CHINESE-AMERICAN
JOINT COMMISSION ON RARAL RECONSTRUCTION

Forestry Series: No. 6

FOREST MANAGEMENT GUIDE FOR TAIWAN

By

PAUL ZEHNGRAFF TAO YU-TIEN
YUAN HSING-CHI, YANG CHI-WEI

TAIPEI, TAIWAN, CHINA

September 1959

CHINESE-AMERICAN
JOINT COMMISSION ON RARAL RECONSTRUCTION

Forestry Series: No. 6

FOREST MANAGEMENT GUIDE FOR TAIWAN

By

PAUL ZEHNGRAFF TAO YU-TIEN
YUAN HSING-CHI YANG CHI-WEI

TAIPEI TAIWAN. CHINA

September 1959

PREFACE

The Chinese-American Joint Commission on Rural Reconstruction has been actively engaged in a forestry development program since it established the Forestry Division in 1951. In the first three years, efforts were concentrated on the following activities: (1) To promote and subsidize the reestablishment of depleted windbreaks and coastal shelterbelts in order to protect agricultural production in the coastal areas. Under this program 5,000 hectares of seacoast shelterbelts and 4,000 kilometers of farm windbreaks have been planted up to 1958. (2) To arouse public appreciation of the value of forest consciousness and public interest in tree planting, and to render financial and technical assistance to the public and private reforestation. By these efforts the annual planting has been increased to nearly 40,000 hectares since 1953, as against 10,000 hectares in previous years. (3) To assist in forest protection, forest research and offshore island reforestation programs. (4) To invite Dr. Tom Gill, a world-known authority on forest policy, to study the forestry problems and to outline a basic forest policy for Taiwan.

Recognizing that the national forest policy and development program must be based upon a reliable inventory, JCRR in 1954 secured the services of a team of 5 aerial survey technicians from the U. S. Forest Service, and support and cooperation from local governmental agencies in conducting a forest resource and land use aerial survey during the period from 1954 to 1956.

The findings of the survey provided a basis for the formulation of a sound forest policy. A forest policy committee composed of local forestry specialists was therefore organized under the Provincial Department of Agriculture and Forestry, for making recommendations on forest policies and management principles. JCRR helped by securing the services of Dr. Tom Gill again and two other American outstanding foresters, Messrs. H. D. Cochran and E. L. Demmon. After one year's work, the specialists submitted a forest policy and a forestry improvement program to the Government. It was promulgated in March 1958 after formal review and approval by the Taiwan Provincial Government and the Executive Yuan. This is the first forest policy in written form published by the Government, and is an important milestone in the history of forestry development of China.

The program calls for the preparation of a practical forest management guide. This was carried out by Mr. Paul Zehngraff, former Chief of the Forestry Division of JCRR in cooperation with Mr. Tao Yu-tien, Director of the Taiwan Forest Administration, and Messrs. Yuan Hsing-chi and Yang Chi-wei of the Forestry Division. The guide establishes forest management objectives for Taiwan and helps in setting up more detailed management plans for individual forest districts and national forest working circles in order to place the island's forest resources under scientific management. Now, upon completion of the work of the authors, I have the pleasure to present by way of preface these brief comments on the development of forestry in Taiwan in recent years.

Chiang Monlin
Chairman, JCRR
September 1959

Acknowledgements

The authors wish to express deep appreciation to Messrs. Chen Lung-hsing, Chou Chen, Hsu Hsieh-hsiun, Kang Han, C. J. Kraebel, Kuo Pao-chang, Lin Kun-mao, Lin Wei-fang, Liu Shen-hsiao, Liu Tung-jui, Wang Tze-ting, Wang Ru-pi, and Yang Pao-lin for their reviewing the manuscript and offering valuable suggestions for improvement.

CONTENTS

INTRODUCTION

The intention of this guide is to present a brief description of forest conditions in Taiwan, based on the Land Use and Forest Resources Aerial Survey completed in 1956, and to set forth the main features of long range management of the forest lands and resources of the Island. It should serve primarily as a policy guide to present and future forest managers in setting up more detailed management plans for individual forest districts and working circles. The guide is intended to cover a period of 40 years, but it should be revised at 10-year intervals, or following each re-survey, so as to serve its intended long range purpose.

MANAGEMENT OBJECTIVES

The long range objective of forest management in Taiwan should be to obtain from the Island's timber lands maximum production of the most suitable wood on a sustained yield basis, consistent with expected population increases. Management efforts, therefore should be directed toward full utilization of forest soil and growing space, and the development of "normal forests", i.e. insofar as possible a proper distribution of area and age classes. Consequently, most of the present natural forest types should be harvested during the next 40 years and replaced with faster growing and more valuable species. Others may be regenerated naturally when possible, or replanted to the original species. The silvicultural management objectives are:

1. *To hold* the present timber area without losing further ground, all national forest lands now carrying species of commercial value must remain as productive forests; this will include clearcutting of all present overmature forests and replanting where natural regeneration of desirable species is not possible.
2. *To improve* the present forest land and forest capital, the best applicable silvicultural management and timber stand improvement should be applied, including artificial reforestation of poorly stocked lands and conversion of low value forest stands to species of highest economic value.
3. *To extend* the present productive forest areas, the following two items should be completed within the period of this plan:
   (a) the present inaccessible forest lands should be made progressively accessible through road construction, and
   (b) the present idle forest lands, if better suited for timber production or protection of watersheds than for any other purposes, should be reforested through artificial means.

FOREST DESCRIPTION

General

Various forest types cover about 55% (1,969,500 ha.) of the total land area in Taiwan. Another 12.4% (442,600 ha.) of the area was formerly forested but is now idle.

Because of the extreme altitude differences in Taiwan, the climate ranges from tropical to frigid. The island, consequently, is divided into distinct climatic zones, as shown below:

Table 1. Vertical Climatic Zone Ranges in Taiwan*

Climatic Zones	Percent of area	Altitude in North		Altitude in South	
		From:	To:	From:	To:
		Meters			
Tropical	56	Sea level	300	Sea level	600
Sub-tropical	31	300	1,500	600	2,000
Temperate	11	1,500	2,800	2,000	3,500
Frigid	2	2,800	3,900	3,500	3,700

* Source of information: Taiwan Forest Research Institute.

The forested area on Taiwan is fairly evenly distributed between four elevation classes, i. e. 0–599, 600–1199, 1200–1999 and 2000+ meters. However the proportion of the forest stands in the higher volume classes increases rapidly with elevation. Only 3.6 percent of the forested land below 600 meters has 100 cu. m. or more per hectare while 60.6 percent of the stands above 2,000 meters have over 100 cu. m. per hectare.

Table 2. Area of Forested Land by Elevation and Volume Classes

Volume Class cu. m. per ha.	Elevation in Meter					Total
	0–599	600–1199	1200–1999	2000–2999	3000+	
	Thousand Hectares					
0– 49	445.2	303.7	181.0	77.6	11.3	1,018.8*
50– 99	45.5	87.6	150.1	89.6	9.5	382.3
100–149	10.9	30.7	71.4	51.1	5.6	169.7
150–199	4.9	14.3	46.2	45.4	4.8	115.6
200–299	1.6	12.6	53.1	64.5	7.9	139.7
300–399	0.7	3.3	16.9	46.0	5.2	72.1
400–499	—	0.5	4.3	12.6	2.2	19.6
500–749	—	—	6.4	25.1	3.0	34.5
750+	—	—	1.6	13.2	2.4	17.2
Total	508.8	452.7	531.0	425.1	51.9	1,969.5

* Bamboo included.

Natural forest types and composition vary directly with elevation. They may be classified into four major groups, namely conifers, mixed stands, hardwoods and bamboo. Conifers, the most valuable species, are mostly found in the high mountain areas, hardwoods and bamboo occur in lower elevations and mixed stands are intermingled in between.

Table 3. Type Distribution

Tropical	Sub-tropical	Temperate	Frigid
Hardwoods	Hardwoods	Hardwoods	Fir
Bamboo	Conifers	Conifers	
	Pine	Cypress	
	Other conifers	Hemlock	
	Bamboo	Pine	
		Spruce	
		Hardwood-conifer mixture	

As seen from the above table, the greatest forest wealth of Taiwan is located in the temperate forest zone, namely between 1,500 meters to 3,000 meters above sea level.

Table 4. Important Commercial Species*

Tropical	Sub-tropical	Temperate	Frigid
Hardwoods	Hardwoods	Hardwoods	Conifers
Acacia confusa	Cinnamomum spp.	Quercus morii	Abies kawakamii
Machilus kusanoi	Zelkova formosana	Lithocarpus spp.	
Machilus zuihoensis	Pheobe spp.	Conifers	
Conifers	Machilus spp.	Pinus armandi	
Pinus luchuensis**	Schima superba	Pinus taiwanensis	
Pinus elliottii**	Castanopsis longicaudata	Pinus morrisonicola	
	Castonopsis stipitata	Pseudotsuga wilsoniana	
	Quercus gilva	Cunninghamia konishii	
	Quercus glauca	Taiwania cryptomerioides	
	Lithocarpus spp.	Chamaecyparis formosensis	
	Conifers	Chamaecyparis taiwanensis	
	Cryptomeria japonica**	Picea morrisonicola	
	Cunninghamia lanceolata**	Tsuga chinensis	
	Pinus massoniana		
	(Pinus taiwanensis)		
	Libocedrus formosana		
	(Pseudotsuga wilsoniana)		

* From chart prepared by Taiwan Forest Research Institute.
** Exotic species.

Table 5. Accessibility of Forested Land by Forest Type

Forest type	Operable			Non-operable	Total
	Accessible	Inaccessible	Sub-total		
	Thousand Hectares				
Conifers	111.9	237.3	349.2	23.8	373.0
Fir-spruce	5.3	51.6	56.9	4.4	61.3
Hemlock	23.3	100.0	123.3	9.7	133.0
Cypress	13.4	26.0	39.4	3.6	43.0
Pine	23.9	42.7	66.6	3.6	70.2
Other conifers	46.0	17.0	63.0	2.5	65.5
Conifer-hardwoods	26.7	25.2	51.9	3.4	55.3
Hardwoods	1,066.1	312.6	1,378.7	48.6	1,427.3
Tropical hardwoods	580.5	20.8	601.3	11.5	612.8
Sub-tropical hardwoods	385.0	154.8	539.8	26.0	565.8
Temperate hardwoods	100.6	137.0	237.6	11.1	248.7
Bamboo	106.9	6.3	113.2	0.7	113.9
Total	1,311.6	581.4	1,893.0	76.5	1,969.5

Type Description and Mangement Guide

Conifer Type

The conifer type covers 373,000 ha., or 19% of the forested land of Taiwan. Five types are recognized in the natural conifer stands which are largely found over 2,000 meters above the temperate hardwood type or conifer-hardwood mixed stands. As they grow on mountains of the higher altitudes, only 111,9000 ha. are accessible at present.

(a) ***Cypress type***—The cypress type comprises *Chamaecyparis formosensis* and *Chamaecyparis taiwanensis*, singly or in combination. They are the most valuable species in Taiwan. The natural range of cypress is at elevations from 1,500 m. to 2,800 m. generally in pure stands. The cypress type occupies 43,000 ha. but only 13,400 ha. is accessible at present. Almost all of the area still covered by this type is in virgin stands of mature or overmature trees ranging in age from 200 to 2,000 years; 82% of the cypress growing stock is in trees 100 cm. DBH or larger. Stands are well stocked with 200–1,200 cu. m. per hectare. Due to the advanced age of the stands, the seed supply is frequently not satisfactory. Moreover, the low ground cover is of such a nature that seed germination is difficult. Natural reproduction after logging therefore is either generally lacking, or it is insufficient. Grass, brush and uncommercial bamboo usually take over the site and prevent the natural seedlings from full development.

The cypress type is the most valuable forest type in Taiwan, but also the slowest growing species. The wood is resistant to termites and rot, and will therefore always be essential to the forestry economy of Taiwan. Despite its comparatively slow growth, the cypress is the most suitable species in Taiwan at elevations above 1,500 m. Efforts should be exerted to perpetuate it, whether by natural regeneration or planting.

Due to the fact that cypress does not reach merchantable sizes in less than 80 years, the general 40-year liquidation period recommended for the present sawlog stands in Taiwan should not be followed for this type, but should be extended over a period of 80 years. The general cutting practice for the original, overmature stands should be clear-cutting, following by planting of cypress. Planting should follow immediately after logging so as to avoid high weeding costs due to invasion by grass and brush. Where the soil is very shallow, especially on south slopes, the cypress may be replaced with *Pinus armandi*, *Pinus morrisonicola* or *Pinus taiwanensis*. Where cypress is found below the elevation of 2,000 m. it may be advantageously replaced with *Cryptomeria japonica*, *Cunninghamia lanceolata* or *Cunninghamia konishii*.

(b) ***Hemlock type***—The hemlock type with *Tsuga chinensis* predominating comprises 33% of the area and nearly 36% of the conifers on the island. It is found at elevations of 2,000 to 3,000 meters, usually associated with fir (*Abies kawakamii*) in the higher altitudes and with temperate hardwoods in the lower.

This type of virgin stands covers 133,000 ha. of which only 23,300 ha. is accessible. The total growing stock is 31,804,000 cu. m.; 92% of this in sawtimber volume of which 86% or 25,155,000 cu. m. is in trees of 50 cm. DBH and over.

The trees are old and large. The average volume per hectare is 239 cu. m. which ranks next to the cypress and fir-spruce types. Because of its high volume per hectare it is one of the most important conifer types in the high mountains. The type consists of highly overmature trees, however, and the mortality is far in excess of growth. The

seed supply is scarce and the low ground cover generally dense. Consequently natural regeneration does not succeed logging.

Because of its stagnant growth the entire operable area of this type should be harvested within the next 40 years. The soils in these elevations are generally shallow, the climate adverse and the growing season short. Since no substitute species has yet been found in sufficient quantity for replacement of this type, its regeneration offers the most serious problem in Taiwan forestry and a challenge to intensified research.

Concentrated efforts should be made to collect sufficient local seed of suitable species for reforestation of this type, and tests with exotic species should be intensified. Among local species hemlock and pines (*Pinus armandi* and *Pinus taiwanensis*) offer the best possibilities on the shallow soils, and *Chamaecyparis* on the deeper soils up to an elevation of 2,800 m.

(c) ***Fir-spruce type***—This type is found in the highest and most inaccessible mountains, generally in elevations above 2,400 m. The major species are *Abies kawakamii* and *Picea morrisonicola* with the former predominating, often in nearly pure stands and usually well stocked, with an average growing stock volume of 323 cu. m. per ha. The total area of this type is 61,300 ha. with a volume of 19,793,000 cu. m.

Although it contains a more than 20% of the total conifer volume, the type at present is relatively unimportant due to inaccessibility. It seems unlikely therefore, that this timber will contribute materially to the national wood economy for the time being.

Very little is known about the management possibilities of this type except that the old overmature stands seem to reproduce themselves satisfactorily following natural mortality and windfall. It would appear, therefore, that a form of shelterwood management or clearcutting with seed trees would assure cheap natural regeneration of the type. The assurance of reproduction being a prerequisite to cutting in these elevations, where future management must of necessity be of a rather extensive type, silvicultural research toward this end should be conducted well in advance of exploitation. Exploitation and management of this type should be planned at an early stage, and a 40-year liquidation goal should be set for the present old stands.

(d) ***Pine type***—The natural pine type consists of four native species which appear in different elevations, namely: *Pinus armandi, Pinus taiwanensis, Pinus morrisonicola, and Pinus massoniana* in the above order from the highest to the lowest elevations.

With the exception of stands of *Pinus taiwanensis* and *Pinus armandi*, the pine type is usually poorly stocked with an average volume of 177.8 cu. m. per hectare, but it is the most accessible natural conifer type. The type covers a total area of 23,900 ha. with total growing stock of 12,485,000 cu. m. In general the pines develop satisfactorily on poor and dry soils and grow naturally on cliffs, ridges and grasslands where other species do not grow. Natural seeding is common on the central mountain range, especially on the sun facing slopes, and after burns.

Efforts should be made to take advantage of these characteristics in extending the type so as to make fuller use of the poorer forest soils. These efforts should include stand improvement cutting and supplementary planting in understocked stands.

Pinus armandi is a five-needled pine which grows to large sizes in elevations from 2,000 m. to 2,700 m. mostly in the northern and central part of the island. To a limited extent it is found in pure stands; most often however it is associated with hemlock, cypress and spruce. *Pinus armandi* is a fast growing timber species which reproduces itself fairly well. The wood is of high quality and it yields high quality

oleoresin. As the higher mountain areas become more accessible, serious efforts should be made to extend this valuable species, especially into the hemlock and cypress types on shallow soils.

Pinus taiwanensis is a two-needled pine which most frequently occurs in pure, but generally thin stands. Occasionally it is found in mixtures with other species on thin soils. It grows in elevations from 750 m. to 2,800 m. particularly in the central part of the island. Its growth is rapid and it develops into large sizes. This pine species is an excellent turpentine producer and the timber is of good quality. Limited, but very successful efforts have been made to extend it through planting. It is exceptionally well suited as a replacement species for low grade hardwoods on thin and exposed soils and should be used more extensively as a standard reforestation species on south and west slopes in elevations from 400 m. and up.

Pinus morrisonicola is another five-needled large pine which appears in elevation from 300 m. up to 2,300 m. throughout the island. It rarely forms pure stands, but is usually found in association with broadleaved species and scattered along ridges. Its growth is fairly rapid and the timber is of excellent quality. Because of its high quality, in combination with comparatively easy accessibility, it has been cut heavily in recent years. No efforts have been made to date to extend this species. It is suitable for replacement of hardwood stands as well as for reforestation of exposed logged over areas in the higher elevations. Efforts should be made to this end.

Pinus massoniana is a 2-needled pine which occurs mostly in the lower elevations in the northern part where it usually develops crooked trunks and is of little commercial use except for pulp.

It reproduces itself exceptionally well. When planted in higher elevations, up to 800 m., it develops fairly well. It grows rapidly in its youth, but slows down considerably after it reaches diameters of about 25–30 cm. It may be planted to limited extents for pulp production, small construction timber and mining timber in easily accessible areas from 500 m. to 1,000 m. elevation.

The pine type also includes two exotic species which were planted to limited extents in former years. Since they were found to develop well in Taiwan, they have been planted rather extensively since 1952. The species are *Pinus luchuensis* which develops well in the northern and central parts of the island in elevations ranging from 300 m. to 1,200 m., and *Pinus elliottii* which develops well from sea-level up to 800 m. Because of its rapid growth on a wide range of soils, *P. elliottii* holds high promise as a major pulp species and for turpentine production. The recent extensive plantations should be carefully watched for any appearance of attacks by insects and diseases which might threaten the development.

(e) ***Other conifer type***—This type covers a total of 65,000 ha. with a volume of 3,590,000 cu. m. Except for the *Cunninghamia lanceolata* and *Cryptomeria japonica*, both of which are introduced and appear in pure, evenaged plantations, other conifers are native, and as a rule appear in mixtures with either broadleaved or coniferous species, and to a limited extent in pure stands. The most important of the natural species are:

Libocedrus formosana which occurs in elevations from 300 m. to 1,800 m. in the northern and central parts, usually associated with broadleaved species. It is an excellent wood which grows rather well on most slopes. Good reproduction is often found in fairly open areas and along river banks. Efforts should be made to extend it through planting.

Taiwania cryptomerioides is found at elevations from 1,000 m. to 2,600 m., generally scattered among the cypress, hemlock and temperate hardwood forests. Where it occa-

sionally appears as a pure stand of small areas, the large, overmature trees are widely scattered. It does not readily reproduce itself and is therefore in danger of extinction through cutting. Due to the difficulties in seed collection and asexual propagation, very little effort other than experimental has been made in the past to cultivate this species as a forest crop.

Because *Taiwania* has many characteristics of a superior forest tree, growing faster and producing larger sizes and better wood than *Cryptomeria*, the propagation of *Taiwania* should be greatly strengthened. Special plantations for seed production should be established at an early date.

Cunninghamia konishii is an excellent timber species which appears in elevations from 1,300 m. to 2,700 m. in the northern and central parts, usually in mixtures with other conifers, rarely with broadleaved species, but occassionally in pure stands on limited areas. This species is well adapted for extension into lower elevations, particularly as a replacement species for hardwoods on northern and eastern slopes where it will grow fast and develop excellent timber. Efforts now underway to this effect should be strengthened as much as the available seed supply will permit.

Pseudotsuga wilsoniana is found scattered among other species in elevations from 800 m. to 2,700 m., mostly in the central part. Although it is an excellent timber species which grows rapidly into large trees, no efforts have been made to cultivate it as a timber crop due to scarcity of seed. Although the cost will be somewhat higher for this reason than ordinary reforestation, efforts should be made to establish parent stands for later seed production and subsequent extension of this valuable species.

Among the introduced species included in the "other conifers" type the following two are the most important:

Cunninghamia lanceolata, which originally was introduced from China mainland, has been widely planted in Taiwan for a number of years. The total reported area planted to this species up to 1956 was 39,595 ha. It is a rapidly growing species which develops well on north and east slopes in elevations from 600 m. to 1,500 m. where it will produce dense stands of high quality and volume. High yielding commercial thinnings are possible at the age of ten years, or before. It reproduces itself satisfactorily through stump sprouting following cutting. Because of its easy establishment and rapid growth it still is the most commonly used coniferous species in the present reforestation program. Inasmuch as past experiences clearly indicate that *Cunninghamia* prefers cool, moist sites, care should be taken in the future not to plant this species on shallow soils or on strongly exposed south and west slopes.

Cryptomeria japonica which originally was introduced from Japan has been widely planted in Tawan for a number of years. The total area reforested with this species up to 1956 is estimated to be 20,000 ha. of which 10,508 ha. was planted during 1948–1956. The growth is very rapid and it produces dense stands of high quality and volume. Commercial thinnings are possible at age 15 or sooner. From the age of 25 years it produces high grade poles. Its best range is from 1,200 m. to 2,000 m. elevation. In Taiwan it does not seem to reproduce itself following cutting. Frequent light commercial thinnings are necessary for its full development. Inasmuch as it develops heart rot at an early age, the rotation should not exceed 40 years on poor sites, or 50 years, on good sites. It should not be planted on shallow soils or exposed sites, nor in elevations below 1,000 m. or above 2,000 m.

Mixed Conifer and Hardwood Type

The conifer and hardwood mixture occupies 55,300 ha. or 2.8% of the total forest in Taiwan. It is the predominant type between the temperate hardwood and the upper conifer types, forming a narrow belt of mixed stands along the contour at elevations ranging from 1,500 m. to 2,000 m.

In future management efforts should be made to convert the greater part of this type to the more valuable conifers, namely *Cunninghamia* and *Cryptomeria* on the north and east slopes and pines on the south and west slopes. On good sites the more valuable hardwoods, namely *Zelkova formosana*, *Michelia formosana*, high-quality oaks (*Quercus spp.*) and tanoaks (*Lithocarpus spp.*) may be perpetuated.

Hardwood Type

The hardwood type occupies 1,427,300 ha., or 72.5% of the total forested area, at elevations from sea level to 2,000 meters. As it predominates at lower altitudes, it is more accessible than coniferous species. Of the presently accessible volume, 70% is in hardwoods and over 40% of it is in trees of less than 40 cm. DBH.

The hardwood type may be further divided into tropical hardwoods, sub-tropical hardwoods, and temperate hardwoods, depending upon elevation and the predominant species present.

(a) *Tropical hardwood type*—Natural tropical hardwood stands are usually found below 300 meters in northern part, or below 600 meters in southern part. The following species usually predominant, occasionally mixed with tree ferns.

Acacia confusa	*Ficus spp.*
Machilus kusanoi	*Trema spp.*
Machilus zuihoensis	*Schefflera octophylla*
Liquidamber formosana	*Sapindus mukorossi*
Mallotus spp.	*Quercus glauca*

The tropical hardwood type, covering 612,800 ha., or nearly 30% of total forested land and 44% of the accessible forested land, has the greatest forest potential, yet it is contributing least on a hectare basis to Taiwan's needs for timber. Due to its comparatively easy accessibility this huge area of forest land was heavily over-exploited for many years. The common practice was to remove the valuable trees, leaving the degraded, understocked stands of inferior species without further attempts to restore the original species and densities. This presents a serious land and forest management problem.

In general, hardwoods are the most suitable type in these lower elevations. Where sufficient natural regeneration of valuable species is present to form a fully stocked stand the less valuable species should be weeded out in stand improvement operations. Where the present stand is too scattered it should be clearcut as soon as possible and replanted with trees of good commercial value. Among these are *Acacia*, Camphor wood (*Cinnamomum camphora* and *Cinnamomum micranthum*), *Machilus kusanoi* and *M. zuihoensis*, and *Bischoffia javanica*, all of which are native. Among exotic species high priority should be given to planting of *Swietenia spp.*, *Tectona spp.*, *Ochroma spp. Cassia siamea* and *Pterocarpus spp.* in the southern part, and Slash pine (*Pinus elliottii*) in the northern and central parts.

(b) Sub-tropical hardwood type—The natural sub-tropical hardwood stands are found

on elevations between 300 m. and 1,500 m. in the north and between 600 m. and 2,000 m. in the south. It is a continuation of the tropical hardwood type and is usually comprised of the following valuable species:

Machilus arisanensis	*Lithocarpus brevicaudata*
Machilus thunbergii	*Lithocapus ternaticupula*
Engelhardtia formosana	*Michelia formosana*
Quercus gilva	*Cryptocarya chinensis*
Castanopsis stipitata	*Cryptocarya konishii*
Castanopsis kawakamii	*Beilschmiedia erythrophloia*
Castanopsis longicaudata	*Schima superba*

The sub-tropical hardwood covers 565,800 ha. of which 385,000, ha. are economically accessible at present. It has been subjected to the same adverse treatment as the tropical hardwood type although to a lesser extent.

Originally this type contained several good hardwood species such as oaks, tanoaks, *Michelia* and *Machilus* etc. In the accessible areas, however, these have been largely removed in past logging, leaving in most places only non-commercial species and scattered cull trees. Where regeneration follows logging, it consists primarily of inferior species resulting from the inferior parent trees left in logging. For this reason, conversion to other species through planting is imperative for most of this type. Consequently, the present stands should be clearcut and planted, preferably to suitable conifers, during the next 40 years. In general *Cunninghamia* spp. offer the best possibilities on north and east slopes at elevation from 600 m. up and *Cryptomeria* from 1,200 m. up. Various pines offer the best growth and development on the more exposed south and west slopes. Local pines recommended are *Pinus massoniana* and *Pinus taiwanensis*. Among exotics the Slash pine may be planted up to 800 m. and Luchiu pine up to 1,000 m.

(c) *Temperate hardwood type*—The natural temperate hardwoods usually occur above 1,500 m. in the north or above 2,000 m. in the south. The most characteristic species are:

Quercus longinux	*Actinodaphne spp.*
Quercus morii	*Lithocarpus amygdalifolia*
Quercus stenophylloides	*Alnus formosana*
Trochodendron aralioides	*Acer spp.*
Illicium leucanthum	

The temperate hardwood type appears to be a climax type. It is the least accessible hardwood with an area of 248,700 ha. of which only 40% or 100,600 ha. are accessible at present.

Although covering a fairly large area in the elevations above 1,500 m. the type as such is of relatively low importance in timber production due to the high logging costs incurred in these areas and the comparatively low price obtained for the products. The sites on which this type occurs, however, are generally good, and suitable for the more valuable conifers. Inasmuch as the temperate hardwood type appears to be a climax type the greater part of it should be liquidated as rapidly as possible and replaced with coniferous species, primarily *Cunninghamia, Cryptomeria* and pines.

Bamboo Type

The bamboo type covers a total of 113,900 ha., of which 94% or 106,900 ha. is accessible. It consists largely of the following three native species:

(a) *Sinocalamus latiflorus* which appears both in pure stands and mixed with broad-leaved trees on elevations below 1,300 m.

(b) *Phyllostachys makinoi* which usually appears in pure stands over large areas. It is widely cultivated in elevations from 100 m. to 1,000 m. in the northern and central parts of the island.

(c) *Phyllostachys edulis* appears in pure stands in elevations from 1,000 m. to 1,600 m., particularly in the central parts where it is rather extensively cultivated.

Other commercial bamboo species are mostly planted around farms or appear in scattered patches. They are therefore either included in this type or other forest types where they occur.

In general the bamboo forests are well managed and they contribute considerably to the island's economy. Being a quick-return forest crop, this type should be extended in certain accessible areas where the forest soils have been exposed to detrimental dry-farming.

CUTTING PLAN

General

Taiwan's forests contain 186 million cubic meters of which 150 million cubic meters are in the sawlog classes.

Broadleaved species constitute 48% and conifers 52% of the total volume. However, of the total growing stock only 97.6 million cubic meters are at present accessible. On the commerecial forest land (accessible, unreserved) the total volume is 83 million cubic meters. The inaccessible forests contain 80.8 million cubic meters. The remaining volume, 22.2 million cubic meters, is contained in areas too steep to manage, and in accessible protection forests in which little cutting has been previously practiced.

Timber growth and drain are about equal on commercial forest land. However, the more valuable conifers are at present being depleted at the rate of over 500 thousand cubic meters annually. Most of the growth is on small hardwood trees.

Forest conditions in Taiwan are unique to the extent that the overwhelming majority of the sawlog volumes is contained in virgin stands which are overmature and deteriorating rapidly. Although in theory drain should not exceed growth, this rule can not be adhered to in the case of overmature forests. They should be harvested and regenerated as early as possible under a rational cutting plan.

With regard to the younger age classes, the species which have been used in reforestation, with the exception of *Chamaecyparis*, are all fast growing and suitable for short rotations only. Considering the above facts together with the actual wood requirement and the indicated population increase, the present forest capital and its growth should be harvested in a period of 40 years and the cutover areas progressively reforested.

Chamaecyparis, because of its slow growth, will be an exception to this rule. The harvest period of this species should be extended over a period of 80 to 100 years which is the minimum length of time required to produce merchantable timber. Following is shown a tabulation of growing stock and net annual growth of the major types of timber, by operability and accessibility.

Table 6. Growing Stock Volume and Net Annual Growth by Species Group, Operability and Accessibility

A. OPERABLE FOREST

1. *Unreserved*

Species Group	Accessible		Inaccessible		Total	
	Growing Stock	Net Annual Growth	Growing Stock	Net Annual Growth	Growing Stock	Net Annual Growth
			(1,000 cu. m.)			
Cypress	8,061	23	12,823	36.6	20,884	59.6
Other conifers	15,950	−25	37,388	−411.1	54,338	−436.1
Hardwoods	59,388	1,207	13,418	923.6	72,806	2,130.6
Total	83,399	1,205	63,629	549.1	148,028	1,754.1
2. *Reserved* (Protection Forests)						
Cypress	2,679	7.7	3,988	11.4	6,667	19.1
Other conifers	2,219	−1.7	9,340	−102.7	11,559	−104.4
Hardwoods	9,278	218.0	3,795	261.2	13,073	479.2
Total	14,176	224.0	17,123	169.9	31,299	393.9

B. INOPERABLE FOREST

1. *Unreserved*

Species Group	Growing Stock	Net Annual Growth
	(1,000 cu. m.)	
Cypress	682	1.9
Other conifers	2,209	−24.3
Hardwoods	3,335	229.5
Total	6,226	207.1

2. *Reserved*

Species Group	Growing Stock	Net Annual Growth
	(1,000 cu. m.)	
Cypress	458	1.4
Other conifers	566	−6.2
Hardwoods	330	22.7
Total	1,354	17.9

Calculation of Allowable Cut

As previously specified, two different cutting cycles should be adhered to in the harvest of the present timber stands, namely 80 years for the *Chamaecyparis* and 40 years for other conifers and hardwoods. The annual allowable cut is calculated as follows.

$$\text{Annual allowable cut} = \frac{\text{Present Volume}}{\text{Liquidation Period}} + \frac{\text{Net Annual Growth}}{2}$$

The annual allowable cut by species groups is thus calculated shown below:

Table 7. Average Annual Allowable Cut by Accessibility and Species Groups

Accessible—Unreserved

Species Group	Volume	Growth	Liquidation Period	Annual Allowable Cut		%
				Total *	Net **	
	(cu.m.)	(cu.m.)	(yrs.)	(cu.m.)	(cu.m.)	
Cypress	8,061,000	23,000	80	112,262	89,810	4.4
Other conifers	15,950,000	−25,000	40	386,250	309,000	15.0
Hardwoods	59,388,000	1,207,000	40	2,088,200	1,670,560	80.6
Total	83,399,000	1,205,000		2,586,712	2,069,370	100.0

Inaccessible—Unreserved

Species Group	Volume	Growth	Liquidation Period	Annual Allowable Cut		%
				Total *	Net **	
Cypress	12,823,000	36,600	80	178,587	142,870	10.6
Other conifers	37,388,000	−411,100	40	729,150	583,320	43.4
Hardwoods	13,418,000	923,600	40	797,250	617,800	46.0
Total	63,629,000	549,100		1,704,987	1,343,990	100.0

Total Unreserved (Accessible & Inaccessible)

Species Group	Volume	Growth	Liquidation Period	Annual Allowable Cut		%
				Total *	Net **	
Cypress	20,882,000	59,600	80	290,849	232,680	6.8
Other conifers	53,338,000	−436,100	40	1,115,400	892,320	26.1
Hardwoods	72,806,000	2,130,600	40	2,885,450	2,288,360	67.1
Total	147,028,000	1,754,100		4,291,699	3,413,360	100.0

* Total wood volume to 8 cm. top diameter of central stem.

** Net merchantable volume=80% of the total.

Table 8. Area of Major Forest Types by Operability and Accessibility

Forest Type	Operable		Inoperable
	Accessible	Inaccessible	
		(1,000 ha.)	
Cypress	13.4	26.0	3.6
Other conifers	98.5	211.3	20.2
Hardwoods	1,066.1	312.6	48.6
Conifer-hardwoods	26.7	25.2	3.4
Bamboo	106.9	6.3	0.7
Total	1,311.6	581.4	76.5
Grand Total			1,969.5

The total annual allowable cut from both accessible and inaccessible unreserved forest is 3,413,000 cubic meters. This is the average annual volume for the 40 year period, however, and does not mean that this cut would be permissible at present. Based upon the present rate of population increase, i.e. 3.5% per year, the annual allowable cut will be proportioned as shown by the broken line on the following chart which assumes that the presently inaccessible forests will be totally developed for extraction in accordance with the road construction plan presented in the last chapter. Without such development the annual allowable cut will of necessity be considerably less as shown by the solid line in the following chart.

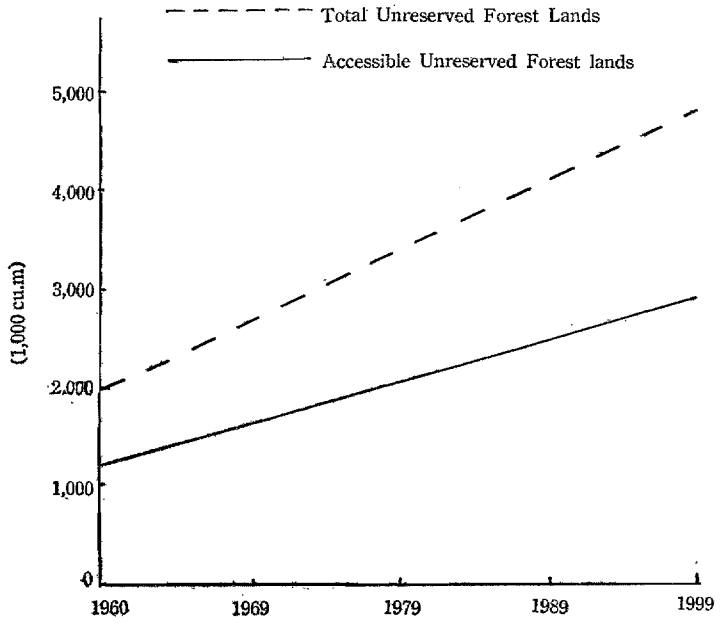

Chart 1. Total Annual Allowable Cut by Accessible Unreserved Forest Lands and Total Unreserved Forest Lands (1960-1999)

Inasmuch as cypress the most heavily exploited species during the past, occurs now in limited quantities only, whereas hardwoods account for by far the greatest part of the forest resources, the total volume of allowable cut is meaningless unless calculated in accordance with volume and growth of the three individual species groups namely, cypress, other conifers and hardwoods. Again, unless the present inaccessible areas are developed according to the accompanying plan, the future allowable cut in cypress must of necessity be much lower than in previous years or it will face extinction on the accessible forest lands within a short time, leaving only a small portion of other conifers and a disproportional large quantity of much less valuable hardwoods for future operations. The following chart and table show the proportioned annual allowable cuts by species groups on both accessible and total unreserved forest lands for the 40-year period.

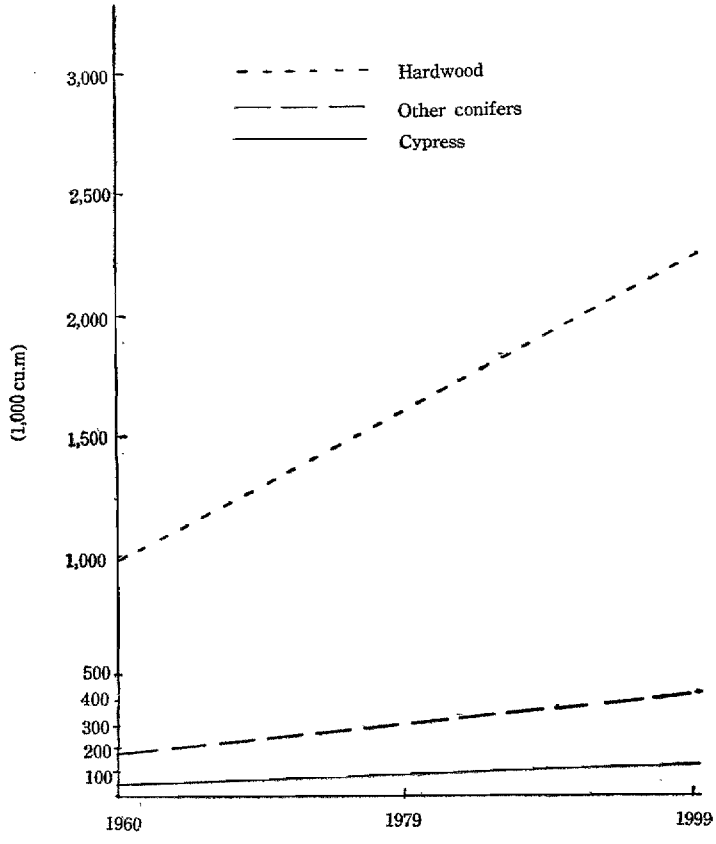

Chart 2. Annual Allowable Cut by Species Groups on Accessible Forest Lands (1960-1999)

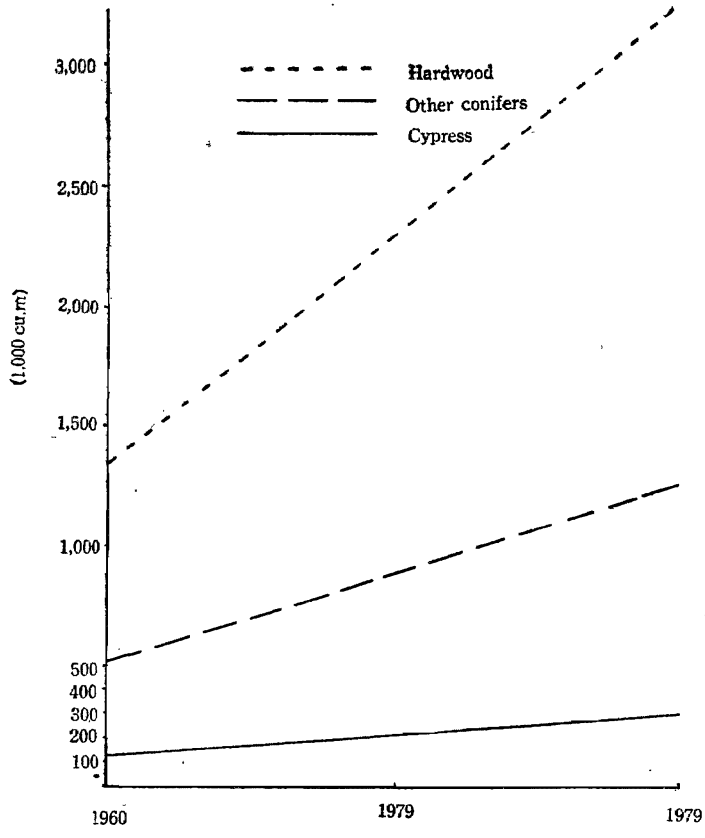

Chart 3. Annual Allowable Cut by Species Groups on Total Unreserved Forest Lands (1960-1999)

Table 9. Annual Allowable Cut on Accessible Unreserved Forest Land and Total Unreserved Land by Group of Species

Unit: cu.m.

Year	Accessible Unreserved Forest Land				Total Unreserved Forest Land			
	Cypress	Other conifers	Hardwoods	Total	Cypress	Other conifers	Hardwoods	Total
1960	53,379	183,655	992,903	1,229,937	138,294	530,354	1,360,095	2,028,743
1964	60,852	209,367	1,131,909	1,402,128	157,655	604,604	1,550,508	2,312,767
1969	70,193	241,506	1,305,667	1,617,366	181,857	697,415	1,788,525	2,667,797
1974	79,535	273,646	1,479,425	1,832,606	206,058	790,227	2,026,542	3,022,827
1979	88,876	305,786	1,653,183	2,047,845	230,260	883,039	2,264,558	3,377,857
1984	98,217	337,925	1,826,942	2,263,084	254,461	975,851	2,502,575	3,732,887
1989	107,559	370,065	2,000,699	2,478,323	278,662	1,068,664	2,740,591	4,087,917
1994	116,900	402,204	2,174,458	2,693,562	302,864	1,161,475	2,978,608	4,442,947
1999	126,241	434,344	2,348,216	2,908,801	327,065	1,254,287	3,216,625	4,797,977

MANAGEMENT OF PROTECTION FORESTS

The allowable cuts shown on the previous charts exclude areas and volumes contained in the protection forests or reserved forests. The areas classified as such in Taiwan involve 379,300 ha. of which 76,000 ha. are grassland or open areas with stocking less than 10%. The total growing stock in the protection forests accounts for 32,650,000 cu. m. Of the forested land within the protection forests approximately 53% of the area and 38% of the volume are located within the accessible forests, the remaining parts being within the inaccessible and inoperable areas.

In the past no cutting has been allowed in the protection forests. Although the vegetative cover is preserved in the high mountain areas, result of this policy has been a high degree of natural mortality and loss of timber, seldom followed by natural regeneration, but often resulting in invasion by brush or grass. Consequently, the protection forests of Taiwan are frequently not fully serving the purposes for which intended namely protection of watersheds. In order to serve this purpose the protection forests should be maintained in the most vigorous growth condition. On accessible areas and good sites this may be attained through intensive management practices, including frequent thinnings of young stands and careful selective cuttings of old stands so as to maintain good spacing and thrifting growing conditions which will maintain a proper combination of both overstory and understory. In addition, the presently idle protection forest lands should be given high priority in the reforestation program.

On steep slopes and shallow soils no cutting may be allowed in protection forest.

Silvicultural management of protection forests should be entrusted only to skilled foresters, and the periodic improvement cuttings should be done under close supervision.

REFORESTATION PLAN

Reforestation Obligations

Forest lands are Taiwan's greatest single potential resource. Due to heavy past exploitation and insufficient reforestation, however, a very great part of these lands is now idle or producing but a fraction of their capabilities. It is essential, therefore, that a vigorous reforestation program will consist of two parts, namely (1) afforestation of the lands which are at present idle or abused and better suited for timber production and watershed protection than for any other purposes, and (2) immediate reforestation of timbered lands as this timber is progressively harvested. Following is a tabulation of the different classes of lands and the annual reforestation obligations consistent with the 40 year cutting program.

Table 10. Average Annual Reforestation Obligations during the 40-year Management Period

Unit: ha.

Classes	Accessible	Inaccessible	Total
A. Idle and misused lands			
Denuded land	15,900	4,100	20,000
Grassland (Class IV land)	143,200	132,800	276,000
Mountain dry farmland (Class IV land)	128,700	—	128,700
Total	287,800	136,900	424,700
Average annual obligation	7,195	3,423	10,618
B. Forested lands (Unreserved—operable)			
Cypress	8,000	3,600	11,600
Other conifers	87,100	168,000	255,100
Conifer-hardwoods	24,200	6,700	30,900
Hardwoods	925,500	269,300	1,194,800
Total	1,044,800	447,600	1,492,400
Average annual obligation	26,120	11,190	37,310
Total average annual obligation	33,315	14,613	47,928

The above annual obligations are average figures over the 40-year period. Since the cutting program is increasing in proportion to the population increase, however, the reforestation of progressively cut over lands will of necessity follow the same pattern. In order not to build up the total reforestation program too drastically over the 40-year period, the afforestation of idle lands should cover the greatest possible area in the beginning and gradually decrease in proportion to the increased reforestation of timbered lands. The reforestation obligations toward the two categories are shown in the following chart.

Reforestation Species

In view of the extreme altitude differences and climatic variations in Taiwan many species are suitable for reforestation. Great care, however, must be exercised in their selection for different localities in order to obtain maximum return on the investments in their planting. The species best suited for different localities, elevations and other circumstances are listed below:

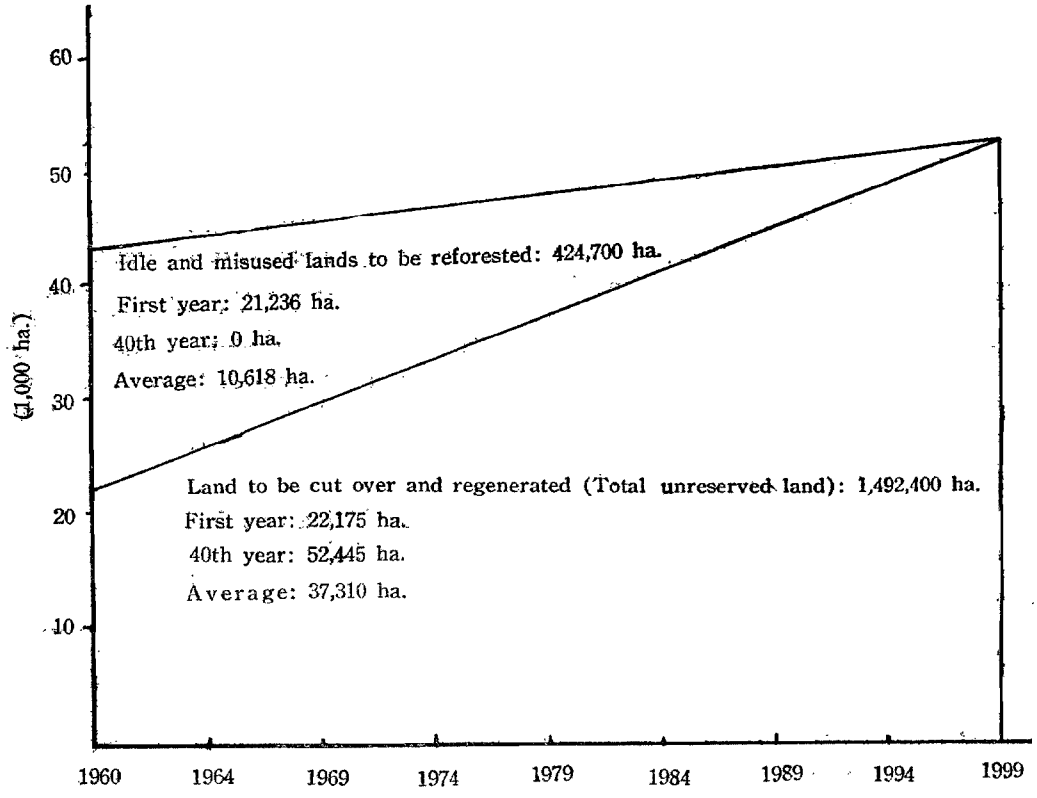

Chart 4. Annual Reforestation Obligations—Idle Land, Misused Land and Total Unreserved Land to be Cut Over (1960-1999)

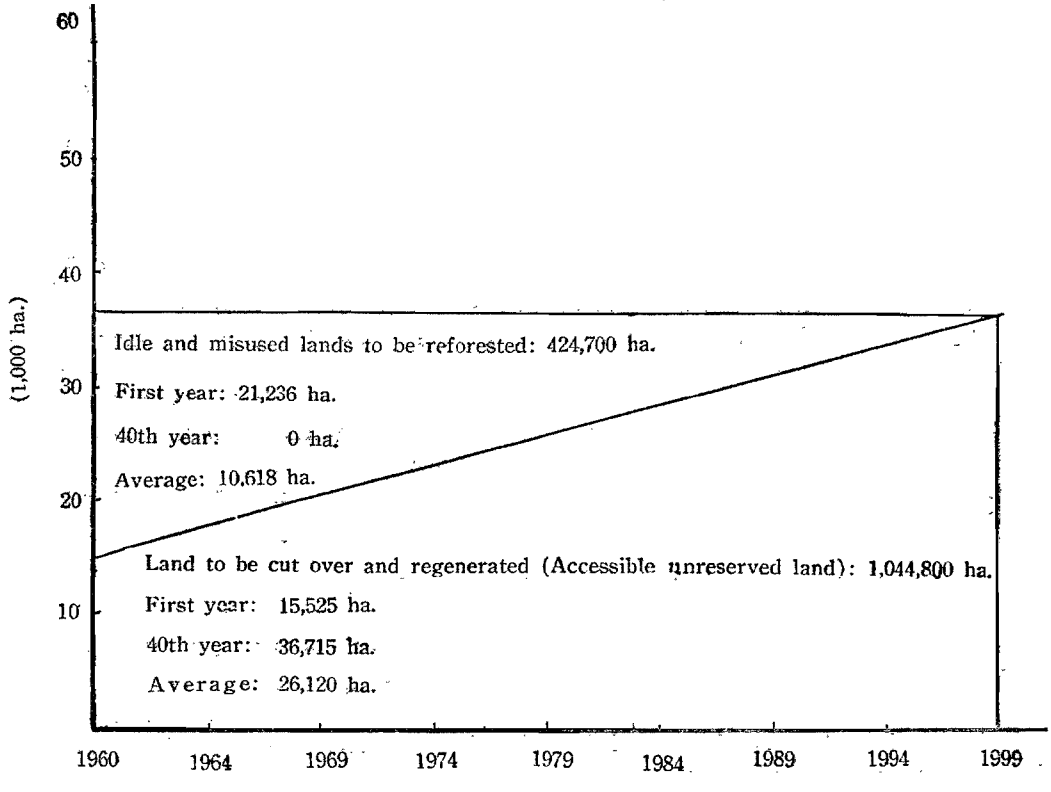

Chart 5. Annual Reforestation Obligations—Idle Land, Misused Land and Accessible Unreserved Land to be Cut Over (1960-1999)

Table 11. Principal Reforestation Species With Their Habitats and Major Uses

Species	Approximate Elevation (m.)			Habitat	Major Uses
	Northern	Central	Southern		
Conifers					
Chamaecyparis formosensis	1,200-2,500	1,600-2,500	1,800-2,700	Deep loamy soils, humid. Less particular to site than C. obtusa var. formosana.	Excellent lumber for various construction purposes, also for furniture, ship building, plywood, etc.
Chamaecyparis obtusa var. formosana[1]	1,400-2,400	1,700-2,600	1,900-2,800	Deep, loamy soils, humid, north and east slopes.	Ditto
Cryptomeria japonica	800-1,800	1,000-2,000	1,200-2,200	Deep sandy loams, humid (Relative humidity 80-90%), rainfall over 1,700 mm., north or east slopes only.	Structural timber and poles.
Cunninghamia lanceolata	500-1,500	600-1,600	800-1,800	Deep sandy loams, humid north or east slopes only rainfall 2000-3500 mm.	Structural timber, poles and pulp.
Cunninghamia konishii	1,200-2,500	1,500-2,700	—	Deep soils, north and east slopes only.	Excellent lumber for structural purposes, poles, coffins, etc.
Hegdoria formosana[2]	400-1,400	600-1,600	—	Deep loamy soils, humid, north and east slopes or in valleys.	Excellent structural timber, and plywood material.
Pinus elliottii	0- 700	0- 800	0- 900	Deep sandy soils with adequate moisture, preferably on south or west slopes.	Structural timber, pulp; turpentine.
Pinus luchuensis	0-1,000	0-1,200	—	Any soils perferably well-drained red clay loam on south or west slopes.	Structural timber, and pulpwood.
Pinus massoniana	200-1,000	400-1,200	—	Any soils except alkaline. South and west slopes only.	Structural timber, pulp, match, furniture, turpentine, etc.
Pinus morrisonicola	800-2,100	1,000-2,300	—	Any soils, preferably deep loams on south or west slopes.	Structural timber, pulpwood, turpentine.
Pinus taiwanensis	800-2,400	1,000-2,600	1,200-2,800	Any soils, preferably deep loams on south or west slopes.	Structural timber, pulpwood, turpentine.
Pinus armandi	—	2,000-2,800	—	Any soils, preferably clay loam on south or west slopes.	Structural timber, pulpwood, turpentine.
Taiwania cryptomerioides	1,400-2,500	1,500-2,600	—	Deep loamy soils with adequate rainfall.	Excellent structural timber, furniture, plywood, etc.

1. Formerly Chamaecyparis taiwanensis.
2. Formerly Libocedrus formosana.

Species	Approximate Elevation (m.)			Habitat	Major Uses
	Northern	Central	Southern		
Hardwoods					
Acacia catechu	—	—	0- 200	Any soils, preferably porous alluvium.	Tannin, charcoal.
Acacia confusa	0- 600	0- 900	0-1,200	Any soil, preferably sandy loam.	Mining props, push-car railroad ties, farm implements; excellent charcoal and fuel woods.
Acacia mollissima	—	—	0- 200	Any soils, preferably sandy loam, summer rainful 890 mm. or more. Does not stand severe drought.	Tannin producer.
Albizzia falcata	—	0- 600	0- 800	Any, but preferably wet soil.	Lumber, plywood, match, pulp; shade tree for tea plantation.
Aleurites spp.	100- 800	100- 900	100-1,000	Rich sandy loam, moist but well-drained, slightly acidic; not windy.	Oil producer, wood for boxes, matches, shoes, etc.
Alnus formosana	100-2,300	200-2,400	200-2,500	Any soils. May survive on poor shallow soil on landsides.	Pioneer tree for reclamation of bare slopes. Pulp, match, fuel, etc.
Bischoffia javanica	0- 500	0- 600	0- 700	Moist sandy loam.	Mining and bridge timber, cross-ties, farm implements, road-side tree.
Calophyllum inophyllum	—	—	0- 200	Sandy soils.	Seacoast windbreak, wood for cross-ties, farm tools.
Cassia siamea	—	0- 400	0- 500	Any soils, preferably red clay loam and well-drained; not windy.	Lumber, furniture, carving, excellent fuelwood and charcoal, road-side tree.
Casuarina spp.	0- 300	0- 400	0- 500	Sandy soils.	Most important windbreak; ties, fuel, etc.
Cinchona spp.	—	500- 800	700-1,000	Deep rich soil, rainfall minimum 2,000 mm.	Quinine production.
Cinnamomum camphora	0-1,000	0-1,200	0-1,500	Deep, rich and moist soils; not windy.	Camphor production, chest, furniture, plywood, carving.
Dalbergia sissoo	—	100- 400	100- 500	Sandy and gravelling alluvium and river beds; optimum rainful 3,300-4,500 mm.	Excellent wood for furniture, ship-building and decoration.
Diospyrus utilis	—	—	0- 200	Deep rich and moist soils.	Seacoast windbreak, wood excellently used for furniture and technological articles.
Eucalyptus citriodora	0- 600	0- 700	0- 800	Any soils, but well-drained; not windy.	Structural timber, cross-ties, oil production, ornamental tree.

Species	Approximate Elevation (m.)			Habitat	Major Uses
	Northern	Central	Southern		
Hardwoods (Cont'd)					
Eucalyptus robusta	0–1,200	0–1,300	0–1,400	Any soils, not windy.	Timber for building and mining, road-side tree.
Garcinia spicata	—	—	0– 200	Sandy, saline soils.	Seacoast windbreaks.
Grevillea robusta	—	0– 200	0– 300	Deep rich and moist sandy soils.	Furniture, road-side tree.
Hevea brasilliensis	—	—	0– 200	Any soils, preferably heavy loam. PH. value 4.3–5.0.	Rubber production.
Hibiscus tiliaceus	0– 100	0– 100	0– 200	Sandy seashore.	Seacoast windbreak; wood for floats.
Leucaena glauca	0– 200	0– 300	0– 500	Any soils.	Pioneer afforestation species, firewood, seeds as fodder.
Mechilia formosana	300–1,500	400–1,700	500–1,800	Moist and rich soil.	Excellent wood for furniture, building, farm implements, technological articles.
Melia azadarach	0– 500	0– 700	0– 900	Any soils, preferably sandy loam, well-drained.	Construction, furniture, coffins, etc.
Ochroma lagopus	—	—	0– 200	Rich and moist loamy soil, well-drained.	Insulating plates, craft building, lifebelts.
Paulownia fortunei	400– 800	500– 900	600–1,700	Well-drained rich and moist sandy loam.	Chests and cabinets, music instruments, shoes, etc.
Paulownia kawakamii	400– 600	500– 700	500– 700		
Pistacia chinensis	0– 400	0– 600	0– 700	Any soils preferably deep sandy loam.	Excellent wood for furniture, also for hammers, pullies, etc.
Pterocarpus indicus	0– 50	0– 100	0– 200	Sandy loam, well-drained; also not windy.	Excellent furniture wood.
Quercus variabilis	—	500–1,800	600–2,000	Any soils, but well-drained.	Cork production, charcoal and fuel wood.
Rhus succedanea	—	0– 200	0– 300	Sandy loam.	Lacquer production.
Sapium sebiferum	0– 200	0– 200	0– 300	Dry and gravelly soils, best development on deep moist soils.	Tallow for soap and candles, wood for furniture, carts, etc.
Santalum album	—	—	0– 200	Stands rocky or gravelly soil, preferably rich soils, avoid saline soils.	Scented sandalwood for distillation and carving.
Swietenia macrophylla	0– 100	0– 300	0– 500	Stands a variety of soils, preferably deep rich soil on well-drained slopes; not windy.	Excellent furniture wood.

Species	Approximate Elevation (m.)			Habitat	Major Uses
	Northern	Central	Southern		
Hardwoods (Cont'd)					
Swietenia mahagoni	—	0- 200	0- 500	Best development on deep soils of lime-stone parent-material; also not windy.	Excellent furniture wood.
Tectona grandis	—	0- 200	0- 500	Deep, porous, rich and well-drained soils, also not windy. Annual temperature 15.8-25.6° C.	Excellent wood for shipbuilding, furniture, house-building and vehicles.
Tamarix aphylla	0- 100	0- 100	0- 100	Resistant to dry saline soil and wind.	Seacoast windbreak and afforestation species; wood for fuel.
Zelkova formosana	300-1,000	400-1,100	500-1,200	Stands shallow soils but prefers moist, rich soils, derived from lime stone on south or east slopes along streams.	Excellent wood for buildings, ships, carts, etc.
Bamboo					
Phyllostachys makinoi	100-1,000	100-1,200	200-1,500	Deep, moist loam; not windy.	Building, furniture, pulp, bamboo articles, etc.
Phyllostachys edulis	800-1,400	1,000-1,600	—	Deep clay loam, well-drained; not windy.	Ditto
Sinocalamus latiflorus	0-1,000	0-1,300	—	Deep sandy loam, not windy.	Ditto

ROAD DEVELOPMENT PLAN

Of the total unreserved timber volumes in Taiwan 63,629,000 cu. m. or 43% is still inaccessible. About half of the inacessible timber is overmature, virgin conifer stands of high value. Due to their advanced age, however, the average annual mortality exceeds growth by a total of 411,000 cu. m. It is imperative, therefore, that these areas be opened up for timber extraction and management as rapidly as possible. Also, unless this timber is made available and harvested within the specified 40-year management period, Taiwan will face increasingly serious timber shortages within this period.

Consequently, a large scale road development program involving 963 km. of primary roads should be started immediately and should be completed within a period of 20 years. The following recommended road development schedule will make directly accessible 33,511,000 cu. m. of high value timber along the primary roads.

The primary and immediate purpose of the road construction program is to salvage the large volumes of overmature timber now occupying these lands. The estabishment of the forest road network will not only facilitate future planting, tending and other management practices, but also benifit control of forest fire, insect, and decease and forest recreation as well. The program will be a long range investment in land utilization and management which will yield high future financial returns.

For construction of forest roads, special funds should be made available by the Taiwan Provincial Government from the forestry proceeds. An independent Forest Road Engineering Corps should be established under TFA. This Corps should be a permanent set-up in order to keep construct work going on continuously.

Table 10. Forest and Land Resource Within Reach of Exploitation by the Proposed Forest Roads

Name of Track	Forest						Non-forest (ha.)	Approximate Length of Roads (km.)
	Conifers		Hardwoods		Total			
	Area (ha.)	Volume (cu. m.)	Area (ha.)	Volume (cu. m.)	Area (ha.)	Volume (cu. m.)		
Tung-heu	2,750	206,000	14,725	1,304,000	17,475	1,510,000	2,725	28.5
A-yu								30
Wen-shui								17
Qua-shan								30
Chia-pan-shan	425	136,000	16,175	1,114,000	16,600	1,250,000	3,850	35
Ta-nan-au	1,225	358,000	8,900	1,025,000	10,125	1,383,000	452	27
Ta-tsou-shui	—	—	5,025	85,000	5,025	85,000	—	6
Ta-hu & Ta-an-chi headwater	62	19,000	6,688	838,000	6,750	857,000	2,100	25
Shui-chang-liu	—	—	7,475	229,000	7,475	229,000	2,825	17
Mei-yuan	15,136	4,249,000	7,374	901,000	22,510	5,150,000	5,200	43.5
Pei-kang-chi	3,413	295,000	11,525	505,000	14,938	800,000	2,225	30
Chin-shui-chi	3,200	844,000	9,375	352,000	12,575	1,196,000	950	30
Tan-ta	47,834	3,855,000	18,074	2,832,000	65,908	6,687,000	33,061	32
Chung-ta								40
Tung-luan-ta								36
Chen-yu-lan								20
Lao-shui-keng	763	171,000	8,437	816,000	9,200	987,000	425	10
Chu-tou-chi & Sha-shan	1,300	162,000	17,675	1,001,000	18,975	1,163,000	10,825	110
Pa-tsu	225	6,000	3,775	87,000	4,000	93,000	—	13
Jui-sui	5,600	827,000	20,350	1,270,000	25,950	2,097,000	4,950	48
Yu-li & Hsiu-ku-luan	7,213	1,384,000	17,712	1,050,000	24,925	2,434,000	6,400	50
Hsin-wu-lu	—	—	4,300	371,000	4,300	371,000	—	10
Nan-tsu-hsien-chi	—	—	12,265	432,000	12,265	432,000	7,615	51
Kwan-shan & Lao-lun	1,263	1,956,000	4,412	2,923,000	5,675	4,879,000	13,612	106
Pingtung & Taitung	100	3,000	30,225	1,905,000	30,325	1,908,000	6,375	91
Total	90,508	14,471,000	224,487	19,040,000	314,995	33,511,000	103,563	936

FOREST ROAD DEVELOPMENT PLAN OF TAIWAN

台灣林道發展計劃圖

0 5 10 15 20 25 MILES

0 5 10 15 20 25 KILOMETERS

角板山綫(角板山)
Chia-pan-shan

大湖大安溪上流綫(司馬限)
Ta-hu & Ta-an chi

北港溪綫(眉原)
Pei-kang chi

眉原綫(咖啡園)
Mei-yuan

水長流綫(水長流)
Shui-chang-liu

東巒大綫(郡坑)
Tung-luan-ta

勞水坑綫(梯子嶺)
Lao-shui-keng

陳有蘭溪綫(和社)
Cheng-yu-lan

濁口霞山綫(埔尾)
Chu-tou-chi
Sha-shan

楠梓仙溪綫(甲仙)
Nan-tsu-hsien-chi

關山羌濃綫(六龜)
Kwan-shan & Lao-lun

桶後溪綫(烏來)
Tung-heu

阿玉綫(烏來)
A-yu

檜山綫(松羅)
Kua-shan

牛門溪綫(牛門)
Niu-men-shui

大南澳綫(大南澳)
Ta-nan-au

大濁水綫(大濁水)
Ta tsou-shui

清水溪綫(銅門)
Chin-shui-chi

丹大溪綫(水裡坑)
Tan-ta

郡大溪綫(社子)
Chung-ta

拔子綫(富源)
Pa-tsu

瑞穗綫(瑞穗)
Jui-sui

太平綫
Tai-Ping

玉里綫(玉里)
Yu-li

新武路綫(新武路)
Hsin-wu-lu

屏東台東綫
(三地一知本)
Ping-tung Taitung

路綫名稱 (起點)..... 角板山綫(角板山)
Proposed Road ..... Chia-pan-shan road

CITY (SHIH) ..... TAIPEI
LARGE TOWN (HSIEN CITY)..... Miaoli
TOWN..... Chungli
VILLAGE ..... Yangmei

RAILROADS:
NORMAL GAUGE, DOUBLE TRACK .....
NORMAL GAUGE, SINGLE TRACK .....
NORMAL GAUGE, PROPOSED .....
NARROW GAUGE .....

HIGHWAYS:
PAVED ROAD .....
UNPAVED ROAD .....
PROPOSED.....

HSIEN BOUNDARY .....
RIVER .....
MOUNTAIN .....
SPOT ELEVATION; IN METERS ..... + 3997

COMPILED
by
Office of the Assistant Director for Industry
ICA/Mutual Security Mission to China
August 1956

REFERENCES

1. W. F. Lin and C. J. Hsieh. 1950. Timbers of Taiwan. Taiwan Special Product Series No. 7. Economics Research Department. Bank of Taiwan.
2. W. F. Lin, P. C. Tsoong and L. M. Chang. 1953. A Synopsis of Trees and Shrubs in Taiwan.
3. W. F. Lin, C. J. Hsieh, T. Y. Chen, R. L. Wang and L. M. Chang. 1956. Report on the Survey of Coast Windbreak Species, Their Ecology and Adaptability in Taiwan. Cooperative Bulletin of Taiwan Forest Research Institute No. 2.
4. Wei-chih Lin, An-chi Chen, Chie-ju Tseng, Sang-gen Hwang. 1958. An Investigation and Study of Chinese Tallow Tree in Taiwan. Bulletin of Taiwan Forestry Research Institute No. 57.
5. Tze-ting Wang. 1951. Bamboo Forests and Bamboo Timber in Taiwan. Taiwan Research Series No. 14. Economics Research Department, Bank of Taiwan.
6. Y. C. Liu. 1958. Silviculture of Cultivated Trees in Taiwan.
7. Y. C. Liu. 1959. Dendrology.
8. Kaohsiung Forest District. 1953. Tropical Forestry in Taiwan.
9. Taiwan Forest Administration. Silviculture of Tropical Species in Taiwan.
10. Taiwan Forest Administration. 1957. Forestry Statistics of Taiwan, 1950–1956.
11. Taiwan Forest Administration. 1958. Abstract of Taiwan Forestry Statistics, 1906–1955.
12. Taiwan Forest Administration. 1958. Forest policies and Forestry Programs of Taiwan.
13. Paul Zehngraff. 1951. Forest Conditions in Taiwan, JCRR Forestry Series No. 1.
14. Tom Gill. 1952. Forest Policy and Program for Taiwan, JCRR Forestry Series No. 2
15. D. E. Doverspike, Paul Zehngraff and H. C. Yuan. 1956. Forest Resources of Taiwan, JCRR Forestry Series No. 3.
16. Tom Gill, H. D. Cochran and E. L. Demmon. 1957. A Forestry Program for Taiwan, JCRR Forestry Series No. 4.
17. Ryozo Kanehira. Formosan Trees. 1936.
18. FAO. 1955. Tree Seed Notes—Arid Areas and Humid Tropics.