan (mainly), Guangdong and South Guangxi	Weaving
Liteng	C. *simplicifolius* c. egregius	0.8-1.5	Hainan	High quality, making furniture and weaving
Ku teng	C. *faberii*	1.0 - 2.0	Hainan	Making furniture
Jiteng	*c. pulchellus* c. tetradactyloides *C. multispicatus* *C. balanscanus*	0.3-0.6	Hainan	weaving
Gongteng	C. *rhabdocladus* C. rhabdocladus var. globulosus	1.5-2.0	Guangxi Hainan, Guangxi, Gaungdong and Yunnan	Making furniture
Xialuteng	C. *gracilis* *C. pulcbellus*	0.4-0.8	Yunnan, Hainan	High quality, weaving and making furiture
Dalutcng	C. nambariensis and its varieties C.palustris and its varieties *C.* platyacantbus and its varieties	2.0-2.5	Yunnan	High quality, making furniture
Xiaoguangteng	C. yunnanensis and its varieties	0.6-1.2	Yunnan	Weaving and making

Table 5: Some potential commercial rattan species for plantations in China

Rattan species	Place of origin	Possible areas for cultivation
C. tetradactylus	Hainan, Guangxi and Guangdong	Fu jian and Yunnan
C. ***simplicifolius***	Hainan	Guangdong, Guangxi and Fu jian
C. *egregius*	Hainan	Guangdong, Guangxi and Fujian
C. *nambariensis*	Yunnan	South Guangxi
C. yunnanensis	Yunnan	South Guangxi
C. gracilis	Yunnan, Hainan	South Guangdong and Guangxi
C. distichus var. ***shangsiensis***	South Guangxi	South Guangdong and Hainan
C. austroguangxiensis	South Guangxi	South Guangdong and Hainan
D. margaritae	Hainan, Guangxi and Guangdong	Fujian and Yuannan

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Research Priorities for the Inventory of Rattan

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Abstract

The realization of the importance of rattans has led to recognition of the urgent need for their more sustainable management. The inventory of a resource provides essential information for management and thus, there has been an upsurge of interest in rattan inventory. As the majority. of research has been done on inventory for timber tree species, this paper begins by identifying the similarities and differences between timber trees and rattans, and their implications for rattan inventory. This is followed by a review of the rattan inventory literature, covering such topics as the purposes of rattan inventory, state-of-the-art knowledge of sampling design and the types of data that can be obtained from inventory. This review identifies gaps in knowledge; more work needs to be done to improve rattan inventory methods. This paper ends with a list of research priorities for the inventory of rattan.

1.0 Introduction

Much research has been done on inventory for timber tree species (e.g. Husch et al. 1972; FAO 1973; Philip 1983). Rattan inventory, hence, need not reinvent the wheel, but will have to modify timber inventory methods to fit the specific characteristics of rattan. This paper reviews the similarities and differences between rattans and timber trees in tropical moist forest and the literature on rattan inventory, followed by research priorities for rattan inventory.

2.0 Rattan Compared to Timber Trees

Similarities

1. Tropical moist forest habitat is difficult to work in. Access can be difficult, because sometimes the steep gradians can make walking tedious, and there is a host of unpleasant plants and animals impeding progress.
2. Accurate maps of tropical moist forest areas are often unavailable, making it difficult to plan sampling designs.
3. The distribution of rattans and timber trees is often scattered (not homogeneous), and this will affect decisions about sampling design.
4. Often there are rattans and timber trees of many species and ages in a given area, making it difficult to identify and categorize them accurately.

Differences

1. Rattans are much more difficult to work with than trees, making rattan inventory researchers daring people indeed.
2. Rattans often grow in clusters of stems, although there are also solitary-stemmed species. Inventories should therefore count clusters as well as stems within clusters.
3. As growth in rattan stems is just in length and not diameter, length is the most important measurement in rattan inventory, not diameter.
4. Timber inventory is usually done on its own, but rattan inventory is much more likely to be part of multi-resource inventory, such as timber species (i.e. in inventories of timber concessions) or non-timber species (i.e. in inventories of extractive reserves of buffer zones of national parks).
5. Wild rattans are mostly harvested by people living in or near forests, and can be their major source of income (Siebert and Belsky 1985).

Much can be gained if local people are involved in rattan management, not only because it is ethical that these resources should continue to benefit those who have always depended upon them, but because otherwise over-harvesting and habitat loss are likely to continue. It is very difficult to 'police' rattans because of their scattered and unpredictable distribution; thus, local people are likely to go on harvesting rattans anyway (Jessup and Peluso 1985). Also, if local people no longer derive economic benefit from the forest, they are likely to attempt to put the forest to agricultural uses (Oldfield 1988).

Therefore, foresters should attempt to involve local people in rattan inventory and think of ways in which the skills and knowledge of both foresters and local people can be used. A recent rattan inventory workshop in East Kalimantan which included foresters, NGO workers and local people has attempted to develop methods for participatory rattan inventory (Stockdale et al. in press).

3.0 Literature Review

3.1 Purposes of rattan inventory

There are a number of possible purposes for rattan inventory. The same purpose can apply to both small-scale and large-scale inventories. The purpose of an inventory is to influence the minimum allowable precision (maximum allowable sampling error) that is selected, and the type of information that is required.

1. Rattan inventory can be part of a multi-resource inventory, for land-use or forest-use planning. A small-scale example might be the inventory planned for the Kayan Mentarang Nature Reserve in Indonesia to assist in planning different/land-use zones (Anonymous 1994); on a larger scale, but for the same purpose, are the National Forest Inventories of the Philippines (Sema 1990), Malaysia (Aminuddin 1990), Indonesia (Revilla, pers. comm.) and Ghana (Falconer, pers. comm.).
2. Rattan inventory can be done to assess the potential for rattan industry development. A village, region or country may wish to assess the potential for rattan-based industry. An example of this is the inventory of the cane potential of Baratang Island in India to determine whether there is a basis for a sports equipment industry (Sharma and Bhatt 1982), or the inventories done in the Gulf Province of Papua New Guinea (Niangu 1990).
3. Rattan inventory can be done to develop a management plan. Two types of inventories are needed for this purpose:

a. Single inventory, to provide information on the distribution and age/size class structure of current rattan populations. Attempts have been made on a small scale in Sulawesi, Indonesia (Siebert 1993) and on a larger scale in the Philippines (Torreta and Belen 1990) to use single inventories to develop management plans. However, the sustainability of the annual allowable cut that has been calculated is questionable, due to lack of adequate information on growth rates.

b. Recurrent inventory, to monitor regeneration, growth and mortality rates of rattans, as well as other changes in the forest. There are no published accounts of recurrent inventory.

3.2 Topics in sampling design

Criteria for choosing a sampling design

The three criteria commonly used to test or compare sampling methods are:

1. Accuracy: the difference between the estimated mean and the true mean;
2. Precision: the range of confidence interval around the esti mated mean; and
3. Cost efficiency: the cost (usually measured in units of time) incurred for a given precision.

   In those cases where it is wished to involve local people in the inventory, the following criterion should be added to this list of desirable attributes for a sampling method:

4. Simplicity: whether the method can be mastered easily by local people or other non-foresters.

Topics such as stratification, the role of remote sensing, systematic vs. random sampling, strip vs. line plot vs. cluster sampling, and sampling unit shape and size are considered below. For each topic, the literature is reviewed to examine how the different options in sampling methods compare in terms of the listed criteria above.

Stratification

Stratifying a sampling area into homogeneous units, or strata, is a way of increasing cost efficiency and is almost universally used in forest inventory. Stratification aims to remove or reduce variance within the strata and maximize variance between strata, and is often based on geographical location, age classes in plantations, and vegetation or soil type (Philip 1983). While increasing cost efficiency, stratification should not be made difficult; in other words, the boundaries of the strata should be easy to identify in the field.

There are a few examples of stratification in rattan inventory, although none of the stratification criteria described below have been tested for their ability to improve precision.

1. The National Forest Inventory of Peninsular Malaysia, which included rattans among other forest products, stratified forests into the following categories; very good, good, medium, logged over, disturbed/spoilt, shifting cultivation, peat swamp, poor/montane (Aminuddin 1990).
2. In India, Nandakumar and Menon (1933) developed a stratification system specifically for rattans. They developed different forms of stratification for different scales of sampling area.
   a. At the State level, stratification was based on:
      - altitude (<800 m, 800-I 600 m, >I 600 m)
      - accessibility to people (accessible, inaccessible)
      - level of protection from biotic interference (low, medium, high).

   b. At the Division level, stratification was based on attributes of natural rattan ‘pockets’, areas of high rattan density which range in size from 3-150 ha. These attributes, estimated for each pocket during a reconaissance survey, are:
      - size (<25 ha, 25-100 ha, >100 ha)
      - stocking density (<1000 shoots per ha, 1 000-2 000 shoots per ha, >2 000 shoots per ha)
      - age class structure (mature; immature ratio 450, 1:50-1:10, >l:10)

The role of remote sensing

Remote sensing techniques using satellite imagery and aerial photography can play a role in stratification by identifying various forest types. However, at present, their role in direct identification of rattan pockets is limited as rattan crowns are mostly covered by the forest canopy. In India, remote sensing methods involving the use of satellite images were tested for their capacity to associate rattan populations with overstory vegetation, to eliminate areas without rattans from the survey (Menon 1993). Although imagery could separate probable rattan-growing areas from those without rattans, it could not identify the actual pocket boundaries within the probable rattan growing areas.

Systematic vs. random sampling

One decision to make when designing an inventory is whether to select sampling units systematically or randomly. The advantage of systematic sampling, in which the sampling units are selected by a systematic routine or spatial pattern, is that it is easier to plan the layout and locate the sampling units in the field; furthermore, all parts of the population are visited and represented in the sample. However, there is a greater chance of bias in systematic sampling than in random sampling, as the pattern of sampling may match or partially match some periodic pattern of variation in the population (Philip 1983).

The consensus of Tandug and Lasmarias (1984) in the Philippines and the KFRI (1991) in Kerala, India, appears to be that both sampling methods are equally accurate and equally precise, but systematic sampling is more cost efficient than simple random sampling.

1. In the Philippines, Tandug and Lasmarias (1984) found systematic methods (line plot sampling and continuous strip sampling) to be as accurate but more cost efficient than sample random sampling.
2. Within a natural rattan pocket in India, KFRI (1991) compared two-way systematic line plot sampling with simple random sampling without replacement, at the same sampling intensity, and found them to have equal precision. The precision of the systematic method was calculated by assuming that there was

no pattern to the variability of the population in the rattan pocket. This assumption was confirmed by regressing the total number of rattan plants in 20 x 4 m plots by the plots' positions from an arbitrary origin; the very low R^2 values indicated an almost random distribution.

Point vs. plot sampling

Point sampling, involving the use of a relaskop, has been tested as part of a multi-resource inventory that included rattans. Point sampling was considered more cost efficient than strip or line plot sampling (Samsudin Musa and Hutchinson 1990) in a study in which timber as well as non-timber forest products (rattan, bamboo, bertam, other palms, ferns) were sampled. Point sampling used prism sweeps of BAF 5 at the plot centre to sample tree species, and 5 m, 2 m and 0.56 m radius fixed plots for sampling non-timber forest products, and the number and the species of regenerating samplings, respectively. Thus, point sampling was not tested directly on rattan. Tandug (then Micosa 1976) and Nur Supardi et al. have outlined a number of reasons why this method would not be as suitable as plot method for rattans.

Another method, which has not yet been tested, is also (confusingly) called 'point sampling' as well as 'plotless sampling' (i.e. point centered quarter method, closest individual method, nearest neighbour method). This method probably will not be as suitable as plot methods for sampling rattans because it is less accurate in populations which are non-random in distribution (Grieg-Smith 1983).

Strip vs. line plot vs. cluster sampling

A number of studies, described below, have compared two sampling methods: plot sampling, in which lines are systematically or randomly chosen and along which plots are systematically sampled; and continuous strip sampling, in which long strips are systematically or randomly chosen and completely enumerated. To summarize the studies which have been done so far, it would appear that strip sampling and plot sampling are equally accurate, but strip sampling is both more precise and more cost efficient. However, this may depend upon the site (see results of the study by Nur Supardi et al.

1995). Another sampling method, cluster sampling, has been tested in one study, and involves the random or systematic selected of a sampling unit, which is then subdivided into smaller, systematically selected units comprising the cluster. It does not appear to provide any advantage over the above two methods.

1. In the Philippines, Tandug and Lasmarias (1984) compared the above methods at 5% and 10% sampling intensities for the line plot sampling method, and 10% 15% and 20% for the strip sampling method, using 10 x 10 m plot sizes for line plot sampling and 10 m width for strip sampling. For all sampling intensities, both methods were comparable in accuracy; the strip sampling method at 10% sampling intensity was the most cost efficient method overall.
2. In Indonesia, Siswanto and Soemama (1988,1990) and Siswanto (1991) have compared these two sampling methods at 10%, 20% and 25% sampling intensities, using 10 x 10 m and 20 x 20 m plot sizes for line plot sampling and 10 m and 20 m widths for strip sampling. Continuous strip sampling with a width of 10 m and a sampling intensity of 20-25% was said to be 'adequate' because the sampling errors (a measure of precision) for these methods (l0-14%) were lowest; their cost efficiencies, however, were not compared.
3. A study in India by KFRI (1991) compared two line plot sampling methods using plots of sizes 20 x 20 m and 20 x 4 m, and three strip sampling methods using 4 m wide strips which were either undivided or divided into continuous plots of two sizes, either 4 x 20 m, or 4 x 100 m. All represented approximately 4% sampling intensity. The lowest sampling error (the greatest precision) was found in the 4 m wide strip divided into contiguous plots of 4 x 20 m. No comparison of cost was made, although KFRI (1991) commented that the 20 x 20 m plots in particular had a plot layout time of at least 10 minutes, which the 4 m wide strips avoided, considerably lowering the cost.
4. In Malaysia, Nur Supardi et al. (1995) have compared these methods with a third method called cluster sampling, in both lowland and hill dipterocarp forests. Cluster sampling method

consisted of 100 x 90 m clusters with 6 subplots of 28 x 10 m. The line plot sampling method (grid sampling method) consisted of 5 grids (2 subplots of 100 x 5 m); the centres of the grids were separated by 100 m. The strip sampling method consisted of 5 strips of 100 x 10 m (4 contiguous subplots of 25 x 10 m). All methods were at 10% sampling intensity. Strip sampling was found to be most cost efficient in the hill dipterocarp forest, but line plot sampling was most cost efficient in the lowland forest.

5. Also in Malaysia, Samsudin Musa and Hutchinson (1990) conducted a study comparing three sampling designs (strip sampling, line plot sampling and point sampling), in which timber as well as non-timber forest products (rattan, bamboo, bertam, other palms, ferns) were sampled. Strip sampling used a principal strip of 25 x 20 m, line plot sampling used a principal plot of 50 x 20 m, and point sampling used prism sweeps of BAF 5 at the plot centre to sample tree species with dbh > 15cm, a 5 m radius fixed plot for sampling non-timber forest products, and 2 m and 0.56 m radius plots for sampling the number and species of regenerating samplings, respectively. The sampling intensity was 10% in each case. Point sampling was found to be the most precise for estimating volume and basal area, but strip sampling was the most precise for estimating the number of tree stems per ha. Point sampling was considered the most cost efficient method overall.

shape size and orientation of sampling unit)

Choosing the shape, orientation and size of sampling units involves balancing three aspects (Philip 1983):

1. the effectiveness of the unit in representing the variance in the population;
2. the ease of boundary definition; and
3. the convenience and cost of using such a sampling unit.

Circular plots are not recommended for inventories in tropical moist forest, as the dense undergrowth makes it difficult to walk in a circle around a central point (Alder and Synnott 1992). Therefore, only squares and rectangles, of a range of sizes, have been compared.

In the Philippines, Tandug (1978) found a square plot to be more cost efficient than rectangular plots. In contrast, a study in Brunei Darussalam by Stockdale and Wright (1995) found that rectangular plots were more cost efficient. Nonetheless, they noted that there are limits as to how rectangular plots should be, owing to increased possibility of boundary error associated with the increased ratio of perimeter to area.

One explanation for the difference between the two studies may be that the rectangular plots were randomly oriented in Tandug's study, whereas in the study by Stockdale and Wright they were oriented parallel to the direction of the slope. Another explanation may be that the topography. in the Philippines was less sharply dissected than in the Brunei study area, causing the variance to be less influenced by the slope and hence, by the orientation of the plot; if so, this highlights the importance of testing sampling designs across different site types.

The optimum sampling unit size in Tandug's (1978) study was 0.01 ha; this was within the 0.0025 to 0.025 ha range found to be optimum in Stockdale and Wright's (1995) study. Within this range the specific size of a sampling unit was determined by the desired precision, the total area under inventory and the parameters to be estimated.

3.3 Types of data that can be obtained from rattan inventory

Some of the important categories of information that can be obtained from inventories, such as species, growth form and possible measurement of rattans, are discussed below. A weakness of some rattan inventories is the quality of the information they obtain. Sometimes one factor is that the people developing the inventory themselves lack the necessary information or techniques.

Species

It is important to identify rattan species, because they are an important indicator of commercial quality and because it is essential for proper management. Scientific names must be used in identifying rattan species. The use of local names leads to confusion and lack of comparability across studies, as different names may be used in different areas for the same species or the local names may aggregate a number of separate species (Dransfield 1992). Serious confusion over taxonomy has occurred in national inventories in the Philippines and Malaysia (Wakker 199 1; Dransfield 1992).

To obtain scientific names, it is best to use a taxonomy guide. If not, local taxonomists may be able to help; if guides are not available, local people can help in sorting out the taxonomy, as they are often skilled at identifying rattan species. In any case, it is good to collect as much voucher herbarium material as possible, for use if there are doubts over the identity of the species.

Growth form categories

As rattan researchers use a variety of names for growth form categories, and as the same terms may have different meanings to different people, it is important that the categories are clearly defined in inventory reports. Rattan plants can be ‘seedlings’ if they have seedling leaves or eophylls, ‘juvenile rosettes’ if they have leaves with an older leaf morphology but no stem and are infertile, and ‘mature rosettes’ if they are fertile, as is the case with stemless species. Plants are ‘solitary’ if they have only one shoot; if they have more, they are often called ‘clumps’, ‘clusters’ ‘shools’ or ‘genets’.

An individual ‘shoot’ is also called a ‘sucker’ or ‘ramet’, and has its own growth form categories. Shoots can be ‘juvenile’ if they have not yet developed a stem, and ‘stems’ if their internodes have begun to elongate. Flowering and fruiting maturity is usually reached before commercial maturity; stems are usually classified as ‘immature’ or ‘mature’ according to the latter definition. The criteria for commercial maturity may vary from country to country, depending upon the economic unit by which stems are sold; Sharma and Bhatt (1982) in India consider a stem which is bare of leaf sheaths for more than 3.7 m (12 feet) of its length to be ‘mature’, whereas Siswanto (1991) and Siswanto and Soemama (1988, 1990) in Indonesia consider a stem ‘half-mature’ if its bare length is 5-15 m, and ‘mature’ if its bare length is greater than 15 m. A study by Stockdale (1994), also based in Indonesia, classified stems with a bare length greater&an 6 m as commercially mature.

Measurements

Some of the common measurements used to quantify rattan are:

1. Counts. All rattan inventories obtain counts of rattan clumps and/or stems.
2. Length, total and commercial. Of all measurements, stem length is the most important as, unlike trees, growth of rattans occurs as an increase in length alone, with diameter remaining relatively constant over the length of a stem. The total length measures the stem from its base to the point at which the uppermost leaf petiole diverges from the shoot. The commercial length measures the dried part of the stem only. Different methods for estimating length are reviewed by Stockdale and Power (1994).
3. Diameter. As the diameter is also fairly constant within a species, there is little point in its measurement.
4. Volume. If diameter is' constant within a species, volume estimates give no additional information to length estimates. If it is necessaryto obtain volume estimates, they should be calculated from length estimates and the known diameter of a species.
5. Weight, green and air dry. The usefulness of weight estimates as measures of quantity has been questioned by Sharma and Bhatt (1982) as, like timber, the weight depends upon moisture content, which decreases progressively after cutting. If it is necessary to obtain weight estimates, they should be calculated from length estimates and the mean weight per unit of length, a value which can be obtained from a subsample of stems.

4.0 Research Priorities for Rattan inventory

1. Involve local people. Work needs to be done on improving the involvement of local people in inventory (if community-based management is desired), and integrating the skills of local people with the skills of the foresters. Methodologies need to be developed for discussing with local people the

purpose of the inventory and its more specific objectives, and for planning the inventory. Tests could be done to evaluate which sampling designs are easier for local people to understand and conduct. For better use of local skills, methods need to be developed which use local knowledge, but cross-check it for accuracy. For example, if an area is unmapped, participatory mapping could be done to obtain local information on an area to develop a more accurate map. Similarly, obtaining information from local people on the distribution of rattan (i.e. the location of natural rattan 'pockets'), or access routes to forests would be useful for determining strata, and planning the logistics of an inventory. Ground surveys could be done to cross-check this information. Local skills in estimating length or identifying species could be taken advantage of, but again, a method for systematically testing accuracy or cross-checking should be developed.

2. Set up permanent plots. Lack of recurrent inventories means that information on regeneration and growth rates of rattan- essential for management - is not .being obtained. Permanent plots need to be set up for all priority species, over a range of habitats.

3. Test stratification criteria. The precision of estimates using different stratification criteria should be tested; this has not yet been done. A study of the correlations between rattan distribution and different stratification criteria, possibly using GIS, would also give some idea as to which criteria would be most suitable for use in stratification. More needs to be understood about natural rattan 'pockets' - What causes them? Are they found everywhere?

4. Test sampling design. Further tests of sampling designs may improve upon current methods. However, future methods would be considerably improved if the criteria for comparison (simplicity, accuracy, precision, cost efficiency) were standardized among researchers and if the studies were conducted across a range of site types.

5. Complete taxonomic keys. The lack of taxonomic keys to mature rattans in some countries and to immature rattans in all

countries is a serious constraint to inventories. It is important that these keys are completed. To summarize the current situation, taxonomic guides for rattans which have developed mature leaf forms have been published for Peninsular Malaysia (Dransfield 1979), Sabah (Dransfield 1984) and Sarawak (Dransfield 1992); one has also been completed recently for India (Basu 1992) and that for Sri Lanka is nearly complete (de Zoysa 1996). The rattans of China, Thailand and the Philippines have been studied in some detail, but taxonomic guides 'have not yet been written. Research has been conducted on the rattans of the islands of New Guinea and Indonesia, but taxonomic inventories are incomplete (Dransfield 1992). Seedling and juvenile rosettes are notoriously difficult to identify as their -leaves do not resemble those of mature plants. No taxonomic guides for these stages have been written, although Dransfield (1984) has described the general categories of first seedling leaf or eophyll and has linked them to genera.

6 Test methods of mensuration. Further tests of methods of measuring stem length may also improve upon current methods. Again, in testing methods, it is important to consider accuracy, precision, time taken and simplicity.

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Bamboo
Assessment and Inventory

Application of Remote Sensing in Bamboo Resources tnventory in tndia

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Abstract

The estimation of natural bamboo resources is necessary for its sustainable development. The potential use of remote sensing data in the form of satellite data products and large-scale aerial photographs are highly promising. The paper deals with the details of the case study conducted on black and white aerial photographs for the estimation of bamboo resources in tropical forests of Kerala, India, with the objective of preparing a detailed stock map for the region. In the present study 1: 15 000 B & W aerial photographs are mainly used for stock mapping the bamboo resources in natural forests. The mapping accuracy was evaluated and found to be 90% level. The use of satellite data (FCC and CCT) for the general mapping and the specific use of aerial photographs for detailed mapping are highlighted.

1.0 introduction

The possibility of cost effective mapping of natural resources, including forests and other related features, was realized when remote sensing data were made available in 1972. Forest resources, being variable in space and also in time, need to be quantified not only at one time, but also repeatedly at regular intervals to facilitate monitoring of these resources in interaction with other land use practices. Remote sensing technology has emerged with a promising potential to fill the long-felt gap of obtaining timely repeated and synoptic information on the natural resources.

Remote sensing data represent a mixture of information pertaining to land surface features. The objective of a user is to extract needed information as precisely as possible. The mapping of land cover and land use pattern, using remote sensing techniques, provides information of practical value in environmental planning and land development. Stratification of vegetation cover with respect to structural features is essential for resource evaluation. The estimation of actual areas of different vegetation types and of different strata in each vegetation cover is the most crucial part in this evaluation.

The bamboo resources of tropical forests are spread over evergreen and moist deciduous forest types. Most areas are inaccessible owing to undulating terrain. Hence, estimating the actual areas of bamboo for resource evaluation is a Herculean task if we adopt conventional field survey methods. On an experimental basis, an attempt was made to map bamboo stock in the tropical forests of Kerala, using remote sensing, satellite false colour composites (FCC) and large-scale aerial photographs. The main aims were to carry out the identification and stratification of bamboo area with respect to its density class, and to assess the feasibility of the use of remote sensing data in natural resource evaluation, especially in bamboo stock mapping.

2.0 Details of the Study

The study was conducted in northern, central and southern parts of Western Ghats region in Kerala. The terrain is rugged and hilly. The elevation ranges from 250 to 2 000 m. The plains of the eastern part of the area are dry and warm almost throughout the year whereas the hills on the western side are wet, warm and humid.

The vegetation exhibits considerable variation in floristic composition and structure. The major forest types, recognized in the area (Champion and Seth 1968) are the West Coast tropical evergreen forests, the West Coast semievergreen forests, southern moist mixed deciduous forests, South Indian moist deciduous forests and southern tropical dry deciduous forests.

2.1 Methodology

The standard remote sensing techniques based on various photo elements and Maslekar 1972) were adopted for visual interpretation of large-scale aerial photographs (Black & White 1:15 000 scale, 23 x 23 cm format, glossy single weight, with 60-80% forward overlap and l0-40% lateral overlap). The general classification of the area was done using satellite false colour composites (IRS-LISS 1 and LISS 2 FCCs) and computer compatible tapes. The photostratification scheme was adopted using photo elements like tone, texture, colour etc. and an interpretation key was prepared for delineation of land cover units. The classification of units into various height classes and density classes was also done using different photogrammetric methods. Based on the visual observations of homogeneity and diversity, different stands of major vegetation types were selected for quantification study. Base maps were prepared in l:25 000 scale from 'Survey of India toposheets' and the interpreted data were carefully transferred for checking the pre-field map. Spot checking was performed for accuracy evaluation and the area estimation was done using Planix-5000 electronic planimeter.

2.2 Results and discussion

The land cover map showing the distribution of bamboo area along with other vegetation types was prepared in 1:25 000 scale for management purpose. The mapping accuracy was evaluated and was found to be of 90% in the case of aerial photographs. The classification accuracy of satellite data products was found to be 65-70%. The area estimates of different density strata along with the sampled information by list count quadrat method (Oosting 1958) of bamboo area will substantiate the resource stock evaluation at a given time.

The study confirmed that the mapping and resource evaluation of bamboos in natural tropical forests can be done effectively and efficiently using large-scale aerial photographs, since the clear tonal variation in aerial photographs delineate the areas with and without bamboos without much effort. The clear textural variation in aerial photographs with respect to crown density status of bamboo can be efficiently used in stock mapping. Moreover, the aerial photographs with their 3D effects give better resolution for photostratification of types.

Broad classification of forest types alone can be differentiated in satellite data, since colour and tone are the two important photo elements available for effective use. Owing to the effect of aerial photographs, the textural characteristics of the feature can also be used for stratification of units. This is very important in bamboo stock map preparation. The tonal and textural variations of bamboo in flowering season and the satellite appearance of sympodial bamboo units in ground sterograms etc. are the other added advantages of this technique.

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Application of Remote Sensing in Bamboo Resource Inventory in Thailand

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Abstract

A study on species and production of bamboo in northern and western parts of Thailand was conducted using remote sensing data incorporated with the data from ground reality. LANDSAT TM imagery, band 2 3 4 (Blue Green Red), with 1:250 000 scale was used for forest type classification and area estimation. Visual interpretation was based on texture, association shape and location.

It was found that bamboos in northern Thailand occur in two main types of natural forest, i.e. mixed deciduous forest with an area of 14 564 065 rai (1 ha = 6.25 rai) and 12 894 846 rai in a combination of mixed deciduous and dry dipterocarp forests. In western Thailand, bamboos occur in three types of natural forests: mixed deciduous forest with an area of 1 298 437; in 2 386 561 rai of mixed deciduous forest over 50% bamboos and in 1 684 062 rai of bamboo forest.

Stand inventory was carried out in selectively distributed 35 plots of 0.1 ha each (selective sampling). There are four main species in northern Thailand: *Gigantochloa albociliata, Dendrocalamus strictus, Bambusa nutans* and *Thyrsostachys siamensis* with a total of 5 700 million culms. *Thyrostachys siamensis, Gigantochlos hasskarliana, Dendrocalamus strictus* and *Melocalamus compactiflorus* with a total of 7 500 million culms represent the bamboo in the western part of the country.

This abstract has received input from Suksord, Kasetsart University and Somjos Saengnit, Royal Forest Department.

Bamboo Resource Inventory in the Philippines

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Abstract

A brief review of the present state of knowledge includes the inventory report of a RP-German Forest Resources Inventory Project. The inventory made use of remote sensing and field sampling procedures. For minor forest products-which include bamboo, rattan and palms-circular plots in 3 cluster corners were used. Estimates of bamboo resources in 10 regions of the country were determined in terms of culm length/ha under old growth dipterocarp forests and residual forests. Erect bamboo species identified include *Schizostachyum lumampao, S. lima, Gigantochloa* levis, and *Dendrocalamus aper. Schizostachyum diffusum* was found to dominate the climbing species. Recommendations to improve the reliability of inventory data are also presented.

1.0 Introduction

In the Philippines, bamboos are found in natural forests, brushlands, marginal lands, riverbanks and backyards in all villages. Some of the most economically valued species are: *Bambusa blumeana, B. vulgaris Dendrocalamus merrillianus, D. asps, Gigantochloa atter, G. levis, Schizostachyum lima, S. lumampao* and *Sphaerobambos philippinenis.*

The supply of bamboo has been diminishing owing to its demand for many uses, and the amounts and distributions of each species need to be assessed. There is, therefore, need for a more comprehensive inventory and study of population density for managenment, utilization and conservation purposes. There have been conflicting reports on the number of species and the amount of resources in the country. In the inventory process, more species may be discovered, taxonomic problems resolved, and the diversity and distribution of this important resource may become more clear.

2.0 The National Forest Resources Inventory

The first nationwide forest resources inventory was conducted during 1969-81 by the Bureau of Forest Development, which reported 353 million clumps of bamboos in the natural forests (Anonymous 1981).

A second national inventory, based on a Philippines-German Forest Resources Inventory Project, was conducted during 1984-87. This adopted a two-stage sampling design based on the most recent available small-scale aerial photographs and on satellite data to obtain a reliable area frame. Subsequently, a stratified, restricted field sampling was carried out to compile the stand structure data of relevant forest strata.

The inventory procedure was designed for forest trees and not specifically for bamboos. Hence the inventory results may not present a good picture of the bamboo resources. As there might have been difficulties and errors in the identification of species and so data in this report are simply categorized as either erect or climbing bamboos. Likewise, the unit of measurement, i.e. m/ha in expressing bamboo stock, is not an ideal basis for predicting growth and yield for bamboos. A more appropriate expression that allows reliable projections for management purposes could be the number of clumps/ha and the number of culms/clump.

Mat paper prints of the 1981 aerial photocover at an approximate scale of 1:60 000 were stereoscopically interpreted. After extensive field checks and using a thematic mapping approach, the interpretation was transferred to the 1:50 000 base map. These forest resources condition maps (FRCM) served to allocate the field samples and to determine the areas of the different strata with the help of a 1 km dot grid.

Field samples were allocated to each province proportional to its forest cover. Data on minor forest products (rattan, bamboo and erect palms) were recorded on circular plots in the cluster corners.

3.0 The Bamboo Resource

The result of the inventory, summarized in Table 1, shows that erect bamboo stock is generally higher in the residual forest than in the old growth dipterocarp forest. Average stock for the 10 regions is estimated at 1 492.22 m/ha for residual forest as compared to only 103.3. m/ha in the old growth forest. Canopy openings brought about by logging operations provided more space for the bamboos to produce culms of merchantable sizes. Microclimatic conditions prevailing in the logged-over (residual) forests are favourable for the growth and development of bamboo clumps.

Table 1: Bamboo stock in different regions of the Philippines (m/ha)

Region	Species Type	Forest St rata old Growth	Residual	Total
1	climbing	2600	2000	4600
	erect		6 200	6200
	Total	2600	8 200	10 800
2	climbing	700	1500	2200
	erect	400	400	800
	Total	1 loo	1900	3000
3	climbing	839	1 632	2 471
	erect	252	5296	5 548
	Total	1 091	6 298	8 0119
4	Climbing	586	787	1 373
	erect	28	27	55
	Total	614	814	1 428
5	ctimbing	1 416	2 247	3 663
	erect	12		12
	Total	1 428	2 247	3 675
6&7	climbing	3 210	3 971	7 181
	erect		163	613
	Total	3 210	4 134	7344
8	climbing	8048	3 833	11 881
	erect			
	Total	8 048	3 833	11 881
9	climbing	2 491	4 749	7 240
	erect	2.38	392	630
	Total	2 729	5 141	7 870
12	climbing	7 543	5 703	13 246
	erect		385	385
	Total	7 543	6088	13 631

Source Forest resources as inventoried by the RP-German Forest Resources Inventory Project (Anonymous

Erect bamboo species found in the old growth forest include Scbizclstadyum lumampao, S. lima and Dendrocalamus asper while those in the residual forests include S. lima, S. lumampao, Gigantochloa levis and Bambusa vulgaris. Bambusa blumeana, which is considered as the most important species for manufacture of furniture, handicraft and other uses was not found in the natural forests. The bamboo-based industries primarily depend on this species for their operation. Bamboo plantations so far established are estimated to be at least 2 000 ha, mostly of Sphaero bambos philippinenesis, required mainly by the banana industry in Southern Philippines.

Climbing bamboo species not commercially valued at present, such as Schizostachyum diffusum, grow abundantly both in the old growth dipterocarp forest and residual forest.

In the open and marginal areas such as agricultural lands, upland farms, brushland, riverbanks and backyards, bamboos such as Bambusa blumeana, Dendrocalamus merrillianus and Gigantochloa levis grow abundantly and represent large resource areas for the furniture industry, construction purposes, vegetable shoots and other uses (Tomboc and Virticio 1995). It is probable that the stock of bamboo found in these areas is greater than in the natural forests. Yet, the inventory data presented above did not include the bamboo stocks found in cultivated lands and other open areas. Information on the exact distribution of each species was also not available. There is, therefore, need to conduct a comprehensive inventory of bamboo in these areas, probably with the use of community-based approaches which recognize the participation of local government units and people's organizations in the countryside.

Moreover, there is an urgent need to implement better methods of propagation and management techniques for bamboo clumps in order to sustain the production of good quality culms for furniture and other bamboo-based industries.

4.0 Recommendations to Improve Bamboo Invertory

The following points are worth considering in the development of an inventory system for bamboo resources in the Philippines:

Village Participation in Inventory of Bamboos Outside Forest Lands

Under the present set-up, wherein local communities are given the opportunity to manage local resources, the Department of Environment and Natural Resources (DENR) could easily set up a coordination network for inventory of bamboos in the different barangays and municipalities. The Community Environment and Natural Resources Officer (CENRO) can coordinate with the local government units to organize a task force for bamboo. inventory on private lands, farmlands and other areas not included in the national forest resources inventory. There is an on-going pilot bamboo inventory project in Central Luzon (Region 3) where survey questionnaires were distributed to local government units to get a 100% inventory of bamboo clumps in different localities. Data gathered will be subjected to field validation using appropriate sampling strategies to ensure reliability of inventory results. The methods discussed by Sharma (1987), Krishnankutty (1988) and Khali Aziz Hamzah (1993) could be modified to suit the actual conditions in communities and non-forested areas where bamboos are growing.

2. Comprehensive Ground Validation Sampling for Bamboos Within Forest Lands

The results of the National Forest Resources Inventory should be subjected to comprehensive ground validation sampling to generate accurate information with respect to taxonomic identity of bamboo species, clump population and number of culms per clump.

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Size of sample plot for Bamboo Forest Inventory

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Abstract

A study of the size of sample plots for bamboo forest inventory was carried out in Sumbawa Island. Only one bamboo species was found in this forest. Two sizes of sample plots 100 x 20 m and 50 X 10 m were compared and no significant differences were found in ultimate numbers of clumps.

1.0 Introduction

Based on ownership, bamboo resources in Indonesia fall into three groups: bamboo forest, community bamboo and bamboo plantation. Bamboo forest is the bamboo occurring in forest area and owned by the government. Community bamboo is the bamboo planted by people and located outside the forest areas, and bamboo plantation is bamboo planted, usually by a company, and located outside forest areas.

Each of the three types has its own characteristics, including management. Each group also has specific techniques for inventory. For bamboo forest, the technique of inventory used is similar to that used for forest vegetation and no specific manual for bamboo inventory is available as yet. This study was aimed at promoting an alternative size of sample plot in the bamboo inventory.

2.0 Material and Method

A bamboo forest area located in Sumbawa Island and owned by the government shows that bamboo spreads from west to east of the island. A study was conducted which is representative of all the boo forest of Sumbania. Only one species occurs in the area, Bambusa bambos. This has a natural regeneration of 2-4 culms/clump/agar and there are 13-27 culms/clump.

Two sample lines were made in the bamboo forest area with the distance between the lines being 4 km. The lines were at a right angle to contour lines. On each of the lines was placed two sizes of sample plots: 20 x 100 m and 10 x 50 m, and each was replicated 5 times.

Data collection in the field was conducted by computing the number of clumps in each plot.

Table 1 shows the number of clumps in each sample plot. For analytical purposes the number of clumps in sample plot size 10 x 50 m was converted into sample plot size of 20 x 100 m.

Analysis of variance compares two sample plot sizes. The average population per hectare would be 295 clumps for sample size of 20 x 100 m and 315 clumps for sample plot size of 10 x 50 m.

Table 1: Number of clumps on each of the sample plot size

Block	Replication	Sample Plot Size	
		20xl00m	10 x 50 m
I	1	112	(25) 100
	2	75	(16) 64
	3	40	(9) 36
	4	31	(14) 56
	5	37	(11) 49
II	1	75	(15) 60
	2	62	(19) 76
	3	56	(16) 64
	4	55	(17) 68
	5	51	(13) 52
Average		59	63

Further Reading

Anonymous. 1990. Laporan inventarisasi potensi hutan bambu Pulau Sumbawa Propinsi Dati I Nusa Tenggara Barat (Report of Inventory of bamboo forest potential of Sumbawa Island, Province of Nusatenggara Barat). Forest Office of Province, Nusatenggara Barat, Indonesia.