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TECHNICAL AND VOCATIONAL FORESTRY AND
FOREST INDUSTRIES TRAINING

B U R M A

FOREST FIRE MANAGEMENT

UNITED NATIONS DEVELOPMENT PROGRAMME

FOOD AND AGRICULTURE ORGANIZATION OF
THE UNITED NATIONS ROME, 1986

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Report prepared for the
Government of Burma
by

the Food and Agriculture Organization of the United Nations
acting as executing agency for
the United Nations Development Programme
based on the work of
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Forest Fire Management Consultant

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ABSTRACT

The increasing demands on the forest resources of Burma require a comprehensive conception and strategy to protect the forest land against destructive influence by man. The ecological balance of many watersheds and other forest land has already been disturbed seriously by unsuitable land-use practices. Besides extended shifting cultivation, overgrazing and uncontrolled fuelwood extraction, wildfires are one of the most important disturbance factors. It is estimated that about 6.5 million hectares of forest land are affected by wildfires each year. They are all caused by man and spread mainly from poorly controlled shifting cultivation or grazing land improvement fires or due to negligence.

Soil depletion and erosion are the most serious consequences and may result into siltation of irrigation and hydro-electric power dams. Furthermore long-term planning goals in plantation establishment are endangered. On the other hand, not too much is known in detail about the fire effects on teak-bearing forests and other fire-climax forest communities.

Recommendations are given to strengthen forest fire management and research in order to avoid long-term ecological and socio-economic goals of forest management. A follow-up project consisting of three components, demonstration, training and research, is proposed.

The Food and Agriculture Organization is greatly indebted to many organizations and individuals who assisted in the implementation of the project by providing information, advice and facilities.

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GLOSSARY

AERIAL FUELS - The standing and supported forest combustibles not in direct contact with the ground and consisting mainly of foliage, twigs, branches, stems, bark, and vines.

BACKFIRE - A fire set along the inner edge of a control line to consume the fuel in the path of a forest fire and/or change the direction of force of the fire's convection column.

CONFINE A FIRE - To restrict the fire within determined boundaries established either prior to the fire or during the fire.

CONTROL LINE - A comprehensive term for all the constructed or natural fire barriers and treated fire edges used to control a fire.

DRAPED FUELS - Needles, leaves, and twigs that have fallen from tree branches and have lodged on lower branches or brush. A part of aerial fuels.

FIREBREAK - Any natural or constructed discontinuity in a fuelbed utilized to segregate, stop, and control the spread of fire or to provide a control line from which to suppress a fire.

FIRE HAZARD - A fuel complex, defined by volume, type condition, arrangement, and location, that determines the degree both of ease of ignition and of fire suppression difficulty.

FIRE MANAGEMENT - All activities required for the protection of burnable forest values from fire and the use of fire to meet land management goals and objectives.

FLASH FUEL - = Fine fuels
Fuels, e.g. grass, ferns, leaves, draped (i.e. intercepted when falling) needles, tree moss, punky wood, and some kinds of light slash, that ignite readily and are consumed rapidly by fire when dry. Generally characterized by a comparatively high surface-to-volume ratio.

FUEL - Combustible material.

FUELBREAK - Generally wide (20-300 meters) strips of land on which the native vegetation has been permanently modified so that fires burning into them can be more readily controlled. Some fuelbreaks contain narrow firebreaks which may be roads or narrower hand-constructed lines. During fires, these firebreaks can quickly be widened either with hand tools or by firing out. Fuelbreaks have the advantages of preventing erosion, offering a safe place for firefighters to work, low maintenance, and a pleasing appearance.

FUEL MANAGEMENT - The act or practice of controlling the flammability and reducing the resistance to control of forest fuels through mechanical, chemical, biological, or manual means, or by fire, in support of land management objectives.

PREATTACK PLANNING - Within designated blocks of land, planning the locations of fire lines, base camps, water supply sources, helispots, etc.; planning transportation systems, probable rates of travel, and constraints of travel on various types of attack units; and determining what types of attack units likely would be needed to construct particular fire lines, their probable rate of line construction, topographic constraints on line construction, etc..

PRESCRIBED BURNING - Controlled application of fire to wildland fuels in either their natural or modified state, under specified environmental conditions which allow the fire to be confined to a predetermined area and at the same time to produce the intensity of heat and rate of spread required to attain planned resource management objectives.

SURFACE FIRE - Fire that burns only surface litter, other loose debris of the forest floor, and small vegetation.

WILDFIRE - Any fire occurring on wildland except a fire under prescription.

1. INTRODUCTION

1.1 PROJECT BACKGROUND

About 70% of the total area of Burma (676,580 km^2) is covered by forest land, about 42% are regarded as closed and degraded forest and 28% as forest fallow containing a large proportion of permanent and shifting agriculture (FAO, 1984). Forest products provide a major financial contribution to the national economy. They are currently equal to rice as major earners of foreign exchange. Equally important is the use of, and the demand for, forest products by the rural and urban population for fuel and construction materials.

The ongoing exploitation of the forest resources and the growing population pressure have resulted in over-cutting, increased occurrence of wildfires and erosion, thus leading to large scale degradation of forest sites and disturbance of the ecological balance of many important watersheds. The total forest depletion is variously estimated at more than 100,000 ha annually. This has prompted the Government to fund large scale reforestation programmes. At present an annual reforestation of 36,000 ha is planned. Likewise the Government is taking endeavour to improve protection of the plantations and other forests from wildfires and other destructive influences.

The importance of the training needs of the forestry sector has been recognized by the Government in its Long Term Perspective Plan and the Four-Year Short Term Plans. Also, under the UNDP Fourth Country Programme, assistance was foreseen to upgrade training programmes and facilities for such training within the Forest Department and the Timber Corporation.

1.2 OUTLINE OF OFFICIAL ARRANGEMENTS

The Project Document "Technical and Vocational Forestry and Forest Industries Training, Burma" BUR/81/001 was signed by the Government of Burma, UNDP and by FAO as executing agency in 1983. The Ministry of Agriculture and Forests (MAF) was designated as the government implementing agency. The project became operational in December 1983.

The 1984 project revisions reassessed the immediate objectives and recommended, among others, to recruit a consultant on Forest Fire Management (3 m/m). The Project Interim Report (FAO 1986) also recommended the termination of the present project after completion of the additional input of the Forest Fire Management Consultant. The consultancy was initiated in February 1986, thus coinciding with the beginning of the forest fire season, and was operational until April 1986.

1.3 OBJECTIVES OF THE FOREST FIRE MANAGEMENT CONSULTANCY

The consultancy was designed to assist the Forest Department of Burma in the effort at improving the forest fire management strategy. The terms of reference of the consultancy gave special attention to:

1. Evaluate the various forest and plantation types and grade them according to potential risk from fire.
2. Review the Department's present strategies and requirements for forest fire protection management.
3. Review available equipment for forest fire protection at the Department and assess appropriate future equipment requirements.
4. On the basis of his findings, propose revised strategies and acting programmes to upgrade forest fire protection in Burma and in particular, identify assistance requirements in this field, and submit them in the format of a project document.
5. Prepare a training manual in forest fire protection suitable for introduction into courses to be conducted by the Burma Forest School.
6. Carry out a basic training seminar for selected staff based on this training manual.

In addition, the Forest Department and the consultant agreed to prepare a forest fire management plan for Maymyo Township as a model plan. Furthermore the research component was included by nominating a forest fire research officer, Forest Research Institute (Yezin).

He accompanied the consultant during the whole mission. With this the Forest Department followed the strong recommendations previously given during the establishment phase of the Burma Forest Research Institute (Farnsworth, 1979; FAO 1981).

2. RESULTS AND CONCLUSIONS

2.1 OCCURRENCE AND EFFECTS OF FOREST FIRES IN BURMA

2.1.1 The role and risk of wildfires in the different forest types

As a result of the great variation in rainfall, temperature, soil and topography, many different forest types are found in Burma. Tropical evergreen forests occur in many places of the highest rainfall zone in the south of the country. Hill and temperate evergreen forests are found in the eastern, northern and western regions where elevation exceeds 900m. The forest type changes to deciduous, then to dry forests along the transects towards the middle of the country as a result of decreasing rainfall.

Detailed classifications of the forests of Burma have been outlined in several descriptions (Troup, 1921; Champion, 1935; Edwards, 1950; Kermode, 1964). For the purpose of evaluating the role of fire in the different forest types, forests were classified according to the standard types currently used by the Forest Department. Since there is either no or low potential fire occurrence/hazard in several of these types, they will be mentioned only in passing; these latter types include:

a. Tidal forests
   These forests are situated within the tidal limits on alluvial flats in the delta and on sheltered muddy coastal areas. They are affected by the rise and fall of the tides. The most abundant species are Rhizophora spp., Heritiera fomes Buch., Carapa moluccensis Lamk., Sonneratia spp., and Excoecaria agallocha Linn.,

b. Beach and dune forests
   These forests form narrow strips along the coasts on sandy beaches and dunes. They consist of deciduous and evergreen species, notably Casuarina equisetifolia Forest.

c. Swamp forests
   These relatively open forests are characterized by small and scattered trees. Relict patches are found in inland

fresh water swamps on low-lying alluvial land, usually near rivers and lakes. The land is inundated periodically during the rainy season.

d. Evergreen forests

Besides the riverine forests situated along the banks of streams and in low lying areas, two major subtypes are distinguished. The giant broadleaf evergreen forests occur mainly in south Tenasserim. Among a great number of species the most important trees in the upper story are Dipterocarpus, Parashorea, Anisoptera, Swintonia and Eugenia spp.; Pentacme, Hopea and Michelia spp., are included in the lower story. Typical evergreen forests are characterized by a dense understory of numerous evergreen tree species or by dense growth of bamboo. The subtype, requiring about 2000 to 2500 mm of annual precipitation, occurs throughout Burma. Various Dipterocarpus spp., and other rainforest species are present, together with Xylia dolabriformis Benth., Gmelina arborea Roxb., Albizzia procera Benth. and Salmalia and Castanopsis spp.

Whereas the coastal forest types are generally not affected by fire, a potential exposure to wildfires exists in the swamp and moist tropical rain forests. In general, the untouched dipterocarp rain forest is characterized by a low load of available ground/surface fuels and a moist inner microclimate. As the forest is being altered by forest management practices (e.g. selective cutting) or opened by small scale shifting cultivation (Taungya), the evergreen forest becomes gradually susceptible to wildfires. Invasion of grasses and sun-exposure of surface fuels lead to increased risk of surface fires. Even light surface fires are apt to cause severe effects on the generally thin-barked and fire-intolerant trees of the rainforest association.

However, it must be recognized that extremely extended drought periods may even dry out the virgin rain forest type. The most severe

effects can be expected in organic terrain, e.g. in peat or swamp forests where deep burning ground fires may burn over long periods and consume the complete biomass. 1/

The other forest types are currently more or less regularly affected by fire and most likely the long-term fire influence has affected their character. Together with the man-made forests (teak, pine, eucalypt and other fuelwood plantations) they are described and evaluated in the following.

2.1.1.1 Mixed deciduous forests

These are economically the most important forests of Burma, as they contain teak (Tectona grandis Linn.) and other commerical hardwoods. They are subdivided into three types, the moist upper mixed deciduous forest, dry upper mixed deciduous forest and lower mixed deciduous forest.

The moist upper mixed deciduous forest is characterized by the presence of the bamboo Bambusa polymorpha Munro and Cephalostachym pergracile Munro. In upper Burma north of the dry zone B. polymorpha is replaced by Dendrocalmus hamiltonii Nees. & Arn. and Dendrocalmus membranaceus Munro with C. pergracile. Good quality teak is usually associated with Xylia dolabriformis Benth. It occurs on well-drained slopes and usually indicates a good quality of soil.

The dry upper mixed deciduous forest is usally characterized by the presence of the bamboo Dendrocalmus strictus Nees. In Upper Burma Thyrostachys oliveri Gamble may predominate, and C. pergracile and B. polymorpha may also occur. Characteristic trees are Tectona grandis, Xylia dolabriformis, Terminalia spp. Pterocarpus macrocarpus Kurz, Pentacme siamensis (Miq.) Kurz, Shorea oblongifolia Thw. and occasionally Dipterocarpus tuberculatus Roxb.

The lower mixed deciduous forest occurs in lower ground, usually on clayey soils, and is characterized by a scarcity or absence of bamboos. The most characteristic form of the subtype is found on alluvial flats near streams. Here teak occurs in quantity, often in pure stands and of large size, but usually not of good shape. Other characteristic species are Lagerstroemia speciosa Pers., Xylia dolabriformis, Terminalia tomentosa W. & A. and others.

1/ The extreme and prolonged 1982-83 drought in the West Pacific - South Asia Region led to disastrous wildfires in the rainforests of Indonesia, Malaysia (Sabah), the Philippines (Mindanao) and in Australia. In Kalimantan/Indonesia within several weeks wildfires destroyed a total of 3.6 million hectares dipterocarp forests, swamp and peat forests.

It can be presumed that the fire has played a major role in the successional development of the mixed deciduous forest and has influenced the distribution and the species composition of this forest type; the same refers to the deciduous dipterocarp forest (see 2.1.1.2).

As was mentioned by Kermode (1964) none of the teak-bearing forests of Burma are primeval virgin forests. All of them have, to some extent, been affected by man. The most lasting effect of all is the "Taungya" shifting cultivation where fire is used as the primary tool for removing the forest canopy and preparing the site for planting.

At first undergrowth and bamboos are felled and piled on the remains of the bamboo clumps. The objective of this is to ensure that there is sufficient fuel to produce a hot fire which will completely kill off the root stocks of the old clumps. With this the recovery and regrowth of bamboo is being retarded. This is an advantage in reducing the competition during the re-establishment of the forest.

On the other hand it has been proved that the "Taungya" fire and cultivation does not kill teak seedling coppice. Already in this development stage teak can therefore be regarded as fire tolerant. During the subsequent successional development, surface fires burn over practically all teak-bearing forests annually. Whilst the shoots of the teak seedlings may get burnt back repeatedly, the rootstock will not be affected by the fire and continues to grow larger year by year. If light is admitted by opening the forest canopy and/or the forest floor is not burnt back for a couple of years, the new shoot will grow with the vigour of coppice and get established within one growing season.

The common type of wildfire in the mixed deciduous forest, mainly caused by escaped Taungya or other agricultural fires, is a surface fire of moderate intensity. The main fuel components are the dry leaves of the teak and the other deciduous trees as well as of the bamboos that are shed during the fire season. Once the teak regeneration has produced a full and vigorous coppice, the flame height will not reach the fire-sensitive terminal buds. The heat yield (or fire intensity) of these light surface fires is generally not sufficient to overcome the temperature-insulating properties of the bark.

Where bamboo is not present, as in parts of the lower moist deciduous type, there is usually an abundance of weeds and small shrubs on the ground, particularly after the canopy is opened. Here, the exotic weed Eupatorium odoratum Linn., has shown a remarkable and aggressive ability to take possession of gaps on the forest floor. This weed also becomes highly flammable during the peak of the fire season.

It can be concluded that a great part of the teak-bearing mixed deciduous forests is characterized on the one hand by the fire tolerance of the most important species and on the other hand by the flammability of the forest fuel which, all together, are the essential properties of a fire ecosystem (sub-climax or fire climax).

It is often assumed that the fire-protection policy has caused the progression of a drier type of forest containing a high amount of teak to a semi-evergreen type in which teak is unable to regenerate naturally. The effect is even more marked in the moist forest which is approaching the evergreen type. Fire protection encourages undergrowth of bamboos, weeds and shade-tolerant trees at the expense of light demanding species such as teak. Periodic surface fires reduce the grass-shrub-understory layer and expose the mineral soil which is most favourable for germination of teak; additionally it has been suggested that teak seeds are very resistant to fire.

Historically there are few observations about the effect of fire in these forests and these are contradictory. An old observation quoted by Troup (1921) described the regeneration process after the gregarious flowering of Dendrocalmus strictus and Bambusa tulda Roxb. on a site where fire protection had been abandoned. Here it was found that the bamboos established themselves in dense masses even where late burning had been carried out in order to destroy the seed. Teak seedlings contemporaneous with young bamboo were not found to survive except on the edges of the flowered areas where the fire had not been so intense. The only successful teak saplings found were those which had already been on the ground prior to the flowering.

Another report deals with the teak selection system and fire protection in the Kangyi Reserve (U Kyaw Zan, 1953). Here it was found

that consequent fire protection over a continuous period of 45 years was successful in establishing teak as well as Xylia dolabriformis. The observation of steady decomposition of the leaves furthermore led to the assumption of increased soil fertility. The final observations in the late 40's, however, show up the contradictory results of fire protection. It became apparent that "the reserve was packed with beautiful stands of teak etc.", though "reproduction of teak was strikingly absent". Controlled burning to induce the natural regeneration of teak was carried out with no appreciable result during the plan period between 1933 and 1948. This was considered to be due to the shading effect of the canopy under the selection system.

The various observations and assumptions led to the abandonment of fire protection except for young teak plantations (Hundley, 1962). All this emphasizes the need for future forest fire research in Burma; this will be discussed in detail in para 2.5.

2.1.1.2 Deciduous dipterocarp forests and scrub forests

The most important forest types within this group are the "Indaing high forest" and the"Semi-indaing forest". Kermode (1964) has classified these forests as the edaphic types of the dry tropical forests and he included to this group, among other shrub associations, the "Indaing scrub forest".

The Indaing high forest occurs over several thousand square kilometers in the drier parts of Lower and Upper Burma. The forest takes its name from the characteristic species Dipterocarpus tuberculatus (In). Over large areas this forest type consists of an almost pure high forest of this species. In Upper Burma teak occurs locally, while Pentacme siamensis, Shorea oblongifolia and other Dipterocarpus spp., are common associates.

The Indaing forests are exposed to frequent and almost annual wildfires. The main fuel are the leaves of the deciduous trees which are shed during the dry season. Depending on the canopy density fire tolerant grasses like Imperata cylindrica (Linn.) Beauv. and Erianthus spp., encroach the forest. These highly flammable "flash" fuels create favourable conditions for surface fires to spread as wind-driven headfires through the bare stands. Crown fires do not occur in this fuel type although crowning (or torching) may be possible where dry leaves are not yet shed completely.

The dominant Indaing species can be regarded as fire tolerant. Observations have shown that particularly D. tuberculatus forms a thick and insulating bark. It has also a remarkable capacity of healing fire scars. During the field research near Yezin it was noted that within a stand the old "In" trees and stumps showed a uniform fire-scar shape on the up-slope side (which can be explained by the increased fire intensity on the lee side of the trees, especially if the fire is driven by the wind or slope). The formation of the fire scar and the healing process was dated back to about 17 years ago.

Fire protection may not lead to drastic changes in species composition. However, species like Quercus spp. and Wendlandia tinctoria D.C. may appear as a dense understory when fire is excluded. The Semi-Indaing forests can be regarded as transition types between the dry teak forest and Indaing. Pentacme siamensis is the dominating species which may occur in pure stands. Other important species besides Shorea oblongifolia and Dipterocarpus tuberculatus are Terminalia tomentosa, Tectona grandis and Xylia dolabriformis. In the understory different bamboo species are found. Besides a grass cover the undergrowth may consist of Flemingia, Dermodium and Indigofera spp. (Papilionaceae) and Phoenix acaulis Buch-Ham. (Palmaceae).

Wildfires sweep regularly through the Semi-Indaing associations. Since Pentacme siamensis shows the same fire-related surviving mechanisms as teak, both species seem to be favoured by the frequent fire occurrence.

The Indaing scrub forest occurs throughout Burma on shallow coarse sandy soils and laterite soils, on ridges in dry and exposed situations and requires between 60 and 200mm rainfall. The forest composition is usually much the same as Indaing and Semi-Indaing. The growth is much inferior to the foregoing types. Besides bamboo (Dendrocalmus strictus) a variety of shrubs are found.

Fire frequency in this scrub forest type is much the same as in other scrub associations, e.g. the "Than-Dahat forest" (with Terminalia oliveri Brandis, Tectona hamiltoniana Wall., Acacia catechu Willd., shrubby bushes and grass cover).

In the extreme dry parts of Burma the surface fuels in the scrub or savannah forest associations are more sparse and patchy. The wide spacing of plants and the bunch-type growing grasses can be regarded as long-term fire effects. This spatial dispersion of the fuel reduces both fire spread and intensity and may lead to irregular burning patterns.

2.1.1.3 Subtropical hill forests

The subtropical hill forests occur in elevations between 900 and 1800 m. Subtypes can be distinguished according to rainfall and site quality. Common species are Quercus spp., Castanopsis spp., Schima wallichii Choisy. (Theaceae) and species of the order Magnoliaceae and Lauraceae. On drier sites Quercus serrata Thunb. becomes characteristic.

The subtropical pine hill forests are characterized by Pinus kesiya Royle ex Gordon and Pinus merkusii Jungh. P. kesiya is found between 1200 and 2400 m whereas P. merkusii extends to lower altitudes and may be found associated with Indaing forest, between 150 and 750 m. Frequent wildfires occur in all of these forest types. The dominating species mentioned above can all be regarded as fire tolerant (see also para 2.1.1.5). Especially Pinus kesiya may form fire-induced open parkland forests. In Southern Shan State it was observed that the annual fires have created pure pine stands over vast areas. In the higher elevation the forest becomes mixed with fire resistant Quercus spp. and Castanopsis spp. In places where fire protection has been carried out, oaks, chestnuts and Bohemia spp. become dominant and more characteristic; this was observed in the reserve forests surrounding Taunggyi.

On higher elevations up to 2700m of the southern Chin Hills temperate species have been replaced by a fire climax woodland of P. kesiya and Rhododendron arboreum W.W.Smith (FAO, 1983). In the temperate pine forest of North Burma, Pinus wallichiana A.B.Jacks forms parkland on exposed slopes which are burnt over frequently (Kermode, 1964).

It also can be assumed that the sub-tropical hill savannahs on the Shan plateau and ridge tops of heights between 750 and 1500 m are seral and fire influenced. Champion (1935) describes the types as "grassy downs with scattered clumps or single trees usually pines, oaks or Schima wallichii".

To the east bracken fern (Pteridum aquilinum) seems to replace the grass. Since pines, oaks and bracken fern are all fire-adapted species, it can be concluded that fire plays a dominant role in maintaining this plant community.

2.1.1.4 Teak plantations

At present it is planned to establish about 12,000 ha of teak (Tectona grandis) plantations annually.

The potential risk (or the probability) of wildfire occurrence in these plantations has to be considered the same as in the forest types mentioned before. The impact of wildfires, however, must be judged by different criteria.

Even if young teak plants are able to survive a surface fire by resprouting or coppicing, this kind of setback cannot be tolerated in high investment plantations. It is very likely that the teak saplings in most plantation areas would be burnt back each year if they were not protected from fire. Even if the young trees are already grown taller, a hot surface fire may damage the cambium tissue or the terminal buds and cause stem deformation or bifurcation. After about five years (or more, depending on site quality and tree vigor) the teak bole can be considered resistant to surface fires of moderate intensity.

The fuel within the young teak plantations varies considerably. Grasses and weeds are the first fire followers on the broadcast burnt planting sites; among others Imperata cylindrica and Eupatorium odoratum are the most aggressive invaders of the plantations. Bamboos which have survived the site preparation resprout vigorously and contribute to the fire hazard.

The drying process of the ground cover varies between the species. Evergreen shrubs may be mixed with annual grasses thus resulting in irregular curing of the fuel complex. During the peak of the fire season the highly flammable leaves of teak are shed and added to the surface fuels.

Altogether a high probability of fire occurrence can be expected within all age classes of teak plantations. During the first years even low intensity surface fires cannot be tolerated in order to ensure the planned and systematic establishment of the plantations. In the subsequent years

surface fires of low or moderate intensity may be tolerated. The suppression of surface fires and/or non-treatment of understory vegetation throughout long periods or during the whole rotation period, however, may result in fuel buildup and increased risk of high intensity fires which may even damage mature teak stands.

2.1.1.5 Other plantations

Besides the establishment of teak plantations the Forest Department is funding large scale reforestation programmes to meet the increasing demand for fuelwood and other forest products as well as for restoration of deforested watersheds and erosion control.

Among the eucalypts the main species is Eucalyptus camaldulensis which shows good growth rates over a variety of edaphic and climatic conditions in the lowlands. The next most important species is Eucalyptus grandis, especially in the higher regions above 900 m elevation. Both species are fairly resistant to surface fires once the crown will not be affected, even if E. camaldulensis can be graded a little more fire sensitive compared to E. grandis.

Both species shed highly flammable leaves thus creating favourable conditions for spread of surface fires. Fire intensity in the wide-spaced eucalypt plantations, however, largely depends on the amount of accumulated fuel and the understory complex. In the dry zone of Burma, where fuelwood supply becomes critical, even small-size fuel is collected by the local population. In the Saing Pyu Plantations (Kyaukpadaung) it was observed that even eucalypt leaves were used for jaggery cooking and the whole of the grass cover was cut for cattle fodder. Here the eucalypt stands are practically bare of surface fuels and are hardly endangered by any fire.

In the moister areas of the country a lush understory of shrubs, bamboos and trees may cause crown fires. In old E. grandis stands fire behaviour may become erratic due to the highly flammable "gum" bark which may cause spotting fires.

Among the pine plantations Pinus kesiya is the main species, followed by Pinus merkusii. Some exotic pines like Pinus patula have been planted in different places. Experimental plots of Pinus pseudostrobus and Pinus oocarpa were established by the Forest Research Institute. The risk of wildfire damage in pine plantations is considerably higher than in the eucalypt plantations. Young pine plantations are characterized by an abundance of aerial and flash fuels (slow self pruning of dead branches, draped needles). This fuel arrangement creates most favourable conditions for crowning fires. The crown fire risk may last even after a distinct separation between crown, branchless bole and forest floor because dead needles shed on understory vegetation provide "ladder" fuels.

However, P. kesiya shows a fairly good tolerance to surface fires. Saplings and young trees may recover as long as the terminal bud is not affected, even if more than 80 to 90 percent of needles are scorched. Pole size and mature trees generally withstand high intensity surface fires.

The fuelwood plantations in the dry zone of Burma mainly consist of Cassia siamea Lam., Acacia catechu Willd., Albizzia lebbek Benth. and, on hill forest sites, Grevillea robusta A.Cun. (Proteaceae; "silver oak"). Leucaena leucocephala has been introduced into the country and is planted in various locations. Like other hardwoods mentioned before these species show a similar fire tolerance. Young plants which are burnt back recover by coppicing. Once a height of 3 to 4 m is reached these fuelwood species generally survive low to moderate intensity surface fires.

The degree of fire damage in all kind of industrial and fuelwood plantations, however, greatly depends on the load and distribution of ground fuels and accompanying vegetation. Fuel management practices therefore become crucial in order to influence the effects and suppression capabilities of potential wildfires.

2.1.2 Forest fire occurrence

2.1.2.1 Fire weather

Weather patterns and the forest fire season of Burma are determined largely by its geographical features and the monsoon. Burma is separated from the neighbouring countries by high mountain walls. Within Burma itself the most important forms of relief are the great plain of Central Burma formed by the valleys of the Irrawaddy. The Arakan Yoma runs along from north to south parallel to the west coast, and the Pegu Yoma runs along from north to south separating the Arakan Yoma from the Central Burma Valley and the Sittang Valley from the Shan plateau and northern ranges of the Tenasserim mountains.

Due to the diversity of relief there are many striking contrasts of meteorological conditions in different parts of the country. In the central part of the country the average rainfall may be as low as 700mm whereas the precipitation along the coast may exceed 5000mm. The mean maximum temperature of over 38°C is found in Central Burma during the months of March and April and mean minimum temperature of 7 °C to 10°C is found to occur in the northern part of Burma during January and February (WMO, 1985).

Lying within the tropics, the asiatic continent to the north and the Indian Ocean to the south, the climate of Burma shows the typical monsoon patterns which largely determine the forest fire season:

a. The northeast monsoon season or winter (December to February)

During the winter the general flow of surface air is from north to south in the northern parts and north-easterly in the rest of the country. In this season the air over the country is mainly of continental origin. Clear sky, low humidity and temperature and a large diurnal variation of temperatures are the usual weather features. Occasional disturbances travelling eastwards across northern Burma can be expected from about the middle of December; the precipitation associated with them is small in amount.

In general atmospheric vapour pressure is low during the dry season. At low elevations the lowest values range from about 16 mb in the north to 22 mb in the south. In higher elevations such as Taunggyi (1436m) vapour pressure drops down to about 12 mb in February. This moisture deficit accelerates the drying of forest fuels and the curing of vegetation. In the deciduous forest types the leaves start to shed and dry very quickly. The month of February can therefore generally be determined as the beginning of the forest fire season.

b. The hot weather season (March to May)

This is a period of continuous and rapid rise of temperature. In March and April day temperatures of 38°C and above occur in Central and Lower Burma. The peak of the fire season is reached by end of March and in April.

During the pre-monsoon period of April and May western disturbances as well as cyclonic storms usually bring some precipitation. The forest fire danger is reduced temporarily during and after these disturbances.

c. The southwest monsoon season (May to September)

The southwest monsoon usually starts in lower Burma about the third week of May. It gradually extends northwards and is usually established over the whole country by about the first week of June. There is no forest fire danger during the rainy season.

d. The retreating southwest monsoon season.
(October and November)

During this transition season the southwest monsoon retreats from Burma. There is no forest fire risk at all.

2.1.2.2 Causes of forest fires

At present statistical data are not available about causes of wildfires. Dry lightning storms occur very seldom, and there are no reports on lightning-caused fires. Therefore it can be assumed that all wildfires are caused by man. The major causes of forest fires can be classified as follows:

a. Shifting cultivation

The "taungya" shifting cultivation is practised within the forested land. The burning of the "taungya" plots is done during the fire season. In many cases the precautions taken are insufficient and the fires spread into the surrounding forest land.

b. Burning of grazing land

Most of the range land is burnt annually for improving pasture quality. The fires are generally not confined and they often spread into the adjoining forest land.

c. Hunting

Although hunting of wildlife is restricted in Burma, the burning for hunting purposes (mostly illegal) is practised in many parts of the country. It contributes to extended forest fires.

d. Other intentionally set fires

Within the rural areas most people consider that vegetation has to be removed by fire, even if the land is not under use. Adults and children like to set fires and do not care about the consequences. In contrast to the urban fire prevention campaigns there is no public information or education concerning fire protection of nature.

e. Negligence

Smoking of the locally made "cheroot" cigars is very common while working or travelling in agricultural and forested areas. Many types of the "cheroots" consist of a mixture of tobacco leaves and tobacco stem particles. These solid particles may glow for a considerable time and act like sparks. They can be regarded as one of the most important fire causes.

Debris burning and cooking/camp fires can also be considered as important fire sources.

In summary it can be stated that there is a low consciousness of the general public concerning the threat and consequences of wildland fires. Public education in this respect becomes essential (para 2.3.1). The relevant strategy, however, has to be based on a sound forest fire reporting and evaluation system (para 2.3.9).

2.1.2.3 Area affected by wildfires

At present no records on forest fire occurrence (size, cause, damage) are available. According to reports and observations carried out during the consultancy, rough estimates of the forested area burnt annually can be made. The appraisal is based on the area of forest land and land classes as determined by LANDSAT imagery in 1980 (FAO 1984); and results of low and higher estimates are shown in Table 1.

For the low estimates it was assumed that only 2% of the closed forests and 10% of the degraded forests are burnt over each year. Within the closed and degraded forests affected by shifting cultivation estimates of 10% and 15% respectively were made. In the higher estimates it was assumed that 5% of the closed forests and 20% of the degraded forests are burnt; the figures for the forests affected by shifting cultivation are 20% and 25% respectively. The low estimate gives a total of about 3.4 million ha burnt annually, the higher estimate gives an area of about 6.5 million ha per year.

Forest Categories	Total area (ha)	Percent of total land area (%)	LOW ESTIMATES: Estimated area affected by annual fires (%)	LOW ESTIMATES: Estimated area affected by annual fires ha	LOW ESTIMATES: Estimated area affected by annual fires Percent of total forested area(%)	LOW ESTIMATES: Amount of burnt organic matter (dry weight) t/ha	LOW ESTIMATES: Amount of burnt organic matter (dry weight) Total t	HIGHER ESTIMATES: Estimated area affected by annual fires (%)	HIGHER ESTIMATES: Estimated area affected by annual fires ha	HIGHER ESTIMATES: Estimated area affected by annual fires Percent of total forested area(%)	HIGHER ESTIMATES: Amount of burnt organic matter (dry weight) t/ha	HIGHER ESTIMATES: Amount of burnt organic matter (dry weight) Total t
1. Closed Forest	22,761,100	33.6	2	455,222	0.96	10	4,552,220	5	1,138,055	2.39	10	11,380,550
2. Closed forest affected by shifting cultivation	10,128,400	15.0	10	1,012,840	2.13	5	5,064,200	20	2,025,680	4.25	5	10,128,400
3. Degraded forest	5,872,600	8.7	10	587,620	1.23	10	5,876,200	20	1,174,520	2.47	10	11,745,200
4. Degraded forest affected by shifting cultivation	8,853,200	13.1	15	1,327,980	2,79	3	3,983,940	25	2,213,300	4.65	3	6,639,900
Total	47,615,200	70.4	-	3,383,662	7.1	-	19,476.560	-	6,551,555	13.8	-	39,894,050
5. Annual de-forestation rate (slash and burning)	100,000	0.147	100	100,000	0.21	100	10,000,000	100	300,000	0.63	100	30,000.000
Grand total of annually burnt organic matter (t):							29,476,560					69,894,050

Table 1: Appraisal of annually burnt forested land and loss of organic matter due to burning, Burma.

2.1.3 The ecological and economical impact of forest fires

As it has been shown in the foregoing, most of the forest associations have developed fire adaptations. The size of the area burnt over each year does not necessarily result in complete forest destructions or loss of forest land. The frequent burning, however, has considerable consequences on forest composition and site quality. The degradation process is often not visible because some of the fire-climax communities like the pine, Indaing and other mixed deciduous forests seem to be relatively stable. The loss of species variety and biomass and the frequent soil depletion, however, lead to severe long-term effects.

An appraisal of the total loss of forest fuel (organic matter) is shown in Table 1. For both the low and higher estimates very conservative figures were chosen. It was assumed that surface fires would burn about 10 t/ha available fuel in the closed and degraded forest types. In the forests affected by shifting cultivation the available fuel was assessed at 5 t/ha and 3 t/ha respectively, due to high fire frequency. Thus the low estimates will result in an annual loss of about 20 million t (dry weight) organic matter and of about 40 million t according to the higher estimates.

To show a more comprehensive picture of organic matter loss, the annual deforestation rate, mainly caused by slash-and-burn practices, should also be taken into consideration. The conservative appraisal of forest conversion shows a loss of 100 t/ha on 100,000 ha annually. In a more realistic picture the calculations are based on 300,000 ha per year which is still only half of the last forest depletion rate appraisal of FAO (1984).

The calculations of both estimates result in the loss of organic matter of about 30 to 70 million tons per year and it could be even higher. The accumulative effects of this do not exclusively affect the soil fertility. In many parts of the country the air quality is highly influenced by the fires. it can be assumed that the combustion products of such fires in the country and its neighbours within the subtropical and tropical region have considerable effects on the global atmospheric quality.

The most serious consequence, however, are the erosion and the loss of topsoil. Although in general the tree/shrub layer will not be removed by the fires, the soil becomes depleted of its protective litter cover just before the beginning of the monsoon. The heavy rains cause the detachment and dispersion of soil particles, and run-off is greatly increased. The Irrawaddy river carries an annual sediment load of 299 million tons per year (Brown and Wolf, 1984; Khoshoo, 1986). Although Burma has a considerably high forest cover, this sediment load is fifth ranked in the world after the Yellow, Ganges, Amazon and Mississippi.

Serious econimic losses are likely to occur in the future. The high investments in irrigation and hydro-electric power dams could be jeopardized through siltation if proper measures in catchment areas and watersheds are not taken.

2.2 FOREST FIRE MANAGEMENT POLICY

2.2.1 Legal provisions

The main legal provisions concerning forest fire protection are laid down in the Forest Department Circulars No.2 and 25 of 1903 and in the Rules for Reserved Forests.

The Forest Department Circular No.2 of 1903 (as amended by Circular No.90 of 1910) contains the instructions for fire control operations in and around reserved forests. As it was mentioned in para 2.1.1.1, the fire protection policy in reserved forests has been abandoned. In the plantation strategy, however, these rules are applied. Unfortunately the forest fire reports, as the base for forest fire statistics,are not provided any more.

The "Responsibilities of government servants (other than forest officers) and of the public in regard to the protection of reserved forests from fire" are laid down in the Forest Department Circular No.25 of 1903 (amended by Circular no.37 of 1903). These instructions are not followed.

The "Rules for reserved forests (B)" contain the prohibition of setting fires between 15 January and 15 June, the necessity of obtaining written permission, and the regulations concerning the surrounding land within two miles of a reserved forest. These rules are not observed anymore.

2.2.2 Present policy and organization

At present forest fire management is largely confined to plantations. Within the Forest Department these responsibilities are shared between the Plantation Division and the Township Forest Officer. The Plantation Division and their sub-units are responsible for fire protection during five years after plantation establishment. After that the responsibility devolves to the townships. With few exceptions, like the Mt.Popa Wildlife Park, there are no fire protection activities outside of the plantation areas.

Within the Forest Department organization there is no central forest fire management unit on national or state/divisional level. The Timber Corporation has no responsibility in forest fire management.

During the fire season (generally between 15 February and 15 May) the fire watchers (fire guards) are stationed within the plantations. Fire guard houses and observation platforms are constructed adjacent to the newly established plantations; the fire watchers are allocated to the most critical areas in and around the compartments (e.g. alongside of trails and roads used by the public). In the field no radio or telephone facilities are available to communicate between personnel or forest office. In some places pieces of metal or bamboo are used as alarm. The height and location of lookouts are often unable to provide a complete cover of forested areas containing compartments of various age classes.

Accordingly all fire detection and initial attack activities are quite isolated and not coordinated.[1/] The efficiency of the fire-watchers (= ground patrols), however, is very high. This is not only due to the remarkably good discipline of the personnel. The villagers, fuelwood gatherers, cattle drovers and other travellers necessarily take notice of the ground patrols who are wearing the official fire guard armlet. Since negligence and deliberately set fires are the main forest fire causes, the permanent presence of ground patrols seems to be essential and effective.

In addition a very important side-effect should not be overlooked. Many of the afforestation areas, especially the fuelwood plantations, are being established in regions of fuelwood shortage. The pressure of fuelwood gathering on all kind of combustible material is very high. The protection of plantations against unplanned and illegal chopping therefore becomes imperative. This additional protection function is being carried out by the fire patrols; it should be taken into account if economic considerations related to the amount of field personnel are made.

1/ The equipment will be discussed in para 2.3.7

2.3 FUTURE FOREST FIRE MANAGEMENT CONCEPTION

The present forest fire situation, as stated before, can be condensed as follows:

a. Fire occurrence: Several million hectares of forest land are affected by wildfires each year. The exact size of burnt area is not known but may even exceed the conservative estimates of 6.5 million ha per year.

b. Impact of fires: Long-term fire influence has favoured fire tolerant/resistant plants and fire-climax communities. The selection of economically desirable species like teak and pine is accompanied by fire-induced soil depletion, erosion, siltation, air pollution and an overall loss of species diversity.

c. Socio-economic constraints: The vast majority of uncontrolled wildfires follows in the wake of traditional agricultural practices and other deep-rooted burning habits of the rural population. Fire management, on the other side, is restricted to the plantations, at least due to budgetary limitations; financial restraints have also impeded the development of organisation, infrastructures and technical skills.

This ecological and socio-economic information as well as the state of organizational and technical development will determine the frame-work of a future conception in integrated forest fire management. All decisions, whether a fire will be tolerated, suppressed or prescribed, have to be based on this information. In Fig.1 (Appendix 1) a generalized scheme shows the most important elements of the "Intergrated Forest Fire Management System".

In the following a description of future needs and strategies in wildfires prevention and control as well as in training and research is given.

2.3.1 Public information and education

Structural fires in urban areas and villages are a major problem in the country. Every year thousands of homes and sometimes large urban quarters are destroyed, mainly during the dry season and due to the high flammability of the structures (wood, bamboo, grass roofing). Public information campaigns concerning the prevention and control of these fires have been carried out for many years, and there is sufficient experience available in the use of mass media.

Relevant activities in forest fire prevention should be initiated accordingly. There are three main target groups which have to be reached through different means of information and education:

a. Children: The most effective multiplying instrument is the school. Increased consciousness of nature protection can be obtained through relevant curricula.
A program should be initiated in coordination with the Ministry of Education. This will take a long time but the effect will be long-lasting.

b. General public: The basic method of public education is through the mass media. The strategy should follow the experience gained in the urban fire campaigns but recognize that the effects are limited in remote places. It should therefore be complemented by activities of local bodies. The introduction of a national wildfire prevention symbol and short standard slogans are highly recommended. They should be used on posters or billboards erected on the roadside of village exists. The design of a fire prevention symbol is given in Fig.2 (Appendix 1).

c. Rural population: In areas where agriculture is mixed with forested land, information campaigns should concentrate on those people using the fire in grassland or taungya burning. Advice should be given on techniques of prescribed burning, confining of fires and safety.
As a long-term goal a system of burning permits should

be approached. The local forester has to play the role as technical adviser creating mutual confidence between farmers and foresters. The forestry extension service should provide relevant leaflets, posters, billboards and other campaign material (e.g. movie).

2.3.2 Organization

The extent and importance of wildfires in Burma requires the establishment of a supervising authority responsible for coordination and control of all activities related to forest fire management. A "Forest Fire Management Unit" should be set up within the Forest Department Headquarters at Rangoon. In the establishment phase a forest protection officer should be assigned to head this unit. This forest officer will receive a relevant basic training during the follow-up project and will be engaged in the implementation of the national demonstration project (para 3.1.3.8).

The head of the Forest Fire Management Unit will be authorized to coordinate fire management activities between the plantation divisions (and their sub-units) and the township forest offices. He will identify fire management needs and supervise the planning and implementation. Special attention will be given to :

- Preattack planning
- Fuel management
- Detection and reporting systems
- Improvement of fire fighting equipment
- Organization and training of fire suppression crews
- Safety of personnel
- Post-fire evaluation
- Coordination of fire prevention campaigns

The Unit will closely cooperate with the Forest Fire Research Officer (Forest Research Institute) and the Burma Forest School.

2.3.3 Preattack planning

Preattack planning is a system of collecting, recording and evaluating information relevant to wildland fire management. The preattack planning should be carried out within the township forest area. It contains the following information related to administrative units (area of responsibility of township forest office or plantation division) and ecological units (preattack blocks):

a. Wildland information

Topography, vegetation types, fuel type, water sources, meteorological particularities (e.g. local wind patterns).

b. Technical information

Localities of fire suppression personnel (fire guard houses, patrol area of fire watchers, local fire brigade, military camp), equipment (fire trucks, water tenders, dozers, plows, communication, water sources), lookout towers, control lines (firebreaks, fuelbreaks, other fuel discontinuity), access (roads, forest roads, foot trails).

Most of this information may be figured on the township forest fire control map, based on a topographic map and showing the vegetation/fuel type. Most of the other information like access, control lines, prescribed burnt areas, water sources, equipment locations etc., is included by using symbols. Information on communication facilities, logistics, cooperators and mobilization plans has to be written.

The preattack plan provides not only the fire command team with valuable information for tactical decision. The annual revision of the plan furthermore discloses needs and stop-gap measures in fire preparedness and maintenance work required.

2.3.4 Fuel management

Fuel management is defined as "practice of controlling the flammability and reducing the resistance to control of forest fuels through mechanical, chemical, biological, or manual means, or by prescribed fire, in support of land management objectives".

Fuel treatment or hazard reduction in young plantations is mostly practised by means of weeding (reducing fuel load and competition) and establishing of firebreaks (separating fuel continuity). The width of firebrakes (locally called firelines) varies from place to place. External firebrakes usually have a width of 6 to 12 m. Internal firebreaks vary between 3 and 6 m and are used as inspection paths. In general the dimension of these firebreaks can be considered as adequate in order to confine a surface fire. Fires which are driven by a strong wind may cross these lines by spotting. Since the spotting distance may even exceed 20m or more, it cannot be justified to enlarge the average width of firebreaks. The fire management officer, while preparing a preattack plan or suppressing an ongoing fire, has to realize that firebreaks are not necessarily self-containing a fire. The firebreaks, like other kind of control or fireline, facilitate fire suppression and improve safety of the firefighters.

In areas of continuous fire-endangered forest cover or in large plantations, the construction of fuelbreaks seems to be an appropriate provision to reduce the forest fire hazard and to limit the spread and intensity of wildfires. The conception of fuelbreaks is based on fuel and/or vegetation modification in order to reduce flammability within "buffer zones" subdividing areas of high fire hazard. On these strips the fire should either stop by itself or be controlled easier due to improved accessibility of the forest land. The reduction of flammability can be obtained by different means of fuel treatment or selection of appropriate plants.

The basic idea of "shaded fuelbreaks" is to maintain the forest cover and to reduce the amount of surface and aerial fuels. Principles of this kind of fuelbreak construction are described in the forest fire management training manual. The advantage of shaded fuelbreaks is to avoid the

diminution of productive forest land and to reduce the visual impact of firelines. A progressive example of this kind, although made on a small dimension base, are the shaded firebreaks within Mt.Popa Wildlife Park.

The construction and maintenance can usually be done by hand (use of the "dah"). Stands with accumulation of highly combustible litter (e.g. pine and eucalypt plantations) or lush growth of understory and competitive trees (teak plantations) may also be treated by prescribed burning. Within pine plantations fuel reduction by prescribed burning should be extended to the entire area planted or at least alongside all public roads/trails. Skill in the use of burning techniques as described in the training manual should be developed in cooperation with the Forest Research Institute.

The integration of local land-use practices in plantation management is showing good results, especially in areas of fuelwood shortage. The permission or concentration of fuelwood gathering (including eucalypt leaves) and cutting of grasses (fodder or roof material) inside the plantations contributes considerably to the fire hazard reduction. Livestock grazing and feeding may also reduce the amount of coppicing vegetation. As it was observed inside pine plantation of Maymyo Township, the local cattle feeds on resprouting hill forest species without damaging the pines. The integration of livestock grazing into production forests and fuel breaks would be of mutual benefit for both the rural population and the forestry sector. The development of such "silvipastoral" systems, as one method in agroforestry, should be studied by the Forest Research Institute.

2.3.5 Fire danger rating

Fire danger rating is a fire management system that integrates the effects of selected fire danger factors into one or more qualitative or numerical indices of current protection needs. Most fire danger rating systems integrate the four major meteorological factors affecting fire behaviour: temperature, air moisture content, wind speed and short and long-term drought effects. Since temperature, humidity and even windspeed are following a more or less predictable diurnal pattern, the most important factor affecting the fire hazard is the amount of rainfall during the fire

season. It becomes crucial in those regions where the amount and distribution of precipitation during the fire season varies from year to year.

In Burma the amount of rainfall during the dry season (between December and March) is negligible; disturbances and small rainfall can be expected in the pre-monsoon period, just before the end of the fire season (see para 2.1.2.1). That means, that there is no set-back of the average fire danger during the most of the fire season. As the curing of the vegetation and the shedding of leaves in the deciduous forests is going on, the fire danger is building up constantly. The "relative" fire danger is "low" during December, "moderate" in January, "high" in February and early March (becoming "very high" with increasing wind), and is generally "very high" by end of March until the break of the rains (it becomes "extreme" during casual or diurnal winds). The fire risk and the expected fire behaviour can be judged by this experience.

However, although there seems to be no need for a fire danger rating system, the Fire Management Officers of the Forest Department and the Forest Research Institute should examine this subject.

Therefore the Fire Research officer was provided with an exemplary fire danger rating system (Australian McArthur Forest Fire Danger Meter).

2.3.6 Detection and reporting of fires, establishment of Fire Management Centers

As it was described in para 2.2.2 the forest fire detection system is restricted to plantation areas and mostly concentrated on the afforestations up to five years old. The survey is furthermore restricted to ground patrols, fire guard houses and small observation platforms. All of these installations are isolated from each other due to the lack of communication facilities.

In areas to be protected (plantations, catchment areas and other selected sites) the detection system should be improved and based on the operation of firetowers. The towers have to be located to ensure the maximum area seen from the least number of points and in order to obtain accurate cross bearings, intercepting at a reasonable angle. The standard

equipment of the lookout towers should consist of a fire finder (or improvised alidade), binocular and radio or telephone; at least one tower of the area surveyed should be equiped with a wind speed/direction indicator and a sling psychrometer. The fire and weather reports will be evaluated by a Fire Management Center (FMC) which should be established in a central location of the area to be protected (e.g. forest office, nursery). The functions of the FMC are as follows:

- Coordinate and monitor all forest fire control activities between Township Forest Office, Plantation Division, fire brigade, military and other government agencies.
- Act as communication relay station
- Dispatch fire fighting crews
- Suppress forest fires with first attack fire crew based in the Center.
- Extend assistance and support outside of area of responsibility if requested.
- Collect and evaluate data and records of the fire management organization.
- Conduct and supervise preattack planning.
- Act as training unit for local fire guards, fire crews.
- Act as information and extension unit on the local level.

The FMC will be supervised by the Township Forest Officer or a Fire Management Officer specially assigned to this duty. He will be assisted by the dispatcher who is in charge of the radio/telephone control in the FMC.

The dispatcher has the following duties:

- Maintain radio/telephone communication with fire towers, fire control personnel and other participating bodies.
- Supervise the radio traffic and ensure radio discipline.
- Keep a log of all messages transmitted by radio/telephone.

- o Keep a record of fire weather reports.
- o Keep a record of exact location of fire crews and equipment being on and off task.
- o Plot the position of the fire on the fire control map.
- o Direct the fire crews and equipment according to the preattack plan.
- o Keep a record of all fire suppression activities, prescribed burning operations and burning permits on the relevant boards and maps.

If a fire truck or any other multi-purpose vehicle (four wheel drive, truck tool box, radio, slip-on tank unit) is available, a first attack crew should be stationed at the FMC during the fire season.

The FMC should provide space for the operations room, sleeping/resting accomodations, bathroom, kitchen, fire fighting tool store. The operations room has to be equiped with radio and/or telephone and the following facilities:

- o Fire location map showing lookout tower positions, preattack plan symbols, predominant fuel type.
- o Burning permit/prescribed burning operations map (legal smoke).
- o Fire-weather state board (showing date, last rainfall, and the hourly data on temperature, relative humidity, wind speed/direction).
- o Prescribed burning/burning permit state board.
- o Fire crew/equipment deployment state board.

The lookout observer has to report every smoke or fire detected; he keeps a logbook on the observations (time, bearing, description of smoke). If meteorological equipment is stationed on the tower, he transmits his readings every hour (temperature, relative humidity or wet and dry bulb temperature, wind speed/direction); he keeps a record of these readings.

If a fire detection and reporting system has been installed according to this design, it may be advisable to reduce the amount of ground patrols and

transfer this personnel to the lookout towers. A fire guard house may be added to the lookout site and provide accomodation for the lookout observer and two or three more fire guards. Since communication is available in this case, this personnel can be dispatched as first attack or reinforcement crews.

It has to be stated, however, that the presence of ground patrols and their importance for the general forest protection duties must not be overlooked. According to the consultants experience in other countries of Asia, Latin America and the Mediterranean region where population pressure and/or fire causes are similar, no comparable efforts, discipline and outcomes have been observed. Both the protection function and the creation of employment opportunities are essential for the implementation of long-term forestry planning. It must be recommended therefore that the Forest Department pursues this policy.

2.3.7 Fire fighting equipment, suppression methods

The availability of fire fighting equipment is largely restricted to different kinds of small brush blades and machetes ("dah"). They are used by all ground patrols and can be considered as a basic hand tool. Beyond this hand tool other fire fighting equipment is poorly designed and not suitable for forest fire suppression. Fire swatters are of the same design as being used in beating sparks and flames on roofs: They have a long bamboo handle (up to 4m long), and in most cases the flap is made of bamboo, rarely made of sheet metal. The flap itself is integrated into the long handle thus being inflexible and not suited for smothering surface fires.

In many fireguard hourse or platforms water buckets can be found although water is not available in these places. Like the long-handled hooks, all this equipment is designed for fighting structural fires and not for wildland fire conditions.

The necessity of equipment improvement is obvious. Its design, however, must take into consideration that (a) the type of fire is usually a surface fire and (b) the personnel usually has to walk to the fire control scene. It therefore is recommended to concentrate on the use of selected hand tools and other light equipment:

a. Fire swatters: Design according to models: flexible flap of reinforced rubber (US type) or sheet steel (German type), 1.5 m heavy duty handle. Suited for smothering fires in grass, weeds and other light fuels.

b. Council rake: This tool consists of an angle iron frame holding 4 tempered steel cutting teeth, attached to a 1.5m wood handle. Highly efficient for trenching work in light brush, duff and small roots and can be used for digging, cutting or raking.

c. Backpack pump: A simple and most portable water pumping outfit. Consists of a 20 l tank, a short length of hose, a hand-operated pump and a nozzle adjustable to a straight stream or spray. Should be made of plastic (less weight compared to steel fire pumps). During tests and demonstrations at Maymyo plantations this fire pump has been proved as most efficient, flexible and economical of all other light equipment.

d. Drip torch: Incendiary device for backfiring and prescribed burning. Consists of a fuel tank (5 l aluminium or stainless steel fount), burner arm, igniter, safety devices. A 3:1 diesel-gasoline mixture is generally used. The drip torch is an essential tool for fast and continuous build-up of lines of fire.

As it was mentioned in para 2.3.6, multi-purpose vehicles like 4-wheel drive pick-ups or trailers may be converted into small fire trucks. The "slip-on pump units" consist of a 450 to 2000 l fiberglass tank, a pump and a live hose reel with about 50m high pressure booster hose. The unit can be mounted or removed from a vehicle in minutes. Out of the fire season the vehicle can be used for other purposes.

If the follow-up project on forest fire management will be realized (see para 3.8 and Appendix 4), models of this kind of equipment will be available in the country. Later on most of the tools may be manufactured locally. Then attention should be paid to the quality. Unlike other tools, fire tools are used only in emergencies, and then under considerable stress. If they are not top quality tools the failure rate will be high. Specifications should accompany tool orders.

The necessity of other equipment like communication systems (radio or telephone) has already been mentioned before. Attention should also be paid to the mobility of personnel. The elapsed time between detection/reporting of a fire and the initial attack can efficiently be reduced by increased mobility of the fire guards. Besides bicycles the use of horses may greatly improve the time of response; pack-horses may even be used to transport light equipment like two-filled backpack pumps and assortment of hand tools.

At present the fire suppression methods are based on the use of the "dah" and green branches used as fire beaters. The backfiring technique is employed in some places although reliable fire torches or fusees are not available. The use of the light equipment mentioned before will enable the fire crews to improve:

- fire line construction with brush blades and rakes (based on the step-up and one-lick methods),
- direct attack of the fire front or spotting fires by using backpack pumps and fire swatters, or light fire trucks, and
- backfiring techniques by using the drip torch.

Altogether it is concluded that under the present socio-economic conditions the highest efficiency in forest fire fighting will be obtained by ground personnel, well trained in the use of appropriate hand tools and light equipment, and by the improvement of the fire detection and communication system.

2.3.8 Safety of firefighters

The usual clothing of fire guards consists of a shirt, the longyi and rubber sandals. The longyi and the rubber sandals are not only impractical or hindering, but also highly dangerous to the personnel. To provide insulation against radiant heat from fire, long-sleeved shirts and pants should be worn; the latter also improves the mobility of the fire-fighter. The personnel should be equipped with adequate foot wear, most suitable are high-topped leather boots. A helmet or at least the locally used cotton hat should be worn.

To improve the overall safety of fire-fighters, special flame-resistant clothing can be made of synthetic fibers like "Aramid". This material has been demonstrated to the Forest Department and it is planned to introduce it on the occasion of the follow-up project.

2.3.9 Post-fire evaluation

Fire reports, if any, are restricted to plantation areas. The evaluation in general is incomplete and not satisfactory. An example of a forest fire reporting and evaluation system therefore has been handed over to the Forest Research Institute. This form should be adapted to the local situation in order to obtain a realistic picture of the wildfire occurrence and impact. Other aspects are included, like fire behaviour observations and data on the fire control activities.

It is highly recommended to introduce a statistical forest fire reporting and evaluation system covering the whole of the forested land. This will enable both fire research and forest administration to rely future management decisions on a sound base of information.

2.4 FOREST FIRE MANAGEMENT TRAINING

Within the Technical Level Forestry Training at the Burma Forest School a total of 68 hours is dealing with the general subject of forest protection; this includes all biotic and abiotic factors as well as protection of fauna. The curriculum is based on scattered information and literature. In order to strengthen the fire management training part, the Burma Forest School therefore requested the preparation of a training manual as a basic source for future courses to be conducted by the school (see para 1.3). Because of the short-term assignment of the consultant and the complexity of his task it was not possible to prepare the training manual in whole during the consultancy. A draft outline of the manual, however, was presented to the Burma Forest School. On the base of this conception the consultant carried out one basic seminar, two presentations and three field training sessions. Participants were senior officials, forest officers, school teachers as well as students and local fire guards. The handtools procured by the FAO training programme were demonstrated during the field exercises.

In order to complete the training prerequisites it is recommended to prepare a final version of the training manual. It should be accompanied by classroom teaching aids (one set of transparencies and one set of slides). This manual should be designed as comprehensive basic source and handbook for teachers, officers and students. In a second phase, on the national level, the Forest Department in Cooperation with the Forest Research Institute should prepare leaflets to be used in the training fire guards as well as in the extension service (distribution to taungya farmers, communities etc).

2.5 FOREST FIRE RESEARCH

Following the recommendations of FAO (Farnsworth, 1979; FAO, 1981) the Forest Department has established a forest fire research unit within the Forest Research Institute and a forest officer has been appointed to this position. His forest fire research background should be enhanced by a fellowship under the follow-up programme. It is desirable to coordinate the timing of this fellowship with two major scientific conferences which both will be held in California, April 1987 (Forest Fire Meteorology Conference and Symposium "Wildland Fire 2000" at University of California, Berkeley). Participation will tie him up with the IUFRO Subject Group S.1.09 (Forest Fire Research) and other institutions which will attend the meetings. In addition to this a study tour to different National Forests and Forest Fire Laboratories (USDA Forest Service) in the Western United States should be organized. It will give him the opportunity to have a close look into research facilities as well as fire management practices in the field. The study programme should include a visit to Australia. The institutions to be visited are the Australian National University, Department of Forestry, and the C.S.I.R.O. National Bushfire Research Unit, both in Canberra, A.C.T. Furthermore the New South Wales Bushfire Council or the Victoria Forestry Commission should be contacted to provide assistance to visit and discuss fire management activities.

The long-term objectives of the future forest fire research programme must be designed according to the actual and specific problems of the forests of Burma. Special attention should be given to:

a. <u>The role and influence of fire on teak-bearing forests</u>

- Establishment of long-term observation plots in mixed deciduous forest types. Different fire interval treatments. Control plots. Regeneration, competition, species diversity, accessibility, fuel load.
- Fire resistance of teak seeds.
- Susceptibility of sapling stem and buds to fire, in order to determine the age and/or size of trees to be protected from fire.

b. Fuel management

- Description of fuel characteristics in the most important forest/plantation types. Fuel load, dynamics, availability.
- Prescribed burning in teak, eucalypt and pine plantations. Timing, techniques, observation of side effects.
- Economical studies: comparison of mechanical treatment vs. prescribed burning.
- Use of animal husbandry in silvipastoral systems: Effects on competition, selective feeding, fuel load.

c. Fire behaviour

Spotting distance of most common fuel types

d. Erosion control

- Establishment of erosion control plots in different forest types surrounding water catchment areas. Comparison of run-off and sediment load in fire-protected and frequently burned sites.

e. Forest fire survey and evaluation

- Preparation of a forest fire reporting form.
- Use of remote sensing for forest fire survey in cooperation with FAO.

3. RECOMMENDATIONS

The increasing demands on the forest resources of Burma require a comprehensive conception and strategy to protect the forest land against destructive influence by man. One of the major threats to sustained multifunctional forestry are uncontrolled wildfires which are all caused by deliberateness and negligence of the rural population. It is assumed that more than 6.5 million ha of forest land are affected by fires each year. Not too much is known about the overall ecological and economical impact of the frequent fires. Long-term land-use planning goals may become jeopardized if extensive wildfires are occurring accidentally rather than being managed or controlled by the authorities. Therefore priority should be given to establish and strengthen a forest fire management organization, to develop skill and to provide adequate funds for equipment, personnel and research.

The recommendations given in the following are condensing the most urgent needs of measures to be taken in the near future.

3.1 FIRE MANAGEMENT ORGANIZATION AND POLICY

(1) Establish a Forest Protection Unit (Forest Fire Management) within the Forestry Department. Appoint one forest officer as the head of this unit. Authorize this unit to carry out, coordinate and supervise all forest fire management activities on the national level (2.2.2, 3.9).

(2) Grant a relevant forest fire management training to this officer (3.8).

(3) Cooperate closely with the Forest Fire Research Unit in order to obtain a clear picture of the role of wildfires in different forest types and sites, especially with regard to watersheds (erosion, siltation) and dynamics of forest development.

(4) Extend the fire protection policy to the water catchment areas around irrigation and hydroelectric power dams.

(5) On the base of this, as long-term goal, prepare a comprehensive statement on fire management policy and incorporate this policy into implementing rules and guidelines (burning restrictions and permits, technical advice).

3.2 RESEARCH

(1) Give absolute priority to provision of funds for the Forest Fire Research Unit newly created at the Forest Research Institute.

(2) Grant a relevant forest fire management and research training to this officer (3.8).

(3) Concentrate on priority research subjects (2.5).

(4) Cooperate with forest fire experts, especially on the regional level (2.5, 3.10).

3.3 MONITORING AND EVALUATION

(1) Introduce a comprehensive statistical forest fire reporting system in order to obtain a realistic picture of forest fire occurrence and impact (2.3.9).

3.4 PUBLIC INFORMATION, EDUCATION, FORESTRY EXTENSION

(1) Initiate, in cooperation with the Ministry of Education, an elementary school curriculum on nature protection. Special attention should be given to the impact and prevention of forest fires (2.3.1).

(2) Introduce a national forest fire prevention symbol (Fig.2, Appendix 1) and relevant slogans to be used in mass media and to be put on billboards, posters etc.

(3) Prepare information leaflets on prevention of forest fires, safe methods of prescribed burning, fire confining and wildfire suppression techniques.

3.5 PREATTACK PLANNING, HAZARD REDUCTION

(1) Give special attention to preattack planning in forest land to be protected (2.3.3).

(2) Provide adequate funds for hazard reduction (fuel management) needs (2.3.4).

3.6 FIRE DETECTION AND CONTROL, SAFETY

(1) Provide adequate funds for the establishment of lookout towers, communication systems and fire management centers within the most critical plantations and watersheds (2.3.6).

(2) Improve the fire control capabilities by procuring adequate handtools and light equipment; pursue the principle of adequate technology (2.3.7).

(3) Give high priority to the safety of fire fighting crews (2.3.8).

(4) Pursue the present policy of deploying fire guards patrolling critical areas, especially in regions of fuelwood shortage. The general aspect of forest protection should not be neglected even when establishing more sophisticated fire detection and suppression systems (2.3.6)

3.7 TRAINING

(1) Extend the Technical Level Training in forest fire management by conducting basic courses during the Forestry Induction and Basic Officers Courses.

(2) Distribute the finalized manual on"Introduction to Forest Fire Management", when received through FAO, to all Township Forest Offices and Plantation Division Units.

3.8 FOLLOW-UP ACTIVITIES

The findings of this report underscore the need of institutional strengthening, stimulation of research and the establishment of an exemplary fire management model to be designed as a demonstration project. The assistance given by the consultancy therefore should be extended and foreign aid should be sought for the following programme:

(1) Fire management training granted to two young forest officers (Forest Department Headquarters, Forest Research Institute),

(2) Establishment of a fire management demonstration project at Maymyo Township,

(3) Strengthening the fire research unit at Forest Research Institute, and

(4) Input of additional consultant service in the final phase of the follow-up.

It is highly recommended to request FAO assistance. This request should be made as soon as possible in order to coordinate the timing of fellowship with two major fire management meetings to be held in U.S.A., in April 1987 (2.5).

A relevant project document proposal is submitted in Appendix 4. A detailed description of activities and inputs is given in the annex to the project document proposal.

3.9 COORDINATION OF UNDP-FAO ACTIVITIES

The fire management activities of the Forest Department, including the follow-up programme, should be coordinated with other UNDP-FAO projects in the country. At present a project proposal on "Pilot Watershed Management for Kinda Dam, Phase I" (BUR/81/003/A/01/12) is going to be implemented. The work plan of the project contains a fire management planning which includes procurement of equipment and consultant services.

It is highly recommended to coordinate these activities in order to harmonize fire management strategies in the country. It should be taken into consideration to hire the two fire management experts, which have been trained under the fire management follow-up programme, as national consultants rather than hiring one more foreign adviser. This would give a desirable stimulation to the national activities. Both projects, however, could be supported by the foreign consultant being assigned to the fire management follow-up.

3.10 REGIONAL COOPERATION

Regional cooperation with neighbouring countries will become necessary in the near future in order to exchange information, develop common strategies and to avoid duplications in research and development efforts. If any regional activities will be discussed (e.g. regional workshops and programmes), the country should play an active role in contributing to such supra-national cooperation. It is therefore recommended to provide assistance and government clearance to forest fire management officers to be sent as delegates of the country.

3.11 FINAL STATEMENT

It is strongly recommended that the Government of the Socialist Republic of the Union of Burma gives the highest priority and importance to the protection of forests and forest land from human elements causing degradation of vegetative, water and soil resources. As a long-term goal the amount of uncontrolled wildfires should be minimized. The government should commit itself to a firm and sincere policy in this regard, which considers the crucial impact on protection of socio-economic factors. This policy should be effected through appropriate legislation and institutional strengthening.

Appendix 1.

FIGURES

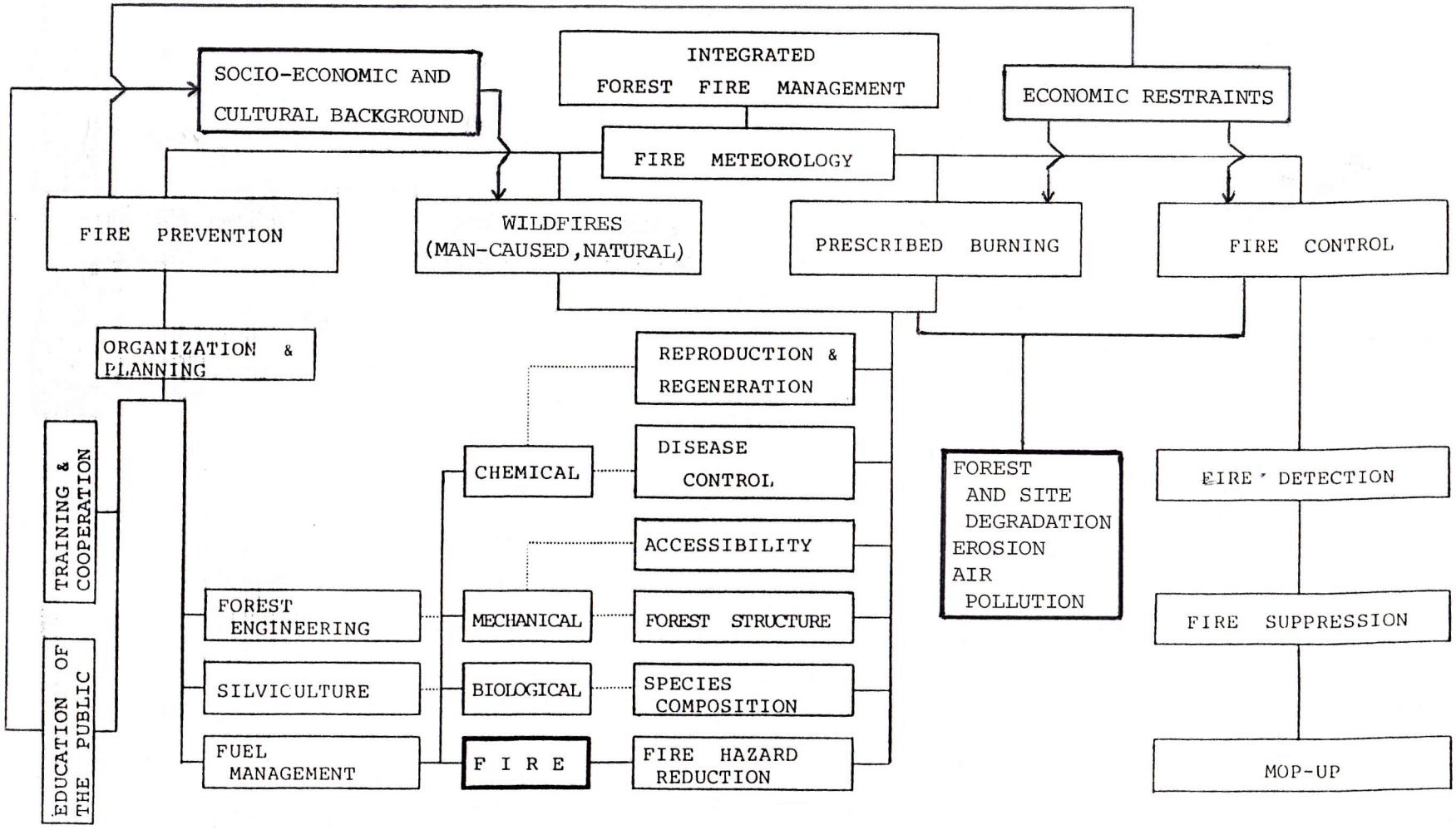

Fig.1: Diagram of Integrated Forest Fire Management

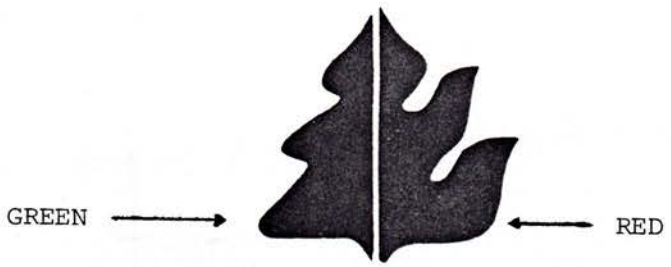

Fig. 2 : Proposed fire prevention symbol
(see para 2.3.1)

Appendix 2.

LIST OF MATERIAL HANDED OVER TO THE FOREST DEPARTMENT

1. Forest Fire Danger Meter (McArthur, Australia)

2. Proceedings of the 2nd "International Symposion on Fire Ecology" (Freiburg University, J. Goldammer ed.)

3. Equipment catalogue (Forestry Suppliers 1985/86)

4. Examples of educational material (U.S.A.)

Appendix 3.

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Appendix 4.

FOLLOW-UP PROJECT DOCUMENT PROPOSAL

ON

BURMA: FOREST FIRE MANAGEMENT

I. PROJECT BACKGROUND

The increasing demands on the forest resources of Burma require a comprehensive conception and strategy to protect the forest land against destructive influence by man. The ecological balance of many watersheds and other forest land has already been disturbed seriously by unsuitable land-use practices. Besides extended shifting cultivation, overgrazing and uncontrolled fuelwood extraction, wildfires are one of the most important disturbance factors. As it is estimated by FAO, more than 6.5 million hectares of forest land are affected by wildfires each year. They are all caused by man and mainly spreading from poorly controlled shifting cultivation or grazing land improvement fires or due to negligence. Soil depletion and erosion are the most serious consequences and may result into siltation of irrigation and hydro-electric power dams. Furthermore long-term planning goals in plantation establishment are endangered. On the other hand, not too much is known in detail about the fire effects on teak-bearing forests and other fire-climax forest communities. Forest fire management and research need to be strengthened in order to avoid jeopardizing long-term ecological and socio-economic goals of forest management.

II. OBJECTIVES OF THE PROJECT

The Government has placed high priority on the protection of plantations, watersheds and other forested areas against destructive wildfires. The Government and FAO therefore had requested the services of a forest fire management consultant in order to evaluate the forest fire risk, to review the fire management strategy and to conduct basic fire management training courses. On the base of his findings (BUR/81/001, Technical Paper No.5) the Government is herein seeking foreign assistance to meet immediate needs in forest fire management development, training and research.

The development objectives of the project are:

(1) To assist the Government in developing an Integrated Forest Fire Management strategy.

(2) To create a Forest Protection Unit (Forest Fire Management) within the Forest Department.

(3) To establish a Forest Fire Research Unit at the Forest Research Institute.

(4) To enable the Government to minimize the overall ecological and socio-economic damages caused by uncontrolled wildfires.

The immediate objectives of the project are:

(1) To establish a Forest Fire Management Demonstration Project in Maymyo Township.

(2) To provide theoretical and practical fire management training of Forest Department personnel in cooperation with the Burma Forest School and the Demonstration Project, Maymyo.

(3) To provide training of two forest officers by granting fellowships.

(4) To stimulate and advise forest fire research.

(5) To procure basic tools and equipment (not available in the country) for the Demonstration Project and the Research Unit.

III. WORK PLAN

The work plan consists of provision of equipment, establishment of the demonstration project, training of personnel and consultant services.

1. Provision of equipment

According to the equipment list in the annex following items for the Demonstration Project, the Research Unit and the Burma Forest School are needed.

1.1 Basic fire fighting hand tools and light equipment

1.2 Fire protective clothing for fire fighters

1.3 Meteorological instruments (fire-weather observations)

1.4 Fire detection equipment

1.5 Communication facilities (radio)

1.6 One 4-wheel drive pick-up truck with slip-on fire fighting unit

1.7 Research instruments

1.8 Basic library stock.

2. Establishment of the Forest Fire Management Demonstration Project

The establishment of this project will be carried out in common responsibility and close cooperation of the Maymyo Township Forest Officer and Plantation Officer, the head of the Forest Protection Unit (Forest Fire Management) of the Forest Department, the Forest Fire Research Officer and the Burma Forest School. The conception of the planning is based on the report on the consultancy in Forest Fire Management (BUR/81/001) and the handbook "Introduction to Forest Fire Management".

During the establishment phase the following construction and planning steps have to be taken:

2.1 Construction of 4 lookout towers on sites previously selected during the BUR/81/001 phase.

2.2 Installation of the radio communication system.

2.3 Re-organization and re-distribution of fire guards (houses, ground patrols) in cooperation with Plantation Division unit.

2.4 Establishment of a Fire Management Center at the Maymyo Forest Nursery.

2.5 Selection and training of a dispatcher

2.6 Preparation of a fire control/preattack map and relevant boards

2.7 Implementation of preattack planning

2.8 Training of firefighters in use of new equipment and fire suppression techniques

3. Training of fire management/research officers

According to the final report of the consultancy on forest fire management it was recommended to give a special fire management training to the future head of the Forest Protection Unit and the Forest Fire Research Officer. Two fellowships should be granted to these officers and consist of a 3-months training in the USA and Australia. Following institutions should be visited and seminars attended:

3.1 Attend the Seminar "Wildland Fire 2000" which will be held at University of California, Berkeley, in cooperation with IUFRO Subject Group S.1.09 ("Forest Fire Research"), the U.S. Forest Service and other institutions. It includes a short study tour. If possible the"Conference on Forest Fire Meteorology" (same month) should be attended.

3.2 Visit of National Forests in California (Yosemite, Stanislaus, Sequoia and others) to study fire ecology and integrated fire management.

3.3 Visit of U.S. Forest Service fire laboratories (research and development)

3.4 Visit of the National Bushfire Research Unit, C.S.I.R.O., Canberra/Australia.

3.5 Visit of the Australian National University Professor of Fire Management, Canberra/Australia.

3.6 Visit of installations/forest types in cooperation with the New South Wales Bushfire Council (Sydney) and/or the Victoria Forestry Commission (Melbourne).

4. Consultant services

Since the basic consultant services have been carried out during BUR/81/001 the mission will consist of a total of 1 m/m. This consultancy should be carried out after finalizing the activities mentioned under para 1 to 3. The consultant will assist the Forest Department in reviewing and evaluating all steps being taken during the follow-up programme. Special attention will be given to :

4.1 Review implementation of the Forest Fire Management Demonstration Project (facilities, planning, training).

4.2 Review the activities of the Forest Protection Unit (Forest Fire Management) and propose revised strategies, if necessary.

4.3 Review and discuss the forest fire research activities

4.4 Prepare a short final project report.

IV. CONTRIBUTION OF THE GOVERNMENT

The Government will grant the facilities and obligations as stated in Annex I to the FAO-TCP guidelines. In cooperation with the FAO Representative in Burma, the Forest Department will be responsible for the procurement of the equipment and the preparation of the study tour. The Forest Department in cooperation with the consultant will be responsible for the implementation of the demonstration project.

The Forest Department will provide funds for the construction of 4 fire lookout towers with fire guard houses and provide office space for the establishment of the Fire Management Center, Maymyo Forest Nursery. It also provides research funds for the establishment of permanent observation and erosion control plots.

V. BUDGET

		US $.
1.	Personnel	
	1 m/m consultant services	12,000
2.	Equipment, supplies and materials	
	according to equipment list (Annex 1)	54,000
3.	Training	
	On-the-job training for two forest	
	officers (3 months)	22,000
4.	General operating expenses	2,000
	Total	90,000

VI. ANNEX: EQUIPMENT LIST

Destinations: FRI = Forest Research Institute (Forest Fire Research Unit)
BFS = Burma Forest School
MTF = Maymyo Township Forest Office
FD = Forest Department Headquarters (Forest Protection Unit).

Note: The selection of items (stock no.) and the calculation of costs have been made on the base of the 1985/86 Forestry Suppliers Catalogue No.35. This catalogue was handed over to the Director, Burma Forest School. An estimated price increase of 5% was added as well as an additional 20% for packing/shipping charges. It is

recommended, however, to varify the costs by consulting the 1986/87 catalogue and to request a "Pro Forma Invoice" (see "Information for International Customers").

The costs of the vehicle and the slip-on fire-fighting unit as well as the size of the unit (to be related to the loading area of the vehicle) should also be verified before finalizing the budget calculation and the order information.

Ordering information for fire retardant fibre material and German tools will be forwarded to the Project by the consultant.

Annex

to

Follow-up Project Document Proposal

Sr. No.	Description	Ordering No. (For Suppl.)	Quantity	Costs Per Item	Costs Total	Destination
1	4-wheel drive Toyota Pick-up (Diesel)	-	1	13,000	13,000	MTF
2	Slip-on fire fighting unit Model BX 10 S (max.80 to 100 gal.tank)	85631	1	4,865	4,865	MTF
3	Communication Equipment					
	- stationary transceivers	-	2	-	-	-
	- tower-based protable transceivers	-	4	-	-	-
	- car-mounted transceiver	-	1	-	-	-
	- hand-held portable transceivers	-	2	-	12,000	MTF
4	Fire-retardant fibre material (Aramia, Nomex) (fire fighters clothing) to be specified according manufaturer's information	-	-	-	3,500	MTF
5	Osborne Fire Finder	85197	1	2,695	2.695	MTF
6	Wind Speed/Direction Indicator	89006	1	375	375	MTF
7	Cup Anemometer	89192	1	110	110	FRI
8	Sling Psychrometer	89194	3	43	129	MTF (2) FRI (1)
9	Case	89196	3	11	33	MTF (2) FRI (1)
10	Replacement Thermometers	89291	5	17	85	MTF (3) FRI (2)
11	Psychrometric Slide Rule	89197	2	4	8	MTF (1) FRI (1)

Sr. No.	Description	Ordering No. (For Suppl.)	Quantity	Costs Per Item	Costs Total	Destination
12	Fuel Moisture Meter	79346	1	120	120	FRI
	Batteries	02179	4	3	12	-
13	Portable Electronic Balance	93475	1	475	475	FRI
14	Fire Weather Instrument Kit	89088	4	89	356	FRI (2) MTF (1) BFS (1)
15	Binocular	91103	5	122	610	MTF
16	First Aid Kit	25114	1	55	55	MTF
17	Drip Torch	85329	10	111	1,110	FRI (2) BFS (2) MTF (6)
18	Council Fire Rake	85207	17	20	340	FRI (2) MTF (15)
19	McLeod Tool	85272	12	51	612	FRI (2) MTF (10)
20	Pulaski Tool	85270	14	34	476	FRI (2) BFS (2) MTF (10)
21	Fire Swatter	85093	7	27	189	BFS (1) FRI (1) MTF (5)

Sr. No.	Description	Ordering No. (For Suppl.)	Quantity	Costs Per Item	Costs Total	Destination
22	Fire Swatter (German type)	-	17	25	425	BFS (5) FRI (2) MTF (10)
23	Backpack Pump (Australian type. Information at BFS)	-	28	30	840	MTF (25) FRI (3)
24	Books					
	- Wright/Bailey : Fire Ecology	59873	2	50	100	FD (1) FRI (1)
	- Brown/David : Forest Fire	59832	2	37	74	FD (1) FRI (1)
	- Fire in Forestry	59891	3	83	249	FRI (1) FD (1) BFS (1)
	- Luke/McArthur : Forest Fire in Australia (Govt. Printing Office, Canberra)	-	3	30	90	FRI (1) FD (1) BFS (1)

Total Costs	42,933
+ 5% increase of costs	2,147
	45,080
+ 20% shipment costs	9,016
GRAND TOTAL	54,096