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The Status of Multipurpose Trees in Thailand

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August 1988

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PREFACE

As the forestry problems are enormous forest researchers have to find the proper program to tackle the existing problem. To promote the general well-being of the Thais there is the need to establish tree-lands wherever possible. To ensure progressively increasing supplies of fuelwood and charcoal as well as industrial wood, establishment of multipurpose trees is considered to be a superb chance for increasing wood productivity as well as restoring a proper ecological balance.

This status report on multipurpose trees was prepared by Dr. Suree Bhumibhamon for further discussion and use as basic information in R & D innovation. I thank Winrock International for kind cooperation in promoting the program on multipurpose trees undertaken in Thailand. And finally, I thank the Committee on Agriculture and Biology, National Research Council, for encouraging and promoting the forestry research program.

(Dr. Somsak Sukwong)
Chairman
Sub-Committee on Research and
Development of Multipurpose Trees
National Research Council
of Thailand

ABBREVIATIONS

ACFTSC	-	ASEAN/Canada Forest Tree Seed Centre
ADB	-	Asian Development Bank
ASEAN	-	Association of South East Asian Nations
BIOTROP	-	Biology Tropical Program
CSIRO	-	Commonwealth Scientific and Industrial Research Organization
DANIDA	-	Danish International Development Agency
ESCAP	-	Economic and Social Commission for Asia and Pacific
E-W Centre	-	East West Centre
FAO	-	Food and Agriculture Organization
FINNIDA	-	Finnish International Development Agency
FIO	-	Forest Industry Organization
F/FRED	-	Forestry/Fuelwood Research for Economic Development
GTZ	-	German Agency for Technical Cooperation
IBRD	-	International Board for Research and Development
ICRAF	-	International Council for Research in Agroforestry
IDRC	-	International Development Research Centre
IFCT	-	Industrial Fund for Cooperation of Thailand
IFS	-	International Foundation for Science
ISTA	-	International Seed Testing Association
IUFRO	-	International Union of Forest Research Organization
JICA	-	Japanese International Cooperation Agency
KUFF	-	Kasetsart University, Faculty of Forestry
NESDB	-	National Economic and Social Development Board
ODA	-	Overseas Development Administration
PFC	-	Provincial Forest Company
PIC	-	Pine Improvement Centre
RECOFTC	-	Regional Community Forestry Training Centre
RFD	-	Royal Forest Department
SIDA	-	Swedish International Development Agency

TDRI	-	Thailand Development Research Institute
TIC	-	Teak Improvement Centre
TISTR	-	Thailand Institute of Scientific and Technological Research
TPC	-	Thai Plywood Company

THE STATUS OF MULTIPURPOSE TREES IN THAILAND

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CHAPTER 1

THE PAST AND PRESENT SITUATION OF FOREST RESOURCES

1.1 OVERVIEW

1. Thailand covers an area of about 518,000 km² with a total land area of 51.312 million ha. The topography is characterized by folded mountains which run from northwest to southeast, with flat alluvial plains intersected by winding rivers and irrigation canals between the mountain ranges; a certain amount of undulating country; and maritime features including mangrove and beach forests. However, Thailand is generally divided into five physiographic regions, including the Northern folded mountains, the Central Plains, the Khorat Plateau, the East, and the Peninsular.

2. Like most developing countries in the tropics where the rate of deforestation is about 11.3 million ha/year (over 76 tropical countries) the rate of depletion of forest resources in Thailand is also high at about 0.5 million ha/year. The environmental and socio-economic aspects of deforestation in Thailand were summarized by Bhumibhamon (1986a). Strategies and future prospects were also clarified in detail.

1.2 DEPLETION OF FOREST RESOURCES

3. The depletion of forest resources in Thailand has mainly been caused by the continuous misuse and mismanagement of forest area. Moreover, the over-exploitation of forest resources and shifting cultivation practices are closely linked with agricultural development, land encroachment (Bhumibhamon, 1986b) as well as the improvement of infrastructure and the establishment of resettlements.

4. Table 1 shows the change in forest resources. As reported previously, the annual depletion rate of forest resources decreased from 9.9% during 1968-1973 (Wacharakitti et al., 1973) down to 3.2% (RFD, 1982). However, a variation in the change of forest area was found both between regions (Table 1) and provinces (Table 2). There are ten provinces in Thailand where forest resources were mostly converted to farming long ago. A small number of remaining trees are, however, scattered over the area.

Table 1. The depletion of forest area in various parts of Thailand, during 1961-1982 (After RFD, 1983).

Region	Number of provinces	Total area (Km^2)	Forest area 1/ (Km^2)					Change 1961-1982
			1961	1973	1976	1979	1982	
North	17	169,640	116,280	113,600	102,330	94,940	87,750	28,530
East	7	36,500	21,160	15,040	12,630	11,040	8,000	11,360
North-East	16	168,850	70,900	50,670	41,490	31,220	25,890	45,010
Central	18	67,400	35,660	23,970	21,830	20,420	18,520	17,140
South	14	70,720	29,630	18,430	20,140	17,600	16,440	13,190
Total	72	153,110	273,630	221,710	189,420	175,220	156,600	117,030

1/ 1961 Aerial photos: 1973, 1976, 1979 and 1982 LANDSAT Imagery.

Table 2. The changing of forest area in each province estimated by LANDSAT imagery during 1978 and 1982 (RFD, 1984).

Regions and provinces	Total area (ha)	Forest area (ha)		Forest area changed (ha)
		1978	1982	
North				
Chiang Rai	1,167,836.9	553,400	483,900	69,500
Prayao	633,506.0	348,700	327,800	20,900
Chiang Mai	2,010,705.7	1,746,700	1,670,200	76,500
Lamphun	450,588.2	283,500	272,200	11,300
Mae Hong Son	1,268,125.9	1,008,100	963,800	44,300
Lampang	1,253,396.1	983,800	944,500	39,300
Nan	1,147,207.2	714,100	651,500	152,600
Phrae	653,859.8	295,800	274,600	21,200
Uttaradit	783,859.2	376,800	349,700	27,100
Phetchabun	1,266,841.6	406,000	376,300	29,700
Pitsanulok	1,081,585.4	363,100	315,100	48,000
Sukhothai	659,609.2	315,600	294,100	21,500
Kamphaeng Phet	680,749.0	300,100	277,700	22,400
Phichit	453,101.3	-	-	-
Nakhon Sawan	959,977.7	114,200	103,700	10,500
Uthai Thani	673,024.6	305,000	286,700	18,300
Tak	1,640,665.0	1,378,800	1,273,800	105,000
East				
Chonburi	436,300	38,000	25,900	12,100
Rayong	355,200	39,500	24,100	15,400
Chanthaburi	633,800	235,600	193,600	42,000
Trat	281,900	99,600	79,400	20,200
Chachoeng Sao	535,100	180,500	135,400	45,100
Prachin Buri	1,195,750	460,100	291,400	168,700
Nakhon Nayok	212,200	50,400	50,200	200
Northeastern				
Kalasin	694,674.6	143,900	100,400	43,500
Khon Kaen	1,088,599.1	155,500	118,400	32,100
Chaiyaphum	1,277,828.7	318,500	247,600	70,900
Nongkhai	733,228.0	91,100	86,000	5,100
Nakhon Phanom	985,249.8	198,500	181,800	16,700
Maha Sarakham	529,168.3	22,300	15,800	6,500
Udon Thani	1,558,938.8	347,800	255,600	92,900
Nakhon Ratchasima	2,049,396.4	365,300	303,600	61,700
Buri Ram	1,032,188.5	77,100	75,800	1,300
Roi Et	829,944.9	38,800	31,600	7,200
Loei	1,142,461.2	477,300	376,000	111,300
Surin	812,405.6	44,100	42,600	1,500

Table 2. (Cont'd)

Regions and provinces	Total area (ha)	Forest area (ha) 1978	Forest area (ha) 1982	Forest area changed (ha)
Si Sa Ket	883,997.6	118,700	100,500	18,200
Sakon Nakhon	960,576.4	188,300	178,700	9,600
Ubon Ratchathani	1,890,608.9	465,500	419,100	46,300
Yasothon	416,166.4	69,400	55,000	14,400
South				
Chum Phon	600,900.8	168,100	151,600	16,500
Ranong	329,804.5	178,100	154,400	23,400
Pangnga	417,089.0	160,500	146,700	13,800
Surat Thani	1,289,146.9	434,600	413,800	20,800
Phuket	54,303.4	4,800	4,600	200
Krabi	470,851.2	52,200	49,200	3,000
Nakhon Si Thammarat	994,250.2	171,500	161,300	10,200
Trang	491,751.9	109,500	108,000	1,500
Phattalung	342,447.0	53,900	53,300	600
Satun	247,897.7	83,300	78,100	5,200
Songkhla	739,388.9	103,800	97,800	6,000
Pattani	194,035.6	7,600	7,300	300
Yala	452,107.8	141,500	129,100	12,400
Narathiwat	447,543.0	90,900	89,000	1,900
Central				
Kanchanaburi	1,948,314.8	1,332,314	1,241,700	91,200
Chai Nat	246,974.6	1,200	1,000	200
Lop Buri	619,975.3	31,900	29,100	2,800
Saraburi	357,648.6	11,900	9,800	2,100
Ayuthaya	255,664.0	-	-	-
Pathum Thani	152,585.6	-	-	-
Bangkok	156,522.1	-	-	-
Ratchaburi	519,646.2	129,100	105,700	23,400
Phetchaburi	622,513.8	282,600	249,700	32,900
Prachuap Khiri Khan	636,762.0	176,700	143,900	32,800
Suphan Buri	535,800.8	72,800	67,500	5,300
Samut Sakhon	87,234.7	-	-	-
Samut Songkham	41,671.7	3,500	3,200	300
Samut Prakan	100,409.2	-	-	-
Nonthaburi	62,230.3	-	-	-
Nakhon Pathom	216,832.7	-	-	-
Ang Thong	96,837.2	-	-	-
Sing Buri	82,247.8	-	-	-

1.3 THE PRESENT GROWING STOCK

5. The existing forest area alone can not be used in determining the forest resources unless the growing stock is taken into consideration. This is due to the fact that areas declared as forest area actually includes a considerable deforested area. Table 3 and 4 show a large variation in the growing stock in relation to the forest type. The highest and lowest stand density was found in Pine Forest (46.71 m^3/ha) and Dry Dipterocarp Forest (5.60-19.91 m^3/ha) respectively. Based on the data from the first measurement of permanent plots (1969-1973) and the second measurement (1975-1979) the stand density of trees with girth at breast height above 100 cm in all forest types has decreased by 10.36-56.4%. Table 5 indicates the volume of the total growing stock in 1978 to be about 185 million m^3 (Thammincha, 1985). However, growing stock in various parts of the country was summarized by TDRI (1986).

1.4 CONSTRAINTS IN THE INDUSTRIAL WOOD SECTOR

6. Long-term concessions are operating for teak (62 units) and non-teak (304 units). Under the present situation, some of these concession areas are still being closed down by both the cabinet declaration of 1979 (32 teak concession areas) and by the army's order (128 non-teak concession areas). Considering the sustained yield basis, the allowable cut of teak and other woods has decreased continuously (Table 6). A list of 182 highly commercial and commercial trees exploited from the concession areas in various parts of the country is shown in Table 7. However, the allowable cut of each treee species varies considerably between species. Based on the situation in 1984, Table 8 shows the quantity and the wood value of the main exploited tree species in Thailand.

1.4.1 Sawmills

7. In 1959, the total number of sawmills and sawnwood factories were 678 and 959 units respectively. The high number of sawmills has encouraged the government to freeze the number. As reviwed by Premrasmi (1977), the number of sawmills in 1977 was 498 units with an output of about 3.25 million m^3 against 5.4 million m^3 if run at full capacity.

8. Concerning the industrial wood sectors, Table 9 shows that the major sector in Thailand is sawmills (Figure 1), sawnwood factories (Figure 2) and wood working factories operated both manually (Figure 3) and by bigger machine tools (Figure 4). Out of the total number, 280 sawmills are less than 60 hp and have an output of 12 m^3/day. 133 sawmills are 60-90 hp with an output of 12-18 m^3/day. While the

Table 3. Stand density of different forest types in different parts of Thailand, based on the data from 2nd measurement of permanent plots (RFD, 1982).

Forest types in different regions	Stand density, m^3/ha (Hoppus)1/				6 year2/ change in density, z
	Highly commercial species	Commercial species	Other species	Total	
1. Dry Dipterocarp Forest					
North	8.02	10.90	0.99	19.91	-26.77
Northeast	4.08	6.16	0.19	10.43	-22.91
East & West	4.29	0.98	0.33	5.60	-56.45
2. Mixed Deciduous Forest					
North	9.04	8.78	3.02	20.84	-47.91
Northeast	6.80	13.36	3.01	23.17	-12.50
East & West	3.94	7.71	5.49	17.14	-10.31
3. Mixed Deciduous Forest with Teak					
North	17.30	9.01	1.98	28.29	-24.64
4. Pine Forest					
North	33.35	13.36	-	46.71	-31.03
5. Dry Evergreen Forest					
Northeast	12.76	6.67	2.47	21.90	-14.18
East & West	-	4.62	3.90	8.52	-45.73
6. Tropical Rain Forest					
South	12.22	9.34	11.78	33.34	-36.74

1/ Volume of trees with girth at breast height (GBH) above 100 cm.

2/ Based on the data from 1st measurement (1969-1973) and 2nd measurement (1975-1979).

Table 4. An estimation of growing stock in various forest types as reported previously (After TDRI, 1986a)

Regions	Timber volume m^3/ha	Forest type	References
Northeast	86.63	DEF	Ratanasermpong, 1978
	98.57	DEF	Wacharakitti *et al*. 1979
	56.80	MDF	" "
	28.97	DDF	" "
	12.66	Farm Forest	" "
	72.86	DEF	Suwannapinant and Siri-patanadilok, 1981
	29.77	DDF	EGAT, 1982
	56.61	DDF	" "
	13.60	DDF	" "
	38.45	DEF	" "
	172.75	DEF	" "
	24.34	DDF+Paddy Field	" "
	1.65	DDF	RFD
	0.65	Disturbed DDF	"
Total	694.35		
Average	49.60		
South	350.00	PRF	EGAT, 1976
	67.40	TRF	EGAT, 1980
	8.40	SCA	" "
	20.40	AA	" "
	88.01	TRF	EGAT, 1981
	22.07	SCA	" "
	161.49	TRF	" "
	34.35	AA	" "
	187.50	TRF	EGAT, 1983
	164.00	AA+Human	" "
	150.25	MEF	EGAT, 1985
	7.84	Disturbed MEF	" "
	73.58	PRF	" "
	4.38	SWF	" "
Total	1,380.57		
Average	92.04		

Table 4. (Cont'd)

Regions	Timber volume m^3/ha	Forest type	References
North	23.72	MDG+DDF	EGAT, 1982
	67.20	DDF+DEF+SCA	" "
	12.54	MDF Site 5	EGAT, 1984
	10.14	" "	" "
	123.08	Mae Khan	Ministry of Agr. and Cooperatives, 1986
	54.44	Mae Tha	
	144.88	Mae Phrik	
Total	436.00		
Average	62.29		
Central/ West	47.77	TRF	EGAT, 1975
	30.99	Semi EF	" "
	34.04	MDF	" "
	25.49	DDF	" "
	23.84	Disturbed For	" "
	27.82	Extra	" "
	29.65	Reservoir	" "
	72.80	MDF	EGAT, 1980
	53.50	DDF	" "
	20.00	SCA	" "
	27.90	AA	" "
	32.10	DDF	EGAT, 1982
	31.50	Disturbed DDF	" "
	30.70	DEF	" "
	25.00	MDF	" "
Total	513.10		
Average	34.24		

Note

AA	=	Agricultural Area
DEF	=	Dry-Evergreen Forest
HEF	=	Hill-Evergreen Forest
DDF	=	Dry-Dipterocarp Forest
MDF	=	Mixed Deciduous Forest
TRF	=	Tropical Rain Forest
SCA	=	Shifting Area
SWF	=	Swamp Forest
PRP	=	Para Rubber Plantation

Table 5. Volume of growing stock of the natural forests in different regions of Thailand, situation in 1978 (After Thammincha, 1984)

Regions	Forest area	Volume of growing stock, m^3			Total
		Highly commercial species	Commercial species	Others	
A. Terrestrial forest					
North	8,711,950	39,8[illegible],615	36,549,698	6,514,709	82,900,020
Northeast	4,781,171	18,005,432	18,005,119	3,766,359	41,072,910
Central	2,292,159	4,783,045	8,089,306	7,377,724	20,250,070
South	1,829,226	13,660,990	6,621,253	10,968,392	31,250,630
Total	17,614,506	76,285,082	70,561,376	28,627,184	175,473,640
B. Mangrove forest					
	135,083	-	-	-	9,369,350
Grand total	17,749,589	76,285,087	70,561,376	28,627,184	184,882,990

Table 6. The annual cut of teak and other woods in Thailand, during 1979-1984

Years	Annual cut (m^3)	
	Teak	Other woods
1979	179,000	2,921,000
1980	97,000	2,446,000
1981	73,000	1,725,000
2	58,000	1,711,000
1983	58,000	1,761,000
1984	48,000	1,984,000*

* Including rubber wood.

Table 7. List of highly commercial tree and commercial trees from the natural forests of Thailand (After Bhumibhamon, 1986b).

Species	Present status		Regions
	Highly commercial	Commercial	
Acacia catechu		X	N, C
A. leucophloea		X	C
A. siamensis		X	N, NE, C
Acrocarpus fraxinifolius		X	N, E, NE
Adenanthera microsperma		X	N, S
Adina cordifolia		X	N, E, NE, S
Afzelia xylocarpa	X		N, E, NE, C
Ailanthus fauveliana	X		N, E, C, S
Alangium salviifolium		X	N, NE
Albizia lebbeck		X	N, E, NE, C, S
A. odoratissima		X	N, C
A. procera		X	N, NE, C
Alstonia scholaris		X	N, E, C, S
Amoora polystachya		X	N, E, NE, S
Anisoptera glabra		X	S
A. scaphula		X	S
Anthocephalus chinensis		X	N, E, NE, C, S
Archidendron jiringa		X	C, E, S
Artocarpus altissimus		X	S
A. lakoocha		X	S
A. lanceifolius		X	S
Avicennia officinalis		X	S
Azadirachta indica		X	C, S
Berrya mollis		X	N, NE, C
Bischofia javanica		X	N, NE, C, S
Bombax anceps		X	N, C
Bouea oppositifolia		X	N, NE, C, S
Brownlowia helferiana		X	N, NE, S
Caesalpinia sappan		X	C
Calophyllum inophyllum		X	N, C, S
C. pulcherrimum		X	S
Cananga latifolia		X	N, E, NE, C, S
Canarium kerrii		X	N, E, NE, S
Carallia brachiata		X	N, E, NE, C, S
Cassia bakeriana		X	N, NE, C
C. fistula		X	N, C
C. garrettiana		X	N, NE, C
Casuarina equisetifolia		X	C, S
Chrysophyllum roxburghii		X	NE, S
Chukrasia velutina	X		N, C, S
Cinnamomum bejolghota		X	N, C, S

Table 7. (Cont'd)

Species	Present status		Regions
	Highly commercial	Commercial	
Cotylelobium lanceolatum		X	N, E, NE, C, S
Cratoxylon spp.		X	N, NE, C, S
Dalbergia cochinchinensis	X		E, NE, C, S
D. cultrata	X		N, NE, C, S
D. dongnaiensis	X		N
Dehaasia kerrii		X	S
Dialium cochinchinense		X	NE, C, S
Dillenia spp.		X	N, E, NE, C, S
Diospyros buxifolia		X	S
D. dasyphylla		X	N, E
D. ebenum		X	S
D. fulvopilosa		X	S
D. mollis		X	N, E, NE, C, S
D. siamensis	X		N, NE, C, S
Dipterocarpus alatus	X		N, E, NE, C, S
D. obtusifolius		X	N, E, NE, C, S
D. tuberculatus		X	N, E, NE, C
Dracontomelon mangiferum		X	N, S
Duabanga grandiflora		X	N, E, S
Durio griffithii		X	S
Erythrophleum spp.		X	NE, S
Erythroxylum cuneatum		X	N, E, S
Eugenia circumcissa		X	E
E. cumini		X	N, C
Fagraea fragrans	X		N, E, NE, S
Firmiana spp.		X	N
Garcinia costata		X	N, S
Garcinia collinsae		X	NE, C, S
G. obtusifolia		X	N, E, NE, C
Garuga pinnata		X	N, E, C
Gmelina arborea		X	N, NE, C, S
Heliciopsis terminalis		X	N, NE, S
Heritiera javanica		X	E, S
H. littoralis		X	C, S
Holarrhena antidysenterica		X	N, NE, C, S
Holoptelea integrifolia		X	N, NE, C, S
Homalium tomentosum		X	N, E, NE, C
Hopea spp.	X		N, NE, C
Horsfieldia lehmanniana		X	S
Hydnocarpus castaneous		X	S
Hydnocarpus ilicifolius		X	N, E, C, S
Hymenodictyon excelsum		X	N, C, S
Intsia bakeri	X		E, S

Table 7. (Cont'd)

Species	Present status: Highly commercial	Present status: Commercial	Regions
Irvingia malayana		X	NE, C
Kydia calycina		X	N
Lagerstroemia calyculata		X	N, E, NE, C, S
L. floribunda		X	N, E, NE, C, S
L. loudonii		X	E, NE, C, S
L. macrocarpa		X	N, NE, C
L. speciosa		X	C, S
L. tomentosa		X	N, C
Lannea coromandelica		X	N, E, S
Litsea grandis		X	S
L. petiolata		X	S
L. pierrei		X	E
Lophopetalum duperreanum		X	N, E, NE
Maclura cochinchinensis		X	N, NE, C, S
Madhuca grandiflora		X	E, C
M. pierrei		X	C
Mammea siamensis		X	N, E, NE, C, S
Mangifera spp.		X	N, E, NE, C, S
Manglietia garrettii	X		N
Manilkara hexandra		X	C
Melaleuca leucadendra		X	E, C, S
Melanorrhoea usitata		X	N, C
Memecylon caeruleum		X	N, S
Mesua ferrea	X		N, E, NE, C, S
Michelia spp.	X		N, E, NE, C, S
Milinsa linesta		X	N, NE, C
Millettia atropurpurea		X	S
M. leucantha	X		N, C, S
Millingtonia hortensis		X	N, C
Mimusops elengi		X	N, C, S
Mitragyna brunosis		X	N, S
Morinda corcia		X	N, E, NE, C, S
Murraya paniculata		X	N, C, S
Myristica cinnamomea		X	S
Nauclea orientalis		X	N, C, S
Neesia altissima		X	S
Nephelium lappaceum		X	C, S
Onceoperma horrida		X	S
Palaquium gutta		X	S
P. obovatum		X	E, S
Parashorea stellata		X	S
Parinari anamense		X	N, NE, C, S

Table 7. (Cont'd)

Species	Present status		Regions
	Highly commercial	Commercial	
Parkia javanica		X	S
Payena spp.		X	S
Peltophorum dasyrachis		X	NE, C, S
Pentacme burmanica		X	C, S
Pentaspadon velutinus		X	S
Phoebe spp.		X	N, S
Pinus kesiya	X		N, NE, C
P. merkusii	X		N, NE, C
Planchonella siamensis		X	S
Premna tomentosa		X	N, E, S
Protium serratum		X	N, NE, C, S
Pterocarpus macrocarpus	X		N, C, S
Pterospermum diversifolium		X	E, C, S
Quercus spp.		X	N, E, NE, S
Rhizophora apiculata		X	C, S
R. mucronata		X	C, S
Sandoricum koetjape		X	N, NE, S
Schima wallichii		X	N, E, NE, S
Schleichera oleosa		X	N, NE
Schoutenia hypoleuca		X	N, E, NE
Shorea curtisii	X		S
S. faguetiana		X	S
S. henryana	X		E, C, S
S. obtusa	X		N, E, NE, C
S. parvifolia	X		S
S. siamensis	X		N, NE, C
S. talura		X	N, E, C, S
S. thorelii		X	N, E, C
Sindora coriacea	X		S
S. siamensis		X	N, NE, C
Spondias pinnata		X	N, E, C, S
Sterculia campanulata		X	N, E, NE, C, S
S. foetida		X	N, E, C, S
S. guttata		X	N, C, S
S. ornata		X	N, C, S
S. villosa		X	N
Stereospermum spp.		X	N, E, NE, E, S
Strychnos nux-vomica		X	NE, C
Styrax spp.	X		N, NE
Tectona grandis		X	N, E, NE, C, S
Terminalia alata		X	N, NE, C, S
T. bellerica		X	N, C

Table 7. (Cont'd)

Species	Present status		Regions
	Highly commercial	Commercial	
T. chebula		X	N, C
T. citrina		X	C, S
T. nigrovenulosa		X	N, E, NE, C, S
Tetrameles nudiflora		X	N, E, NE, C, S
Toona ciliata		X	N, E, NE, C, S
Vatica odorata		X	N, E, NE, C, S
Vitex canescens		X	N, E, NE, C, S
V. pinnata		X	N, E, NE, C, S
Walsura spp.		X	N, NE, S
Wrightia tomentosa		X	N, E, NE, C, S
Xerospermum intermedium	X		E, NE, S
Xylia kerrii		X	N, E, NE, C, S
Xylocarpus granatum		X	C, S
X. moluccensis		X	N, E, NE, C, S

Table 8. The amount and value of the main tree species exploited in Thailand (RFD, 1984)

Species	Volume (m^3)	Value (million baht)
Afzelia xylocarpa	27,856	136.5
Dalbergia cochinchinensis	29	0.3
D. oliveri	2,488	20.9
Dipterocarpus sp.	589,907	1,415.8
D. tuberculatus	49,364	118.5
Hopea sp.	27,105	132.8
Irvingia malayana	81,121	194.7
Lagerstroemia calyculata	44,246	106.2
L. macrocarpa	4,254	10.2
Pterocarpus sp.	38,063	186.5
Shorea sp.	80,835	396.1
Tectona grandis	48,172	469.3
Xylia kerrii	168,888	827.6
Others	869,407	1,999.6

Table 9. Major industrial sectors in Thailand

Industrial wood sectors	No. of factory
Sawmills (of various sizes)	
a. with machines	3,331
b. with manual sawing	1,190
Plywood	14
Veneer	13
Fibreboard	2
Particle board	3
Parquet	55
Pulp and paper	33
Total	4,641

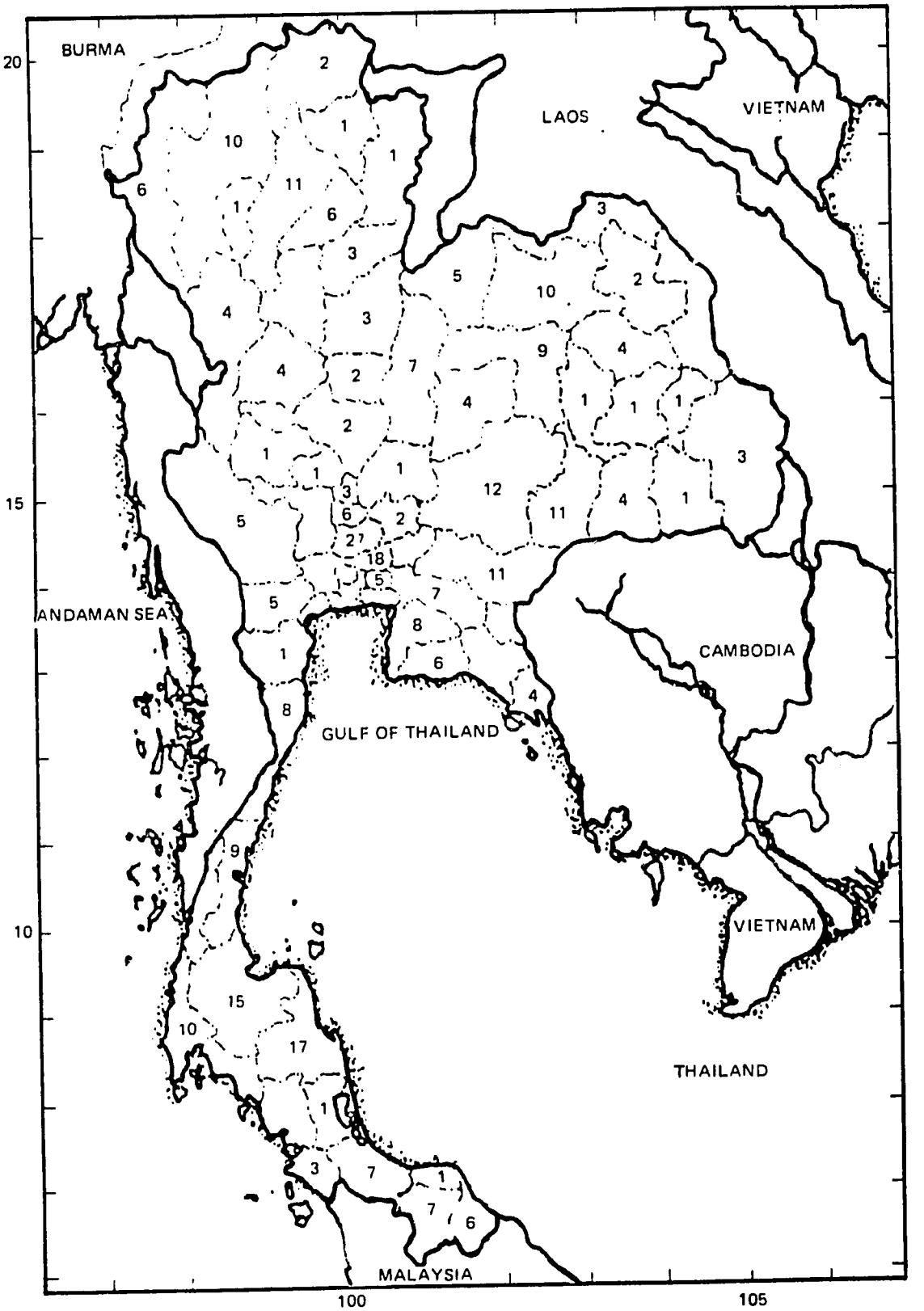

Figure 1. Location and number of sawmills in Thailand, 1984.

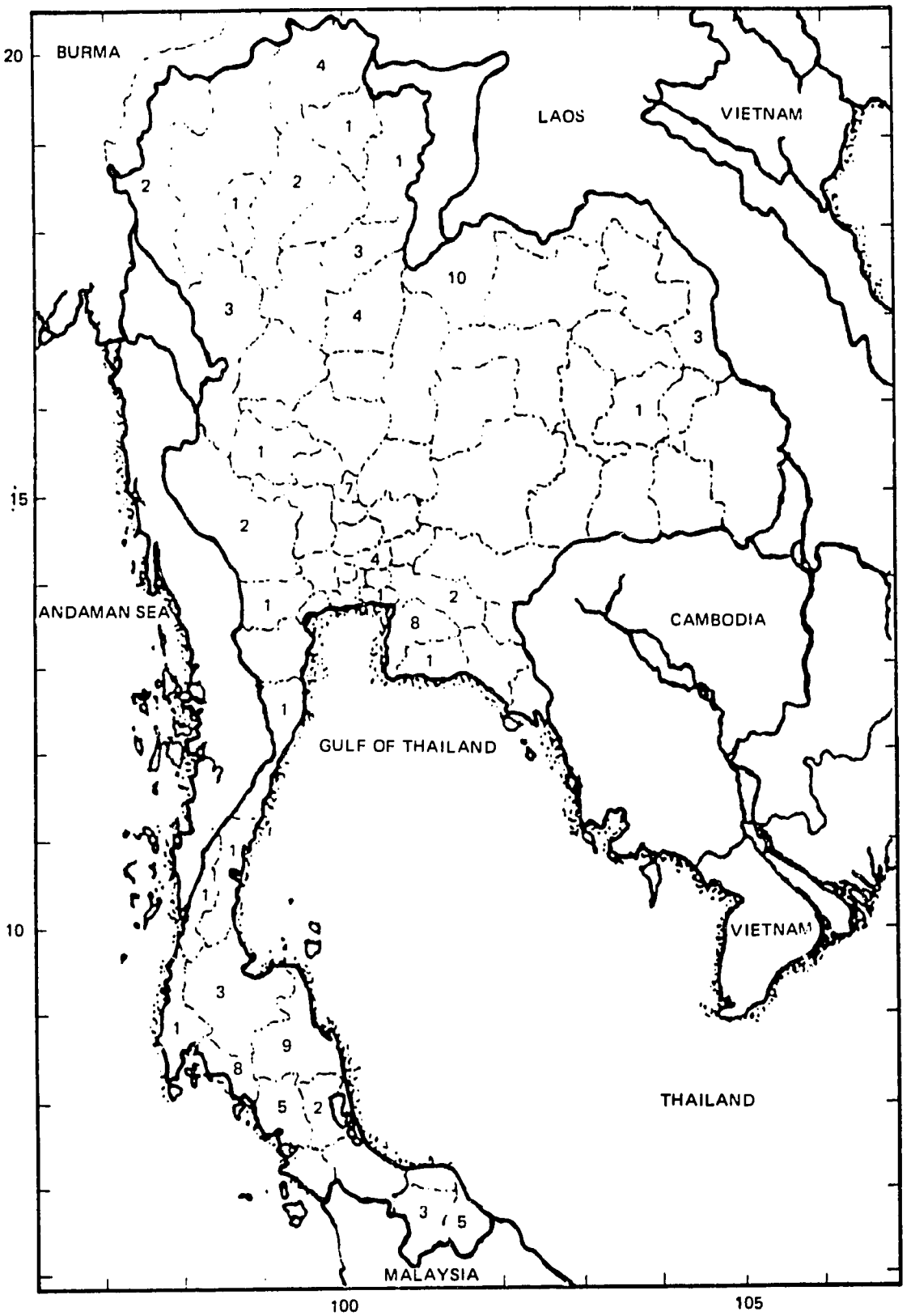

Figure 2. Location and number of sawn wood factories which operate using manual work.

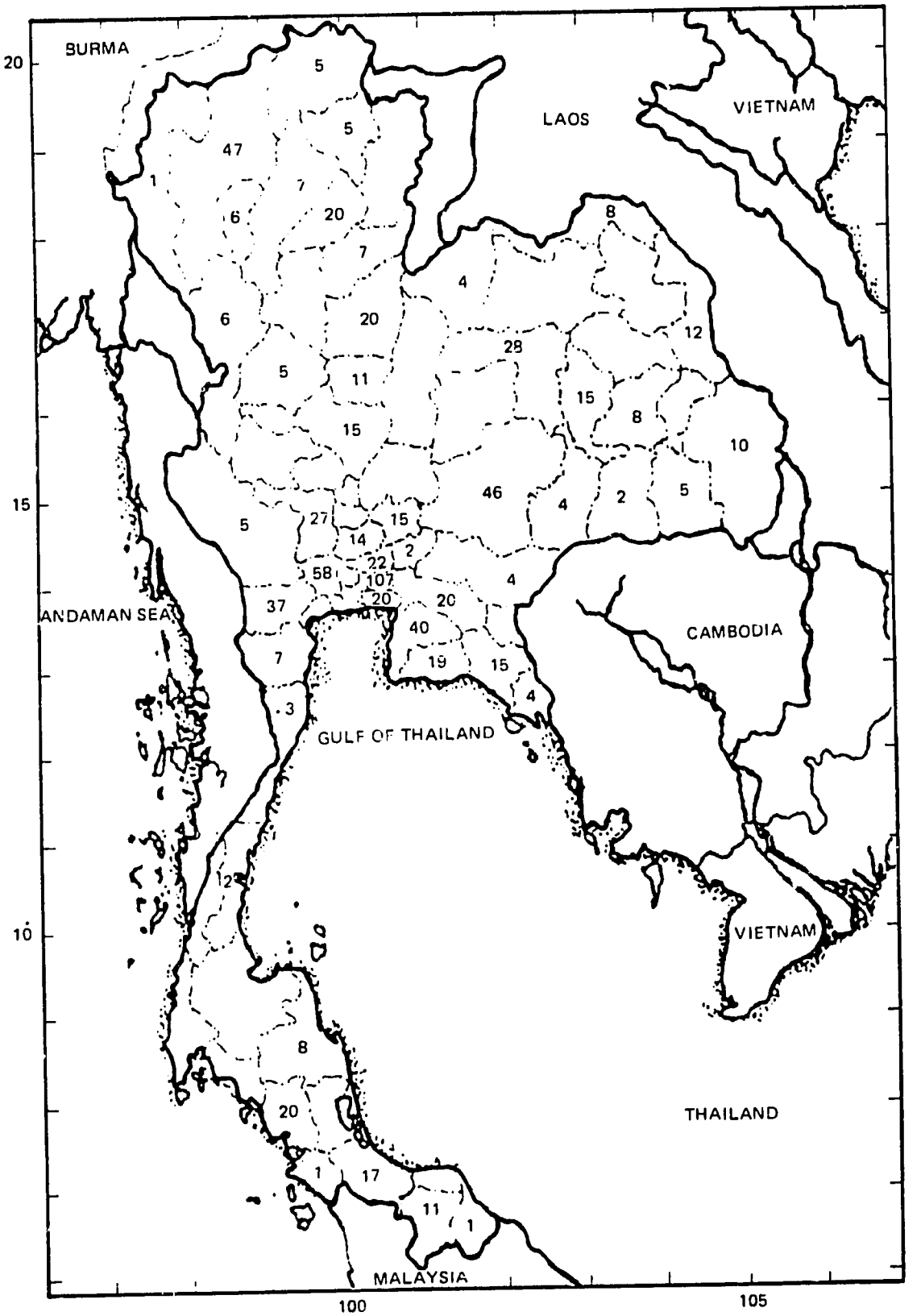

Figure 3. Location and number of wood working factories which operate using manual work.

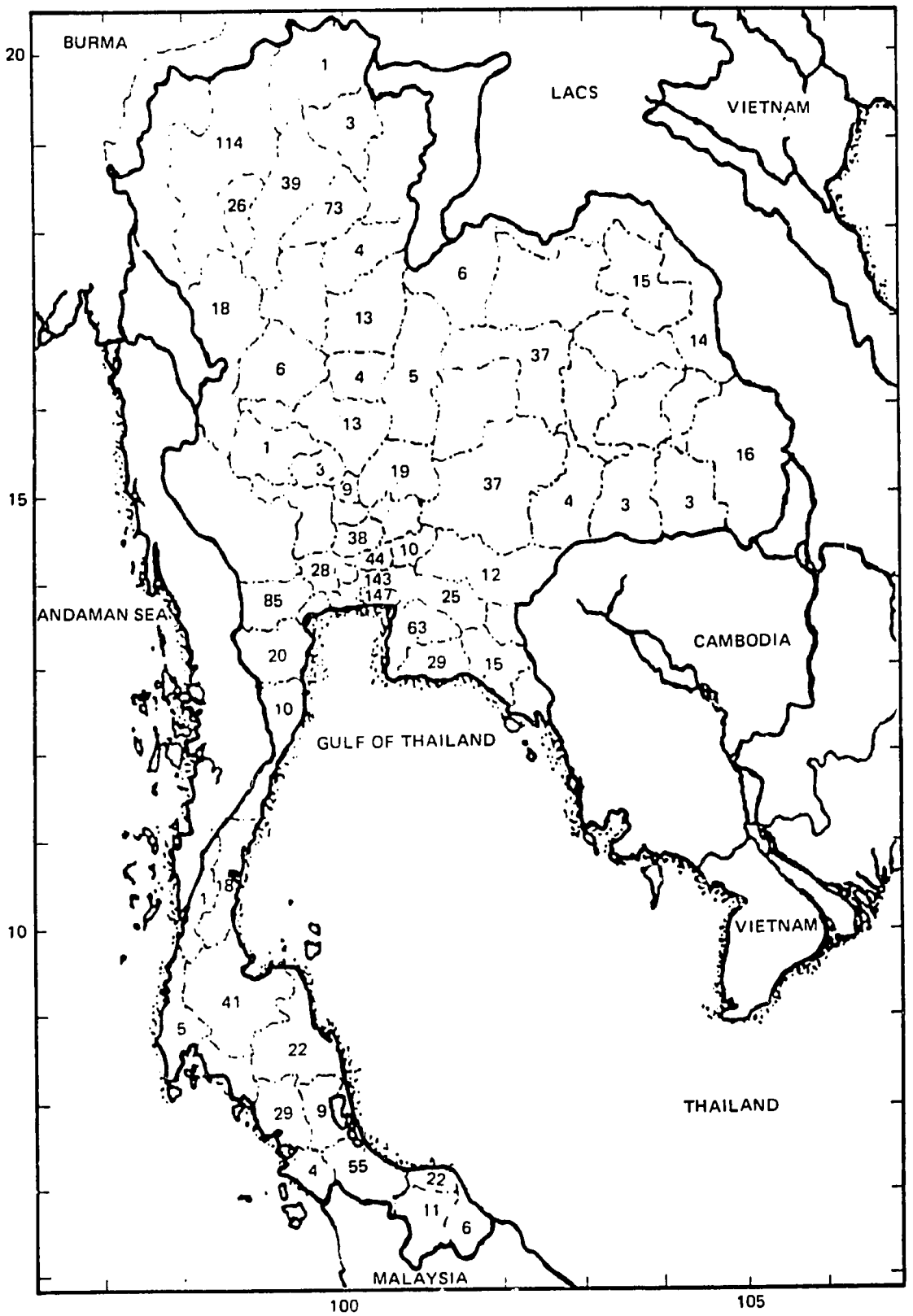

Figure 4. Location and number of wood working factories which operate with bigger machinery.

remainder are of greater than 90 hp and cut in excess of 18 m^3/day. The total capacity for all sawmills is 37,794 hp.

9. Under the present situation, none of these sawmills can run at full capacity. Based on a 300 day year basis, the total capacity of these sawmills is close to 2 million m^3 or 2.6 million m^3 at full capacity. The actual production of sawnwood is however, only 1.28 million m^3 per year.

10. In a survey of the constraint on the wood supply, 43 sawmill owners indicated that the shortage of wood directly affected the actual production of the sawmill. They recommended the government to allow them to cut trees in forest areas previously closed and also to lease more deforested land for a future reforestation program.

11. Table 10 shows the trend in imported wood both in terms of volume and costs. The imported wood declined continuously during 1979-1983. This was due to wood scarcity in the countries of origin. However, the cost of imported wood increased considerably during the time investigated.

12. In 1976, the Timber Merchants Association had 100 firms dealing with importing wood from neighboring countries. Due to the declining market for timber logs and sawnwood as well as strict regulations on wood preservatives, only 30 firms still import logs and sawnwood at present.

1.4.2 Plywood and veneer

13. Thailand has had plywood factories established since 1951. The location and number of veneer and plywood factories in Thailand are shown in Figures 5 and 6.

14. About 40,000 m^3 of teak veneer is needed by the local market per year. For other economic tree species, such as *Shorea* sp., *Dipterocarpus* sp. *Hopea* sp. about 100,000 m^3 of veneer are required per year.

15. Due to the shortage of material, most plywood factories have been importing logs from Malaysia and Indonesia. With the imported logs, the production of plywood was able to be increased from 3.48 million sheets in 1974 to 8.1 million sheets in 1984. The Plywood and Veneer Association of Thailand has encouraged the government to provide them with more incentives, but the future of the raw material supply remains unsolved. The Association also has claimed that the government has increased the import duty from 1-3% to 3-6%. This high rate is counter-productive to their efforts to compete in foreign markets. Moreover, the

Table 10. The amount and value of wood imports in Thailand during 1979-1983

Countries	Imported wood (m^3)				
	1979	1980	1981	1982	1983
Burma	34,622	11,206	26,195	15,797	29,019
Indonesia	218,610	109,977	101,285	83,086	99,533
Laos	11,114	9,018	2,934	6,705	2,834
Malaysia	751,028	296,992	438,858	372,374	475,717
Singapore	11,843	6,463	3,550	6,463	4,051
W. Germany	4,093	279	2,474	2,467	555
Others	1,800	416	280	1,560	2,590
Total	1,033,110	434,351	575,576	488,452	614,299

Countries	Imported wood (US dollars)				
	1979	1980	1981	1982	1983
Burma	3,730.77	868.14	2,088.82	1,883.73	12,568.18
Indonesia	24,754.59	13,598.50	16,116.45	15,142.09	16,776.86
Laos	1,446.50	1,377.91	439.09	921.86	426.23
Malaysia	55,834.77	34,354.23	60,928.55	56,945.41	70,194.68
Singapore	1,450.00	886.41	544.77	1,142.45	662.14
W. Germany	524.68	35.50	341.09	463.45	70.32
Others	251.32	61.50	119.95	458.50	685.14
Total	87,992.63	51,182.19	80,579.14	76,957.49	101,383.55

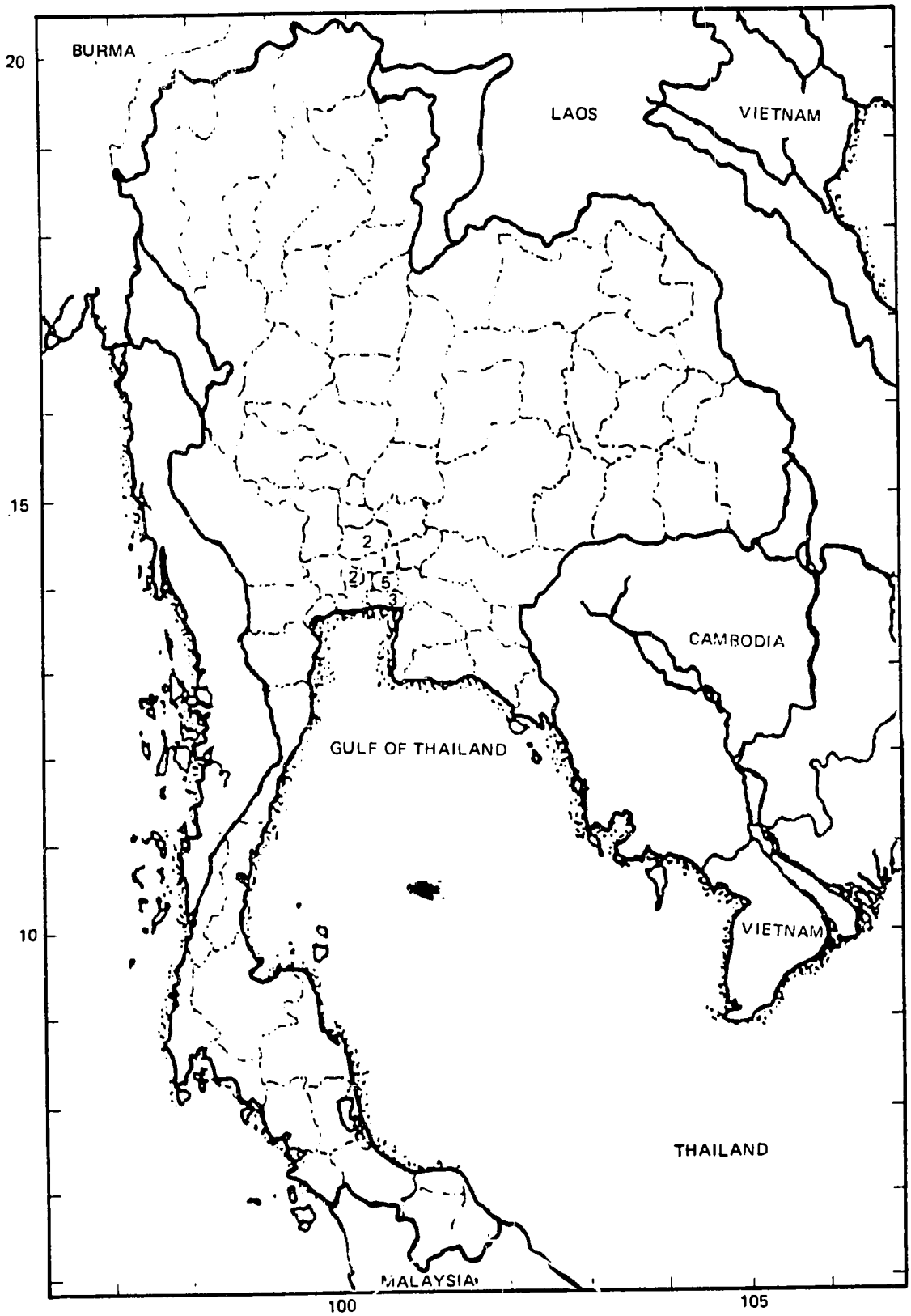

Figure 5. Location and number of veneer factories in Thailand, 1984.

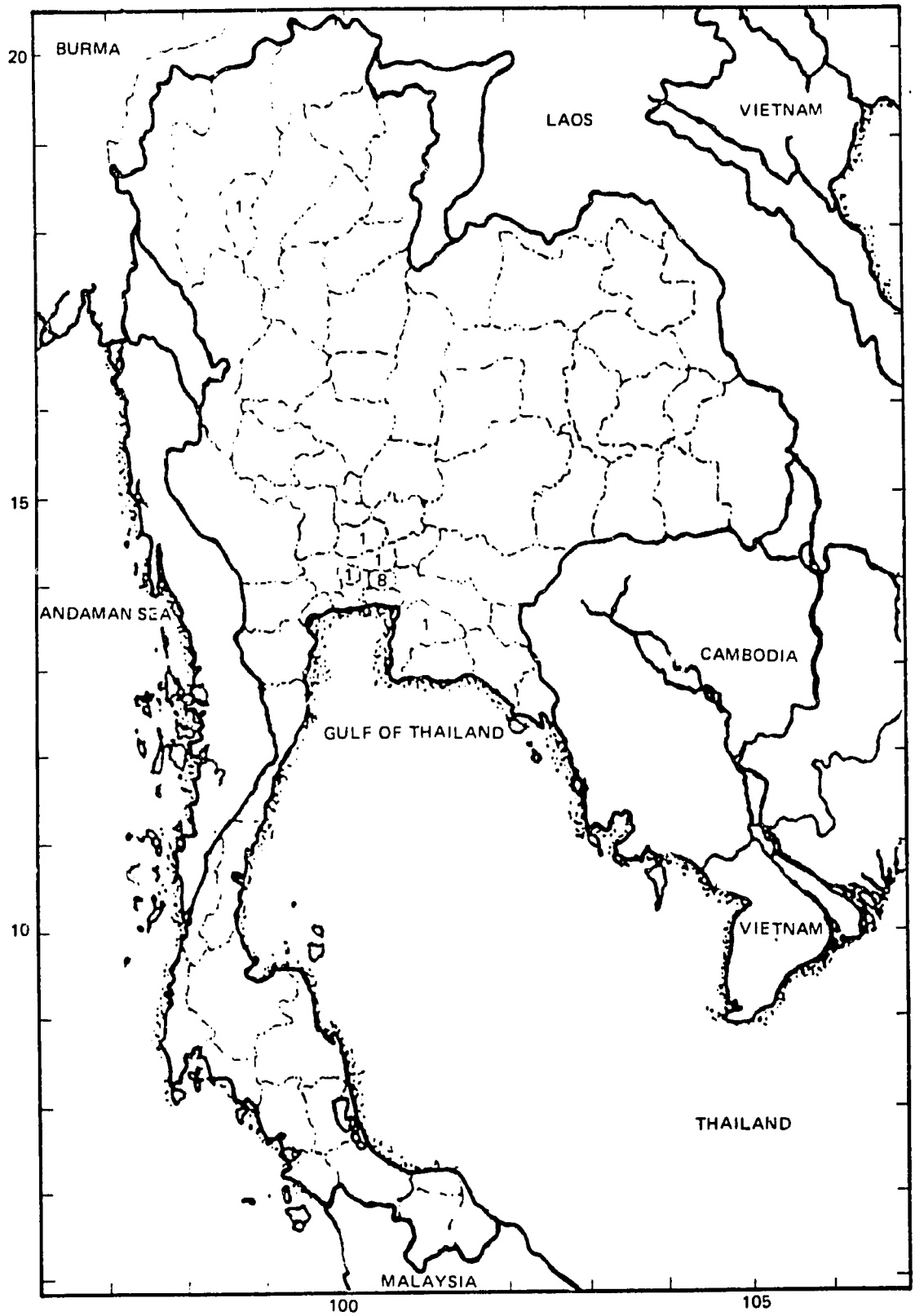

Figure 6. Location and number of plywood factories in Thailand, 1984.

government also collected a 7.7% excise tax on the finished products.

16. Veneer products are not only used in the plywood industry, they are also needed in other wood industries such as match, ice cream pad, toothpick, etc. Multipurpose trees to serve these needs are required.

1.4.3 Hardboard

17. Hardboard plants are operated in the form of particle board and chipboard plants. Location and number of these factories are shown in Figures 7 and 8. Thai Plywood Co. has about 80-90 tons/day capacity and runs non-stop. Fancy and perforated hardboard has a good market if sales promotion is carried out. The raw material supply for hardboard is sufficient due to the large-scale plantation of fast growing trees. Moreover, agro-waste like bagasse, cassava stem, saw-dust, bamboo, etc. is also a good source of raw material for this industry.

18. Chipboard has been running on a very restricted output as the market is limited. Cellocrete also faces the same problems and has ware-houses full of unsold boards. Medium density fibre board, the so-called MDF has been financially supported by IFCT to utilize abundant bagasse in the northeast and increase production was increased to 316,500 boards in 1986 and is to reach a maximum capacity of 527,500 boards per year in the future.

19. Hardboard factories are the main market for tree farmers who grow *Eucalyptus camaldulensis*. Other multipurpose trees like *Leucaena leucocephala* and *Acacia mangium* are aimed at supplying these factories.

1.4.4 Pulp and paper

20. Pulp and paper industries are still in the market area as the demand of paper per capita per annum has increased from 5.77 kg in 1972 upto 8.18 kg in 1977. Total paper consumption increased from 228,699 tons in 1972 to 296,567 tons in 1977.

21. Pulp used in Thailand is mainly imported from foreign markets, including U.S.A., Sweden, Canada, Finland, Soviet Union, and Japan. About 155,000 tons of pulp was imported in 1981 but slightly decreased to 135,000 tons in 1982.

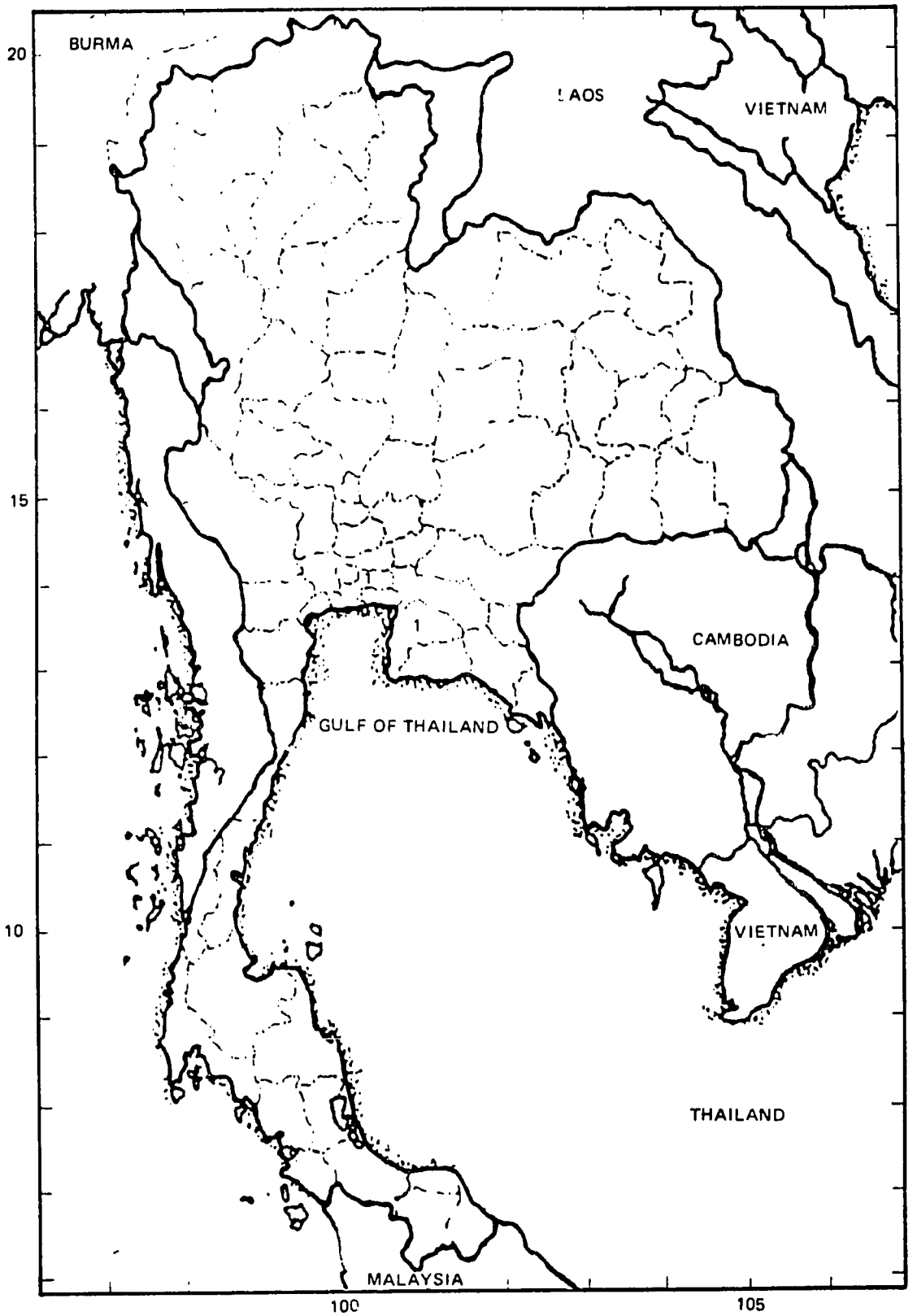

Figure 7. Location and number of fibre board factories in Thailand, 1984.

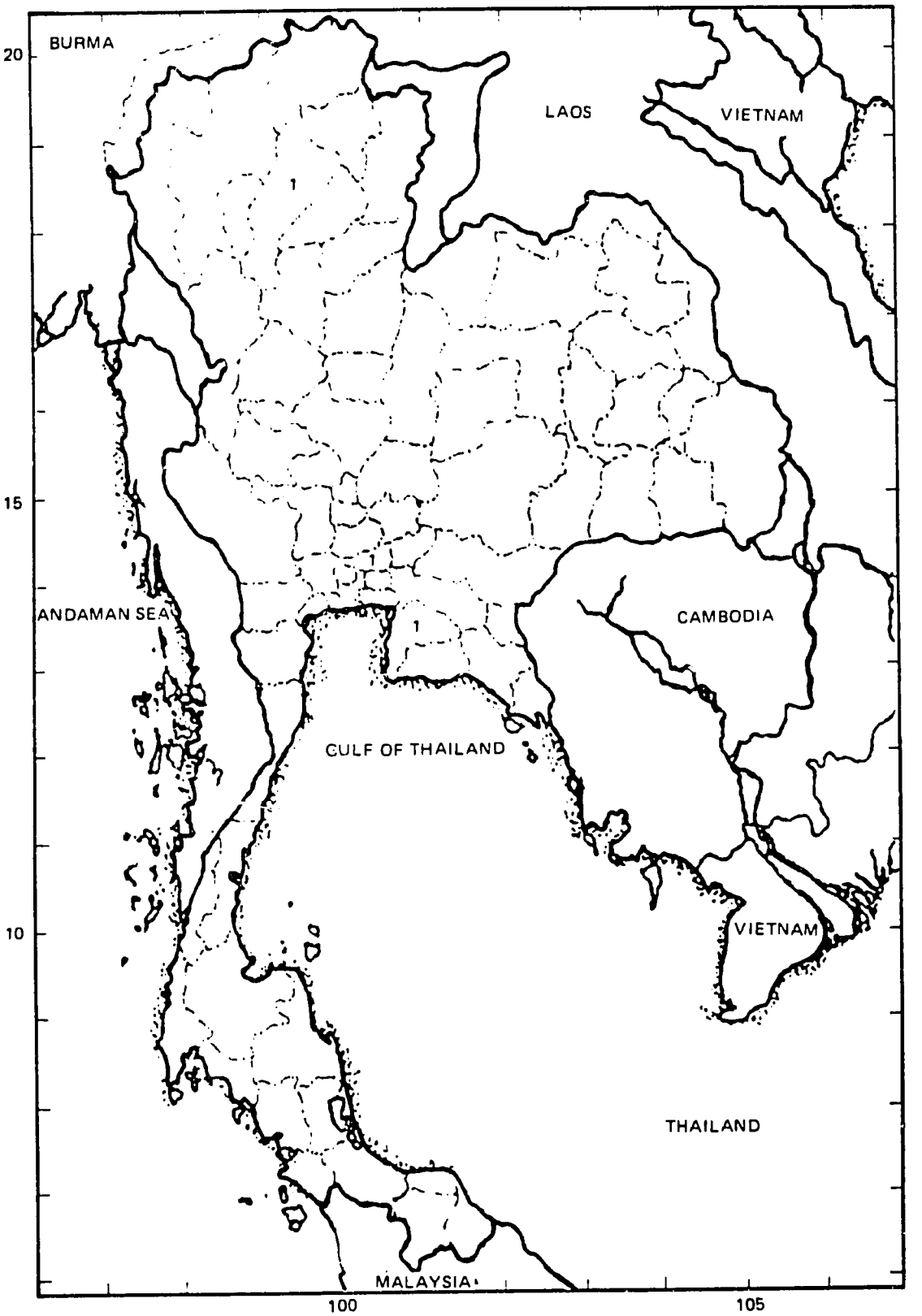

Figure 8. Location and number of particle board factories in Thailand, 1984.

22. Thailand imported about 50,305 tons of newsprint in 1972 and this increased to 93,182 tons in 1985. Additionally, waste paper has been imported for making small-sized and recycled paper. In 1977, about 101,932 tons of waste paper was imported from foreign markets witth a value of about 220 million baht.

23. The Pulp and Paper Industries Association, comprised of 18 pulp and paper mills (Figure 9), has produced about 300 metric tons of straw paper per year as well as about 50,000 tons of printing and writing paper per year. The production of kraft paper will be increased from 250,000 tons/year in 1984 to 300,000 tons/year in 1987. The Association forecasted that paper consumption in Thailand would increase by 10-20%.

24. There is great potential for Thai farmers to grow fast growing trees, including lowland tropical pines, bamboo, *Acacia mangium*, *Eucalyptus camaldulensis*, *Melia azedarach*, etc.

1.4.5 Furniture

25. Thailand has produced good furniture made of teak, other valuable woods, and rattan for domestic use and foreign markets. Three kinds of furniture are made in Thailand for exporting, including assembled and finished furniture, knock-down or completely knock-down, and furniture components, both furnished and unfurnished. Export earnings are about 100 million baht per annum.

26. Shortage of teak wood and other wood suitable for furniture requires the urgent planting of economic trees with desirable traits. In 1984, rattan production was 1.6 million kg (19.3 million baht) while bamboo production was 48.4 million culms for *Thyrsostachys siamensis* (241.9 million baht) and 0.56 million culms for other kinds of bamboo (6.7 million baht). To provide sufficient rattan for the furniture industry RFD (1983) reported that rattan imports increased from 0.35 million kg in 1979 (6.8 million baht) upto 6.38 million kg in 1983 (40.1 million baht).

1.4.6 Parquet and laminated wood

27. As tree logs have reduced in size, parquet and mosaic parquet flooring have been the major items both for the domestic and foreign markets. About 65 parquet (Figure 10) and 20 mosaic parquet flooring factories are operating at present. Output of parquet made from hardwood has reduced and may be substituted by wood of other fast-growing trees having high basic wood density, i.e. *Acacia auriculaeformis*.

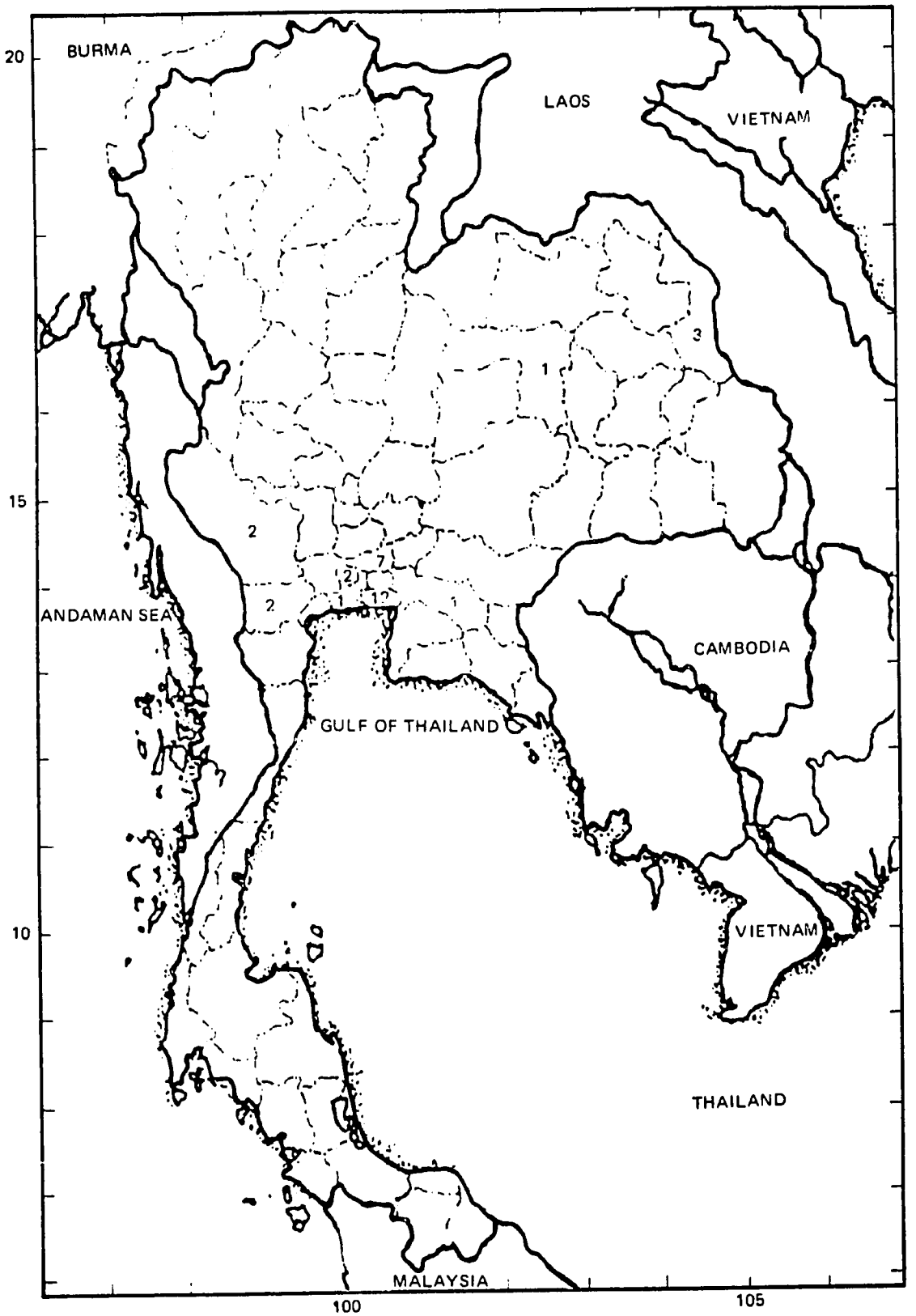

Figure 9. Location and number of paper mills in Thailand, 1984.

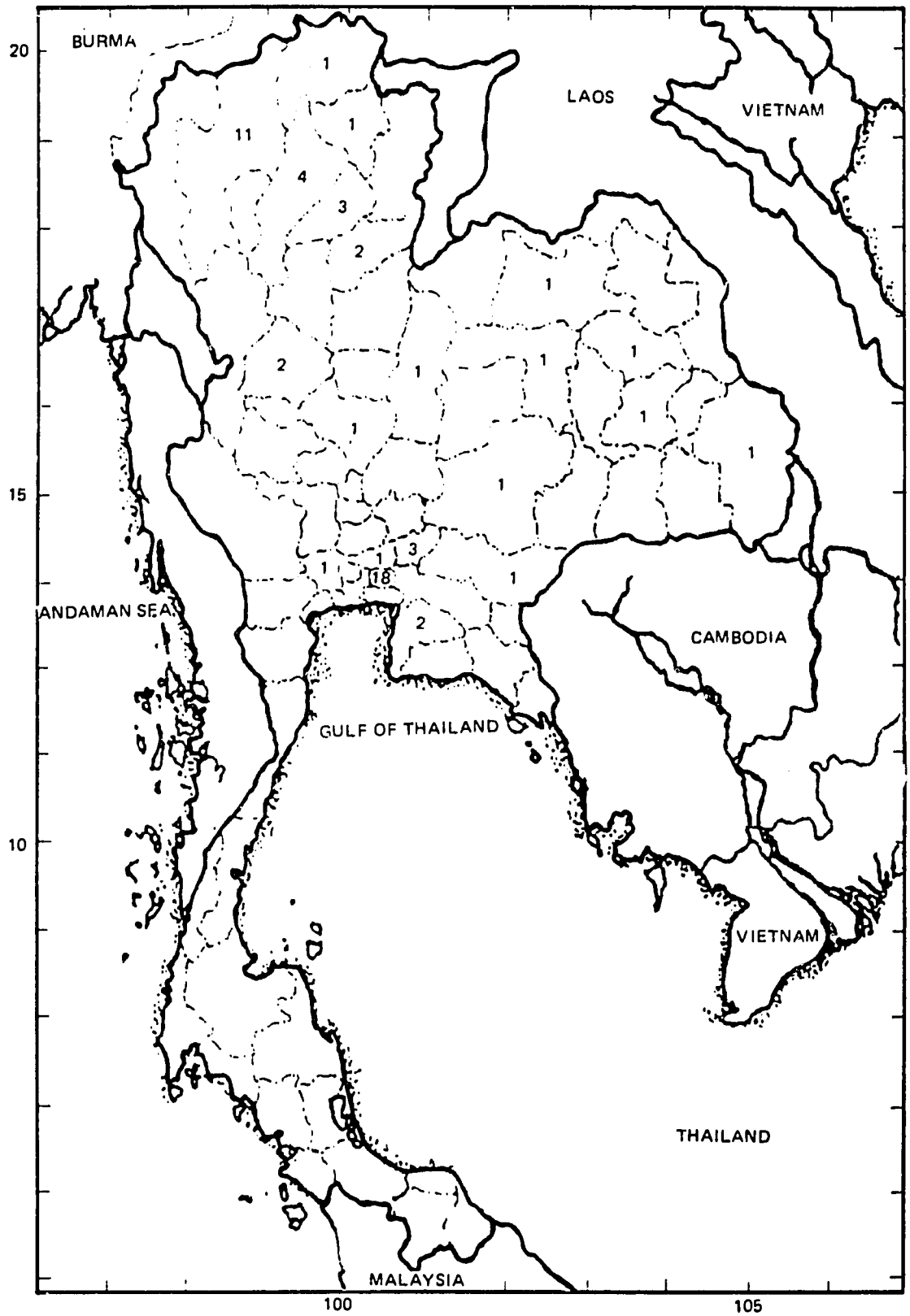

Figure 10. Location and number of parquet factories in Thailand, 1984.

28. Due to the wood scarcity, laminated wood has also been claimed to be used to substitute for wood originating from big trees. Thinning woods can also be used for laminated wood. Tongue-and-groove laminated flooring has already been introduced by FIO (Corvanich, 1980) for the domestic market.

1.5 SHORTAGE OF FUELWOOD

29. Thailand greatly relies on imported oil for transportation, electricity supply, and industrial use. It is expected that forest trees as a renewable resource can be developed as other non-commercial sources to decrease the dependency on imported petroleum.

30. Following the trend of other developing countries, 83% of the total wood consumption in Thailand is used as fuelwood and charcoal. The annual fuelwood consumption is 13.40 million m^3 (Chantavoraparb, 1983) while the charcoal consumption is 3,378 million kg, equivalent to 22.2 million m^3 of wood (Urapeepatanapong & Mungkorndin, 1983). This is however, lower than the values of Backer and Openshaw (1972) who estimated that the fuelwood and charcoal needed in 1985 was 64.1 million m^3 and would increase to 81 million m^3 in the year 2000. The tree species used as fuelwood or charcoal are listed in Table 11. People in different parts of Thailand use any available wood sources. At present, each Thai consumes about 0.41 m^3 of fuelwood and 123.68 kg of charcoal annually. Fuelwood is also used in various industrial sectors.

31. Table 11 shows the import and export of fuelwood and charcoal in Thailand. In most years export earnings have been higher than the cost of imports. Charcoal produced from mangrove has been the main export item while charcoal produced from dry land trees has supplied the domestic market.

Table 11. Imports and exports of fuelwood and charcoal in Thailand during 1979-1983 (RFD, 1983, 1984)

Items	Years					
	1979	1980	1981	1982	1983	1984
Fuelwood						
Imports (million kg)	small	small	0.78	0.28	0.24	-
(1,000 baht)	7	6	135	57	48	-
Exports (million kg)	small	-	small	0.08	-	0.12
(1,000 baht)	32	-	9	352	-	1974
Charcoal						
Imports (million kg)	0.49	2.04	2.64	5.43	7.46	9.08
(1,000 baht)	696	5,619	4,169	8,583	11,731	14,848
Exports (million kg)	32.03	39.74	51.34	64.74	70.28	54.70
(1,000 baht)	31,199	49,174	63,767	83,837	94,026	75,909

CHAPTER 2

THE NEED FOR TREE PLANTING

2.1 HISTORICAL RECORDS

32. The first inscription stone recorded before 1350 the granting of ownership rights to Thais who grew fruit trees on public land. The list of tree species which appeared in the inscription were coconut, tamarind, areca palm, jack fruit, palmyra palm etc.

33. For the Ayudhaya period (1350-1767), historical records indicate only the land titles provided to administrators. The area provided to them depended much on their position. Fruit trees and agricultural crops still remain the main plants grown in the area.

34. During the periods 1767-1787 and 1787-1868 of the Dhonburi and Early Bangkok periods, forests belonged to the feudal chiefs. Cholitkul (1983) reported that teak was exploited by the Burmese and the Chinese. The Dutch and the British came later and over-exploited the teak forest in cooperation with the feudal chiefs. The forest logging was later on controlled by Bangkok governmental offices and the western companies had to sign an agreement prior to any logging operation. The agreement also indicated that the contractor should plant 4 teak seedlings for every teak tree harvested but such an agreement received a poor follow-up programe. Problems arising during this period led to the establishment of the Royal Forest Department (RFD) in 1896. Mr. H. Slade, the first RFD Director General reported the over-exploitation of natural teak forest with the actual cut in 1896 being about 3.5 times the allowable cut based on the sustained yield basis.

The first private teak plantation was established in Phrae in 1906 (Boonkird, 1981). Later on, RFD established more teak plantations in the form of agro-forestry in which teak was grown in association with upland rice.

2.2 TREE PLANTING IN THE NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT PLANS

35. Thailand's First National Economic and Social Development Plan (1961-1966) stated that 50% of the total area of the country should be conserved as forest area. In this plan, RFD were to establish teak and non-teak plantations of 5,000 and 8,000 rai per year respectively. Additionally, the policy of tree farming was adopted.

36. In the Second National Economic and Social Development Plan (1967-1971), the targets for teak and non-teak plantations were 90,000 and 50,000 rai respectively. Conservation plantations were also estab shed to improve the deforested watershed areas. FIO and the state-owned TPC also established intensive industrial plantations.

37. In the Third National Economic and Social Development Plan (1971-1976), reforestation in the deforested areas was actively promoted and the target was planned to be 150,000 rai for industrial plantations and 92,500 rai for environmental plantations.

38. In the Fourth National Economic and Social Development Plan (1976-1981), the annual planting program for all species was set for 500,000 rai. Appropriate technology to produce the cheapest seedlings was described and introduced. Reforestattion was done mostly and any available poorly preserved forest. In this plan the private sector and other volunteer bodies were encouraged to participate in tree planting.

39. In the Fifth National Economic and Social Development Plan (1981-1986), the annual planting program was limited to 300,000 rai. Tree farming was effectively encouraged so as to supply sufficient wood for the wood industry and energy purposes. Conservation plantations, mainly for erosion control, were established in larger areas. At the end of this plan period a National Forest Policy was approved by the Cabinet.

40. For the Sixth National Economic and Social Development Plan (1986-1991), three main programs related to tree planting have been adopted, including planting fast growing trees, economic trees and the establishment of community forests.

The list of fast-growing trees promoted in the present plan are *Acacia mangium*, *Rhizophora mucronata*, *Toxicodendron succedanea*, *Ailanthus*, and native and exotic pines. Teak has been selected as the economic tree with top priority. Tree farmers can join the state organizations to establish more teak plantations. Concerning tree planting in the community forest program, four main groups of promising trees were recommended, as follows:-

1. <u>Fuelwood</u>

Azadirachta indica, *Cassia siamea*, *Casuarina equisetifolia*, *C. junghuhniana*, *Peltophorum dasyrachis*, *Acacia auriculaeformis*, *Leucaena leucocephala*, *Eucalyptus camaldulensis*, and *Combretum quadrangulare*.

2. Edible flowers or fruit

Azadirachta indica, *Cassia siamea*, and *Leucaena leucocephala*.

3. Utensil wood

Azadirachta indica, *Cassia siamea*, *Eucalypttus camaldulensis*, *Acacia mangium*, bamboo, and rattan.

4. Planting in schools and temples

Mimusops elengi, *Ficus religiosa*, etc.

2.3 FOREST POLICY AND TREE PLANTING

41. The National Forest Policy approved by the cabinet in December 1985 indicated that the forest area in Thailand should cover about 40% of the total land area, including 25% which would be utilized for economic considerations. The Clear Cut System is applied and it is recommended to replant the cutting area immediately. More incentives should be provided to tree farmers and forest law must be improved so as to promote more tree planting. Fuelwood plantations should also be established so that the farmers who plant trees for fuelwood can earn their living by selling fuelwood and charcoal as well as selling to nearby industrial wood factories.

CHAPTER 3

CHOICE OF TREE SPECIES

42. Tree planting in Thailand is generally done in various ways. In the poorly-conserved forest, it is recommended to do enrichment planting by using native trees so as to disturb the existing forest resources only slightly.

43. Small trial plots of economic and fast-growing tree species in the form of species and provenance trials, ex situ gene conservation, etc. have been established in various parts of the country. Early evaluation can provide the possibility of introducing the right provenances to grow as plantations in the tested areas. Later evaluation can be used in the proving phase.

44. In general, in the planting program in Thailand, four main planting activities can be grouped, including industrial plantations, environmental plantations, farm woodlots, and planting multipurpose trees. Table 12 list 99 native and exotic tree species planted in various forms in Thailand. Most of these trees have been planted by RFD and other state organizations in various parts of the country.

45. At present, 21 Regional Forest Offices of RFD are responsible for tree planting in all provinces. The number of tree species chosen for planting is 42 (Table 13). However, not all the species receive high attention by most Regional Offices. Species shown interest by more than five Regional Forest Offices were *Eucalyptus camaldulensis*, *Tectona grandis*, *Acacia auriculaeformis*, *Leucaena leucocephala*, *Gmelina arborea*, *Pterocarpus macrocarpus*, *Melia azedarach*, *Peltophorum pterocarpum*, *Anacardium occidentale*, *Acacia catechu*, and *Azadirachta indica*. It is also necessary to note that the planting area of any selected species in any of the Regional Forest Offices varied considerably.

46. There are 670 District Forest Offices which are established in all districts and administered by District Forest Officers. They listed 42 native and exotic tree species selected for planting in all forms in their area. Slight differences in the list of selected trees chosen by Regional Forest Offices and District Forest Offices were observed (Table 14).

47. The Provincial Forest Companies (PFC) are semi-governmental organizations in which FIO has a 51% share. There were 36 main tree species exploited by these companies, including *Dipterocarpus alatus*, *Xylia kerrii*, *Pterocarpus*

Table 12. Trees selected for planting in Thailand.

Species	Native or exotic tree species	Planting in the form of				
		Industrial plantations	Farm wood lots	Environmental plantations	Multi-purpose trees	Others
Acacia auriculaeformis	E	X	X	X	X	-
A. catechu	N	-	X	-	X	-
A. mangium	E	X	-	-	-	X
A. siamensis	N	-	X	X	-	-
Adina cordifolia	N	-	-	-	-	X
Afzelia xylocarpa	N	-	-	-	-	X
Ailanthus triphysa	N	X	-	-	-	-
Albizia falcataria	E	X	-	-	-	-
A. lebbek	N	-	-	-	-	X
A. procera	N	-	-	-	-	X
Aleurites montana	N	X	-	-	X	-
Alstonia macrophylla	N	X	-	-	-	-
Anacardium occidentale	E	-	-	-	X	-
Anisoptera costata	N	X	-	-	-	-
Anthocephalus chinensis	N	X	-	-	-	-
Azadirachta indica	N	X	-	-	X	-
Bambusa arundinaceae	N	-	-	-	X	-
Bauhinia spp.	N	-	-	-	-	X
Bombax insignies	N	X	-	X	X	-
Broussonetia papyrifera	N	X	-	-	X	-
Butea monosperma	N	-	-	-	-	X
Calophyllum inophyllum	N	-	-	-	-	X
Calotropis gigantea	N	-	-	-	-	X
Cassia bakeriana	E	-	-	X	-	-
C. fistula	N	-	-	X	-	X
C. siamea	N	-	X	-	X	-
Casuarina equisetifolia	E	X	X	X	-	-
C. junghuhniana	E	X	X	X	-	-
Ceriops decandra	N	X	-	-	X	-
Cinchona ledgeriana	E	-	-	-	X	-
Chukrasia velutina	N	X	-	-	-	-
Corypha umbraculifera	N	-	-	-	X	-
Cotylelobium lanceolatum	N	-	-	-	-	X
Dalbergia cochinchinensis	N	X	-	-	-	X
Delonix regia	E	-	-	X	-	-
Dipterocarpus alatus	N	X	-	-	-	-
D. obtusifolius	N	X	-	-	-	-
D. turbinatus	A	X	-	-	-	-
Eucalyptus alba	E	-	-	-	-	X
E. camaldulensis	E	X	X	X	X	-

Table 12. (Cont'd)

Species	Native or exotic tree species	Planting in the form of				
		Industrial plantations	Farm wood lots	Environmental plantations	Multipurpose trees	Others
E. citriodora	E	-	-	-	-	X
E. deglupta	E	X	X	X	X	-
E. tereticornis	E	-	-	-	-	X
Fagraea fragrans	N	X	-	-	-	X
Garuga pinnata	N	-	-	-	-	X
Gliricidia sepium	N	-	-	-	X	-
Gmelina arborea	N	X	-	-	X	-
Hevea braziliensis	E	X	-	-	X	-
Hopea odorata	N	X	-	-	-	X
Homalium damronggianum	N	-	-	-	-	X
Hydnocarpus anthelmintica	N	-	-	-	-	X
Intsia palembanica	N	X	-	-	-	X
Irvingia malayana	N	X	-	-	-	-
Jacaranda filicifolia	E	-	-	X	-	-
Lagerstroemia calyculata	N	-	-	X	-	-
L. macrocarpa	N	-	-	X	-	-
L. speciosa	N	-	-	X	-	-
L. tomentosa	N	-	-	X	-	-
Lannea grandis	N	X	-	X	-	-
Leucaena leucocephala	E	X	X	-	X	-
Litsea grandis	N	-	-	-	-	X
Mangifera indica	N	X	-	-	X	-
Melaleuca leucadendra	N	-	-	-	X	-
Melia azedarach	N	X	-	X	X	-
M. dubia	N	X	-	-	-	-
Mesua ferrea	N	-	-	-	-	X
Millingtonia hortensis	N	-	-	-	-	X
Ochroma lagopus	E	X	-	-	-	-
Parkia javanica	N	X	-	-	X	-
P. speciosa	N	-	-	-	X	-
Parashorea stellata	N	X	-	-	-	-
Peltophorum inerme	N	X	X	-	-	-
Pinus caribaea	E	X	-	-	X	-
P. kesiya	N	X	-	-	-	X
P. merkusii	N	X	-	-	X	-
P. oocarpa	E	X	-	-	-	-
Pterocarpus indicus	E	X	-	-	X	-
P. macrocarpus	N	X	-	-	X	-
Rattan	N	-	-	-	X	-
Rhizophora spp.	N	-	-	X	-	-

Table 12. (Cont'd)

Species	Native or exotic tree species	Planting in the form of				
		Industrial plantations	Farm wood lots	Environmental plantations	Multipurpose trees	Others
Samanea saman	E	X	X	-	X	-
Sandoricum indicum	N	-	-	-	X	-
Semecarpus curtisii	N	-	-	-	-	X
Sesbania grandiflora	N	-	-	-	X	-
Shorea talura	N	-	-	-	-	X
Sindora siamensis	N	-	-	-	-	X
Spondias pinnata	N	-	-	-	X	-
Sterculia foetida	N	-	-	-	X	-
Swietenia macrophylla	E	X	-	-	-	-
Tabebuia pentaphylla	E	-	-	X	-	-
Tamarindus indica	N	-	-	-	X	-
Tectona grandis	N	X	-	-	-	-
Terminalia catappa	N	-	-	X	-	-
Tetrameles nudiflora	N	X	-	-	-	-
Thyrsotachys siamensis	N	X	-	X	X	-
Xylia kerrii	N	X	-	-	-	-
Zollingeria dongnaiensis	N	-	-	-	-	X

Table 13. The choice of tree species of 21 Regional Forest Offices in Thailand, by rank.

Species	Score
Eucalyptus camaldulensis	17
Tectona grandis	15
Acacia auriculaeformis	15
Leucaena leucocephala	12
Gmelina arborea	11
Pterocarpus macrocarpus	10
Melia azedarach	8
Peltophorum inerme	6
Anacardium occidentale	5
Acacia catechu	5
Azadirachta indica	5
Xylia kerrii	4
Afzelia xylocarpa	4
Rhizophora spp.	3
Casuarina equisetifolia	3
Dipterocarpus alatus	3
Parkia javanica	3
Acacia mangium	2
Cassia siamea	2
Bombax spp.	2
Hopea odorata	2
Dalbergia cochinchinensis	2
Swietenia macrophylla	2
Pinus kesiya	2
Chukrasia velutina	2
Parkia speciosa	2
Cassia garrettiana	1
Fagraea fragrans	1
Bruguiera cylindrica	1
Litsea grandis	1
Alstonia macrophylla	1
Ceriops spp.	1
Albizia procera	1
Spondias pinnata	1
Pithecellobium dulce	1
Sindora siamensis	1
Mangifera indica	1
Ailanthus triphysa	1
Casuarina junghuhniana	1
Pinus merkusii	1
Intsia palembanica	1
Calamus caesius	1
Dejonix regia	1

Table 14. The choice of tree species recommended by various organizations including Regional Forest Offices (1), District Forest Offices (2), Provincial Forest Companies (3), and State Organizations (4).

Species	Source of recommendation			
	1	2	3	4
Acacia auriculaeformis	+	+	+	+
A. catechu	+	+	-	+
A. mangium	+	-	-	+
Afzelia xylocarpa	+	-	+	-
Ailanthus triphysa	+	-	-	+
Albizia procera	+	-	-	-
Alstonia macrophylla	+	+	+	+
Anacardium occidentale	+	+	+	-
Anthocephalus chinensis	-	-	-	+
Azadirachta indica	+	+	-	+
Bombax insignies	+	+	-	-
Bruguiera cylindrica	+	-	-	-
Cassia fistula	+	+	-	+
C. siamea	+	+	-	-
Casuarina equisetifolia	+	+	+	+
C. junghuhniana	+	+	-	-
Ceriops decandra	+	-	-	-
Chukrasia velutina	+	-	-	+
Dalbergia cochinchinensis	+	+	-	+
Delonix regia	+	+	-	+
Dipterocarpus alatus	+	+	-	+
Eucalyptus camaldulensis	+	+	+	+
E. deglupta	-	-	-	+
Fagraea fragrans	+	-	-	-
Gmelina arborea	+	+	+	+
Hevea braziliensis	-	+	-	-
Hopea odorata	+	+	+	+
Tutsia palembanica	+	+	-	-
Lagerstroemia calyculata	-	+	-	-
L. macrocarpa	-	+	-	-
L. speciosa	-	+	-	+
L. tomentosa	-	+	-	-
Leucaena leucocephala	+	+	+	+
Litsea grandis	+	-	-	+
Mangifera indica	+	+	-	-
Melaleuca leucadendron	-	+	-	-
Melia azedarach	+	+	+	+
M. dubia	-	+	-	-
Ochroma lagopus	-	-	-	+
Oroxylum indicum	-	+	-	-

Table 14. (Cont'd)

Species	Source of recommendation			
	1	2	3	4
Parkia javanica	+	+	-	+
P. speciosa	+	-	-	+
Peltophorum pterocarpum	+	+	+	+
Pinus kesiya	+	+	+	-
P. merkusii	+	+	-	+
Pithecellobium dulce	+	-	-	-
Pterocarpus indicus	+	-	-	+
P. macrocarpus	-	+	+	-
Rhizophora sp.	+	+	-	-
Sandoricum indicum	-	-	+	+
Shorea roxburghii	-	+	-	-
Sindora siamensis	+	-	-	-
Spondias pinnata	+	-	-	-
Swietenia macrophylla	+	+	-	+
Tabebuia pentaphylla	-	+	-	-
Tamarindus indica	-	+	-	-
Tectona grandis	+	+	+	+
Terminalia catappa	-	+	-	-
Tetrameles nudiflora	-	+	+	+
Xylia kerrii	+	+	-	-

macrocarpus, *Anisoptera costata*, *Shorea obtusa*, etc. The companies presently utilize logs of exploited economic trees harvested from logging concession areas. In return, they are supposed to plant trees using the concession fees for that particular year, with the main objectives being the renewal of forest resources; preventing land encroachment and shiftting cultivation; providing logs for use in the future; sustaining wood supply in the industrial wood sector; improving soil fertility by proper erosion control; improving the watershed areas; creating more jobs in rural areas; selecting better tree species for future planting programs. It should be noted that in many cases, tree planting using concession fees cannot be done due to the limitations in land availability. A list of trees selected for planting by these companies is also shown in Table 14. However, the companies recommended that the choice of tree species should be based on good growth and multiple uses. They recommended the government to support more teak planting in the future.

48. There are two main state organizations in Thailand dealing with tree planting on a large scale, i.e. Forest Industry Organization (FIO) and Thai Plywood Co. (TPC). The choice of tree species for the planting program of both organizations is similar and includes 31 species (Table 14). However, the choice of tree species for TPC plantations depends on the needs of TPC factories.

49. Tree farmers who intend to grow trees on as large a scale as other agricultural crops are now establishing plantations on leased or private land. This group estimates that more than 80 percent of trees growing as tree farms in Thailand have been established by them. However, the choice of tree species selected by tree farmers is limited in number, including *Eucalyptus camaldulensis*, *Tectona grandis*, *Acacia auriculaeformis*, *Acacia mangium*, *Eucalyptus deglupta*, *Gmelina arborea*, *Azadirachta indica*, *Pinus caribaea*, and also *Hevea braziliensis*.

50. Farmers commonly grow fruit trees in any available place or on a large scale as orchards. Table 15 is a list of 92 fruit trees planted in different parts of the country. Fruit trees not only yield fruit for consumption or selling in the market but also eventually provide woody stem which is chopped down for use as fuelwood. As fruit is an important export item, in the Sixth National Economic and Social Development Plan it is planned to increase fruit production from 5.40 million ton in 1987 upto 6.03 million ton in 1991. Annual export value during 1982-1984 was 3,355 million baht.

Table 15. List of fruit crops planted by farmers in Thailand

Scientific name	Common name	Origin:native (N) or exotic (E)
Achras sapota	Sapodilla	E
Aegle marmelos	Beal fruit	N
Aglaia domestica	Lancet, Langsium	N
Anacardium occidentale	Cashew nut	E
Annona cherimola	Cherimoya	E
A. muricata	Soursop	E
A. reticulata	Castard apple	E
A. squamosa	Sugar apple	E
Areca catechu	Betel nut	N
Artocarpus champeden	-	-
A. communis	Bread fruit	N
A. heterophyllus	Jack fruit	N
Averrhoa bilimbi	Cucumber tree	-
A. carambola	Belimbing, Carambola	E
Baccaurea sapida	Rambeh, Rambi	N
Bouea burmanica	Marian plum	N
B. gandaria	Gandaria	N
Canarium album	Chinese chestnut	E
Carica papaya	Papaya	E
Citrus aurantifolia	Lime	N
C. aurantium	Sour orange	N
C. grandis	Pomelo	N
C. hystrix	Leech lime, Kaffer lime	N
C. ichangeensis	Citron	N
C. japonica	-	-
C. limon	Lemon	E
C. medica	-	N
C. reticulata	Tangerine, Mandarin	-
C. sinensis	Orange (Sweet)	E
Cocos nucifera	Coconut	E
Coffea robusta	Coffee	E
Cola acuminata	Kola nut	E
Dimocarpus longan	Longan	N
Diospyros kaki	Persimon	E
D. siamensis	Sapote	N
Durio zibethinus	Durian	N
Elaeocarpus madopetalus	-	N
Eriobotrya japonica	Loquat	-
Eugenia aequea	-	-
E. cumini	Jamboian	N
E. jambos	Rose apple	-
E. javanica	Wax jamble	-
E. malaccensis	Malay apple	-

Table 15. (Cont'd)

Scientific name	Common name	Origin:native (N) or exotic (E)
Felonia limonia	Wood-apple	N
Ficus carica	Fig	E
Flacourtia indica	Governor plum	N
Fragaria chiloensis	Strawberry	E
Garcinia atroviridis	-	E
G. cowa	-	N
G. dulcis	Garcinia	N
G. mangostana	Mangosteen	N
G. schomburgkiana	-	N
Lepisanthes fruticosa	-	N
L. rubiginosa	-	N
Litchi chinensis	Litchi	N
Madhuca grandifolia	-	N
Mangifera foetida	Bachang mango	N
M. indica	Mango	N
Manilkara kauki (L.)	-	N
Muntingia calabura	Japanese cherry	E
Nephelium hypoleucum	-	N
N. leppaceum	Rambutan	N
N. mutabile	Pulasan	N
Nypa fruticans	Nypa palm	N
Otophora cambodiana	-	N
Persea americana	Avocado	E
Phoenix dactylifera	Dates	E
Phyllanthus acidus	Star-gooseberry	N
P. emblica	Embric myrobalan	N
Pithecellobium dulce	Manila tamarind	E
Prunus avium	Sweet cherry	E
P. cerasus	Cherry (sour)	E
P. persica	Peach	E
P. salicina	Japanese plum	E
Psidium guajava	Guava	E
Punica granatum	Pomegranate	E
Pyrus communis	Pear	E
P. malus	Apple	E
P. pyrifolia	Japanese pear	E
Salaca edulis	Salacea	N
S. rumphii	-	N
Sandoricum indicum	Santol	N
Spondias cytherea	Otaheite apple	E
S. pinnata	Hog plum	N
Sterculia nobilis	Chinese chestnut	E

Table 15. (Cont'd)

Scientific name	Common name	Origin:native (N) or exotic (E)
Tamarindus indica	Tamarind	N
Theobroma cacao	Cocoa	E
Zizyphus jujube	Chinese date	E
Z. mauritina	Indian jujube	E

51. In association with fruit trees, ornamental plants have also been selected to grow at home or in public places, i.e. along the road-side, in schools, temples or office yards. The planting of these ornamental plants has been activated during the past few years so as to develop more green areas both in the cities and in the countryside. There are 59 common ornamental plants being selected to be grown in Thailand (Table 16). In some cases, the branches and pruned wood can be used as fuelwood.

52. The Thais used wood mainly for fuel and charcoal in the household or elsewhere. Fuelwood is collected from the natural forest or from any available source close to the house. A survey of the trees used intensively as fuelwood or charcoal in different parts of the country is shown in Table 17.

53. Additional choices of tree species selected to grow in Thailand have been emphasized in other ways. In order to support government policy in developing green areas recreational areas have been established by using selected ornamental plants (Table 16). In some special cases, the choice of tree species has been limited to a specific purpose, for instance religious trees (Table 18), trees appearing in Thai literature (Table 19). The establishment of recreational areas has been carried out since the Fourth National Economic and Social Development Plan and more trees have been planted by many social groups.

Table 16. List of selected trees for planting as ornamental plants in Thailand.

Scientific name	Common name
Acacia tomentosa	Jungle nail
Albizia lebbek	Koko
Amherstia nobilis	Amherstia
Araucaria araucana	Hardy monkey puzzle
A. bidwillii	Bumya-bunya
A. excelsa	Hoop pine
Bambusa vulgaris	Golden bamboo
Bauhinia acuminata	Snowy orchid tree
B. monadra	Anchor
B. purpurea	Orchid tree
Bixa orellana	Annatto
Bombax ceiba	Red cotton tree
Brownea grandiceps	Asoka sponge
Butea monosperma	Flame of the forest
Caesalpinia pulcherrima	Peacock flower
Callistemon lanceolatus	Bottle brush tree
Cananga odorata	Ylang-Ylang
Cassia bakeriana	Pink shower
C. fistula	Golden shower
C. nodosa	Lebernum
C. surattensis	Scramble egg
Casuarina equisetifolia	Iron wood
Cochlospermum religiosum	Torch wood tree
Crescentia alata	Calabash tree
Datura metel	Thorn apple
Delonix regia	Flame tree
Diospyros hasseltii	Ebony
Erythrina suberosa	Indian coral tree
E. variegata	Coral tree
Eucalyptus spp.	Eucalypt
Ficus bengalensis	Banyan tree
F. elastica	Indian rubber fig
F. religiosa	B-tree
F. retusa	Chinese banyan
Gardenia collinsae	Gardenia
Gliricidia sepium	Madre de Cacoa
Grevillea robusta	Silk oak
Hura crepitans	Monkey's dinner bell
Kigelia pinnata	Sausage tree
Lagerstroemia indica	Crape myrtle
L. macrocarpa	Pride of India
L. speciosa	Queen flower

Table 16. (Cont'd)

Scientific name	Common name
Mesua ferrea	Rose chestnut
Melia azedarach	Persian lilac
Michelia alba	White champac tree
Millingtonia hortensis	Indian cork tree
Murraya paniculata	China box tree
Pinus kesiya	Three needle pine
Plumeria acuminata	Frangipanni
P. rubra	West Indian red-jasmine
Podocarpus macrophylla	Buddhist pine
Ptychosperma macarthurii	Mac Arther palm
Quisqualis indica	Rangoon creeper
Salix babylonica	Weeping willow
Saraca zollingeriana	Asoka tree
Spathodea campanulata	African tulip tree
Tabebuia chrysantha	Golden tree
T. pentaphylla	Tabebuia
Terminalia catappa	Singapore almond
Triplaris cumingiana	Palo santo

Table 17. Trees presently used as fuelwood in various parts of Thailand

Scientific name	Origin:native (N) exotic (E)	Regions
Acacia auriculaeformis	E	NE, C, N, S
A. catechu	A	N
A. formensis	E	N
Albizia odoratissima	N	N
A. procera	N	N, C
Alstonia scholaris	N	N
Anisoptera costata	N	N
Anthocephalus chinensis	N	C, N
Avicennia officinalis	N	S, SE
Azadirachta indica	N	N, C
Bauhinia malabarica	N	N
Betula alnoides	N	N
Bischofia javanica	N	N
Bruguiera gymnorrhiza	N	S, SE
B. cylindrica	N	S, SE
B. parviflora	N	S, SE
Canarium subulatum	N	N
Cassia garrettiana	N	C
C. siamea	N	N
Casuarina equisetifolia	E	C, S, N
C. junghuhniana	E	C
Ceriops tagal	N	S, SE
Cleistanthus gracillis	N	C
Chrysophyllum cainito	N	N
Dalbergia nigrescens	N	NE
Dipterocarpus intricatus	N	N
D. obtusifolius	N	N, C
D. tuberculatus	N	N, C
Diospyros rhodocalyx	N	C, NE
Duabanga grandiflora	N	N
Elaeocarpus spp.	N	N
Engelhardtia spicata	E	N
Eucalyptus camaldulensis	N	C, N, S, E
Eugenia cumini	N	N
Fagraea fragrans	N	C, N, S
Fernandoa adenophylla	N	N
Garuga pinnata	N	N
Gmelina arborea	N	N
Hevea brasiliensis	E	C, N, S
Intsia palembanica	N	S
Irvingia malayana	N	C, N
Kandelia candel	N	S
Lagerstroemia calyculata	N	N, C

Table 17. (Cont'd)

Scientific name	Origin:native (N) exotic (E)	Regions
Leucaena leucocephala (common)	N	C, NE
L. leucocephala (giant)	E	C, NE, N, S
Lumnitzera littorea	N	SE, S
L. racemosa	N	SE, S
Mangifera indica	N	N
M. caloneura	N	N
Melia azedarach	N	C, N, NE
Morinda corea	N	E
Moringa oleifera	N	C
Muntingia calabura	E	N
Peltophorum dasyrachis	N	N
Pithecellobium dulce	E	C
Pterocarpus macrocarpus	N	N, C
Phyllanthus emblica	N	N
Quercus spp.	N	N
Rhizophora apiculata	N	S, SE, C
R. mucronata	N	S, SE, C
Schleichera oleosa	N	C, N
Schima wallichii	N	N
Sesbania grandiflora	N	N, C, S
Sindora siamensis	N	N, NE
Shorea obtusa	N	C, N
S. roxburghii	N	C, N
S. siamensis	N	C, N
Sonneratia caseolaris	N	S, SE
Stereospermum fimbriatum	N	N
Tamarindus indica	N	E
Tectona grandis	N	N
Terminalia alata	N	C
T. catappa	N	C
Thyrsostachys siamensis	N	N
Vitex canescens	N	N
V. pinnata	N	N
Xylia kerrii	N	C
Zizyphus mauritiana	E	C, NE

Table 18. List of religious trees grown in Thailand as ornamental plants

Scientific name	Origin:native (N) exotic (E)	Regions
Acacia catechu	N	N, SW, C
Azadirachta indica	E	C, S, N
Bambusa spp.	N	N, S, E, W, C
Barringtonia acutangula	N	NE, N, S
Borassus flabellifer	E	C, N, E, S
Citrus aurantium	E	N, C
Crateva religiosa	N	N, SE
Dalbergia sissoo	N	N
Erythrina variegata	N	N, C
Eugenia cumini	N	C, N
Ficus bengalensis	N	C
F. religiosa	E	C, E, N
Gossypium braziliense	E	N, EN
Hopea odorata	N	N, SW, C
Mangifera indica	N	SW, C, N, E, S
Manilkara hexandra	N	C
Myristica iners	N	S
Phyllanthus emblica	N	SE, SW, C, N
Shorea robusta	E	C
Talauma candollei	N	N, S, C
Terminalia chebula	N	N, C

Table 19. List of trees appeared in Thai literatures selected to grow as ornamental plants.

Scientific name	Origin:native (N) exotic (E)	Regions
Acacia farnesiana	E	C, N, SW, S
Aglaia odorata	N	N, C, S
Alangium salvifolium	N	C, N, E
Albizia lebbeckoides	N	C, N
Amherstia nobilis	N	C
Anthocephalus chinensis	N	C, N, S, E
Azadirachta indica	E	C, S, N
Barringtonia acutangula	N	NE, S, N, C
B. racemosa	N	C
Bauhinia acuminata	E	C, S
B. monandra	E	C
B. purpurea	E	N
Bombax ceiba	N	C, SW, E
B. valetonii	N	N, SW, C
Caesalpinia pulcherrima	E	E, N, C
Calotropis gigantea	E	N, C
Cananga odorata	E	S, C, N
C.odorata var. fruticosa	N	S, C
Cassia alata	E	N, C, S
Cassia fistula	N	SW, C, N, E
Citarexylum spinosum	E	C
Cochlospermum religiosum	E	N, C
Crateva magna	N	C, N, SW
C. religiosa	N	N, E
Cratoxylum pruniflorum	N	SW, S, N, C, E
Delonix regia	E	C, N, S
Dichrostachys cineria	N	C
Eriobotrya bengalensis	N	N, SW, E, SE
Ervatamia coronaria	N	C, N
Eugenia cumini	N	C, N
Fagraea fragrans	N	C, S, E, N
Feronjella lucida	N	C, NE
Gardenia jasminoides	E	N, C, SW
G. lineata	N	SW, NE
Goniothalamus giganteus	N	S
Gossypium barbadense	-	-
Harrisonia perforata	N	C, N
Hibiscus mutabilis	E	N, C
H. rosa-sinensis	E	C, S, N
H. syriacus	E	C
Horsfieldia irya	N	C, S
Hydnocarpus anthelmintica	N	C, E, S
Indigofera tinctoria	E	C, N

Table 19. (Cont'd)

Scientific name	Origin:native (N) exotic (E)	Regions
Ixora coccinia	E	C
I. finlaysoniana	N	C
I. macrothyrsa	E	C
Lagerstroemia calyculata	N	N, E, S, SE, SW
L. indica	E	N, C
L. loudonii	N	SE, E, S
L. macrocarpa	N	E, NE, N, C
L. speciosa	N	SW, C, S
Lawsonia inermis	E	C
Leucaena leucocephala	N	C, SW, S, N
Magnolia coco	E	C, N
Mammea siamensis	N	SE, S, C, N
Manilkara hexandra	N	C
Mesua ferrea	N	N, C, S
Michelia champaca	N	C, S
Michelia alba	N	C
Millingtonia hortensis	N	N, SW, C
Mimusops elengi	N	S, N, C
Murraya paniculata	N	S, C, N
Nerium indicum	E	C
Nyctanthes arbor-tristis	E	C
Ochna integerrima	N	S, C, SE, E, N
Pandanus tectorius	C	C, S, N
Peltophorum pterocarpum	E	SW, S, N, NE, C
Plumeria acuminata	E	C
P. rubra	N	N, C, S
Pterocarpus indicus	N	SW, N, C
Pterospermun acerifolium	N	S, N
Radermachera ignea	N	C, N
Samanea saman	N	S, SW, E
Saraca declinata	N	S, C, N
S. indica	N	C, S
S. thaipingensis	N	C, S
Sesbania grandiflora	E	S, N
Shorea roxburghii	N	N, NE, C, N
Sonneratia caseolaris	N	C
Sterculia foetida	N	N, S, C, E
Talauma candollii	N	S, N, C
Thevetia peruviana	E	C, N
Urena lobata	N	C, N, S
Vatica diospyroides	N	S, C
Wrightia religiosa	N	E, C, SE

CHAPTER 4

SEED PROBLEMS

54. The seed problems of some developing countries in Asia were discussed for the first time in the IUFRO Symposium held in Bergen, Norway, in 1973 (Bhumibhamon, 1973; Kittinanda, 1973). This meeting was considered to be one of the best IUFRO meetings as the seed researchers from the developing countries and the developed ones had chances to discuss the seed problems at length. The issues of seed quality, technically and genetically, were pointed out later in another IUFRO Symposium held in Bangkok in 1984. The main seed problems relating to tree planting in Thailand are the selection of tree species, seed quality, seed production, seed collection, seed extraction, seed storage, seed testing and seed exchange (Bhumibhamon, 1973; Bhumibhamon & Atipanumpai, 1983).

55. The selection of tree species is the main problem in determining the research needed and the requirements of the related technological development. As was outlined in detail in Chapter 3, tree species have been selected for planting in various forms. DANIDA Workshop on Seed Procurement held in Chiangmai in 1973 limited the number of species of interest and only five main groups of tree species were recommended, including teak, pine, dipterocarp, gmelina, and eucalypts (RFD/DANIDA, 1979). ASEAN/Canada Forest Tree Seed Centre located in Thailand also listed 31 tree species common for planting in the ASEAN member countries (ACFTSC, 1983). The Project Steering Committee has discussed the problems intensively and listed 7 main core species which are of interest to all member countries, including *Acacia auriculiformis, Acacia mangium, Dipterocarpus alatus, Gmelina arborea; Pinus caribaea,* and *Pterocarpus macrocarpus* (ACFTSC, 1984; 1985). ASEAN/Australia Tree Improvement Program also emphasized the breeding of limited numbers of tree species, including *Acacia* sp., *Eucalyptus.*, *Albizia* sp., *Tectona grandis* and *Gmelina arborea*.

56. Seeds of most species used in Thailand have been collected from unclassified seed sources or from any available source. A small portion of seed lots of *Tectona grandis, Pinus kesiya, Pinus merkusii, Melia azedarach* and *Eucalyptus camaldulensis* have been collected from seed production areas, seed orchards or purchased from selected seed sources. In relation to seed procurement, the seed quality can be handled by using technology available in the country.

57. Seed production is one of the main problems, particularly in the seed production areas and the first generation seed orchards of various species. Generally, selected trees with good phenotypical characteristics yield poor crops. Flower induction of native pine has been tried but long-term studies are still required. Lack of basic information on seed production of most tree species selected for planting requires intensive long-term study.

58. Seed collections of *Tectona grandis, Pinus kesiya* and *Pinus merkusii* are generally well planned. This is due to the long-term bilateral tree-improvement program supported by DANIDA since 1963. Collection of other tree seeds still requires better planning and thus should be undertaken after the exploration of the natural population and superior mature plantations as well as marking the selected stand for seed collection.

59. Seed extraction of some species is simple but a number of species like *Azadirachta indica, Gmelina arborea, Melia azedarach* still require proper treatment in order to handle the seed-lots with care. Macerators could, however, be adapted for this use.

60. Problems related to recalcitrant seeds are still being investigated. Species of interest in this particular issue are *Dipterocarpus alatus, Hopea odorata, Azadirachta indica, Melia azedarach,* and some fruit trees planted in the social forestry program. Seed storage for practical needs and gene conservation differ in the procedures. Both areas of research are needed for recalcitrant seeds in most tropical countries.

61. Testing of forest trees seeds is done practically only on a small scale. Research on seed testing has been done at Kasetsart University and at the ACFTSC. However, the ISTA Rule on Seed Testing has been applied only when conducting seed research. It is expected that large-scale seed trading will be the only way to emphsize the need for proper seed testing.

62. Seed exchange for research is on rather a small scale. DANIDA has supported large-scale seed collection of *Tectona grandis, Pinus kesiya,* and *Pinus merkusii* for distributing to various countries in need. Seed used in Thailand was mainly received from specific organizations, for instance Eucalypt and Acacia seeds were received from CSIRO in Australia, lowland tropical pine seeds were obtained from CFI in England, Paulownia and semi-tropical fruit tree seeds were supplied from China, and Leucaena seeds were directly mailed

from Hawaii etc. However, after proper species and provenance testing, it is often very difficult to get seeds of promising provenances to grow on a larger scale.

63. Constraints in seed procurement have been evaluated using questionnaire and interview. It was found that most Nursery Centers in Thailand collected or bought seed from unclassified seed sources. Often, the Nursery Centrees cooperated with the Seed Centres to supply sufficient seed. However, the Nursery Managers recommended that Seed Centres should be located in various parts of the country and be responsible for seed used in each region. Regional Forest Offices claimed that seed used in their planting programs were mainly collected from unclassified seed sources. Most offices have considered the need for better seed, while Phitsanuloke, Chiang Rai, and Phrae RFOs stressed that seed quality was the major problem for them. To promote tree farming, District Forest Officers recommended that the government should provide assistance with seed. About 33% of Provincial Forest Companies collected seed, 62% of unidentified seed was bought from forestry agencies or the private sector, and about 5% of the seed was imported from foreign countries. Generally, regardless of seed quality, the seed supply for the annual planting programs of most Provincial Forest Companies was sufficient. In contrast Kanchanaburi and Surin companies claimed that the problems of seed supply still remained. Forest Industry Organization and Thai Plywood Co. collected seed both from unclassified and classified stands but there is a program to use seed of better quality as soon as it is available.

CHAPTER 5

CONSTRAINTS ON NURSERY TECHNIQUES

64. The cost of nursery seedlings has dropped considerably during recent years because of intensive research and development in all aspects of nursery production. A list and the distribution of Nursery Centres established by all sectors is shown in Table 20 and Figure 11.

65. RFD Forest Nurseries in Thailand are managed to produce seedlings for mass planting programs both on public and private land. FIO and TPC Forest Nurseries produce seedlings of required species for planting in their own plantations. The surplus seedlings are sold in the market or by contract. There are also many small nurseries run by the Highway Department in all provinces as well as other governmental agencies. Tree farmers also establish nurseries of various sizes. Modern technology has been introduced into these nursery centres.

66. Most nursery sites in Thailand have been established in areas which are flat and fertile, soil pH is generally neutral, they are free from weeds, have sufficient labour supply, and are located close to a water reservoir. Eventhough transportation is easiest if the distance from the market to the nursery is short, only some nursery centres meet this requirement. Nursery centres are mainly established using labour, though in most centres some machinery has been introducted.

67. Seedlings have been generally raised in clear plastic bags but more recently black tubes have been used instead. Paper pots and plastic tubes have been tried and introduced into the Thai market. Soil mediums used vary according to the availability at the nursery sites. However, top-soil, sand, ash, burnt rice chaff, rice straw, etc. are commonly used. Compost has been produced by governmental and private nurseries from vegetation mixed with cow dung and research on microbes with high potential for stimulating decomposition is being carried out. In this respect, genetic engineering of related microbes is required.

68. Chemical fertilizers are commonly used at the Nursery Centres but research on the nutrient requirements of selected tree species is still needed. Under the present situation, nursery managers recommend that a modern forest nursery should be established and at the same time a training program on nursery techniques should be developed, though it was pointed out that sufficient budget to run the nursery was needed.

Table 20. List of forest nurseries in Thailand.

Regions and nursery names	Locations	Owners	Established in	Area (ha)
A. North				
Wang Chin	Phrae	FIO	1979	48.0
Lampang	Lampang	RFD	1967	36.8
Uttaradit	Uttaradit	RFD	1975	12.8
Bo Kaew	Chiang Mai	RFD	1965	9.6
Phrae	Phrae	RFD	1975	48.0
Petchabun	Petchabun	RFD	1978	35.2
Kamphaeng Phet	Kamphaeng Phet	RFD	1975	NA
Chiang Rai	Chiang Rai	RFD	1977	14.4
Mae On	Chiang Mai	RFD	1975	72.0
Huay Din Dum	Chiang Mai	RFD	NA	NA
Tak	Tak	RFD	1975	12.2
B. Central				
Saraburi	Saraburi	RFD	1975	56.0
Ratcha Buri	Ratcha Buri	RFD	1980	16.0
Bhudhamonthon	Nakhon Pathom	RFD	1970	1.6
Nakhon Nayok	Nakhon Nayok	RFD	1978	48.0
Sing Buri	Sing Buri	RFD	1.6	NA
Bangkok	Bangkok	RFD	1975	0.5
Phitsanulok	Phitsanulok	RFD	NA	NA
Uthai Thani	Uthai Thani	RFD	1978	64.0
Nakhon Sawan	Nakhon Sawan	RFD	NA	NA
Chainat	Chainat	RFD	NA	0.8
Nakhon Ratchasima	Saraburi	RFD	NA	NA
C. Northeast				
Nongkhai	Nongkhai	RFD	1980	16.0
Surin	Surin	RFD	1971	80.0
Chaiyaphum	Chaiyaphum	RFD	1977	NA
Ubon Ratchatani	Ubon Ratchatani	RFD	1978	8.0
Nong Teng Chakkarat	Nakhon Ratchasima	RFD	1975	88.0
Khon Kaen	Khon Kaen	RFD	NA	NA
Sakon Nakhon	Sakon Nakhon	RFD	NA	NA
Somdet	Kalasin	FIO	NA	40.0
Srisaket	Srisaket	RFD	1981	32.0
Loei	Loei	RFD	1981	10.7
Khok Phet	Buriram	Private	1985	2.0

Table 20 (Cont'd)

Regions and nursery names	Locations	Owners	Established in	Area (ha)
D. East				
Chanthaburi	Chanthaburi	RFD	1975	NA
Rayong	Rayong	RFD	1979	56.0
Sra Kaew	Prachin Buri	RFD	NA	48.0
Prachin Buri	Prachin Buri	RFD	1977	32.0
Chon Buri	Chon Buri	RFD	1976	16.0
Chachoengsao	Chachoengsao	FIO	NA	NA
Thai-Swedish	Chachoengsao	Private	1985	NA
Eucalypt chipwood	Rayong	Private	1985	NA
E. West				
Kanchanaburi	Kanchanaburi	RFD	1975	NA
Asoke Rangsan	Kanchanaburi	Private	1983	NA
F. South				
Chumporn	Chumporn	RFD	1975	72.0
Prachuap Khiri Khan	Prachuap Khiri Khan	RFD	1975	NA
Trang	Trang	RFD	1975	NA
Phangnga	Phangnga	RFD	1978	0.8
Kanchanadit	Surat Thani	FIO	1974	0.5

NA Not available
RFD Royal Forest Department
FIO Forest Industry Organization

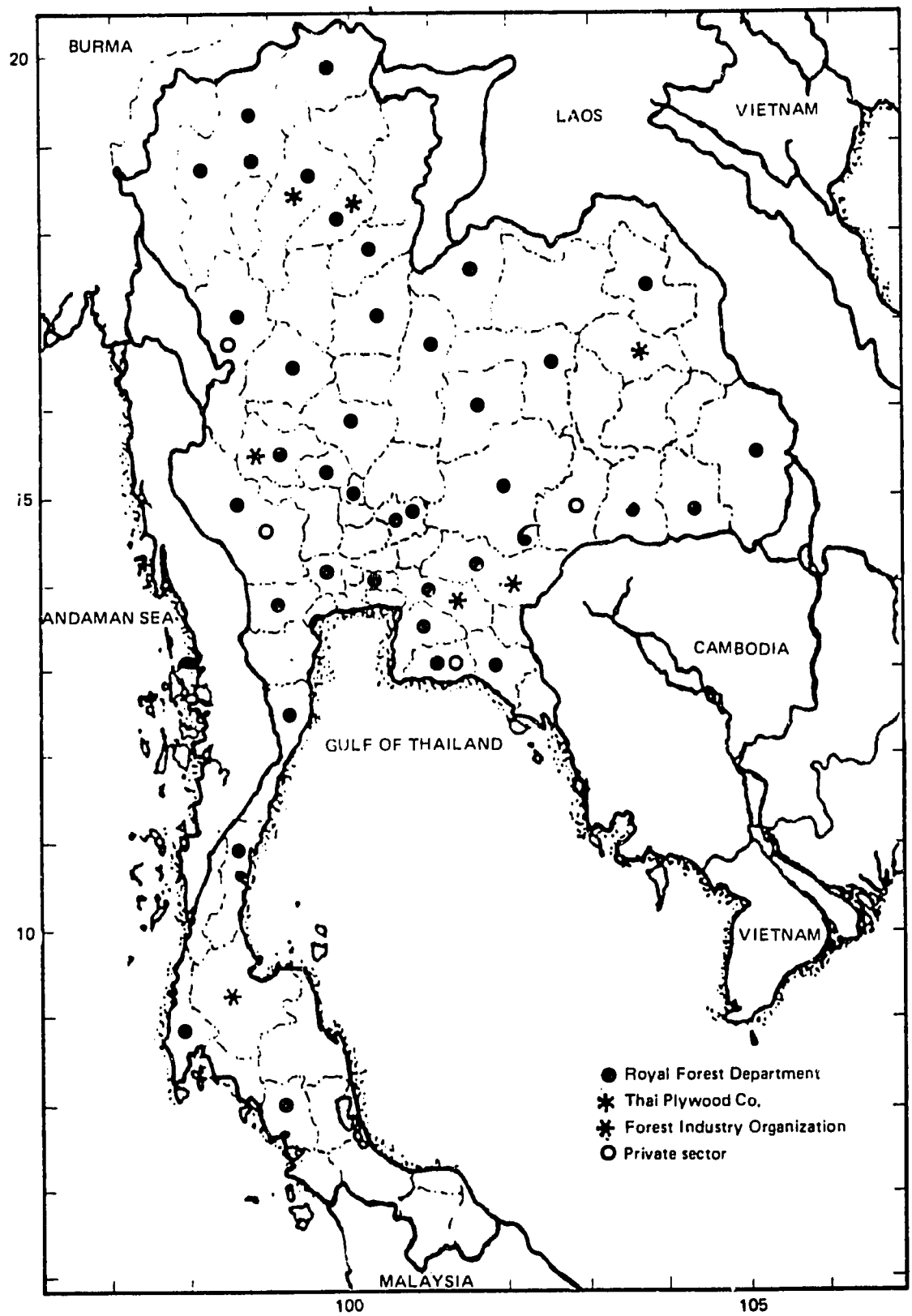

Figure 11. Location of forest nurseries in Thailand.

69. In order to produce the cheapest possible seedlings of fast-growing trees on a large scale, the Prime Minister's Office appointed an Ad Hoc Committee on Modern Nursery Techniques for Fast-Growing Tree Plantation Establishment in Thailand (No. 77/1982) on June 22, 1982. The Committee is comprised of 18 members representing various organizations agreeing to promote modern nursery techniques and also to encourage the private sector to take an active role in tree farming.

70. In interviewing various groups to find their views on the constraints affecting the introduction of modern nursery techniques, it was found that the Regional Forest Offices thought that the limitations on the budget would effect the establishment of nursery centres most. About 67% of the cases studied emphasized the urgent need for developing modern nursery techniques.

71. Provincial Forest Companies have also taken part in developing the Nursery Centres (41%). The companies considered that nursery work relied too much on precipitation and that low rainfall in any year would prevent the development of better seedling quality. This reliance was due to poor watering systems as well as limited sprinkler use (17%). The companies claimed that most seedlings were produced in traditional ways in which seedlings are grown in clear plastic bags and kept under tree canopies for shade.

Concerning the role of the Forest Industry Organization in seedling production it was found that seedlings were raised in 5 nurseries. Mae Moh Nursery Centre in Lampang produced about 3.7 million teak stumps annually. Other FIO nurseries raised other tree species. The top ten in the list were *Eucalyptus camaldulensis, Alstonia macrophylla, Acacia auriculaeformis, Dipterocarpus alatus, Pterocarpus macrocarpus, Leucaena leucocephala, Melia azedarach, Gmelina arborea, Dalbergia cochinchinensis, and Lagerstroemia speciosa.* FIO had developed sowing techniques for teak seed and used heavy machinery. It had also developed a nursery block made of coconut fibres, but this technique was still in the early stages of development.

72. TPC produces seedlings for its need and partly for contract sale. Although traditional techniques are still used well-trained nursery workers allows the company to produce good seedlings from good genetic material.

CHAPTER 6

CONSTRAINTS ON TYPES OF TREE PLANTING AND MANAGEMENT

73. About 4 types of tree planting can be identified in Thailand: enrichment planting, environmental plantations, industrial plantations, and community forestry plantations.

6.1 ENRICHMENTT PLANTING

74. According to National Forest Policy, conserved forest should occupy about 15% of the total area of the country. At present, to reach this total, a few more percent of the land area is still required to be established as conserved forest. The conserved forest already established includes the categories: National Park, Wildlife Sanctuary, Nature Park, Non-hunting Area, Natural History and Wildlife Centre, Wildlife Research Centre, Wildlife Park, and Wildlife Breeding Centre (Table 21). As noted earlier, conserved forests have been extensively disturbed, leaving gaps of various sizes for natural regeneration.

75. In the areas where forest has been continuously disturbed enrichment planting using native trees has been carried out but on rather a small scale. Tree planting to improve poorly productive forest already covered an area of 560,764 rai in 1984.

76. Generally, seedlings used for planting are obtained from any RFD Nursery Centre, with advance notification of the number of seedlings required. Most plantings have been prepared in the traditional way without additional fertilizer application or any special treatments.

6.2 ENVIRONMENTAL PLANTATIONS

77. Environmental plantations have been established in many forms. The main portion of this form of planting is in watershed catchment areas, in which trees have been planted in deforested or abandoned areas. A ground-cover of trees reduces the problems of erosion and promotes water infiltration. Additionally, planted trees can reduce the problem of surface run-off.

78. *Pinus kesiya, Pinus caribaea, Chrysophyllum cainito,* and *Betula alnoides* are the trees selected for planting.

Table 21. Types of conserved forest in Thailand, 1984 (RFD, 1984).

Type of conserved forest	Units	Total area (Rai)
National Park	49	15,809,251.71
Nature Park	57	819,190.00
Wildlife Sanctuary	25	12,602,800.50
Non-hunting Area	32	1,567,960.75
Natural History and Wildlife Centre	7	9,150.00
Wildlife Research Centre	1	300.00
Wildlife Park	2	15,345.00
Wildlife Breeding Centre	8	4,330.00
Total	181	30,828,327.96

79. Generally, establishment is carried out by land clearing and then planting trees in rows as a monoculture. In the early days, seedlings were shipped by helicopter or loaded into trucks but later on temporary nurseries were established nearby for raising seedlings. In most planting programs in hilly areas the spacing used is 4x4 m.

80. RFD (1984) reported that the total planted area in the watersheds reached 575,900 rai in 1983. Areas planted in 1984, 1985, and 1986 were 56,325, 48,000 and 51,300 rai respectively.

81. In the area of problem soils, including acid soil, saline soil, drought areas, flood-prone areas, and left-over mining areas, tree plantings have been done on a small scale but have high potential for further development in the near future.

82. Tree planting along road sides, in schools, temples and industrial estates, provides chances for developing more green areas to obtain the indirect benefits of trees on mankind. Seedlings used for conservation plantations have been provided by RFD or other governmental agencies, or bought from private nurseries.

6.3 INDUSTRIAL PLANTATIONS

83. Small scale industrial plantations were established before 1960. Since then, the need for large scale planting has been recognized. RFD, FIO, and TPC have played an active role in establishing plantations of economic tree species. The Silviculture Division and Regional Forest Offices of RFD plant trees using the government budget, while FIO and TPC used both the government budget and logging concession fees. Concerning tree planting using the concession fees, some Provincial Forest Companies encourage FIO to establish plantations on their behalf. The total area of industrial plantations established by these groups is close to 2 million rai.

84. The situation in Thailand indicates that tree planting should be done by the private sector if sufficient wood for the wood industry is required. Shortage of wood and the increasing imports of wood encourages tree farmers to grow some fast-growing and economic trees. RFD (1984) reported that 758 tree farmers grew trees on their own land during 1979-1984 covering an ara of 44,979 rai. During this period, 39 tree farmers also planted trees on leased land, covering an area of 140,689 rai. Effective planting programs by tree farmers have been carried out on a larger scale since then.

6.4 COMMUNITY FORESTRY PLANTATIONS

85. With FAO support, a Seminar on Forestry for Rural Communities was conducted by the Faculty of Forestry, Kasetsart University (KUFF, 1983). Later, a program on community, or social forestry was developed. A KU/FINNIDA Workshop on Community Forestry was arranged in 1984 which will lead to the establishment of the Regional Community Forestry Training Centre to be sponsored by the Asian Development Bank and the Government of Switzerland. The Faculty of Forestry has also set up a curriculum on social forestry which has already been used in the 1986 academic year.

86. Problems of shifting cultivation and land encroachment caused by human pressure and the lack of common property of forest resources has provided the need to develop community forestry plantations. The objectives in establishing this type of plantation are mainly aimed at increasing green areas to supply sufficient wood for various purposes as well as solving environmental problems and preventing the destruction of watershed areas. The community receives additional income by selling wood and thus may indirectly save the government budget for increasing the area of state-owned plantations. Specifically, cooperation between the state and the farmer has resulted in the strengthening of mutual cooperation.

87. The Thais have long experience in growing fruit trees or trees which directly provide their needs for cooking, providing warmth in winter, for use as fuelwood in connection with the recuperation of women following childbirth, for making fires to drive insects away from cattle, for using in cottage industries, for burning corpses, for making kitchen utensils etc. Fuelwood has been gathered in home gardens and from either communal land or reserved forest nearby. Over-exploitation of fuelwood seems be the common practice in Thailand. The extra money earned is generally used for social affairs in the village. Unlike those who live terrestrially, farmers who live near mangrove forests have tried to establish *Rhizophora* plantations. At present, village woodlots have been established in some critical provinces. Provincial and Regional Forest Offices are now considering the need for establishing more village woodlots and using them as recreational areas (Prakthong, 1984). The choice of tree species is shown in Table 17. Srisawas (1983) reported on a survey of farmers who showed a negative attitude to tree planting on their own land, particularly if they had stayed permanently in a forest area for more than 10 years. Villagers believed that plantation establishment would limit their crop-growing areas or areas for raising cattle.

However, the majority of farmers (79.17%) agreed to establish village woodlots on community land. Bhutaraporn (1983) concluded that there were several factors affecting the success of establishing village woodlots, including misunderstanding project design, management problems social constraints, and people participation.

In connection with this program, fuelwood plantations for cottage or small industries have also been established.

88. Fruit tree farming has been promoted by the Department of Agriculture. The kind of fruit trees selected for planting depends on the species suitable for the planting site. The planting system is still largely the traditional way. However, modern fruit tree farming has been successfully established in Thailand in which irrigation and fertilizer application is used. Combining cropping systems with medicinal plants or vegetables has provided greater possibilities for farmers to earn more income and the high value of fruit enables farmers to earn a good income.

89. The Thais traditionally stay in groups, large or small, by the river side or road-side. People in remote villages usually plant trees around their houses and on boundaries. The composition of trees grown differs from region to region. Bamboo is normally grown on the out-skirts followed by mixed fruit trees or multipurpose trees.

90. Shelterbelts are established in farm areas so as to protect houses and crops from wind and dust. Shelterbelts also present over heating from direct sunshine. They consist of rows of trees, one or many, planted with narrow spacing. *Casuarina equisetifolia, Casuarina junghuhniana, Eucalyptus camaldulensis* are commonly used in establishing shelterbelts in Thailand.

91. Road-side trees are established along both highways and village roads. Generally, the trees selected are meant for growing as economic trees, like *Tectona grandis, Dipterocarpus alatus, Lagerstroemia calyculata*. However, flowering trees, e.g. *Jacaranda filicifolia, Cassia floribunda, Lagerstroemia speciosa, Tabebuia pentaphylla* and some multipurpose trees e.g. *Azadirachta indica, Tamarindus indica, Eucalyptus camaldulensis, Acacia auriculaeformis* have been planted extensively in Thailand. For village roads where the size is relatively small, growing trees that could provide multiple uses is recommended, for instance growing *Tamarindus indica*. Villagers will have trees for shade and fruit can be collected for consumption or to sell in nearby markets, with the benefits going to the local community.

92. Urban planting has been done in various forms e.g. road-side trees, miniature parks in squares, trees planted in the middle of roads, or the establishment of larger recreation areas like parks. Khemnark (1983) reported that there should be a green area of one rai per 100 city dwellers but that the ratio in Bangkok was one rai per 3,750 persons. There is a great need to develop more green areas. Bangkok and big cities are now planting more trees wherever possible.

93. Site preparation for planting is generally done by using simple machines except for large-scale planting done by state organizations or private enterprises where tractors and other heavy machines are been widely used for site preparation. Planting in all cases is done by manual work, with or without adding compost to the planting holes.

Regional Forest Offices claim that labour problems exist particularly in the areas where agricultural crops are grown intensively. The survey indicated that tree planting in the central plains was claimed to lack a proper planting system.

94. Trees are planted in rows or in clumps depending on the planting type. However, the major part of the plantations established (71%) have been monocultures. The rest have been established in the form of agro-forestry in which trees are planted in association with maize, cassava, soya bean, cotton, green gram, peanut etc., and the management prctices are compatible with the cultural practices of the villagers. It is believed that the villagers would have better a living standard by increasing their income through this system as well as from growing more than one single crop a year. More information on the development of agro-forestry programs can be obtained from Boonkird (1986) Petchmak and Kiatwudhinon (1984).

95. The spacing used for different types of tree planting varies remarkably. Enrichment planting and some cases of urban planting has no system, but the spacings commonly used in tree farming are 2x2, 2x3, 3x3, 2x4 and 4x4 m depending on the species and the end-uses and even wider spacing of 2x8 has been established in agro-forestry programs. As regards environmental plantations, fuelwood plantations, or animal feed plantations a narrow spacing is normally required.

96. Tending is needed in all tree planting programs. Experience in Thailand indicates that tree farmers have to spend more budget and effort in tending trees after planting than in preparation and planting itself. Poor survival percentages of planted trees are mainly caused by biotic enemies, planting season, and forest fire. However, high

survival percentages have been observed in tree farming but replanting is still needed, particularly after 3 months of establishment or in the following growing season if the budget is limited. Forest officers have claimed that plantation management is generally poor and villagers take little care of the trees planted on public land. Mae Hong Son Provincial Forest Company pointed out that it was extremely difficult to manage plantations established in the proper way. Nan, Ranong, Nakorn Phanom, and Chaiyaphum PFCs, also pointed out similar problems though their situations were generally better. Nevertheless, tree farmers have encouraged the government to provide assistance in plantation management.

97. In order to reduce the number of plants competing with planted trees, weeding has been done manually, by ploughing with tractors or by reliable chemical control. Provincial Forest Companies use both mechanical (42%) and chemical (75%) weed control. However, experience in TPC plantations shows that 70% of yearly expenditure will be used for weed control. Reducing weeding cost is a necessity because weed elimination is needed not only for promoting better tree growth but also for reducing the possibility of forest fire.

98. Fire protection is one of the most important procedures in managing forest plantations. Forest fire in Thailand is entirely caused by human factors and occurs frequently during November and May. Small farm woodlots require good weed control which can be done manually by volunteer villagers. Fire lines are needed in larger tree farms or environmental plantations. Land-use planning prior to plantation establishment is needed so that roads can be used as a form of fire-line. The design of the TPC Lad Krating Plantation where the whole plantation area is divided into small plots of equal size, covering an area of 100 rai each can be described as excellent. The road surrounding each plot allows the forest fire brigrade to manage fire control effectively. Fire towers, vehicles, and trained firemen can improve the efficiency of fire control. A lack of one of these requirements would reduce the possibility of controlling forest fire in a plantation, as is shown in the cases of Mae Hong Son, Surin, Nan, Sri Saket and Chaiyaphum Provincial Forest Companies.

99. Thinning is required in plantations where narrow spacing is used. Systematic thinning and selective thinning are generally used in Thailand particularly in economic tree plantations. The utilization of small-size thinned wood requires technological innovation in the industrial wood sector.

100. Pruning is required in tree farming or agro-forestry systems so as to improve the stem quality. Some species with poor natural pruning like *Acacia mangium* require pruning at an early stage. As regards *Tectona grandis, Melia azedarach* or *Azadirachta indica,* pruning would improve the stem form but chemical treatment in the cut area is required. In the farm woodlots, pruned wood can be used as fuelwood.

CHAPTER 7

SPECIES AND PROVENANCE TRIALS

7.1 SPECIES TRIALS

101. As the number of highly-commercial and commercial tree species in Thailand is 182 and the number of planted tree species in all forms is 99, the number of tree species used should be limited so that intensive R & D can be carried out. Under the present situation, planted trees can be divided into slow growth economic trees, fast growing trees, multipurpose trees, and trees growing in watersheds or degraded land. Each planting system requires proper R & D programs.

102. Species trials of Eucalypt and Acacia have been established in various parts of the country. Eucalyptus species trials comprising 30 species were established first at the Pine Improvement Centre. Sa-ardavut (1980 a, b, c, d) reported that the results of the early trials showed that *E. camaldulensis* was the most promising both in terms of survival percentages and growth performance. Other trials were established on high land (Huay Bong) and at medium elevation (Mae Tang) in Chiang Mai as well as on low land in Surin (Tha Tum). *E. camaldulensis* was the most promising eucalypt species on all sites. However, *E. brassiana* was the most promising tree in dry areas.

103. Studies of species trials of eucalypt at the TPC Seed Centres indicated that *E. deglupta, E. camaldulensis,* and *E. tereticornis* were the promising tree species in Uthaithani province, about 350 kms north of Bangkok (Bhumibhamon, 1985).

104. Eighteen mixed species trials of nitrogen-fixing trees were established at Chan Thuek in Nakhon Rachasima and at Pathiu in Chumporn in 1982 (Yantasath, 1984). Based on one-year-old seedling evaluation, it was found that the promising species were, in order, *Leucaena leucocephala, E. camaldulensis, L. diversifolia, Casuarina junghuhniana* while at Pathiu *E. camaldulensis* grew best, followed by *Albizia falcataria, Casuarina equisetifolia*, etc.

105. Other mixed species trials was established at the Pine Improvement Centre in Chiang Mai. Kingmuangkow (1980) reported that early evaluation showed that the most promising species were *Pinus caribaea* var. *hondurensis, Pinus oocarpa,* and *Eucalyptus camaldulensis.*

106. Granhof and Chataecha (1980) reported the species trials of 5 coniferous species established at Huay Bong,

including *Pinus kesiya, P. merkusii, P. caribaea, P. oocarpa,* and *Cupressus lusitanica.* It was found that all species increased volume production as a result of intensive cultivation. *P. caribaea* and *P. oocarpa* were the most promising species.

107. Fifty mixed species of *Eucalyptus* and *Acacia* have been established at 5 locations in Thailand, including Ratchaburi, Sai Thong in Prachuap Khiri Khan, Huai Tha in Sri Sa Ket, Sakaerat in Nakhon Ratchasima, and Khao Soidao in Chanthaburi. Pinyopusarerk and Puriyakorn (1986) reported the early results of *Acacia* sp. based on 6 m. old seedlings planted in the field. The most promising species were *A. auriculaeformis, A. leptocarpa,* and *A. crassicarpa.* There were several species having poor development at an early stage, including *A. shirleyi, A. polystachya, A. melanoxylon, A. flavescens, A. cincinnata, A. mangium,* and *A. holosericea.*

7.2 PROVENANCE TRIALS

108. The first provenance trials were the National Provenance Trials of *Tectona grandis* established in 1965 in Lampang, Thailand. The trials consisted of 30 local seed sources, the experimental design RCB with 5 replications. Each block consisted of 24 trees planted with the spacing 2x2 m. Systematic thinning was done in 1971 and 1977. Only 6 trees were left in each plot after the last thinning operation. Results showed poor juvenile-mature relationships, particularly Pitsanulok provenance which had poor development in the early stages but showed excellent growth in the 14th year (Pinyopusarerk, 1980). Sumantakul (1980) reported that more teak trials were established at the later stages but some of them were abandoned due mainly to poor tending.

109. Two and four International Teak Provenance Trials were established in 1973 and 1984 respectively. Some trials comprised 4 provenances from Thailand, 1 provenance from Indonesia and 3 provenances from India. The experimental design was RCB with 4 replications. The trials were planted with the spacing 4x4 m and the plot size of 49 trees. Sumantakul (1980) reported that the Thai and the Indian provenance were both the best and poorest ones. Kolkaz provenance from India had poor survival percentages and was susceptible to insect damage. However, Pinyopusarerk (1980) reported that in Sukhothai Kerala provenance, when established, was the best. The assessment of the International Teak Provenance Trials has been outlined by Pinyosarerk and Keiding (1981).

110. *Pinus merkusii* Provenance Trials were estabished in 1970 at Huay Bong, Chiang Mai. The experimental plot

comprised 3 blocks consisting of 14 seed sources each. The survival percentages ranged from 63% to 96%. At the age of 13 years old the best provenances were Surin and Sri Saket from the Southern part of the NE region. Changtragoon (1984) claimed that, based on long-term observations, provenance selection should be made at tne later stages of growth development, preferably at the rotation age.

111. *Pinus kesiya* Provenance Trials were established at Huay Bong, Chiang Mai. The trials comprised 7 sources from Thailand, 5 sources from the Philippines, 5 sources from Zambia, and 1 source from Malawi. The planting design was RCB with 4 replicattions. Each block consisted of 36 trees planted with the spacing 4x4 m. It was found that the most promising provenances at age 3 were Mae Rid and Doi Inthanon, Chiang Mai.

112. Two Internaional *Pinus caribaea* Provenance Trials were established at Huay Bong in Chiang Mai and The Sae in Chumporn, Granhof (1980) reported that the planting design in Chiang Mai was RCB with 5 replications. The planting design in Chumporn was Balanced lattice with 5 replications. 'In both places there were 36 trees per plot planted with the spacing 3x3 m. Results showed that trees grown in Chumporn had slightly higher survival percentages compared to the north. In both cases, however, the survival percentages were more than 80%. Though the growth of *P. caribaea* in Chumporn was higher than in Chiang Mai the form was relatively poor. This was due to the problem of foxtailing. In all cases, the most promising provenances at 4 years were Alamicamba, Poptun, and Rio CoCo.

113. Two *Pinus oocarpa* Provenance Trials were also established in both Chiang Mai and Chumporn. The planting design in Chiang Mai was 4x4 Balanced Lattice with 5 replications while 2x4 RCB with 5 replications was used in Chumporn. Each plot consisted of 36 trees planted with 3x3 m spacing. Granhof (1980) reported that *P. oocarpa* had high survival percentages at both sites (over 95%). Fast growing provenances seemed less stable in form than slower ones and stem form seemed considerably poorer in the south than in the north. In general, the most promising provenances were Camelias, Rafael, Dola Hill, and Mountain Pine Ridge.

114. Several provenance trials of *Eucalyptus camaldulensis* have also been established. Powsujja and Saardavut (1984) reported that RFD had established provenance trials at 4 sites, including 2 sites in Chiang Mai (Mae Sanaam, Mae Taeng), Tak and Surin. All sites differed remarkably in elevation. Poor survival percentages were found in Surin. Results also showed that Petford, Mary River and

Gibb River provenances performed best at high elevation while Catheline, Gibb River, Erwin River and Cununerra adapted well in dry lowland areas.

115. Kasetsart University established provenance trials of *Eucalyptus camaldulensis* in Uthaithani in 1982, comprising 16 provenances. The design used was CRB with 4 replicattions. Each plot consisted of 25 trees planted with 4x4 m spacing. Results showed that the best provenances mostly originated from north Australia, including Petford, Gilbert River, Gibb River, and Catheline. Based on this result, restricted northern Australian provenance trials comprising 16 provenances were additionally established in Lad Krating Plantation, Chachoengsao, in 1985. Genetic variability in certain morphological characteristics was again observed.

116. *Gmelina arborea* has been one of the most promising tree species in the last decade. For this reason, Provenance Trials have been established in Kanchanaburi comprising 31 provenances, including provenances from Thailand, India, and Sri Lanka. Kanchanaburangura (1979) reported large variation in germination and survival percentages. The present situation shows poor survival percentages in most cases, due to heavy insect damage in the study area.

CHAPTER 8

RESEARCH PRIORITIES IN MULTIPURPOSE TREES

8.1 SPECIES PRIORITIES

117. As the number of trees selected for planting in Thailand is relatively high, the need to limit the number is geuinely required so that an intensive research and development program can be undertaken. A study, by interview, of the tree species chosen for research purpose by 81 foresters and related scientists directly or indirectly responsible for tree planting has been carried out (Table 22). A list of the top ten chosen trees was drawn up, with *Eucalyptus camaldulensis* coming out as the most popular tree species. Other exotic trees which received high popularity for research were *Acacia auriculaeformis, Leucaena leucocephala* and *Acacia mangium*. Among native trees, *Tectona grandis* received the most interest while *Melia azedarach* and *Azadirachta indica* came second and third respectively. It is necessary to note here that for the forecast for the next five years *Azadirachta indica* and *Melia azedarach* still remain in the main tree-priority lists.

118. In 1983, FAO and ESCAP organized a Regional Workshop on Wood-Energy Development in Bangkok. There were nine countries in the region including Thailand which participated in this Workshop. The list of priority fuelwood species suggested in the meeting is shown in Table 23. However, the scoring system for fuelwood species in Thailand as discussed in this meeting did not represent the actual situation of the country. It was found in this meeting that scientists from South Asia and South East Asia have different choices of priority species.

119. A meeting on an AID Forestry Fuelwood Research and Development Program in early 1984 in Bangkok listed the priority species for fuelwood and charcoal which might have been of interest to member countries in the Asia and Pacific Region. Thailand proposed Casuarina, *Eucalyptus* sp., *Acacia auriculaeformis, A. mangium, Leucaena leucocephala* and *Melia azedarach* as the priority species (USAID, 1984).

120. The Asian Regional Workshop on "Increasing the Productivity of Multipurpose Tree Species" held in Kandy in 1984, recommended a list of priority species for Moist/wet, Arid/Semi Arid, and Mountainous Zones. In the Moist/Wet Zone, a long list of trees recommended was presented and only 14 species were kept on the priority list while only 12 and 9 species were listed for Arid/Semi Arid and Mountainous Zones

Table 22. The most common trees selected for research at the present and in the next five years as outlined by 81 persons, by rank.

Species	Ranking	
	At present	In the next 5 years
Eucalyptus camaldulensis	48	37
Tectona grandis	32	20
Acacia auriculaeformis	32	24
Leucaena leucocephala	27	10
Melia azedarach	27	20
Pinus kesiya	18	18
Azadirachta indica	15	22
Bamboo	14	13
Dipterocarpus alatus	14	16
Acacia mangium	13	29

Table 23. Proposed species in FAO/ESCAP Workshop on Wood-Energy Development in 1983, based on 9 countries representatives.

Species	Countries interested
Acacia auriculaeformis	8
A. mangium	7
A. modesta	5
A. nilotica	5
A. senegal	5
A. tontilis	4
Albizia spp.	7
Azadirachta indica	6
Calliandra calothyrsus	5
Cassia siamea	4
Casuarina equisetifolia	7
Combretum quadrangulare	1
Eucalyptus spp.	9
Glyricidia sepium	5
Leucaena leucocephala	9
Mangrove species	7
Melia azedarach	6
Moringa spp.	3
Pithecelobium dulce	5
Populus spp.	6
Prosopis spp.	4
Robinia pseudoacacia	6
Salix spp.	7
Sesbania spp.	6
Tectona grandis	6
Zizyphus spp.	6

respectively. In this IUFRO Planning Workshop, a Multipurpose Tree Species Network in Asia and the Pacific was proposed (Table 24), with member countries in the region being able to participate in any network of need to their countries.

121. Based on returned questionnaires, Regional Forest Offices in Thailand showed different levels of interest in proposed multipurpose trees. Species of high interest for the RFOs were *Eucalyptus camaldulensis*, followed by *Azadirachta indica*, *Acacia mangium*, Bamboo, *Leucaena leucocephala*, *Melia azedarach*, *Acacia auriculaeformis*, rattan, etc. (Table 25).

122. Ten species Networks were proposed in the Kandy meeting in 1984. As reviewed by 81 Thai scientists, 6 species Research Networks were recommended: the *Acacia* species Network received highest priority, followed by the *Eucalyptus* Species Network, *Azadirachta* and *Melia* Species Network, Bamboo Species Network, *Albizia* and *Leucaena* Species Network, and Rattan Species Network.

8.2 RESEARCH PRIORITIES

123. Forestry research needs in developing countries have been pointed out by the World Bank and FAO (1981). The research priorities as shown in Table 26 indicate 4 main areas, including forestry in relation to agriculture and rural development, forestry in relation to energy production and use, management and conservation of existing resources (mainly natural forest) and industrial forestry. Callaham and Buckman (1981) listed the key areas needed for future research programs with more emphasis on lesser-known species, critical forest types, reforestation in left over areas, growth and yield of natural forest and fast-growing trees, logging and utilization of wood waste during processing, etc.

124. Brunig (1982) outlined the viewpoints of the Directors responsible for forestry research in Asia. Directors in the South East Asian countries were interested in silvicultural research in natural forests, hydrology and management, effects of clear-cutting, agro-forestry systems; utilization of lesser-known species, utilization of small timber, afforestation in degraded sites, and fuelwood plantations. Table 27 shows the priority list for regional cooperative activities. Lundgren (1986) reported the priority ranking for fuelwood plantations as recommended in an FAO and ESCAP joint workshop held in Bangkok in 1983. The dissemination of information among institutions is greatly needed. This of course encourages the need for an Information Centre for fuelwood species.

Table 24. The proposed species networks in Asia and the Pacific recommended in the Kandy Meeting, After Shea & Carlson, 1984.

Proposed species networks								
(1) Network species	(2) Leader	(3) Coleader(s)	(4) Participating countries	(5) Lead institution	(6) Participating institutions	(7) Participating institutional agencies	(8) Most likely source of external funding	(9) Aid for supporting regional network activities
1. Acacia sp. (a) A. nilotica (b) A. auriculiformis (c) A. senegal (d) A. tortilis (e) A. mangium	India	Malaysia	Indonesia (e+b) Thailand (e+b) Philippines (e+b) Taiwan (b+e) Bangladesh (a+b+e) PNG (b+e) Nepal (b) Sri Lanka (s+e) Pakistan (a+e+d) China (b+e)	3 7	1,2,4,6 8,9,10 11,12,13 14,16,18,19 20,21	UNDP ODA ICRAF CSIRO GTZ E-W Center FAO	GTZ IDRC USAID UNDP ODA (India) IBRO World Bank	USAID
2. Bamboo	Bangladesh	China (utilization) Thailand (Harvesting & Seed)	All countries	1,2,21	All except 5 & 13	IDRC ODA FAO	IDRC ODA	IDRC USAID

Table 24. (Cont'd)

Proposed species networks								
(1) Network species	(2) Leader	(3) Coleader(s)	(4) Participating countries	(5) Lead institution	(6) Participating institutions	(7) Participating institutional agencies	(8) Most likely source of external funding	(9) Aid for supporting regional network activities
3. (a) Albizia & (b) Leucaena	Philippines	Taiwan	Leucaena All countries U. of Hawaii India Bangladesh Nepal Malaysia China Taiwan Pakistan PNG Sri Lanka	15(a) 14(b) 19(b)	Leucaena All except 17,8,9,10 1,2,3, 7,8,10 11,12,13, 16,18	ODA (CFI) GTZ ICRAF East West Center FAO	GTZ (Malaysia) USAID World Bank	USAID
4. Eucalyptus spp.	India E. camaldulensis E. microtheca	Indonesia E. deglupta E. urophylla	All countries	3 6. 12	All	UNDP USAID ODA FAO	World Bank	

Table 24. (Cont'd)

Proposed species networks								
(1) Network species	(2) Leader	(3) Coleader(s)	(4) Participating countries	(5) Lead institution	(6) Participating institutions	(7) Participating institutional agencies	(8) Most likely source of external funding	(9) Aid for supperting regional network activities
5. (a) Dalbergia sissoo (b) Morus alba (c) Populus spp.	Pakistan		Bangladesh (a) Nepal India Indonesia (b) China (c) Sri Lanka (b)	12	1,2,3,6 18,22	GTZ FAO ODA	GTZ (China) USAID	USAID World Bank
6. Azadirachta (Melia) spp.	Thailand		India Bangladesh Nepal Pakistan Philippines Malaysia & Taiwan Sri Lanka Indonesia	23	1,3,6,7, 8,11,12,14,15 18,19,20	IDRC FAO ODA (Nepal)	IDRC World Bank	IDRC USAID

Table 24. (Cont'd)

Proposed species networks								
(1) Network species	(2) Leader	(3) Colleader(s)	(4) Participating countries	(5) Lead institution	(6) Participating institutions	(7) Participating institutional agencies	(8) Most likely source of external funding	(9) Aid for supporting regional network activities
7. Rattan	Malaysia	Philippines	Indonesia Thailand Bangladesh India Taiwan PNG Sri Lanka China Pakistan	7 14-Co.	1,2,3,4 5,6,8,9 10,12,13 15,17,18 19,20,21	IDRC FAO	IDRC World Bank	IDRC USAID
8. Prosopis cineraria	India		Pakistan	3	2,12,22	UNDP USAID ODA ICRAF FAO	IDRC World Bank	USAID
9. Salix spp. and Robinia pseudacacia	India		Nepal China Pakistan	3	2,11,12,22	GTZ	GTZ (China) World Bank	USAID

Table 24. (Cont'd)

Proposed species networks								
(1) Network species	(2) Leader	(3) Coleader(s)	(4) Participating countries	(5) Lead institution	(6) Participating institutions	(7) Participating institutional Agencies	(8) Most likely source of external funding	(9) Aid for supperting regional network activities
10. (a) Alnus nepalensis (b) Grewia oppositifolia	Nepal		Pakistan China India Philippines(a)	11	2,3,12,14, 16,22,	GTZ FAO ICRAF ODA (Nepal)	GTZ (Pakistan) World Bank ODA (Nepal)	USAID

Table 25. Priority list of the interest in Multipurpose Tree Research Networks shown by 21 Regional Forest Offices in Thailand.

Priority	Species	Level of interest (%)				
		Lowest	Low	Medium	High	Highest
1	*Acacia auriculaeformis*	5.2	26.3	42.1	21.0	-
2	*A. mangium*	15.7	10.5	31.5	21.0	21.0
3	*Albizia Spp.*	68.4	15.7	15.7	-	-
4	*Azadirachta indica*	10.5	10.5	31.5	42.1	5.1
5	Bamboo	42.1	10.5	15.7	26.3	5.2
6	*Eucalyptus spp.*	-	5.2	5.2	57.8	31.5
7	*Leucaena leucocephala*	-	31.5	31.5	21.0	5.2
8	*Melia azedarach*	26.0	21.0	31.5	15.7	15.7
9	Rattan	47.3	26.3	15.7	15.7	-
10	*Salix* sp.	73.6	10.5	15.7	-	-

Table 26. List of research priorities in developing countries proposed by the World Bank and FAO (1981).

Key Area I Forest in relation to agriculture and rural development

(A) Sociological and institutional research

1. Knowledge of the natural environment by forest societies.

2. Data on the infrastructure of human societies in the forests.

3. Determination of the perceived role of trees and forests in rural welfare.

4. Origin and solution of conflicts for land.

5. Determination of adaptability and response to innovative systems.

6. Definition and testing of incentives to incorporate trees.

7. Guidelines for project preparation.

8. Extension methods.

9. Institutional aspects.

10. Economic returns from alternative farming systems incorporating trees.

(B) Farming systems using trees

1. Effects and systems of intercropping, including animals;identification of potential agro-forest combinations.

2. Mycorrhizal and other microbiological relations

3. Mulching effects on soil chemistry and structure.

4. Impact on soil fertility of burning manure and crop residues.

Table 26. (Cont'd)

5. Ground preparation (especially arid and degraded sites).

6. Soil nutrients (especially nitrogen and phosphorus, salinity).

7. Moisture relations.

8. Irrigation.

9. Sand dune stabilization.

10. Shelterbelts.

11. Choice of species and provenance.

12. Seed collection, storage, testing, zonation, certification.

13. Silvicultural treatment (coppicing,pollarding).

14. Vegetative propagation.

15. Potential of tree breeding.

(C) Watersheds (catchments) and range management

1. Farming systems appropriate for upland areas.

2. Alternati[illegible] for fodder production on and off farms.

3. Improvement of alpine pasture lands.

4. Impact of land use on water yield,quality and timing.

5. Impact on stream flow patterns of shifting cultivation.

6. Cost and effectiveness of watershed management.

7. Determination of run-off rates and sediment yield.

8. Carrying capacity and grazing control to minimize range production.

Table 26. (Cont'd)

9. Least cost approaches to range improvement.

10. Improvement of savannah range lands.

11. Improvement of arid zone range lands.

(D) Wildlife in relation to rural welfare

1. Ecological monitoring of animal habitats.

2. Animal population dynamics.

3. Socioeconomic aspects of the place of animal products in rural life.

Key area II Forestry in relation to energy production and use

(A) Silviculture of biomass/fuelwood species and systems

1. Choice of species and provenance.

2. Tree breeding.

3. Seed research.

4. Vegetative propagation,tissue culture,cell genetics.

5. Ground preparation methods.

6. Silvicultural methods.

7. Pests and diseases.

8. Fire control systems.

9. Effect of repeated cropping on soil.

(B) Yield, harvesting and properties

1. Yield assessment.

2. Harvesting and transport methods.

3. Density and calorific value.

Table 26. (Cont'd)

4. Chemical content.

(C) Industrial research related to village technology

1. Improved stove and crematorium design.

2. Improved fuelwood and charcoal preparation methods.

3. Small-scale crop processors, generators,wood preservation.

4. Use of residues.

(D) Comparison with alternative fuels (social,technical and economic efficiency)

(E) Wood-based derivatives

1. Pyrolysis.

2. Gasification.

3. Pelletization.

4. Methanol,ethanol and liquid fuel technology.

Key area III Management and conservation of existing resources (mainly natural forests)

(A) Resource survey

1. Land-use planning methods.

2. Soil and land use survey and evaluation.

3. Land mapping according to the ecological potential to sustain population.

4. Monitoring changes of forest area.

5. Inventories of accessible natural forest.

Table 26. (Cont'd)

(B) Conservation

1. Methods to identify and quantify unique biotic associations.

2. Methods to conserve genetic resources and ecosystems.

3. Monitoring changes within ecosystems and species.

4. Policy and legal aspects of conservation.

5. Underlying ecological and biological processes.

(C) Silvicultural systems for natural forests

1. Biological limitations to the transformation of tropical forest ecosystems.

2. Impact of different types of utilization.

3. Natural regeneration.

4. Artificial enrichment.

(D) Whole tree use

1. Harvesting.

2. Utilization.

3. Effects on site.

(E) Use and marketing of secondary species

1. Inventory.

2. Properties.

3. Information and market intelligence.

(F) Wood preservation

Table 26. (Cont'd)

Key area IV Industrial forestry

(A) Silviculture and management

1. Choice of species and provenance.
2. Seed collection, storage, testing, zonation, certification.
3. Vegetative propagation, tissue culture,cell genetics.
4. Tree breeding.
5. Ground preparation.
6. Spacing,weeding,thinning,pruning.
7. Fertilization and soil nutrients.
8. Mycorrhizal and microbial relations.
9. Intergrated pest management.
10. Fire control systems.

(B) Wood properties

1. Anatomical.
2. Chemical.
3. Physical/mechanical.
4. Pulp, paper, boards.
5. Composites.

Table 27. Priority list of research activities identified by experts in Asia (cf Lundgren, 1986).

Priorities	Description of activity
1	- Promote transfer of research results and experiences between research institutions.
	- Assist the establishment of demonstration plots for species testing; provenances; planting densities; species mixtures; agro-silvo-pastural combinations; nitrogen-fixing trees.
2	- Support genetic research with tree breeding, vegetative propagation, and tree improvement.
3	- Strengthen national seed centers, seed collection and storage, seed treatment procedures.
	- Conduct comprehensive survey of extension experience in relation to wood energy development.
4	- Formulate guidelines for preparing national strategies for wood energy development.
	- Assist in introducing procedures for monitoring and evaluating community forestry projects.
	- Assist in introducing conservation oriented curricula in school.
5	- Evolve procedures for assessment of fuelwood supply of village woodlots, homesteads, plantations, strips, and line plantings.
	- Exchange seeds between countries within the region and procure seeds from outside the region.
	- Modernize and upgrade nursery and plantation methods (high density planting, irrigation, fertilization, pest control).
	- Collect seeds of species suitable for fuelwood plantations; evaluate genetic variability.
	- Document agro-silvi-pastoral experiences with reference to their economic sustainability.

Table 27. (Cont'd)

Priorities	Description of Activity
6	- Promote local level organizations to participate in the management and utilization of forest resources in a sustainable way.
	- Conduct a comprehensive survey of fuelwood species with respect to agroclimatic zones, silviculture, management, and growth and yield.
	- Assist in the establishment of seed orchards and seed supply areas.
	- Assist in developing extension techniques for wood energy, including stove improvement.
	- Implement programs to introduce improved wood burning stoves.
	- Carry out surveys of supply/demand and socio-economic surveys relating to wood energy and the role of women and children.
7	- Modify existing silviculture and management practices with reference to fuelwood production.
	- Assist in introducing community forestry oriented curricula in forestry training and education institutions.
	- Improve charcoal manufacturing techniques.
8	- Prepare national and local level plans for increasing fuelwood supplies.
	- Strengthen institutional capability to identify sustainable agro-forestry farming systems.
	- Prepare case studies on economics of agro-forestry programs and the comparative advantage of agro-forestry versus agriculture in different land-use patterns.
	- Prepare a study of financial incentives and technical assistance being provided in the region to promote tree planting.

Table 27. (Cont'd)

Priorities	Description of Activity
	- Improve pre-processing of fuel drying and intensification.
9	- Assist the introduction of microcomputers at field stations for research and community forestry projects.
10	- Develop appropriate methods for harvesting and transport of plantation material.
	- Assist in introducing measures to provide access to fuelwood by rural poor through legal measures and systems of distribution, storage, and pricing mechanisms.

125. Research topics recommended to be given high priority in this meeting were in order: species trials, nursery techniques, provenance trials, genetics, spacing trials, reclamation of wastelands, establishment techniques, grazing/fodder, shelterbelts, nitrogen-fixing trees, biomass productivity, etc.

126. In the IUFRO Kandy Meeting, Burley and Stewart (1985) outlined the status of research programs while Shea and Carlson (1984) summarized the possible research activities. These research topics were ranked in order from highest to lowest priority, including silvicultural and management research, genetic improvement of MPTS, choice of species, designing agro-forestry systems, cost-effective techniques for nursery-stock production, use of nitrogen-fixing organisms with MPTS, cost effective techniques for tree establishment and maintenance, pest management systems, and utilization studies. When analyzing the frequency of the five most important activities by zones, it was found that areas of research needed in the Moist and Wet Zone were, in order: tree breeding; spacing, thinning and rotation; foliage manipulation; tree species mixtures; vegetative propagation; improved nursery-stock production etc.

127. In the present study, a survey of research work was done by interviewing 81 forest scientists about major on-going research and research in the next five years (Table 28). Under the present situation, most Thai forest scientists indicated their satisfaction with the on-going research activities. Only 20 of them claimed that the research conducted at the present was unsatisfactory. When discussing the existing problems, the majority of forest scientists stressed that forest research policy was inconsistent and undirected so that most research programs differed remarkably and moreover, that it was difficult to turn the results into practical applications. Forest scientists acknowledged that they have been active in the programs but claimed that support from official organizations was relatively low. Forest scientists lacked sufficient research funds and capable teams to tackle the problems. Additionally, they have little contact with related organizations and thus the dissemination of information is often prevented. Also the majority of them considered it necessary to improve the scientific atmosphere in forestry research organizations.

Table 28. The most common trees selected for research at the present and in the next five years as outlined by 81 persons, by rank.

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Pinus kesiya	18	18
Azadirachta indica	15	22
Bamboo	14	13
Dipterocarpus alatus	14	16
Acacia mangium	13	29

CHAPTER 9

FOREIGN AID FOR RESEARCH AND TRAINING PROGRAMS

128. Thailand has received considerable help from various organizations and international agencies. Foreign aid programs on tree planting and related aspects have been given in the form of mutual bilateral cooperation or regional cooperation. Often, the foreign aid comes in the form of an international program.

9.1 BILATERAL COOPERATION

129. DANIDA has given technical assistance and supported manpower development in certain key areas, including seed procurement, seed technology, tree improvement, silvicultural practices, nursery techniques, seedling production, and vegetative propagation. DANIDA has also supported two excellent projects, namely the Teak Improvement Centre and Pine Improvement Centre which were established in 1962 and 1968 respectively. Nursery techniques have been developed from applicable traditional technology from Denmark, with special emphasis on raising pine and eucalypt seedlings. The application of these techniques are however limited. Programs on manpower development, exploration, provenance trials, seed orchard establishment, gene conservation, controlled pollination and some vegetative propagation were well operated and were of great benefit to the needs of the country.

130. SIDA has played some role in giving technical assistance to the industrial wood sector. Social forestry programs, particularly the role of social forestry curriculum development and women's participation in forestry work have been emphasized. This organization also paid attention to fuelwood plantations and modern nursery techniques. Moreover, IFS in Sweden provided small research grants to young qualified researchers.

131. FINNIDA has emphasized the support of forestry programs and recently has given assistance to FIO and the King's Project in Ban Wat Chan, Chiang Mai. A nursery has been established in the Mae Cham Project with the aim of producing 1.5-2.5 million seedlings a year. The technology transfered was for propagating pine and other selected fast-growing trees. FINNIDA has also provided Thailand with a program on man-power development in various fields of forestry and more recently has actively worked on conventional training for forest technicians.

132. JICA has long provided assistance to Thailand in man-power development, terrestrial and mangrove forest ecology, and logging, and in 1983 set up a bilateral program in Nakorn Ratchasima on training needed for the reforestation program. The main aim of this program is to apply mechanization in plantation practices. JICA has supported the R & D program of the RFD, providing equipment and experts to promote better research results and has also supported the project on shifting cultivation in the Northeast as well as planting trees in problem soils in the South.

133. USAID has provided long term assistance to Thailand in the form of bilateral cooperation. During 36 years of establishing mutual assistance to Thailand, much effort has been expended in the fields of agriculture, education, medicine, rural development and infrastructure improvement. Only small programs on forestry have been given to Thailand in this time. One of the main projects was the role of renewable resources, in which primary farm woodlots were established in areas where fuelwood was in short supply. A program on the development of charcoal kilns was also activated during 1981-1984. In this fuelwood project, simple nursery techniques were introduced and about one million seedlings were raised and planted in the form of fuelwood plantations in 8 provinces in the north-eastern part of Thailand. The mixed-cropping system was generally used. Early evaluation of the existing fuelwood plantations reflected the need for an intensive tree-breeding program. The termination of the project, however, prevented proper silvicultural treatment of planted trees and limited the dissemination of information to the people interested. One of the best parts of most USAID programs was that USAID paid high attention to manpower development and thus the participants could strengthen their capability in developing forest resources afterwards.

134. The National Academy of Sciences in collaboration with the University of Hawaii, has been active in promoting planting of nitrogen-fixing trees, under the responsibility of TISTR. This project was established in 1982. Small nurseries were established on 3 sites, namely Chumphon, Nakhon Ratchasima, and Narathiwat. In the new additional proposal, tree improvement is taken into consideration.

9.2 REGIONAL COOPERATION

135. ACFTSC has been active in seed collection, seed procurement, seed certification and vegetative propagation since 1983. The Centre has been collecting all the necessary scientific equipment for seed testing. Man-power development has been carried out in an active way along with the update of laboratories. Under the present situation (1986), there is

expected to be an extension of the second phase. This project is considered to be one of the best of its kind in the region. Young scientists from the ASEAN contries have a great chance to work together, sharing information and experiences.

136. ASEAN/New Zealand Reforestation Project established in 1979 in the Philippines is aimed at researching and operating nursery work and plantation establishment. Young forest scientists often attend the training program or workshops organized by this project. Work has been done on tropical pines, *Gmelina*, and some eucalypts.

137. ASEAN/Australian Forest Tree Improvement Program was planned in 1985 and became effective in 1986. Nine programs were proposed for action, including breeding Acacias, Eucalypts, teak, *Gmelina*, and *Abbizia*, reproductive biology, seed production, species and provenance trials, and conservation of indigenous forest genetic resources. This program is still inactive but could provide the opportunity for scientists who work in the same key area to join hands and work together if operated.

138. ADB with the government of Switzerland established the Regional Community Forestry Centre (RECOFT) at Kasetsart University. This project is aimed at man-power training in subjects related to community forestry. Parctical training is one part of the program, to provide experience to persons in charge of the program.

139. The Forestry/Fuelwood Research and Development Project (F/FRED) based at Kasetsart University since 1986 is a global project aiming at research planning and development, network development research, and global research support. The program was planned to emphasize multipurpose trees with the choice of tree species based on the list prepared by MacDicken et al. (1985), information management systems, small grants program, and network activities. A program on land and forest management to support the MPTS program was also planned. The duration of the project for the first phase is 5 years. However, it is too early to report on the advance of the project.

9.3 INTERNATIONAL COOPERATION

140. FAO has played an important role in global forestry development in all aspects. A fuelwood program, community development and minor forest products are among the excellent programs operated by this organization. A tree-planting campaign has been actively carried out. Recently, FAO has provided assistance in forestry education with special emphasis on social forestry curriculum development.

141. IDRC has played an excellent role in some multipurpose tree programs like bamboo and rattan. Innovative biological technologies have been promoted in connection with man-power development. IDRC also provides chances for capable young scientists to conduct research for the needs of the country and the region.

142. UNDP in collaboration with FAO have undertaken the Development of Diversified Forest Rehabilitation Project in Northeast Thailand. Nursery techniques have been developed in their main nurseries to produce multipurpose tree seedlings for tree farming, woodlots and shelterbelt establishment. About 3 million seedlings were raised during 1981-1985 and about 1,000 families participated in the project.

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