AERIAL PHOTOGRAPHY AND FOREST MANAGEMENT PLAN IN THE ENCROACHED NATIONAL RESERVE FOREST IN THE KINGDOM OF THAILAND

PROGRESS REPORT

MARCH, 1987

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

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CONTENTS

I. INTRODUCTION

1. Purpose of the Study

The purpose of this study entitled the "Aerial Photography and Forest Management Plan for the Encroached National Reserve Forest in the Kingdom of Thailand", aims to contribute to the promotion of the forest village plan, to finding a solution to the problem of quickly dwindling forest resources and to the optimum administration and management of the remaining national forest, while co-existing with the farmers, by taking aerial photographs of the target study area covering, two million hectares and by formulating a forest management plan for agroforestry development and environmental conservation in the model area covering twenty thousand hectares.

2. Study Area

The study area lies in the western part of the central region of Thailand adjacent to the border with Burma and covers an area of two million hectares extending over five province of Tak, Uthai Thani, Kamphaeng Phet, Suphan Buri and Kanchanaburi, including the model area of twenty thousand hectares established therein. (Refer to Fig. I-2-1~2)

Aerial photography during 1986/87 covered one million hectares on the north as the one million hectares on th south was already photographed during 1985/86. The main survey for the national forest management plan was conducted in the study area and in its environs with major emphasis placed on the model area.

3. 1986/87 Study Items

During 1986/87 which was the second year of study, aerial photographs were taken, the basic map was prepared, photographs were interpreted and forest type map was prepared, and the main survey for the national forest management plan was conducted.

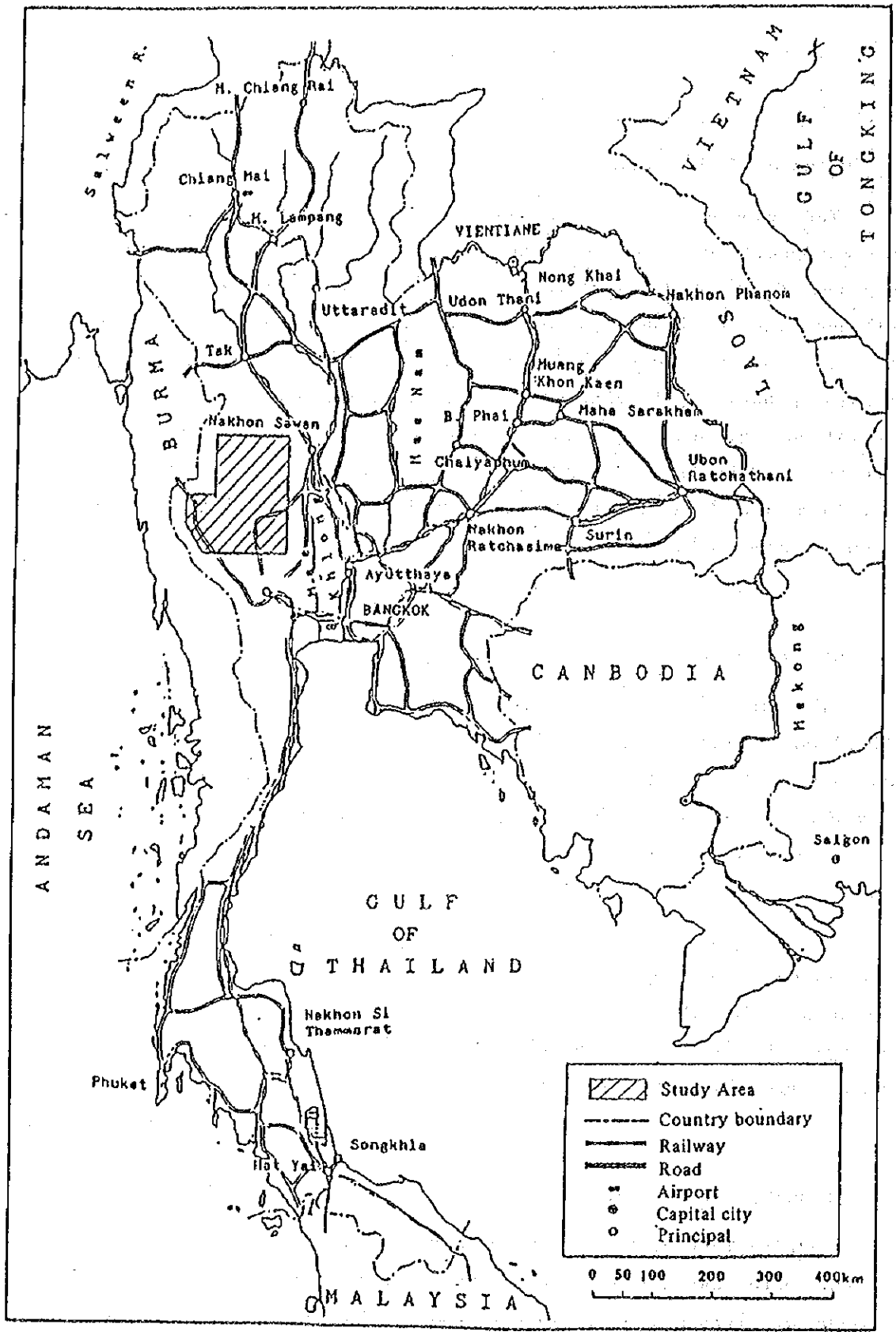


Fig. I-2-1 Study Area

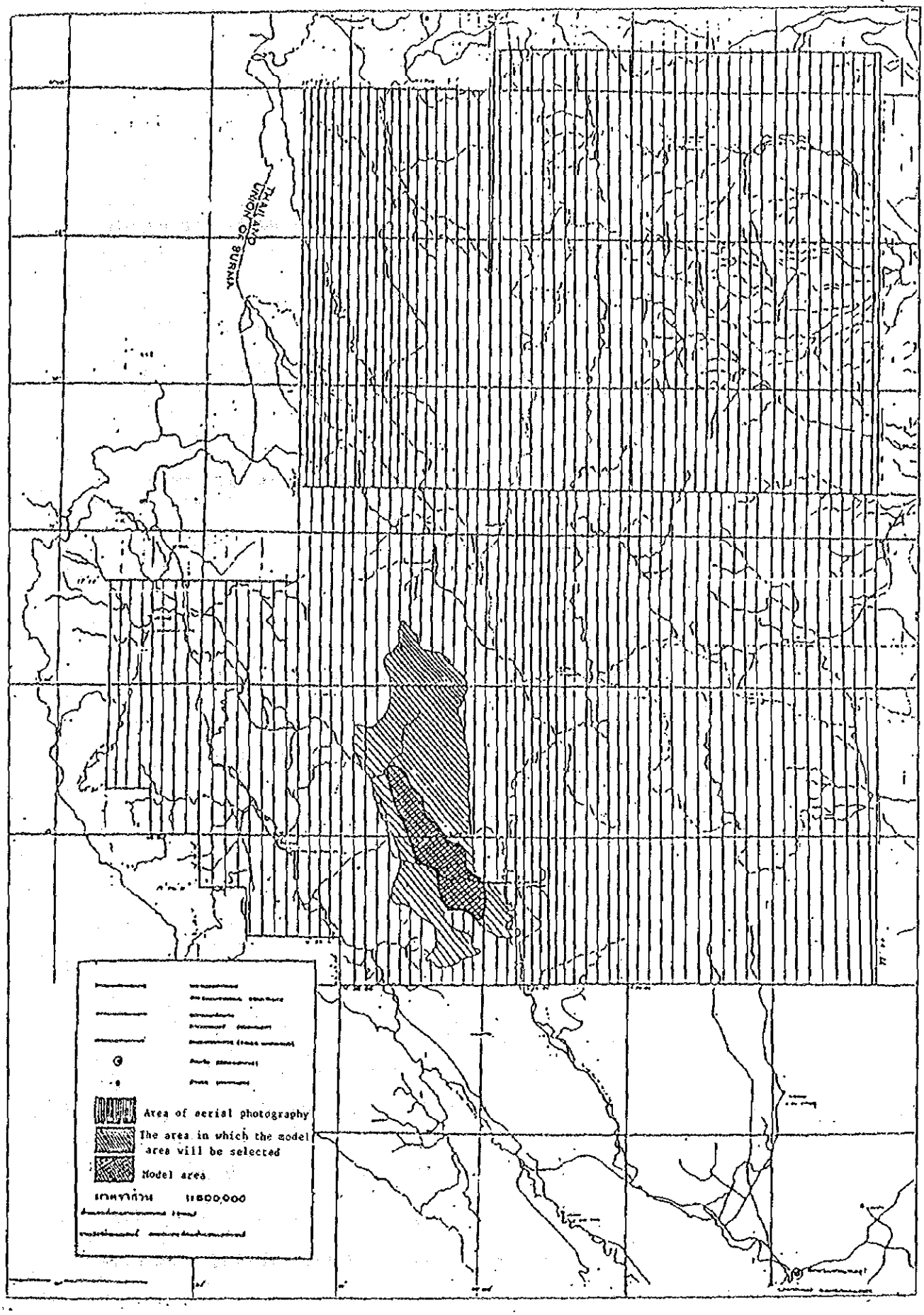


Fig. 1-2-2 Model Area

(1) Aerial photographing

1) Preparatory work in Japan

2) Field work in Thailand

① Acquisition of photographing permit and flight permit

② Aerial photographing

3) Work in Japan

(2) Preparation of the basic map

1) Work in Japan

① Aerial triangulation

② Preparation of the topographical map

(3) Photo-interpretation and preparation of forest type map

1) Field work in Thailand

① Aerial photo-interpretation

② Field cross-checking

③ Data collection

2) Work in Japan

① Preparation of the forest type map

② Site analysis

(4) Main survey for the national forest management plan

1) Preparatory work in Japan

2) Field work in Thailand

① Survey of land use plan

② Survey of forest villages and tropical farming

③ Forest survey and fact-finding survey of forest management

④ Soil survey

3) Work in Japan

① Examination on site classification

② Examination on land use classification

③ Compilation of the field survey findings

4. Organization and Study Schedule of the Field Survey Teams

(1) Organization of the field survey teams

The organization and survey period of each field survey team are as follows.

Team	Responsibility	Name	Survey period	No. of days
Aerial photography	Team leader	Takehiko HIRANO	Aug.12'86 - Aug.31'86	20
			Nov.11'86 - Feb.28'87	110
	Photo processing	Akira NAGASE	Dec.11'86 - Feb.28'87	80
	Photographing	Masao IWATA	Nov.24'86 - Feb.17'87	86
	Pilot	Kiyoshi ONO	Nov.24'86 - Feb.17'87	86
	Ground staff	Yoji EBARA	Dec.1'86 - Feb.17'87	79
Photo-interpretation and forest type map preparation	Team leader, photo-interpretation and data collection	Tadao OHARA	Aug.12'86 - Sep.20'86	40
	Photo-interpretation and data collection	Sumio ICHIKAWA	"	"
	"	Kozo KATO	"	"
	"	Kota SHIMOKAWA	"	"
Main survey for the national forest management plan	Overall supervision, team leader	Mitsuma MATSUI	Jan.10'87 - Jan.29'87	20
	Land use master plan	Kazushi YUMOTO	Dec.11'86 - Jan.29'87	50
	Forest management	Shigeki KOIKE	"	"
	Forest village	Tadao OHARA	"	"
	Tropical farming/ livestock raising	Sumio ICHIKAWA	"	"
	Soil	Teruji NAKAMURA	"	"
	Forest type	Kota SHIMOKAWA	"	"

(2) Survey schedule

The survey schedule is as follows.

1) Aerial photography

Ordinal No.of day	Date		Contents of survey work
1	Aug.12,'86	Tue.	Lv.Tokyo-Ar.Bangkok (CX 501/CX 703) Aerial photographing team leader
2	13	Wed.	Courtesy call on Japanese Embassy, JICA and RFD, Meeting on contents of study and arrangement of schedule at RFD.
3	14	Thu.	Data collection and application procedures for photographing permit
⟨	⟨		
17	28	Thu.	
18	29	Fri.	Courtesy call on Japanese Embassy, JICA and RFD.
19	30	Sat.	Sorting of data.
20	31	Sun.	Lv.Bangkok-Ar.Tokyo (TG 740)
1	Nov.11,'86	Tue.	Lv.Tokyo-Ar.Bangkok (JL 717) Aerial photographing team leader
2	12	Wed.	Courtesy call on Japanese Embassy, JICA and RFD.
3	13	Thu.	Arrangement of schedule with RFD.
4	14	Fri.	Arrangement for the dispatching of security officers and processing of photographs at RTSD.
5	15	Sat.	Sorting of data.
6	16	Sun.	Holiday
7	17	Mon.	Preparation for shipping of fuel, etc. at Nakhon Sawan Airfield
8	18	Tue.	Meeting at Aviation Dept of the Ministry of Agricultural Cooperatives to arrange for the use of Nakhon Sawan Airfield
9	19	Wed.	Meeting with Mr. Direk, Nakhon Sawan Airfield Station Manager

Ordinal No.of day	Date	Contents of survey work
10	Nov.20,'86 Thu.	Arrangement for lodging at Nakhon Sawan Airfield
11	21 Fri.	Meeting on ordering and procurement method of additional fuel for the photographing plane
12	22 Sat.	Sorting of data.
13	23 Sun.	Holiday
14	24 Mon.	Lv.Tokyo-Ar.Bangkok (TG 641), pilot and cameraman
15	25 Tue.	Courtesy call on JICA and RFD, servicing of the airplane
16	26 Wed.	Test flight
17	27 Thu.	Obtaining of flight information at Nakhon Sawan Airfield
18 ∫ 20	28 Fri. ∫ 30 Sun.	Servicing of the airplane
21	Dec. 1,'86 Mon.	Camera test over the photographing area
22	2 Tue.	Film development and photograph inspection at RTSD, preparation for moving to Nakhon Sawan Airfield
23	3 Wed.	Moving of team leader and cameraman to Nakhon Sawan Airfield by an overland route
24	4 Thu.	Readying of work site at the Airfield
25	5 Fri.	Moving of photographing plane to Nakhon Sawan Airfield
26 ∫ 30	6 Sat. ∫ 10 Wed.	Aerial photographing
31	11 Thu.	Lv.Tokyo-Ar.Bangkok, photograph processor

Ordinal No.of day	Date	Contents of survey work
32	Dec.12,'86 Fri.	Courtesy call on JICA and RFD. Team leader and photograph processor move to Nakhon Sawan for arranging work with flight crew.
33	13 Sat.	Aerial photographing
34	14 Sun.	
35	15 Mon.	Photograph processing and forwarding to Bangkok
⟨	⟨	Aerial photographing, photograph processing and inspection
88	Feb. 6,'87 Fri.	Aerial photographing, photograph processing and inspection. Delivery of some photo-graphs
⟨	⟨	
93	11 Wed.	
94	12 Thu.	Completion of aerial photographing
95	13 Fri.	Preparation for moving to Bangkok
96	14 Sat.	Moving of photographing plane to Bangkok
97	15 Sun.	Moving of team leader to Bangkok
98	16 Mon.	Servicing of airplane, photograph inspection
99	17 Tue.	Transferring of pilot, cameraman and ground staff to other project
100	18 Wed.	Photograph processing, inspection, photo coverage index map preparation, delivery of photographs
⟨	⟨	
108	26 Thu.	
109	27 Fri.	Courtesy call on Japanese Embassy, JICA, RTSD, RFD
110	28 Sat.	Lv.Bangkok-Ar.Tokyo (TG 640)

2) Photo-interpretation

Ordinal No.of day	Date		Contents of survey work
1	Aug. 12, '86	Tue.	Lv.Tokyo-Ar.Bangkok (CX 501/CX 703)
2	13	Wed.	Courtesy call on Japanese Embassy and JICA Thailand office for consultation and pre-arrangement, courtesy call on RFD for pre-arrangement.
3	14	Thu.	Discussion on survey work at RFD, preparatory work
4	15	Fri.	Aerial photo-interpretation
5	16	Sat.	
6	17	Sun.	Holiday
7	18	Mon.	Aerial photo-interpretation
∫	∫		
12	23	Sat.	
13	24	Sun.	Holiday
∫	∫		
14	25	Mon.	Aerial photo-interpretation
19	30	Sat.	
20	31	Sun.	Holiday
21	Sept. 1, '86	Mon.	Pre-arrangement of schedule for field work, preparatory work
22	2	Tue.	Moving (Bangkok - Kanchanaburi - survey area)
23	3	Wed.	
24	4	Thu.	Field survey o cross-checking of classification by land use, forest type and forest form o confirmation of sample plots and pricking of these on aerial photographs
∫	∫		
31	11	Thu.	Moving (survey area - Bangkok)
32	12	Fri.	Reporting completion of field work to JICA Thailand office, compilation of photographs at RFD
33	13	Sat.	Summarizing of field survey results
34	14	Sun.	Holiday

Ordinal No.of day	Date	Contents of survey work
35 ⟩ 38	Sept.15,'86 Mon. ⟩ 18 Thu.	Revision and correction of aerial photo-interpretation, revision of contact prints and traced pictures
39	19 Fri.	Call on Japanese Embassy, JICA Thailand office and RFD to report team's departure to Japan, preparation for departure to Japan
40	20 Sat.	Lv.Bangkok-Ar.Tokyo (TG 640)

3) Main survey for the national forest management plan

Ordinal No.of day	Date	Contents of survey work
1	Dec.11,'86 Thu.	Lv.Tokyo-Ar.Bangkok (TG741)
2	12 Fri.	Courtesy call on RFD, arrangement of overall schedule
3	13 Sat.	Preparation for field survey
4	14 Sun.	
5	15 Mon.	Courtesy call on JICA Thailand office, explanation of survey contents and arrangement of schedule at RFD
6	16 Tue.	Moving (Bangkok - Kanchanaburi - survey area)
7	17 Wed.	
8 ⟩ 15	18 Thu. ⟩ 25 Thu.	Field survey o survey on land use status o forest survey o hearing and questionnaire survey on forest villages, tropical farming and livestock raising o Soil survey
16	26 Fri.	Moving (survey area - Bangkok)
17	27 Sat.	Sorting and calculating of the field note
18	28 Sun.	
19	29 Mon.	Summarizing of field survey findings with counterparts at RFD
20	30 Tue.	
21	31 Wed.	Compilation of survey findings and internal meeting

Ordinal No.of day	Date		Contents of survey work	
22	Jan. 1,'87	Thu.	Holiday	
23	2	Fri.	Pre-arrangement of survey schedule for January at RFD	
24	3	Sat.	Preparatory work for field survey	
25	4	Sun.		
26	5	Mon.	Moving, visit to the Asean-Canada Forest Tree Seed Centre for observation	
27	6	Thu.	Visit to Sakaerat Reforestation Project Site for observation, collection of data on planted land	
28	7	Wed.	Collection of data on plantations at Banpong Regional Forest Office	
29 ⟩ 31	8 ⟩ 10	Thu. ⟩ Sat.	Investigation of growing results at existing Teak plantation	
32	11	Sun.	Moving to model area	o Overall team leader Lv.Tokyo-Ar.Bangkok o Explanation of survey progress to overall team leader
33	12	Mon.	Field survey	o Courtesy call on JICA and RFD
34 ⟩	13 ⟩	Tue. ⟩	o Forest survey o Hearing and questionnaire survey on forest village, tropical farming and live-stock raising o Soil survey o Acquisition of data	o Information exchange with and acquisition of data from various divisions of RFD
38	17	Wed.		o Moving of Work Supervisory Team to the survey team
39 ⟩ 41	18 ⟩ 20	Sun. ⟩ Tue.	Guided tour of the survey area by the Work Supervisory Team and explanation of survey work to the Team	
42	21	Wed.	Acquisition of information and data through hearings at Kanchanaburi	
43	22	Thu.	Acquisition of data at Banpong Regional Forest Office, moving to Bangkok	

Ordinal No.of day	Date	Contents of survey work
44	Jan.23,'87 Fri.	Meeting at RFD
45	24 Sat.	Reorganization of field survey findings
46	25 Sun.	
47	26 Mon.	Compilation of field survey findings, acquisition of data at RFD
48	27 Tue.	Conference at RFD (presentation of survey findings)
49	28 Wed.	Call on Japanese Embassy and JICA Thailand Office to report Team's departure for Japan, courtesy call on RFD for farewell
50	29 Thu.	Lv.Bangkok-Ar.Tokyo (CX 750/CX 500)

II. SURVEY IMPLEMENTATION

Aerial photographing, preparation of the basic map, photo-interpretation and preparation of the thematic map, and a full scale survey for the national forest management plan were carried out. The survey contents and survey results are as described below.

1. Aerial Photographing

(1) Description of work execution

1) The base office for aerial photography

A parking space for the airplane was secured at the airfield attached to the Ministry of Agricultural Cooperatives where is located in Nakhon Sawan City, and the office was established therein.

2) Equipment used for aerial photographing and photo-processing

① Airplane : Cessna TU 206F
② Survey camera : WILD RC-10 15/23
③ Film development : KODAK Film Processor Bathamat 1140
④ Contact print : ZEISS Contact Printer KG-30
⑤ Contact processor : KODAK Royal Print Processor

⑥ Rectifier : ZEISS Automatic Rectifier SEG-V

⑦ Aerial film : KODAK PLUS-X 2402

(2) Aerial photographing

An area of one million hectares was photographed on a scale of 1:20,000 over 55 planned courses and the results listed on Table II-1-1 were obtained. The outline of the photographed area is shown in Fig. II-1-1.

(3) Development, processing and inspection of photographs

Photographs were developed, processed and inspected for overlaps, sidelaps, deviation from the courses, cloud images and others at RTSD (the Royal Thai Survey Department) and a photo coverage index map was prepared on a scale of 1:250.

(4) Security officers

Photographing was executed in the presence of the following security officers dispatched from RTSD.

December 1986	Lt. Col. Chamnong Chanthamala Personnel Division Lt. Col. Montol Bomroongpruek Planning and Project Division
January 1987	Lt. Col. Supot Thongwut Aerial Photography Division Lt. Col. Chamnong Chanthamala Personnel Division
February 1987	Lt. Col. Ratchai Phadungwai Aerial Photography Division Lt. Col. Siriwat Phlerngphi

(5) Results

The results of the work described in (2) and (3) above were delivered as follows.

① Negative film 1 set

(Delivered to RTSD in accordance with the regulation of

Thailand.)

② Contact prints 2 sets
(Delivered to RFD)

③ Photo index 1 set
(Delivered to RTSD in accordance with the regulation of Thailand.)

④ Enlarged photo 1 set
(Delivered to RFD.)

2. Preparation of the Basic Map

Based on the accomplished results of work executed in 1985/86 (air-photo signals, control point survey, levelling, aerial photographs), the aerotriangulation survey was carried out and a topographical map on a scale of 1:10,000 as a basic map was prepared in Japan. In order to carry out these works in Japan, security officers dispatched from Thailand were accepted.

(1) Aerotriangulation survey

Aerial photographs for preparing the basic map of the model area were 76 models (Refer to Table II-2-1), with respect to which the aerotriangulation survey was carried out. Using as reference the results of the field work (control point survey, levelling) and spot heights on the existing 1:50,000 map, primary calculation was carried out with respect to the planimetric locations and elevations, and after examining the calculation results, the aerotriangulation survey was executed by means of the block adjustment technique. The residual calculation at control points is as listed on Table II-2-2.

Principal equipment used are as follows.

1) Dot engraver : Wild PUG II
2) Comparator : ZEISS Stereo Comparator
3) Computer : FUJI FACOM M150-F System

AREA FOR AERIAL PEOTOGRAPHY

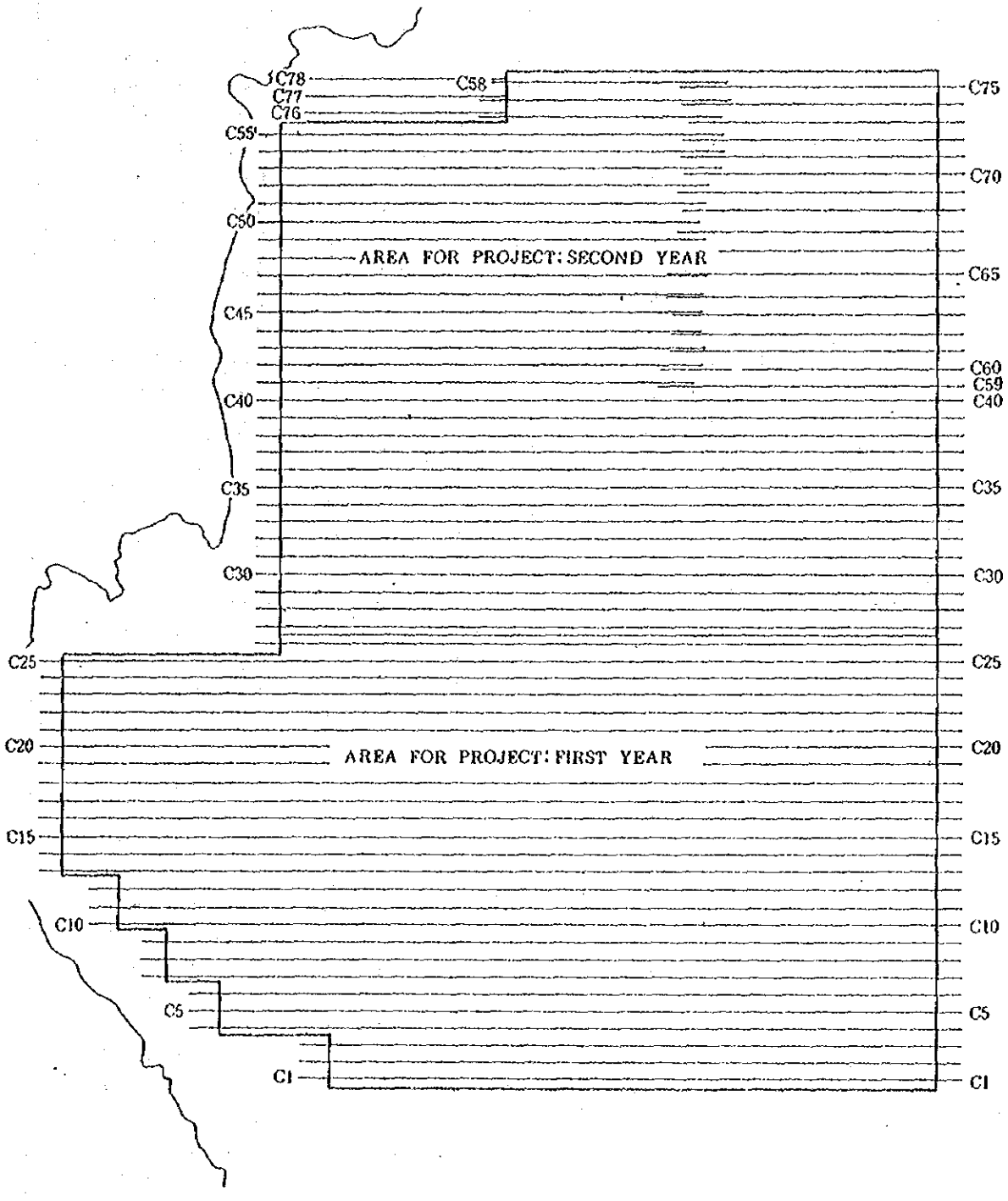


Fig. II-1-1 Map of Flight Plan

Table II-1-1 Result of Aerial Photography
(Second Year)

Course №	Photo №	No. of Photographs	Roll №	Date of Aerial Photography
C 24	1 – 81	81	11	Jan. 20 1987
C 25	1 – 81	81	11	Jan. 20 1987
C 26 A	1 – 24	24	11	Jan. 20 1987
C 26 B	1 – 40	40	1	Dec. 13 1986
C 27 A	1 – 30	30	11	Jan. 20 1987
C 27 B	1 – 34	34	1	Dec. 13 1986
C 28 A	1 – 50	50	11	Jan. 20 1987
C 28 B	1 – 15	15	1	Dec. 15 1986
C 29 A	1 – 8	8	13	Jan. 31 1987
C 29 B	1 – 57	57	9	Jan. 18 1987
C 30	1 – 63	63	9	Jan. 18 1987
C 31	1 – 63	63	9	Jan. 18 1987
C 32 A	1 – 19	19	8	Jan. 15 1987
C 32 B	1 – 33	33	14	Feb. 5 1987
C 32 C	1 – 18	18	8	Jan. 15 1987
C 33 A	1 – 40	40	8	Jan. 15 1987
C 33 B	1 – 13	13	14	Feb. 5 1987
C 33 C	1 – 16	16	8	Jan. 15 1987
C 34 A	1 – 40	40	8	Jan. 15 1987
C 34 B	1 – 17	17	14	Feb. 6 1987
C 34 C	1 – 12	12	8	Jan. 15 1987
C 35 A	1 – 16	16	7	Jan. 10 1987
C 35 B	1 – 11	11	13	Jan. 31 1987
C 35 C	1 – 23	23	7	Jan. 10 1987
C 35 D	1 – 10	10	9	Jan. 18 1987
C 35 E	1 – 13	13	8	Jan. 15 1987
C 36 A	1 – 47	47	7	Jan. 10 1987
C 36 B	1 – 17	17	1	Dec. 15 1986
C 37 A	1 – 46	46	7	Jan. 10 1987
C 37 B	1 – 17	17	1	Dec. 15 1986
C 38 A	1 – 37	37	7	Jan. 10 1987
C 38 B	1 – 25	25	1	Dec. 15 1986
C 39 A	1 – 46	46	7	Jan. 10 1987
C 39 B	1 – 16	16	1	Dec. 15 1986
C 40 A	1 – 42	42	6	Jan. 9 1987
C 40 B	1 – 20	20	8	Jan. 14 1987
C 41 A	1 – 19	19	6	Jan. 9 1987
C 41 B	1 – 11	11	15	Feb. 12 1987
C 41 C	1 – 17	17	6	Jan. 9 1987
C 42	1 – 41	41	6	Jan. 9 1987
C 43	1 – 41	41	6	Jan. 9 1987
C 44	1 – 41	41	6	Jan. 9 1987
C 45	1 – 44	44	6	Jan. 9 1987
C 46 A	1 – 15	15	12	Jan. 22 1987
C 46 B	1 – 14	14	3	Dec. 29 1986

Course №	Photo №	No. of photographs	Roll №	Date of Aerial Photography
C 46 C	1 – 16	16	12	Jan. 24 1987
C 47 A	1 – 14	14	12	Jan. 22 1987
C 47 B	1 – 12	12	3	Dec. 29 1986
C 47 C	1 – 18	18	13	Feb. 2 1987
C 48 A	1 – 27	27	5	Jan. 9 1987
C 48 B	1 – 10	10	13	Jan. 31 1987
C 49 A	1 – 25	25	5	Jan. 9 1987
C 49 B	1 – 13	13	13	Jan. 31 1987
C 50 A	1 – 17	17	4	Dec. 30 1986
C 50 B	1 – 20	20	13	Feb. 2 1987
C 51 A	1 – 29	29	4	Dec. 30 1986
C 51 B	1 – 9	9	12	Jan. 24 1987
C 52 A	1 – 11	11	12	Jan. 24 1987
C 52 B	1 – 31	31	4	Dec. 30 1986
C 53	1 – 37	37	4	Dec. 30 1986
C 54 A	1 – 16	16	2	Dec. 18 1986
C 54 B	1 – 25	25	13	Feb. 2 1987
C 55 A	1 – 17	17	7	Jan. 10 1987
C 55 B	1 – 9	9	2	Dec. 18 1986
C 55 C	1 – 15	15	7	Jan. 10 1987
C 56	1 – 18	18	2	Dec. 17 1986
C 57	1 – 19	19	2	Dec. 17 1986
C 58	1 – 17	17	2	Dec. 17 1986
C 59	1 – 24	24	3	Dec. 26 1986
C 60	1 – 25	25	3	Dec. 26 1986
C 61	1 – 23	23	3	Dec. 26 1986
C 62	1 – 22	22	3	Dec. 26 1986
C 63	1 – 22	22	3	Dec. 26 1986
C 64 A	1 – 9	9	12	Jan. 22 1987
C 64 B	1 – 19	19	3	Dec. 26 1986
C 65	1 – 26	26	10	Jan. 19 1987
C 66	1 – 27	27	10	Jan. 19 1987
C 67	1 – 27	27	10	Jan. 19 1987
C 68	1 – 27	27	10	Jan. 19 1987
C 69	1 – 27	27	10	Jan. 19 1987
C 70	1 – 27	27	3	Dec. 29 1986
C 71	1 – 28	28	2	Dec. 16 1986
C 72	1 – 27	27	5	Jan. 4 1987
C 73 A	1 – 8	8	13	Feb. 2 1987
C 73 B	1 – 22	22	2	Dec. 16 1986
C 74	1 – 27	27	2	Dec. 16 1986
C 75	1 – 26	26	2	Dec. 16 1986
C 76	1 – 21	21	12	Jan. 22 1987
C 77	1 – 21	21	12	Jan. 22 1987
C 78	1 – 19	19	12	Jan. 25 1987
Ground Total		2,312		

Table II-2-1 Aerial Photographs for Preparation of the Basic Map

Course	Photo	No. of photographs	Number of model
C 4	20 - 25	6	5
C 5	20 - 26	7	6
C 6A	22 - 29	8	7
C 7A	21 - 30	10	9
C 8	21 - 32	12	11
C 9	25 - 36	12	11
C 10B-1	5 - 13	9	8
C 11	25 - 31	7	6
C 12A	27 - 33	7	6
C 13	28 - 32	5	4
C 14A	29 - 32	4	3
Total	11 courses	87	76

Table II-2-2 Block Adjustment for Aerial Triangulation

RFD Project

NAME	X-coordinate X	Residual VX	Y-coordinate Y	Residual VY	Residual of distance VS	Elevation H	Residual VH
510100	164558163	0.47	4872068.8	0.34	0.58	782.00	-0.33
973800						738.00	4.00
510200	1644755.72	-0.35	4820377.3	-0.23	0.42	621.87	1.05
965400						654.00	0.76
972100						721.00	-2.30
971400						714.00	2.28
976900						769.00	-1.28
981900						819.00	1.78
972200						722.00	-2.13
967300						673.00	1.81
610301	1640555.36	-0.02	4776562.6	0.20	0.20	895.91	2.67
988300						883.00	2.85
972100						721.00	0.19
976400						764.00	-4.46
989800						898.00	0.70
981900						819.00	2.36
989400						894.00	-0.31
985200						852.00	-2.31
989800						898.00	-4.47
981800						818.00	-1.65
991800						918.00	2.08
981600						816.00	-1.81
989600						896.000	-0.83
977800						778.00	-1.34
974200						742.00	-0.94
992400						924.00	-4.75
510400	1632974.05	0.48	4843577.1	-0.10	0.49	723.61	-2.61
510700	1636038.81	0.43	5010044.12	-0.15	0.46	279.87	-1.55
981500						815.00	4.58
978600						786.00	-1.21
981600						816.00	-1.46
974200						742.00	-1.17
985000						850.00	4.42
986700						867.00	-1.55
987300						873.00	3.22

NAME	X-coordinate X	Residual VX	Y-coordinate Y	Residual VY	Residual of distance VS	Elevation H	Residual VH
985600						856.00	3.28
974500						745.00	0.19
995200						952.00	-2.24
935400						354.00	-3.21
947800						478.00	1.00
900001						180.00	-4.89
900002						180.00	1.10
900003						180.00	1.07
900004						180.00	1.20
870468						704.68	-2.39
871656						716.56	-1.14
875526						755.26	1.17
874960						749.60	2.76
879246						792.46	0.73
875783						757.83	2.86
900005						180.00	1.57
900006						180.00	1.18
510500	162453202	-0.69	487172.81	0.25	0.73	872.80	-0.02
510600	162228130	-0.71	492411.18	-0.13	0.72	825.39	0.93
876011						760.11	0.61
875927						759.27	1.49
874704						747.04	2.85
861893						618.93	0.55
837581						375.81	-0.19
963300						633.00	0.34
510800	162177567	-0.31	502062.44	0.54	0.62	192.42	-1.15
866695						666.95	0.84
857159						571.59	0.65
844475						444.75	-0.42
824454						244.54	3.05
823501						235.01	-0.85
510900	161811497	0.71	498867.48	-0.71	1.00	260.24	0.52
981500						815.00	-3.90
992700						927.00	4.83
975800						758.00	-4.78
900008						180.00	3.81
900009						180.00	-1.00

MAX. ERROR RS 1.00 RH -4.89

MEAN. ERROR RS 0.58 RH 1.94

(2) Preparation of the topographical map

Using the results obtained by the aerotriangulation survey, a topographical map of the model area of 20,000 ha was prepared on a reduced scale of 1:10,000 with the contour interval of 10 m and auxiliary contour of 5 m by going through such processes as mechanical plotting of details, compilation and drawing. The adjoining sheet is as shown on Fig. II-2-1.

1) Major equipment used

Precision stereo plotter: Wild Stereo Plotter A8

Co-ordinatograph : Daini-Seikosha Xynetics 1100

2) Accuracy of the topographical map

Planimetric location of features: 2.0 mm on the map

Elevation of spot height: 4/3 of the contour interval

Contour line : 2/1 of the contour interval

3. Aerial Photo-interpretation and Preparation of Forest Type Map

(1) Aerial photo-interpretation

Aerial photographs (see Table II-3-1, List of Aerial Photographs) covering the model area of 20,000 hectares were interpreted for land use, forest type and forest form.

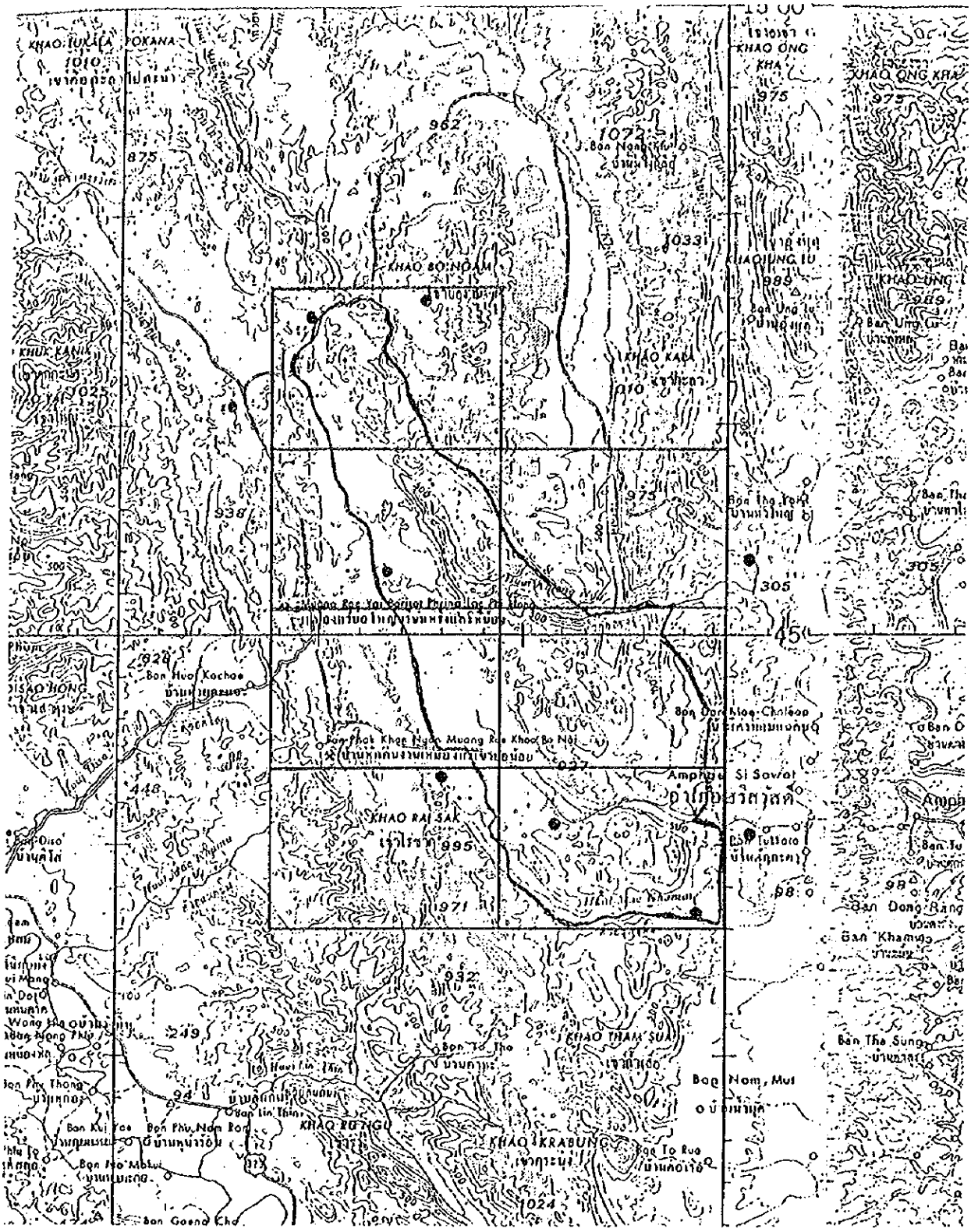


Fig. II-2-1 Information on Topographic Mapping

Mapping Area

Index to Adjoining Sheet

Air-photo Signal

1 : 250,000

Table II-3-1 List of Aerial Photographs (taken in 1985/86)

Course No.	Photo No.	No. of photographs
C5A	20 - 26	7
C6A	23 - 30	8
C7A	22 - 30	9
C8	22 - 31	10
C9	26 - 35	10
C10B	7 - 13	7
C11	25 - 31	7
C12A	28 - 34	7
C13	28 - 33	6
C14A	29 - 32	4
Total		75

1) Photo-interpretation for land use

The aerial photographs were interpreted for land use according to the proposed standard table for classification of land use, and as a result of cross checking the interpreted classification on the spots, the land use classification on the spots, the land use classification of the model area other than forest was determined as follows.

Classification	Symbol	Remarks
Farm land	A	
Grass land, grazing land	G	
Village	V	
River	R	
Bare land, rocky land	B	
Plantation, orchard	P	
Others	O	quarry, telecommunication station

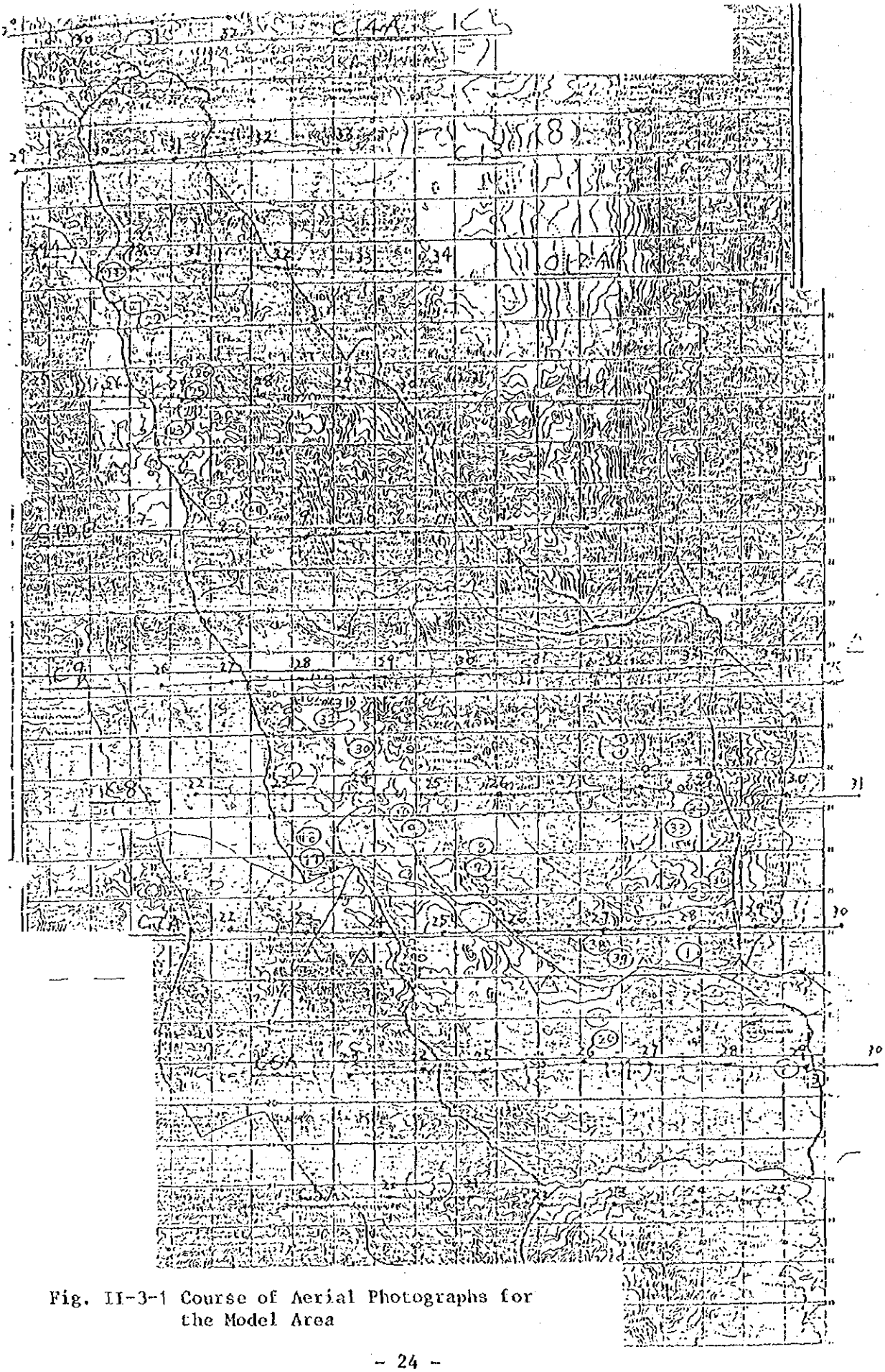


Fig. II-3-1 Course of Aerial Photographs for the Model Area

Division lines were drawn to demarcate each land use which was interpreted and classified and the applicable symbols were entered.

2) Photo-interpretation for forest type and forest form

The forest area was interpreted for forest type and forest form, and demarcated on the map according to the proposed classification criteria. When the sample plots set up for the forest survey conducted in 1985/86 were indicated on the aerial photographs interpreted and demarcated as above, it turned out that two sample plots, No. 17 and No. 18 consisted of two classes of forest type and the two other sample plots, No. 2 and No. 20 consisted of three classes of forest type, so that each of these four sample plots was restructured according to its respective class of forest type. Also, crown density and crown diameter were measured for each sample plot, based on which results the classification was reconsidered. The results of interpretation were cross-checked on the spot.

The criteria for classifying the forests by forest type and forest form derived from the foregoing results are as shown below.

o Forest type

Classification	Symbol
Tropical Evergreen Forest	T_E
Mixed Deciduous Forest	M_D
Deciduous Dipterocarp Forest	D_D
Bamboo Forest	B_F
Secondary Forest	S_F

o Forest form

Classification by terrain	Mountainous terrain Hilly terrain Flat terrain	M H F	
Classification by crown diameter class	Large diameter tree Middle diameter tree Small diameter tree	La Mi Sm	Crown diameter of upper story tree 17m and more from 11m to under 17m less than 11m
Classification by tree height class	High Middle Low	H_3 H_2 H_1	Mean tree height of upper story trees 23m and more from 18m to under 23m 17m and less
Classification by crown density class	Dense Intermediate Scattered Thin	D_4 D_3 D_2 D_1	Crown density of upper story trees 61% and more 51% - 60% 41% - 50% 40% and less

Interpreted demarcations were revised or corrected based on the foregoing criteria.

(2) Preparation of aerial photo stand volume table

An aerial photo stand volume table was prepared to estimate the stand volume of each forest stand classified by forest type and forest form. The stand factor used the crown density of the upper story trees which are measurable on the photograph. Using the dotted grid scale, the number of dots on the crown of upper story trees in the sample plot was counted, and its percentage to the total number of dots on that sample plot was defined as the crown density. The percentage was determined by the unit of 5%. (Refer to Table II-3-2 and Fig. II-3-2 for data used in

preparing the aerial photo stand volume table)

Formula for estimating the stand volume by aerial photo:

$$\log V = -0.932 + 1.632 \log R \quad (r = 0.87910)$$

or

$$V = 0.117\ R^{1.632}$$

wherein: V: Stand volume per ha, m^3/ha

R: Crown density of the upper story trees, by the unit of 5%.

The stand estimated volume V_E estimated by the stand volume formula was tested to conform to the actual stand volume V_A. As a result of F-test, it was found significant at the level of 5%. The formula for correcting the estimated stand volume V_E to actual stand volume V_A is as follows.

$$V_A = -3.29 + 1.073 \quad (r = 0.88727)$$

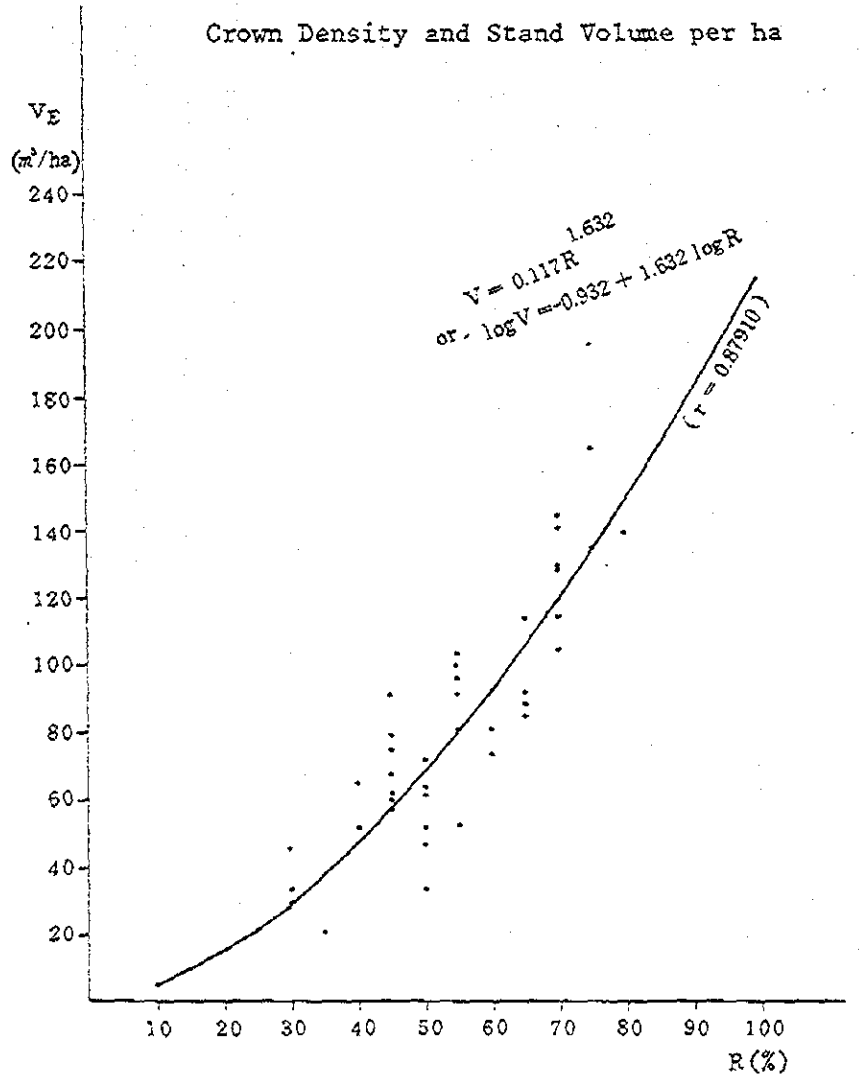
The following table summarizes all of the foregoing.

R (%)	V_E(m^3/ha)	V_A(m^3/ha)	R (%)	V_E(m^3/ha)	V_A(m^3/ha)	R (%)	V_E(m^3/ha)	V_A(m^3/ha)
5	2	—	40	48	48	75	134	141
10	5	2	45	58	59	80	149	157
15	10	7	50	69	71	85	165	174
20	16	14	55	81	84	90	181	191
25	22	20	60	93	96	95	198	209
30	30	29	65	106	110	100	215	227
35	39	39	70	120	125			

Table II-3-2 Data used in preparing the Aeiral Photo Stand Volume Table

No.	Plot No.	R(%) Crown density	V_A(m^3/ha) Actual volume	V_E(m^3/ha) Estimated volume	$V_A - V_E$
1	1	40	41	48	−7
2	2−1	50	64	69	−5
3	2−2	40	52	48	4
4	3	30	44	30	14
5	4	55	103	81	22
6	5	20	16	16	0
7	6	35	21	39	−18
8	7	40	65	48	17
9	8	65	92	106	−14
10	9	65	85	106	−21
11	10	50	47	69	−22
12	11	50	62	69	− 7
13	12	45	68	58	10
14	13	50	34	69	−35
15	14	30	34	30	4
16	15	70	141	120	21
17	16	65	114	106	8
18	17-2	75	135	134	1
19	18-1	70	130	120	10
20	19	55	96	81	15
21	20-1	50	72	69	3
22	20-2	70	105	120	−15
23	21	70	115	120	− 5
24	22	40	42	48	− 6
25	23	55	53	81	−28
26	24	45	47	58	−11
27	25	40	39	48	− 9
28	26	40	48	48	0
29	27	45	60	58	2
30	28	40	65	48	17
31	29	65	89	106	−17
32	30	70	129	120	9
33	31	60	74	93	−19
34	32	80	140	149	− 9
35	33	50	52	69	−17
36	34	55	91	81	10
37	35	55	100	81	19
38	36	45	75	58	17
39	37	60	81	93	−12
40	38	45	62	58	4
41	add-3	45	79	58	21
42	〃-4	50	91	69	22
43	〃-6	40	38	48	−10
44	〃-8	45	91	58	33
45	〃-1	75	196	134	62
46	〃-2	75	165	134	31
47	〃-7	70	145	120	25

$$\begin{cases} \log V = -0.932 + 1.632 \log R \quad (r = 0.87910) \\ V = 0.117\, R^{1.632} \end{cases}$$


Crown Density and Stand Volume per ha
V_E (m^3/ha)
240
220
200
180
160
140
120
100
80
60
40
20
$V = 0.117R^{1.632}$
or. $\log V = -0.932 + 1.632 \log R$
($r = 0.87910$)
10 20 30 40 50 60 70 80 90 100
R(%)

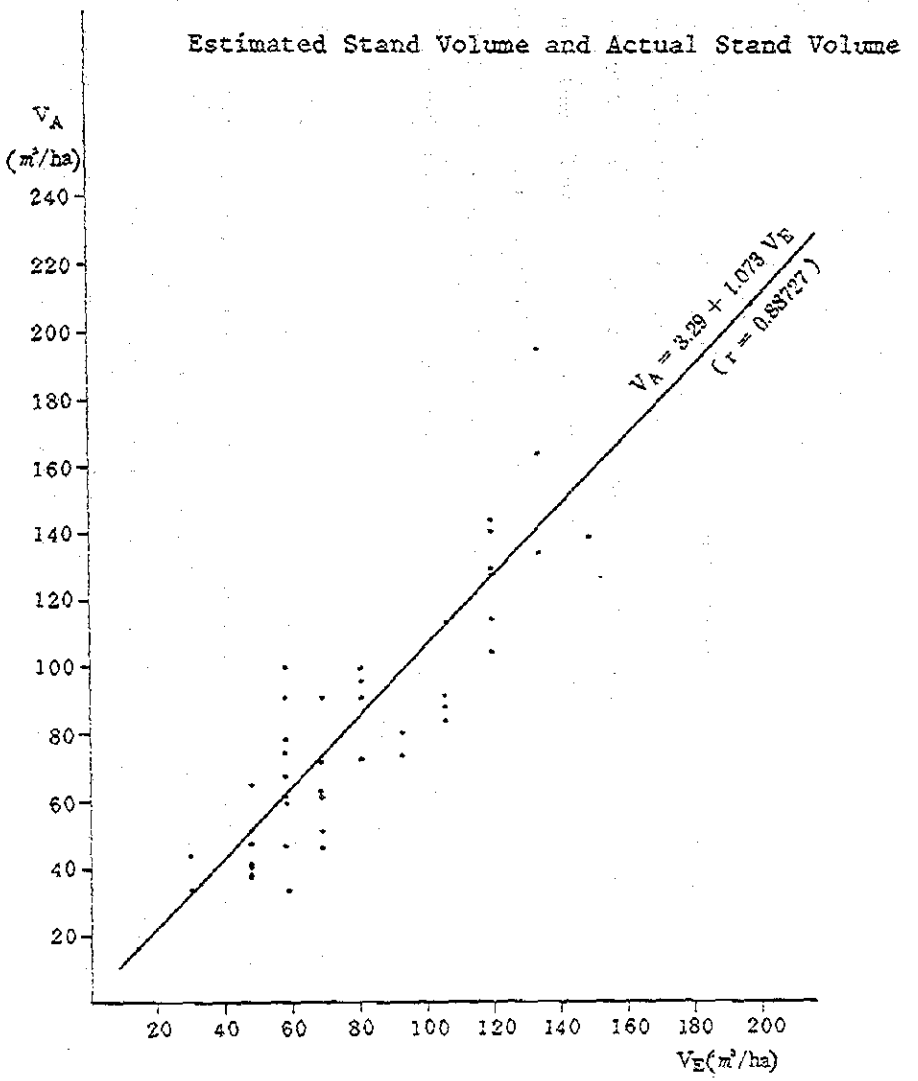

Estimated Stand Volume and Actual Stand Volume
V_A (m^3/ha)
240
220
200
180
160
140
120
100
80
60
40
20
$V_A = 3.29 + 1.073\ V_E$
($r = 0.83727$)
20 40 60 80 100 120 140 160 180 200
V_E(m^3/ha)

Fig.II-3-2

(3) Preparation of forest type map

The interpreted division lines by land use, forest type and forest form were transcribed onto the 1:10,000 topographical map to prepare the draft forest type. Compartments by the natural borders such as ridge, river and road were set up and numbered respectively. Sections by land use, forest type and forest form were established as sub-compartments and respectively numbered, too. The forest type map was prepared by fair draughting of the draft forest type map.

(4) Area measurement and growing stock estimation

The area for each sub-compartment was measured on the basis of the draft forest type map. The crown density of each sub-compartment was measured on the applicable aerial photograph, and the growing stock was estimated from the volume per ha according to the aerial photo stand volume table.

The result of area measurement on existing land use is as shown on II-3-3.

(5) Preparation of a forest inventory book

A forest inventory book was prepared by putting together the results of interpretation, area measurement and growing stock estimation and other data.

A form of forest inventory sheet is as shown on Table II-3-4.

4. Site Analysis

(1) Topographical analysis

Meshes of 2cm x 2cm (= 4 has.) each were set up on the 1:10,000 topographical map and the following factors were metered or measured for each mesh. Categorical classification of each factor is as shown on Table II-4-1.

Table II-3-3 Result of Area Measurement on Existing Land Use

(Unit: ha)

Working Area	Compartment No.	Forest Land		Non-forest Area									Total
		Forest Area	Over-left Area	Farm Land	Plantation	Village	Barren Land	Grass Land	River	Others	Grass Land & Form Land	Sub-Total	
				A	P	V	B	G	R	O	G/A		
Khao Prateusri Bor Rae	1	481.24		76.39		3.27	23.71	2.95				106.32	587.56
	2	1,135.18		29.85			16.38	0.46				46.69	1,181.87
	3	1,249.49	53.79	16.88		2.11	2.56	23.64				45.19	1,348.47
	4	1,298.59	62.88				3.71					3.71	1,365.18
	5	1,125.93	70.49		10.99	0.29		4.39				15.67	1,212.09
	6	1,125.57	141.03										1,266.60
	7	1,160.57	181.29										1,341.86
	8	590.15							4.11			4.11	594.26
	Sub-total	8,156.72	509.48	123.12	10.99	5.67	46.36	31.44	4.11			221.69	8,897.89
Srinagarind	1	934.67		41.24	17.48	1.69	1.02					61.43	996.10
	2	800.76											800.76
	3	773.26	39.72										813.00
	4	1,029.48	12.30					13.04			1.26	14.30	1,056.08
	5	733.62	20.83	123.12		0.40	30.81			4.90		159.23	913.68
	6	1,019.09	77.22	14.41		1.32					19.02	34.75	1,131.06
	7	838.35	7.17	60.24		1.29	24.76			1.07		87.36	932.88
	8	694.85	195.67				2.42					2.42	892.94
	9	715.26	102.51				1.91					1.91	819.68
	10	750.61							12.70			12.70	763.31
	11	1,056.11							43.22			43.22	1,099.33
	12	1,262.62											1,262.62
	13	1,123.14	131.58					12.87				12.87	1,267.59
	Sub-total	11,731.84	587.00	239.01	17.48	4.70	60.92	25.91	55.92	5.97	20.28	430.19	12,749.03
Total		19,898.56	1,096.48	362.13	28.47	10.37	107.28	57.35	60.03	5.97	20.28	651.88	21,646.92

Table II-3-4

FOREST INVENTORY SHEET

sheet no.

REGIONAL FOREST OFFICE	WORKING AREA	NAME OF AMPHOE

Division			Area (ha)			Forest type					Growing stock					
compartment	sub-compartment	land use	forest area	over-left area	non-forest area	forest formation	terrain	crown diameter class	tree height class	crown density class	number of tree per ha (DBH 10 cm & up)	stand volume per ha	volume	altitude	general soil type	remarks

o Altitude

The altitude in the center of each mesh was metered by the interval of 100 m.

o Aspect of the slope

The aspect of the longest slope in each mesh was measured in terms of nine azimuthes shown on Table II-4-1.

o Gradient

The gradient was measured in terms of the number of contour lines inside the inscribed circle of each mesh.

o Microtopography

Local Microtopography within each mesh measured.

o Valley density

The number of rivers and streams (as determined on the 1:10,000 contour map) in each mesh was counted.

Table II-4-1

Item	Topographical analysis									
	Altitude		Aspect of the slope		Gradient		Microtopography		Valley density	
	Code No.	Category (m)	Code No.	Category	Code No.	Category (°)	Code No.	Category	Code No.	Category (Number of rivers & streams)
Classification	1	- 100	1	N	1	- 5	1	Mountain ridge, Plateau (Gradient 1)	1	0
	2	101 - 200	2	NE	2	6 - 8	2	Mountain side (convex surface)	2	1 - 3
	3	201 - 300	3	E	3	9 - 13	3	Mountain side (concave surface)	3	3 - 9
	4	301 - 400	4	SE	4	14 - 18	4	Mountain side (except 1 & 2)	4	10 - 19
	5	401 - 500	5	S	5	19 - 23	5	Mountain foot (Gradient 1)	5	20 -
	6	501 - 600	6	SW	6	24 - 30	6	Steep cliff (Gradient 8, 9)		
	7	601 - 700	7	V	7	31 - 40				
	8	701 - 800	8	NW	8	41 - 45				
	9	801 - 900	9	none (Gradient 1)	9	46 -				
	10	901 -1,000								

(2) Other basic factors

According to the existing data and data collected on the field, each mesh was classified by each of the following factors.

o Geological structure

Sheet No. 7, "Thong Pha Phum" of the "Geological Map of Northern Thailand, 1:250,000" was used as the geological map.

o Soil type

The soil type according to the result of the soil survey conducted on the spot of survey area was used.

o State of devastation

Land collapse and land slide were examined by aerial photo-interpretation, but no devastated land by collapsing of hillside or land slide was found.

o Climate

The "Climatic Regions of Thailand" was used, according to which the survey area belongs to the climatic zone of "Mountainous with cool dry season in valleys (B5)" within the "Tropical Monsoon Climate with Long Rainy Season".

Item	Basic Factors					
	Geological Structure			Soil Type		
	Code No.	Category		Code No.	Category	
Classification	1	Quaternary, Tertiory	q – ng	1	Eutric Nitosols	Ne
	2	Jurassic, Triassic	j – t	2	Eutric Cambisols	Be
	3	Permian	P (sh,ss,ls) P 2–1 (ls)	3	Vertic Luvisols	Lv
	4	Carboniferous	h	4	Lithosols	I
	5	Carboniferous, Devonian	h – s	5	Rendzinas	E
	6	Devonian, Silurian	d – s			
	7	Ordovician	O (ls,sh) O'sh (sh) O'l (ls)			

The results of (1) topographical analysis and (2) measurement and determination of other basic factors are summarized on the site analysis table (separately attached).

(3) Land type classification

For proper administration and management of the national forest, a land use plan for forest land is necessary. The land use classification which is necessary as the basic information for formulating such a plan ought to be based, not on existing land use, but on natural conditions of the site. The first step in land type classification is therefore to roughly group the land subject to land use capability classification and land use classification by their common natural properties. The grouping of land in the current survey was carried out by respectively overlaying the results of the topographical analysis and applicable basic factors. The factors taken up for grouping were climate, geological structure, macro-topography, forest type and soil type. However, each of climate and geological structure of the entire model area was assumed to belong to the same category in view of the fact that the climate of the entire model area belongs to Category B5 (Mountainous with cool dry season in valleys) and its geological structure, although it comprises Mesozoic to Paleozoic sedimentary rock consisting of ls (limestone), ss (sandstone) and sh (shale), has some portions in each geological time which remain unclassified.

As a result, the three factors, namely, macrotopography classified into M, H and F, forest type classified into T_E, M_D and D_D, and soil type classified into Ne, Be, Lv, I and E were used for grouping, from which the following 18 combinations emerged. (Refer to Fig. II-4-1~3)

Major class of terrain	Forest type \ Soil type	Ne	Be-c	Lv・Be-r	E・I
F	T_E	○	-	-	-
	M_D	○	○	○	○
	D_D	-	-	○	○
H	T_E	-	-	-	-
	M_D	○	○	○	○
	D_D	-	-	○	○
M	T_E	-	-	○	○
	M_D	-	○	○	○
	D_D	-	-	-	-

(○ : existence - : non existence)

Upon further study from the viewpoint of soil productivity, the area was classified into the following eight groups. However, the mountainous topography (M) which is neither fit for farming or livestock raising nor productive as a production forest but which should be protected as a forest was deemed as one group.

Group of Land Type Classification

Group 区分	Types belonging to each group
I	F T_E Ne
II	F M_D Ne, FM_D Be
III	F M_D Lv・Be
IV	H M_D Ne, HM_D Be
V	H M_D Lv・Be
VI	FD_D Lv・Be, HD_D Lv・Be
VII	FM_DE・I, HM_DE・I, FD_DE・I, HD_DE・I
VIII	MT_E(Lv・Be, E・I), MM_D(Be, Lv・Be, E・I)

Fig. II-4-4 illustrates the land type classification in the model area.

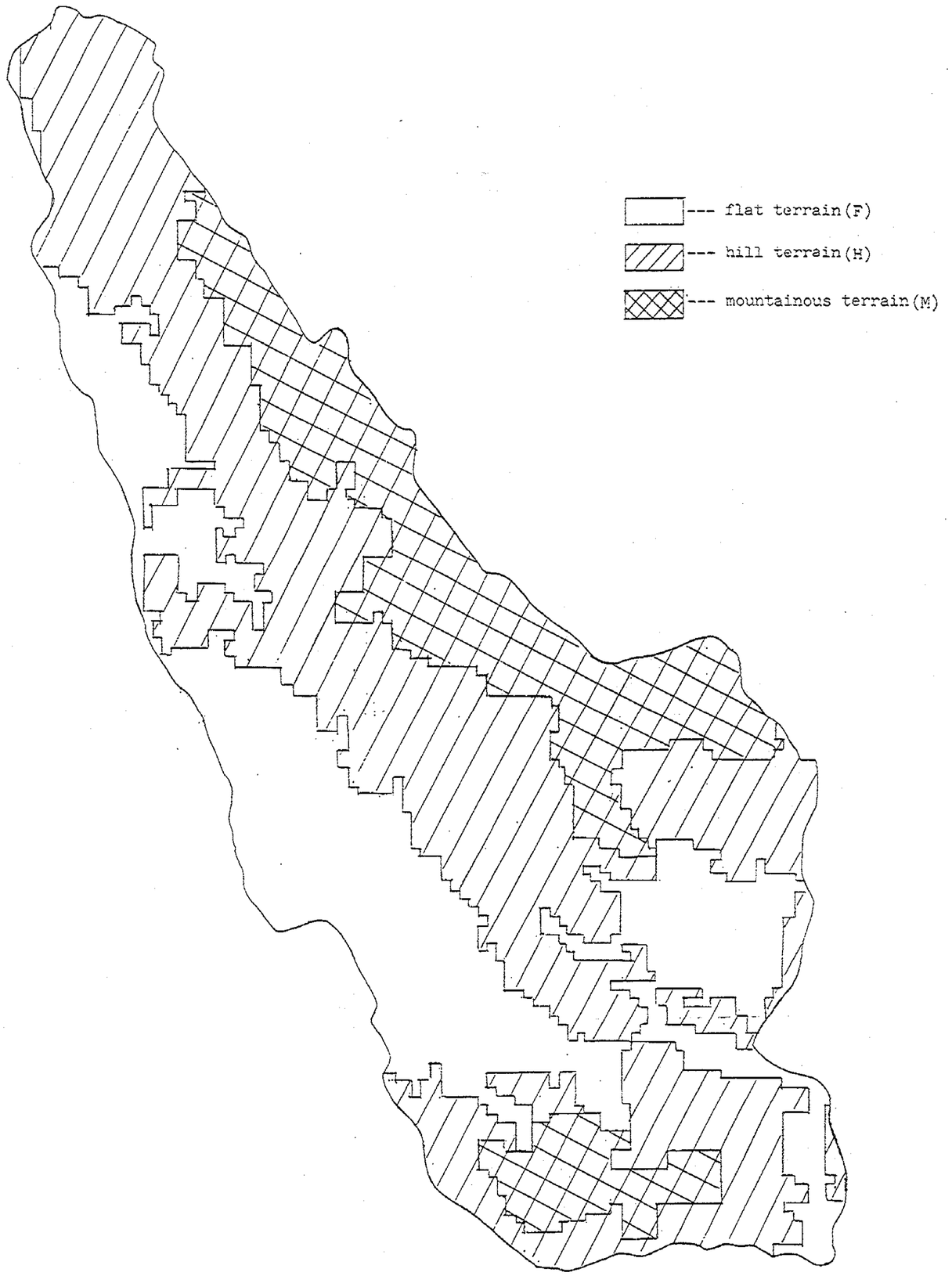


Fig. Ⅱ－4－1　　MAJOR CLASS OF TERRAIN

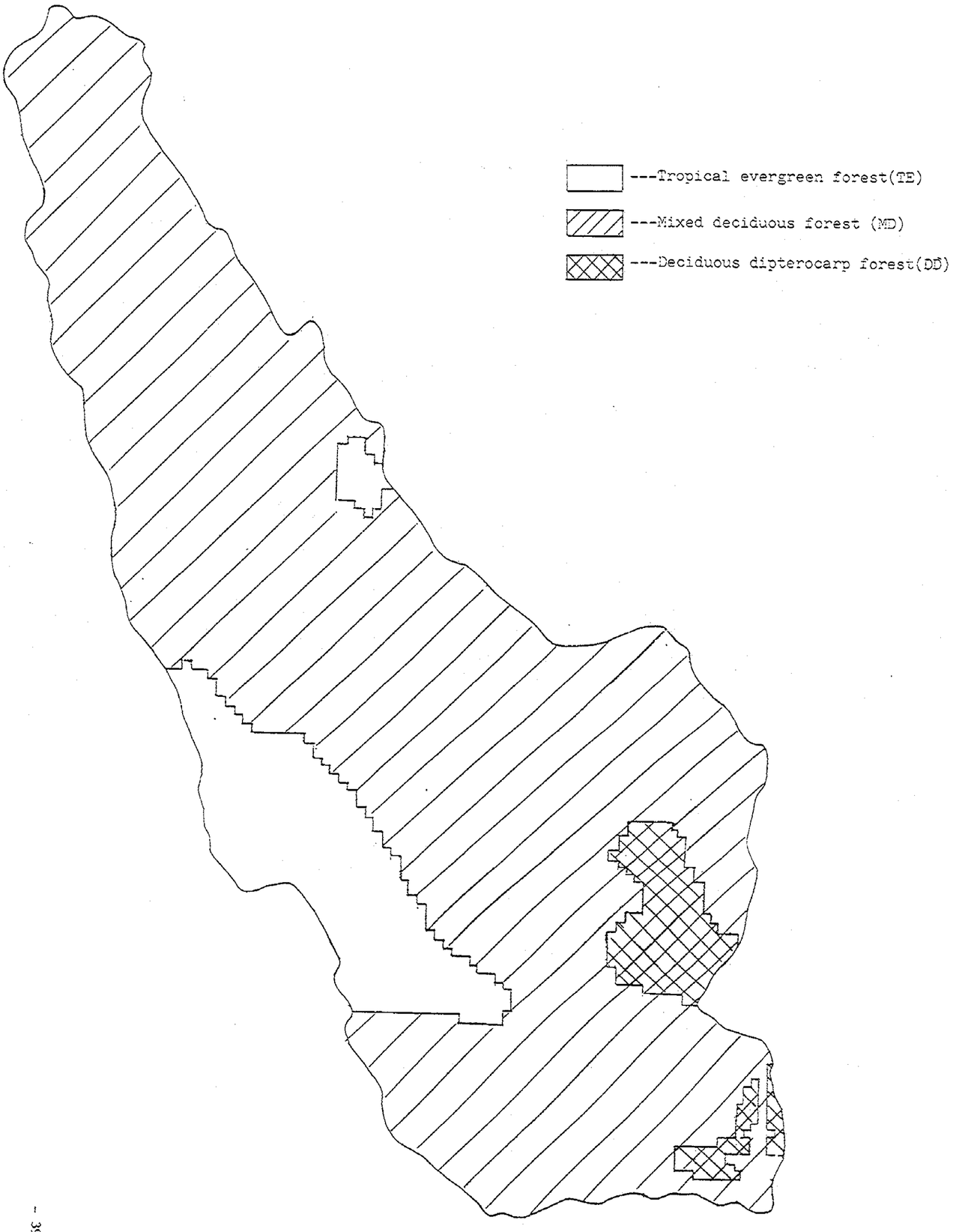


Fig. Ⅱ－4－2　FOREST TYPE

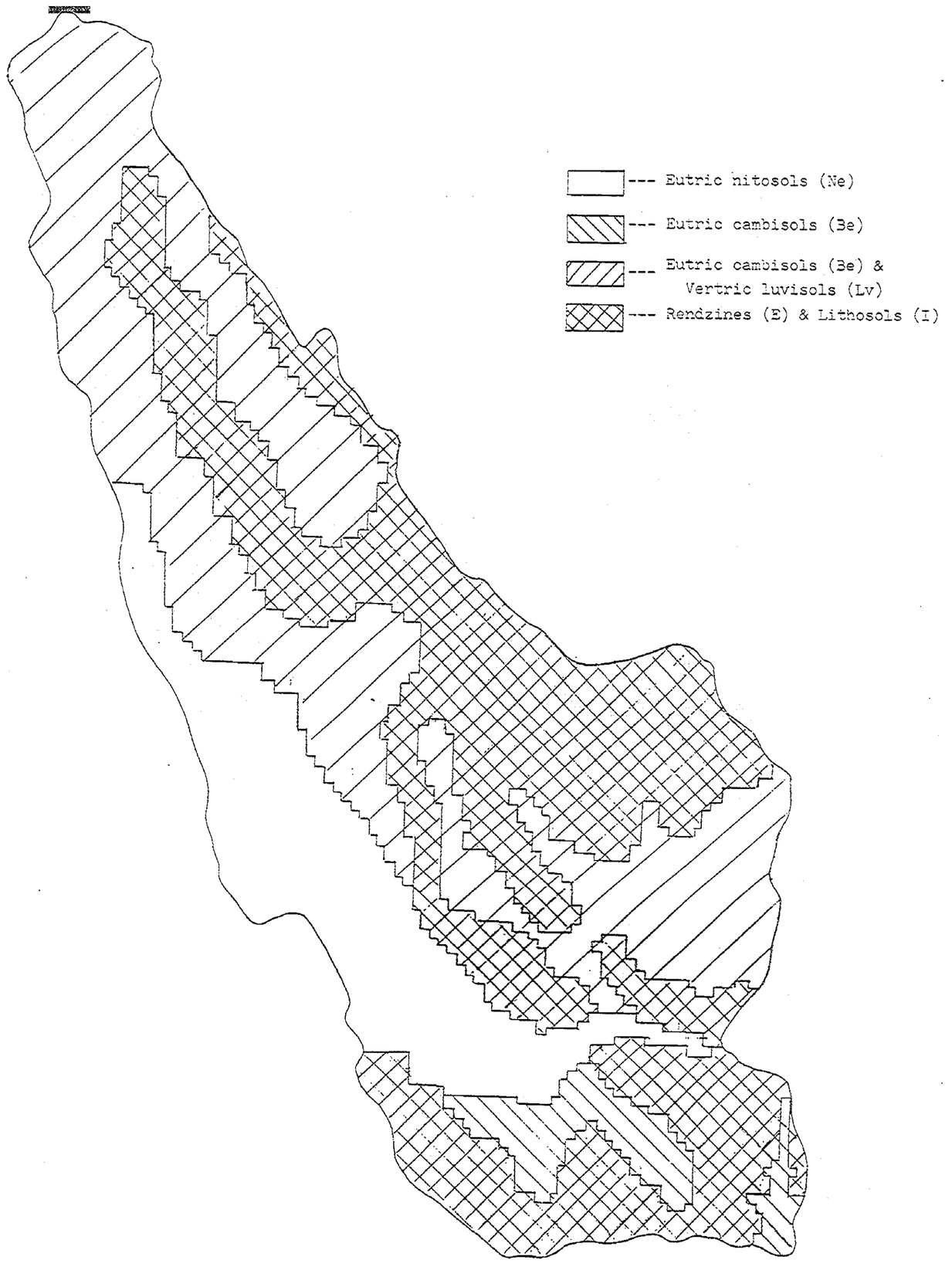


Fig. Ⅱ－4－3　　SOIL TYPE

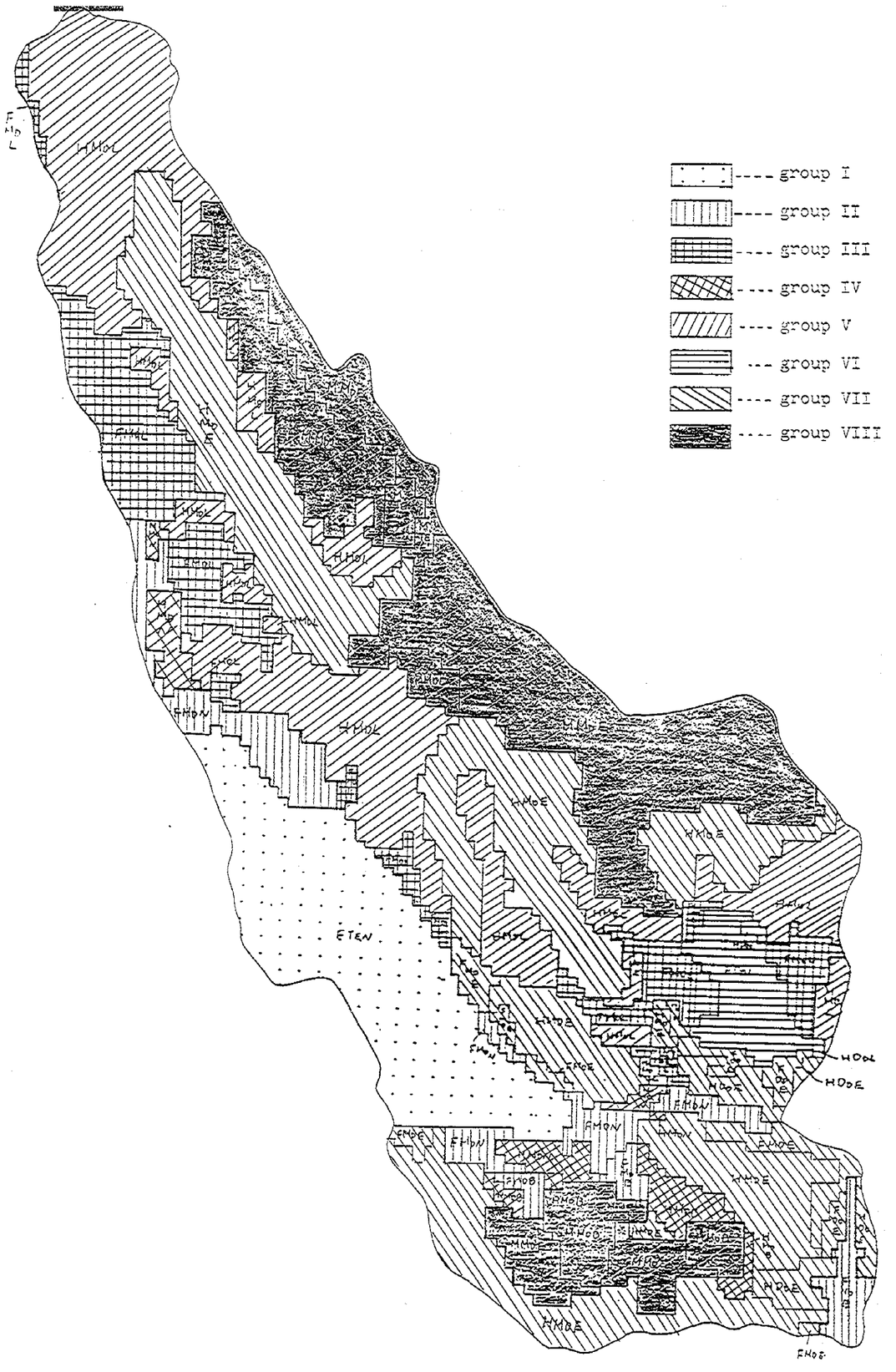


Fig. I－4－4 LAND TYPE CLASSIFICATION

(4) Land use capability classification

Land use capability classification means to further classify the land thus grouped into grades according to its potential use, whether it is for agriculture, forestry or livestock raising. Seven groups excluding Group VIII (mountainous topography) in the model area were classified in terms of the natural conditions of each site on the basis of comprehensive evaluation of the factors restricting the productivity of "agriculture", "forestry", and "livestock raising", respectively. Grades into which land is classified are as follows:

Grade I	Most suitable place
Grade II	Moderate suitable place
Grade III	Suitable place
×	Unsuitable place

1) Land use capability classification for agriculture

① Suitability for arability

The relative ease of cultivation and the preventability of erosion were evaluated in relation to the gradient which is a limiting factor, and suitability of each site in terms of arability which combines both of the foregoing was determined.

Suitability for Arability

Gradient	Relative ease of cultivation	Preventability of erosion	Arability
~ 5°	5	5 (5)	5 (5)
6° ~ 8°	4	4 (4)	4 (4)
9° ~ 13°	3	3 (2)	3 (2)
14° ~ 18°	2	2 (1)	2 (1)
19° ~ 23°	1	1 (0)	1 (0)
24° ~	0	0 (0)	0 (0)

( ): in case of soil type Ne

② Suitability for growability

The limitations on the growth range of roots and the maintainability of soil fertility were evaluated in relation to the soil which is a limiting factor, and suitability of each site in terms of growability which combines both of the foregoing was determined.

Suitability for Growability

Soil type	Limitations on the growth range of roots	Maintainability of soil fertility	Growability
Nc	4	3	4
Bc	3	4	3
Bc・Lv	2	2	2
I・E	1	2	1

③ Land use capability classification for agriculture

The suitability of each site as a result of an interaction between arability and growability was evaluated, based on which the model area was classified into four classes of farmland, namely, Grades I through III and unsuitable place.

Land Use Capability Classification for Agriculture

Gradient	Soil type			
	Nc	Bc	Bc・Lv	I・E
～ 5°	I	I	II	III
6°～ 8°	I	II	III	III
9°～ 13°	III	II	III	III
14°～ 18°	III	III	III	×
19°～ 23°	×	III	×	×
24°～	×	×	×	×

× ―― unsuitable place

2) Land use capability classification for forestry

① Suitability for silviculture

The relative easiness of forestation and tending and maintainability of soil fertility for silviculture were evaluated in relation to the gradient of each site which is a limiting factor, and suitability of each site for silviculture which combines both of the foregoing was determined.

Suitability for Silviculture

Gradient	Relative ease of forestation	Tending and maintainability of soil fertility	Suitability for silviculture
～13°	4	4	4
14°～18°	3	3	3
19°～23°	2	2	2
24°～30°	1	1	1
31°～	0	0	0

② Suitability for growability

The limitations on the growth range of roots and the restrictions on absorption of nutrients and water were evaluated in relation to the soil which is a limiting factor, and suitability of each site in terms of growability which combines both of the foregoing was determined.

Suitability for Growability

Soil type	Limitations on the growth range of roots	Restrictions on absorption of nutrients and water			Growability
		Water permeability	Water retentivity	Moisture	
Ne	4	4	4	4	4
Be	3	2	3	3	3
Be・Lv	2	1	2	2	2
I・E	1	4	1	1	1

③ Land use capability classification for forestry

The suitability of each site as a forest land resulting from the interaction between the suitability for silviculture and growability was evaluated, based on which the model area was classified into four classes of forest land, namely, Grades I through III and unsuitable place.

Land Use Capability Classification for Forestry

Gradient	Soil type			
	Ne	Be	Be • Lv	I • E
～ 13°	I	I	II	III
14°～ 18°	I	II	II	III
19°～ 23°	II	II	III	×
24°～ 30°	III	III	×	×
31°～	×	×	×	×

× – unsuitable place

3) Land use capability classification for livestock raising

① Suitability for maintainability

The relative easiness of maintenance work and the preventability of erosion for maintainability as a natural grass land were evaluated in relation to the gradient of each site which is a limiting factor, and the suitability of each site in terms of maintainability which combines both of the foregoing was determined.

Suitability for Maintainability

Gradient	Relative ease of maintenance work	Preventability of erosion	Maintainability
～ 8°	4	4 (4)	4 (4)
9°～ 18°	3	3 (2)	3 (2)
19°～ 23°	2	2 (1)	2 (1)
24°～ 30°	1	1 (0)	1 (0)
31°～	0	0 (0)	0 (0)

( ) : in case of soil type Ne

② Suitability for growability

The limitations on the growth range of grass roots and the restrictions on absorption of nutrients and water were evaluated in relation to the soil which is a limiting factor, and suitability of each site in terms of growability which combines both of the foregoing was determined.

Suitability for Growability

Soil type	Limitations on the growth range of roots	Restrictions on absorption of nutrients and water			Grow-ability
		Water permeability	Water retentivity	Moisture	
Nc	4	4	4	4	4
Bc	4	2	3	3	3
Bc・Lv	3	1	2	2	2
I・E	2	4	1	1	1

③ Land use capability classification for livestock raising

The suitability of each site as a natural grass land resulting from an interaction between the maintainability and the growability was evaluated, based on which the model area was classified into four classes of grazing land, namely, Grades I through III and unsuitable place.

Land Use Capability Classification for Livestock Raising

Gradient	Soil type			
	Nc	Bc	Bc・Lv	I・E
～ 8°	I	I	II	III
9°～18°	II	II	II	III
19°～23°	III	II	III	III
24°～30°	×	III	III	×
31°～	×	×	×	×

× -- unsuitable place

4) Preparation of a site analysis map

Land use capability classification for each of agriculture, forestry and livestock raising was summarized and a site analysis map - land use capability classification map - of the model area was prepared, which is as per the survey results attached hereto. Land use capability classification for each of agriculture, forestry, and livestock raising is as shown on Fig. II-4-5~7.

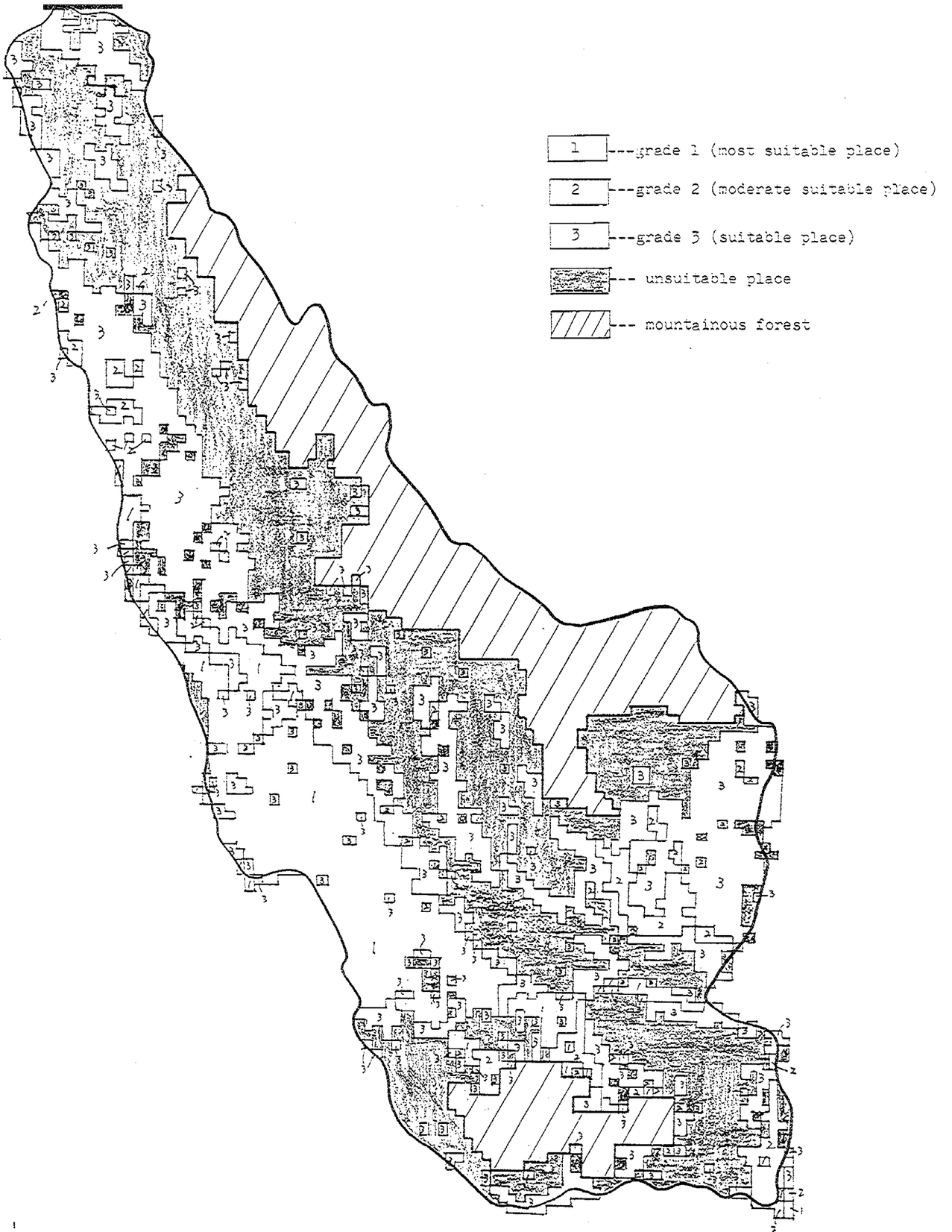


Fig. II-4-5 LAND USE CAPABILITY CLASSIFICATION
- FOR AGRICULTURAL LAND -

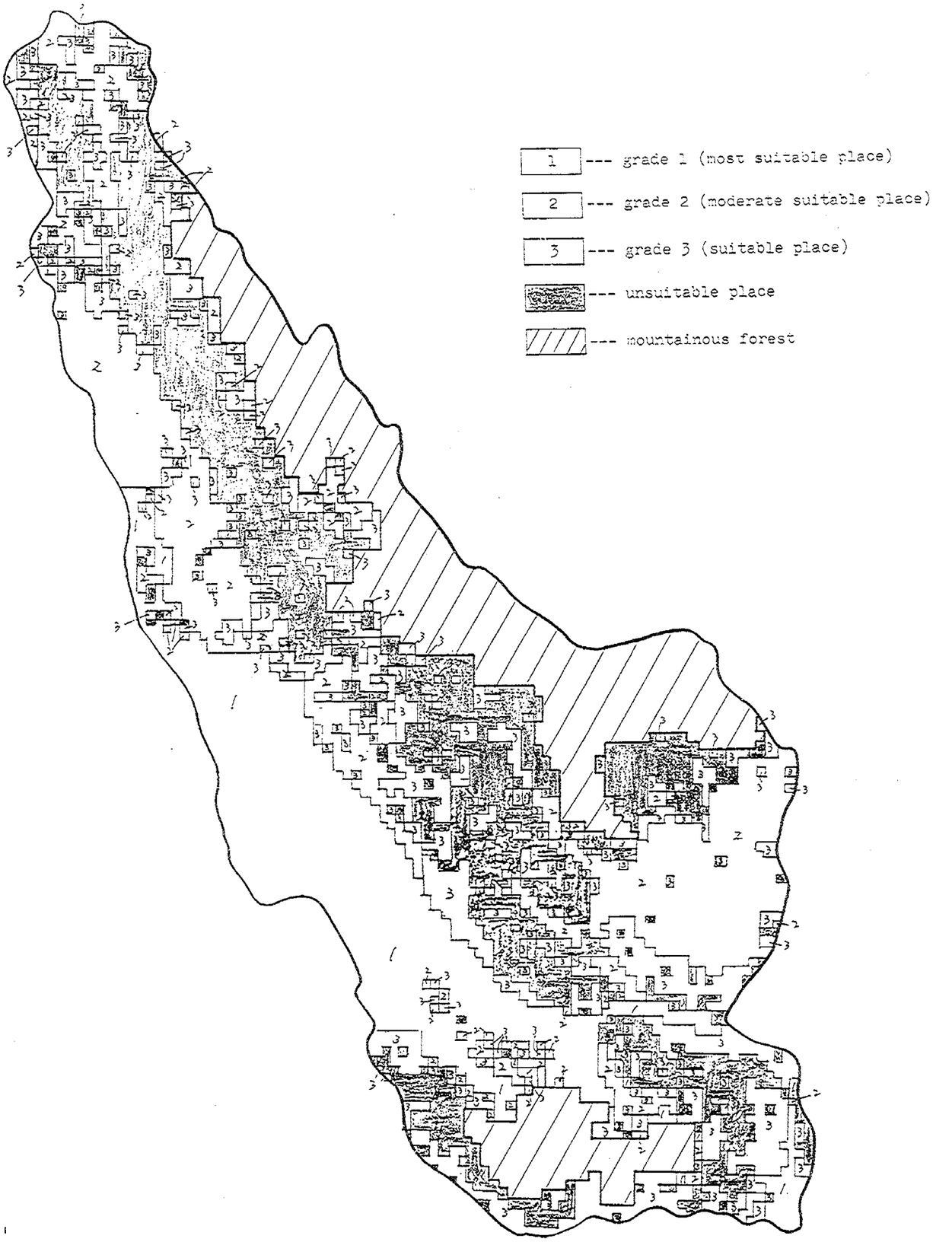


Fig. I-4-6 LAND USE CAPABILITY CLASSIFICATION
- FOR FORESTRY LAND -

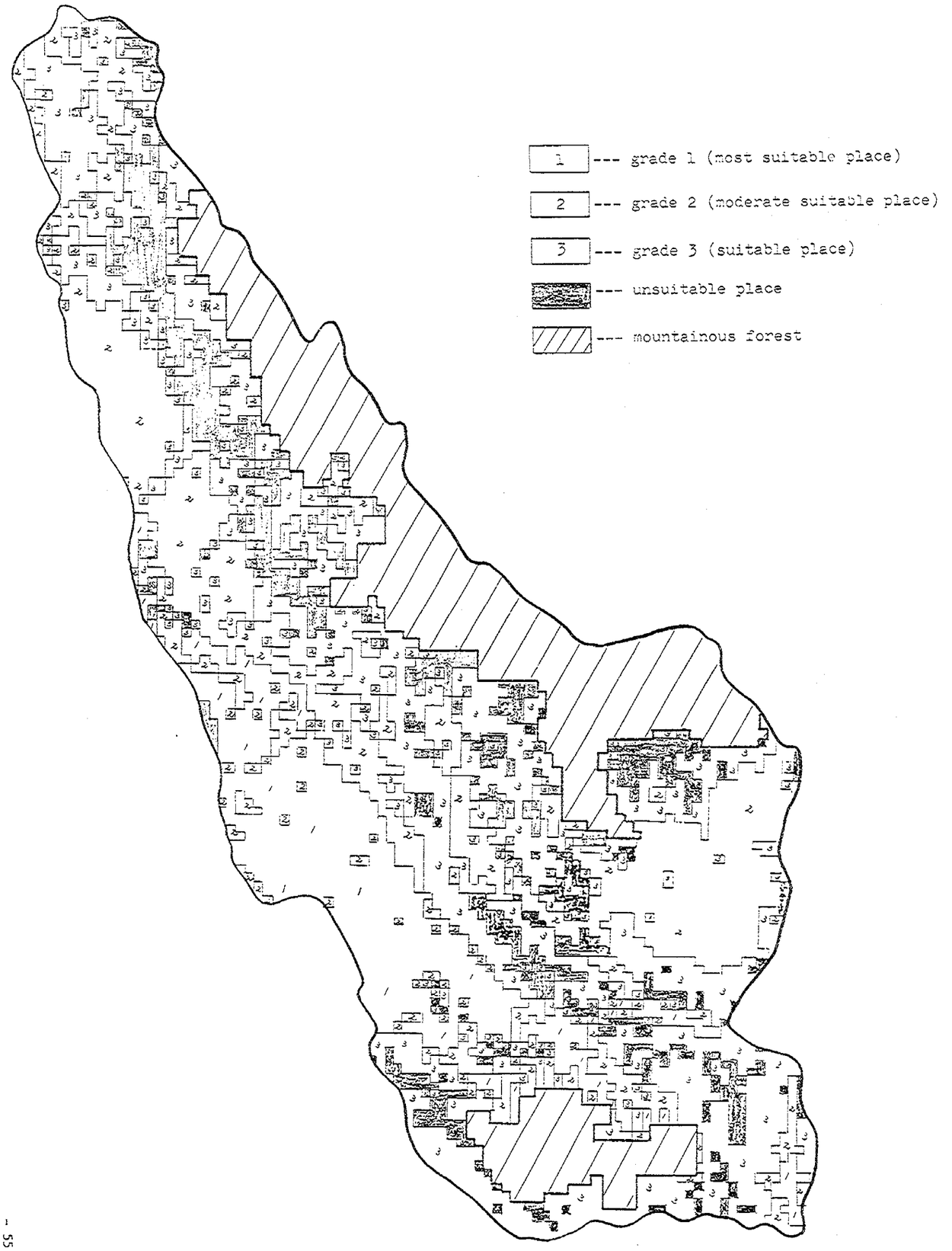


Fig. Ⅱ－4－7 LAND USE CAPABILITY CLASSIFICATION
- FOR STOCK FARMING LAND -

5. Main Survey for the National Forest Management Plan

(1) Field works

1) Survey for the land use plan

① Existing land use

Data on land use were collected during the current survey as a premise for preparing a proposed land use plan. According to these data, the ratio of the forests to the total land area in Kanchanaburi Province, where the survey area is located, is quite high compared to the national average and the average for the central region, indicating that forests are still preserved there while the ratio of the agriculture-related land such as paddy fields and orchards is low, suggesting that Kanchanaburi Province is an exceptional area in the central region of Thailand. (Refer to Table II-5-1)

Table II-5-1 Existing Land Use

(Unit: ㎢)

Region / Kind of land use	Whole Kingdom		Central Plain Region		Kanchanaburi Province	
	Area	%	Area	%	Area	%
Total	513,115.0	100.0	67,398.7	100.0	19,483.2	100.0
Forest	154,027.9	30.0	18,075.7	26.8	12,125.2	62.2
Living land	4,143.5	0.8	694.3	1.0	76.0	0.4
Paddy field	117,815.5	23.0	16,994.6	25.2	751.5	3.9
Cash crop	47,084.8	9.2	8,607.6	12.8	1,739.6	8.9
Orchard	19,050.4	3.7	1,803.8	2.7	91.3	0.5
Horticulture	548.8	0.1	209.3	0.3	10.6	0
Grass land	1,225.3	0.2	222.1	0.3	8.7	0
Barren land	6,256.9	1.2	264.0	0.4	29.7	0.2
Others	2,643.0	0.5	227.9	0.4	33.1	0.2
Unclassified	160,318.9	31.3	20,299.4	30.1	4,617.5	23.7

② Attrition of forests

The attrition in the size of forest areas is as shown in Table II-5-2. Every figure follows a sharp declining trend, from which it is easily understood why the priority in formulating the land use plan lies in preventing the decrease in the size of the forest areas.

Table II-5-2 Annual Attrition of forest Areas

(Unit: km²)

Region / Year	Whole Kingdom		Central Plain Region		Kanchanaburi Province	
	Area	%	Area	%	Area	%
Total	513,115	100.0	67,399	100.0	19,483	100.0
1961	273,629	53.3	35,661	52.9	17,793	91.3
1973	221,707	43.2	23,970	35.6	13,549	70.0
1976	198,417	38.7	21,826	32.4	13,417	68.9
1978	175,224	34.2	20,426	30.3	13,329	68.4
1982	156,600	30.5	18,516	24.5	12,417	63.7
1985	149,053	29.0	17,228	25.6	11,562	59.3

③ Existing roads

The road conditions in Kanchanaburi Province and the model area are as shown on Fig. II-5-1 and Fig. II-5-2 respectively. Although national highway route No. 323 and route No. 3199 are wide and well paved good roads, the other roads, excepting for the few which are maintained by a mining company, are rugged and difficult to travel on except during the dry season.

Access from Kanchanaburi City, which is the industrial center of Kanchanaburi Province to the model area can be made via a paved road as far as Srinagarind Dam, but the road on the west bank of the reservoir is quite poor in many places and cannot function as an industrial road as it is. The mining company which passes through the model area crosses its trucks on its own dedicated ferryboat over the reservoir to the east bank instead of using this road.

Thong Pha Phun located in the northwestern part of the Province is a base for the wood industry in this area. A road from the model area leads to this area, but this road is unpaved and poorly aligned and requires large scale improvement in the future. At any rate, hauling of timber is possible during the dry season but difficult during the rainy season under the existing road conditions.

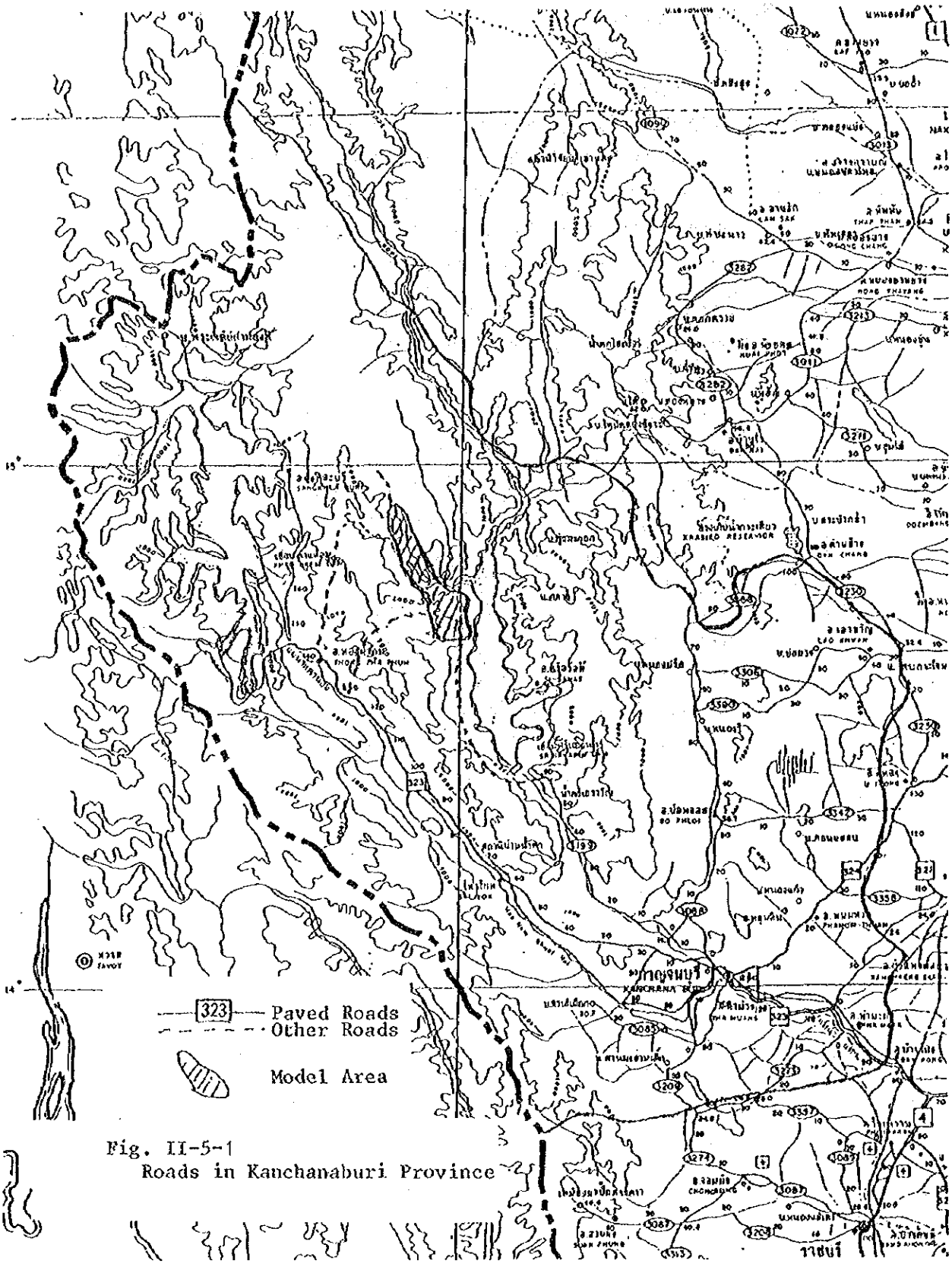


Fig. II-5-1
Roads in Kanchanaburi Province

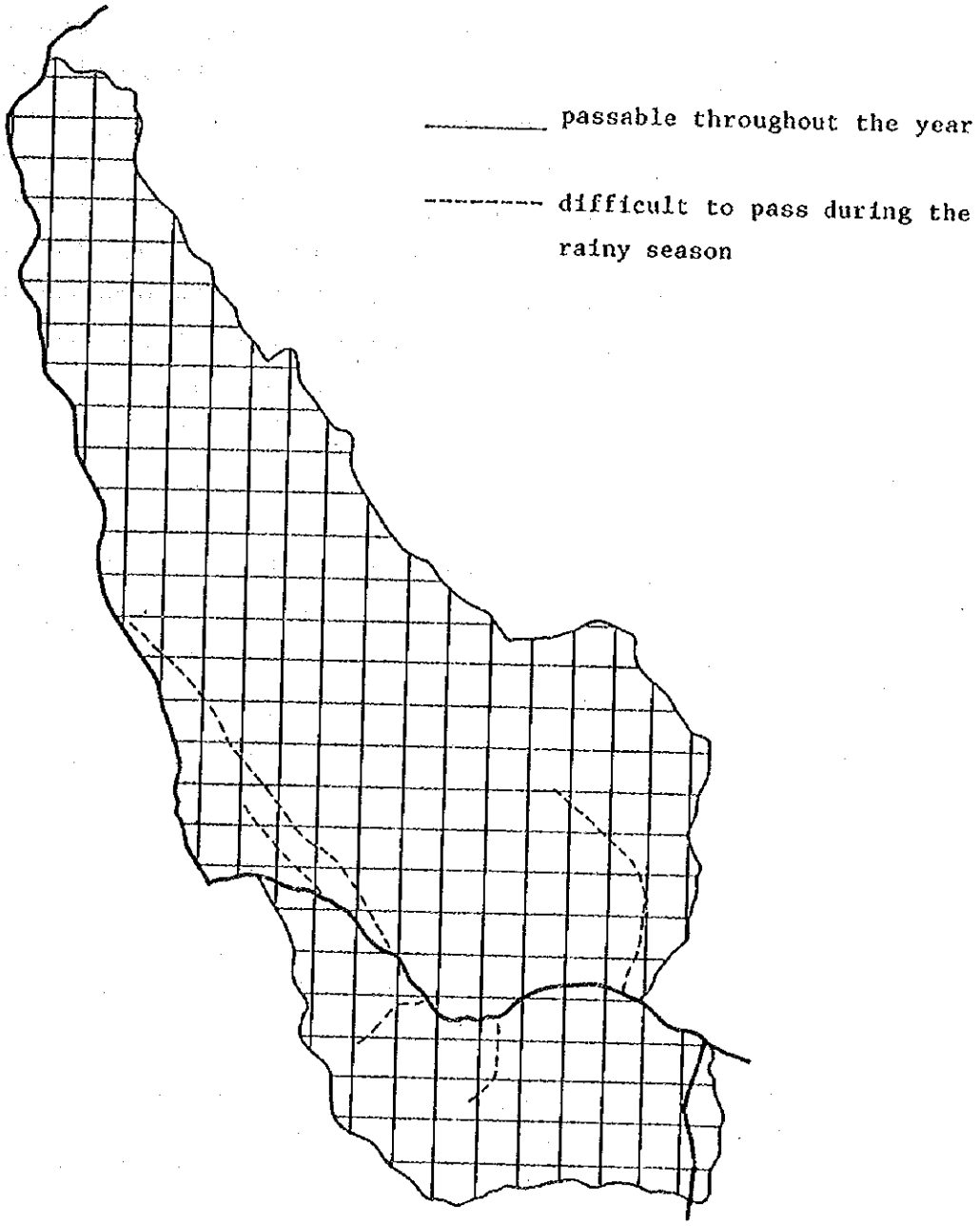


Fig. II-5-2 Roads in the Model Area

2) Survey on forest village and tropical farming

(1) Implementation of the survey

The inhabitants living in the model area (20,000 has.) were surveyed as a part of the survey on forest village and tropical farming. The survey aims to clarify family composition, kinds of farm crops, planting area, yield, prices of farm products, income, etc. and was conducted on 86 families of nine villages of Klong-Ngu, Huai Ban Kao, Phu Toei, Doug Yai, Doug Glang, Dong Lek, Pak Muang, Phu Muang, and Phu Ta Ma. The locations where survey was conducted and the number of families surveyed at each location are as shown on Fig. II-5-3 and Table II-5-3.

Table II-5-3 Number of Surveyed Family and Village Name

Number of surveyd family(No)	Village	District	Amphoe	Province
1 (№1)	Klong-Ngu	Chalae	Thong Pha Phum	Kanchanaburi
2 (№2, 3)	Huai Ban Kao			
52 (№4~55)	Phu Toei			
9 (№56~64)	Dong Yai	Dan Mae Chalaop	Si Sawat	
5 (№65~69)	Dong Glang			
6 (№70~75)	Dong Lek			
1 (№76)	Pak Muang			
2 (№77, 78)	Phu Muang			
8 (№79~86)	Phu Ta Ma			
Total 86				

All inhabitants of the model area: Estimated to be about 100 families.

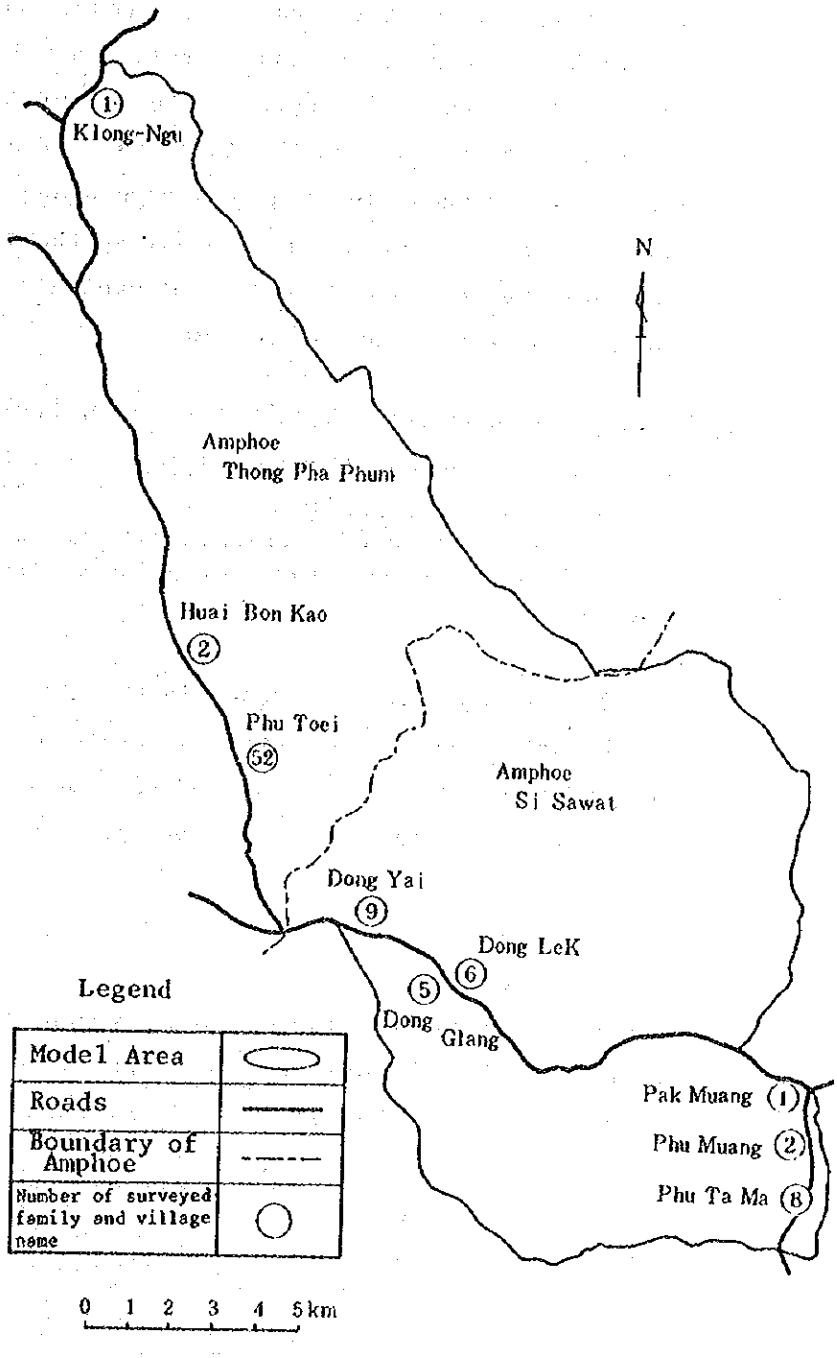


Fig. II-5-3 Study Location of Forest Village and Tropical Farming

② Survey method

The survey was conducted by interviewing all inhabitants (estimated to be about 100 families) within the model area using a pre-determined questionnaire (refer to the material attached at the end of this report) similar to that used in the basic survey. The actual sample size covered, however, was 86 families, as 14 families (particularly those in Dong Yai, Dong Gland and Dong Lek) were out of the model area during the dry season and could not be interviewed. The contents of the questionnaire were for as follows.

- o Family composition (family size, sex, age)
- o Living environment (house, assets, fuel, food)
- o Actual operating conditions
  (area cultivated, agricultural implements used, kinds of crops grown, crop yield, income, etc.)
- o Others

Besides the questions included in the questionnaire, the inhabitants were asked what they intended to do from now on, and how were the living condition before they moved to the present place, etc. as appropriate.

③ Survey results

Based on the entries in questionnaire sheets, answers were summarized by survey item. The survey findings are as presented in Table II-5-4. Findings on each survey item are as outlined below.

Table II-5-4 Summary of Survey Results

Dec., 1986 - Jan., 1987

Item				Total	Mean value per family	Remarks
Number of surveyed family				86		
Settlement duration (years)					4.8	
Working force (families)	Full-time farmer			25 (29.1%)		
	Part-time farmer			54 (62.8%)		
	Non-farmer			7 (8.1%)		
Members of family (persons)	Total			429	5.0	
	Sex	Male		229	2.7	
		Female		200	2.3	
Area of living space (wah²)				23,025	267.7 (0.6) rai)	400 wah² = 1 rai = 0.16 ha
Area of farm land (rais)	Own	Upland		3,034	44.7	69 families
		Paddy		51		
	Leased	Upland		125	11.4	11 families
		Paddy		0		
	Planted	Upland		1,165.1	15.6	78 families
		Paddy		51		
Annual cash income (bahts)		Farm		389,530	9,534.3	1US$ = about 25 bahts
		Non-farm		428,700		
Household economy	Rice consumption (kgs/week)			1,405.0	16.3	
	Cash outlay on food (bahts/week)			14,006.2	162.9	
	Fuel consumption (m³/week)	Firewood		12.486	0.431 (29 families)	1 m³ = 320 kgs
		Charcoal		15.829	0.259 (61 families)	1 m³ = 87 kgs (*Eucalyptus camaldulensis*)
	Method of acquisition of each fuel (families)	Firewood	Total	29 (33.7%)		
			Collection	29 (33.7%)		
			Purchase	0		
		Charcoal	Total	61 (70.9%)		
			Home-made	57 (66.3%)		
			Purchase	4 (4.6%)		
Prevalent state of agriculture and livestock raising	Annual cash farm income (bahts)		Livestock	8,000	4,930.8	79 families
			Farm crop	381,530		
	Livestock production (actual raising quantity)		Cattle	2		1 family
			Water buffalo	1		1 family
			Chicken	902		59 families
			Duck	42		8 families
	Farm crop production (planted area, rais)		Total	1,449.1 (100.0%)		Total planted area included intercrop and mixed cropping
			Maize	492.0 (34.0%)	14.9	33 families
			Rice	357.0 (24.6%)	7.8	46 families
			Castor bean	168.6 (11.6%)	6.0	28 families
			Chilli	20.5 (1.4%)	2.9	7 families
			Taro	12.0 (0.8%)	4.0	3 families
			Ground nut	9.0 (0.6%)	3.0	3 families
			Soy bean	4.0 (0.3%)	2.0	2 families
			Fruits	372.0 (25.7%)	62.0	6 families
			Others	14.0 (1.0%)	4.7	3 families
Awareness of inhabitants	Previous occupation (%)		Full-time farmer	39.5		
			Part-time farmer	41.9		
			Non-farmer	17.4		
			Unknown	1.2		
	Adequacy of the size of farm land (%)		Adequate	55.8		
			Inadequate	43.0		
			Unknown	1.2		
			Desirable area (rais)		41.1	
	Water supply for the cultivated land (%)		Sufficient	95.3		
			Insufficient	1.2		
			Unknown	3.5		

a. Settlement duration

Average settlement duration of 86 families is 4.8 years, from which it can be seen that many of them have moved in recently.

b. Working forms

The inhabitants were classified by the working form into full-time farmers, part-time farmers and non-farmers. Full-time farmers accounted for 29.1% of the total, part-time farmers for the majority of 62.8% and non-farmers 8.1%.

c. Family composition

The total number of members of 86 families is 429 persons, which means that the average family size is 5.0 persons. When the distribution of families by family size is reviewed, the families with three to six members are the largest in number as shown in Fig. II-5-4, with families with six members in particular accounting for 23.3% of the total. The population distribution by age group of every five years is as shown in Fig. II-5-5. The age composition of family members shows that the age group of 15-19 accounts for 14.9% of the total, the age group of 10-14 of 13.3% and the age group of 5-9 for 11.9%, with the three groups of between 5 and 19 which represent the younger generation jointly accounting for about 40% of the total.

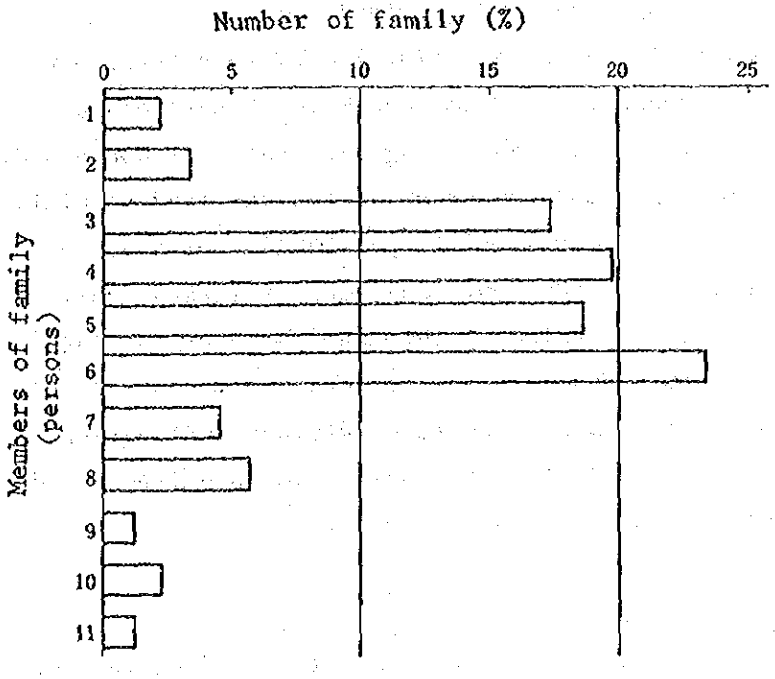


Fig. II-5-4 Distribution of Families by Family Size (86 families)
Dec.,1986 - Jan.,1987

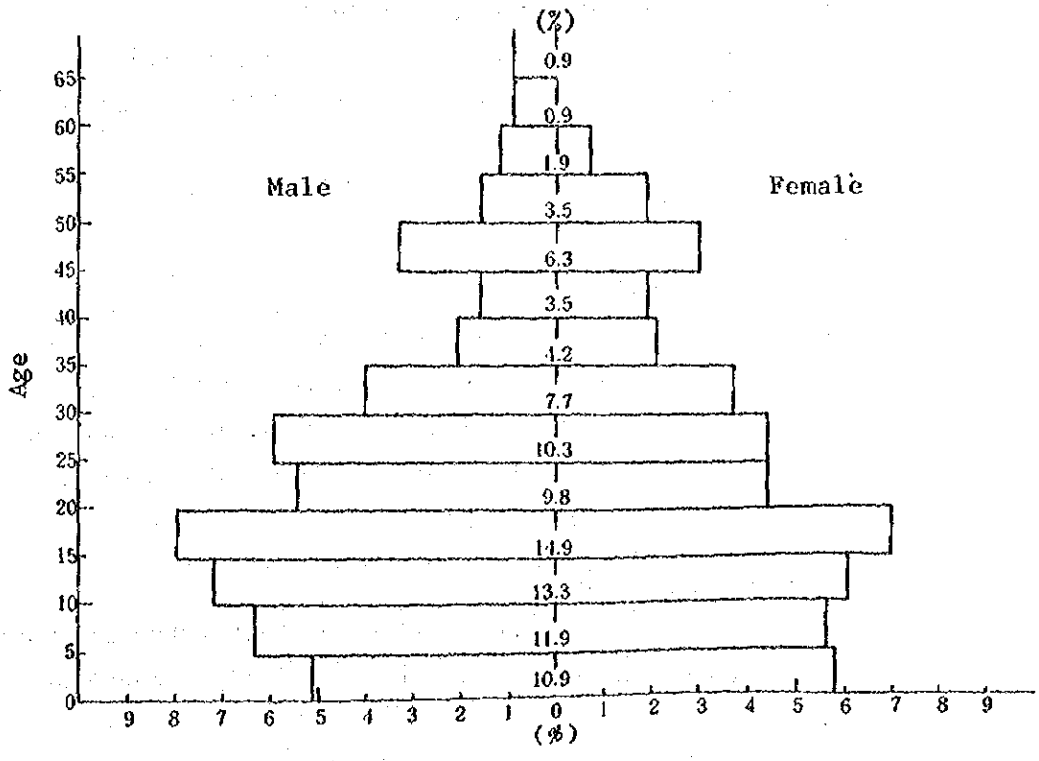


Fig. II-5-5 Age Composition of Family Members (86 families, 429 persons)
Dec.,1986 - Jan.,1987

d. Areas of living space and farmland

The average living space is 267.7 wak^2 (0.67 rai) per family. Altogether 69 farm households own farmland totalling 3,085 rais, averaging 44.7 rais per household. 11 families operate farming on leased farmland totalling 125 rais, averaging 11.4 rais per family. Of all the families surveyed (86 families), 78 families actually cultivate their farmland. The total area of farmland actually cultivated by owner farmers and tenant farmers is 1,216.1 rais, averaging 15.6 rais per cultivating farm household. Most of the farm land is upland fields, with only a few water paddy fields.

e. Annual cash income

The average annual cash income of all the families surveyed (86 families) is 9,514.3 bahts, consisting of 4,529.4 bahts from sales of farm products and 4,984.9 bahts from non-farm employment.

The average annual cash farm income of 79 farm households is 4,930.8 bahts, consisting of 4,829.5 bahts from sales of farm products and 101.3 bahts from sales of livestock products.

f. Household economy

i) Rice consumption

Polished rice consumption per family is 16.3 kgs. per week on average, which is equivalent to 849.9 kgs. per year. Assuming that hulling yield is 80% and polishing yield in 94%, 849.9 kgs. of polished rice is equivalent to 1,130.2 kgs. of unhulled rice.

ii) Cash outlay on food

Cash outlay on food per family is 162.9 bahts per week on average, which is equivalent to 8,494.1 bahts per year.

iii) Fuel consumption

Two kinds of fuel, firewood and charcoal, are used. The usage mode and method of acquisition vary depending on each village and each family. As shown on Table II-5-5, some families use only charcoal, some use only firewood and some use both, but the families which use charcoal account for 70.9% of all families surveyed which is much larger than the percentage of families which use firewood. Firewood is gathered by the families themselves, and charcoal is also produced captively.

Firewood consumption per family is 0.431 m^3 per week on average, or equivalent to 22.474 m^3 per year, and charcoal consumption is 22.5 kgs. (equivalent to 0.259 m^3 of log) per week on average, or equivalent to 1,173.2 kgs. (equivalent to 13.505m^3) per year.

Table II-5-5 Method of Acquisition of Each Fuel
(86 surveyed families)

Division	Firewood			Charcoal		
	Total	Collection	Purchase	Total	Home-made	Purchase
Number of family	29	29	0	61	57	4
%	33.7	33.7	0	70.9	66.3	4.6

Contain plural answer

g. Prevalent state of agriculture and livestock raising

i) Livestock production

Major livestock in the model area are cattle, water buffaloes, chickens and ducks. As shown in Table II-5-6, 67 families out of 86 families surveyed are raising chickens and ducks sheerly for self-consumption. Very few farm households raise cattle and water buffaloes. Inhabitants in this area are not strongly oriented toward stock raising.

Table II-5-6 Livestock Production in the Model Area
(86 surveyed families)

Year: 1986

Kind of livestock	Actual raising quantity	Annual cash income		Raising-family	
		bahts	%	number	%
Cattle	2	8,000	100.0	1	1.2
Water buffalo	1	0	0	1	1.2
Chicken	902	0	0	59	68.6
Duck	42	0	0	8	9.3
Total		8,000	100.0	69	

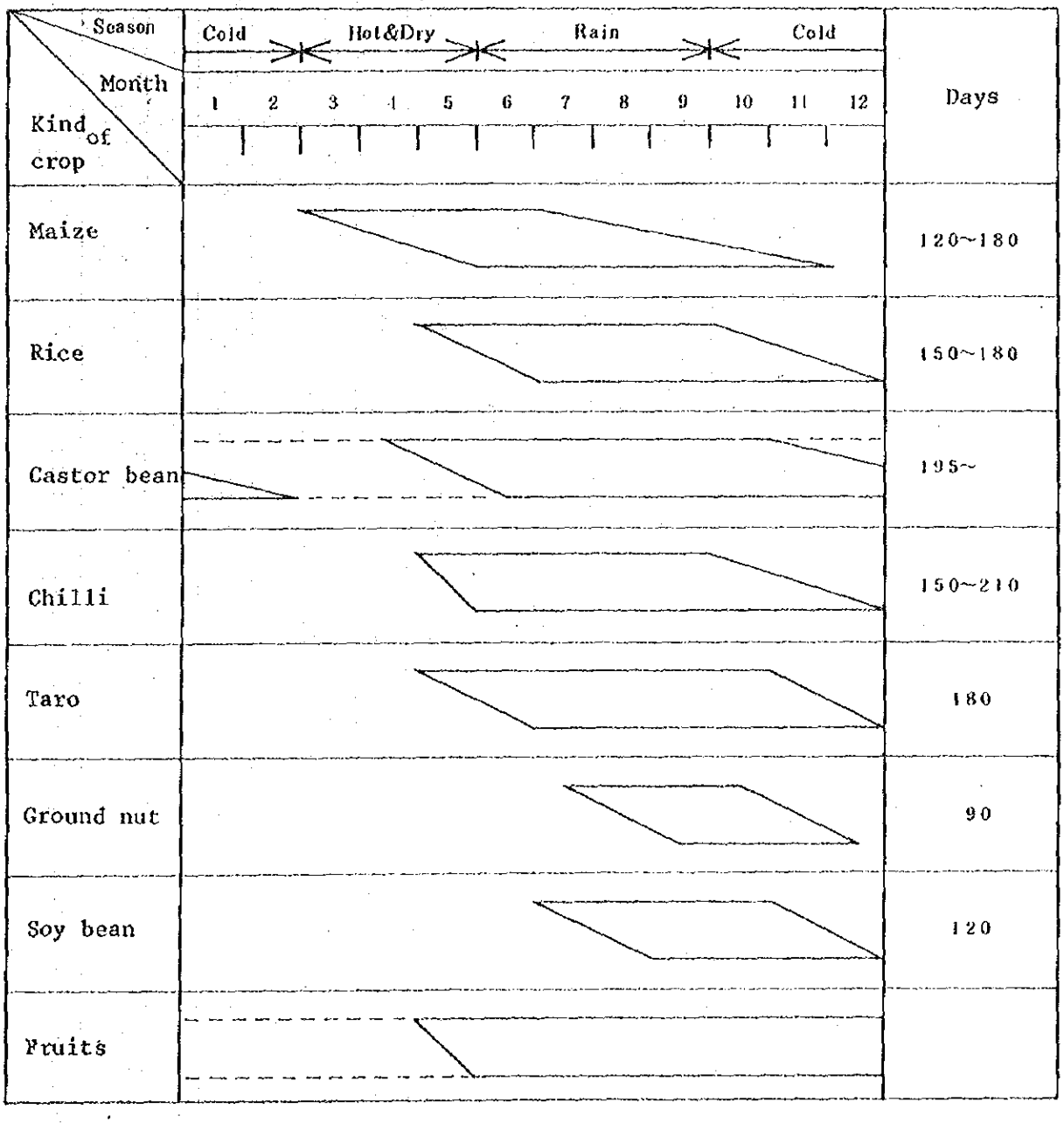
ii) Farm crop production

The cropping seasons and the climatic conditions in the model area are as shown in Table II-5-7. As no irrigation facility is available and natural water supply must be relied on natural condition, the cropping seasons are concentrated in the rainy season. As can be seen from Table II-5-8, dry field crops such as maize and castor beans which require little water except in the case of rice are mostly planted. Major cash crops are maize and castor beans, which together account for most of the annual cash revenues from sales of farm products. As can be seen from Fig. II-5-6, annual cash revenues per rai are extremely high for peppers and groundnuts but generally low for other crops.

As only a very few fruits trees have reached the economically productive age, fruit production and income from them are quite low despite the large planted area.

Table II-5-7 Cropping Seasons and Climatic Conditions in the Model Area

1. Kind of crop and cropping season Year: 1986



2. Climatic Conditions

Meteorological station	Air Temperature (°C)			Annual rainfall (mm)	Annual rainy days (days)	Remarks
	Maximum	Minimum	Annual mean			
Srinagarind Dam	31.0	22.0	26.5	998.1	133	1981 - 1985
Si Sawat	33.2	19.6	26.5	998.2	122	1983 - 1985

Table II-5-8 Farm Crop Production in the Model Area (86 surveyed families)

Year: 1986

Kind of crop	Planted area (rais)	%	Seed quantity (Kgs)	Seed cost (bahts)	%	Yield (Kgs)	Annual cash income (bahts)	%	Yield per rai (Kgs/rai)	Annual cash income per rai(bahts/rai)	Number of cropping family	%	Planted area per family (rais)
Maize	492.0	34.0	2,016.0	5,375	8.5	126,620	134,306	35.2	257.4	273.0	33	38.4	14.9
Rice	357.0	24.6	4,441.0	4,030	6.3	68,724	0	0	192.5	0	46	53.5	7.8
Castor bean	168.6	11.6	459.7	12	0.1	15,986	78,564	20.6	94.8	466.0	28	32.6	6.0
Chilli	20.5	1.4	20,550 plants	0	0	1,200	39,300	10.3	58.5	1,917.1	7	8.1	2.9
Taro	12.0	0.8	54.0	0	0	3,400	6,800	1.8	283.3	566.7	3	3.5	4.0
Ground nut	9.0	0.6	45.0	25	0.1	4,520	18,920	5.0	502.2	2,102.2	3	3.5	3.0
Soy bean	4.0	0.3	14.0	—	—	520	2,440	0.6	130.0	610.0	2	2.3	2.0
Fruits	372.0	25.7	—	52,224	82.5	—	78,200	20.5	—	210.2	6	7.0	62.0
Others	14.0	1.0	—	1,600	2.5	—	23,000	6.0	—	1,642.9	3	3.5	4.7
Total	1,449.1	100.0		63,266	100.0		381,530	100.0			131		

Planted area: Total planted area included intercrop and mixed cropping.

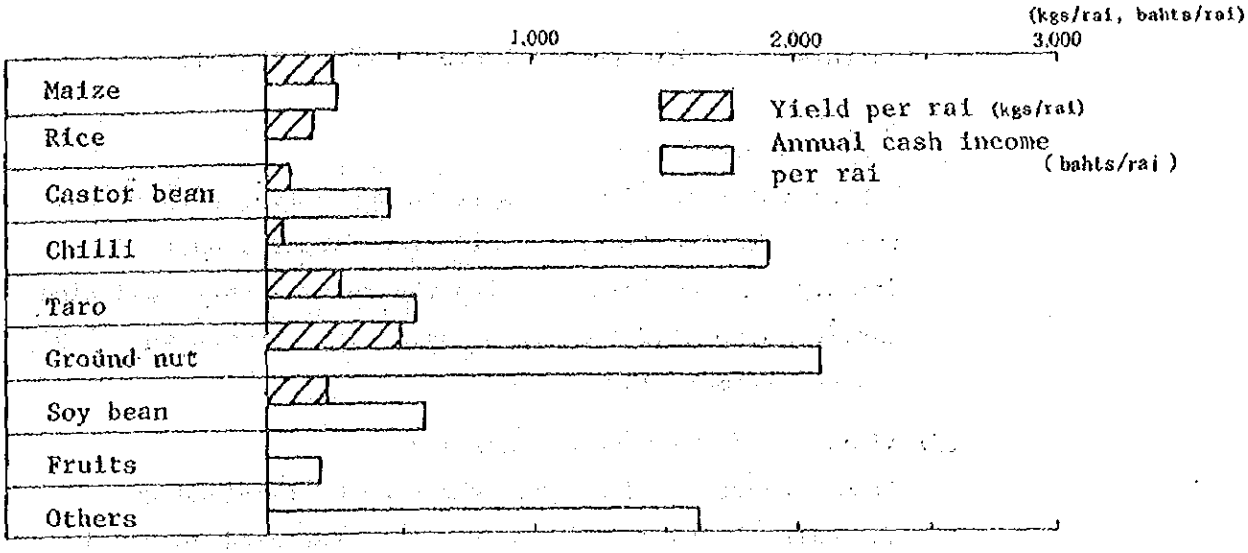


Fig. II-5-6 Yield and Annual Cash Income per rai of Each Kind of Crop
Year: 1986

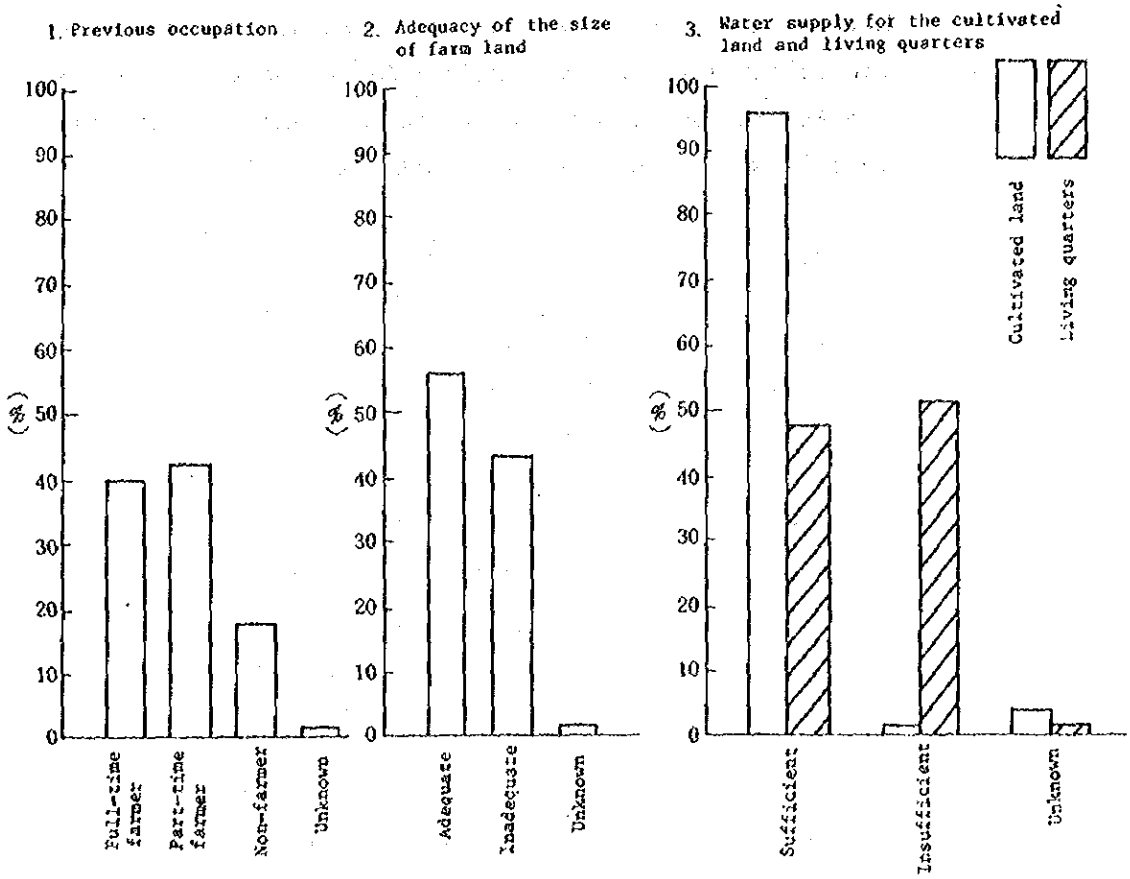


Fig. II-5-7 Awareness of Inhabitants Dec.,1986 - Jan.,1987

h. Awareness of inhabitants (Refer to Fig. II-5-7)

i) Previous occupation

Inhabitant's previous occupation was surveyed under the three classifications of full-time farmers, part-time farmers and non-farmers, with the results that full-time farmers accounted for 39.5%, part-time farmers for 41.9% and non-farmers for 17.4%.

ii) Adequacy of the size of farmland

To the question of whether the size of farmland was adequate, 55.8% of all the families surveyed answered that it was, adequate whereas 43.0% answered inadequate. The average size of farmland desired by the inhabitants who answered "inadequate" is 41.1 rais per family.

iii) Water supply for the cultivated land and living quarters

Most of the inhabitants answered that water supply for the cultivated land was ample. As for water supply to the living quarters 51.1% of the inhabitants answered that it was inadequate and 47.7%, "sufficient".

④ Comments

For farm crop cultivation, flat land and gentle sloped land are used. In general, farm land is cultivated perennially, but if the size of land holdings is large, a part of it is fallowed after a few years of cropping and cultivation is shifted to some other new place within one's holdings.

Inhabitants living inside the model area obtain cash income from cultivation of such crops as maize and castor beans and from hired labor during the dry season.

Agriculture in this area is operated by family labor which employs conventional farming methods so that its productivity is low. The daily wage of a hired labor is around 30 to 40 bahts (1 US$ equals around 25 bahts). Also, no rice cropping for home consumption can be observed within the designated area of the National Park. As a result, the income level of the inhabitants of the model area is low, and the ratio of cash outlay for food to their annual cash income is extremely high.

From the results of the current survey, it was found that the planted area of rice per rice cultivating family (46 families) is 7.8 rais while the necessary area for cultivating rice for home consumption is 5.9 rais when calculated from the unhulled rice requirement of 1,130.2 kgs. obtained by converting the annual rice consumption per family into the weight of unhulled rice and yield per rai of 192.5 kgs. The average area of cultivate land per farming family (79 families) is 15.6 rais, which is almost equal to the size of the farm land provided per family under the forest village program of RFD.

When the age composition of the family members is reviewed, the younger generation between 5 and 19 years of age is large in number and is expected to provide the

necessary labor force for the forest village program in the future.

In order to distribute the annual work load more evenly and increase cash revenues, it is meaningful to select crop species with high marketability and land productivity as well as dry season crop species and combine them properly or to induce the TAUNGYA system into the forest village program. Among the farm crops cultivated in the model area, chilli might be cited as a crop which generates high income per unit area and is also easy to cultivate.

As for livestock production, raising of chickens and ducks which provide sources of protein for home consumption is desirable, but raising of cattle which requires a large land space ought to be restricted from the viewpoint of promoting intensive use of land.

As for cultivation methods, matters which ought to be considered are to avoid burning of vegetation on the cultivated land because this practice causes the loss of organic matters in the soil, and to introduce perennial crops as they serve to retain the fertility of soils.

3) Forest survey

① Regeneration survey

In order to grasp the state of regeneration of saplings, a survey was conducted in the sample plots which were set up in the unfelled forest and in the felled over forest with different felling time outside the model area and also within the model area as follows.

a. No. of sample plots surveyed

o Inside the model area (49 sample plots)

Logging block	1985/86 survey	1986/87 survey
Logging block 1 (operated cut 24-26 years ago)	8 plots	4 plots
Logging block 2 (operated cut 21-23 years ago)	16 plots	3 plots
Logging block 3 (operated cut 18-20 years ago)	4 plots	1 plot
Logging block 4 (operated cut 15-17 years ago)	6 plots	
Logging block 5 (operated cut 12-14 years ago)	7 plots	

o Outside the model area (12 sample plots)

Logging block	1986/87 survey
Logging block 7 (operated cut 6-8 years ago)	2 plots
Logging block 8 (operated cut 3-5 years ago)	6 plots
Logging block 9 (operated cut 0-2 years ago)	4 plots

b. Method of sapling survey

A survey belt of 1m x 40m = 40m^2 was set up at the starting point and ending point of each sample plot, and the number of saplings classified by size into the following four categories was counted.

i) Tree height less than 30 cm
ii) Tree height above 30 cm but below 130 cm
iii) Tree height above 130 cm and G.B.H. below 14 cm
iv) G.B.H. above 15 cm but below 45 cm

c. Number of saplings

The number of saplings (converted to per hectare equivalent) for each forest type tabulated in Table II-5-9 is the sum of those counted in 1986/87 and those of the sample plots surveyed in 1986/87.

Table II-5-9 (1) Number of Saplings for Each Forest Type

(trees/ha)

Forest type		Sample plot Number	Sample plot Size (ha)	29cm ≧ T.H.	129cm ≧ T.H ≧ 30cm	T.H ≧ 130cm G.B.H. ≦ 14cm	45cm ≧ G.B.H. ≧ 15cm	Total
T_E	F	15	0.112	9,518	5,786	2,938	643	18,883
	H	5	0.04	7,200	5,025	1,650	300	14,175
	M	–	–	–	–	–	–	–
	Average	20	0.152	8,908	5,585	2,599	553	17,645
M_D	F	23	0.172	3,477	10,732	1,419	203	15,831
	H	11	0.084	1,940	3,869	822	155	6,786
	M	–	–	–	–	–	–	–
	Average	34	0.256	2,973	8,484	1,227	191	12,875
D_D	F	5	0.040	4,425	15,300	1,375	375	21,475
	H	2	0.016	1,000	3,125	687	188	5,000
	M	–	–	–	–	–	–	–
	Average	7	0.056	3,446	11,821	1,179	322	16,768
Whole average		61	0.464	4,976	7,936	1,670	323	14,905

F: Flat Land Forest H: Hilly Forest M: Mountainous Forest

Table II-5-9 (2) Number of Saplings for Each Forest Type inside the Model Area

(trees/ha)

Forest type		Sample plot Number	Sample plot Size (ha)	29cm ≧ T.H	129cm ≧ T.H ≧ 30cm	T.H ≧ 130cm G.B.H. ≦ 14cm	45cm ≧ G.B.H. ≧ 15cm	Total
T_E	F	13	0.096	24,330	12,140	6,320	1,410	44,200
	H	–	–	–	–	–	–	–
	M	–	–	–	–	–	–	–
	Average	13	0.096	24,330	12,140	6,320	1,410	44,200
M_D	F	19	0.140	13,750	106,130	2,390	730	123,000
	H	10	0.076	3,220	8,470	2,630	190	14,510
	M	–	–	–	–	–	–	–
	Average	29	0.216	8,610	57,550	2,610	470	69,250
D_D	F	5	0.040	11,530	32,810	1,810	570	46,720
	H	2	0.016	2,000	6,250	1,380	380	10,010
	M	–	–	–	–	–	–	–
	Average	7	0.056	7,790	23,490	1,730	600	33,610
Whole average		49	0.368	15,610	25,160	3,570	810	45,150

Table II-5-9 (3) Number of Saplings for Each Forest Type outside the Model Area

(trees/ha)

Forest type		Sample plot Number	Sample plot Size (ha)	29cm ≧ T.H	129cm ≧ T.H ≧ 30cm	T.H ≧130cm G.B.H.≦14cm	45cm ≧ G.B.H. ≧ 15cm	Total
T_E	F	2	0.016	9,125	4,562	1,562	250	15,499
	H	5	0.04	7,200	5,025	1,650	300	14,175
	M	–	–		–	–	–	–
	Average	7	0.056	7,750	4,892	1,625	285	14,552
M_D	F	4	0.032	5,062	10,781	2,156	31	18,030
	H	1	0.008	3,375	4,250	1,250	–	8,875
	M	–	–	–	–	–	–	–
	Average	5	0.04	4,725	9,475	1,975	31	16,206
D_D	F	–	–	–	–	–	–	–
	H	–	–	–	–	–	–	–
	M	–	–	–	–	–	–	–
	Average	–	–	–	–	–	–	–
Whole average		12	0.096	6,490	6,802	1,771	177	15,240

d. Results of the sapling survey

The results of all sample plots surveyed (a total of 61 plots inside and outside the survey area) are as follows.

o The number of saplings per ha was 14,905 trees. When reviewed by size, the smallest trees of category i), with tree heights shorter than 30 cm, accounted for about 34%, category ii), trees with tree heights shorter than 130 cm, for about 53%, category iii), trees with tree heights above 130 cm but G.B.H. below 14 cm, for about 11%, and category iv), trees with G.B.H. above 15 cm but below 45 cm, for about 2%.

o The number of saplings classified by forest type varies wildly among plots, but when reviewed in terms of overall averages of all sample plots surveyed, it was 17,645 trees/ha in T_E, 12,875 trees/ha in M_D and 16,768 trees/ha in D_D.

According to the Table, in T_E, the number of trees decreases as they grow from shrub stage to high trees,

indicating a normal plant succession.

In M_D and D_D, however, the number of trees between 30 cm and 129 cm in height is larger than that of trees below 30 cm in height. There may be various reasons for this, but on the whole, M_D and D_D are more susceptible to invasion by weeds and bamboos than T_E as they are thinner, which inhibits the germination and growth of the saplings.

Further analysis and study of the survey findings are required to derive conclusions with respect to the state of regeneration and related matters.

② Sample plot survey

The sample plot survey in 1986/87 was carried out in the logging blocks where felling operation is currently under way and in the logging blocks where felling was done recently, both of which are outside the model area, as well as on supplementary sample plots set up inside the model area as described below.

a. Locations where sample plots were set up

Sample plots were set up as follows.

o Inside the model area (50 locations)

Logging block	1985/86 survey	1986/87 survey
Logging block 1 (operated cut 24-26 years ago)	9 locations	4 locations
Logging block 2 (operated cut 21-23 years ago)	16 locations	3 locations
Logging block 3 (operated cut 18-20 years ago)	4 locations	1 location
Logging block 4 (operated cut 15-17 years ago)	6 locations	
Logging block 5 (operated cut 12-14 years ago)	7 locations	

o Outside the model area (12 locations)

Logging block	1986/87 survey
Logging block 7 (operated cut 6-8 years ago)	2 locations
Logging block 8 (operated cut 3-5 years ago)	6 locations
Logging block 9 (operated cut 0-2 years ago)	4 locations

b. Size and shape of sample plot

The size of a sample plot is 1 ha. (250m x 40m)

c. Method of setting up sample plots

In the 1985/86 survey, the spots that were clearly identifiable on aerial photographs were selected as the starting points for surveying each sample plot so that their actual locations could be easily identified by comparing with aerial photographs. In the 1986/87 survey, forest type was interpreted on the basis of aerial photographs and areas which must be surveyed were determined and compared with the ground conditions; then the spots clearly identifiable were pricked on the aerial photographs and made the starting points for surveying each sample plot.

From each of the foregoing points, surveying was carried out first to the starting point of each sample plot. Then a 250 m long, 40 m wide sample plot was demarcated from the starting point of that sample plot.

The locations of sample plots set up (altogether 50 locations combining those set up in 1985/86 and those set up in 1986/87) are shown in Fig. II-5-8.

d. Tree mensulation method

All standing trees with 46 cm or more G.B.H. in the sample plots were surveyed one by one. The items measured are as follows.

o Tree species

All trees species which occur were entered in the survey sheet in local names and later changed into botanical names according to the tree species codes of the Manual for Forest Inventory in Thailand upon completion of the field survey.

o Girth breast height (G.B.H.)

G.B.H. was measured by the units of 1 cm using a diameter tape.

o Total tree height and clear length

Measured by the units of 1 m using a hypsometer. Clear length was defined as the height up to the first largest spreading branch.

o Quality

Quality was classified into the eight categories of: decay, sweep, twist, knot, lump, forked tree, ingrown bark, and crack.

o Canopy horizon

Canopy horizon was classified into upper story and lower story.

o Volume calculation

The volume was calculated for each sample plot. Three kinds of volume tables currently used in Thailand were used for volume calculation: the volume tables for Teak (*Tectona grandis*), for DIPTEROCARPACEAE (*Dipterocarpus* spp., *Anisoptera glabra, Hopea odorata, Parashorea stellata, Anisoptera scaphula, Dipterocarpus obtusifolius, Dipterocarpus tuberculatus, Hopea ferrea, Shorea talura, Shorea leprosula, Shorea curtisii, Shorea gratissima, Hopea* spp.), and for other tree species (*Afzelia Xylocarpa, Pterocarpus macrocarpus, Dalbergia dongnaiensis, Xylia kerrii, Sindora siamensis,* other trees), respectively.

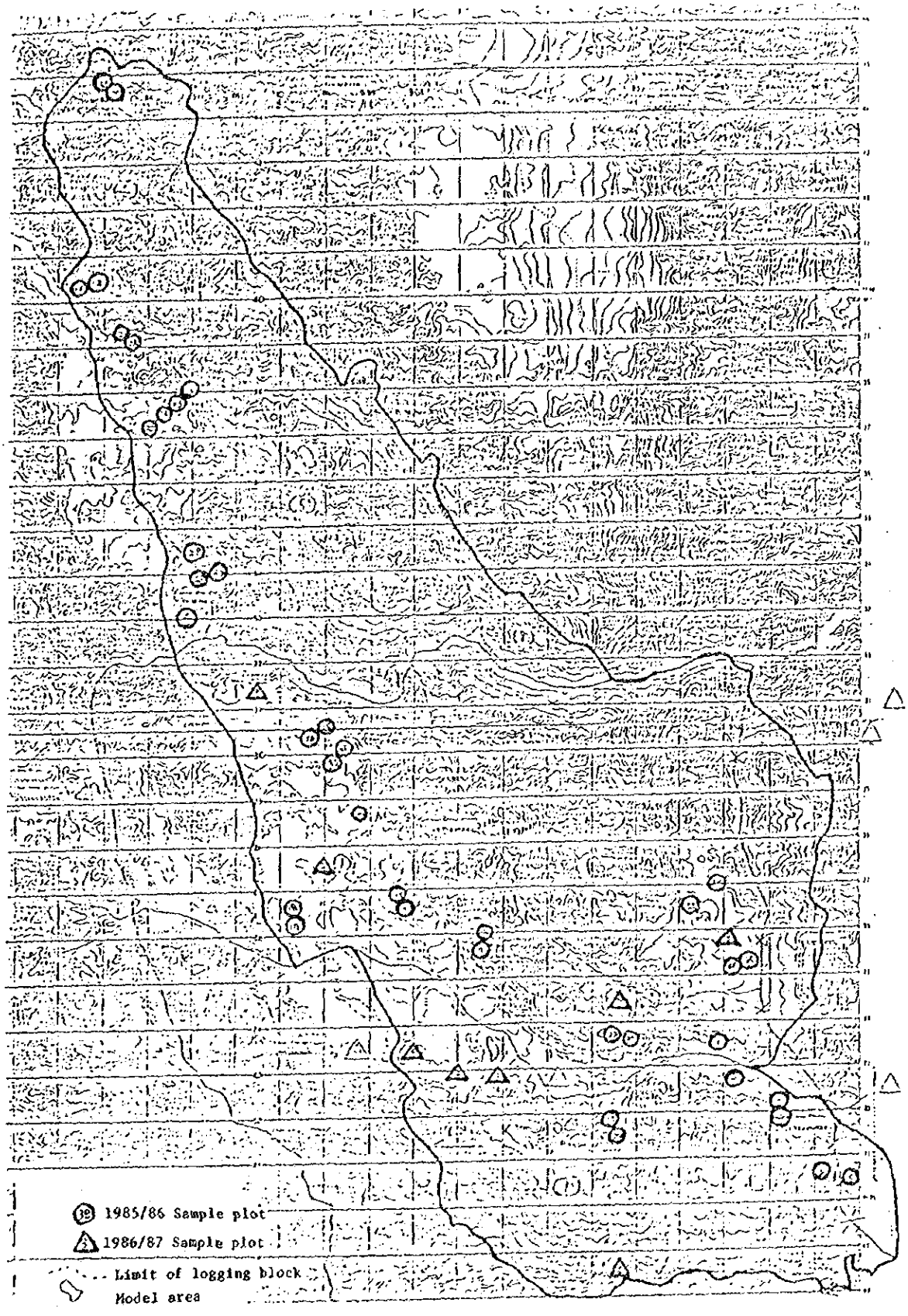


Fig. II-5-8 Location of Sample Plot

e. Results of the sample plot survey

The results of the sample plot survey conducted at 12 locations outside the model area are as shown in Table II-5-10, and the results of 8 locations inside the model area are as shown in Table II-5-11.

The tree species composition by forest type obtained by the sample plot survey (at 50 locations) conducted during 1985/86 and 1986/87 within the model area is as shown in Table II-5-12. Comprehensive analysis and study of these data along with the data obtained in the previous fiscal year are being scheduled.

Table II-5-10 (1) Results of the Sample Plot Survey outside the Model Area

No.	Plot No.	Logging block No.	Plot size (ha)	Forest type	Number of tree (G.B.H. 46cm& up)								Total	Mean value					
					Upper				Lower					G.B.H. (cm)		T.H (m)		C.L (m)	
					DIPTERO-CARPACEAE	5 main species	Others	Sub-total	DIPTERO-CARPACEAE	5 main species	Others	Sub-total		Upper	Lower	Upper	Lower	Upper	Lower
1	1	9	1.0ha	T_E, H, Mi, H_3, D_2	5	0	37	42	1	1	191	193	235	211.3	84.4	36.2	21.0	25.3	15.1
2	2	9	1.0	T_E, H, Mi, H_3, D_2	2	0	37	39	2	0	258	260	299	162.7	81.3	37.0	20.0	24.3	13.5
3	3	9	1.0	T_E, H, Mi, H_3, D_2	0	0	43	43	0	0	217	217	260	212.1	77.5	30.8	19.0	23.3	12.6
4	4	9	1.0	T_E, H, Mi, H_3, D_3	0	0	33	33	3	0	186	189	222	260.4	99.1	34.6	18.2	24.0	18.7
5	5	7	1.0	M_D, F, Sm, H_1, D_1	0	0	19	19	0	0	101	101	120	144.5	96.1	15.3	10.9	9.7	6.5
6	6	7	0.8	M_D, F, Sm, H_1, D_1	0	0	24	24	0	0	94	94	118	153.7	96.9	15.7	10.6	9.2	6.5
7	7	8	1.0	M_D, F, Sm, H_2, D_1	0	0	34	34	0	1	129	130	164	161.3	82.0	19.3	12.6	12.5	8.3
8	8	8	1.0	T_E, F, Mi, H_3, D_2	8	0	27	35	11	1	174	186	221	169.5	74.7	31.3	16.7	22.1	11.2
9	9	8	1.0	T_E, H, Mi, H_3, D_3	3	0	38	41	6	0	205	211	252	202.0	84.9	30.2	16.0	18.6	10.9
10	10	8	1.0	M_D, H, Sm, H_2, D_1	0	1	29	30	0	2	110	112	142	185.7	99.7	20.0	13.4	11.1	7.4
11	11	8	1.0	T_E, F, Mi, H_3, D_2	16	0	28	44	17	0	214	231	275	198.4	65.8	31.8	17.7	22.5	11.8
12	12	8	1.0	M_D, F, Sm, H_2, D_1	0	0	24	24	0	0	131	131	155	127.4	82.7	19.0	12.0	6.1	7.0

5 main species ..... *Afzelia xylocarpa*, *Pterocarpus macrocarpus*, *Dalbergia dongnaiensis*, *Xylia kerrii*, *Sindora siamensis*

Table II-5-10 (2)

No.	Plot No.	Number of tree (G.B.H. 101cm & up)									Volume (m³)										
		Upper				Lower				Total	Upper				Lower				Total (per ha)	per tree	Crown density (%)
		DIPTERO-CARPACEAE	5main species	Others	Sub-total	DIPTERO-CARPACEAE	5 main species	Others	Sub-total		DIPTERO-CARPACEAE	5main species	Others	Sub-total	DIPTERO-CARPACEAE	5main species	Others	Sub-total			
1	1	5	0	35	40	0	0	47	47	87	17.8	0	194.3	212.1	0	0	82.6	82.6	294.7	3.39	50
2	2	2	0	35	37	2	0	51	53	90	6.2	0	96.1	102.3	0	0	82.1	82.1	184.4	2.05	60
3	3	0	0	36	36	0	0	35	35	71	0	0	224.6	224.6	0	0	55.7	55.7	280.3	3.95	45
4	4	0	0	31	31	2	0	62	64	95	0	0	235.6	235.6	1.6	0	104.8	106.4	342.0	3.60	55
5	5	0	0	18	18	0	0	36	36	54	0	0	18.3	18.3	0	0	23.9	23.9	42.2	0.78	30
6	6	0	0	19	19	0	0	35	35	54	0	0	28.1	28.1	0	0	21.1	21.1	61.5	1.14	30
7	7	0	0	33	33	0	0	26	26	59	0	0	54.7	54.7	0	0	24.5	24.5	79.2	1.34	40
8	8	6	0	24	30	3	1	23	27	57	24.9	0	75.7	100.6	4.1	0.8	26.9	31.8	132.4	2.32	50
9	9	3	0	35	38	4	0	42	46	84	11.0	0	150.1	161.1	6.7	0	67.1	73.8	234.9	2.80	60
10	10	0	1	26	27	0	0	41	41	68	0	2.1	52.0	54.1	0	0	41.1	41.1	95.2	1.40	30
11	11	16	0	27	43	13	0	41	54	97	82.9	0	86.5	169.4	35.3	0	66.7	102.0	271.4	2.80	50
12	12	0	0	15	15	0	0	33	33	48	0	0	20.4	20.4	0	0	25.8	25.8	46.2	0.96	35

Table II-5-11 (1) Results of the Sample Plot Survey inside the Model Area

No.	Plot No.	Logging block No.	Plot size (ha)	Forest type	Number of tree (G.B.H. 46cm & up)									Mean value					
					Upper				Lower				Total	G.B.H. (cm)		T.H (m)		C.L (m)	
					DIPTERO-CARPACEAE	5main species	Others	Sub-total	DIPTERO-CARPACEAE	5main species	Others	Sub-total		Upper	Lower	Upper	Lower	Upper	Lower
1	1	2	1.0	T_E F La H_3 D_4	5	0	37	42	5	0	148	153	195	187.3	94.0	33.0	17.6	20.0	10.4
2	2	2	1.0	T_E F Mi H_3 D_3	2	0	24	26	6	0	230	236	262	197.8	78.9	34.0	18.2	21.8	10.1
3	3	1	1.0	M_D F Mi H_3 D_2	1	0	25	26	0	12	110	122	148	180.6	83.4	31.5	18.2	14.0	9.7
4	4	1	1.0	T_E F Mi H_3 D_2	1	0	46	47	0	0	226	226	273	140.4	68.0	34.4	16.7	19.4	9.5
5	5	1	1.0	T_E F Mi H_3 D_3	11	0	50	61	22	0	223	245	306	195.0	84.6	38.9	20.8	28.7	12.8
6	6	1	1.0	D_D H Sm H_2 D_1	0	1	59	60	0	15	191	206	266	110.7	70.7	21.3	15.3	10.2	7.2
7	7	2	1.0	M_D H La H_3 D_1	0	10	40	50	1	11	132	144	194	164.4	80.5	31.3	18.8	20.0	10.8
8	8	3	1.0	D_D F Sm H_2 D_2	0	1	41	42	0	3	155	158	200	145.0	82.4	22.0	14.5	14.0	7.2

5 main species ..... *Afzelia xylocarpa*, *Pterocarpus macrocarpus*, *Dalbergia dongnaiensis*, *Xylia kerrii*, *Sindora siamensis*

Table II-5-11 (2)

No.	Plot No.	Number of tree (G.B.H. 101cm & up)									Volume (m³)										Crown density (%)
		Upper				Lower				Total	Upper				Lower				Total (per ha)	per tree	
		DIPTERO-CARPACEAE	5 main species	Others	Sub-total	DIPTERO-CARPACEAE	5 main species	Others	Sub-total		DIPTERO-CARPACEAE	5 main species	Others	Sub-total	DIPTERO-CARPACEAE	5 main species	Others	Sub-total			
1	1	5	0	36	41	1	0	38	39	80	10.2	0	124.7	134.9	2.4	0	58.8	61.2	196.1	2.45	65
2	2	2	0	24	26	2	0	48	50	76	3.4	0	101.3	104.7	3.1	0	57.6	60.7	165.4	2.17	55
3	3	1	0	24	25	0	2	29	31	56	1.8	0	49.1	50.9	0	1.4	26.3	27.7	78.6	1.40	45
4	4	1	0	27	28	0	0	13	13	41	1.8	0	75.4	77.2	0	0	13.6	13.6	90.8	2.21	50
5	5	10	0	48	58	5	0	48	53	111	13.1	0	168.8	181.9	4.6	0	61.3	65.9	247.8	2.23	55
6	6	0	0	34	34	0	0	16	16	50	0	0	29.2	29.2	0	0	9.2	9.2	38.4	0.77	40
7	7	0	9	36	45	1	4	22	27	72	0	14.5	103.7	118.2	5.1	4.7	21.6	31.4	149.6	2.08	40
8	8	0	1	36	37	0	2	33	35	72	0	0.7	59.2	59.9	0	1.0	29.6	30.6	90.5	1.26	45

Table II-5-12 (1) Composition of DISPTEROCARPACEAE by Forest Type inside the Model Area

(trees/ha)

Forest type		Sample plot		*Dipterocarpus*				*Hopea*				*Shorea*					Anisoptera			*Parashorea*	Total
		Number	Size (ha)	101	521	522	Subtotal	305	529	581	Subtotal	551	566	568	571	Subtotal	320	303	Subtotal	317	
T_E	F	13	12.6	–	–	–	–	7.7	4.2	–	11.9	0.1	–	–	9.9	10.0	–	0.7	0.7	0.2	22.8
	H	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	M	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Average	13	12.6	–	–	–	–	7.7	4.2	–	11.9	0.1	–	–	9.9	10.0	–	0.7	0.7	0.2	22.8
M_D	F	19	16.8	0.1	–	–	0.1	0.2	0.3	–	0.5	–	–	–	0.5	0.5	–	0.1	0.1	–	1.2
	H	10	8.4	–	–	0.1	0.1	–	–	–	–	–	–	–	0.1	0.1	–	–	–	0.1	0.3
	M	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Average	29	25.2	0.04	–	0.04	0.1	0.16	0.2	–	0.36	–	–	–	0.36	0.36	–	0.04	0.04	0.04	0.9
D_D	F	5	4.8	–	–	10.4	10.4	–		–	–	–	–	–	–	–	–	–	–	–	10.4
	H	3	2.2	–	–	–	–	–	–	–	–	2.7	–	–	–	2.7	–	–	–	–	2.7
	M	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Average	8	7.0	–	–	7.1	7.1	–	–	–	–	0.9	–	–	–	0.9	–	–	–	–	8.0
Whole average		50	44.8	0.02	–	1.12	1.14	2.3	1.3	–	3.6	0.15	–	–	3.0	3.15	–	.0.22	0.22	0.09	8.2

101: *Dipterocarpus* spp. 521: *Dipterocarpus obtusifolius* 522: *Dipterocarpus tuberculatus*
305: *Hopea odorata* 529: *Hopea ferrea* 581: *Hopea* spp. 551: *Shorea talura*
566: *Shorea leprosula* 568: *Shorea curtisii* 571: *Shorea gratissima* 320: *Anisoptela scaphula*
303: *Anisoptera glaba* 317: *Parashorea stellata*

Table II-5-12 (2) Tree Species Composition by Forest Type inside the Model Area

(trees/ha)

Forest type		Sample plot		DIPTEROCARPACEAE	Principal species other than DIPTEROCARPACEAE						Others	Total
		Number	Size (ha)		*Afzelia xylocarpa* (302)	*Pterocarpus macrocarpus* (310)	*Delbergia dongnaiensis* (518)	*Xylia kerrii* (564)	*Sindora siamensis* (628)	Sub-total		
T_E	F	13	12.6	22.8	–	0.4	0.5	–	–	0.9	217.7	241.4
	H	–	–	–	–	–	–	–	–	–	–	–
	M	–	–	–	–	–	–	–	–	–	–	–
	Average	13	12.6	22.8	–	0.4	0.5	–	–	0.9	217.7	241.4
M_D	F	19	16.8	1.2	–	1.6	3.0	3.7	–	8.3	146.2	155.7
	H	10	8.4	0.3	0.8	2.5	4.1	7.5	–	14.9	179.2	194.4
	M	–	–	–	–	–	–	–	–	–	–	–
	Average	29	25.2	0.9	0.3	1.9	3.3	5.0	–	10.5	157.2	168.6
D_D	F	5	4.8	10.4	0.4	1.7	1.9	11.0	–	15.0	213.8	239.2
	H	3	2.2	2.7	0.4	7.3	5.0	11.4	–	24.1	332.7	359.5
	M	–	–	–	–	–	–	–	–	–	–	–
	Average	8	7.0	8.0	0.4	3.4	3.0	11.1	–	17.9	251.1	277.0
Whole average		50	44.8	8.2	0.2	1.7	2.5	4.5	–	8.9	188.9	206.0

4) Fact-finding survey on forest work

In order to obtain data necessary for formulating a forest working plan within the model area, a survey was conducted to collect data on timber production, works of national parks, forestation project, utilization of wood and other relevant matters mainly in Kanchanaburi Province. The achieved results are as follows.

ⓘ Timber production

a. Current state of timber production

In 1986, the Ban Pong Regional Forest Office which has jurisdiction over the survey area granted concessions to seven business establishments allowing to fell 43,397 trees at 56 sites covering an area of about 178.8 km^2 in Kanchanaburi Province. Actually, however, 44,691 trees amounting to a cut volume of 156,509.65 m^3 was felled by five business establishments. About the same volume of yearly production is considered to be scheduled for the future in this area.

b. Actual state at the production site

As no felling work was under way in the model area for which a plan is being worked out this time, the actual state at the felling site in Logging Block 9 bordering the model area on the north was investigated. The trees to be cut included as many as 18 species. When one of the field notes recording the trees to be marked with the stamp of permit was checked, 16 tree species appeared. Tree species composition in terms of the ratio of the number of trees was, 42.2% of *Chukrasia tabularis*, 19.7% of *Michelia* spp., 13.5% of *Cedrela tonna* and *C. microcarpa*, and 12.2% of *Manglietic insignis*, with these four species jointly accounting for 87.6% of the total. (Refer to Table II-5-13)

Trees were felled almost at a right angle to the slope

mainly with a large chain saw. Felled trees were quickly stamped and bucked into 5 m (1 log) pieces at the felling site. Sometimes, they were bucked into 10 m (2 log) long pieces.

For gathering the timbers, a wheel type large tractor (timber jack, etc.) was used. At the other site in Amphoe Thong Pha Phum, skidding of timbers by elephants was also seen.

c. Existing condition of logging road

This area is mainly covered by lime stone, and forms a Karst topography with steep rocky peaks protruding over a table-land like topography. Ground water system is therefore well developed, causing a complex unevenness on the ground surface in some places.

Soil consists of clay loam originating from lime stone parent material and has adequate ground bearing capacity to withstand the load of truck in the dry state, but when the rainy season sets in, the moisture content of soil rises and the ground bearing capacity falls and the soil becomes muddy.

The topography and geological structure being as such the local logging roads were constructed by avoiding excavation of rocks as much as possible and by adapting their alignment to match the microtopography. The roads, with the exception of ore haulage roads for mines, therefore, are forest roads that are usable only during the dry season. The situation is the same with the spur roads which branch out from forest roads. On both of these roads, there are several places where the surface slope is too steep and where drainage must be improved.

Table II-5-13 List of Species and Numbers for Felling in Logging Block 9

No.	Code No.	Division	Species name	Tree numbers	%
1	516		*Chukrasia tabularis*	263	42.2
2	515		*Cedrela toona & C. microcarpa*	84	13.5
3	307		*Manglietia insignis*	76	12.2
4	309		*Michelia* spp.	123	19.7
5	505		*Albizzia lebbeck*	27	4.3
6	303	DIPTEROCARPACEAE	*Anisoptera* spp.	18	2.9
7	625		*Pentacme suavis*	–	–
8	527		*Gmelina arborea*	3	0.5
9	304		*Artocarpus lanceifolius*	4	0.6
10	507		*Amoora polystachya*	1	0.2
11	572		*Syzygium cumini*	10	1.6
12	305	DIPTEROCARPACEAE	*Hopea odorata*	1	0.2
13	544		*Protium serratum*	1	0.2
14	508		*Artocarpus lakoocha*	4	0.6
15	317	DIPTEROCARPACEAE	*Parashorea stellata*	1	0.2
16	310	Important species	*Pterocarpus* spp.	5	0.8
17	526		*Garuga* spp.	2	0.3
18	585		*Lagerstroemia tomentosa*	–	–
Total				623	100.0

② National Park

a. The Srinagarind National Park

The southern half of the model area belongs to the territory of the Srinagarind National Park. The duties and responsibilities of the administration office of the Park which has direct jurisdiction over the model area mainly consists of maintenance and repair work, as shown in Table II-5-14.

Traffic facilities for access to the Srinagarind National Park are extremely poor by comparison to the Erawan National Park and Sai Yok National Park. For instance, there is no paved national highway that goes as far as the Park. The number of visitors to the Park, therefore, is not many, being 1/15 that of the Erawan National Park and 1/5 that of the Sai Yok National Park. However, since the area was designated as a national park relatively recently and plans for its improvement are now under way while survey work for the construction of a national highway is also in progress, increased utilization of the Park is anticipated in the future.

Table II-5-14 Srinagarind National Park Office

1. National park office
   - o Center
     5 staffs, 50 workers (Worker's daily wage: 35 bahts - 45 bahts)
   - o Stations
     No. 1 5 staffs
     No. 2 6 staffs

2. Number of visitors
   - o Annual number of tourists: about 25,000 - 30,000 (almost all of them from Bangkok)

3. Work of office
   - o Provision of services to the tourists
   - o Execution of survey on forest
   - o Forest protection

4. Facilities (for accommodation)
   - o Bungalows 4 (each accommodates 15 guests)
   - o Floating houses 5 (each accommodates 10 guests)

   * Whatever planned were completed five years ago.

b. Administration policy and administration plan for the national park

Besides the National Park Law, RFD's National Park Department provides the park offices with the guidance on park administration based on the following way of thinking.

- o Although squatters living within parks are tolerated now, the Department wishes to move them if any likely settlement can be found.
- o Designated boundaries of parks will not be changed.
- o Planting of only existing tree species will be permitted within the parks. Planting of Teak which are not indigenous in this area will not be permitted as a rule.
- o Felling within parks is permissible only if approved. In principle, there is no forest block where cutting is prohibited.

Only a few national parks have established classification of zones and prepared administration plans. The classification of zones is as shown in Table II-5-15.

Table II-5-15 Classification of Zones for National Park

Symbol	Name	Designated contents
IUZ	Intensive Use Zone	The zone in which buildings for lodging of visitors and staff are located.
ORZ	Outdoor Recreation Zone	Area larger than IUZ for sightseeing and rest. The zone calls for particular care lest it be devastated by trespassers.
PZ	Primitive Zone	The zone shall be retained in the natural state as botanical resources are abundant. The zone also serves as a source of agricultural water to irrigate the plains.
SNRZ	Strict Nature Reserve Zone	The most important resource of the national park where abundant plant societies exist, including easily decayable, beautiful and rare plants. The zone also occupies an important position as a water source.
SUZ	Special Use Zone	The zone in which various activities had been carried out even before the area was designated as a national park, and where such activities if their continuation were approved, would conform to the purpose of administering and operating the national park.
RZ	Recovery Zone	Although nature has been savaged, there is either some forests left or other environmental conditions are such that nature can be restored and where recovery of nature is necessary.

③ Sanctuary for wild life

Within the model area set up this time, there was no so-called sanctuary for wild life such as a wild animal reservation, hunting-prohibited area, biopark, etc.

④ Watershed preservation area

There was no area designated for watershed preservation within the model area or Kanchanaburi Province.

⑤ Countermeasures against forest fire

a. Existing conditions in the survey area

i) Forest fire countermeasure organization

The Forest Fire Control Department of the Kanchanaburi Provincial Government has set up preventive fire fighting centers at the four locations of Tha Thong Mon, Si Sawat, Sai Yok, and Thong Pha Phum, and provides each of them with a lookout tower, fire fighting and communications equipment and supplies and two patrol men, etc.

ii) Forest fire incidence

The forest fire incidence in Kanchanaburi Province in 1986 was as shown in Table II-5-16, and the same tendency is supposed to continue every year.

b. Forest fire countermeasures

As preventive measures against forest fire, education, advertisement, publicity, patrolling,etc. are carried out relatively actively, but the team was unable to actually see or to obtain data on the most effective fire fighting facilities such as fire lines and fire belts.

It is understandable that even if fire lines and fire belts were provided their maintenance and management would not be easy in this area where the mean annual temperature is high and trees and herbs grow quickly,

but it is considered necessary to set up fire break tree belts and the like in areas where the risk of fire hazard is high.

Table II-5-16 Forest Fire Incidence of Each Month in Kanchanaburi Province

Year 1986

Center / Month	Si Sawat		Sai Yok		Tha Thong Mon		Thong Pha Phum		Total	
	Frequency	Area (rais)	Frequency	Area (rais)	Frequency	Area (rais)	Frequency	Area (rais)	Frequency	Area (rais)
Dec.	-	-	-	-	-	-	-	-	-	-
Jan.	10	163	6	160	8	118	2	21	26	462
Feb.	42	504	32	468	39	468	21	252	134	1,692
Mar.	34	426	24	265	32	407	18	201	108	1,299
Apr.	13	97	7	46	10	68	4	24	34	235
May	4	30	3	14	3	22	2	10	12	76
Total	103	1,220	72	953	92	1,083	47	508	314	3,764

Forest Fire Incidence by Causes in Kanchanaburi Province

Center / Causes	Si Sawat		Sai Yok		Tha Thong Mon		Thong Pha Phum		Total	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Burnt field	26	25.24	22	30.56	23	25.00	14	29.78	85	27.07
Camping	21	20.39	14	19.44	20	21.74	8	17.02	63	20.06
Felling tree	18	17.48	13	18.06	16	17.39	6	12.77	53	16.88
Livestock farming	11	10.68	7	9.72	10	10.87	5	10.64	33	10.51
Forest recreation	11	10.68	6	8.33	9	9.78	5	10.64	31	9.87
Hunting	9	8.74	6	8.33	8	8.70	6	12.77	29	9.24
Officers' carelessness	2	1.94	2	2.87	1	1.09	3	6.38	8	2.55
Fire/Burn	3	2.91	-	-	2	2.17	-	-	5	1.59
Unknown	2	1.94	2	2.78	3	3.26	-	-	7	2.23
Total	103	100.00	72	100.00	92	100.00	47	100.00	314	100.00

⑥ Forestation project

a. Forestation projects accomplished in Amphoe Thong Pha Phum and Amphoe Sai Yok, to which the model area belongs, were investigated by the form of execution as shown in Table II-5-17. According to this table, forestation seems to have been implemented under three different systems, of which the ratio of compulsory reforestation accompanying felling under the concessions is characteristically high at 67.6%.

Table II-5-17 Actual Forestation in 1986 by the Form of Execution

Execution form	Amphoe Thong Pha Phum			Amphoe Sai Yok			Total			Rate (%)
	Planting	Tending	Area	Planting	Tending	Area	Planting	Tending	Area	
(Watershed management)										
Cost of power station	300	3,350	3,650	--	--	--	300	3,350	3,650	
Forest village	300	1,100	1,400	--	--	--	300	1,100	1,400	
Sub-total	600	4,450	5,050	--	--	--	600	4,450	5,050	9.7
(R F D)										
Silviculture Div.	600	3,517	5,067	300	2,700	6,800	900	6,217	11,867	22.7
(Concessions)										
Kanchananburi Forest Co.	2,729	4,251	13,127	3,000	3,934	13,888	5,729	8,185	27,015	
Thong Pha Phum Forest Assoc.	949	1,048	8,267	--	--	--	949	1,048	8,267	
Sub-total	3,678	5,299	21,394	3,000	3,934	13,888	6,678	9,233	35,282	67.6
Total	4,878	13,266	31,511	3,300	6,634	20,688	8,178	19,900	52,199	100.0

(Notes) Units in rais. Silviculture refers to the operation of tending two to six year old planted forests.

b. Growth conditions of planted trees

In order to acquire a grasp of the growth conditions of the planted Teak trees, a growth survey was conducted by the sample plot method by selecting 9 planted areas in Thong Pha Phum District and 5 planted areas in Sai Yok District as described below.

i) Survey method

o Each sample plot is 0.08 ha in area and rectangular in shape, being 40m x 20m, and set up at a place that indicated average growth conditions typical of each applicable planted area.

o Following items were measured for all planted trees within the sample plots.

Number of trees

Spacing

Planted year

Total tree height (T.H.).....
in units of 1 cm on trees less than 1 m high, 10 cm on trees between 1.1 m and 2 m high, and 50 cm on trees 2.1 m or higher.

Girth breast height (G.B.H.)...
in units of 1 cm. Basal girth was measured on trees less than 1.3 m high.

ii) Survey results

The results of this survey are outline below and also summarized in Table II-5-18.

o The spacing was 3m x 3m at one location, 2m x 2m at one location, 4m x 2m at one location and 4m x 4m at the remaining 11 locations.

o When compared with the height curve of the yield table for Teak prepared as a research data by Kasetsart University, the tree heights of the planted trees range between site indices 15 and 30. (Fig.II-5-9)

As above, Teak is considered fairly promising species for planting in the model area judging from the survey results in the already planted areas.

Table II-5-18 Results of Growth Survey of Teak Plantation

Plot No.	Location	Plot size (40x20 cm) (ha)	Spacing	Species	Age (Planted year)	Number of trees		G.B.H. (cm)			T.H. (m)		
						per plot	per ha	Min.	Max.	Mean	Min.	Max.	Mean
1	Thong Pha Phum Forest Village	0.08	4 x 4	Teak	6 (1981)	44	550	17	70	45	4.0	14.5	11.3
2	"	0.08	4 x 4	Teak	1 (1986)	38	475	(1)	(12)	(6)	0.1	1.3	0.7
3	"	0.08	4 x 4	Teak	7 (1980)	61	763	5	39	24	2.0	7.5	5.5
4	"	0.08	4 x 4	Teak	4 (1983)	44	550	9	54	41	1.3	8.0	6.6
5	"	0.08	4 x 4	Teak	5 (1982)	38	475	15	60	34	4.0	8.5	6.4
6	"	0.08	4 x 4	Teak	5 (1982)	46	575	17	49	38	4.5	10.0	8.0
7	"	0.08	4 x 4	Teak	4 (1983)	39	488	8	32	23	2.0	7.0	5.3
8	"	0.08	4 x 4	Teak	3 (1984)	48	600	1	29	16	0.6	6.0	4.3
9	"	0.08	4 x 4	Teak	2 (1985)	28	350	(2)	(16)	(7)	0.3	4.0	2.2
10	Sai Yok National Park	0.08	3 x 3	Teak	33 (1954)	21	263	83	159	114	22.0	31.0	26.7
11	"	0.08	4 x 4	Teak	7 (1980)	36	450	9	85	48	7.0	17.0	14.0
12	"	0.08	4 x 4	Teak	12 (1975)	40	500	47	89	68	14.0	21.0	18.1
13	"	0.08	2 x 4	Teak	10 (1977)	41	513	10	75	53	3.0	19.0	14.4
14	"	0.08	2 x 2	Teak	30 (1957)	27	338	71	179	97	17.0	22.0	20.6

(Notes) ( ): Basal girth

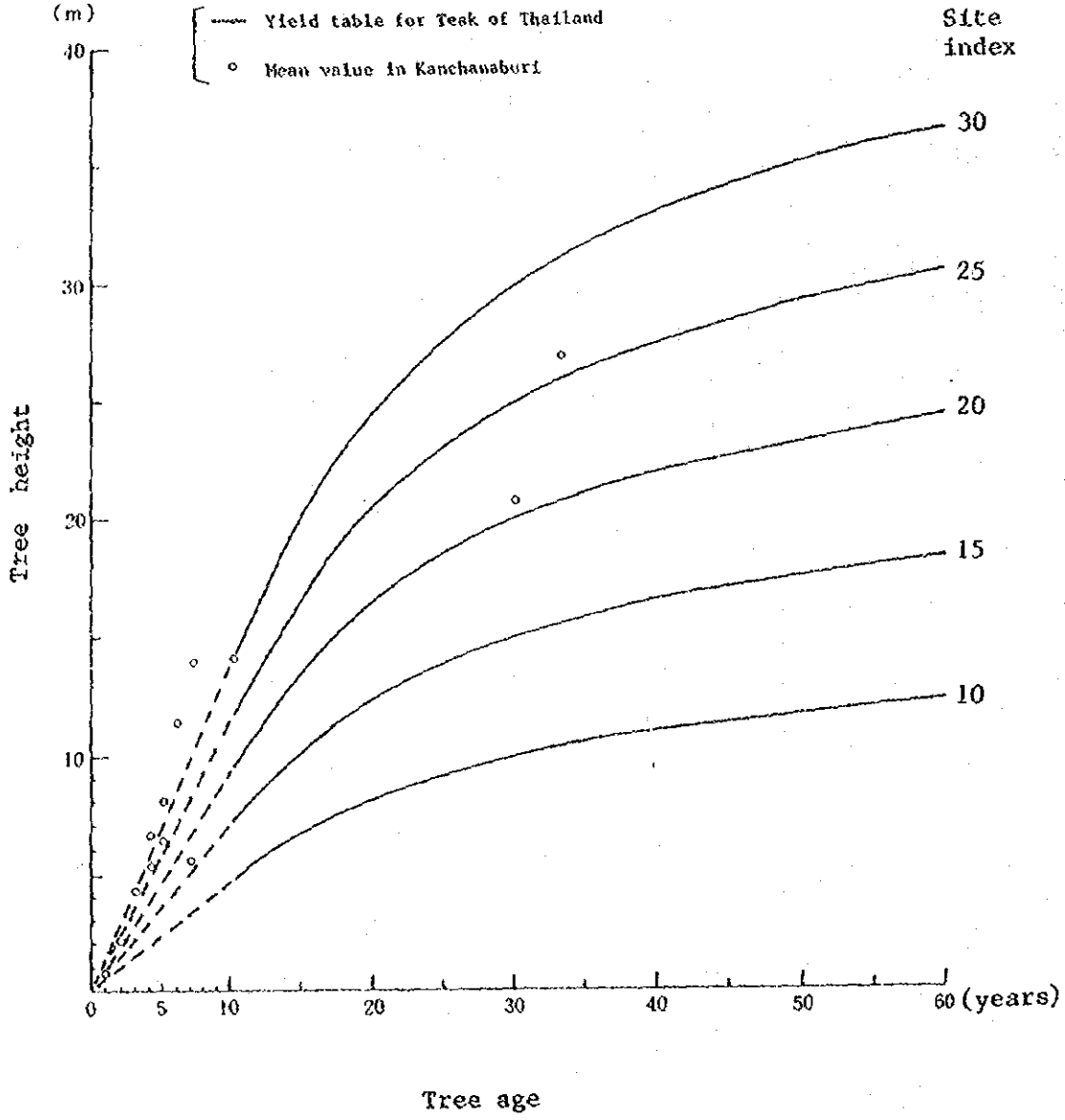


Fig. II-5-9 Tree Height Curve of Teak Plantation

⑦ Utilization of timber and bamboo

a. Actual state of timber utilization

Kanchanaburi Province to which the survey area belongs has a forest area of 12,417 km^2 against its total area of 19,483.2 km^2, so that its ratio of forest to the total area is 63.73%. This is more than double the forest ratio of 30% for the whole of Thailand, by which Kanchanaburi may justifiably be called a forest province.

On the other hand, the population of the province is 599,373 persons and its population density is 31 persons per square kilometer, which is about 1/3 the population density of 103 persons per square kilometer for the whole of Thailand. The province therefore, is a sparsely populated area.

As can be inferred from these facts, Kanchanaburi is a timber producing province but its local timber consumption is small.

When the prevalent state of timber-related industries in Kanchanaburi Province is reviewed, there are five mechanized sawmills, 31 mechanized wood working shops, four manual sawmills and four wood-work products manufacturing and marketing shops, and the smallness of their numbers suggests that most of the timbers produced are shipped out of the province as logs.

It is difficult to grasp the scale of these sawmills. At one sawmill, building materials were being produced by 35 employees mainly with four band saws and three circular saws, and the Team was able to learn only that around 20 m^3 of wood is processed daily per one machine in operation, while the quantity of timber hauled in and the quantity of product shipped out could not be grasped. The Team also learned that the major tree species handled by the sawmill are *Xylia kerrei, Dipterocarpus alatus, Shorea obtusa, Shorea*

siamensis and *Ceriops tagal*, and that the price of 15cm x 15 cm x 5m lumber is 513 bahts.

b. Growth and use of bamboo

i) Growth of bamboo

There are many bamboo groves in Thailand wherein about 50 species are said to occur. Kanchanaburi Province also abounds in bamboo species, and the following eight species were actually seen by the Survey Team in the survey area.

- o *Bambusa blumeana*
- o *Bambusa burmanica*
- o *Bambusa arundinacea*
- o *Bambusa tulda*
- o *Cephalostachyum pergracile*
- o *Dendrocalamus asper*
- o *Oxytenanthera albociliata*
- o *Schizostachyum aciculare*

Many of these bamboo species grow gregariously. Some of the larger stubs had a G.B.H. reaching about 15 m, some had 100 or more stems growing out of one stub, or some of the stems had a G.B.H. of 53 cm, and some of the species indicated a growth so spectacular that the crown diameter of one stub exceeded 35 m. These instances are summarized in Table II-5-19. Relatively speaking, thick and tall bamboos tend to grow on fertile soil in flat land and in valley channels, while thin and short bamboos tend to grow on shallow soil in stone area. However, hardly any intrusion of bamboo was found at T_E stand with covered crown.

ii) Use of bamboo

Bamboo, the growth habitat of which is widely distributed as stated above, is extensively utilized for building structures, furnitures and handicrafts throughout Thailand. Accordingly, there are many processing shops of bamboo, and bamboo groves are

cultivated around farm households in the plains east of Bangkok.

According to the RFD statistics, the bamboo production quantities changed from 63.2 million pcs. in 1981 to 52.9 million pcs. in 1982, 45.1 million pcs. in 1983, 48.9 million pcs. in 1984 and 34.4 million pcs. in 1985. Production and consumption data of bamboo in Kanchanaburi Province, however, were unobtainable.

Table II-5-19 Growth of Bamboo

Plot No.	Forest type	Stub G.B.H. (cm)	Number of per stub	Stem G.B.H. (cm)		Stub crown diameter (m)
				Large	Small	
31	T B F	1,200	110	21	18	31.32
31	"	1,180	74	24	21	25.36
31	"	1,230	124	25	25	32.12
31	"	720	59	29	27	25.19
31	"	900	38	23	20	24.86
31	"	1,350	82	24	22	25.40
15	"	550	47	19	16	38.00
15	"	1,100	7	23	21	10.02
15	"	1,431	52	25	24	26.46
15	"	920	52	22	18	29.98
15	"	385	14	19	17	17.38
15	"	335	15	22	18	11.15
15	"	1,000	92	22	20	25.88
16	"	600	30	22	11	25.00
22	M D F	320	17	17	16	8.72
22	"	570	15	13	8	7.00
12	"	1,550	50	48	43	26.00
12	"	620	66	48	45	21.32
12	"	621	54	44	42	28.00
12	"	750	29	43	34	27.04
3	M D H	1,515	45	30	28	18.50
3	"	420	12	29	28	24.32
3	"	518	13	32	28	12.90
7	"	550	8	15	14	12.50
7	"	250	18	13	12	10.80
8	"	1,400	28	34	30	16.00
8	"	940	22	47	45	15.00
8	"	2,945	54	40	37	35.62
8	"	615	15	50	47	29.13
8	"	1,300	8	53	48	19.36

5) Soil survey

① Survey outline

In 1985/86, soil survey was conducted mainly in the forest lands on the hillside slopes and flat lands within the model area. In this fiscal year, following survey was conducted mainly on cultivated lands and their surroundings as well as on already planted forests in the model area including its neighboring areas.

a. Based on the 1985/86 survey results, approximate condition of the soil distribution in the model area was inferred. In 1986/87 soil pit survey soil profile survey at 14 spots and simple soil profile survey to establish boundaries at about 300 spots were conducted within the model area mainly in areas which were likely to be classified as land suitable for farming under the land use classification in order to confirm and/or to revise the soil classification and its boundaries as well as to reclassify the soil type according to the needs for studying the possibility, suitability and productivity of using each particular piece of land - particularly as farm land.

b. In order to roughly estimate the soil distribution in Kanchanaburi and its environs including the model area and to study the relationship of crop species and planting species (mainly Teak) with soil, soil profile survey was conducted at 15 spots in the forest village near Thong Pha Phum and in the planted forests within the Sai Yok National Park, and a simple soil profile survey was conducted at more than 20 spots in the cultivated land located between south of the model area and Erawan, in the cultivated land on the east of the model area across the Mae Khlong River, and also in the cultivated land on the lowland extending between Erawan and the outskirts of Kanchanaburi.

The contents of the soil profile survey were the same

as in the 1985/86. Likewise, soils were classified in accordance with the Soil Map of the World of FAO-UNESCO, although some of the names were changed based on the survey conducted in 1986/87.

The results of the soil profile survey were as presented in Table II-5-20.

② Approximate soil distribution in the model area

The topography of the model area may be roughly divided into the steep mountainous zone consisting of limestone, the flat land, and the gently sloped hill land. The distribution of soil derived from limestone as the principal parent material and which is formed under the sub-tropical climate with a dry season that lasts for about four to five months clearly corresponds to these land features.

From the distribution pattern of each soil, it was inferred that the level surface had tilted these past diastrophism, and the mountainous area in the severely tilted side remained as a steep mountainous zone notwithstanding the erosion and weathering, since its geological structure consists of hard and solid limestone, and that the mountaintops on the more severely tilted side remained as a gentle hill land, while sediments which had thickly deposited inbetween these two became a flatland. (Refer to Fig. II-5-10) And, the above process through which the present topography was formed, and the fact that limestone was the constituent seem to have had a large bearing on the formation of the soil.

Table II-5-20 Results of the Soil Profile Examination

No.	Location & topography	Inclination (°C)	Type of soil	Thickness (m)	Color	Humus	Texture	Structure	Gravel				Hardness	Moisture	Leaching & accumulation	Mycorrhiza & mycelium	Root	Remarks
									Form	Size	Weathering	Content						
61	Flat	2	Bg	More than 1.0	7.5YR3/2 - 5YR4/4	Abundant - Common	Clay	Blocky			---		29 - 32	Moist	(Mn-Fe mottle)	--	Common	pH5.5(A_1) 6.6(B_2)
62	Flat	0	G	More than 1.0	7.5YR2/2 - 7.5YR4/2	Abundant	Clay	Blocky			---		24 - 30	Moist	(Mn-Fe concretion)	--	Common	pH5.3(A) 5.8(B_2)
63	Flat	1	Ne-f	More than 1.0	7.5YR2-3/1 - 5YR3/6	Abundant	Clay - Clay loam	Blocky	Angler	Fine	Fresh	Common	22 - 30	Moist	(Clay)	--	Many	pH6.6(A_1) 5.6(B_2)
64	Gentle slope	5	Ne-s	More than 1.0	5YR3/4 - 2.5YR3/6	Common	Clay loam	Blocky			---		25 - 30	Dry to moist	--	--	Common	pH6.5(A_1) 6.7(B_1)
65	Hill middle slope	13	Bv	More than 0.5	7.5YR3/2 - 5-7.5YR4/4	Abundant	Clay - Clay loam	Nutty, Blocky			---		26 - 30	Dry	--	--	Many	pH6.6(A_1)
66	Hill gentle slope	6	Be	More than 0.5	5YR3/1 - 5YR3/3	Abundant	Clay loam	Nutty	Rounded	Fine	Strongly weathered	Scanty	32 - 34	Dry	--	--	Common	
67	Flat	0	Bg	More than 0.5	7.5YR3/1 - 5YR4/6	Common	Clay loam	Blocky			---		27 - 32	Dry	(Mn concretion)	--	Common	pH5.8(A_1)
68	Hill gentle slope	6	Be	More than 0.5	7.5YR3/2 - 5YR3/6	Common	Clay loam	Nutty			---		25 - 32	Dry	--	--	Common	
69	Hill gentle slope	10	Be	0.5 - 0.6	5YR2/1 - 5YR3/4	Abundant	Clay loam - Clay	Nutty, Blocky	Angler	Small	Fresh	Abundant	17 - 31	Dry	--	--	Many	pH6.6(A_1)
70	Flat	0	Bg	More than 0.5	7.5YR2-3/2 - 7.5YR4/4	Abundant	Loam - Light clay loam	Blocky			---		28 - 30	Moist	(Mn-Fe mottle)	--	Common	
71	Hill gentle slope	3	Be	More than 0.6	7.5YR2/1 - 7.5YR4/4	Common	Loam	Nutty			---		20 - 32	Dry to moist	--	--	Common	pH6.4(A_1)
72	Hill gentle slope	6	Be	More than 0.5	7.5YR2/1 - 7.5YR5/6	Common	Loam - Clay loam	Blocky			---		19 - 31	Dry to moist	--	--	Common	
73	Hill gentle slope	6	Le	More than 0.6	5YR3/2 - 2.5-5YR5/8	Common	Loam - Clay	Nutty, Blocky			---		22 - 32	Dry to moist	Clay	--	Common	pH6.4(A_2) 6.3(B_2)
74	Hill gentle slope	4	Lc	More than 0.6		Scanty	Loam - Clay							Dry	Clay	--	Common	pH6.4(B_2)
75	Flat	0	Be	More than 1.0	7.5YR2/1	Very abundant	Loam - Clay	Nutty, Blocky			---		32 - 33	Dry to moist	--	--	Many	
76	Flat	0	Be	More than 0.5	7.5YR2-3/1 - 7.5YR3/4	Abundant	Loam	Nutty, Blocly			---		27 - 31	Dry	--	--	Common	
77	Hill gentle slope	4	Lg	More than 0.5	7.5YR3/2 - 5YR4/4-6	Common	Loam - Sandy clay	Blocky			---		31 - 32	Dry	Clay	--	Few	
78	Flat	0	Gp	More than 0.5	7.5YR3/2 - 75YR5/4	Common	Clay loam	Blocky			---		26 - 29	Dry	(Fe-Mn concretion)	--	Few	
79	Flat	0	Gp	More than 0.5	7.5YR2/2 - 7.5YR4/4-6	Abundant	Sandy loam - Clay	Nutty	Rounded	Fine	Fresh	Scanty	28 - 32	Dry	(Fe-Mn concretion)	--	Few	
80	Flat	0	Ne-s	More than 1.0	2.5YR2/4 - 10R3/4	Common	Loam - Clay loam	Blocky			---		9 - 25	Dry to moist	(Clay)	--	Common	
81	Flat	0	Ne-s	More than 1.0	2.5YR2/3 - 10R-2.5YR3/4	Abundant	Loam - Clay loam	Blocky			---		12 - 26	Dry to moist	(Clay)	--	Common	pH6.7(A_1)
82	Flat	0	Ne-f	More than 1.0	5YR3/3 - 10R3/4	Common	Loam - Clay loam	Blocky			---		22 - 32	Dry to moist	(Clay)	--	Few	pH6.4(A_1)
83	Flat	0	Ne-s	More than 1.0	5YR2/4 - 10R3/4	Common	Loam - Clay loam	Blocky			---		10 - 23	Dry to moist	(Clay)	--	Common	pH6.6(A_1) 6.1(B_3)
84	Flat	0	Ne-f	More than 1.0	5YR2/2-3 - 10R3/6	Abundant	Clay loam	Blocky			---		24 - 32	Dry to moist	(Clay)	--	Common	pH6.2(A_1)
85	Flat	1	Ne-f	More than 1.0	5-7.5YR2/2 - 2.5YR4/8	Common	Loam	Blocky			---		25 - 31	Dry to moist	(Clay)	--	Common	pH6.8(A_1)
86	Flat	2	Lv	More than 0.8	2.5YR2/2-3 - 10R3/3	Abundant	Clay	Nutty, Blocky			---		24 - 32	Moist	Clay	--	Common	pH6.2(A_1)
87	Hill gentle slope	3	Ne-f	More than 1.0	2.5YR2/2 - 10R3/4	Abundant	Clay loam - Clay	Blocky			---		22 - 28	Moist	(Clay)	--	Many	pH6.4
88	Hill gentle slope	6	Be-c	0.7	5YR2/1 - 5YR3/4	Abundant	Loam - Clay	Blocky	Rounded	Fine - Small	Weathered	Scanty	29 - 32	Dry to moist	--	--	Common	pH6.3
89	Hill gentle slope	8	Lv	More than 0.6	5YR2/1 - 2.5YR4/6	Abundant	Clay loam - Clay	Blocky			---		31 - 33	Dry	Clay	--	Common	

(Notes) No.61 to No.64, No.80 to No.89) inside the model area

No.65 to No.79 outside the model area

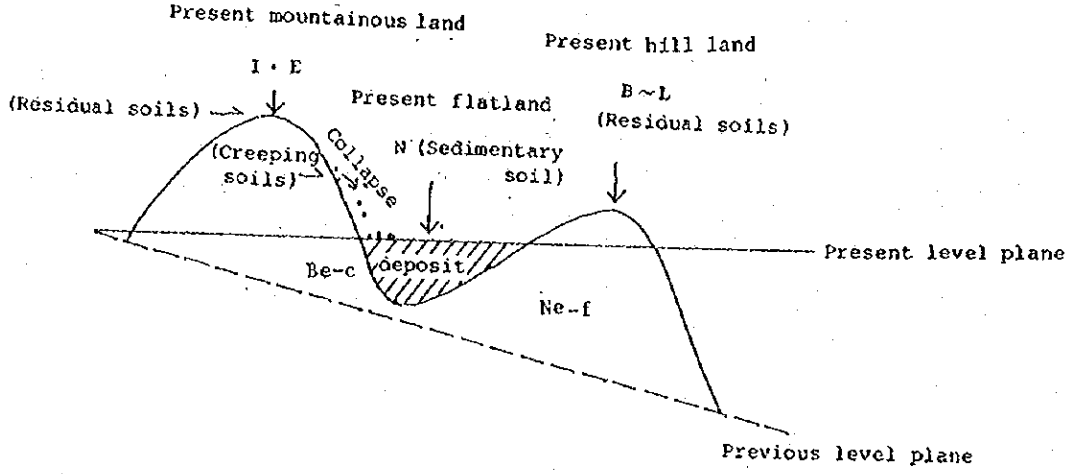


Fig. II-5-10 Typical Illustration of Change in Level Plane and Soil Formation

Specifically, outcropping rocks and boulders are found everywhere in the steep mountainous zone which is distributed with quite shallow layers of Lithosols (I) and Rendzinas (E). The hill land zone is distributed with Cambisols (B) or Luvisols (L) with slight argillation, while the flatland is distributed with quite a thick layer of highly productive Nitosols (N). Their rough horizontal distribution is as shown on Fig. II-5-11. Naturally, soils with intermediate characteristics occur near the boundaries of each type of soil.

Every one of these soils distributed in the model area is slightly clayey, but weakly acidic soil with a high degree of base saturation which contains a lot of weatherable minerals and organic matters which supply plant nutrients in abundance and which thus greatly affect the fertility and productivity of soil.

Generally, strongly acidic clayey soils with a low degree of base saturation which contain little organic matters and weatherable minerals are formed in the tropical zone as chemical reactions proceed quickly and rocks and

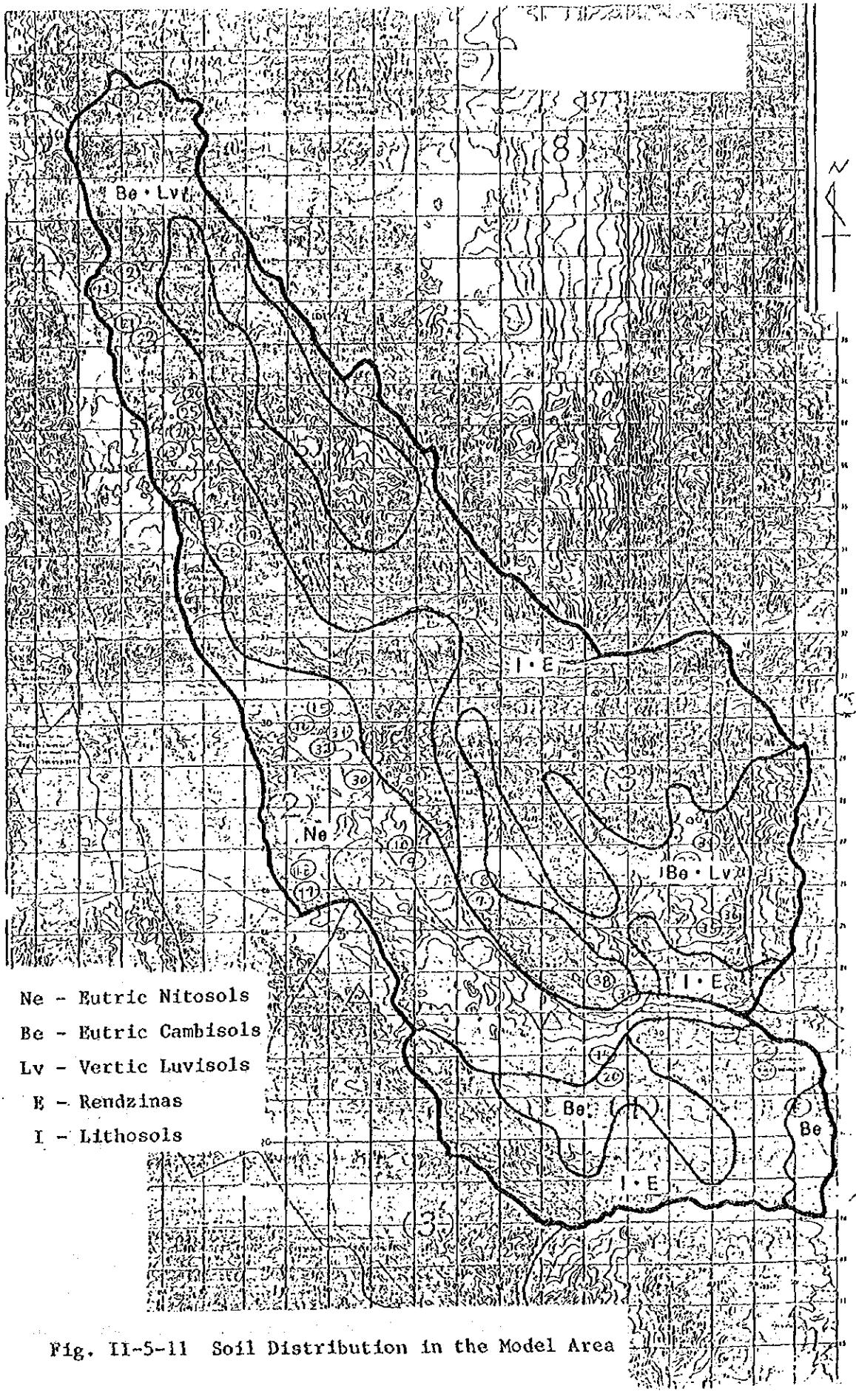


Fig. II-5-11 Soil Distribution in the Model Area

minerals also weather quickly due to high temperature and precipitation.

In areas which have a dry season as in this model area, however, disintegration and weathering are retarded because the moisture content becomes short, even if only temporarily during a particular season, so that organic matters, sand, weatherable minerals, etc. are retained in the soil and the effluence of basic matters is also reduced. Also, bases are thought to have existed in abundance in this model area to begin with as the soils originated from limestone (basic rock) as the parent material, and soils are presumed to contain a lot of organic matters which are readily adsorbed by the bases.

Accordingly, the soils distributed in the model area, with the exception of Lithosols and Rendzinas distributed in the steeply sloped areas, may be considered to be of better quality among the soils in the tropical and/or subtropical zone and therefore would not constitute any major obstacle to land use.

③ Characteristics of the soils distributed in the model area

a. Nitosols (N)

This soil is mainly distributed in the flatland in the southwestern part of the model area.

Unlike the soils distributed in the hill land and mountainous zone, the parent materials of this soil are not limestone per se but considered to be the thick sedimentary layer of weathered limestones added with shale, sandstone, chert, etc. The properties of this soil are also greatly different from that of typical soil in the hill land and mountainous zone.

It has an extremely deep soil horizon (the Team came across a well drilling site during the field survey and confirmed the thickness of this soil horizon to be

at least 10 m or more), is red to red brown in color, is slightly clayey and has an argillic B horizon though not a genuine argillic B horizon which obstructs the growth of roots. Its boundaries are unclear and no abrupt change is seen to have taken place in the textural classes. (Refer to the section on Luvisols described later) It shows a porous, well drained, deep and uniform profile. Its root system is deep, has a high water holding capacity and rich basic parent material and still retains weatherable minerals, so that it has good potential use for agriculture and forestry.

Here, Eutric Nitosols (N_e) which has a higher degree of base saturation than other types of Nitosols is distributed. Even among the same Eutric Nitosols (N_e), however, distinctive differences can be found in the color and firmness though no significant differences exist in organic contents, texture, soil structure, etc. Firmness in particular is considered to have a large influence on farming, Eutric Nitosols is further subdivided into the following two sub-groups.

1) Ne-soft (s)

Mainly distributed in very flat land and is considered to be a typical Nitosols.

It is of strongly reddish color between 2.5 YR and 10R in hue. Its profile is homogeneous with hardly any change, and is soft overall. The value indicated by a hardness meter is around 10 mm (about 1.4 kgs/cm^2) for the soft layer and in the range of 26 to 29 mm (about 20 to 30 kgs/cm^2) even for the hardest layer, which are considerably low for soils in the sub-tropical zone in the dry season when soils tend to harden.

Its soil property is clayey and contains no stones.

ii) Ne-firm (f)

Mainly distributed in places with slight topographical changes such as in the peripheries of flat land or in slightly undulating places of flat land.

Its hue ranges between 5 and 2.5 YR and is lightly more brownish than Ne-s, and its profile also shows some changes. Ne-f deeper than 70 - 80 cm from the top soil is approximately the same as Ne-s but the shallower layers are harder than Ne-s. The value indicated by a hardness meter ranges around 22 - 33 mm (about 8.5 - 85 kgs/cm^2) and appears quite compact to the eye.

The soil property is clayey, but locally contains slightly more sandy layers sometimes. Stones are not contained.

As above, Ne has been classified into two sub-groups, but even among the same Ne-s or Ne-f, some differences are observed in the thickness of A horizon and organic contents depending on the place. These differences have not been especially classified, but they seem to be attributable to the length of period that forests having been formed on the soil, and organic contents are lean at places where forests had been cleared and utilized as farm land from long ago and are rich in places where forests still exist.

Nitosols is considered to be one of the best soils in the tropical zone and suitable for cultivation of a broad range of crops. It has a relatively high natural fertility, and Ne-s in particular has the largest potential for agriculture among soils distributed in the model area. In order to achieve high yield, however, fertilization is considered necessary in most cases, and its conservation is also considered necessary as it is slightly susceptible to

erosion.

At present, most of the cultivated land and tropical evergreen forest (T_E) in terms of the forest type are formed on this Nitosols. Particularly the tropical evergreen forests, other than those in areas where Nitosols is distributed are seen only where abundant water supply is available. Besides T_E, mixed deciduous forest (M_D) and large diameter bamboo forest (B_F) are also seen in areas where Nitosols is distributed.

Soils which had been classified as Ne and Nd in the 1985/86 survey have been reclassified as Ne-s or Ne-f, and some of the soils classified as Bc have been changed and reclassified as Ne-f.

Nitosols is equivalent to Paleustulfs and Rhodustalfs pp. according to the U.S. Soil Taxonomy.

b. Cambisols (B)

It is widely distributed in the hill land and mountainous zone throughout the entire model area.

It is weakly weathered and does not have any specific illuvial horizon or eluvial horizon, and may be considered as a soil in the transitional stage of development into various other soils in which these specific properties are well developed. Accordingly, Cambisols display diverse profiles. Here, Eutric Cambisols (Be) with a high degree of base saturation and high organic contents is mainly distributed.

There are the residual type and the colluvial type of Eutric Cambisols, since these two types have greatly different profile and are considered to be considerably different in productivity, Eutric Cambisols was further subdivided as follows.

i) Be-colluvial (c)

Distributed from the lower part of the mountain slope

toward the mountain spur in the steep mountainous zone.

It is a colluvial type of soil formed by deposition and constant supply of sediments and organic matters crumbling down from the upper slopes or conveyed by the surface water.

It has a high degree of base saturation and a well developed soil structure. It has an A horizon (Mollic A horizon) which contain a lot of organic matters which have been completely blended with mineral substances and is black to dark brown in color and as thick as 30 to 50 cm, as well as a B horizon which is dark reddish brown to dark brown and contains a lot of organic matters.

Its textural classes are clay loam to clayey and sometimes contains half-weathered or decayed fine stone but the quantity is small. Cracks are sometimes observed between A horizon extending to B horizon.

It is fairly hard during from the dry season (the value indicated by a hardness meter roughly ranges between 25 mm or about 14 kgs/cm^2 to 32 mm or about 63 kgs/cm^2) but seems t become fairly soft during the rainy season. As its rooting system is deep and a lot of organic matters and weatherable minerals are contained, its productivity is high so that it is considered usable for both agriculture and forestry. Particularly in cultivating cotton and chilli, Be-c is considered more suitable than Ne-s or Ne-f.

At present, the area in which Be-c is distributed comprises mixed decidous forest (M_D) and large diameter bamboo forest (B_F).

ii) Be-residual (r)

Be-r is widely distributed in the hill land zone

which is considered to be the remnants of old mountain tops, as stated already.

It is a residual type of soil which was presumably formed by the in situ weathering of limestone parent material and it has a black-brown A horizon and a reddish brown B horizon. It is considered to be a soil in the transitory stage to a more weathered Luvisols which will be discussed later.

Soil horizon is relatively deep, and the whole profile is compact and quite firm particularly in the layer around 30 to 40 cm deep from the top soil which seems to be limiting the growth of roots. The value indicated by the hardness meter is around 26 mm (about 17 kgs./cm^2) in the soft layer and around 33 mm (about 85 kgs./cm^2) in the hard layer, both of which are slightly harder than Ne-t and Be-c which were mentioned earlier.

Texture is clay loam to clayey and sand sometimes remains in part. Sometimes, it also contains half-weathered or decayed fine stone although the quantity is small.

It is usable for both agriculture and forestry but as its rooting area is not large, its productivity is considered inferior to Ne-s, Ne-f and Be-c.

At present, the area in which Be-r is distributed comprises mixed deciduous forest (M_D) mixed with small diameter bamboos, but the tree height is not so high and the crown density is also slightly thin.

The foregoing has described Eutric Cambisols which has divided into two sub-groups. Besides these typical Be-c and Be-r, many other Eutric Cambisols which indicate properties that are between these and Nitosols (particularly Ne-t), Luvisols, Rendzinas, Gleysols, etc. frequently occur. Every one of these

are included in either Be-r or Be-c except the type in between Be-r or Be-c and Gleysols which was especially classified as Gleyic Cambisols (Bg).

Gleiic Cambisols is cambisols with hydromorphic properties found in the topsoil and layers down to the depth of 100 cm, and is distributed in places where the ground water level is high or where there is plenty of water like dales and depressions. In agriculture, therefore, crop species that can be cultivated are slightly restricted. In forestry, however, no major restriction seems to exist.

Cambisols is widely distributed in the tropical and sub-tropical zone but is not a typical soil in these regions. It is a type of soil that occurs throughout the world, and the brown forest soil in Japan is also included in this category.

Be-c corresponds to Eutropepts in the U.S. Soil Taxonomy, Be-r to Eutrochrepts pp. or Ustochrepts pp., Bg to Aquic Entrochrepts, respectively.

Soils classified as Be in the 1985/86 survey were subclassified into Be-c and Be-r, and a part of soils classified as Be were reclassified and changed to Be-r.

c. Luvisols (L)

It is a type of soil distributed in slightly spacy, flat or gently sloped lands in the hill land, and is considered to have been developed from Be-r or Ne-f which had been further subjected to strong weathering, and therefore occurs in succession to or mixed with these.

Luvisols is a clayey soil characterized by having a distinctive argillic B horizon which occurs in accompaniment to the abrupt changes in soil structure and by a high degree of base saturation. Here, vertic

Luvisols (Lv) which belongs to the category of Luvisols is distributed.

Vertic Luvisols is a type of Luvisols in which cracks develop from the dark-brown A horizon to the reddish brown B horizon during the dry season and which has slightly vertic properties. As small aggregates and organic matters on the topsoil infiltrate along the cracks during the dry season to the beginning of the rainy season, it contains lots of organic matters down to the relatively deep places, and its B horizon also has a distinct soil structure.

These cracks disappear during the rainy season when the subsoil (the layer between 25 cm to 100 cm in depths) becomes wet and swells, and the surfaces of aggregate structure becomes glossy by being polished by the pressure generated inside the subsoil. If the crack is large and also deep, part of the subsoil is pushed up to the topsoil by the pressure generated in the subsoil and the soils become churned and mechanically mixed, but here distinct vertisol properties cannot be observed as the crack is narrow in width, although deep.

The soil texture of A horizon which is about 30 cm thick is clay loam while that of B horizon is clayey, both of which contain hardly any stone.

As it has a high degree of base saturation and abundant organic matters, its productivity is inferior to Nitosols and Cambisols since its permeability and drainability are lowered and the growth of roots is restricted by the argillic B horizon. When the profile was actually observed, it was confirmed that the growing roots run in the horizontal direction at the depth of about 30 cm but do not extend much into B horizon. Since the growth of roots is restricted at around 30 cm in depth, its use for forestry becomes

slightly disadvantageous compared to its use for agriculture or for livestock raising.

In terms of present forest type, deciduous dipterocarp forest (D_D) and mixed deciduous forest (M_D) are distributed on this soil but these forests give the impression that their crown density is low and the forest soil dry.

It corresponds to Vertic Haploxeralfs in the U.S. Soil Taxonomy.

Some of the soils classified as Bc, Bv and Nd in the 1985/86 survey were changed to Lv based on the survey of this fiscal year.

d. Rendzinas (E) and Lithosols (I)

Both of these soils are distributed in the steep mountainous zone and partly in the gently sloped area of spur zone.

These are shallow soils which lie on calcareous rocks having Mollic A horizon only (refer to the section on Cambisols stated previously) and no B horizon, and contain rocks, boulders and a lot of stones. Here, the thickness of soil horizon is within up to around 70 cm, but in some places it is quite shallow, being less than 10 cm thick.

Soils with soil horizon of less than 10 cm in thickness were defined as Lithosols and distinguished from Rendzinas which were defined as soils having more than 10 cm thick soil horizon. Also, even if the thickness of soil horizon is less than 10 cm, if the base rock is neither rock nor rock bed but conglomerate, such soils were defined as Rendzinas. Although they are named differently, there is no difference between the two in terms of soil color, textural classes, soil structure and organic matter contents, etc. The distinction was made only because

of the difference in the thickness of their soil horizon. It is only natural however that Lithosols should contain many more rocks and boulders than Rendzynas.

Forests also grow on these shallow soils, and mixed dedicious forest (M_D) mixed with many small diameter bamboos and deciduous dipterocarp forest (D_D) were seen, but the crown density of these forests were low and tree heights were also low. Since water becomes extremely short during the dry season, small diameter bamboos were also defoliated.

In general, even the farm crops with shallower roots than trees are deemed to require soils with at least 80 cm or thicker soil horizon to have a satisfactory rooting volume and ample water holding capacity. Accordingly, there is little hope that soils with thin soil horizon like Rendzinas and Lithosols for agriculture or forestry, and in addition to this, such topographical conditions as outcropping rocks boulders and steeply sloped land make their utilization even more difficult.

However, since the soil horizon itself has a high degree of base saturation and contains a lot of organic matters and weatherable minerals even though it is thin, these soils can be utilized for grazing land in the gently sloped land. It is also considered possible to grow cotton and chilli in places which are gently sloped and where the soil horizon is of a reasonable thickness (50 to 70 cm). It would naturally be difficult to use mechanical power in such an event because of the rocks and boulders.

In the U.S. Soil Taxonomy, Rendzinas corresponds to Rendolls, but there is no particular soil name applicable to Lithosols which are therefore classified as Lithic sub-groups.

Soils classified as Bh in the 1985/86 survey were changed to E.

e. Gleysols (G)

This is a type of soil distributed in the lowlands, depressions and along dales. It indicated hydromorphic properties due to the influence of stagnant waters ascribable to poor drainage, high ground water level, or immense surface water due to large discharge during the rainy season.

At places affected by stagnant water and ground water, clayey soils containing iron and manganese mottles and concretions can be observed near the top soil. Such soils become hard and cracked on the surface and indicate slightly vertic properties during the dry season, and become fairly soft and highly viscous during the rainy season. At present, many of the places have been turned into so-called swamps where hygrophytic herbs grow thick.

At places which are affected by surface water during the rainy season (the ground water level is also high in such places), the soils are close to sandy loam as fine clay particles run off with water and a large amount of lime accumulations and concretions are seen contained even in the topsoil. Such places do not become so-called swamps because although there is plenty of water, it is not stagnant. Tropical evergreen forest (T_E) is formed there, but the growth of roots seems to be restricted in the shallow layers as individual trees are seen to have platy roots.

Gleysols is unsuitable for forestry and is mainly utilized for water paddy field and for growing bananas and palm trees, but even in such an event, it is necessary to take appropriate measures for irrigation and drainage.

(2) Examination on land use classification

1) Site classification

As a result of land type classification and land use capability classification, suitability classes of land based on the natural conditions of the site were obtained for each of agriculture, forestry and livestock raising. The site classification further attempts to determine the priority rating in land use, for each of agriculture, forestry or livestock raising, with due regard to various social and economic conditions such as: ① ease of access to the site, ② vulnerability of the site to soil erosion, collapse, land slide, flooding and inundation and other natural calamities, and ③ public utility function of forest.

① Ease of access to the site

The road conditions in the model area have already been described in the section on the survey for land use planning. The ore hauling road of the mining company (8 m wide) which starts from the car ferry terminal on the right bank of the reservoir located at the southeastern most end of the model area traverses the model area in the ease-west direction and extends as far as the Logging Block 9 by passing through the western side of the model area toward north. This road is not paved but well maintained and is passable for ordinary motor vehicle. Some roads branch off from this mining company's road, one of which goes south on the eastern side of the model area (on the right bank of the dam) and leads to Kanchanaburi via Erawan National Park, and another leads to Thong Pha Phum from the north side of the model area, but both of them are unpaved and damaged in some places and are unfit to be used for traffic especially during the rainy season. There are several other roads for logging which branch off from said mining company's road in the model area, but all of these are dead-end roads and in a ravaged state.

In view of such road conditions, there is no special priority for the use of the land within the model are for agriculture, forestry or livestock raising in terms of the ease of access to the site.

② Vulnerability of the site to soil erosion, collapse, land slide, flooding and inundation and other natural calamities

If there are any places which are highly vulnerable to soil erosion, collapse, land slide, flooding and inundation and other natural calamities, such places must be protected on a priority basis from the use in any of agriculture, forestry or livestock raising. According to the results of field reconnaissance and aerial photo-interpretation, however, there is no such place within the model area. In this context, there is no site that shall be given preference for use in agriculture, forestry or livestock raising.

③ Multiple function of forests

The eastern side of the model area comprises the Srinagarind Dam. Therefore, it is necessary that this area functions as the source of water supply to the dam. It is also important to prevent surface soil erosion into the dam. However, when the natural site conditions of the model area are considered, it will suffice to consider the sloped areas on both sides of the river that flows into the dam as the sites for the water reserve function of the forest, irrespective of interpreting each mesh in terms of gradient, localized topography, soil and other factors. Compartment 8 of the Khao Praleusri Bor Rae Working Block, Compartments 10, 11 and 12 of the Srinagarind Working block are to be reserved for this purpose.

④ Priority ranking for utilization

As stated in the section on land type classification, areas which shall be excluded from intensive utilization are the areas having mountainous topography, areas with 31° or larger gradient, and areas for preventing surface soil erosion. Other areas can be used for agriculture, forestry and livestock raising respectively. In view of the actual state of the local inhabitants which the survey on forest villages and tropical farming and livestock raising revealed, however, there is no need to give preference to livestock raising on the whole, but in the gently sloped areas of Group VII (FM_D E·I, H M_D E·I, F D_D E·I, H D_D E·I) classified according to land type classification, it is considered more suitable to utilize the grass land for livestock raising rather than for agriculture or for forestry. If it is not to be used as grassland, however, it is best to keep it as forest.

The Table II-5-21 shows priority ratings for use in agriculture and forestry.

Table II-5-21 Priority Rating of Land Group for Agriculture and Forestry

Soil type	Division	Gradient						
		~5°	6~8°	9~13°	14~18°	19~23°	24~30°	31°~
Ne	A	1	1	2		×	×	×
	F	1	1			2	3	×
Be	A	1	2		3		×	×
	F	1	1			2	3	×
Lv · Be	A	2	2	3		×	×	×
	F	2	2			3	×	×
I · E	A	3	3		×	×	×	×
	F	3	3			×	×	×

(Notes) A: Agriculture
F: Forestry

From the above priority rating, the following classification results.

a: A1·F1, b: A2·F1, c: A2·F2, d: A3·F2, e: A3·F3,
f: F only g: Unfit for both agriculture and forestry

In all four classes other than a. A1·F1, c. A2·F2, and g. unfit for both agriculture and forestry in the above classification, forestry shall be given preference. On a and c, a study will be made in the section on land use classification for the entire model area. Class g which is unfit for both agriculture and forestry shall be the zone in which the existing state of forests shall be maintained.

2) Land use classification

Since the land use classification constitutes the core of the national forest management plan, it is necessary to clarify the purpose of preparing a land use plan and to examine each land use carefully with due regard to not only natural site conditions but to future socio-economic development trends, intentions of the government, desires of the local inhabitants and other diverse considerations.

In the model area surveyed this time, the ratio of forest area is high, but the road conditions are poor as stated before. Not only that, national parks account for a large portion of the area and forest work in the parks is severely restricted. On the other hand, as highly fertile flat lands are widely distributed inside and outside the parks, the number of farmers who have cleared the lands and settled without permission is also large.

The southern half of the model are is designated as a national park, but selective cutting of trees in the area had already been its round by the operators who were given the consessions for logging before the area was designated as a park so that in many places the forest type is poor and good trees are scarce.

The policy for the land use classification is predicated on the premise that sites classified as "A1·F1", "A2·F2" may be the agro-forestry area, "A2·F1", "A3·F2", "A3·F3", and "F only" shall be the forestry area, and "sites unfit for both agriculture and forestry" shall be the protection area. And that the proposed land use classification is as shown in Table II-5-22 and Fig. II-5-12. The classification shall be adjusted and completed at the time of preparing the working arrangement.

Table II-5-22 Proposed Land Use Classification

Area	Classification	Remarks
Protection area	National park	Landscape conservation zone, facilitieszone, vegetation recovery zone, experimental plot
	Sites difficult to work on Experimental plots, etc.	Steeply sloped land, rocky land
		Experimental plot, seed collecting area
Forestry area	Man-made forest	Working area for clear cutting and artificial reforestation
	Natural forest	Selective cutting and bamboo forest working
Agro-forestry area	Man-made forest	Agro-forestry complex working
	Fuelwood forest	Fuelwood forest for captive use
	Bamboo forest	Bamboo forest for captive use
	Farm land	
	Residential site	

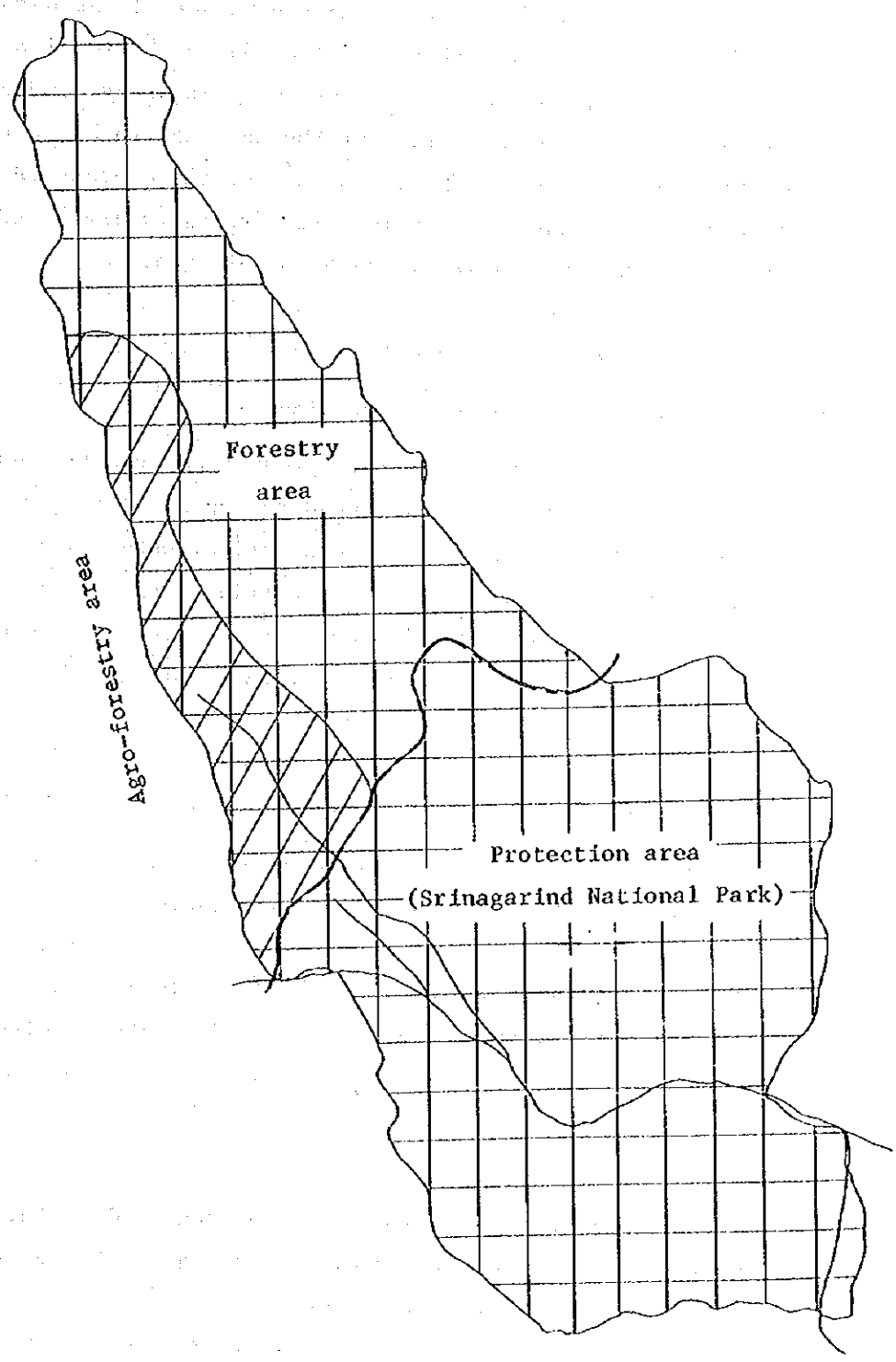


Fig. II-5-12 Land Use Classification Plan of the Model Area

III. SUBJECTS OF FUTURE STUDY

The work for 1987/88 shall be to analyze in detail the data obtained through the basic study conducted in 1985/86 and the basic plan for land use classification obtained as a result of the main study conducted in 1986/87; also to prepare a guideline for the national forest management plan, and formulate the forest working plans for the encroached area (agro-forestry area), timber production area (forestry area) and the protection area (preservation area) in the model area.

1. Analysis of Already Collected Materials

(1) Forest inventory and forest working

To map out plans for the timber production area (forestry area), analysis and study shall be conducted on stand composition, the state of and the method for regeneration, method for selective cutting and natural forest work, cutting cycle, bamboo forest work, man-made reforestation and other matters. The areas for man-made forest work and natural forest work shall be classified, too.

(2) Forest village and tropical farming

To map out plans for the encroached area (agro-forestry area), individual items of the questionnaire survey shall be analysed to elucidate the sizes of the residential plots and farm lands of the inhabitants who shall participate in this project, scale of facilities, agricultural production and other relevant matters.

(3) Soil

Soil classification map shall be prepared as data for formulating the forest working plan, especially the forest village project and agro-forestry project.

2. Preparation of a Guideline for the National Forest Management Plan

A guideline for the national forest management plan shall be prepared by summarizing the results of the main study in 1986/87, site

analysis and land use classification and with due consideration to the forest work plan for the model area.

3. Formulation of the Forest Work Plan for the Model Area

A model forest work plan shall be worked out for the following three areas.

(1) Encroached area (agro-forestry area)
   1) Land Use Right Guarantee Project (Sor Tor Kor)
   2) Forest village project
   3) Agro-forestry project
   4) Commual forest project

(2) Timber production area (forestry area)
   1) Timber harvesting method
   2) Forest road network
   3) Forest fire prevention network
   4) Reforestation plan

(3) Protection area (preservation area)
   1) Watershed conservation plan
   2) Plan for sanctuary for wild life
   3) Plan for national park

4. Preparation of a Remote Sensing Manual

A manual for monitoring changes in forest land use shall be prepared by utilizing the remote sensing technique. The test area for preparing the manual shall be model area, and the tests shall be conducted by using the aerial photographs and the forest type map, etc.

5. On-the-spot Verification and Deliveration

The guideline for the national forest management plan and the forest work plan for the model area prepared shall be checked on the spot, and the adaptability of these shall be verified with the Thai side. Particularly the handling of inhabitants living within the model area and plans

for them must be thoroughly discussed.

6. Preparation of the Final Products

As the final products, a report on the formulation of the national forest management plan and related documents (soil classification map, site classification and land use classification map, charts and figures for the national forest management plan, forest inventory register) shall be prepared.

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