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IMPACT OF SELECTION FELLING IN A FOREST ECOSYSTEM IN KERALA

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IMPACT OF SELECTION FELLING IN A FOREST ECOSYSTEM IN KERALA

Chapter I

I. INTRODUCTION

The tropical wet evergreen forests of Champion and Seth (1968) very often equated to tropical rainforest (Schimper, 1903 and Richards, 1952) is defined as "a closed community of essentially, but not exclusively, broadleaved, evergreen, higrophilous trees, usually with two or more layers of trees and shrubs and with dependent synusiae of other lifeforms such as vines and epiphytes. It does include the characteristic vegetation of the humid tropics, even where this has a somewhat seasonal climatic regime, as well as those of moist elevated areas of the tropics" (Hamilton, 1976). This type of forest is typified by pantropic families such as, Lauraceae, Myrtaceae, Sapotaceae, Dipterocarpaceae, Clusiaceae, Melastomataceae, etc. and are distributed more or less astride the equator in America, Africa and Southeast Asia.

In India, such type of forests are confined to Western Ghats, northeastern regions and islands of Andamans. As this type of forest is a storehouse of plywood industries, railway sleepers, etc., and to sustain an uninterrupted flow they are seldom clearfelled and the commonest silvicultural system adopted is the Selection System. In essence, it envisages removal of mature, usually the oldest or largest trees, as scattered individuals, repeated indefinitely, by means of which continuous establishment of reproduction is encouraged and an uneven stand maintained. During the process of selective extraction, the exploitable girth class, the felling cycle and the number of trees to be removed in a given unit area are the major criteria employed.

By this method it is generally believed that the evergreen nature of the forest is not endangered and there is no setback in the ecological status on account of over exploitation and the bumpy nature of the canopy is never permenantly disturbed. The girth limit is generally 180 cm. at breast height (1.4 meteres) and the felling cycle usually 30 years. The maximum number of trees permitted to be removed from any one hectare, during each felling cycle used to be 8 to 12 in number. However, due to increasing pressures and in areas with a preponderance of over mature trees, a shorter felling cycle is adopted and sometimes the number of extracted species are also violated beyond the prescriptions of Working Plans, thus endangering the continuity of operation.

This type of felling which helps to maintain an uneven stand has the following assumed advantages.

1.1 Advantages

1. It ensures gross production whether measured in biological or economic terms making way for increae in merchantable yield.

2. It offers stability of environmental conditions and influences that is not available in even aged stands.

3. It helps to maintain a continuous cover of a protection forest on steep slopes in order to prevent erosion, landslides, avalanches or run off.

4. The danger of fire is less in uneven stands since the fuels are shaded.

5. It is generally regarded as being less susceptible to damage from biotic enemies like fungi, mistletoe etc., because the most injurious species do not attack all age classes of a given species.

6. Since environmental conditions are maintained in a more or less stable equilibrium, the entire plant and animal populations of the stand remains relatively stable. The risk of violent or unforeseen fluctuations is sharply minimised.

7. It ensures presence of a permanent seed resource.

8. Due to permanent vertical closure of the stand damage due to wind is reduced. However, by creation of extensive gaps wind can funnel and accelerate sufficiently to cause great damage.

1.2 Disadvantages

1. The progress of regeneration and the condition of the growing stock are often submerged in an uneven stand and hence more difficult to evaluate the results of operations.

2. It is necessary to cover a larger area to harvest a given volume in one operation.

3. It reduces the productivity of the forest by contributing to dysgenic selection.

4. Environmental factors like shade, root competition, microclimate, etc., would be subjected to drastic fluctuations, which may retard natural regeneration of important species.

5. When a tree is felled a lot of damage is done to the surrounding trees and the gaps caused depend upon the height of the tree and size of the

crown. The sawyer will cut out all saplings in the vicinity of tree trunks in order to erect the required scaffolding at site. The resultant leaf litter and wood debris are generally burnt. Thus, hardly any regeneration is left in the gap.

6. When large gaps are created invariably they are colonised be heliophilous pioneers like Macaranaga, Leea, Eupatorium, Lantana etc., which are difficult to exterminate.

7. The complexity of operation is such that it requires supervisory skill and attention by an experienced and efficient forester.

While successive Working Plans repeatedly adhere to this type of felling, on the assumption that it causes less damage an indepth study has not been so far undertaken to analyse the possible environmental impacts. This project is an attempt to fill in this lacuna with the following objectives.

1.3 Objectives

1. To investigate the changes in situ that are likely to be brought upon in microclimatology particularly ambient temperature, relative humidity, soil temperature, and incidence of light available to various strata.

2. As this system is meant to facilitate natural regeneration, the regeneration status of the extracted species have been worked out.

3. To investigate the phenological pattern of the understorey.

4. To evaluate the structure of plant communities and their successional patterns.

5. To assess the damage to the residuals due to logging operations.

1.4 Marking and Felling Rules

To facilitate a scientifically based forestry operation clearcut guidelines have been provided for marking and felling the trees. Some of these rules are outlined below:

1.4.1 Marking rules

a. Only merchantable species above the prescribed girth limit should be marked.

b. Number of trees prescribed per unit area should not exceed.

c. Marked trees should be well distributed within the coupe so that lasting gaps are not created due to felling of marked trees. An average distance of atleast 20 meters should be maintained between two marked trees.

d. Marking should proceed from one end of the coupe to the other.

e. Trees standing on precipitous stopes and difficult terrains should not be marked.

f. If more than maximum number of trees prescribed are available silviculturally preferance should be given to trees of higher classes and the lower limit should be retained for the next felling cycle.

g. Trees should be numbered with a chistle at two places, one at the breast height and the other at the base of the tree on the opposite side of breast height marking. Irrespective of species all trees should be serially numbered. The marking register should contan the tree number, species, girth at breast height and also remarks like buttressing, hollowness etc., Volume of logs and firewood obtainable should also be recorded.

h. In view of the technical skill involved marking should be done by a trained officer, not below the rank of a Forester.

i. The Range Officer and the Divisional Forest Officer should conduct check measurements of 25%

and 10% respectively and the initials of the officer should be put against the tree number checked.

i. Dead or uprooted trees may also be marked if they are capable of yielding timber.

1.4.2. Felling rules

a. Felling should commence from one end of the coupe and proceed systematically to the other end. Trees should be felled uphill and axed at the lowest possible level. Before deciding on the directions of fall due consideration should be given to possible damages of valuable standing trees and trees of advanced growth.

b. In buttressed trees felling should be done where the pronounced buttress ends.

c. If dragging is required after felling the direction of fall should as far as possible be opposite to the direction of dragging.

d. All damaged trees in the course of felling should be converted if saleable.

e. After completion of extraction the coupe should be throughly gone through and tending operations carried out for successful regeneration of desired species.

At the expiry of the contract period the Range Officer should prepare and submit the liability report giving the following details:

a. Number of trees handed over to the contracter, number of trees felled, number of trees felled hollow and number of trees left out by the contractor.

b. The logs converted, registered, transported, remaining in coupe, etc.

c. Irregularities, if any, detected.

Chapter II

II. STUDY AREA

2.1 Physiography

Pothumala Felling Series, in Nelliampathy Range, Nemmara Division, Palghat District has been chosen in view of its proximity and also for continuous long term monitoring. The area lies between $10^{\circ}25'$ and $10^{\circ}30'$N latitude and $76^{\circ}35'$ and $76^{\circ}45'$E longitude. Nelliampathy is a plateau situated at an elevation of about 900 m.

It is situated immediately south of the Palghat gap and rises steeply from the Palghat plains to an average elevation of about 900 m. Its eastern edge is formed by the Vested Forests of Nemmara and is some what drier while the southern and western parts receive copious rainfall resulting in luxurient evergreen forests. While the vast extent of the natural evergreen forests have been eliminated by cash crops like coffee, tea, cardamom, etc., two siginificant patches are still left undistrubed - one in the catchment of a tributory of Kuriarkutty river and the other along the southern and adjoining Sholayar hydel project. The location of all the areas is depicted in Fig. 1.

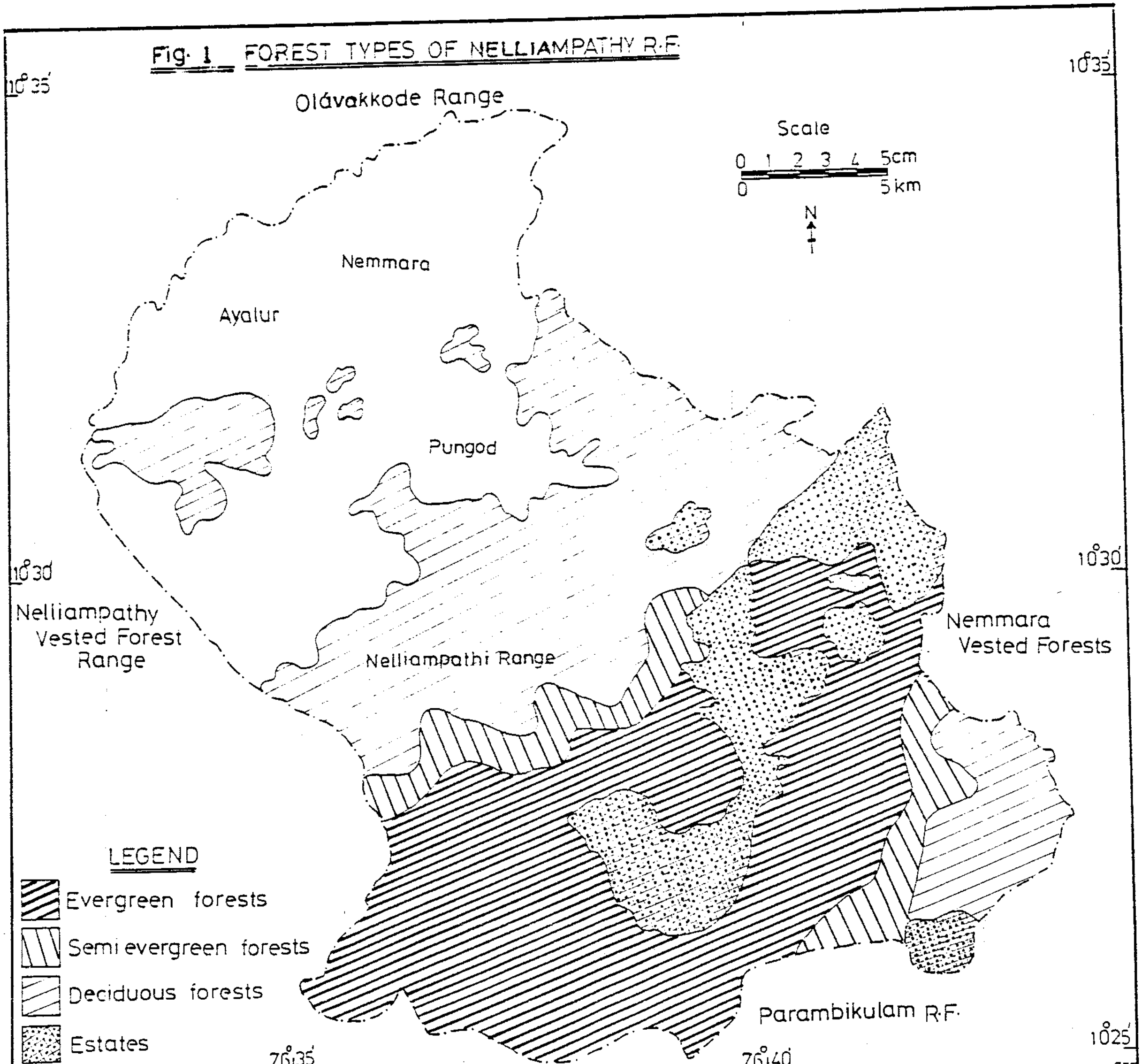


Fig. 1 FOREST TYPES OF NELLIAMPATHY R.F.
10°35′
10°35′
Olávakkode Range
Scale
0 1 2 3 4 5cm
0 5km
N
Nemmara
Ayalur
Pungod
10°30′
10°30′
Nelliampathy Vested Forest Range
Nelliampathi Range
Nemmara Vested Forests
LEGEND
Evergreen forests
Semi evergreen forests
Deciduous forests
Estates
Parambikulam R.F.
76°35′
76°40′
10°25′

2.2. Climate

The climate of this area is of a typical tropical monsoon type. The mean annual rainfall is about 3660 mm and at least four seasons could be encountered. The dry season lasting from January to March accounts for just 2% of the total rainfall. 7.4% of the total rainfall is contributed by the premonsoon thunder showers lasting from April to May. The bulk of the precipitation (76.6%) however is brought about by the South West monsoon lasting from June to September while the Retreating Monsoon from October to December accounts for 14%.

There is no marked or appreciable difference in the mean annual temperature. It varies from 20.2^{o}C during November to 25.5^{o}C during May, the hottest season of the year. Thus the mean thermic amplitude is just of the order of 5.3^{o}C. The Ombrothermic diagram depicted in Fig.2. shows the climatic regime of Nelliampathy. (Source: Orange and Vegetable Farm, Nelliampathy).

2.3 Vegetation

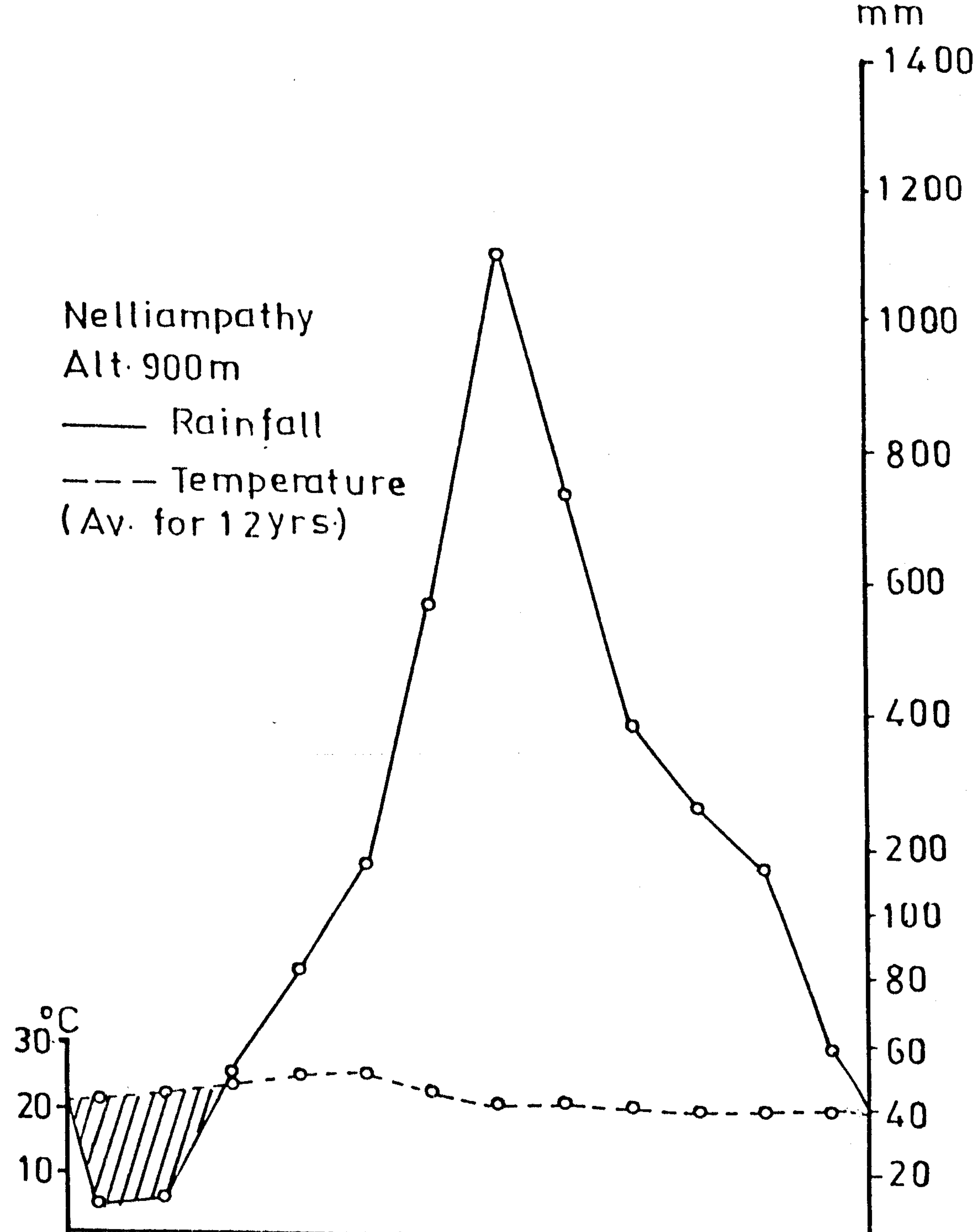
As expected, the vegetation of the area is of tropical wet evergreen type (West Coast Tropical Evergreen Forest - Champion and Seth, 1968) Pl. 1.

Atleast three distinct strata can be recognised. The top storey reaching a height of about 40-45 m. is dominated mostly by <u>Palaquium ellipticum</u> and <u>Cullenia exarillata</u> interspersed with <u>Mesua ferrea</u>, <u>Dysoxylum malabaricum</u>, *Calophyllum tomentosum* and *Canarium strictum*. The second stratum of about 25 to 30 m. is mostly dominated by *Agrostistachys meeboldii* and *Myristica dactyloides*. The third tier is composed of small trees and large shrubs of various species of *Syzygium* and *Unona pannosa*. An enumeration of all species above 10 cm. gbh. in an area of 2500 m^2 shows that 34 species representing 379 individuals have been recorded. The vegetation is of *Cullenia* - *Palaquium* association. Data pertaining to vegetational analysis are given in Table 1. and the distribution of species according to the girth classes are given in Fig. 3.

It is seen from Fig. 3 that the graph follows a 'L' shaped curve with species of the lower girth classes dominating and those of the exploitable ones viz; above 210 cm. represented by 29 out of the 379 individuals, ie., 7.6%. The potential ones for future exploitation ie, from 30 to 210 cm. constitute roughly 50%.

2.4 Soils

The soils of the evergreen forest of Nelliampathy are blackish in colour, rich in humus content and organic carbon. They are acidic in reaction and pH is seen to be around 5. The root system of the trees are largely confined to the upper layers and rarely exceed a depth of one meter. The nutrients are mostly held in the litter.



	J	F	M	A	M	J	J	A	S	O	N	D	
T	20·7	21·6	23·7	25·0	25·5	23·0	20·6	21·3	20·9	20·6	20·2	20·6	22·0
P	10	12	49	83	188	570	1107	734	394	272	181	61	3661

Fig· 2 Nelliampathy – Ombrothermic diagram

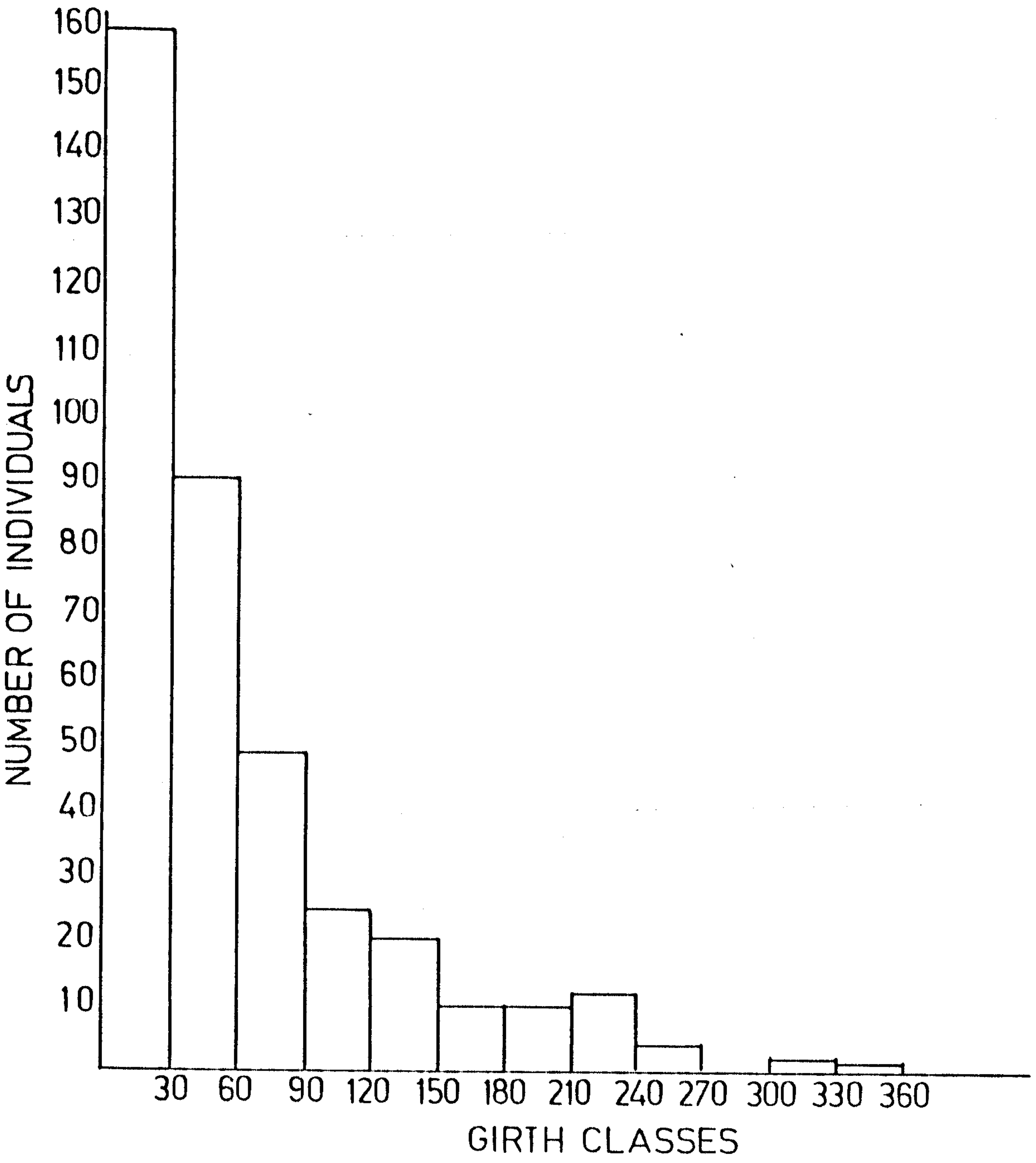


Fig. 3 Analysis of vegetation by girth classes

Table 1

Tree enumeration

Sl. No.	Name of the species	Relative frequency	Relative density	Relative Basal area	IVI
1.	Cullenia exarillata	10.80	7.36	40.80	58.96
2.	Palaquium ellipticum	9.40	6.30	20.80	36.50
3.	Unona pannosa	7.80	12.53	9.00	29.33
4.	Agrostistachys meeboldii	8.90	8.43	11.25	28.58
5.	Mesua nagasarium	8.75	6.43	9.20	24.38
6.	Drypetes alata	7.40	3.80	12.20	23.40
7.	Lasianthus ciliatus	7.40	0.85	14.75	23.00
8.	Canarium strictum	7.40	0.90	14.70	23.00
9.	Holigarna arnottiana	7.00	1.80	14.00	22.80
10.	Neolitsea zeylanica	7.00	2.40	12.70	22.10
11.	Psychotria sp.	3.80	0.40	16.80	21.00
12.	Isonandra lanceolata	3.80	1.00	16.00	20.80
13.	Holigarna grahamii	2.40	0.90	16.70	20.00
14.	Atalantia wightii	1.90	0.80	17.20	19.90
15.	Macaranga peltata	1.90	0.40	17.40	19.70
16.	Polyalthia fragrans	1.90	0.35	16.75	19.00
17.	Macaranga peltata	1.90	2.35	14.55	18.80
18.	Jambosa munronii	1.90	0.45	16.45	18.80
19.	Calophyllum tomentosum	1.42	1.65	15.53	18.60
20.	Artocarpus heterophyllus	1.42	1.00	14.58	17.00
21.	Bischofia javanica	1.42	1.60	13.98	17.00
22.	Memecylon malabaricum	1.42	0.80	14.18	16.40
23.	Euonymous crenulatus	0.95	0.60	10.45	12.00
24.	Aporosa lindleyana	0.95	3.00	7.85	11.80
25.	Antidesma menasu	0.95	2.00	4.85	7.80
26.	Euphoria longana	0.95	1.00	5.05	7.00
27.	Comphandra polymorpha	0.47	0.38	5.95	6.80
28.	Litsea floribunda	0.47	0.35	5.18	6.00
29.	Mallotus beddomeii	0.47	0.20	4.73	5.40
30.	Phoebe lanceolata	0.47	0.20	4.73	5.40
31.	Glochidion sp.	0.47	0.18	2.35	3.00
32.	Dysoxylum malabaricum	0.47	0.12	1.81	2.40
33.	Goniothalamus thwaitesii	0.47	0.10	1.31	1.88
34.	Actinodaphne bourdilonii	0.47	0.12	0.81	1.40

Chapter III

REVIEW OF LITERATURE

3.1 Overview

Literature pertaining to selection system are rather scattered and most of them were found to deal with logging damages and regeneration problems. The proceedings of the symposium on "Long term effects of logging in Southeast Asia" covers various aspects of this system (Biotrop, 1978). Most of the articles in this deal with, biological changes, impact on general environment, soil erosion and hydrological regime, socio-economic and techno-economic survey, logging damages and the effect of logging on residual stands, changes in microflora and microfauna and occurrence of pests and diseases.

An overall account of the selection system prevailing in various countries were given by Arnot and Landen (1937, for Malaysia); Stracey (1959, for India); de Rosayro (1957, for Sri Lanka) and Nicholson (1970 and 1979 for Southeast Asian countries).

For purposes of convenience various facts of this study are treated indivdually.

3.2 Microclimate

Microclimate forms one aspect of this study where literature shows extreme poverty. A good account of the microclimatic conditions, especially those of temperature and relative humidity for various stations in the Western Ghats of India were given by Pascal (1984). Majid and Jusoff (1987) studied the impact of logging on the soil temperature in a lowland dipterocarp forest in Malaysia.

3.2.1 Light

Light as one of the crucial factors in the evergreen forests have been stressed by many authors and notable publications in this direction are those of Evans (1956), Ashton (1958), Evans and Whitemore (1960), Nicholson (1960 and 1969), Federer and Tanner (1966), Alexandre (1982a and b), Salminen, et al. (1983) and Chazdon and Fetcher (1984).

3.3 Regeneration

The process of natural regeneration in the evergreen forests in exceedingly complex and therefore very little is known about it. Richards (1952) quotes that "much of what is written about the so called natural regeneration of the evergreen forests refers to the reproduction of a few economic species under conditions rendered more or less unnatural by timber exploitation. Besides, the various factors that control the intensity and direction of natural regeneration viz., Phenology, seed predation, viability, germination, establishment and survival, light and shade conditions etc., are imperfectly known". However, publications concerning regeneration are enormous. Almost all the Working Plans prepared by the forest officers include the status on regeneration survey conducted by them. Some of the notable publications on this aspect from different parts of the country are those of Chengappa (1944, for Andamans); Champion (1929) and Krishnaswamy (1952, both for India); Fanshawe (1952, for British Guyana) Holmes (1956-57, for Sri Lanka); Ayliffe (1952) and Brooks (1942, both for Trinidad), Pitt (1960, for Amazon); Taylor (1954 for West Africa) Meijer (1970 and 73, for South East Asia), Miquet (1955 for La Reunion). Walton (1954), Nicholson (1958) and Wyatt Smith and Foenander (1962) described the regeneration status due to logging operations.

3.4 Phenology

This refers in essence to the leaf fall, new flushing, flowering, fruiting etc., and as far as the evergreen species are considered the data are quite inadequate. In general, phenological data are obtainable from the field notes of the botanists or the local floras. But precise data about the periodicities of flowering and fruiting are not generally available as most of the areas are not visited all around the year for atleast a few successive years. However, case studies from a few countries are available and are seen through the works of Landen (1957), McClure (1968), Medway (1972), Ng and Loh (1974) and Cockburn (1975, all of them for Malesia); Wycherley (1973, for Micronesia); Hilty (1980, for Pacific Columbia); Koelmeyer (1959, for Sri Lanka) and Franke, et al.; (1974) and Opler, et al.; (1980, both for Costa Rica).

3.5 Succession

It is a continuous process of gradual replacement of one community by another in the development of vegetation towards a climax. It can be 'primary' when it is developed on an area devoid of any earlier vegetation or 'secondary' after destruction of whole or part of the original vegetation. Studies pertaining to this aspect are rather scarce for the evergreen forests, but for, some of the notable publications like, Bazaz (1983), Brokaw (1982), Denslow (1978), Finegan (1984) and Whitmore (1986).

3.6 Logging damages

From the foresters and conservationists point of view this has been the most important problem and several studies were conducted to assess the logging damages and to suggest remedial measures. Some of the important publications are, Nicholson (1958, for Borneo); Redhead (1960, for Nigeria); Fox (1968 for Maleysia), and Rapera (1978, for Philippines); Pong Sono (1978, for Thailand) and Soriaenigara (1978) and Tinal and Palenewen (1978, both for Indonesia). Damages due to roadlaying was stressed by Mason (1974).

Chapter IV

METHODOLOGY

The methodology adopted varies with different aspects of the study.

4.1 Selection of Areas:

During the year 1985, 723 trees in an area of 118 ha. and estimated to yield 3269 cum.m. of timber were earmarked for selection felling. Cullenia exarillata and Palaquium ellipticum, the two plywood species constituted roughly 98.5%. The rest were Holigarna arnottiana, Calophyllum tomentosum, Mesua ferrea, Artocarpus heterophyllus and Myristica dactyloides.

Out of this 118 ha. an area of 11 ha. comprising a total of 68 marked trees for felling were demarcated for longterm monitoring and also to serve as a bench mark. An area of four hactares felled in 1980 was also chosen for comparative purposes in studying microclimate, regeneration, phenology and succession of plant communities.

An area of about 6.5 ha. having a total of 40 marked trees and felled in 1985 was intensively studied for logging damages and also for other aspects mentioned earlier.

The methodology adopted for different aspects of the study are as follows:

4.2 Microclimatic studies

4.2.1 Atmospheric temperature and relative humidity

To study the atmospheric temperature and relative humidity, monthly, automatic recording, thermohygrographs were installed at a height of four meters above the ground level in the control plot, area that was felled in 1980 and also that of 1985. Regular monthly visits were made and the graph papers were changed every month from January to December 1985. Thus data for a complete one year was gathered.

4.2.2 Soil temperature

During the same period soil temperature was also measured once a month, with the help of soil thermometer at four places in each of the three plots at 8 A.M., 12 noon and 4 P.M. respectively at a depth of about 10 cm.

4.2.3 Light intensity

For studying the intensity of light available to various strata four huge trees in each plot were chosen and were nailed with bamboo pegs upto the first branching. The incidence of light available at the ground level, 10 m. 20m. and 30 m. above the ground were measured with the help of a pocket lux meter in the early morning, mid noon and evening. Data on this aspect was gathered for a full year of 1985.

4.3 Regeneration Studies

Regeneration survey was conducted by laying out sample plots 1 x 1 m. Twelve such plots were laid out in all the three areas. Data were gathered only for the extracted species. In the case of the area felled in 1980 and in the controlled plot the regeneration survey was carried out for three years. The species were énumerated for:

(a)	Unestablished seedlings	-	less than 40 cm. height.
(b)	Established seedlings	-	40 to 100 cm. height.
(c)	Advanced growth	-	over 100 cm. height but below 10 cm. gbh.
(d)	Saplings	-	young trees from 10 to 50 cm. gbh.

4.4 Phenological studies

This study was restricted only to the species constituting the second and third storey. One hectare area in control plot and the area felled in 1980 were demarcated. Monthly visits were made and with the help of a devised score card visual observations were made on flowering and fruiting. Observations pertaining to this were carried out for three years, in the controlled plot and in the area felled in 1980.

4.5 Successional studies

This study was restricted to succession in gaps only. The gaps were divided conveniently into small gaps, large gaps and extensive gaps. Besides the gaps artificially created by felling, gaps induced by natural tree fall were also taken into consideration. A total of twelve gaps in each of the three plots were measured for their size and the trend of succession in each gap was monitored for two years in the control plot and in the area felled in 1980. As far as the area worked in 1985 only one year data was gathered.

4.6 Logging damages

This has been broadly categorised into three groups viz., damages to the bole, damages to the crown and damages to the bark. A total of 40 trees during the process of felling were monitored for various damages caused.

4.6.1 Damages to bole

In this case the actual damage caused to the main trunk was investigated. It was also noted whether the damages to the bole were due to the crown of the felled trees or due to the main trunk.

4.6.2 Damages to the bark

In this case the nature of the damage was restricted to complete peeling of the bark or only partial damage. Here again the causal agent viz., the crown or the bole was investigated.

4.6.3 Damages to the crown

The diameter of the crown of the evergreen tree species are generally large, often about 35 to 40 meters and the damages by it are of enormous magnitude. In this case, as soon as the tree was felled, the diameter of the crown was measured and the damages caused by it to the crown of other species were also investigated.

4.7 Damages due to road laying

Another notable damage during selection felling is the damage caused by road laying. Despite the prescriptions of working plans, in practice the trees are initially felled and to facilitate easy dragging and loading, road alignments are made. In this way many valuable species are cut down.

To estimate the damages due to this process a two kilometre stretch of road out of 11 km. laid during constru-ction was closely followed to ascertain how many trees of various girth classes were removed and also the species involved.

4.8 Damages due to elephant dragging

Till now, only the conventional method of elephant dragging is in vogue. Because of this process a lot of and saplings are trampled. To estimate the loss, ten areas involving elephant dragging were fixed. The distance of dragging involved was atleast 50 meters. During this process, the total damage, partial damages to seedlings and saplings were investigated.

Chapter V

MICROCLIMATIC STUDIES

5.1. Atmospheric temperature

In all the three areas, an automatic, monthly recording, thermohygrograph was installed at a height of four meters above the ground level. The marked graph papers were changed every month (Fig.4). A specimen of the marked graph paper is appended herewith (Fig.4). The data obtained are presented in Table 2.

Table 2

Mean atmospheric temperature (in centigrade)

Month	Core area	1985 felled area	1980 felled area
January	12.8	13.0	19.8
February	13.4	13.8	19.4
March	15.6	15.8	23.2
April	17.2	17.8	24.8
May	17.4	18.0	25.2
June	15.6	15.2	22.8
July	14.4	14.0	20.2
August	14.7	14.3	21.0
September	13.5	13.8	20.8
October	13.0	13.3	19.8
November	13.0	14.8	19.7
December	12.8	14.9	19.8
Mean	14.4	14.9	21.4

5.2 Rlative humidity

Data on relative humidity were gathered in the same way as atmospheric temperature by installation of thermohygrographs in all the three areas. The analysed data are presented in Table 3.

It was also attempted to find out the relationship between atmospheric temperature and relative humidity and the data are represented in Figures 5, 6 and 7.

Table 3

Relative humidity

Months	Core area			1985 felled area			1980 felled area		
	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
January	80	52	66	80	50	65	80	44	62
February	82	48	65	82	42	62	80	36	58
March	80	44	62	80	42	61	78	38	58
April	96	50	73	96	48	72	96	48	72
May	96	66	81	96	64	80	94	62	78
June	100	85	93	100	84	92	100	72	86
July	100	90	95	100	88	94	98	70	84
August	98	82	90	96	76	81	94	68	81
September	95	81	88	95	76	86	96	64	80
October	88	74	81	86	70	78	84	62	73
November	82	70	76	80	68	74	80	54	67
December	80	68	74	80	62	71	80	52	66

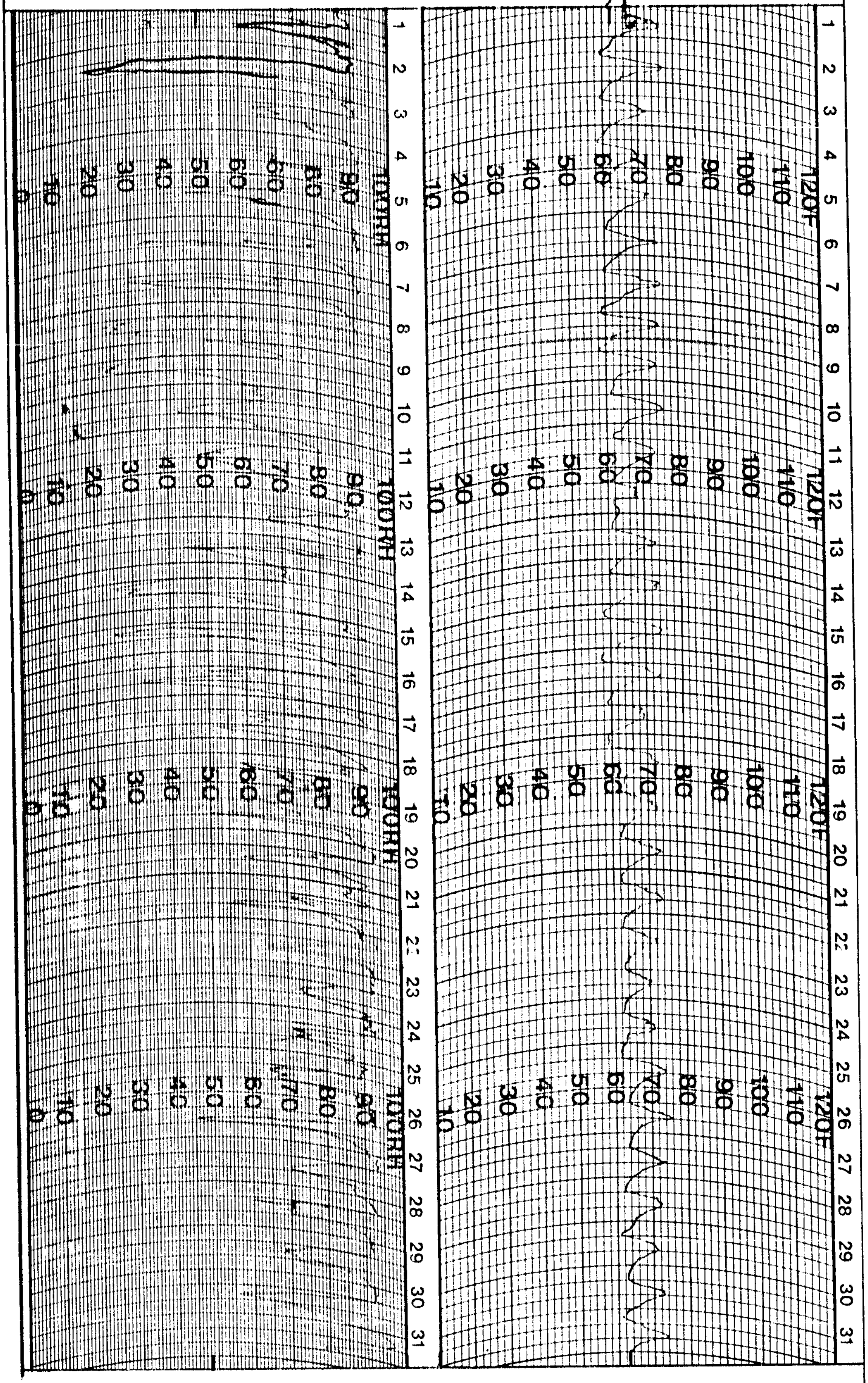


Fig.4 Monthly record of temperature & humidity

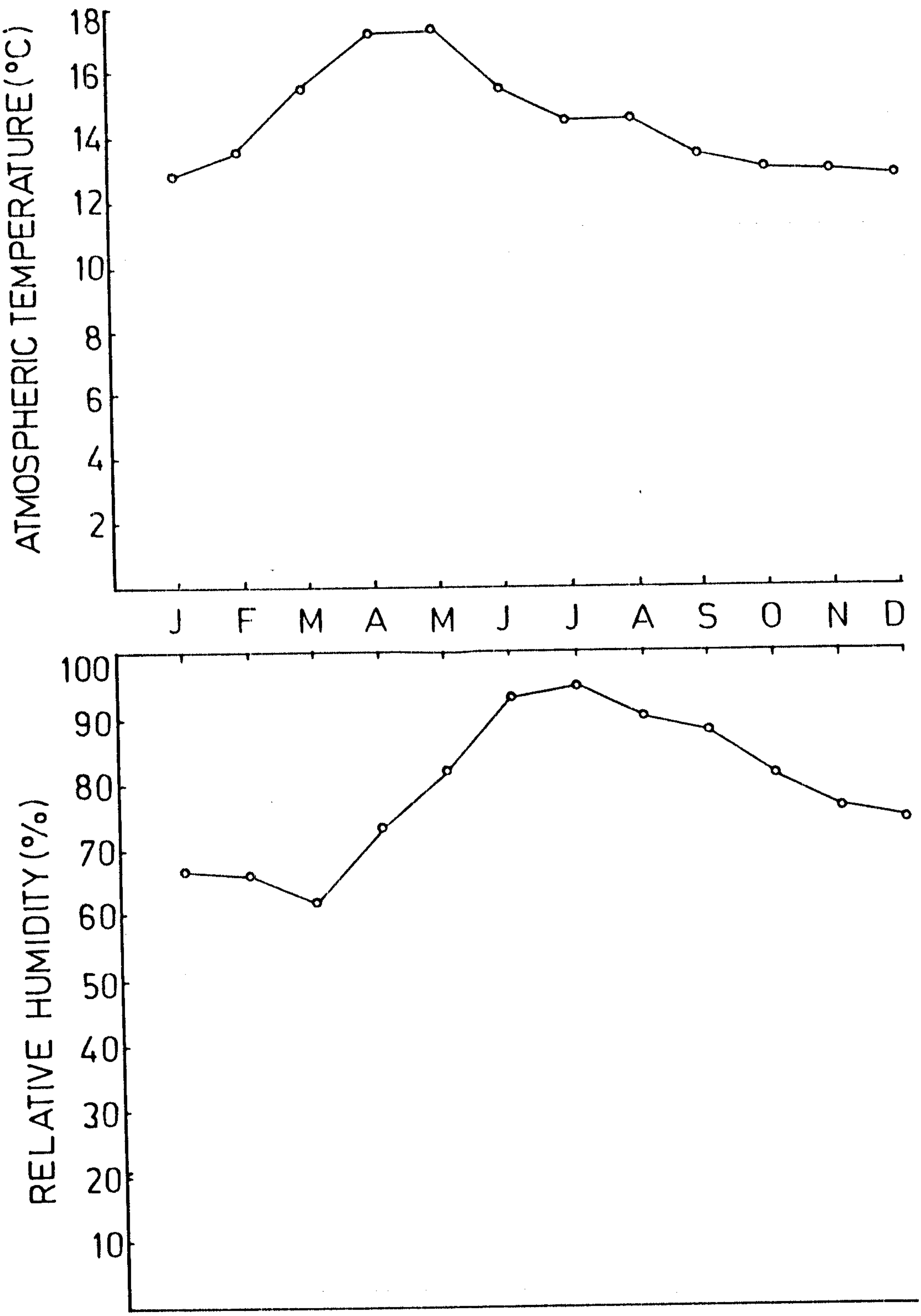


Fig. 5 Relationship between atmospheric temperature and relative humidity in core area

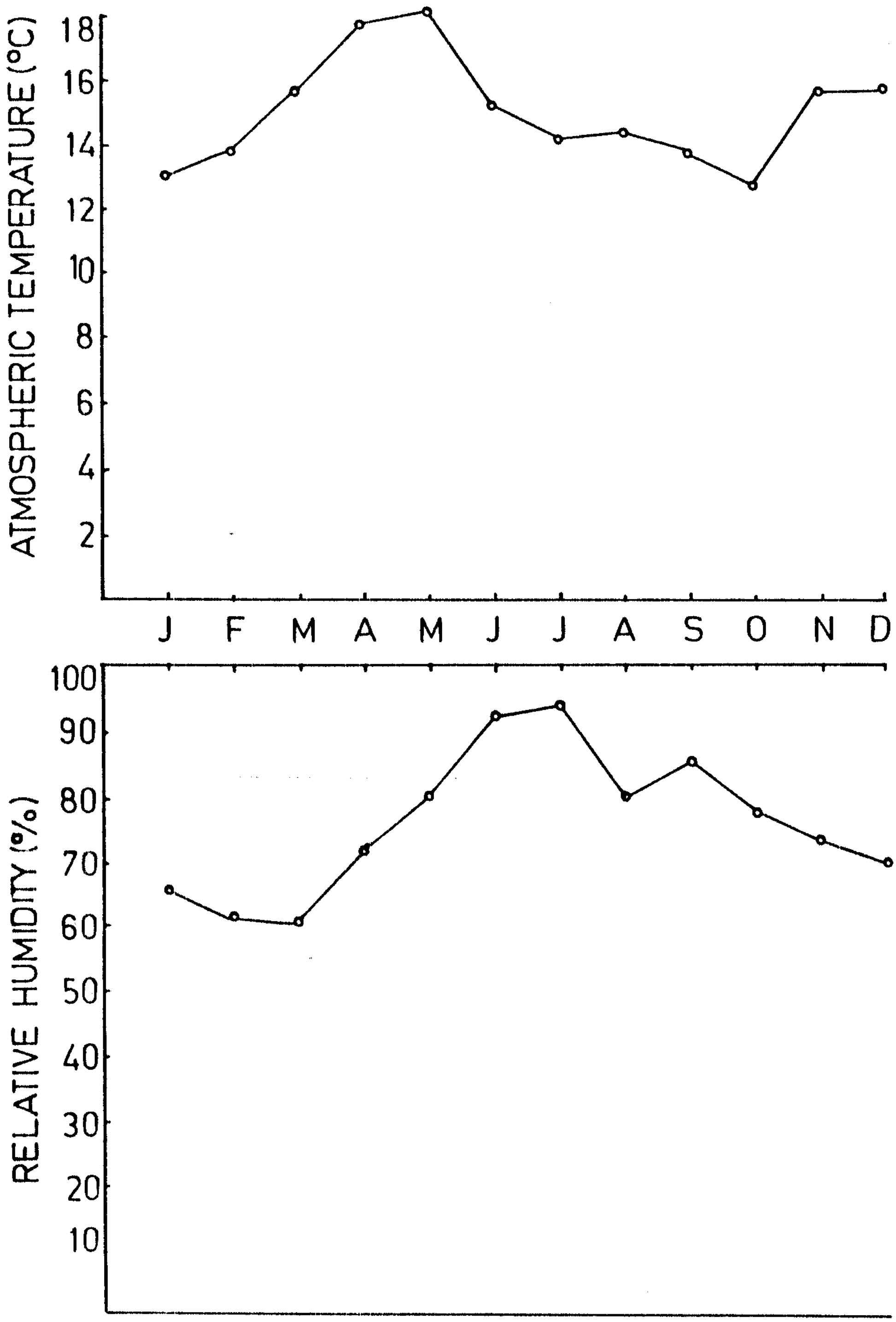


Fig.6 Relationship between atmospheric temperature and relative humidity in 1985 felled area

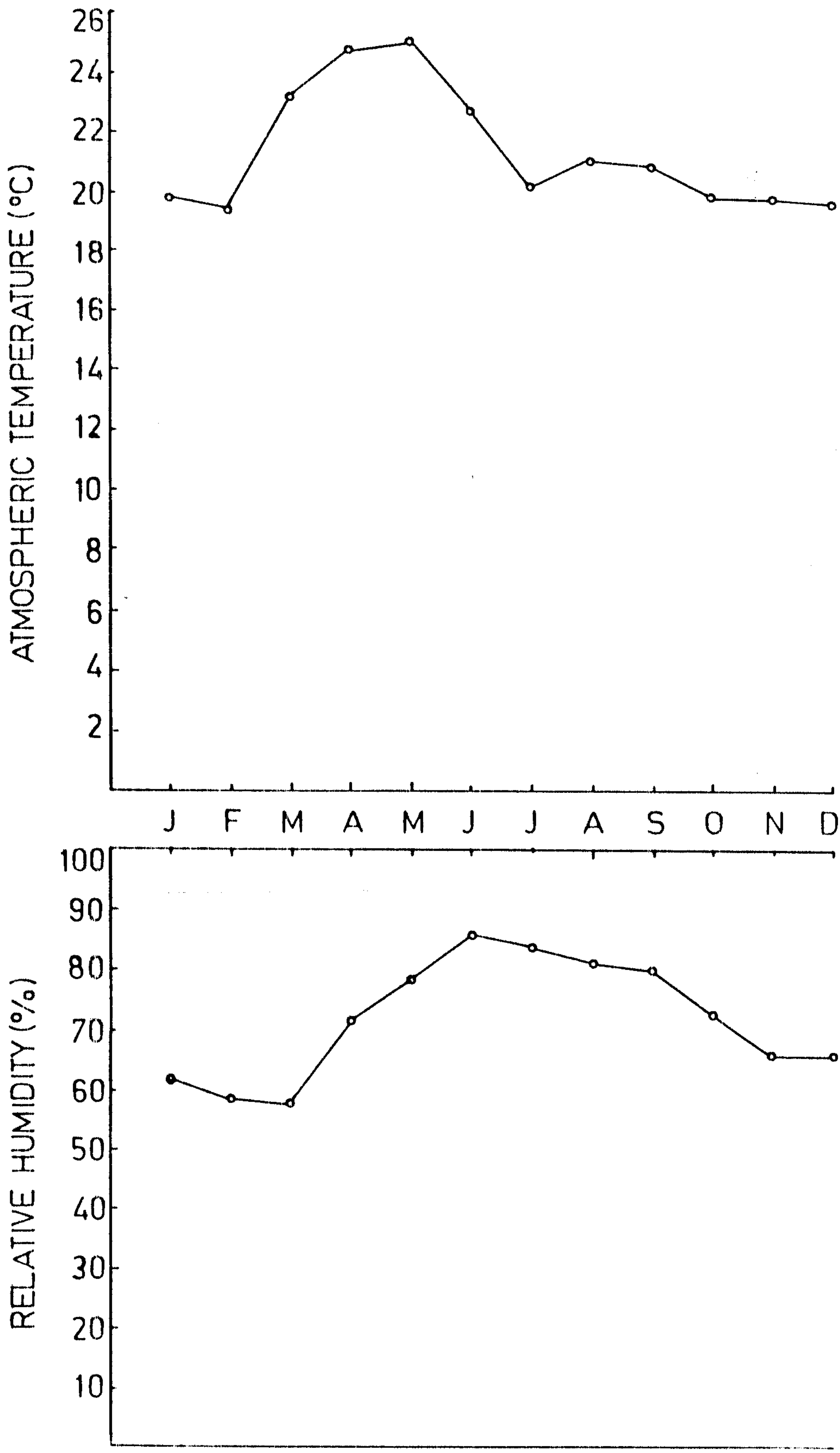


Fig. 7 Relationship between atmospheric temperature and relative humidity in 1980 felled area

5.3 Soil temperature

In all the three study plots four localities were randomly selected. A soil thermometer was inserted at a depth of 10 cm. and readings were taken for every four hours at 8 A.M.; 12 noon and 4 P.M. The data gathered from January to December 1985 were analysed and the average obtained for all the four localities are presented in Table 4 and Figure 8.

Table 4

Soil temperature (in centigrade)

Month	Core area	1985 felled area	1980 felled area
January	20.2	20.6	26.6
February	21.2	21.8	27.8
March	23.4	24.0	28.5
April	24.2	24.0	28.2
May	24.2	24.0	28.5
June	22.0	23.0	26.1
July	20.0	23.4	26.3
August	21.8	23.0	26.0
September	21.2	22.0	25.6
October	20.2	22.6	26.0
November	19.6	21.4	25.2
December	18.8	21.4	24.8
Mean	21.4	22.6	26.6

5.4 Light Intensity

One of the avowed objectives of Selation System is to permit optimum light to reach the ground and the secondary strata so that desired species could be either regenerated successfully or canopy manipulation could be sufficiently augmented.

During the year 1985 twelve trees (four in each site) were selected. The trees were nailed with bamboo pegs upto the first branching. With the help of a digital, pocket lux meter displaying a range of 1 to 1,99,000 lux, readings were taken at ground level, 10m, 20m and 30m. height. The recordings were taken at 8 A.M., 12 noon and 4 P.M. Averages of all the readings are presented in Table 5.

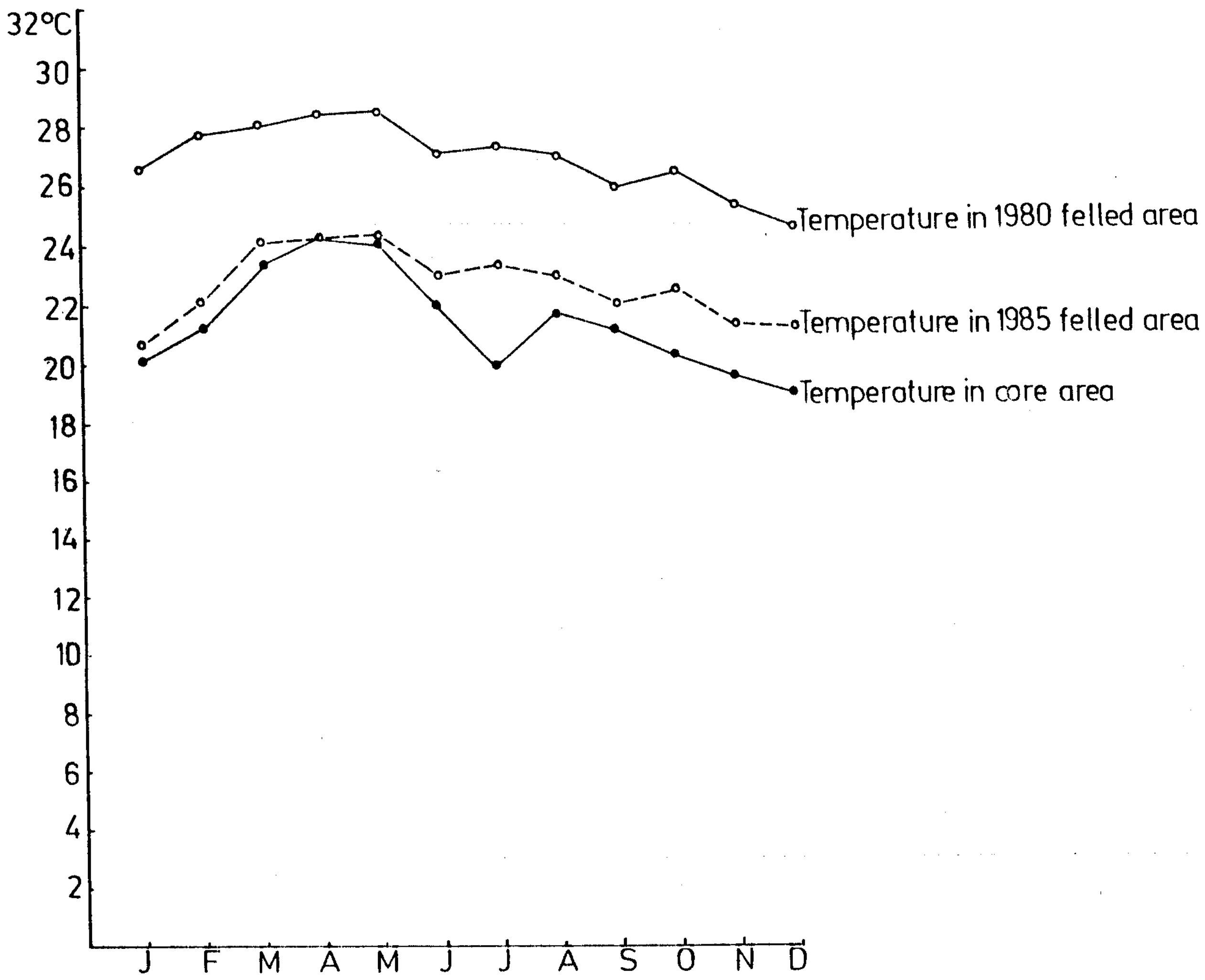


Fig. 8 Mean soil temperature

Table 5

Light intensity at different levels

Time	Core area				1985 felled area				1980 felled area			
	G.L.	10 m	20 m	30 m	G.L.	10 m	20 m	30 m	G.L.	10 m	20 m	30 m
8 A.M.	800	928	1075	1130	879	978	1134	1320	3700	11375	49380	69879
12 noon	1250	1351	1472	2080	1347	1571	1789	2789	6841	44879	79873	121373
4 P.M.	975	1071	1322	1689	997	1431	1542	1879	4231	31373	46744	49874

5.2.1 Regeneration studies

The process of natural regeneration of the wet evergreen forests is exceedingly complex and although it is of practical importance to the foresters very little is known about it. Much of what is written about the so called natural regeneration refers to the reproduction of a few economic species under conditions rendered more or less unnatural by timber exploitation. Further, the various factors that control the intensity and direction of natural regneration viz; phenology, seed predation, viability and germination, establishment and survival, light and shade conditions are imperfectly known.

Regeneration survey was conducted in 12 plots in each of the three localities by laying out plots of 1 x 1 meter. Data were gathered only for the extracted species and the rest were grouped under the category ´Miscellaneous species´.

Table 6 to 8 gives the regeneration status in all the three localities. It has to be reiterated that the findings are an average for three years in the area felled in 1980 and the core area.

Table 6

Regeneration survey in core area (for 3 years)

Species	U.S.	E.S.	A.G.	S
<u>Cullenia</u> <u>exarillata</u>	24	18	12	7
<u>Palaquium</u> <u>ellipticum</u>	88	74	21	4
<u>Holigarna</u> <u>arnottiana</u>	2	::	1	::
<u>Calophyllum</u> <u>tomentosum</u>	4	2	::	::
<u>Mesua</u> <u>ferrea</u>	::	3	7	4
<u>Artocarpus</u> <u>heterophyllus</u>	::	::	4	2
Miscellaneous	4	1	1	::
Total of important species	118	97	45	::
Grand Total	122	98	46	17

U.S. Unestablished seedlings (<40 cm height)
E.S. Established seedlings (40-100 cm. height)
A.G. Advance growth (>100 cm. in height but below 10 cm. gbh.)
S. Saplings (young trees of 10-50 cm. gbh.)

Table 7

Regeneration survey in 1985 felled area (for one year)

Species	U.S.	E.S.	A.G.	S
<u>Cullenia</u> <u>exarillata</u>	14	2	1	::
<u>Palaquium</u> <u>ellipticum</u>	64	3	2	::
<u>Holigarna</u> <u>arnottiana</u>	1	::	::	::
<u>Calophyllum</u> <u>tomentosum</u>	1	::	::	::
<u>Mesua</u> <u>ferrea</u>	1	1	::	::
<u>Artocarpus</u> <u>heterophyllus</u>	::	::	::	::
Miscellaneous	24	14	::	::
Total of important species	81	6	3	::
Grand Total	105	20	3	::

Table 8

Regeneration survey in 1980 felled area (for 3 years)

Species	U.S.	E.S.	A.G.	S
<u>Cullenia</u> <u>exasillata</u>	::	4	1	::
<u>Palaquium</u> <u>ellipticum</u>	::	7	2	1
<u>Holigarna</u> <u>arnottiana</u>	::	1	::	::
<u>Calophyllum</u> <u>tomentosum</u>	::	2	1	::
<u>Mesua</u> <u>ferrea</u>	::	4	2	::
<u>Artocarpus</u> <u>heterophyllus</u>	::	::	::	::
Miscellaneous	77	46	21	17
Total of important species	::	18	6	1
Grnd Total	77	64	27	18

5.2.1 Phenological Studies

Increase in the intensity of light may at times alter the phenological pattern of the second and third storied species. To test this hypothesis experiments were undertaken in one hectare area in all the three study sites. While the observations in the core area and in 1980 felled area were carried out for three full years, in 1985 felled area it was restricted to only one year. The three areas were visited every month and by devising a score card visual observations were made on flowering and fruiting. Six species typical to the second and third storeys, were selected and the data gathered are presented in the following tables (Tables 9, 10 and 11).

Table 9

Phenology of six common second storied species (core area)

1984

Species	J	F	M	A	M	J	J	A	S	O	N	D
Agrostistachyes mecholdii	Fl	Fed Fr	Fr	Fr							Fl	Fl
Kneema altenuata	Fr								Fl	Fl	Fr	Fr
Myristica dactyloides	Fr							Fl	Fl	Fr	Fr	Fr
Drypetes alata					Fl	Fl	Fr	Fr	Fr			
Polyalthia coffeoides	Fr	Fr	Fr							Fl	Fl Fr	Fr
Euphoria longana	Fl	Fr						Fl	Fr	Fr		

1985

Species	J	F	M	A	M	J	J	A	S	O	N	D
Agrostistachyes mecholdii	Fl	Fld Fr	Fr								Fl	Fl
Kneema altenuata	Fr								Fl	Fl	Fr	Fr
Myristica dactyloides	Fr							Fl	Fl	Fr	Fr	Fr
Drypetes alata					Fl	Fl	Fr	Fr	Fr			
Polyalthia coffeoides	Fr	Fr								Fl	Fr	Fr
Euphoria longana	Fl	Fr						Fl	Fl Fr	Fr	Fr	

1986

Species	J	F	M	A	M	J	J	A	S	O	N	D
Agrostistachyes mecholdii	Fr	Fr	Fr								Fl	Fl
Kneema altenuata	Fr	Fr							Fl	Fl	Fr	Fr
Myristica dactyloides	Fr							Fl	Fl	Fr	Fr	Fr
Drypetes alata					Fl	Fl	Fr	Fr	Fr			
Polyalthia coffeoides	Fr	Fr								Fl	Fr	Fr
Euphoria longana	Fl	Fl							Fl	Fr	Fr	

Table 10

Phenology of six common second storied species (1985 felled area)

Species	1985											
	J	F	M	A	M	J	J	A	S	O	N	D
Agrostistachys maboldii	Fl	Fl & Fr	Fr	Fr							Fl	Fl
Knema attenuata	Fr								Fl	Fl	Fr	Fr
Myristica dactyloides	Fr							Fl	Fl	Fr	Fr	Fr
Drypetes elata					Fl	Fl	Fr	Fr	Fr			
Polyalthia coffeoides	Fr	Fr	Fr							Fl	Fl & Fr	Fr
Euphoria longana	Fl	Fr						Fl	Fr	Fr		

Table 11

Phenology of six common second storied species (1980 felled area)

Species	1984												1985												1986											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Agrostistachys maboldii	Fl	Fl & Fr	Fr	Fr							Fl	Fl	Fl	Fl & Fr	Fr	Fr							Fl	Fl	Fr	Fr	Fr								Fl	Fl
Knema attenuata	Fr								Fl	Fl	Fr	Fr	Fr								Fl	Fl	Fr	Fr	Fr	Fr							Fl	Fl	Fr	Fr
Myristica dactyloides	Fr							Fl	Fl	Fr	Fr	Fr	Fr							Fl	Fl	Fr	Fr	Fr	Fr							Fl	Fl	Fr	Fr	Fr
Dryoetes alata					Fl	Fl	Fr	Fr	Fr								Fl	Fl	Fr	Fr	Fr								Fl	Fl	Fr	Fr	Fr			
Polyalthia coffeirdes	Fr	Fr	Fr							Fl	Fl & Fr	Fr	Fr	Fr								Fl	Fl	Fr	Fr	Fr								Fl	Fl	Fr
Euphoria longana	Fl	Fr						Fl	Fl	Fr			Fl	Fl						Fl	Fr	Fr			Fl	Fl						Fl	Fr	Fr		

5.2.3 Successional studies

Gaps of varying sizes are often created in the evergreen forests by natural mortality of trees as well as by felling operations. The size of such gaps depend on various factors like the number of trees extracted, their girth limit and the distance involved between two neighbouring trees. While succession is a natural process in the vegetation dynamics it is very often altered or even deflected by various factors. The tendency of secondary succession in these gaps is generally towards the restoration of "climatic climax" although in extreme cases may deflect the succession towards the stabilisation of 'biotic climax'.

For purposes of convenience the gaps were divided into small (less than 25 m^2), large (25 to 100 m^2) and extensive (over 100 m^2). 12 such gaps in each of the three localities were selected and the successional trend monitored for two years in the core area and 1980 felled area and for one year in 1985 felled area.

The results are depicted below:

Succession in small gaps

Cullenia - *Palaquium* association

↓

Natural tree fall

↓

Elatteria cardamum

↓

Cullenia - *Palaquium* - *Calophyllum*

Succession in large gaps

Cullenia - *Palaquium* association

↓

Logging operations

↓

More light in the ground

↓

Elatteria cardamum

Laportea crenulata, *Heckeria subpeltata*

and

Helicteres isora

↓

congenial microclimatic

conditions for regeneration

↓

Cullenia - *Palaquium* - *Calophyllum*

Succession in extensive gaps

Cullenia - *Palaquium* association

↓

Extensive openings due to logging

↓

Drastic alteration of microclimate

like, increased light, low atmospheric

humidity and soil moisture

↓

Pioneers like *Macaranga peltata*,

Leaf indica and *Laportea crenulata* appear

↓

Toddalia asiatica and *Elatteria cardamum*

↓

closure of canopy

↓

congenial microclimate for germination

↓

Cullenia, *Palaquium* and *Mesua* appear

5.2.4 Logging damages

During the study period a total of 723 trees were marked for felling. Of which 68 trees were excluded since they were located in the core area. Of the balance of 655 trees, 40 trees were monitored during felling for the logging damages. All the trees having a diameter of over 10 cm. were recorded and rated according to damage classes; ie, no damage, bark damage, bole damage, crown damage, bark and crown damage and fallen trees. The damage classes are defined as follows:

(a) No damage.

(b) bark damage - trees with bark scars as a result of logging;

(c) bole damage - trees with bole knocked down;

(d) crown damage - trees with visible broken branches affecting the following percentages of the crown;
0-25, 26-50, 51-75 and 76 to 99%

(e) bark and crown damage - trees having both bark and crown damaged.

(f) fallen trees - trees knocked down completely due to logging.

The results are presented in Tables 12 and 13.

Table 12

Types of damages in diameter classes in 6.5 ha.

Class of damage	Diameter class (in cm.)							Total	Percentage
	10-20	20-30	30-40	40-50	50-60	60-70	>70		
No damage	184	112	72	36	16	10	8	438	34.4
Bark damage	47	24	20	10	8	4	8	121	9.5
Bole damage	23	18	4	7	8	4	7	71	5.6
Crown damage	152	89	72	27	17	18	9	384	30.1
Bark and crown damage	58	43	18	10	9	10	24	172	13.5
Fallen trees	30	19	9	7	9	6	8	88	6.9
Total	494	305	195	97	67	52	64	1274	100.00

5.2.5 Damages due to road laying

Road laying, reaching far out to the felling and storing sites serve as dispensible means of transportation in developing countries. Generally, the trees are initially felled and alignment of road takes places to facilitate easy dragging and loading. Due to this process a lot of small trees and saplings are cut and this alters the ecosystem significantly. The roads are left abandoned after transportation of the logs and since the roads pass through slopy areas, in the next season after rains all top soil gets washed out, causing serious erosion problem.

A two kilometre stretch of road during the process of laying was closely monitored for removal of trees and the results are presented in the following table.

Table 13

Damages due to road laying (length 2 km)

Diameter class (in cm.)	Number of individuals cut and removed	Percentage
< 10 cm.	178	35.6
10 to 20 cm	164	32.7
20 to 30 cm	84	16.7
30 to 40 cm	62	12.2
> 40 cm	14	2.8
Total	502	100.0

5.2.6 Damages due to elephant dragging

Hauling of logs by elephants still continues to be the practice in developing countries to facilitate easy transportation. During this process damage to big trees are negligible but the seedlings and saplings are very often trampled upon by the elphants and also get crushed due to the dragging of huge logs.

An attempt was made to quantify the number of saplings damaged during the process. Ten localities involving dragging 32 logs over a distance of 50 m. were closely observed and the damages, mostly partial were noted. No attempt was made to quantify the seedlings crushed.

The data are presented in the following table.

Table 14

Damages due to elephant dragging
(average for 10 localities)

Diameter class (in cm.)	Number of individuals damaged	Percentage
< 10 cm.	98	35.2
10-20 cm.	74	26.6
20-30 cm.	68	24.5
> 30 cm.	38	13.7
Total	278	100.0

Chapter VI

DISCUSSION

The tropical wet evergreen forests are a fragile and delicate ecosystem and even minor disturbances to it drastically trigger chain reactions.

The selection system as practiced at present is a very complex phenomenon involving lot of labour force. Establishment of a labour colony prior to axing takes precedence and substantial area is cleared and the debris burnt for this purpose (Pl. II.)

During this process of extraction the environment gets drastically altered and some of the aspects of the present study are discussed here.

6.1 Microclimatic studies

6.1.1 Atmospheric temperature

The mean atmospheric temperature in the core area varies from 12.8°C to 17.4° C thus exhibiting a thermic amplitude 4.6°C. As a rule December and January form the coldest part of the year while April and May are the hottest season.

As against the core area, the one felled in 1985 shows a minimum of 13°C and the maximum of 18°C, exhibiting a variation of 5°C. Most of the increase in the temperature took place after August, ie. after the felling was over.

On the contrary, the area felled during 1980 shows remarkable variations. While the minimum temperature recorded was 19.4°C the maximum was as high as 25.2°C.

Thus the difference in the minimum atmospheric temperature varied from 12.8° to 19.8°C while the maximum from 17.4° to 25.2C between the areas not felled and the one subjected to felling in the past. Averagewise also a difference of 7°C was felt.

6.1.2 Relative Humidity

The mean relative humidity in the core area seldom falls below 60% and during June, July and August remains constantly above 90%. An absolute maximum of 100% has been recorded during the rainy season and an absolute minimum of 44% was recorded during the month of February.

There is not much difference between the core area and the 1985 felled area. The average remains constantly above 60% and the absolute maximum and minimum are also more or less the same.

On the contrary there is a striking difference in the area felled during 1980. The average touches 58% and the minimum goes down to as low as 36%.

Taking the mean alone into consideration there is a difference of 7% during the dry season and 11% during the rainy season between the area unworked and the area worked earlier.

6.1.3 Soil temperature

There is a striking difference in the soil temperature between the areas unworked and the area worked in the past. A difference of 5.2°C is encountered between the two.

While the minimum soil temperature recorded in the core area was 18.8°C in the area felled in 1980 it was as high as 24.8°C thus showing an increase of 6°C. Similarly, the maximum also showed an increase of 4.3°C. There has been a significant increase in soil temperature between the core area and the area felled in 1985. But this increase is seen only during the later part of the year, ie, after the felling season was over. Thus, even within a span of about 3 months, there has been an increase in temperature, the difference being 2.6°C.

6.1.4 Light intensity

Measurements for taking light intensity has been already described. The services of an efficient tree climber was utilised for this purpose (Pl. III).

There has been significant variations in the light intensity not only between the three areas but also during different times of the day.

In the early mornings at the ground level the difference was of the order of 3100 lux between the unworked and worked area. At different levels of 10m; 20m and 30m the light intensity showed differences of 10,447, 48,305 and 68,749 lux respectively.

During the noon the differences at the four levels are of the order of 5,331, 43,528, 78,401 and 1,19,293 lux respectively.

In the evenings the differences are 3,356, 30,302, 45,422 and 48,185 lux at ground level, 10m, 20m, and 30m.

Besides these, light measurements were also taken at the ground level before and after felling the trees. All the forty trees were measured for availability of light and it was seen that on an average the difference varied from 21,000 to 29,100 lux respectively.

6.2 Regeneration studies

A critical evaluation of the regeneration survey in the core area showed that *Palaquium ellipticum* forms the majority of unestablished seedlings followed by *Cullenia exarillata*. Both the species successfully established themselves but further stages of advanced growth and saplings were seriously handicapped because of insufficient light conditions. Species like *Holigarna arnottiana*, and *Calophyllum tomentosum* did not reach beyond the stage of advanced growth. On the other hand, in the case of Mesua ferrea and Artocarpus heterophyllus there were practically no unestablished seedlings but advance growth and saplings were fairly common. Miscellaneous species were very few (2.1%).

In the area felled during 1985 observations were taken for the whole year and the emphasis was to find out which species regenerated successfully in six months time, ie, after logging operations were over. Here too, Palaquium ellipticum tops the unestablished seedlings, followed by Cullenia exarillata. 6.5% of the total of these two species reached the stage of established seedlings, while 3.8% reached upto advanced growth. None of the species attained the sapling stage.

The 'Miscellaneous Species' constituted 22.8% among the unestablished seedlings and 70% among the established ones. None of them could reach beyond this stage.

Such a high percentage of 'Miscellaneous Species' are dominated by Macaranga peltata, Leea indica Elatteria cardamum, Laportea crenulata, Helicteres isora, Chromolena odorata and Strobilanthes spp.

In the area logged in 1980, not a single important species was seen in an unestablished condition. All the unestablished ones belong to the category of 'Miscellaneous Species'. A few established seedlings and seedlings of advance growth of the important species were seen scattered here and there. The regeneration survey showed that 86.6% of the species fall under the 'Miscellaneous category'.

It is thus seen, that natural regeneration of desired species in selectively logged area is very poor and this is due to the drastic changes in the microclimatic conditions, viz. soil and atmospheric temperature, relative humidity and enormous light availability.

6.3 Phenological studies

Phenologically the six understoreyed species do not show any variation at all in all the three places. That is, selective logging did not have any influence on the flowering and fruiting pattern.

Species like Agrostistachys meeboldii and Polyalthia coffeoides commence their flowering by October-November and the fruits persist till March-April. The two Myristicaceous species, Knema attenuata and Myristica dactyloides show an early flowering from August-September and fruiting commences from October onwards. The mature fruits persist till January and because of short viability and a long dry spell seedlings are rarely encountered. Drypetes alata flowers and fruits during the rainy season while Euphoria longana shows two seasons of flowering and fruiting, one during January-February and the other during August to October.

6.4 Successional studies

Succession in small gaps does not pose serious problem. Whenever a natural tree fall takes place the first to colonise, the area is invariably Ellateria cardamum. Because of its dense and spreading foliage the microclimatic conditions beneath are not subjected to drastic changes. Soon the original species like, Cullenia, Palaquium and Calophyllum establish.

Succession in large gaps is rather a little complicated. Because of logging operations more light reaches the ground and the pioneer species here again is Elatteria cardamum. Soon other species like Laportea crenulata, Heckeria subpeltata and Helicteres isora appear. Once congenial microclimatic conditions are obtained regeneration of Cullenia, Palaquium and Calophyllum are facilitated.

The succession in large gaps is still more complicated. Because of extensive openings created due to logging, drastic alteration of microclimate takes place. This results in increased light, low atmospheric humidity and soil moisture. In such a situation pioneers like, Macaranga peltata, Leea indica and Laportea crenulata appear followed by Toddalia asiatica and Elatteria cardamum. By closure of the canopy microclimatic conditions, may gradually become congenial for successful germination of Cullenia, Palaquium and Mesua.

But this process is quite long and observations have to be continued for nearly more than two decades atleast.

6.5 Logging damages

One of the basic tenets of selective logging is to minimise the damages to the residuals. This requires the presence of trained and experienced forest officers who should actually be on the field during the felling operations.

Uptill now felling of trees is by the conventional method viz., axing the trees from the bottom. Plates IV to VI; VII to XI and XIV to XV depict the various stages of axing and felling of *Cullenia exarillata*, *Palaquium ellipticum* and *Myristica dactyloides* respectively. Although the Working Plans prescribe that axing should be from the top end of the buttress, violation of this rule is not uncommon as exemplified by Plates XII, XIII and XVI.

Table 12 reveals that in a 6.5 ha. area, 1274 individuals over 10 cm. diameter were encountered. In the same area 40 trees were felled during the year 1985.

During the process of selective logging of these 40 trees, 438 individuals escaped without any damage. The rest constituting 64.6% were subjected to various types of damages.

The same table also shows that damages to trees of lower girth classes viz., less than 20 cm in diameter are quite high. The damages to bole (Pl. XVIII and XIX) are comparatively less as opposed to bark, crown and both (Pl. XXIII and XXIV). The high incidence of crown damage (46%) is to be ascribed to the tall nature of the trees and the huge and spreading crowns they possess.

Besides the logging damages mentioned above damages due to natural mortality of the trees (Pl. XVII) and secondary damages due to many trees dashing against each other (Pl. XXI) or due to uprooting of buttresses (Pl. XXII) are also common. Added to these are also other factors like billeting (Pl. XXV and XXVI) and cutting and stacking of the top ends (Pl. XXVII and XXVIII) with the result no regeneration is rendered possible underneath.

While the rules prescribe a minimum of 20 meters distance between two marked trees, instances are also encountered where hardly 12 meters distance was seen in the study area (Pl. XX).

All these instances point to the conclusion that sufficient precautions had not been taken before and during felling.

6.6 Damages due to roadlaying (Pl. XXIX to XXXI

Table No.13 shows the extent of damage caused due to laying of roads. Without adequate consideration for the terrain the trees are initially felled and the roads are aligned in such a way that proximity to the felled trees was the main criterion employed. Because of this, in a two kilometer stretch of road nearly 502 trees of various girth classes ranging from 10 to 40 cm in diameter had to be removed. Of this nearly 70% of them belong to the diameter class of less than 20 cm. and the rest above. These trees can very well serve the purpose for subsequent fellings.

6.7 Damages due to elephant dragging (Pl. No.XXXII)

From Table No. 14 it is seen that damages due to elephant dragging is also quite significant. In a 500 metere stretch the damages done due to elephant dragging account for 278 individuals. Trees of even upto nearly 40 cm. in diameter do not escape damage. Significantly, damages to trees of upto 20 cm. diameter class are quite high.

Besides all those above mentioned factors, the loading operations also cause considerable damage (Pl. XXXIII to XXXVI). For this purpose strong logs (in the study area (Drypetes alata was exclusively preferred) of upto 30 cm. diameter are cut from the forests.

All these factors contribute to large formation of gaps. A one hectare area in which six trees were removed was measured for the gap created. The net result being that 68% of the canopy was opened up (Pl. XXXVIII) and in the subsequent year the regeneration status of the desired species was found to be almost nil. Only the useless and miscellaneous species like <u>Heckeria subpeltata</u>, <u>Laportea crenulata</u>, etc. came up (Pl. XXXVII).

For a comparative purpose an intensely felled area in Ranni Division was visited during the year 1985. Here the number of trees removed exceeded twelve and the opening created was nearly 95% (Pl. XXXIV and XXXX).

Chapter VII

CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

Selection system as being followed in the Western Ghats of South India is considered to be the best sylvicultural system despite its advantages and disadvantages. Arbitrary increase or decrease in the felling cycle, extractable number of trees per unit area and the girth limit have no scientific basis. Shorter felling cycles to as low as 15 years, number of trees exceeding 12 per hactare and girth limit of as low as 150 cm. GBH are commonly encountered. Besides, no attempt has been made so far to assess the impact of this system from various environmental angles. The present study carried out for over three years point to the following conclusions:

1. There is a marked increase in the minimum atmospheric temperature consequent to selective logging and this account for roughly 7°C. More or less a corresponding figure was obtained for absolute maximum also.

2. Regarding mean relative humidity the difference exhibited is 22%. During the dry season it accounts for 7% and during rainy season of the order of 11%.

3. The minimum soil temperature shows an increase of 6°C and maximum 4.3°C between worked and unworked areas. This difference is felt even within a short span of three months.

4. The incidence of light available to variable strata also shows remarkable variations. At the ground level at 8 A.M. the difference was of the order of 3,100 lux while at the 10, 20 and 30 cm. level it was 10,447; 48,305 and 68,749 lux respectively. The difference at noon at the four levels are of the order of 5,331, 43,528, 78,401 and 1,19,293 lux respectively. In the evenings it is of the order of 3,356, 30,302, 45,422 and 48,185 lux respectively at various levels between the worked and unworked areas.

5. The difference in light intensity at the ground level ranges between 2,10,00 and 2,91,00 lux immediately before and after felling.

6. Natural regeneration of the desired species in selectively logged area is very poor and this can be attributed to drastic changes in the microclimatic conditions, viz., soil and atmospheric temperature, relative humidity and abundant light availability at various levels.

7. Succession in small gaps due to natural tree fall does not alter the ecosystem considerably. But large gaps created due to selective felling may take enormous time for recouperation and one is not sure whether 'climatic climax' may be attained at all.

8. Logging damages due to selection felling is found to be particularly heavy in the study area. Nearly 46% of the damages can be ascribed to crown damage. The tall nature of the trees and their large, spreading crowns are responsible for such a situation.

9. Secondary damages due to many trees dashing against each other during the process of felling are heavy.

10. Besides all these factors, billeting, stacking the boles and cut ends do not permit regeneration.

11. Unscientific road alignment and elephant dragging also add to the misery. Potential species for the subsequent felling cycles do not escape damage.

12. Even if one adheres strictly to the Working Plan prescriptions of 6 trees per hactare the opening created is found to be of the order of 68%.

In view of what have been stated above, the following recommendations are made:

RECOMMENDATIONS

The selection system as being practised in the Western Ghats of South India may be economically viable in the short run but ecologically not so in the long run since the sustained and uninterrupted flow of resources are seldom obtained. The Government of Tamil Nadu, after a careful auditing of this systêm had discontinued it and the Government of Kerala should also be complimented for following Tamil Nadu. If, however, for any reasons, this practice has to be revoked the following recommendations are worth consideration:

1. As a safeguard against economic trees being damaged, on which future yields depend, as a deterrent against non compliance with the regulations the penalties for damage should be substantially increased.

2. Marking of trees for felling should be done atleast by a Range Officer's status and any violations of the Working Plans should be seriously viewed. Out of 40 trees monitored for felling atleast four instances of close markings were seen (upto 11 m. distance). Also axing the buttressed trees at the bottom was a very common phenommenon.

3. Silviculturally about 40 species are known to be of commercial importance. But in a given area concentrated heavy felling of a couple of species are seen. With poor regeneration after logging the chances of such species getting vanished in course of time appear bright. Hence research activities should be geared up to generate more information on the wood quality of the secondary species.

4. Since the removal of six trees per hectare creates large openings, (as high as 68%) it is recommended that the number of species may be reduced to two per hectare. Also the felling cycle may be increased to 50 years by which time adequate information on the secondary crops may be available.

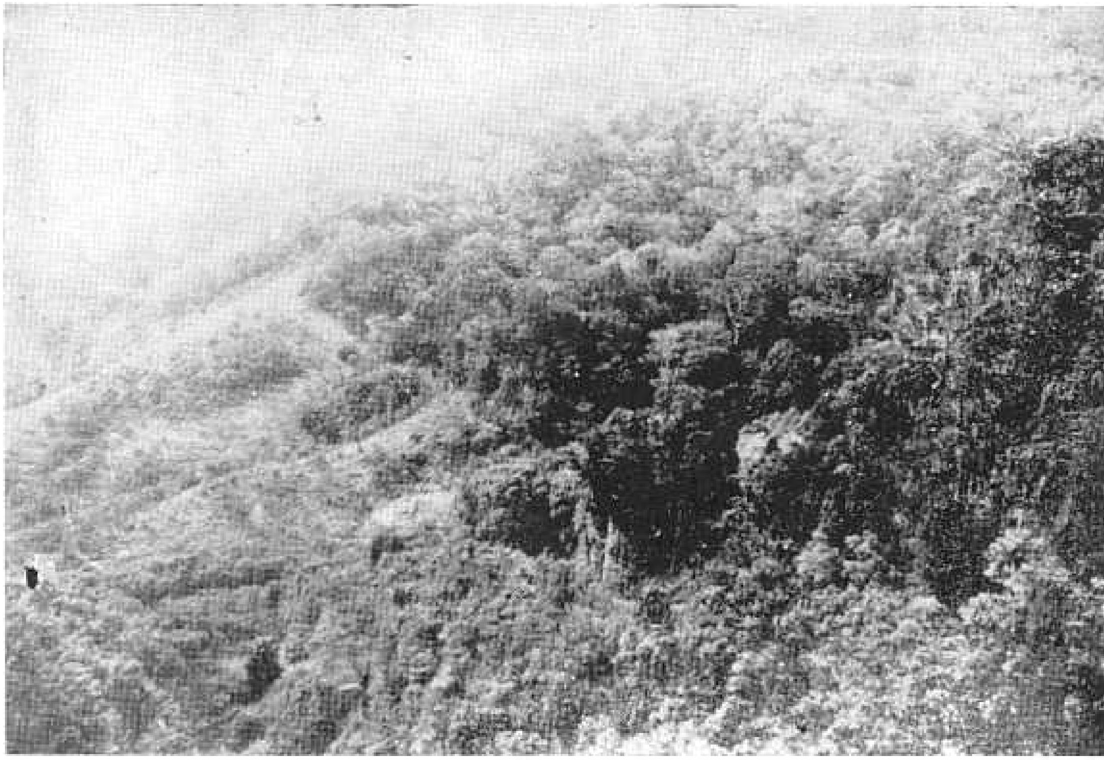
5. Ecological studies on species regeneration requirement, assessment of microenvironmental conditions should be initiated.

6. To facilitate the last two recommendations mentioned above, substantial areas should be set apart as Permenant Preservation Plots to monitor the growth rate and patterns of various species.

7. At present the logged areas are left to nature without any follow up actions on grounds of paucity of funds. Planting of desirable species is necessary to adequately restock the commercial timber.

8. Judicious selection of machinary and equipment have to be used in the forests in combination with the manual wokring of men and elephants to achieve harmony and to offset setbacks to soil and seedlings.

9. In view of the excessive damages caused by the crown it is desired that the top ends must be removed initially before axing at the bottom.



Pl. I A view of the evergreen forest before working.

Pl. II. Establishment of labour colony - note the tree clearing.

Pl. III. A tree climber pegging trees for taking light measurements.

Pl. IV. Initial axing of *cullenia exarillata*.

Pl. V. *Cullenia exarillata* about to fall.

Pl. VI. *Cullenia exarillata* - a fallen tree.

Pl. VII. *Palaquium ellipticum* - Initial axing.

Pl. VIII. *Palaquium ellipticum* - moderate incision

Pl. IX. *Palaquium ellipticum* - Deep incision

Pl. X. *Palaquium ellipticum* - about to fall

Pl. XI. *Palaquium ellipticum* - a fallen tree - note the openings created

Pl. XII Buttress of *Palaquium ellipticum*

Pl. XIII Buttress of *Cullenia exarillata.*

Pl. XIV. *Myristica dactyloides* - about to fall.

Pl XV. *Myristica dactyloides* - about to fall

Pl. XVI. *Cullenia exarillata*- note the split buttress.

Pl. XVII Natural mortality of ***Elaeocarpus tuberculatus***

Pl. XVIII ***Palaquium ellipticum*** - Bole damage -

Pl. XIX. *Palaquium ellipticum* - Bole damage - close up

XX. Close felling of *Cullenia* (felled) and *Palaquium* (about to fall)

Pl. XXI. Secondary damage to *Canarium strictum* a valuable species

Pl. XXII. Secondary damage-due to uprooting of buttress

XXIII Crown damage

XXIV Total damage

Pl. XXV. Billeting

Pl XXVI Billets

XXVII. Top ends being cut

XXVIII Top ends being stacked

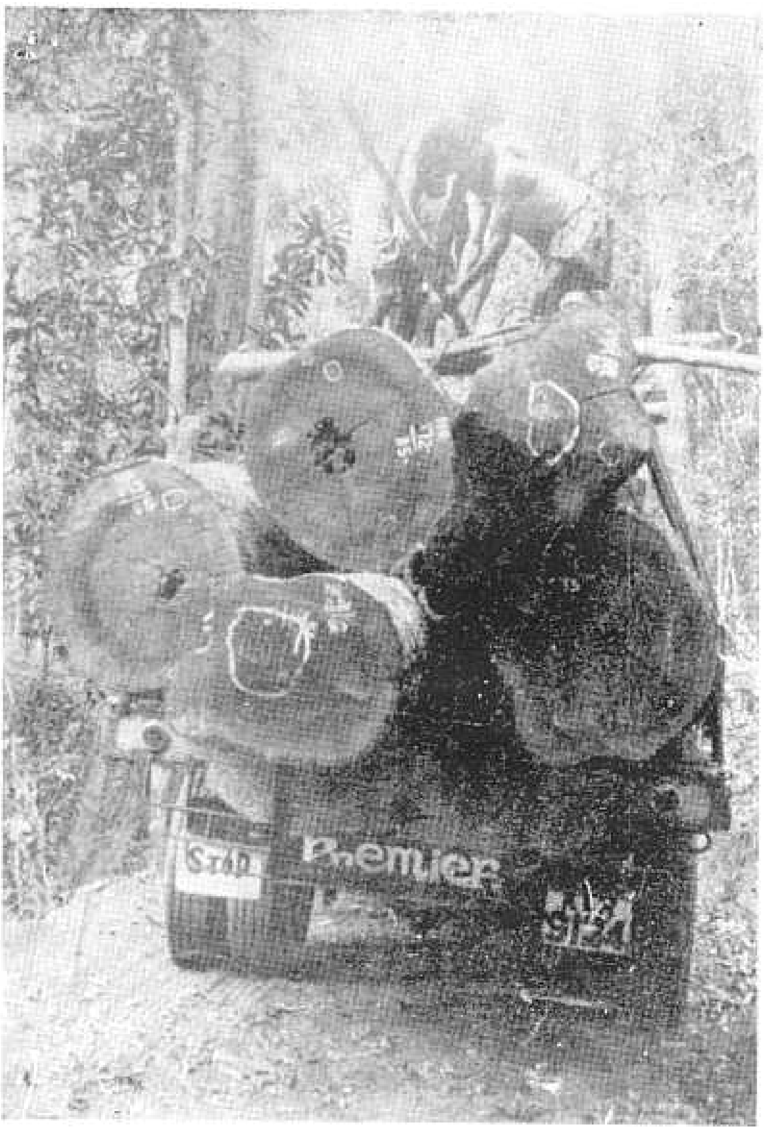
Pl. XXIX. Road laying process

Pl XXX. Road alignment Note the removed

Pl. XXXI. Bulldozer helping in laying roads

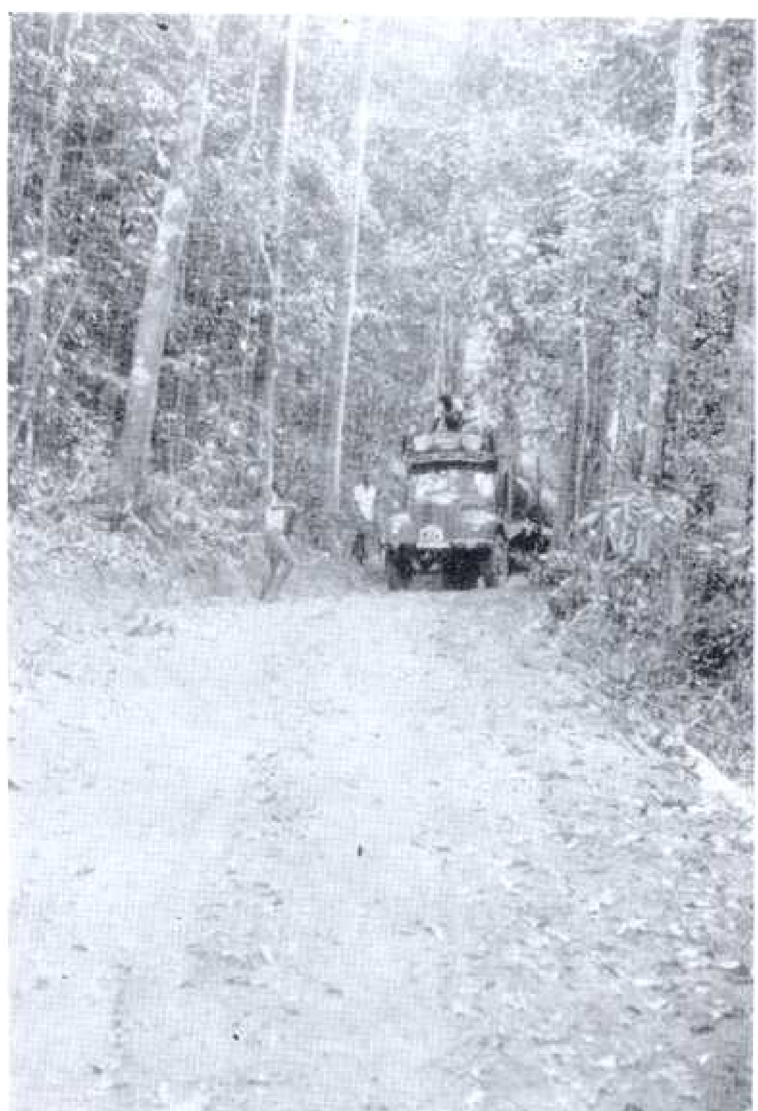
Pl. XXXII. Elephant dragging - see nil regeneration

XXXIII Initial loading



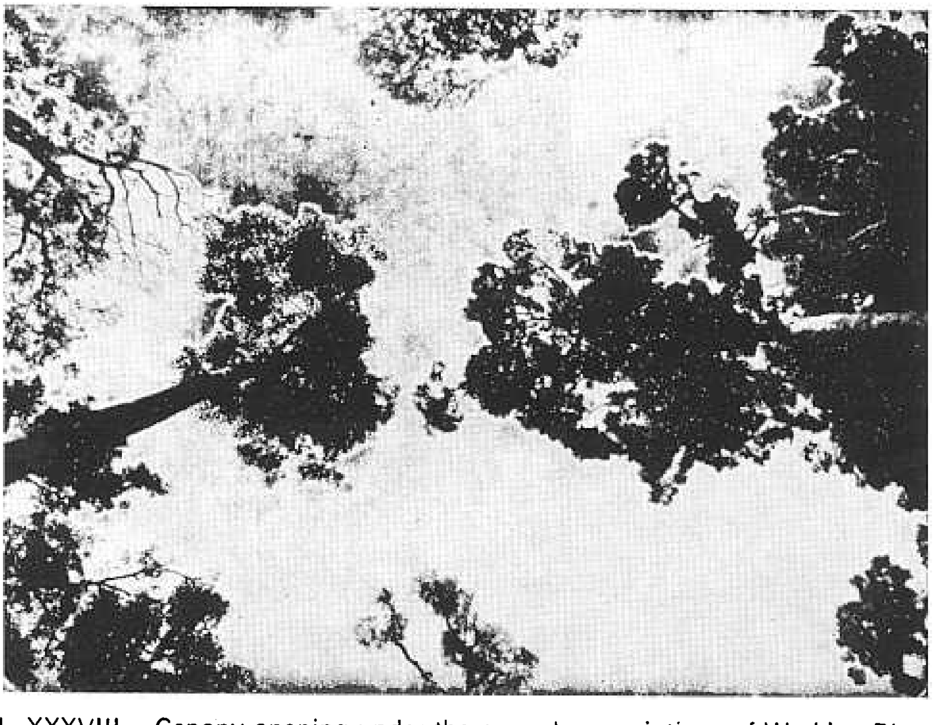
XXXIV. inishing touches loading

Pl. XXXV. Loading operations completed

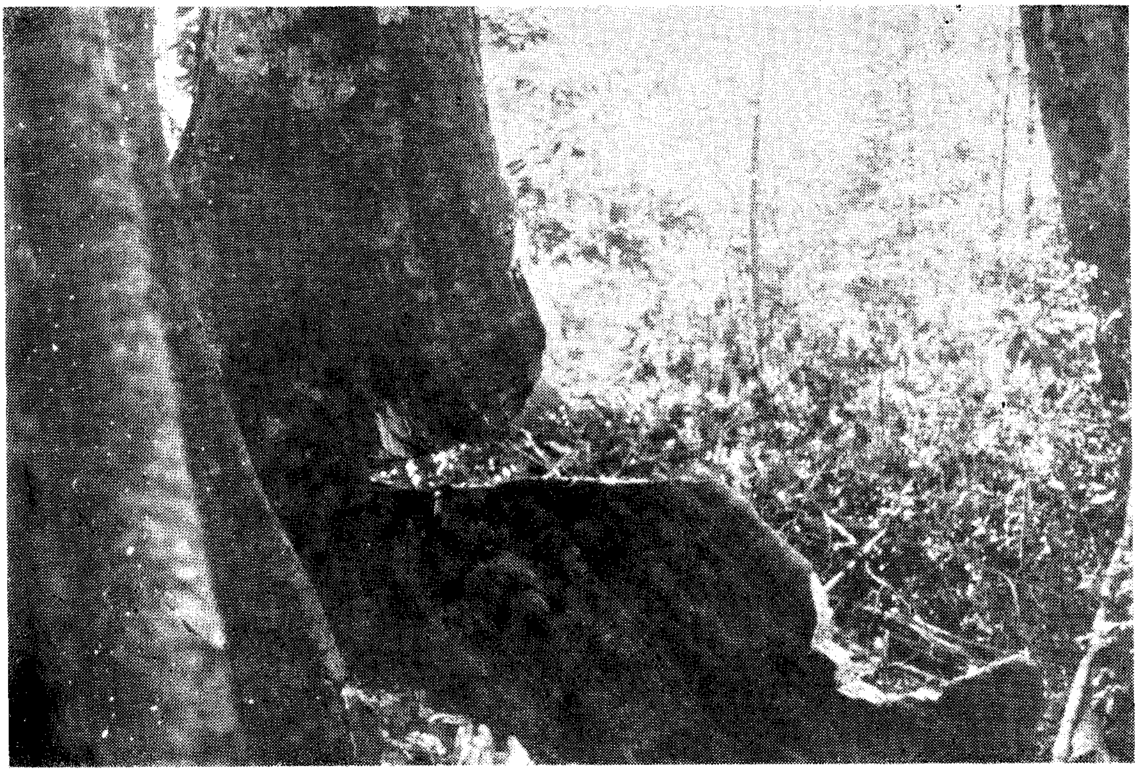


Pl. XXXVI. Vehicle with timber proceeding towards destination

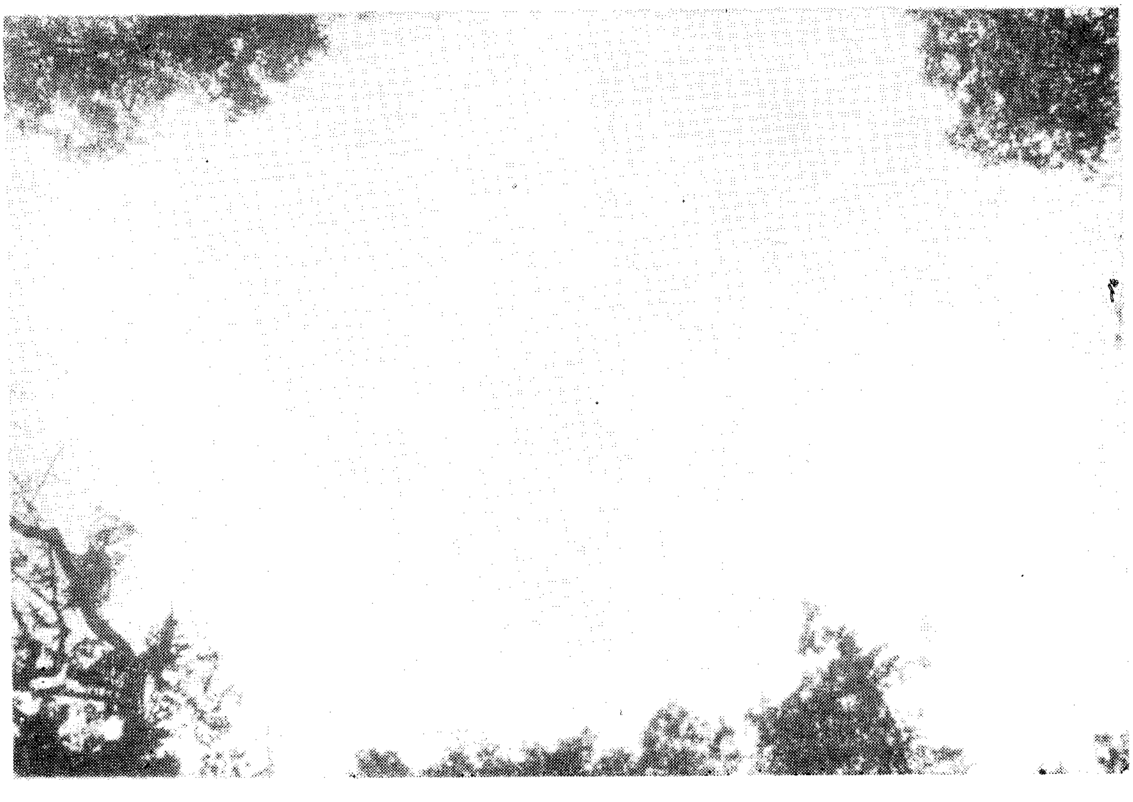
Pl. XXXVII. Regeneration of miscellaneous species after selection felling.



Pl. XXXVIII. Canopy opening under the normal prescriptions of Working Plan.



Pl. XXXIX. An evergreen species being axed – adjacent tree cannot escape damage.



Pl. XXXX. Extensive opening created in an extensively felled area.

Chapter VIII

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10. Right of road inisde the coupes should not be allowed. Proper survey for location and construction of roads have to be taken up before logging operations.

11. While marking the trees, an arrow indicating the direction of fall should also be shown.

Despite all these recommendations, no matter how great the value we attach to our future crop, we need to sacrifice a portion of this value in the process of logging. We have to yield a small portion of tommorrow's potential crop to gain today's, so called, optimal benefits.

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