

A PLAN FOR IMPROVING FOREST FIRE MANAGEMENT
IN THAILAND

by

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ABSTRACT

The values of Thailand's forests probably are higher than those of its other natural resources. Forests are not only valuable for timber but also for recreation, wildlife, and watershed.

Wildfires are considered a very important forest problem in some tropical countries, especially India, Burma, The Philippines, Indonesia, Australia, Brazil, Venezuela, Colombia and Honduras. A number of attempts have been made to reduce the occurrence and to control forest fires, but many have not been successful, primarily because of the lack of funds to do a proper job.

The majority of forest fires in Thailand are man-caused, resulting primarily from camping, debris burning, shifting cultivation, hunting, highway travel, and incendiarism. These wildfires can be classified (based on characteristics, damages, and control techniques) into three major types: plantation, natural forest, and grassland.

Up to the present, because of lack of funds and expertise, an effective forest fire control organization has not been developed in Thailand, despite the many senior Thai foresters and experts from many agencies of the world who have made a large number of worthwhile recommendations.

If fire control is to be developed fully in Thailand an appropriate organizational structure with defined work hours, manpower, centralization and administration tasks will have to be adopted. All of

these factors should be carefully considered and implemented in both district and general fire plans.

Presuppression is the largest and most involved element of most forest fire organizations. Many important factors must be taken into account. An effective and economical detection system, good communication and better equipment, which must be suitable for fighting fire in heavy forest fuels and for use by unskilled men, are required.

Fire prevention should be very important in Thailand, because most wildfires are man-caused and preventable. Great stress should be laid on advertising in a fire prevention campaign.

There are three suppression methods which can be used in the present situation of forest fire control in Thailand. These methods are: clearing a fireline, backfiring, or application of water, sand or light soils. Often a combination of all three methods is preferable.

Law enforcement would be the most important tool for establishment of a forest fire control operation in Thailand. The objective of law enforcement should be to increase cooperation from the general public by educating and warning.

Prescribed burning seems to be really needed both in plantation programs and in natural forest management plans in Thailand. The objectives of fire application would be: stand improvement, site preparation for seeding and planting, improvement of wildlife habitat, improvement of cutting methods, improvement of accessibility, control of insects and diseases, and use in land clearing.

Research initially should provide the scientific foundation for fire management through local studies and the adaptation of work from other areas in ignition, combustion, fuel characteristics, fire danger measurement, fire prevention, fire ecology, fire use, fire suppression techniques, and fire control planning.

Fire control improvement is very expensive, but many factors suggest that it is badly needed in Thailand. It is impossible for Thailand to protect all of its forest area from fire immediately. A good start should be made soon and constantly expanded as finances allow.

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1. INTRODUCTION

The Kingdom of Thailand, centrally situated in Southeast Asia, is bordered by Burma, Laos, Cambodia and Malaysia. It lies between 5 and 21 degrees north latitude, and between 97 and 106 degrees east longitude. It includes an area of about 200,000 square miles and has a population of over 36 million. The country is made up of four main regions: namely, the Central Plain, the Northeast Plateau, the Northern Region, and a narrow strip of land in the south facing the Gulf of Thailand to the east and the Indian Ocean to the west.

Thailand has large forest resources of hardwood, rubberwood, and bamboo, but only relatively small stands of pine. More than 51% of the total land area is covered with forest of various types. It may be classified, according to Champion (1962) into the following major types: the Evergreen (30%) and the Mixed Deciduous (70%). The evergreen type is subdivided into Hill-Evergreen, Tropical-Evergreen, Conifers, and Mangrove. The Mixed Deciduous type is subdivided into Mixed Deciduous and Dry Dipterocarps types (Appendix A).

Politically, Thailand is a constitutional monarchy. The Forestry Department, under the direction of the Ministry of Agriculture, is responsible for applying sound conservation and utilization practices to the natural resources of National Forests. All the forest of Thailand is the property of the state, the policy of the government having always been to manage its forest for the benefit and welfare of the general public. The sustained supply of forest products for local consumption and export trade, and the maintenance of forest cover for the protection of the

watershed are the main objectives of forestry in Thailand.

There has been a long history in Thailand of using fire indiscriminately in the forest. The Forestry Department has recognized that forest fires have been seriously damaging the forest of the country for many years. But the task of establishing and organizing for forest fire control is formidable, because funds are not available to undertake the initial work. Therefore, the Thai Forestry Department requested a grant from the Canadian International Development Agency (CIDA). Under the Colombo Plan, arrangements were made between the CIDA and the Government of Thailand for me to train and study in forest fire management in Canada. The training programs were provided for practice and discussions with many forest fire officers both at the headquarters in Toronto and at many field offices throughout Ontario, for approximately seven months, from February to September, 1972. Other opportunities were provided for graduate studies at U.B.C., leading to a Masters degree in forestry. All of my experiences will be applied in preparing the plan and in starting a forest fire control organization for Thailand in 1974.

The purpose of this thesis is to study forest fire control organization and the use of fire in Canada and to try to apply the principles to the situation in Thailand. The thesis will furnish a general statement of principles for fire management in Thailand. It is always difficult to introduce well developed systems from one area to other places that have a very different nature, but nevertheless some methods based on Canadian experience can be applied to improve fire management in Thailand. These measures are mainly the establishment of fire prevention, detection, and suppression systems, and the development of methods of fire application.

A major difficulty has resulted from the very limited data available and general lack of records of past fire control activities and fire occurrences in Thailand. Fortunately, some senior Thai foresters, as well as experts from several foreign agencies, have made a large number of recommendations for overcoming the fire problems in Thailand. These recommendations are good basic guides for studying how to develop proper plans for Thailand.

Throughout the preparation of this thesis, I had opportunities to work, discuss, and study in many situations:

1. Working as a counterpart for seven months with Mr. J.C. Macleod, the expert on forest fires from CIDA, in preparing the basic recommendations to the Thai government relating to the protection against fire for the forests of Thailand.
2. Training in forest fire suppression as a suppression crew member, crew boss, and fire supervisor in Ontario (Fire Suppression Course II) for seven months.
3. Studying at U.B.C. provided an excellent opportunity for learning from many experienced professors, not only about the problems relating to forest fire organization, but also a great deal about forest fire economics, ecology, policy and law. Directed studies on these topics provided the background for this thesis.
4. Discussing with many forest fire officers on field trips throughout Western Canada provided good opportunities to study both the forest fire problems and the views of officers at nearly all levels concerned with protecting forests from fire. It was particularly fortunate that the trip to the Northwest Territories, Yukon, Alberta and British Columbia was made during the fire season in 1973.

5. Collecting information from tropical countries provided some very good examples. Information about forest fire organization, forest fire law and legislation was collected from fourteen southern states of the U.S.A. and twelve tropical countries around the world. Many ideas and methods from other regions can be applied to improve the situation in Thailand.

This study reviews the nature of forest fires and their effects on vegetation, and considers ways to improve forest fire management in Thailand. It consists of five parts:

- 1) a review of the literature about the forest fire situation in Thailand and the status of forest fire management in other tropical countries with related conditions;
- 2) analysis of methods for forest fire program improvement;
- 3) description of methods and objectives for fire application;
- 4) proposals for research studies in ecology, prevention, and suppression techniques; and
- 5) estimation of the costs of fire control organization in order to compare these with potential benefits and to explain the reasons why forest fire control is needed in Thailand.

Because so little is known about fire management in Thailand and similar countries, it has been necessary to rely heavily on North American experience. Some of the suggestions made herein may have to be modified as operational experience is gained in Thailand and results of fire research become available there.

2. LITERATURE REVIEW

2.1 Introduction

A major difficulty in improving forest fire management in Thailand is the very limited data and lack of written records available on fire causes and results of past fire control activities. Fortunately, some senior Thai foresters and experts from many agencies on the world have made studies and have realized that some action must be taken soon to control forest fires. This chapter is an attempt to review the status of forest fire in Thailand and to compare it with similar tropical countries.

2.2 The Forest Fire Situation in Thailand

2.2.1 The Values of Forests

The forests of Thailand constitute an important and valuable resource. They supply raw material to saw-mills and other timber based industries and they yield many minor forest products that contribute to local small industries. Wood using industries include 500 saw-mills, four pulp and paper plants, two plywood and veneer plants, four chipboard plants, two fibreboard plants, and about 500 woodworking plants (National progress report on forests, 1971). A big pulp and newsprint mill using local long-fibred species was to be established in 1973 by the Thai Newsprint Company.

Teak (Tectona grandis) lumber and timber from the forests of Thailand have for many years been an important export product recognized for its excellent quality throughout the world. Other species also produce many other valuable woods including Yang (Dipterocarpus alatus), Rosewood (Dalbergia cochichinensis), Ebony (Diospyros mollis) and Pine (P. Khasya

and P. Merkusii) to name only a few. There has always been an abundance of wood and other forest products for local use and a surplus for export. Total value of wood and forest products was about \$456.5 million in 1971. Direct revenue to the government from stumpage and fees was about \$61.5 million (National progress report on forests, 1971, Table 1). To the end of 1970, the area planted amounts to 117,200 acres of which 57% was teak. There was about 5,200 acres of pine plantation, and the pine plantation program of the Thai Newsprint Company started in 1973 with about 3,200 acres a year.

Timber values are high, but possibly even higher in the long run are the watershed, soil and site values. Most low-land farmers, who produce the bulk of the crops in this largely agricultural economy, are entirely dependent on naturally controlled water run-off, as only a small percentage of the farmers have artificial irrigation. Large hydroelectric developments also depend heavily on wooded watersheds. Macleod (1971) noted that:

"Forest in northern Thailand is the important mountain and watershed area for the Chao Phya River and its tributaries on which many irrigation and hydroelectric schemes depend; ...even if the dams originally had the capacity to hold sufficient water for operation, during the dry season, the silt and other products of erosion caused by fire will reduce that capacity in a very few years."

Rindt (1969) reported similarly that:

"Forested mountains constitute a watershed which absorbs water during the rainy season and meters it out during the dry months much as melting snowpacks serve that purpose in the more northerly climates."

Also the forests of Thailand are becoming more and more in demand for public recreation. National parks and recreational areas were encouraged by the National Development forestry programs, and these,

TABLE 1

Production of timber and other forest products of Thailand.
(Based on the National progress report on forestry for 1971.)

Item	Products (m ³) ³	Value (Baht) ² Per m ³	Total Value (1000 Baht)	Royalty Per Unit (Baht) ⁴ (Approx)	Total Direct Revenue (Baht)
Teak	263,514	4,700	1,218,516	150 -	39,527,100
Other species	2,312,388	3,200	7,399,542	20 -	46,247,760
Charcoal	1,681,197	150	252,179	12 -	20,174,264
Fuel Wood	450,787	75	33,809	8 -	3,606,296
Rattan	569,296	100	56,993	10 -	5,699,260
Dama & Gum	(D.C.L.) ² 220,332	(D.C.L.) 150	33,050	10 -	2,203,320
Yang oil	(D.C.L.) 654,688	(D.C.L.) 180	117,884	10 -	6,546,880
Bamboo	1,996,620	10	19,966	--	--
TOTAL	--	--	9,131,899	--	123,004,880

Note

- 1) \$1 (Canadian) is about 20 baht.
- 2) D.C.L. is Decalitre.
- 3) m³ is cubic metre.
- 4) The Royalty depends on species and quality of production.

according to Krit (1966), can be classified as follows:

a) National Parks: The Royal Thai Forest Department, in co-operation with the Tourist Organization of Thailand, encourages outdoor living and recreation to enhance the physical and mental health of the public. Since the promulgation of the National Park Act in 1960, seven national parks have been constituted, and another ten places are listed as future national parks.

b) Forest Parks: Small forest parks have also been created in various localities spread over the entire kingdom. These usually are places with superbly beautiful natural features such as scenic landscapes and picturesque cliffs and waterfalls. Amenities like picnic and camping grounds, lodges, biking trails, etc., are provided for tourists and vacationists.

c) Arboreta: There are twelve arboreta which serve not only for educational and scientific purposes but also as recreational grounds where travellers and tourists may find shade, rest and peace.

d) Botanical Gardens: There are only two botanical gardens in Thailand. One was established in 1942 and the other in 1971.

e) Game Reserves: Up to 1971, only three game reserves have been surveyed, demarcated and legally described, covering a rather extensive area of about 1,500 square miles. The Royal Forestry Department takes responsibility for these wildlife areas.

These recreation areas are in various localities, and different types of forest well spread over the whole country, and many of them are facing problems with wild fires.

2.2.2 Forest Fire Occurrence and Area Burned

(a) Natural Forest: No records have been kept of the number of fires, or areas burned over, in Thailand. There is no need to keep records of fires in natural forests because all forest areas in the north and northeast of the country burn over every year, and some places may suffer multiple burns in one season. Macleod (1971) estimated that:

"These two regions account for more than 70% of the total forested area and contain more than that percentage of the important timber species. The east and the south together have a little less than 20% of the total area and suffer much less from fire. Under these circumstances it can be fairly estimated that the annual area burned amounts to something in excess of 46,930,000 acres."

Thiem (1970) made some calculations of losses caused by the hill tribes in burning for shifting cultivation. These calculations were based on data provided by the Royal Forestry Department and studies made by F.A.O. in the Asia and Pacific Region. He estimated that:

"Some 5,180,000 hectares of forest areas were either lying fallow or being burned by the hill tribes. Using the F.A.O. figure of \$17.8 annual value per hectare of forest cleared, the monetary loss in forest values for Thailand by shifting cultivation alone should be \$92,155,800."

Thiem (1969) also studied soil and water losses from burned and unburned areas from 1960 to 1968 and concluded that:

"Burning will greatly increase soil and water losses especially if the areas are burned consecutively every year. When the areas are fire-protected for six years; run-off and sediment yield will gradually decrease. However, if the areas are fire protected for six years and then burned, the first year of burning will be most beneficial, as soil and water losses will be the lowest. Repeated burning will, however, increase run-off and sediment yield in subsequent years."

In the natural pine stands, the annual fires have kept the

surface litter reduced to the extent that the fires do little damage to mature trees that have not been wounded. However, in the several pine forests used for resin tapping, the boles have been deeply and crudely gouged by the tappers and fire has intensified the damage. Macleod (1971) believed that:

"The tappers use fire to increase resin flow and are themselves another cause of forest fire damages."

(b) Forest Plantation: There are numerous plantations that have already suffered from fire and, in many instances, may be even more susceptible to damage by fire in the future. Lane (1970) reported that:

"Fire is the major hazard in the plantation areas and has caused tremendous damage, often year after year. These are a major factor in the choice of species for plantation and often result in either failure or very open stocking ... Only eighty percent of the teak planted was successful and only 30% of the other species. The success of plantation programs depends entirely on effective protection against fire."

Up to the present, pine plantations have suffered little from fire. They form only a small fraction of the total, about 5,200 acres (1970), but the pine planting program of the Thai Newsprint Company will be started in 1973, three years later, and should reach a rate of 3,200 acres annually. These pine plantation programs probably will face serious damage from fire, according to Rindt (1966) who said:

"Forest fires burn over large areas in Thailand each year. They are a serious and a real threat to the pine plantations. A fire in them could be a major disaster and could be the controlling factor in discouraging a pine-based pulp and paper industry."

2.2.3 The Forest Fire Season

Thailand is lucky so far as fire weather is concerned, because its

three-month season is short in comparison to the six-month season in Canada, and to the year round season in southern California. According to Macleod (1971) the fire season in Thailand differs in two areas:

"In the north and northeast it is considered to run from late January to early May or just over three months. In the south and east, the fire season is very short and normally occurs for one month only."

McCutchan et al. (1969) described the fire climates in Southeast Asia as follows:

"During the normally dry period (November through April) three types of synoptic-scale disturbances are usually responsible for rain in Southeast Asia...Fire climates are not only affected by temperature, humidity, wind speed and precipitation but the most important factors are rainfall and cloud cover."

A brief tabular summary of climatological data for three representative weather stations (Thailand Meteorological Department) ranging from north to south in 1951 - 1965 (Table 2) follows. Both the south and east have about the same amount of rainfall, 115 - 120 inches per year and during the so-called dry season rains may occur on any day. This is unlike the situation in the north and northeast, where the average annual rainfall is about 35 - 40 inches and where there is a most definite dry period during which even small rains infrequently occur. There is a normal variation of perhaps two or three weeks at either end of the season in occasional years. The fire season usually starts during the latter part of December up to mid-January.

TABLE 2
Climatological Data for Thailand
(1951 - 1965)

A. Location

<u>Province</u>	<u>Part</u>	<u>Latitude</u>	<u>Longitude</u>	<u>Elevation ASL (M.)</u>
Chieng Mai	North	18°47' N.	98°59' E.	311.00
Surin	Northeast	14°53' N.	103°29' E.	145.00
Trang	South	07°37' N.	99°40' E.	14.32

B. Climatological Data

<u>Province</u>	<u>Rainfall Mean (ins)</u>	<u>R.H.% (Mean)</u>	<u>Temp.F° (Mean)</u>	<u>Wind (Knots)</u>	
				<u>Mean</u>	<u>Max.</u>
Chieng Mai					
Dec.	0.70	49.1	83	1.4	37
Jan.	0.47	42.8	84	1.5	45
Feb.	0.43	34.2	90	2.0	54
Mar.	0.74	30.0	95	2.5	54
Apr.	2.02	33.6	97	3.1	63
Surin					
Dec.	.01	50.3	86	3.9	30
Jan.	.06	43.3	88	3.5	33
Feb.	.33	42.4	90	3.3	32
Mar.	1.52	42.5	96	3.5	40
Apr.	2.89	45.3	97	3.5	44

Continued

TABLE 2 (Continued)

Province	Rainfall	R.H.%	Temp.F ^o	Wind (Knots)	
	<u>Mean (ins)</u>	<u>(Mean)</u>	<u>(Mean)</u>	<u>Mean</u>	<u>Max.</u>
Trang					
Dec.	3.99	64.3	87	8.3	40
Jan.	1.61	57.3	90	10.4	40
Feb.	1.00	50.5	93	9.5	45
Mar.	2.33	50.8	96	6.6	41
Apr.	6.01	56.3	95	5.1	50

2.2.4 Causes of Fires

The majority of forest fires in Thailand are man-caused. Eighty per cent of the fires are lit on purpose, most for some real or imagined gain, the remainder being accidental. Most lightning storms are accompanied by heavy rains and the fires are extinguished before they spread. Macleod (1971) assumed that lightning must cause a few forest fires in Thailand, but this cause can be considered of negligible importance. The man-caused fires can be described as follows:

Campfire: Anyone in Thailand can enter or work in the forest during the fire season. These people may be campers, picnickers, hunters, or fishermen, who start fires for cooking or for providing light or warmth which commonly spread to the surrounding forest (Dusit, 1968).

Debris burning: The rural people of Thailand are pushing into the foothill and mountain forests in their search for arable land. These low-land Thai farmers apply the slash-and-burn method carelessly, so that many fires set to clear land spread through the forest. Fires are also set to dispose of rubbish or garbage and to burn ranges and meadows (Macleod, 1971).

Shifting Cultivation: Many hill-tribes live in the mountains throughout Thailand. Their practice of shifting cultivation is the cause of many fires each year. Thiem (1970) calculated that hill-tribes, in burning for shifting cultivation in Thailand, covered about 5,180,000 hectares a year.

Highways: Highway Department employees normally use fire for clearing and cleaning roadsides and let it burn through the forest near roads. Rindt (1969) noted that:

"It is common practice to use fire to clear roadsides of grass and brush, and fire is allowed to spread beyond the roadsides to burn uncontrolled through the forests."

Incendiary: A large number of fires are set maliciously, for example by rural people who dislike what they consider to be arable land used for forest plantations. Rindt (1969) noted that:

"A fire this year did serious damage to the pine plantation at Kunkong (the name of a district in the north of Thailand)."

Hunters: The hunters, normally, use fire for various purposes in pursuit of game and give no thought to the consequences.

Smokers and Railroads: It should be said that cigarettes and trains' sparks rarely are responsible for fires, because the initial ignition temperature is too low. However, matches thrown into the grass and still burning do reach the necessary temperature (Budowski, 1966).

2.2.5 Types of Fire

According to Davis (1959), forest fires are classified into three types, surface, ground and crown. In Thailand ground fire is most common. Fires in Thailand can be broken into three general types based on burning characteristics, average damage, and control techniques which are affected mainly by the vegetation and topography. These types are as follows:

Plantation type: The predominant fuel in plantations of all species is the grasses which form a dense and continuous layer in the open area mixed with small trees. Normally, young trees are the dominant fuel type. Fires burn easily and rapidly in this type, do considerable damage, are quite common, and are moderately difficult to control.

Open grassland types: Predominant fuel is again various species of grasses and brush. The overstory is very restricted, occurring in small patches in the gullies, if at all. Topography usually is flat. Fires occur easily in this type, but do not cause much damage. The most common, and most serious, fire in this type is the fire which escapes to the dry dipterocarp forest or to the teak forest. This type of fire is not difficult to control.

Forest type: The major fuel in teak or pine forest is the grasses and understory in the open mature stands. Locally, pine or teak natural regeneration may be the dominant fuel type. Topography is generally steep, and then the fire tends to spread rapidly. Slope is the major factor determining rate and direction of spread. Saplings and regeneration usually are killed outright, while larger trees, including mature trees, are often damaged. Since slopes are steep and rainfall intense, burned areas may suffer serious

erosion and surface runoff. Fire under this condition burns hotter and is much more difficult to control and extinguish because of the large volume and size of fuel. This type of fire does much more damage than the others, but is very difficult to evaluate in monetary terms.

2.2.6 Ecological Effects

Generally speaking, there are not many references available about fire effects on plant communities, forest structure and wildlife, in Thailand. Basic research studies on these aspects are badly needed.

After temporarily cultivated land is abandoned, succession takes place, beginning with grasses and shrubs which burn easily in the dry season. Fire spreads easily from grass areas into adjoining forests if conditions are favorable. In most parts of Thailand fire is misused in clearing forest vegetation as part of the so-called "slash-and-burn" method. Krit and Pirot (1962) found that:

"The soil loss on the burned plot amounted to approximately 38 tons a rai whilst the soil loss in the unburned forest plot was only 2 tons. The impoverishment of the soil by burning is astoundingly greater than usually imagined."
(1.5 rai equal 1 acre.)

Thiem (1969) also studied soil and water losses from burning in tropical deciduous forest in the north of Thailand (1960 - 1968). The results of the study can be summarized as follows:

- "1) Burning will greatly increase soil and water losses especially if the areas are burned consecutively every year. Repeated burning will increase runoff and sediment yield in subsequent years.
- 2) Fire may change the quality of the soil in teak forest.
- 3) Accumulation of organic matter in the different types of forests will result in increased stability of the soil.

- 4) Slope also plays a significant role in soil and water losses such as the rate of runoff. Plant cover, especially bamboos, with compact root systems which help in binding the soil together also has a great influence in determining the rate of soil and water losses."

Champion (1962), when writing about plant associations in teak-bearing forests, concluded that:

"The undergrowth is also greatly influenced by the annual fires. It consists mostly of deciduous shrubs and grass with a tendency to evergreens in the damper sites. Small regeneration of tree species including teak is fairly abundant but on examination much of it is found to be from large misshapen root-stocks, of indefinite age, which have been repeatedly burnt back."

Teak has a remarkable fire resisting power but still can be damaged by fires. In some areas, teak seedlings take about twenty years to grow high enough and strong enough to withstand a light fire (Macleod, 1971).

On the other hand, burning has advantages for teak forest. It keeps teak growth more uniform, burns undesired species, and weeds and improves the growth of some young trees. In some areas not burned for several years, teak seedlings will be covered by bamboos, or may be surrounded with so much fuel that a very fierce fire is likely to cause much damage. The effects of forest fires in each area must be studied carefully.

Some fires will be good. Others will be bad. It appears certain that fire management will be needed to ensure that the desired effects will be achieved. The aim should be to reproduce the desirable effects of fire and to diminish its undesirable consequences. Prescribed burning near the beginning of the dry season may accomplish many silviculturally desirable objectives with little or no ecological impact.

2.2.7 Forest Fire Control Practices

Up to the present, an effective forest fire control organization has not been developed in Thailand. Krit (1966) noted that:

"The only practice is generally to clear fire lines around a block of forest plantations, when the fire hazard becomes very high."

Dusit (1968) stated that:

"The only measure that the Forest Department could currently adopt, out of its limited budget, is to build and maintain the fire line around the block of forest plantations."

Macleod (1971) reported that:

"The practice of forest fire control in Thailand has been minimal or non-existent...The only significant efforts have been a few small ad hoc programs on forest conservation ...A few patrolmen have been employed at experimental forest plots and at some plantations;...Some pre-suppression fire-guards have been made with and around plantations and small experimental forests."

The agents which cause damage to the forest consist of man, insects, disease, fire and other natural calamities. But the injury done by human beings (illegal cutting) rates the most serious for the forest of Thailand. Therefore, the Forestry Department has to concentrate all of its resources and efforts to curb such malpractices, and protection against diseases, insects and fires is still in the experimental stage in Thailand.

2.2.8 The Attitude of People to Forest Fire

Measures suggested to improve forest protection in Thailand often would interfere with the liberties which the people take for granted. They look upon the forest as a nuisance, and the person that can clear and burn

the largest area is considered the most industrious in his town.

Enforcement, besides being very unpopular, has usually proven to be very difficult. Dusit (1968) noted that:

"The forest officers who are charged with the responsibility to safeguard the forest from destruction have been treated by the community as the 'public enemy'. Some of our energetic foresters were killed while performing their duties in the forests."

Almost all fires are intentionally set by man, usually with a definite initial purpose. Macleod (1971) pointed out that:

"The attitude of the public in Thailand toward fire in the forest is such that almost anyone entering or working therein during the fire season is a very serious threat to forest fire. Practically all people, including some of the professional foresters, appear to have no serious compunction about letting fire run through the forest... In Thailand, most of the forests that were susceptible to fire have been cleared and burned by the rural people, who are very poor and uneducated, for agriculture purpose."

Rindt (1969) also found that:

"There are disagreements about the effect of forest fires on hardwood timber types in Thailand. Some people claim that fires benefit hardwood growth. Others claim that fires damage it. There is need to know the facts."

Because everyone in Thailand has been able to use fire in the forest for almost any reason, anytime, even government employees, such as Department of Highway workers, can start, and leave untended, roadside fires in forested areas.

2.2.9 Forestry Laws Concerned with Fire

There are no specific forest fire control acts in Thailand. The only two acts that can be used as tools in forest protection are:

a) Forestry Act 1941 (amended by Forestry Act (No.3), 1951),

Section 54 ...

"No person may clear, RAZE or do anything to destroy a forest unless within areas prescribed by the Minister by notification in the government Gazette unless by authorization of the competent official."

Section 72 (ter)

"Whoever contravenes Section 54 shall be liable to imprisonment and not exceeding one year or a fine not exceeding four thousand baht (20 baht equals \$1) or both ...In offences under this section, if committed over an area exceeding fifty rais (2½ rais equal 1 acre), the offender shall be liable to imprisonment from six months to five years and a fine of from two thousand to twenty thousand baht...In the event of conviction under Section 54, if it appears the offender needs possession of the forest land on which the offence was committed, the court is empowered to give judgment ordering the eviction of such person from such land."

Section 74 (bis)

"All tools, equipment, animals and vehicles for transport or any machinery used in the commission of offences or used as accessories to obtain results in the commission of offences under Section 54, shall be confiscated whether or not persons have been convicted for such offences."

b) National Park Act, 1961.

Section 16:

"Within the national park, no person shall (1) Hold or possess land, nor clear or Burn the forest;...(18) discharge rubbish or things at the place not provided for such purpose;...(19) leave any loose article which may cause fire."

Section 24:

"Whoever violates Section 16(1) shall be punished with imprisonment not exceeding five years or fine not exceeding twenty thousand baht, or both."

Section 27:

"Whoever violates Section 16(18) shall be punished with fine not exceeding five hundred baht."

These two acts do not have adequate clauses to permit forest-officers to deal with forest fire problems which involve natural forests and forest plantation areas. Legal measures to prevent forest fire should be more specific and more severe than these clauses. As use of fire is a deeply entrenched custom with rural people everywhere, forest fire acts should be written in simple but enforceable terms.

2.2.10 Pressures for Improvement

The Forestry Department has recognized that forest fires have been seriously damaging Thailand's forests for many years. Over the years, large numbers of recommendations have been made for overcoming the fire problems. These suggestions were as follows:

Champion (1962) suggested that:

"Uncontrolled burning is universal in the deciduous and pine forests. It is recognized that at present, full protection is unattainable, but steps can be taken to reduce the damage done to the growing stock and the soil."

Krit (1966) when writing about forestry development in Thailand, noted that:

"Thoughts have been given to the creation of fire-fighting units, construction of fire observation towers, and procurement of fire-fighting equipment, but under the present (1966) circumstances, it will probably be some time before such things materialize."

Dusit (1968) also noted that:

"Forest fire is second to human activities in causing damage to natural stands and impoverishing forest soil."

Rindt (1969) reported that:

"Pine plantations represent a large investment of public funds as well as valuable timber resources. A fire protection and fire suppression plan should be developed for the pine areas. Necessary fire-fighting equipment and instruments to measure fire weather should be obtained. The hill tribes and rural people who are the principal labour source in the pine areas, should be trained to fight forest fires."

Lane (1970) believed that fire is the major hazard in the plantation program and has caused tremendous damage, often year after year. He summarized his recommendations:

- 1) A forest officer be appointed for full time work on forest fire control methods and receive training abroad.
- 2) Reduction of fire damage be a major subject in public campaign.
- 3) Practical steps be carried out to reduce fire damage by clearing fire lines, controlled burning, establishing fire stations, fire patrolling, and constructing look-out towers.
- 4) Burning of roadside vegetation be prohibited in reserved forests.

Little action to implement these recommendations had been taken until 1971. Then Mr. J.C. Macleod, the forest fire expert from CIDA, was assigned to provide advice and make recommendations to the Royal Forestry Department concerning forest fires in Thailand. Macleod (1971) gave both general and specific recommendations about regulation, organization, training, and funds. He also emphasized that:

"Even if no funds are budgeted for fire control next year, there need be no slackening of effort to provide protection against fire."

2.3 Status of Forest Fire Control in Other Countries with Related Conditions.

Fire has a long history of occurrence in the tropics, and its effects upon the physical and cultural environment have been profound (Batchelder, 1966). There are many unknowns and misconceptions about the exact role of fires in tropical areas (Budowski, 1966). How old is fire? Is lightning fire possible or a factor of importance in tropics? Does the tropical rain forest ever burn?

Budowski (1966) believed that:

"Fire is widespread in all tropical countries, usually connected with primitive agriculture and grazing. Lightning was possible and before man's arrival burned large areas of forest and savannas periodically. Man's influence is suspected to date back between 10,000 to 50,000 years ago."

Wildfires were considered a very important forest problem in many tropical American countries, especially Brazil, Venezuela, Columbia and Honduras, where at times great efforts and expenditures have been made towards their control. Budowski (1966), when he discussed forest fire management in South America, noted that:

"In British Honduras controlled fires were recommended some 20 years ago and according to a later Annual Report (1962) practised with apparent success.

In Guatemala, recommendations for early fires were made for pine in 1950, but at this stage none have been practised in appreciable scale.

In Nicaragua, the F.A.O. Mission had been experimenting for many years. Educational campaigns were limited to leaflets, road signs and radio programs, all advocating suppression of fires but rarely suggesting substitutes for the beneficial effects achieved by fires."

Fire is one of the most serious dangers to the forests and grasslands in many countries of Asia. A number of attempts have been made to reduce the occurrence of and to control forest fires. Most of them have not been successful, primarily because of the lack of funds to do a proper job.

In the Philippines Kimbal (1971) reported:

"Actual percentage of area burned is not known and quotes from various sources range from 25 - 27% of public land... There are many laws, regulations, directives and administrative orders regarding illegal activities in the public forest. Generally, they are adequate to do the required job, but very few are enforced."

In India, Kadambi (1957):

"Fire is one of the chief enemies of forest which does incalculable harm to forest growth in the country. A single uncontrolled fire can ruin a forest and finish off the work of generations of forest officers and wipe out the advantages which may have occurred to crop, through years of laborious effort."

The Indian Forest Act, 1927, Section 26:

"Prohibits any person setting fire to a reserved forest or, in contravention of any rules made by local government in this behalf prohibits kindling any fire or leaving any fire burning, in such a manner as to endanger a forest. Violation of the Act is punishable with imprisonment for a period of six months or-a fine of Rs. 500 or with both, in addition to such compensation for damage done to the forest as the convicting court may direct to be paid."

Troup (1940) discussed forest fire protection in Asia saying:

"The forest laws generally prohibit, within reserved or Crown forests, the firing of grass or undergrowth. For example, under Federated Malay States Forest Enactment, 1934, 'it is illegal to leave fire burning, whether within or without a reserved forest, in such manner as to endanger the forest... The rightholders, concessionaires, employees, and those in receipt of Government emoluments who live near the forest are bound to assist in extinguishing fires in, or preventing them

from spreading into reserved forests, Such compulsory attendance at fires is required by the India, Burma, and Ceylon Forest Acts."

In Australia, the Forestry Act provides for the control of fire on dedicated forests, but problems of controlling other rural fires are dealt with under the Careless Use of Fire Act. Luke (1949) noted that:

"The present Forest Act does not give the forester sufficient powers to suppress fire on neighbouring lands."

In New Zealand, fire prevention and control is now principally contained in the Forest and Rural Fire Act (1947) but comparable provisions are contained in the Forests Act (1949) for the protection of state forests not protected by Fire Districts and which do not, therefore, come under the former act. Boardman (1950) believed that:

"The Forest Act and Rural Fire Act together with the Fire Services Act, 1949 (which protects urban districts), and the Forest Act 1949 (which protects state forests not brought under the act) now provides the necessary machinery for a complete coverage of New Zealand with respect to fire prevention and control."

In Trinidad, fires in teak plantations have become a perennial problem. The causes of fires and their effects on the tree crop and the site were discussed by Murray (1961) who noted that:

"The most pressing problem associated with teak in Trinidad today is the hot surface fires which sweep through approximately 50% of all plantations each year. Often the same coupe is burnt twice in the same dry season."

In the same report Murray (1961) suggested that:

"The real answer to the fire problem lies in the education of the general public...The ordinary citizen must be made aware of the cumulative effects of fires on soil and vegetation; the public conscience must be aroused."

In letters from many fire control headquarters in the southern U.S.A., some valuable suggestions were given to me.

Mr. Del W. Thorsen (Forest supervisor of the National Forest in North Carolina) suggested that:

"I realize that tropical forests do consist of extremely heavy growth which when dried produces vast quantities of fuel. This vegetation also is a hindrance to suppression efforts. Therefore equipment versus manpower with hand tools is a very valid question...The area of equipment possibilities and combinations is very broad and will take quite a bit of analysis and trial and error to come up with suitable equipment."

Mr. John W. Graffin (Group Leader, Forest Fire Management, Southern Area, State and Private Forestry) advised me that:

"The key is that every able bodied person is subject to 'fire call' if conditions warrant...Training is most important in preparing for this."

Mr. Ragnar W. Johansen, who is Project Leader, Southern Forest Fire Laboratory, suggested in a letter to me that:

"Before any fire organization plans can be made, one must become familiar with many facets of the problem such as: magnitude of the problem, geography, soils, and tree species of the area involved, manpower and equipment resources available, personal expertise, extent of road systems and airports, and the monies available to do the job."

2.4 Summary

The natural and managed roles of forest fire in Thailand and other tropical countries are discussed. The causes of these fires and their effects on the tree crop and site are reviewed. Although almost all fires are man caused, the specific causes of fires are not known with any degree of certainty.

Wildfires are considered to be a very important forestry problem in many tropical countries, especially Brazil, Venezuela, Columbia, Honduras, Guatemala, Nicaragua, the Philippines, Trinidad, Australia and New Zealand. In these countries many attempts have been made to reduce fire occurrence and damage. Most of them have not been successful, primarily because of the lack of funds and expertise.

3. FIRE PROGRAM IMPROVEMENT

3.1 Introduction

A good fire control program is not the result of a single act or deed; it is an ongoing day-by-day process. What is started well should be continued as any valuable forest area can be burned if one year goes by without protection. For this reason alone, it will be necessary to plan a long range program that will be assured of adequate financing. The plan at the start should be small and later constantly expanded as manpower and finances allow, with the goal being never to cut back on protected areas. Knowledge of the amount and values of the land to be protected will thus be necessary to determine the priorities for this protection.

The eventual objective of this program would be to place all hazardous areas in the country under intensive fire control management, but certainly this is not possible immediately because establishing a sound fire control organization is very expensive. Inputs and outputs must be considered carefully. At present, with the low level of development of the forest areas to be protected, it is also a formidable job physically. However, many factors suggest that a good forest fire control program is badly needed in Thailand, and in the near future a start should be made in a small, particularly valuable area.

3.2 Fire Prevention

Fire prevention would be the most important aspect of a fire control program in Thailand, because most forest fires in Thailand are man-caused. The opportunities in fire prevention are tremendous. Money and

effort spent in fire prevention pays off in two ways: suppression costs are saved; and damage to the resource is lessened.

The eventual goal of fire prevention will be achieved when a majority of the population of Thailand understands the message about the damage done by forest fires and the need for fire prevention. Prevention is difficult to organize and often it is very hard to determine the effectiveness of any particular program. Mr. J.C. Macleod, the Canadian forest fire control expert, who had been working on forest fires in Thailand, suggested to me (personal communication) that:

"I realize, of course, that fire prevention in this free land is going to be an uphill fight...The land, where everyone has been able to use fire for almost any reason in the forest, and where even government employees such as Department of Highway workers can start, and leave untended, roadside fires in forested areas, it is inevitable that they won't want to give up these privileges. It is going to be your job, to convince them that it is in their own best interests to maintain good forests, and that is one of the major reasons for starting now."

3.2.1 Forest Fire Prevention Campaign

Everyone knows fire damages the forest, but sometimes they lose sight of just how serious these fires are. The Forest Department, also, has recognized for many years that forest fires have been seriously damaging the forests of the country, and indeed, without adequate prevention against fire, many desired methods of forest management simply cannot be applied. A campaign for preventing forest fires must be undertaken soon.

The whole attitude of the public and also of many government officials, including some foresters, towards fire in the forests must be changed. A forest fire prevention campaign to accomplish the desired

objective would require a concentration of effort in a variety of directions for at least a decade or probably for much longer. A strong effort should be made to seek the cooperation of all government agencies in fire prevention. The public cannot be expected to be careful with fire in the forests if the government officials do not see fit to ensure that their own employees or agents use some common sense in respect to the use of fire. It should be constantly borne in mind that informed public opinion in Thailand is ultimately the most potent instrument for influencing the behaviour of individuals, organizations and the government, all of whom must change their ways if the forests are to be saved from fire.

The information service of the Forestry Department is the only agency that can be involved in forest fire advertising. This service should be provided with sufficient funds to increase greatly its forest conservation campaign, particularly with respect to forest fire prevention. I certainly hope that a widespread campaign through the use of posters and other advertising media will start in 1974 or as soon as possible thereafter.

Many advertising ideas used in forest fire prevention campaigns in Canada and the United States can be applied to Thailand, but all need careful study before application as some slogans may create negative reactions. For example, I would like to adapt some North American ideas to suit the nature of Thai people as follows:

- Tigers, bears and cobras are considered dangerous wild animals in Thailand, and thus they are usually classified as the enemy of man. For this reason, the Smokey Bear symbol should be replaced with an "Elephant", as Thai people believe that the elephant is the king of wild animals and the most powerful living thing in the forest. Posters such as those in Figures

1 and 2 should be widely distributed.

- The slogan, "Remember, only you can prevent forest fire" should be changed to "Even you can help to prevent forest fire" because in Thailand nobody wants to do any work alone but prefer to help others or work in a group.

- The slogan "Protect the wealth of the west" should be changed to "Protecting forests can make you wealthy" because everyone wants to become rich even when they know it is impossible to do so.

-The slogan "Use ashtray to prevent forest fire" does not apply to Thailand because I believe that the initial ignition temperature of cigarettes is too low to be a cause of burning. "Don't play with matches" is more suited to the situation in Thailand.

- The name of "Keep green program" may not be accepted by Thai people because the majority of forest fires are light ground fires that never turn any big trees to brown. Such fires usually destroy only the undergrowth and grasses. The forest canopy will still be green even while the fire is burning, or soon after burning it will be green again.

Many slogans could be translated directly to Thai, such as, "Promise that you will be careful with matches, camp fires", etc., "A century to grow, an hour to burn", etc.

The signs and posters designed for mass appeals should be modified to create specific "how-to-do" and other educational items for local use. While the program is aimed primarily at general use, consideration must be given to make it effective in local situations.

Each year before the fire season, a campaign program should be planned in advance. Samples of posters, signs, advertising mats, pictures,

radio scripts and other items should be discussed in the pre-organization committees to improve the program. Because the great majority of forest fires in Thailand are man-caused, it is essential that the prevention campaign must work very well, for then there would be many fewer forest fire hazards in the country.

3.2.2 Advertising for Fire Prevention

Selection of the best approach to public education in fire prevention leads to the question of media--and means of presenting fire prevention messages. These run the full gamut of communication techniques employed in advertising. Many tropical countries have failed by using the wrong means of advertising to prevent fires. No one method is best, but many are necessary. There are differences in ideas regarding their respective merits in meeting particular situations. Davis (1959) classified available media as follows:

- Signs and Posters: These must be designed so as to very aptly and strikingly characterize a major point, both through careful choice of wording and some chromatic appealing or memorable visual images. These effects can be produced through the wide variety of techniques developed by commercial artists for business advertizing. The points to be kept in mind are: (1) the message on the poster must be appropriate to the public, (2) it must be posted at strategic locations, (3) it must hang straight and be placed at eye level, and (4) damaged signs must be repaired or replaced immediately.

- Written and illustrated material in newspapers, magazines, pamphlets, and leaflets: These should provide essential details and give a more complete story. Fire prevention slogans or messages should be published or transmitted as a public service. It is important that the information should be checked

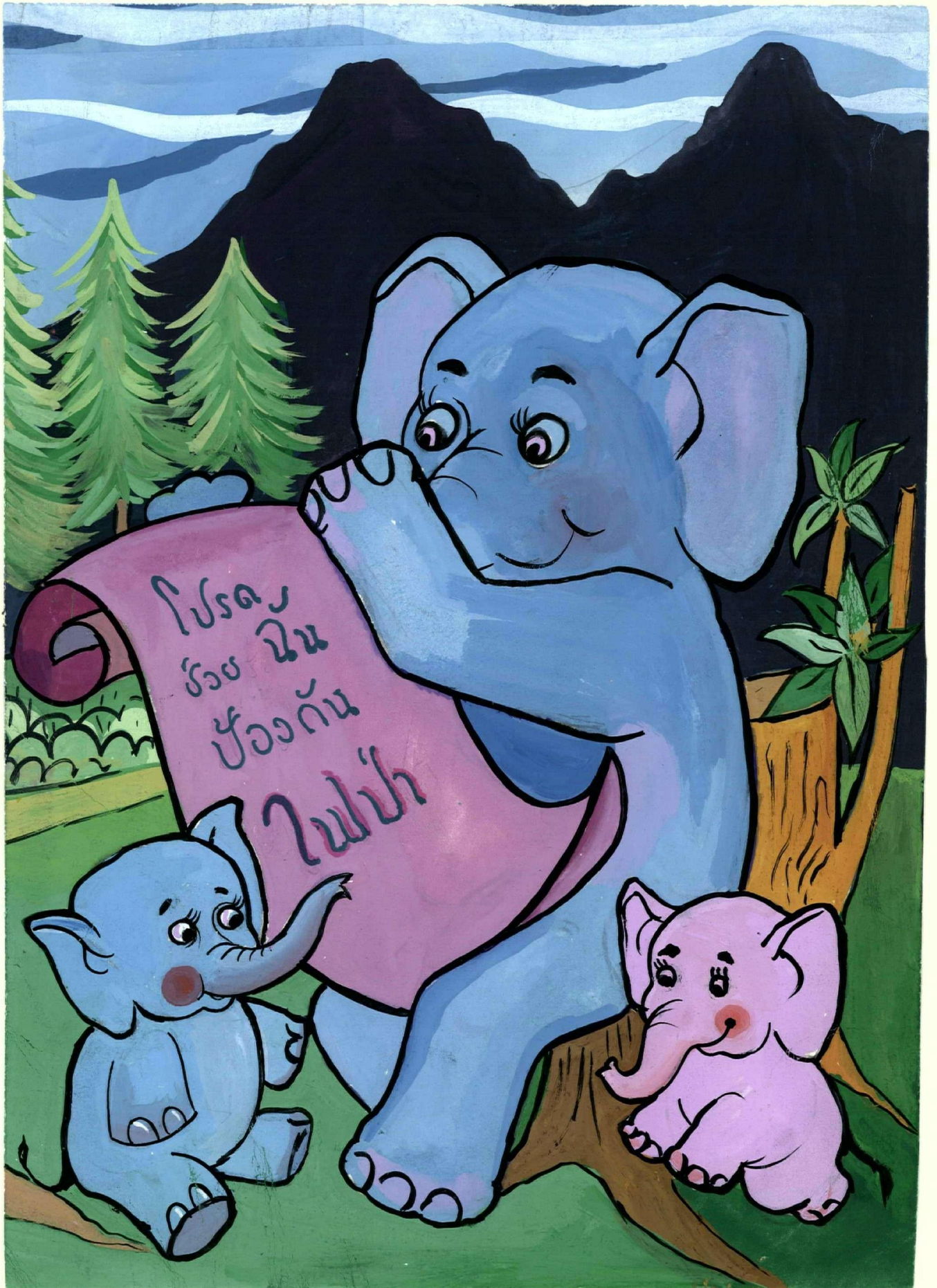
by the local forester or responsible officer in the area before release. Otherwise, confusion may arise if incorrect or inappropriate material is issued.

- Radio, still pictures, motion pictures, and television: Television is expensive and not accessible to many groups. Radio should be used for both spot announcements and longer programs. Motion and still pictures can be used combined with spoken lectures, in free public presentations. This is an extremely flexible and effective medium, as it can be fashioned to entertain and inform large sections of the nation's worst fire-offenders, the largely illiterate rural and hill dwellers. Perhaps radio is the best means to inform the public of important announcements regarding forest fires in Thailand because it can reach a large portion of the population in the shortest time.

- Personal group contacts: Every group or community has certain attitudes and ideas about forest fires. They may also be ignorant of conditions which need to be changed, or indifferent to that need. The key individuals should be contacted directly to transmit a fire prevention message to groups.

- Individual contacts: A personal contact with one or two people, talking about fire prevention or pointing out fire hazards, takes a lot of time per person contacted but the impact will be great. In contrast the radio or T.V. program which contacts large audiences may take relatively little effort per person contacted, but few people will really get the message. For Thailand, I expect that individual contacts would be the most significant point of understanding. It may consist of personal interviews or contacts made by fireguards in greeting or visiting.







3.2.3 Prevention Through Education

Without close cooperation from local people, little forest fire prevention could be accomplished, therefore, in addition to the amending of the forest law, the strengthening of forestry staff, and increasing of the budget of the Forestry Department, education is extremely important. Forest fire protection should be a compulsory topic in the curriculum of the kindergarten, primary and secondary schools as well as in higher education.

There is no better way than instructing the children, not only because they are the adults of the future, but also because of the way they affect their parents. Teachers in schools near forests may be willing to use a fire topic as the subject for compositions, in return for giving the class a talk about the need for preventing forest fires. The children must be consistently taught that forests are in essence their own property managed for them by the government. Picture drawing and poster design contests, even for very small prizes, interest the children, leave a long-term impression and almost ensure that some parents will become involved.

Girl and boy scouts and other organized nationwide civic groups can play an important part. Active participation is a good way to stimulate interest, so much of the material designed to promote greater understanding amongst children can be prepared on a central office level in the Forestry Department and then passed down to the field units in the appropriate localities.

It would be desirable to create a new consciousness in the people

regarding the importance of forests and regarding the repercussions of forest fires on the economic future of the country. Such education should be aimed at all social levels, by means of courses, lectures, and conferences in the various schools. In the first place, it should acquaint the people with the tree and its life, and then encourage them to develop a love for nature and an appreciation for the benefits dispensed by nature when one gets to know it.

3.2.4 Prevention through Enforcement

Normally, law enforcement should be the final step in a fire prevention program, but for Thailand it should come first or at the same time as education and the prevention campaign. Law enforcement must be a necessary tool of fire prevention in Thailand, for without law, or if law is not applied when needed, the program will fail.

Law enforcement is essential in dealing with incendiary fires, though discretion and a thorough understanding of the local situation are necessary. Many incendiary fires are the result of a local attitude of indifference, even approval, regarding woods burning and are not set with criminal intent, and therefore the specific cases have to be considered as local problems.

Penalties for accidental setting of fires through carelessness or negligence are necessary in the prevention program for Thailand. Costs of authorized fires that escape boundaries and spread upon and damage another person's property should be recoverable, including suppression costs and property damage.

Basically, forest fire law and its enforcement are an educational

tool to be used wisely and firmly, and they must be accompanied by prevention education. Without understanding and support from local people, forest fire enforcement could not be successful.

3.3 Forest Fire Control Organization

The aim of this chapter is to review the principal problems in building and operating a forest fire control organization in Thailand, and to present a way of developing an organization designed to achieve the needs of the country. This knowledge is only a basic organization required to handle the initial operation and it should be capable of expansion to a large scale organization in the future.

3.3.1 Factors Affecting Organization Structures

The Royal Forest Department of Thailand was founded in 1896 by a Royal Decree, on September 18, 1896, issued by King Rama V. The administration of the department has a long history. The department was divided into seven divisions, namely:

- 1) Forest management
- 2) Forest control
- 3) Park
- 4) Silvicultural research
- 5) Forest product research
- 6) Finance, and
- 7) Office of the Secretary (Krit, 1966).

There are also the territorial administration which consists of 21 forest districts, and 644 forest protection units set up in the various

localities considered valuable as forest (directly responsible to the Royal Forest Department). Apart from these, there are also 67 provincial forest offices and 470 township forest offices being directly answerable to the provincial governors. Also under the direct control of the forest department is a forestry school, which is a vocational school offering two-year ranger courses. (The reorganization was done in 1972, Appendix C.)

It will be seen that this organization set up does not follow the international form. At present, fire control still is at the experimental stage as part of the management and silvicultural divisions, so if fire control is to be developed into a full function in Thailand, some type of organizational structure will have to be created. There are many factors about fire control organization that have to be considered:

- 1) Fire control is a seasonal job; when the need arises, it is the most urgent of all forestry operations. Sometimes it is very difficult to employ the right person for this work at the right time.

- 2) Fire control plans must be made in advance. There is no time to prepare plans while a fire is burning.

- 3) Normally, the organization must be both centralized and decentralized. The headquarters in Bangkok must be the central office co-ordinating one region with another and the man on the ground must be controlling the fire.

3.3.2 Manpower

Fire control organization needs various types and sources of manpower. Professional fire control men should devote full time to the problems of fire control. They would be most concerned with suppression

or planning and improvement of the system during the off season, but during the fire season, they would be concerned with fire prevention and suppression activities. They also would be responsible for training programs, and maintenance of communications and detection systems, carrying on a permanent fire prevention campaign and coordination of the overall fire control operation, as well as improving fire fighting tools and methods. Trained persons from deputy district officer level might be classified as professional control men.

Fire control must be recognized as every forester's responsibility and, when necessary, it should be a part of every forester's job. All permanent employees in the field should be given some training in fire control. Chiefs of protection units and their staffs must be classed as part-time firemen. Normally, they would work at their regular jobs, but in an emergency they would be available to supplement the regular suppression crews. This is only one suggestion that would facilitate more extensive and higher quality fire suppression in Thailand. The greatest advantage in using these regular employees would be in having permanent fire crews, large enough to meet the peak demand that might occur only once or twice a year at the lowest cost.

Seasonal employees, that is the labourers and crew members who work directly under the supervision of the fire control people, are the backbone of the suppression labour force. They should be hired only three months a year for the fire season and be given a training course at the beginning of the season. They should be given very little responsibility and must work under close supervision. Local hiring should be coordinated with the chiefs of the villages but the forest authority should not put up any threats

of force.

The other source of manpower is men borrowed, as required, from other government agencies and local woods-oriented industries. There are many logging concessions, sawmills, parks offices, and Highways Department offices which have manpower located beside the forest. They should be available as additional manpower for fire fighting on public forest lands.

The Army is another very powerful potential resource for fire control in Thailand. The Army of Thailand is a well structured organization and suited for carrying out the operational aspects of a fire control program. They have leadership, personnel, equipment, communications, transportation and other facilities throughout the country, all of which are necessary for the implementation of a national fire control program. However, they would still require some training in the applied fundamental methods and techniques of fire prevention, detection, organization and suppression.

3.3.3 Work Hours

Fire control activities must operate independent of a regular work week. During periods of extreme or high hazard, all unit crews must be available 24 hours a day, seven days a week. This does not mean they will work 24 hours a day, but they must be available. However, as nobody wants to work straight through without any days off, and long hours each day are not conducive to good work, arrangements should be made to allow for time off or payment should be made for overtime labour.

3.3.4 Centralization

Forest fire control organization should be flexible. It should be able to work effectively at all administrative levels and be adaptable to the characteristic urgency of fire suppression. For example, during the life of a fire, the normal chain of command may be reversed. The fire boss of a particular fire is the man in complete charge of that fire. His decisions should not be changed by any superiors who are not familiar with the situation in that area. If it is necessary, men and equipment may be transferred from one district to another to make more efficient use of them. A sample organization chart for fire control is included in Appendices D and E. All various types of the responsibility shown will be needed in the long run. Until the program expands, some of the jobs can be combined in a single position or perhaps altered.

3.3.5 Administration

At the start of the forest fire control program, the fire control unit might form part of the management division. Macleod (1971) suggested that this unit should reach divisional status and be responsible for protection against fire, insects and disease.

Under general guidance from headquarters in Bangkok, fire control plans should be made by district foresters and their staffs. The flexible structure of the fire control organization must also be applied to the administration. Whether the job of fire control is big or small, plans should be prepared and be kept under review and revised from time to time. Maintaining written plans covering normal and emergency operations would be

the logical first step in ensuring that any given situation is to be handled in the proper way.

3.3.6 Training

Forest fire control organization in Thailand is a very new field, and very little work has been done in the past, so training will be a major function for a number of years. It should be regarded as highly as the need for fire control on the ground.

Training should be carried out at more than one level. All forest officers of the department stationed in the north and northeast of the country should have a good grasp of policy and also know something of how fires are fought. Furthermore, fire control training is a continuing process that should be repeated year after year until all concerned can fill their roles in the fire control organization with the most efficiency.

Training should be undertaken for a few weeks in advance of the fire season or early January. The crews that have been employed in previous years will not need to spend much time on training. The subject materials provided should include the use of tools and equipment, methods of fire line construction, fire behaviour, communications, and fire camp construction.

New foresters should receive some fire control instruction while undergraduates, so courses in the fundamentals of fire control should be included in the curriculum of Kasetsart University in Bangkok, the Forestry Ranger School in Prachinburi province and the Forest Worker School at Tak province.

3.3.7 Staff

The field work in fire control should be at the district level. The district forester is the man that should be given both the responsibility and the authority to deal with fire. The following positions should be found in the proposed complete district fire control organization:

- Assistant District Forester

This man should be in charge of all forest protection programs for the district. He should be trained in organization and policy for forest fire control. His position is as a direct assistant to the District forester concerned with fire control. He will be responsible for overseeing the operation of the fire season suppression activities. In the event of a major fire, he might be the person to assume the position of fire boss. Presuppression activities also are his direct responsibility and should be initiated or closely supervised by him, and planning functions should not be delegated. He should keep in close contact with headquarters in Bangkok. The training of men to fill these positions might be a big problem in the beginning, but all these individuals would have to be given a short practical session of instruction on fire control from headquarters.

- Deputy Chief Protection Unit

This position is as a direct assistant to the chief of the protection unit. He should take responsibility for all aspects of fire control in his unit area. His work is under supervision of the assistant district forester.

- Fire Warden (honorary)

This position might be considered the most important of the jobs

X of forest fire control in the field. The chief of a village, or the owner of a logging concession should take this position. He should be the man that actually comes into contact with the man on the ground, whether it is a logger cutting on his concession or a shifting cultivator practising his system of agriculture on public land. He should work under supervision of the Deputy Chief of the protection unit. The qualifications for an honorary fire warden are: interested; reliable; available; informed; maintains contact up and down the administration ladder; can be used when needed; trained and has a vehicle (at least a bike).

- Fireman

This man might be a seasonal employee or transferred from other duties, but should have a good knowledge of fire suppression techniques. His basic skill might be as a fire fighter. His skill will vary from fighting fire under local field conditions up through the individual who is knowledgeable about almost any fire situation. A worker in the "fireman" category should be capable of holding any one of a number of specific jobs depending on the particular fire problem such as, suppression crew, lookout fireman, fire patrol man, and also fire warehousemen's assistant.

- Dispatcher

This position may become important in the future after a widespread system of lookout towers and fire patrol is established. This job involves monitoring the radio or telephone system, receiving fire calls from the lookouts, plotting fire locations, and then dispatching the most suitable control force. A high degree of knowledge about the district, roads, trails, fuel conditions, and fire behaviour is necessary. This man is the number one office assistant of the Assistant District Forester.

3.4 Fire Control Plans

3.4.1 General Plans

A plan for improving forest fire control in Thailand should consist of four parts: The objectives, the goals, the operations and the development plan. To be worthwhile planning must be based on facts, and so a careful analysis and appraisal of the existing situation is necessary. As the situation regarding forest fires can vary from place to place, the plans to cope with these conditions must also vary.

Forest fire control activities in Thailand must be carried out by authority of the Forestry Department. The aim is to hold the number of fires to an absolute minimum. Suppression activities should be designed to keep the amount of burned area within a level set by the local forest manager. Laws, regulations, directives and administrative orders should be fairly and thoroughly enforced.

The goals of fire control plans should be implemented on a five year basis (Appendix H) with major evaluation and improvements scheduled. The goals which should be set up are: expand the fire prevention program; carry out a field evaluation of fire problems; set up the fire control areas; set up and maintain a basic fire evaluation information system.

Working plans for fire control procedures are necessary at all levels; the Headquarters District, and Protection unit. The Headquarters should be responsible for: coordination with other resources; providing guidelines for services and administration; financial allocations; providing prevention program direction, and training.

The district offices should be responsible for: coordination of protection units; administrative support for protection unit; fire prevention and enforcement; and training. The protection unit should be responsible for: field work in all fire control activities, administration of fire control personnel; basic evaluation and planning.

These programs should be planned as far in advance as possible and designed to serve as many functions as possible, such as road construction, timber management, reforestation, and watershed management. Planning will be done at the headquarters level after initial recommendation from the district and unit level. The planning should originate at headquarters fire control headquarters in Bangkok where standard guidelines for analysis of the fire control situation can be drafted and submitted to all districts which have a fire problem. After that, all the individual plans can be reviewed, and evaluated by the central office.

3.4.2 District Plans

Most information in district plans will be based on accumulation of local facts and their analysis. It can be presented by a series of district base maps, on which the resources and all physical features of each district can be shown with special emphasis on transportation, manpower, and equipment sources. It is suggested that fire records be kept for all fires that occur in the district.

Facts, such as place, size, fuel, cause of fire, damage and control action should be recorded (Appendix G). After a complete plan is available, the headquarters should make final adjustments and decide on the rate and direction of the future program. Details of topics required on

district plans are shown in Forest Fire Control and Use by Brown and Davis (1973).

3.5 Fire Presuppression

When first starting fire control in Thailand many problems will occur. There will be inadequate equipment, expertise, manpower, transportation, communications, and the biggest problem of all will be lack of money. Basic requirements must be arranged for well in advance of any fire suppression action. Presuppression is the largest and most involved element of most fire organizations, and there are dozens of factors that should be taken into account. Some important factors are described below.

3.5.1 Detection

It was mentioned in item 2.1.4 that most forest fires in Thailand are man-caused, surface fires. It is very hard to determine the effectiveness of any particular detection program. The development of effective and economical detection systems requires careful consideration about the intensity, frequency, causes, and location of fires. To be efficient the detection of fires must be a planned operation, making use of all the possible means of detection, including ground patrols, observations from lookout towers, air patrol or cooperation by the public in reporting fires. The systems must be considered as follows:

Ground Patrol:

This system is a very simple arrangement but, as with most things, it can be vastly improved if executed methodically. Ground patrol can be carried out on foot, on horse, bicycle, or small truck. Patrolling where there are no roads may be on foot, horse, or, if trails permit, bicycle. The

patrolman should be a keen observer, adept at making use of various vantage points, such as tall trees and ridgetops. If he knows his area well, he can do quite a good job of detection. He should know not only the topography of various trails, but also the work and habits of the people who are using the forest. The areas assigned to a patrolman by this system should be the most valuable or those where the danger of fires starting is most acute. This system would be the most practical for a newly formed fire control organization like Thailand's, not only because there is a lack of modern facilities but also because of its relative inexpensiveness. Patrol by bicycle crews (Figure 4) has been tested in fire protection experimental areas and found to work very well.

Lookout System

Lookout towers should be developed for wider coverage of areas than is possible by ground patrols. From the simple use of the vantage points selected by the ground patrolmen it has developed into a modern and precise practice. A good lookout system has to be developed gradually, since funds rarely permit building a complete system at the beginning. Nevertheless, an initial plan of development should be made in order to avoid costly mistakes. From all data on the protection area, it is possible to make the final selection of lookouts and prepare a general plan for the system. Installation can then proceed as funds become available.

A lookout system should be developed first in some teak plantation areas that are facing fire problems. Lookouts would be valuable not only to detect fires but also to prevent the theft of teak.

Figure 4. PATROL BY BICYCLE CREW.



Air Patrol

At present, air patrol is becoming extensively used in many countries and is likely to increase. In general, however, the use of aircraft for this purpose is not necessary in Thailand except during a few weeks a year in the periods of extreme fire hazard. Probably fixed-wing aircraft which patrol to prevent illegal cutting could do fire patrols at the same time.

3.5.2 Communication

The methods of communication should be checked out before construction of access routes and towers, while development of a detection system is being planned. There are two systems that might be used in Thailand. Ground-line telephones will work well where the distances are comparatively short and where the local people will not cut the wire. This system should be developed in teak plantation areas or in some experimental areas.

Radio networks will probably be used eventually and there may be good reasons for starting out with that form of communication. There are also the existing radio networks in the protection section of the Forestry Department that exist to protect forests from illegal cutting. During the fire season, these radio networks should be made available for fire control.

All operators should be trained from the outset to follow standard operating procedures very strictly. Poor operating procedures are sometimes not only very frustrating, but they can be costly and possibly disastrous.

3.5.3 Transportation

Good forest fire management demands good transportation. The vehicle situation in the Forestry Department at present is extremely poor. A four-wheel drive vehicle is essential in rural Thailand. The standard one ton 4x4 'pick up' is a satisfactory tool for fire control use, for it can carry men, cargo and equipment as well as a tank or trailer. The number of vehicles necessary depends on the local situation and every district will have to be analysed individually with the idea in mind of keeping travel time to a one-hour maximum. Travel time should be reduced as finances allow and protection becomes more intensive. Care must be taken that any vehicle purchased for fire control use can also be employed outside of the fire season for other jobs.

The Forestry Department of Thailand as a government agency operating on limited funds cannot construct many kilometres of roads. The best solution is for the loggers to construct their own access roads to standards described and enforced by the Forest Authority. These roads will then become good forest fire control road systems. Normally, no thought is given to alignment, surfacing, erosion control, location or maintenance of logging roads. Many logging roads are just mud tracks often following a river, so that after the logging is finished and maintenance ends, most will be impassable within a year.

Small motorcycles and bicycles are cheaper, well-adapted to travel on rough roads, and can be used on trails quite efficiently and safely, sometimes they even go where a jeep cannot. A forest fire guard could travel by motorcycle and thus cover a larger area than by foot. The use

of horses should be another possibility. They are much slower on roads but they can go in areas where roads and trails are poorly developed.

Transportation by air is limited in Thailand. It should be used primarily for patrolling to prevent fire and illicit cutting, but not for transportation, as it is not practical and costs too much.

3.5.4 Equipment

There should be two factors in mind when selecting fire fighting equipment, namely, the job that is required of a particular piece of equipment and the persons who are going to use it. Fire fighting equipment takes many forms from the expensive helicopter down to the common shovel. In Thailand, for the next few years, there is very little use to be gained from airplanes, bulldozers or even power saws. The equipment that should be selected must be suitable for fighting fires in heavy forest fuels, and for use by unskilled men requiring a minimum of training. However, as the area of plantations extends, heavy mechanical equipment should be provided for fire line construction and a number of large capacity water tankers should be secured.

Hand Tools

Hand tools provide the basis of fire fighting equipment in highly developed fire fighting organizations in Canada, the U.S.A. and Australia. It is reasonable to apply this system also to Thailand. Some tools are plentifully distributed around the country in local uses other than fire fighting but others will have to be purchased by the department and kept just for these emergencies. A suggested tool distribution for a ten-man fire fighting crew, without water, is:

TABLE 3

Tools suggested for ten-man fire fighting crew, without water.

Tool	Mountain Areas	Grassland	Dipterocarp forest	Remark
Swatter	3	3	10	All tools should be locally made. This 10-man crew is suitable for natural forest wild-fires.
Shovel	4	3	5	
Macleod tool	1	-	4	
Grubhoe	3	2	-	
Fire rake	2	5	-	
Crosscut saw	1	-	1	
Axes	1	-	1	

All the sharp tools should have a file with them. The foreman should have a compass, map and all the necessary fire forms. A portable radio is also very necessary. Back firing torches may be needed sometimes. In addition, each man on the crew should be equipped with a hard hat and proper footwear. There should be an adequate supply of drinking water and food, and also first aid equipment, either in a large kit for the group or individual one-man kits.

Power tools

A Pump-unit crew should be provided for big plantations where there are more intensive fires. Pump specifications should be carefully chosen for their proposed use. A pump that weighs less than 40 lbs will

perform well at pressures in excess of 200 lbs, and will deliver an adequate volume of water for most fire fighting purposes in Thailand. The most suitable pump for general fire fighting purposes should be the centrifugal type.

Slip-on tankers can be designed to fit on a vehicle not usually used for fire fighting. There are various types of slip-on tankers but the ones chosen should be completely self-contained with the pump and live-reel mounted on the tank. The unit should not be so big that it will become completely unmanageable, the optimum size is probably about 150-200 gallons, designed for a light rear-wheel-drive truck.

All fire control equipment should not be designed as single purpose items but rather should be planned to be capable of serving the whole field of forestry from business management through reforestation and timber management. But during periods of high and extreme build up all equipment should be on stand by for fire fighting purposes. A suggested list of fire fighting tools for a unit (25,000 acres, and 320,000 acres) is given in Table 3.

3.5.5 Building

At the beginning of the fire control organization program, construction of facilities is necessary. Some crew quarters, offices and headquarters may temporarily be located in the same place as the protection unit, but new buildings should be designed for practicality and economy.

Lookouts should be constructed as high as possible above the ground for greatest visibility. Guardhouses should be located at optimum

spots to encourage permanency of the forest guards and help build up a better work force. Bunkhouses should be maintained for seasonal use in remote areas in which there is no other choice of housing.

These buildings might cost a lot of money. Generally, the lowest-priced combination of efficiency, durability, ease of maintenance, looks and comfort should be picked and it should blend in with the typical type of construction in the future.

3.6 Fire Suppression

The previous chapters have discussed many things leading up to the actual fighting of forest fires, which is the whole purpose of this report. Effective and economical fire suppression can be accomplished by good decision making and correctly applying solutions to each tactical problem. The responsible person must be ready to modify tactics during suppression action whenever there is a significant change in the behavior of a fire. The application of fire suppression methods is a highly applied skill, but the emphasis here is only on general methods that may be useful for typical situations in Thailand.

3.6.1 Fire Suppression Methods

There are three methods of suppressing fire which can be used in the present state of forest fire control in Thailand: these methods are: clean fire line, back firing and application of water, sand or light soils. In some areas where there are dangerous fuel types, and large fires can be expected, a combination of all three is preferable. Almost all fires in Thailand are surface fires, which can generally be extinguished by direct

application of water or by the construction of a clean fire line directly across the fire front.

The use of backfiring is sometimes needed. In many situations, direct attack becomes impossible and attempts to use it merely result in a greater loss to the forest estate than the amount sacrificed during a backfiring operation. Backfiring requires a carefully considered plan of attack designed to reduce the total area likely to be burned, and demands skill and experience. Correct fire suppression methods and tactics are described in detail by Brown and Davis (1973) in their Forest Fire Control and Use text. However, these elements should be indicated in a fire plan, and local fire control manuals should be written to facilitate instruction and improve practice.

3.6.2 Patrol and Mop-up

After the fire is considered under control, it is the end of forest fire fighting, but the fire control operation is not finished yet. Mop-up is one of the most important parts of fire control. There should be some patrol men watching for spot fires to prevent fire from breaking over control lines. Patrolling for spot fires outside control lines is also important. Both patrol and mop-up must continue until it is certain that the fire is absolutely out, which normally would require them to be maintained for two to three days after the last smoke was seen.

3.6.3 Damage Assessment

Damage assessment is the final job following mop-up, and it should take into consideration damage to soils, watershed, valuable timbers, regeneration, and other land uses. It may take a few years to complete

fully agreed and defensible methods but a start must be made soon.

3.7 Forest Fire Law Enforcement

As discussed previously in item 3.1.4 regarding fire prevention in Thailand, enforcement should be of primary importance. Similarly, in forest fire suppression, law enforcement also is an extremely powerful tool. The processes of law enforcement in Thailand can be described as follows:

3.7.1 Organization:

The most effective way of control of man-caused fire would be the division of the forest land into small units, based on natural boundaries. Adequately trained men and equipment are to be posted to each unit which is located in or near the forest under its responsibility. The facilities that should be fully provided are office buildings with living quarters, fire fighting equipment, transportation, communication and safety requirements. Each unit area should be divided into small compartments by a series of fire lines which are kept continually clear of undergrowth and wide enough to use for patrolling or to constitute a base from which the fire fighter can start.

Law enforcement should be a primary duty of all forestry department employees, and all forest officers should keep in mind that law enforcement is their responsibility.

3.7.2 Warning and Citation:

All persons who are responsible for causing a careless or

negligent fire should be issued a "Notice of Unlawful Burning Citation" for a first offence. In addition, the violator should be informed of his civil liability for all damage caused by the fire. This warning does not preclude prosecution by the forestry department in criminal or civil action. This interim move might lead to better cooperation from the local people.

3.7.3 Investigation of Fire:

After the fire is suppressed the fire boss should make a thorough investigation in an effort to locate the origin of the fire. He should look for any evidence that might indicate the cause or an offence, such as tracks, particles of clothing, remains of camp fires, discarded cans, etc. This should be a methodical search, planned in advance so as not to unintentionally destroy evidence. All possible witnesses at or near the fire should be questioned. Records should be made during the investigation of such things as time of day, whom contacted, weather conditions, items or evidence found at scene, etc.

3.7.4 Interview witnesses:

Generally, it is very difficult to interview witnesses in cases of forestry crimes in Thailand. The key witnesses normally do not want to get involved in something which does not concern them or their property, and most people still believe that the forests belong to nobody. The interviewer should make a general statement regarding the purpose of the interview. The introduction should establish a good relationship between the interviewer and the person being interviewed. He must be careful not to elicit false

information through improper questioning. He may permit discussion of matters unrelated to the crime in order to place the person interviewed at ease, but he must not permit the person being interviewed to become evasive. An interview should be conducted as soon as possible after the discovery of the violation, but the interviewer should not rush to an interview without first deciding who should logically be interviewed first. The interviewer should take as much time as is required for a complete and thorough interview. Interviewing should be by local forestry officers.

3.7.5 Testifying in Court:

The most important part of law enforcement in Thailand is testifying in court. If many forest fire criminals are freed in court, the act itself will be a failure. So, the forester must do his best to maintain the power of the forest fire law.

Preparedness is most important for testimony in court. The officer should review thoroughly his original notes, sketches, photographs, plates, and fire report. All the answers should lead to a chronological account and should be consistent. Revisiting the fire scene may prove helpful.

While testifying in court the forest officer should be controlled in mannerisms, speak clearly, be polite, pay strict attention to questions, giving brief, complete answers, watch for trick questions, testify only to facts, and be straightforward and truthful.

3.8 Summary

The ultimate goal should be to place all hazardous areas in Thailand under intensive fire management. In order to achieve this, many factors must be taken into account. An effective and economical detection system involving ground patrols and lookouts is required. A radio network for good communication and better fire fighting equipment will have to be provided. Developments of methods of prevention and suppression, which are suitable for fighting fire in heavy forest fuels and for use by unskilled men who have a minimum of training, is required.

Improved laws and better enforcement might be the most important aspect for establishment of an effective forest fire control operation in Thailand. The objective of the laws should be to increase cooperation by educating and warning the general public. At the same time the forester must keep doing his best to maintain the power of the forest fire law by helping enforce it fairly.

Because improvement of fire control is essential, but expensive, it should start in local areas and on a small scale. Fire control plans should be expanded as sound results are achieved and financing becomes available.

4. FIRE APPLICATION

4.1 Introduction

Forest fire management is concerned not only with fire control problems but also with fire use or fire application. Fire has been responsible for much of the variety we find in nature and for that reason we can say fire is good when it does what we want it to do. Good prescription and careful management are the best ways to use fire to do what we want.

It seems highly probable that prescribed burning is a tool that is really needed in both plantation programs and in natural forest management plans in Thailand. Some early burning practices have been done in young teak plantations for several years as a hazard reduction measure. Also a few trials have been made of prescribed burning in natural teak bearing forests for preparing seedbeds and planting sites in an attempt to obtain a better distribution of age groups, but the methods used were not the best available. Macleod (1971) noted that "The process appears to be effective in end results, but the output per man day is far too low". In the same report he advised that "The increased use of prescribed fire should be made in the future and therefore it would pay dividends if plans were made to improve field practices".

Improved methods of conducting prescribed burning should be developed in Thailand, and early burning programs should be widely practised in the future. Better planning and equipment should be properly applied.

A prescribed burn can be used for many purposes and even when used

for just one purpose there may be side benefits to other resources. The conducting of prescribed burns also provides an excellent opportunity for giving fire fighters needed experience.

On the other hand, prescribed fires can be harmful as well as beneficial. It is a complex tool and should be used only by those properly trained, as it calls for the use of many of the basic principles used in fire suppression. Proper diagnosis and detailed planning are needed for each and every area (U.S.D.A. For. Serv. Georgia, 1972). Nevertheless, the use of controlled fires depends on objectives and methods for proper fire application.

4.2 Objectives of Fire Application

A prescribed burn has the advantages of being a planned rather than an emergency activity. It also offers full opportunity to take advantage of what is known about fire behavior and the changes to be expected from variations in fire weather. It is more carefully planned than the control of unwanted fires. There could be many reasons for prescribing fire in the forests of Thailand and local prescriptions are needed. This study is only a simple guide for forest managers to make decisions and plans. However, the basic principle objectives of fire application for Thailand should be as follows:

4.2.1 Stand Improvement

Many of the teak-bearing forests in Thailand now have low-value and poor-quality trees, and other species often occupy the land best suited to growing teak. Unwanted species, especially bamboos, normally suppress

teak seedlings. In areas where there is low rainfall during part of the growing season, competition for water may be significant. Generally, physical elimination of bamboo and unwanted species is not economically practical. These unwanted species can only be kept from competing with teak stands by using prescribed burning.

4.2.2 Site Preparation for Seeding and Planting

Fire alone can expose adequate mineral soil and control competing vegetation until seedlings become established. Normally on teak bearing sites competing vegetation is a big problem, but fortunately, teak has more fire resisting power than other species, and burning can encourage teak regeneration by destroying its less fire-resistant competitors.

Kadambi (1972) has recorded that:

"In Burma, a burning experiment in a young crop of teak with bamboo between 1900 and 1908 resulted in the almost complete removal of bamboo and, compared to the unburned plot, there was 43 per cent more girth increment of teak trees in the burned plot."

Burning a second year teak plantation in India has indicated that the burning is advantageous, resulting in: (1) improved growth of teak; (2) plants in the burned portion requiring fewer weedings; (3) more uniform teak growth; and (4) a mixture of timbers and superior types of undergrowth appearing (Kadambi, 1972).

Generally, in preparing sites for natural regeneration in Thailand, the knowledge of the anticipated seed crop and the date of earliest seed fall in each forest is essential. For teak, burning should be done as early as possible after adequate seed crop has fallen. For other species, burning should be done in advance of the initial seed fall. This date will vary by species and locality.

4.2.3 Improvement of Wildlife Habitat

Fire is an efficient and economical tool for improving food and cover conditions for certain wildlife species. Then a program for controlling or use of fire has a significant influence on wildlife habitat.

The effects of fire on wildlife resources are of vital importance to the future. At the present time prescribed burning is highly recommended for wildlife habitat management in the southern United States, but in Asia very few aspects of fire use have been studied. The major wildlife species benefiting from the use of prescribed fire for habitat improvement are deer, quail, and doves (U.S.D.A., Georgia, 1972). Fire can be employed to remove competing species, to encourage desired browse, and to increase the quality of vegetation in an area (Henderson, 1972).

Prescriptions for burning should recognize the biological requirements of the preferred wildlife species, and the condition of stands. The proper size and time of burns are critical to success in the use of fire in managing wildlife habitat.

In Thailand it would appear that wildfire has aided in the degradation of some soils and most of the vegetation cover. Fire seems to be an essential factor, however, in maintaining suitably large areas of savanna forest exploitable by both wild herbivores and domestic livestock.

4.2.4 Improvement of Cutting Methods

Fire may be an essential tool in carrying out silvicultural systems, where wood production is the primary value of the forest. For example, in selecting teak and some other species for cutting, markers need

better visibility and better accessibility to do the desired job. Fire can be a means of thinning over-dense stands in certain situations. After cutting, the large volume of slash is not only a fire hazard but also prevents natural regeneration of teak and some valuable species. The ground should be cleared by prescribed fire. However, fire is a dangerous tool. It should be applied with skill, and very cautiously, in commercial timber types.

4.2.5 Improvement of Accessibility

Prescribed burning could improve accessibility and visibility for many purposes. Burning off underbrush improves the efficiency of timber selecting, marking and harvesting. Removing accumulated material before harvesting provides safety for timber markers and loggers due to better visibility. Hunters and hikers also benefit from easier travel. Fire can also remove brush, litter and unwanted plants to control species composition and to create a better pattern of plants while improving accessibility for recreation.

4.2.6 Control of Insects and Diseases

Insects and diseases are a serious menace to some of Thailand's commercially important tree species. For example, teak bee hole borer (Xyleutes ceramicus), which seriously attacks teak stands (Dusit, 1968) has a larva stage under teak's fallen leaves. The use of fire is the most practical method of controlling this borer. The danger of many kinds of insect and disease populations developing in slash areas and attacking green timber is another important factor that should encourage prescribed burning.

4.2.7 Use in Land Clearing

Up to the present, complete land clearing and burning of forested sites to enable the establishment of teak and coniferous plantation has been practiced in Thailand. This is done on a systematic basis, and is almost universally used. The areas prepared for forest plantations are commonly cleared of existing cover by methods similar to the clearing of land for agriculture.

Fire still is a most powerful and economical tool for land clearing, but this use of fire has been an important factor conditioning the attitude of agricultural people toward the forest (Macleod, 1971; Brown and Davis, 1973).

Fire is powerful "medicine" and evidence is abundant that it can be extremely harmful (Davis, 1959). Yet with accurate and skilful application, it can be a good prescription in particular situations.

4.3 Methods of Fire Application

To use prescribed fire successfully, Brown and Davis (1973) advised that "several exacting requirements must be met". These requirements are knowledge of fire behavior, fire danger ratings, burning techniques and advance planning of any prescribed burning operation. The objective of prescribed burning and weather factors must be correlated closely with the proper ignition technique. Sometimes, when variations in prescribed weather conditions occur, combining two or more ignition techniques can achieve good results. The following burning techniques are popular in the United States, Canada, Australia and New Zealand. Some might be applied to Thailand at the

present time and others may be suitable for future use, when the value of forests has increased. The following methods are only simple guidelines for fire application. Local requirements may make some combinations to best accomplish the purpose intended and to prevent harmful effects to the forest resources.

4.3.1 Back Fire

The back fire technique consists primarily of backing fire into the wind. Fire is started along a prepared base line, such as a road, plowed line, stream, or other form of barrier, and allowed to back into the wind (U.S.D.A. For. Serv., Georgia, 1972).

On flat or gently sloping terrain, the line of fire is set at right angles to the wind direction. In steep topography, it is set along the ridgetop. An additional fire break is required for each line of fire set, usually about every 100 to 200 meters (Brown and Davis, 1973).

This method is the easiest and safest type of prescribed fire, but when used in heavy rough and sapling size stands, steady winds and secure base control line are required.

It could be applied to teak or coniferous plantations in Thailand to reduce fuel hazard or to control insects and diseases.

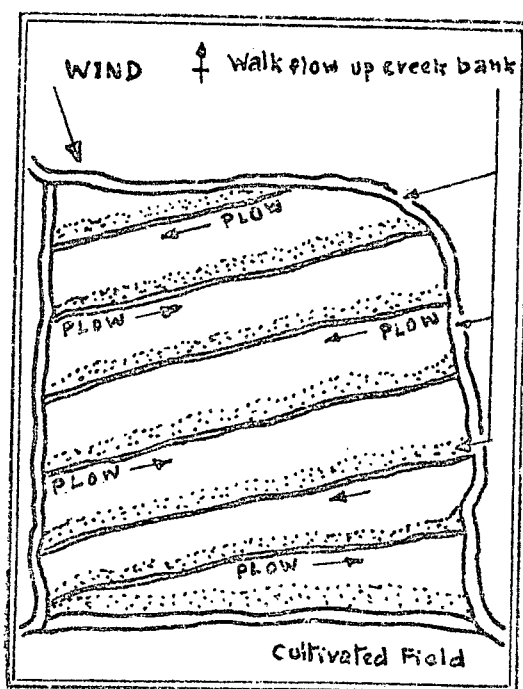


Figure 5. BACK FIRE.

4.3.2 Flank Fire

The flank fire technique consists of treating an area with lines of fire set into the wind which burn outward at right angles to the wind, after a burned safety strip has been established along a firebreak (Brown and Davis, 1973).

It is used quite often to secure the flanks of a strip-head fire, backing fire or other methods as they progress. This method can stand little variation in wind direction and needs expert crew coordination and timing (U.S.D.A. For. Serv., Georgia, 1972).

It is useful for a small area, light to medium fuels, fast area ignition, and for securing the flanks of other burning techniques.

This method could be applied to a small high value natural forest area or plantations that need more intensive fire protection.

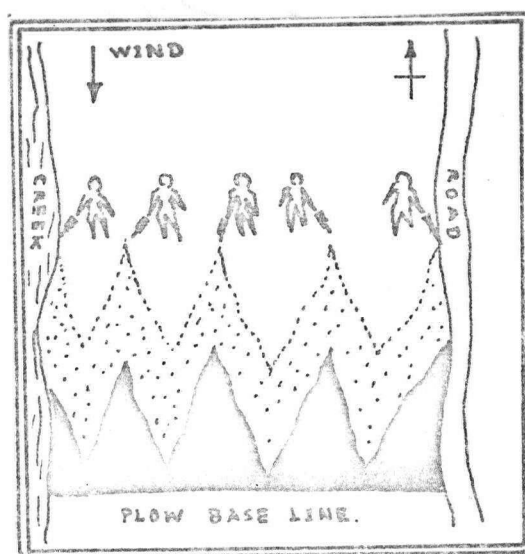


Figure 6. FLANK FIRE.

4.3.3 Head Fire

This method consists of setting fire to run with the wind or upslope. It is the reverse of the back-burn technique, though the head fire is seldom permitted to run freely for any considerable distance in a prescribed burning project. Usually a broad safety strip of firebreak is burned out first, then the line of fire is set at a predetermined distance from it and parallel to it and permitted to burn into it with the wind. This creates a new burned strip. As soon as it has burned out, a new line of fire is set parallel to it and the process is continued until the entire area to be treated has been burned over (Brown and Davis, 1973).

This technique is useful for small areas with light and even distribution, and requires use in cool weather, flat fuels, high fuel moisture content and low wind shifts. It could be applied to moist-deciduous or some evergreen forests in flat areas of Thailand, and probably could be used to develop wildlife habitat.

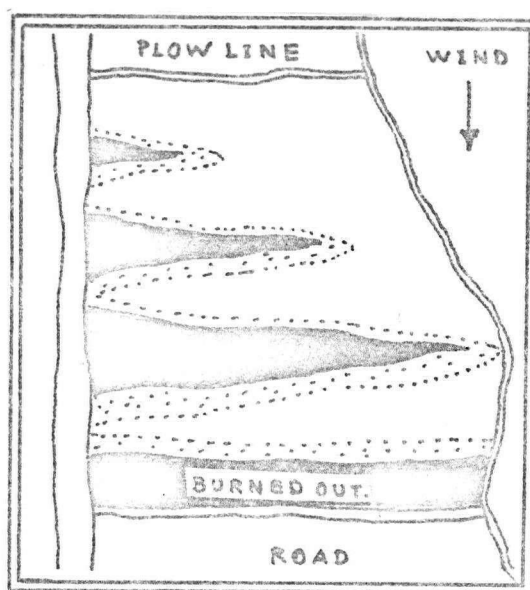


Figure 7. HEAD FIRE.

4.3.4 Spot Fire

This method consists of spacing set fires far enough apart that they will not interact yet will cover the area intended by the end of the burning period. It is designed to avoid strong convective activity. The purpose is to reduce fuel hazards over large forest areas at low cost and minimum damage to the forest stand (U.S.D.A. For. Serv., Georgia, 1972).

The spot technique requires considerable experience by the prescribed burner. Timing and spacing of the individual fire spots are the keys to successful application of this method. It can be used with light variable winds and it is useful for using in uniform fuels and allows fast ignition.

This method could be applied to natural teak forest in Thailand. The special advantage is to reduce fuel hazards over large areas at low cost. Fires will be spread only on exposed slopes, dry sites and unwanted areas. The large area can be treated in a single burning period with little or no construction of interior firebreaks. Aerial ignition methods also might be used in this system.

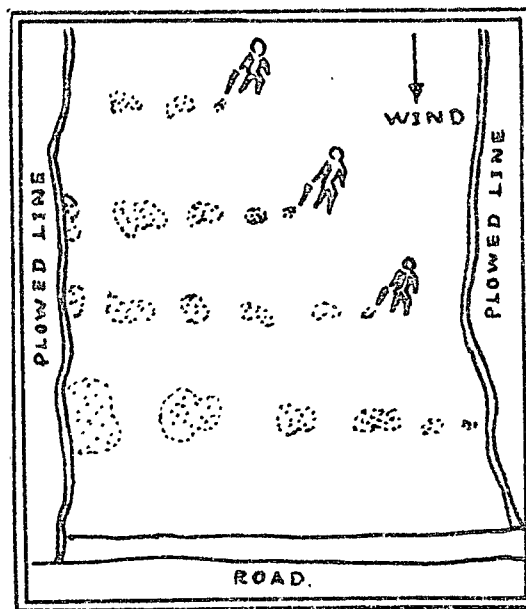


Figure 8. SPOT FIRE.

4.3.5 Ring Firing

This technique consists of starting fires along the outer edge of an area and letting them spread toward the center. The base control line, usually on the down wind side of the burn area, is made secure with back and flank firings. The method is applicable on small areas of an acre or two in light to moderate fuels or as an auxiliary to strip and centre firing in larger areas.

This method of firing has been widely used in Thailand for a long time, in slash disposal efforts on areas preparatory to planting.

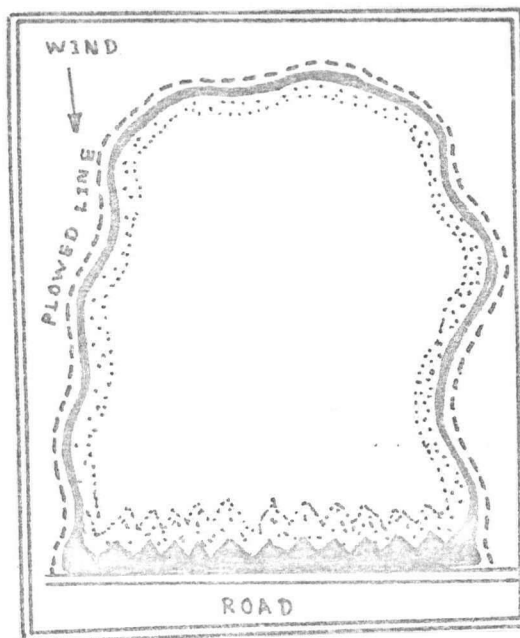


Figure 9. RING FIRING.

4.3.6 Chevron Burn

This technique consists of establishing the line of fire in a crescent or V-shaped pattern. In general, the chevron pattern is made to conform to that of the rear of a wildfire or to the mirror image of a natural head fire. This gives stability to the front of the backing fire. The technique may be supplemented by use of flank fire or head fire techniques, depending on circumstances (Brown and Davis, 1973).

The chevron technique may be suited to use in hilly areas of natural teak forest in Thailand to prepare sites for seeding, and should be used in combination with other techniques for stand improvement.

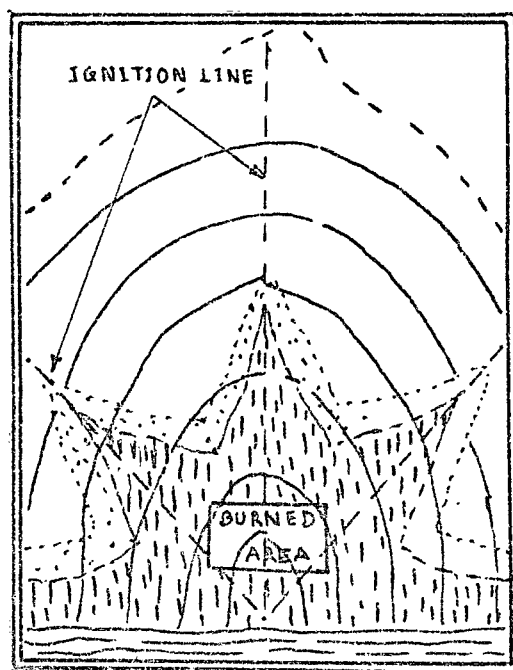


Figure 10. CHEVRON BURN.

4.4 Summary

The aim of this chapter is to define general prescribed burning guidelines. In addition, forest managers should consider the objectives of burning, the fuel in the area, general weather conditions, and topographical characteristics in order to select the proper method and the proper time for a safe but effective burn. A small test area should be burned before the actual ignition plan is put into effect. This test fire is a last-minute check of ambient conditions and can be used to adjust ignition times and methods. The test fire is carefully controlled so that, if conditions prove unfavorable to immediate burning, further ignition can be halted. If forest managers could predict with certainty that a prescribed burn will not become uncontrolled the objectives of burning will be significantly beneficial and the net effects on local ecology will be favorable.

5. RESEARCH STUDIES

5.1 Introduction

Everyone knows that fires can damage the forest, but no one realizes just how much damage they can do. Many local people and some professional Thai foresters seem to believe that annual fires are nature's way of keeping the forest ecology in balance. Some believe that fires benefit teak forest, but others claim that fires damage it. What are the facts? Research can provide the information that people need to know.

Fires can reduce forest yields, kill seedlings and start decay and insect attacks in larger trees. Hardwoods are particularly susceptible to fire wounding and decay may start in these wounds. Sometimes, severe fire, or repeated light fires, can start serious erosion.

All these things need research studies on a small scale before large investments in fire control are carried out in Thailand. Research initially should provide the scientific information as follows:

5.2 Basic Studies of Ignition and Combustion :

These studies will identify significant variables and develop fuel classification scales that will lead to more precise and effective field studies. This research should prove helpful in developing local information for a variety of types and show:

- How composition of fuels influences rate of ignition and combustion.
- How relative humidity affects the probability of ignition.
- How combustion is affected by differences in the controlling variables.

5.3 Important Fuel Characteristics

The fuel characteristics that need to be studied include the size, shape, amount, compactness, arrangement, and vertical distribution of individual pieces of fuel. These basic studies will lead to a better understanding of fuels. But research should be aimed directly at the characteristics of fuels that make control of forest fires difficult, that result in varying rates of spread, and that contribute to fire damage (Nelson and Bruce, 1958).

5.4 Fire Danger Measurement and its Application

Fire control organizations cannot obtain full value from danger measurements unless stations are located and operated according to acceptable technical standards. Danger measurements may be put to other important uses, such as guiding administrators in the issuing of burning permits, manning fire towers, general organization planning, and desirability of woods closures. For Thailand, good records for several years could be used to measure the effectiveness of fire prevention efforts (Nelson, 1961).

5.5 Fire Prevention

Almost all fires in Thailand are man-caused and presumably preventable. Research should be done to determine why people set forest fires. Stopping man-caused fires may depend on the pattern of leadership in a community and the attitudes and characteristics of forest residents. Studying of local problem areas may help pinpoint both the motives of fire starters and the most effective prevention methods.

5.6 Ecological Studies

Forest fires can affect trees and other vegetation, animals, and the soil in many ways. Detailed knowledge of fire effects is needed to guide the management of Thailand's forest whether it be to plan efficient fire control, to mark burned areas for salvage or to plan effective use of fire.

The studies of direct effects of fires, such as average mortality, and growth loss under various weather and stand conditions, could give an actuarial basis for improved fire damage appraisal, and for the economic analysis of fire control costs. Indirect effects also merit some study. Fire research should provide information of fire effects on livestock, game, insects, soil and watersheds.

5.7 Techniques of Fire Use

Prescribed fire is one of the least expensive tools in the forester's kit for treating large areas. Nevertheless, local studies of fire use may lead to more efficient techniques of handling fire. Research should be done into methods for regeneration of difficult areas, and into controlling unwanted species on teak bearing forest. Prescribed burns at various times in the dry season should be tested.

5.8 Suppression Techniques

The most difficult of all problems facing fire control organization is suppression. Research studies may be needed in equipment development, and improved transportation and communication systems. These studies should be done in addition to the new program in Thailand for immediate

needs, but formal research is not required now.

5.9 Fire Control Planning

Studies should be made on the beginning projects. As more is learned about weather, fuels, effects, prevention, and suppression techniques, and the many other elements that enter into fire control, more basic facts will accumulate with which to plan more effectively.

These facts should be:

- What is the best distribution of funds among prevention, detection and suppression?
- How much money is needed (Table 4) to produce a really effective organization?
- Is the present unit organized in the management branch in the best administrative position for operations?
- Is the communication system adequate to meet emergencies?
- How much can the government afford to pay for fire control?

5.10 Summary

Fire control organizations have a continuing job of studying their own operational problems, and need to hire skilled investigators to help in solving local problems of fire prevention, in deciding what types of equipment are most suitable for local use, and in developing applications for the findings of basic research. The research work is a valuable tool in initiating and furthering the success of a forest fire program in Thailand.

Some of the fundamental studies may have been done already in similar tropical countries. Results from studies of fuel characteristics, basic ignition and combustion, and also methods of fire danger rating might

be borrowed from developed countries and applied to Thailand. But some aspects require intensive local study, e.g., fire prevention, fire suppression, fire planning, fire use, and ecological impact studies.

TABLE 4

Brief description of personnel and financing
required for five year program.

Period	Activities	Number of Personnel			Cost (\$)	
		Profes- sional	Tech- nician	Labour	Salaries	Equip- ment
1974	Collect data & information	1	2	8	3,340	1000
1975-76	Fire planning studies	1	2	8	8,280	2000
1975-78	Initiate ex- perimental studies on all necessary as- pects (at least fire prevention, fire suppres- sion, fire ecology and fire use)	2	4	16	27,520	8000
	Total	4	8	32	39,140	11000

Notes

- 1) Professional officer should be a graduate from the school of forestry at Kasetsart University. (Salary plus diem allowance is about \$100 a month.)
- 2) Technicians should be graduates from the Ranger School (two year course, salary plus diem allowance is about \$60 a month).
- 3) Labour should be seasonal jobs that last only four months. (Salary is about \$25 a month.)
- 4) This amount of money does not include transportation and communication.

6. COST OF FIRE CONTROL

6.1 Introduction

The important cornerstone of forest fire control management in Thailand will be economics. Fire control is of long-term benefit, and once started it should be continued, so it is necessary to plan a long range program that will be assured of adequate financing. It may be better to protect a quarter of the forest adequately than to protect all of it poorly. A plan of starting small and constantly expanding as finances allow, with never a cutting back of protected areas, should be the goal.

6.2 Cost of Fire Control Units

If fire control is to be developed into a function of the Royal Thai Forestry Department, some expenses have to be considered very carefully. Men have to be trained, equipment purchased, communications developed, transportation facilities made available, and new jobs created with their additional salaries. These operations cost a lot of money. It is impossible for Thailand to protect all of its forest area from fire immediately. The best way is to protect the most important areas first, and then later expand to the lower value areas.

Considering the forest area of Thailand, 100,000 square miles in total 25,000 square miles of natural teak forest and 117,200 acres (1970) of plantation, it is very difficult to estimate the cost of forest fire control organization for the whole forest area.

However, it can be said that each plantation area should have its own forest fire control plan and the expenses should be covered by an annual

budget.

Macleod (1971) proposed a fire control plan for the 9140 acres of future pine plantation in the north of Thailand and estimated the costs of first year organization as follows:

1. Fire control equipment	\$16,260
2. One technical fire control officer	\$ 960
3. One lookout man	\$ 360
4. One dozer operator	\$ 840
5. Two patrol men	\$ 720
6. Fifteen-man crews stand by (3 months)	\$ 1,350

Total expense is \$20,490. It may be about \$3,500 for the next year operation, or it is about 30 cents per acre for fire protection. This seems to be very expensive compared to 18 cents per acre in Canada and 22 cents in the U.S.A. However, this plan includes the lookout man, dozer operator and patrol men who might be considered as permanent staff. If seasonal jobs only were counted the expense would drop to \$2,690 annually, or about 25 cents per acre, or if these resources cover 25,000 acres the cost will drop down to 14 cents per acre.

The costs of fire control should be included in the annual budget for a plantation program from the beginning. Each 100 square kilometer unit (25,000 acres) should be protected at a cost of \$11,375 for the first year and \$1,445 annually thereafter (Tables 5 and 6). There should be about forty fire control units for the forest plantations of Thailand costing about \$445,000 for the first year and about \$57,800 annually.

Considering the 25,000 square miles of natural teak forest, each 500 square miles should be set up as one unit area for fire control. It will cost \$35,525 for the first year, and may be about \$4,240 annually (Tables 5 and 6). There should be fifty units distributed around the country.

Some flammable species, like pines both in the plantation and natural forest, may cost more to protect from fire, but some hardwood species may cost less. Such factors must be carefully considered in forest fire planning.

This amount of money does not include the overhead expenses such as cost of supervision, buildings, facilities, safety, some communication and some transportation. These figures show that it is impossible for Thailand to start protecting all forest area from fire at the same time. The idea of an "adequate control method" (Brown and Davis, 1973) should be considered for this situation, until the results from research show what type of forest should be protected and for how long each type will need protection from fire. For example, many people believe that teak trees need protection against fire only in the seedling stage which lasts about three to five years after logging. Normally teak forests have a thirty years felling cycle and a 180 years rotation, so that only one-sixth of the whole area has to be protected. If this hypothesis is true, fire protection will cost only one-sixth of the above estimates.

TABLE 5

Cost of Forest Fire Fighting Equipment

Item	Cost(\$) Per Unit	Plantation unit (25,000 acres)		Natural forest Unit (500 sq.ms.)		Remarks
		Quantity	Total cost (\$)	Quantity	Total (\$)	
Fire fighting shovels	3	15	45	15	45	Locally made
Fire rakes	4	15	50	10	40	Locally made
Back pack pumps	35	10	350	10	350	Imported
Axes	2	12	24	20	40	Locally made
Drip torches	39	5	195	5	195	Imported
Cross cut saw	3	10	30	10	30	Locally made
Slip-on-tank (75 gal.)	1360	1	1360	1	1360	Imported
Land Rover truck	5500	1	5500	1	5500	Imported
Radio trans- ceivers (one set)	2000	1	2000	1	2000	Imported
Fire lookout tower & equip- ment	400	1	400	4	1600	Imported
Fire weather instruments	125	-		1	125	Imported
Dozer D4 cat.	20000	-		1	20000	Imported
Total			9930		31285	

Note

1) Locally made equipment estimated by author's experience.

The prices should be good for the year 1971 but some may be about 10% higher in the year 1974.

2) Imported equipment costs in Canadian dollars from the list of Wajax Company; including shipping, packing and duty.

TABLE 6

Cost of manpower for forest fire organization

Items	Cost(\$) Per day	Plantation Unit (25,000 acres)		Natural Forest Unit. 320,000 acres (500 square miles)		Remarks
		Quantity	Total Per year (\$)	Quantity	Total Per year (\$)	
Fire technician	2	-	-	1	720	Full time
Lookout man	1.5	1	135	4	540	Seasonal
Dozer-operator	2	1	180	1	180	Seasonal
Patrolman	1	2	180	5	450	Seasonal
Standby crews	1	5	450	15	1350	Seasonal
Equipment maintenance and fuel	-	-	500	-	1000	
Total			1445		4240	

Note

- 1) The current budget for Forestry Department is about 300 million baht (about 15 million dollars). If the Department decides to reduce one percent of its current program for fire control, it would ensure a start being made.
- 2) The fire control unit in plantation areas is more important than in natural forest, and natural teak forest should come before other species.

6.3 Summary

There is no doubt that fire control organizations cost much money, but many factors suggest that it is badly needed in Thailand. Forest fire control projects involve long run returns and do not produce direct revenue, so it is very hard to persuade people to adopt them. The valuation and appraisal of loss in timber and forest value are very complicated but reasonable procedures. These processes will bring forward examples to help people realize how much forests were damaged by fire, and the level of fire control expenditures may be considered more appropriate then.

7. CONCLUSIONS

Obviously, it is difficult to draw firm conclusions about how fire management should be improved without further careful discussion with concerned senior foresters in Thailand. My plan for improving fire control should serve as a foundation from which I can urge desirable future developments. By bringing together information about methods used in well established North American fire management agencies and testing their ideas against the situation in Thailand I hope that it will be possible to effect many improvements.

High priority should be given to a program of collecting data on which fire control planning can be initiated to include number, size and cause of fires by time periods and location, and also there should be a complete network of rainfall stations.

Some aspects of the thesis can be used directly. The posters and ideas for fire prevention could be implemented relatively easily. The draft law will require searching examination by forest law supervisors and senior foresters, careful review politically, and then, hopefully, Royal assent. The plans for buying equipment, building new facilities, and hiring necessary staff also must be reviewed carefully. Perhaps, outside agencies as well as the most concerned Thai industrialists can be persuaded to lend support to those Thai foresters who view indiscriminate use of fire with deep concern. The information and ideas presented must be translated into the Thai language. Hopefully, they also will be translated into an effective action program which will capture and hold the interests and energies

of both villagers and professional managers. The issues are real and very important. Fires must be managed soon to preserve our teak forests, protect our watersheds, and provide much more pleasant environments in which to work and live. It might take one or two generations to achieve a big change in the public's attitude towards forest fires, but it is imperative that such changes be made. If foresters of today do not play an active part in the program, how can we expect the further generation to do so?

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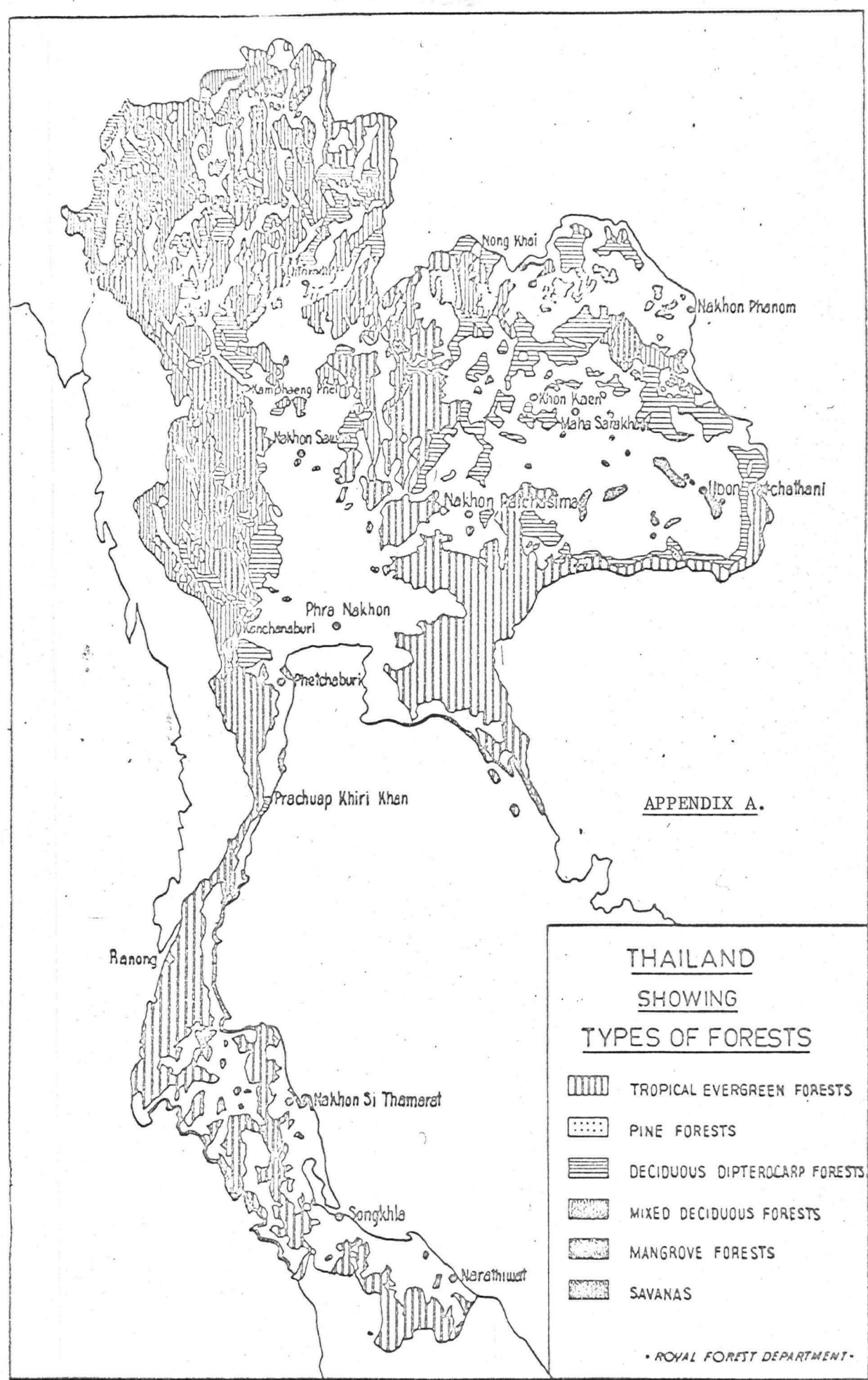


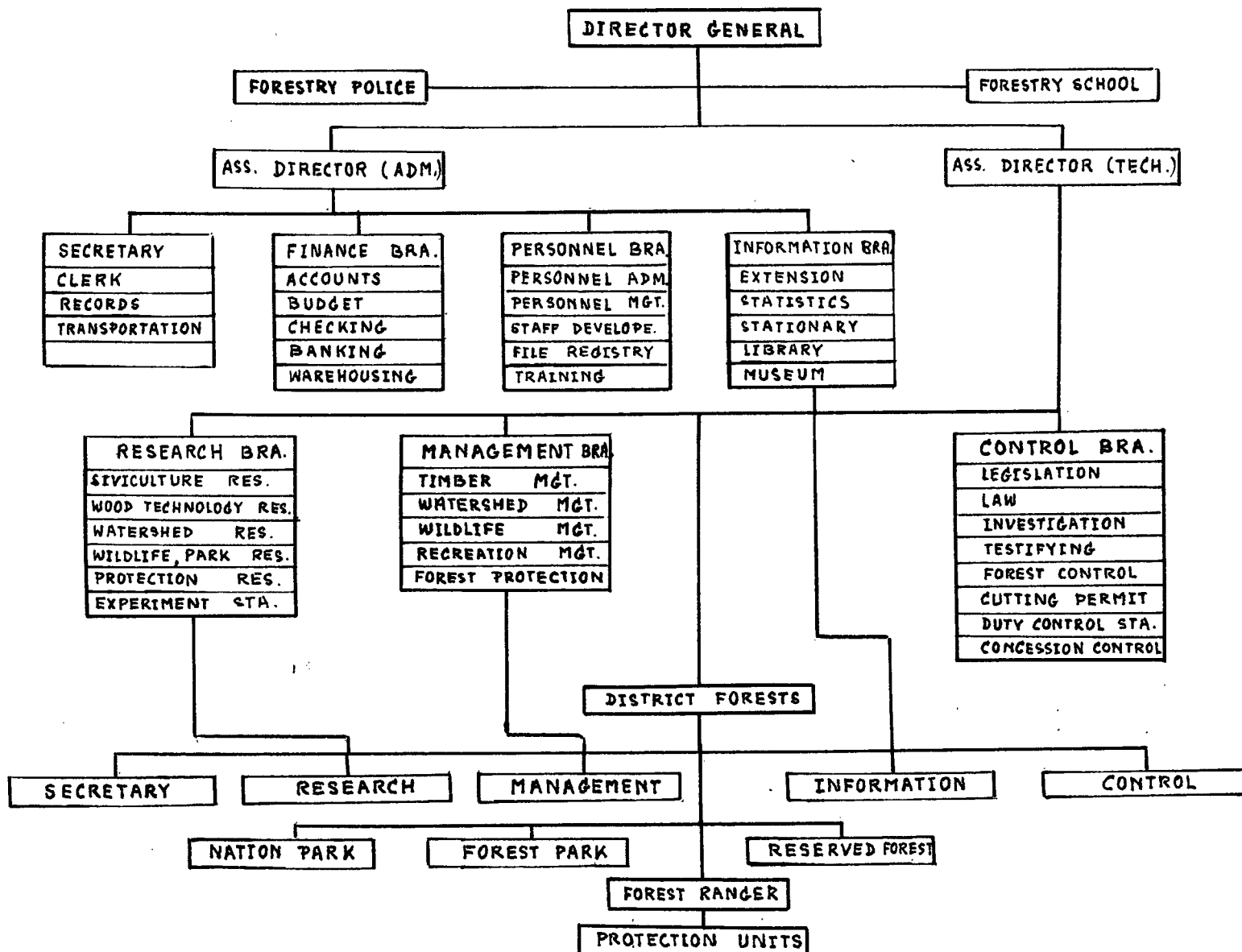
Table showing type of forests and other strata for all regions of Thailand (in Km.²)

No.	Region	Area	Forest Area	Percentage	Type of forests and other strata											
					Teak Plant.	Non - Teak Plant.	Evergreen	Mixed Dec.	Dry Dipt.	Pine	Man - grove	Scrub	Swamp	Shifting Cultivation	Agricultural land	Other
1	North	171,186	116,275	67.92	149.8	42.4	17,647	41,373	53,802	1,350	-	1,911	-	20,705	30,306	3,901
2	North - East	170,226	78,153	45.91	41.2	24.1	26,127	11,713	40,236	12	-	-	-	18,081	58,20	13,707
3	East	36,394	21,163	58.15	4.2	0.1	17,878	161	2,819	-	300	-	-	2,629	11,579	1,025
4	West	49,263	35,056	71.16	4.0	37.9	13,742	5,247	6,632	-	33	-	-	2,190	10,772	1,343
5	South	69,064	38,770	55.41	1.5	23.4	32,188	-	-	-	3,348	2,416	793	4,381	21,875	2,937
6	Central	17,877	605	4.76	9.6	14.7	581	-	-	-	-	-	-	-	17,272	-
Total		514,910	290,022	56.32	210.1	142.6	108,163	58,494	103,489	1,362	3,681	4,327	793	47,986	176,901	-

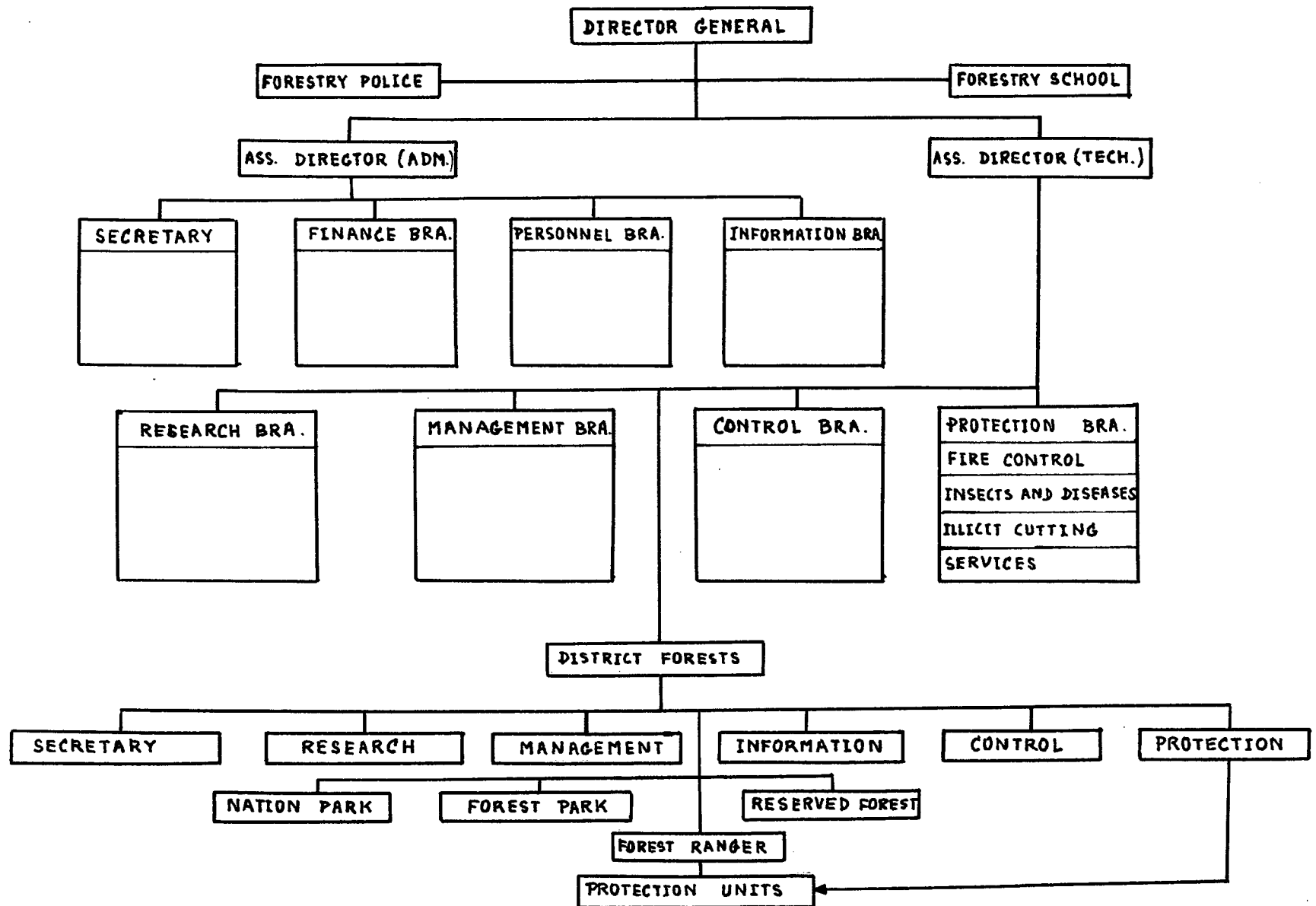
Remarks

1. The area of each province is obtained from land Classification Surveys Record.
2. The areas of several forest types and other strata other than forests are obtained from Photo - interpretation results of photo scales 1:60,000 taken in 1961.
3. Forest area in the West including Bamboo forest in Kanchanaburi Province is about 9,362 Km.².
4. Agricultural land in the South including Rubber Plantation is about 6,700 Km.².
5. Forest Plantations are recorded up to December 1970.

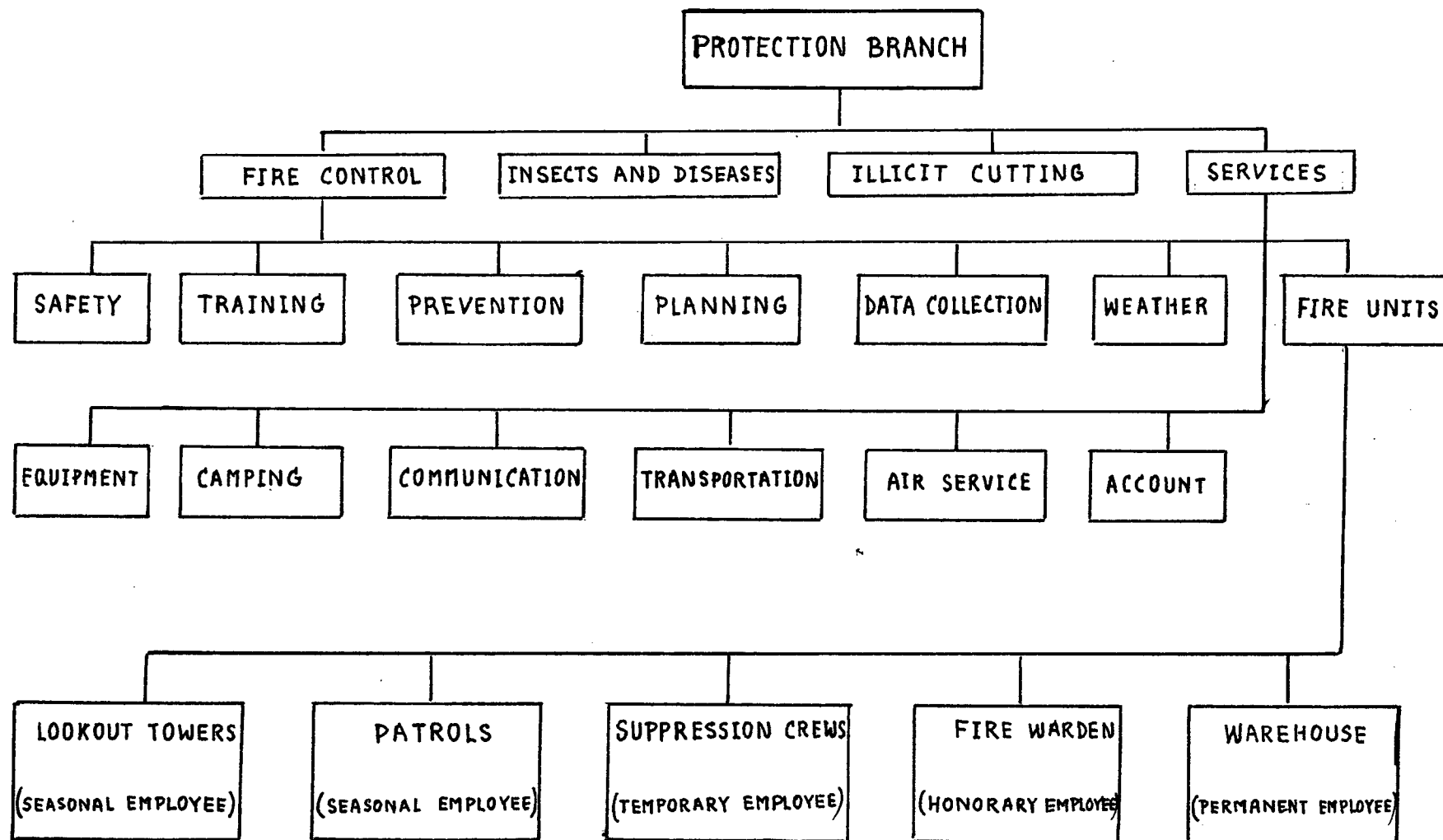
APPENDIX C. ORGANIZATION CHART, 1972, ROYAL THAI FORESTRY DEPARTMENT.



APPENDIX D. ORGANIZATION CHART (PROPOSED) ROYAL THAI FORESTRY DEPARTMENT.



APPENDIX E. ORGANIZATION CHART (PROPOSED) FOREST PROTECTION BRANCH.



APPENDIX F

FOREST FIRE ACT

B. E. 2516

(HYPOTHETICAL)

IN THE NAME OF HIS MAJESTY, KING BHUMIBOL ADULYADEJ

IS GRACIOUSLY PLEASED TO PROCLAIM THAT:

Whereas it is expedient to have a law on Forest Fire;

Be it, therefore, enacted by the King, by and with the advice and consent of the Constituent Assembly acting as the National Assembly, as follows:

Section 1. This Act shall be called the "Forest Fire Act, B.E. 2516".

Section 2. This Act shall come into force as and from the day following the date of its publication in the Government Gazette.

Section 3. All other laws, rules and regulations in so far as they are already provided by this Act, and are contrary to or inconsistent with the provisions of this Act shall be replaced by this Act.

Section 4. In this Act:

(1) "Forest" means an area of land proclaimed to be forest under a Forest Act, which carrying forest growth, that may be damaged by fire.

(2) "Timber land" means any natural forest or forest plantation which has enough timber or woody brush, standing or down, to constitute a fire hazard to itself or adjoining lands.

(3) "Flammable material" shall include, but is not limited to refuse, debris, waste forest material, brush, stumps, logs, rubbish, fallen timber, grass, stubble, leaves and slash.

(4) "Officer" means the person appointed by the Minister for the execution of this Act.

(5) "Director-General" means the Director-General of the Forestry Department.

(6) "Department" means the Royal Forestry Department.

(7) "Minister" means the Minister who takes charge and control for the execution of this Act.

Section 5. The Minister of Agriculture shall take charge and control for the execution of the act, and shall have the power to appoint competent officials and to issue Ministerial Regulations for the execution of this Act. Such Ministerial Regulations shall come into force upon their publication in the Government Gazette.

Chapter 1

Fire Season

Section 6. The period from the first day of January to the 30th of April in each year shall be a fire season.

(1) Except under the authority of fire permit, no person shall start a fire or ignite working fire in or near the forest or timber land during a fire season for any purpose other than cooking or obtaining warmth.

(2) Upon application therefore an officer may issue a fire permit.

(3) A fire permit may be cancelled or suspended at any time by an officer, and immediately upon receiving notice of such cancellation or suspension, the permittee shall extinguish any fire started under the permit.

Chapter 2

Prevention Measures

Section 7. No person shall:

(1) Within or adjacent to timber land, dispose of a lighted match, or other flaming or glowing substance, or any other substance or thing in such condition that it is likely to ignite a forest.

(2) Set fire or cause or procure the setting on fire of any flammable material on timber land, without notifying the nearest officer and without taking reasonable precautions both before and after lighting the fire and at all time thereafter to prevent escape thereof.

(3) Deposit or leave unattended on any railroad or highway right-of-way within or adjacent to forest, any fire or live coals, or set or maintain thereon any fire for the purpose of cooking, heating, or providing light or warmth unless such fire is enclosed within a stove, drum, fireplace or other properly prepared location.

(4) Within or adjacent to a forest, set a backfire, or cause a backfire to be set, except under the direct supervision of the officer, or unless it can be established that the setting of such backfire is necessary for the purpose of saving life or valuable property.

(5) Without authority, destroy, deface, or remove any notice, sign, or poster of the Department, posted for the better protection of wood lots, forests, or wild land from fire trespass.

(6) Light or maintain within or adjacent to a forest an open fire or campfire without clearing flammable material surrounding such fire as necessary to ensure against the escape or spread thereof, or leave such fire before it is extinguished.

(7) Kindle or start, or direct another to kindle or start, any fire in or near a public road or highway within or adjacent to timber land unless it is under control at all times, and properly extinguished before left.

Section 8. Every member of a road construction or maintenance crew, whether employed by the Highway Department, or the commissioners and every road contractor or subcontractor of said state road department and their employees shall keep all fires set by them under control, and confined to the right-of-way and shall suppress all fires discovered and detected by them within fifty meters of the center line of the right-of-way of the public road or highway.

Section 9. No person shall wilfully, maliciously, wantonly, or negligently set on fire or cause or procure to be set on fire any forest or timber land, or plantation not owned, leased or controlled by him or them.

Chapter 3

Extinguishment of Fire

Section 10. An officer may, at any time in the interest of forest protection, extinguish a fire or order any person in charge, or apparently in charge, of a fire to extinguish the fire.

Section 11. Every person who has started a fire in a forest, that is not kept under control, shall report the fire without undue delay to an officer and in any prosecution or an action the onus is upon him to prove that he so reported the fire.

Section 12. No person shall:

(1) Hinder, obstruct, or impede an officer in performance of his duties.

(2) Refuse or neglect to provide any privately owned requirement or to render assistance when required.

Chapter 4

Penalties

Section 13. Whoever violates section 7 (4) (7) (8) and section 9.....shall be punished with imprisonment not exceeding five years or a fine not exceeding twenty thousand baht (\$1.00 is about 20 baht), or both.

Section 14. Whoever violates section 7 (1) (2) (3) (5) and Section 11.....shall be punished with imprisonment not exceeding one month or a fine not exceeding one thousand baht or both.

Section 15. Whoever violates section 6 (1) (2) and section 12 (1) (2).....shall be punished with a fine not exceeding five hundred baht.

Section 16. All equipment, instruments, and vehicles used by any person in committing the offence of burning the forest shall be forfeited regardless of whether they belong to the offender, and whether any person is convicted.

Chapter 5

Regulations

Section 17. The Minister may make regulations:

- (1) declaring part of the country to be a fire district and declaring the name that each fire district shall bear;
- (2) declaring any period of fire season in any year to be fire season in a fire district or any part of a fire district;

- (3) declaring any fire district to be a restricted fire zone;
 - (4) for any other reason for the purpose of fire control.
-

Note: This hypothetical Forest Fire Act is based on:

- 1. Forest Act 1941 (Thailand)
- 2. National Park Act 1961 (Thailand)
- 3. State-Forest Fire Laws Southern Region (U.S.A.)
- 4. Forest Fire Prevention Act 1970 (Ontario)
- 5. Forest Act 1962 (British Columbia)
- 6. Forestry Act 1972 (India)

11. Equipment Requirement

List of Hand tools.....

List of Power tools.....

List of Machine hours.....

12. Weather Data by Burning period..

Temperature

Relative Humidity

Wind Direction

Wind Speed

13. Topography

Elevation

Slope

14. Cause of Fire.....

15. Map Reference.....

FIRE MAP

Scale 1:

Note: Form to be completed and dispatched to District Officer
within 12 hours of end of fire.

APPENDIX G

FIRE DISCOVERY REPORT FORM

1. Name of Observer.....

Lookout No.

Patrol No.

Protection Unit..... District.....

2. Fire Name.....

3. Fire Number.....

4. Time of Discovery.....

Hours.....

Date.....

5. Azimuth.....

6. Location:

Zone No.

Compt. No.

Close to

7. Fuel Type

Grass..... Dry Dipterocarp forest.....

Fern..... Teak forest.....

Pine..... Others.....

8. Position on Slope

Flat..... Middle of slope.....

Base of slope..... Top of slope.....

9. Amount of smoke

Heavy

Light

10. Colour of Smoke

Grey - white.....

Yellow - white.....

Black.....

11. Direction of Smoke

N S Straight up.....

NE..... SW.....

E W

SE..... NW.....

12. Wind

Speed.....

Direction.....

13. Other Remarks:

.....
Station Dutyman's Name

Time Notified.....

Reporting Time.....

APPENDIX H

Brief Five-year Plan for Forest Fire Management

1. Project Schedule

Program Item	Years and Months of Application																Remarks				
	1974				1975				1976				1977					1978			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4		1	2	3	4
1. Expert advisers																					
2. Survey and Data Collection																					
3. Establish Fire Control Units																					
4. Develop Fire Control Plan																					
5. Develop communication Network																					
6. Equipment purchase																					
7. Install Weather Station																					
8. Fireline Construction																					
9. Fire Prevention Campaign																					
10. Training																					
11. Research Studies																					

Note

1. Fire season lasts from January to April (Jan.-1, Feb.-2, Mar.-3, Apr.-4)
2. Expert advisers and some equipment should be requested from C.I.D.A.
3. Equipment (Tables 3 and 6), Fire control units (Table 4), Communication and Research Studies follow suggestions in the text.