CHINESE-AMERICAN

JOINT COMMISSION ON RURAL RECONSTRUCTION

Forestry Series: No. 3

FOREST RESOURCES OF TAIWAN

By

George E. Doverspike

Paul Zehngraff Hsing-chi Yuan

Second Printing

TAIPEI, TAIWAN, CHINA

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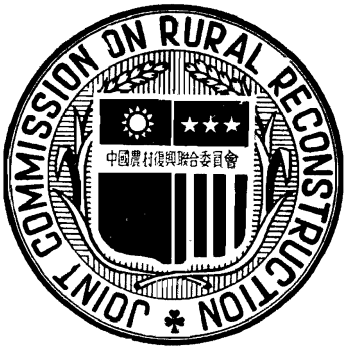

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FOREWORD

The Land Use and Forest Resource Survey of Taiwan was a Chinese-American cooperative project sponsored by the Joint Commission on Rural Reconstruction with technical assistance from the Forest Service, U. S. Department of Agriculture. The technical personnel was furnished by various cooperative agencies, namely, the Provincial Department of Agriculture and Forestry, the Taiwan Forest Administration, the Taiwan Forest Research Institute, the Taiwan Agriculture Research Institute and the National Taiwan University. The project was actively supported by the Chinese Ministry of National Defense, the Chinese Air Force, the Chinese Combined Service Forces, the Bank of Taiwan and the U.S. Military Assistance Advisory Group.

This survey started in April 1954. Photo plot interpretation and photo delineation (including field check) were completed in May 1955 (including basic training programs). Ground work was finished in June 1955, mapping in September 1955 (excluding printing) and compilation of data in March 1956.

The project was under the direction of George E. Doverspike, assisted by Earl J. Rogers, Assistant Project Leader and in charge of photo interpretation; Mackay B. Bryan, in charge of forest field work; Emile Hsia, soil conservationist; Stephen E. Webb, cartography; and Stanley R. Johnson, compilation. Upon the American specialists' departure from Taiwan, H. C. Yuan and T. N. Liao of the Taiwan Forest Administration were in charge of photo interpretation and forest field work respectively; C. W. Yang of the Joint Commission on Rural Reconstruction was in charge of cartography after December 1954. P. L. Yang of the Taiwan Forest Research Institute took over compilation work after October 1955.

The objectives of the survey were to yield (1) reliable statistics on forested land area and timber volume, including current growth, mortality and other data needed to formulate forest policy so as to assure a proper management of forest resources of Taiwan toward a continuous harvest of indigenous forest products, and (2) present status of land use to facilitate establishing land use policy, so as to assure proper land use, eliminating soil loss and contribute to agricultural production and power development.

A basic statistical report consisting of 24 tables was completed and distributed to interested agencies and schools in April 1956. In addition, sets of 1/50,000 topographic maps overprinted with land use and forest types, and standsize and problem area classes were issued in March 1956. Since each set consists of 103 sheets covering the island and is of too much detail to be used for province-wide planning, the information was condensed and printed on 1/250,000 topographic maps for office use.

The following interpretive report contains statistical data and analyses the forest situation in Taiwan. It is associated with a land use report which presents nonforested land statistics data and further analyses land use conditions in detail.

The total land area refers to the main island of Taiwan. The small islands usually included as part of the land area are not included in the statistics of this survey.

In order to avoid mis-interpretation of the data, the reader is cautioned to pay particular attention to the definitions of terms used especially when comparing the data in this report with statistics from other sources.

ACKNOWLEDGEMENT

The Joint Commission on Rural Reconstruction wishes to express appreciation of the cooperation by the Provincial Department of Agriculture and Forestry, the Taiwan Forest Administration, the Taiwan Forest Research Institute, the Taiwan Agriculture Research Institute, the National Taiwan University, and the Provincial College of Agriculture in their furnishing technicians to the Survey Team, providing information and offering suggestions during the course of the work.

Special credit is due to the Chinese Ministry of National Defense and the Chinese Air Force in taking the aerial photographs on the sampling strips of Taiwan from which the basis statistics was compiled, the Survey Bureau of the Combined Service Forces in printing 1/50,000 and 1/250,000 forest resource and land use maps, the Bank of Taiwan in helping card punching, sorting and tabulation for compilation work, and MAAG in furnishing the basic maps as well as in loaning camping equipment.

Grateful acknowledgement is also made to the members of various agencies from whom much helpful data and information were obtained particularly for the Chapter "Forest Industries". Special thanks are due to all those who helped in reviewing the manuscript of this report and offered suggestions of great value.

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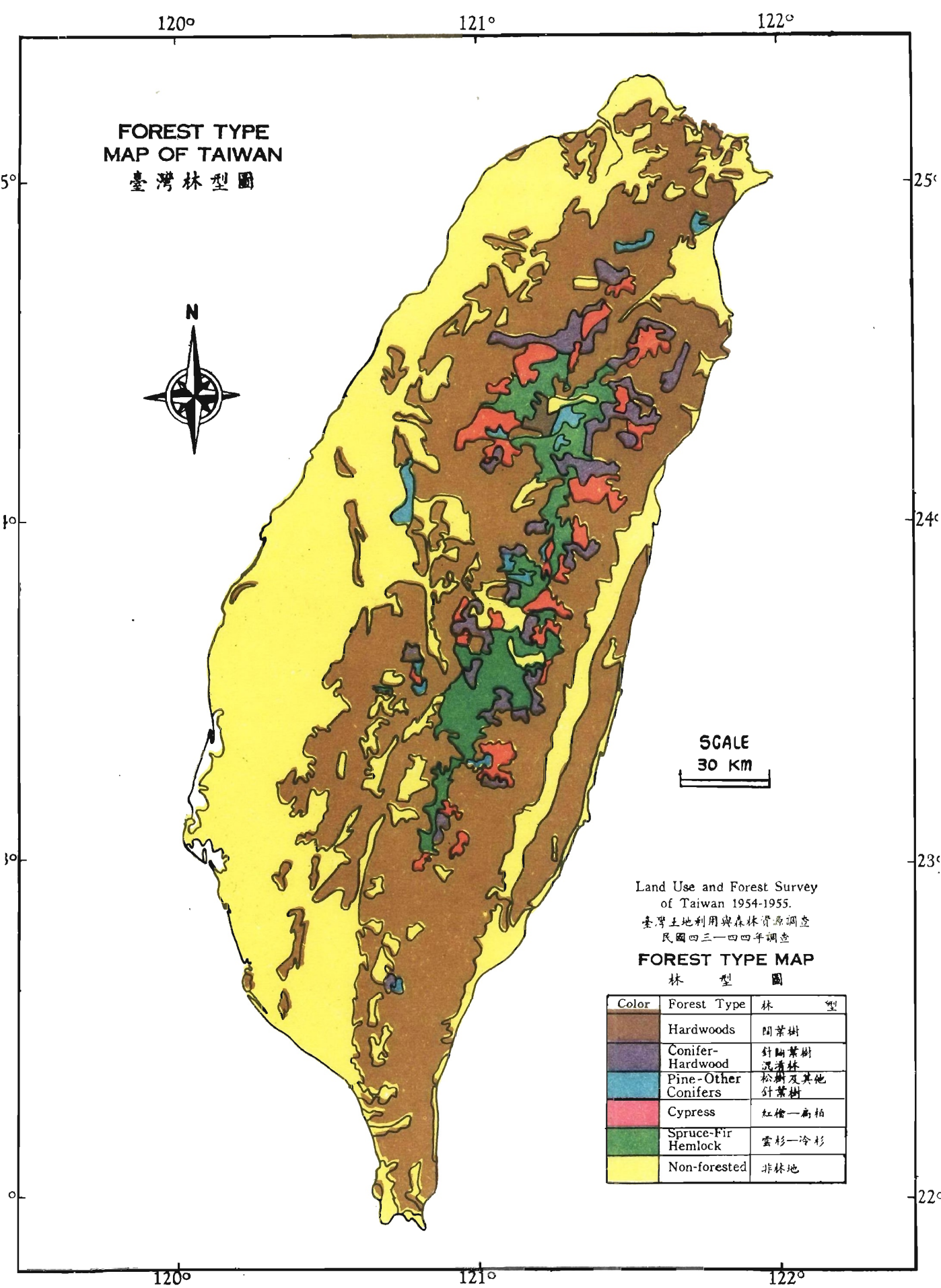


Figure 1 Forest type map

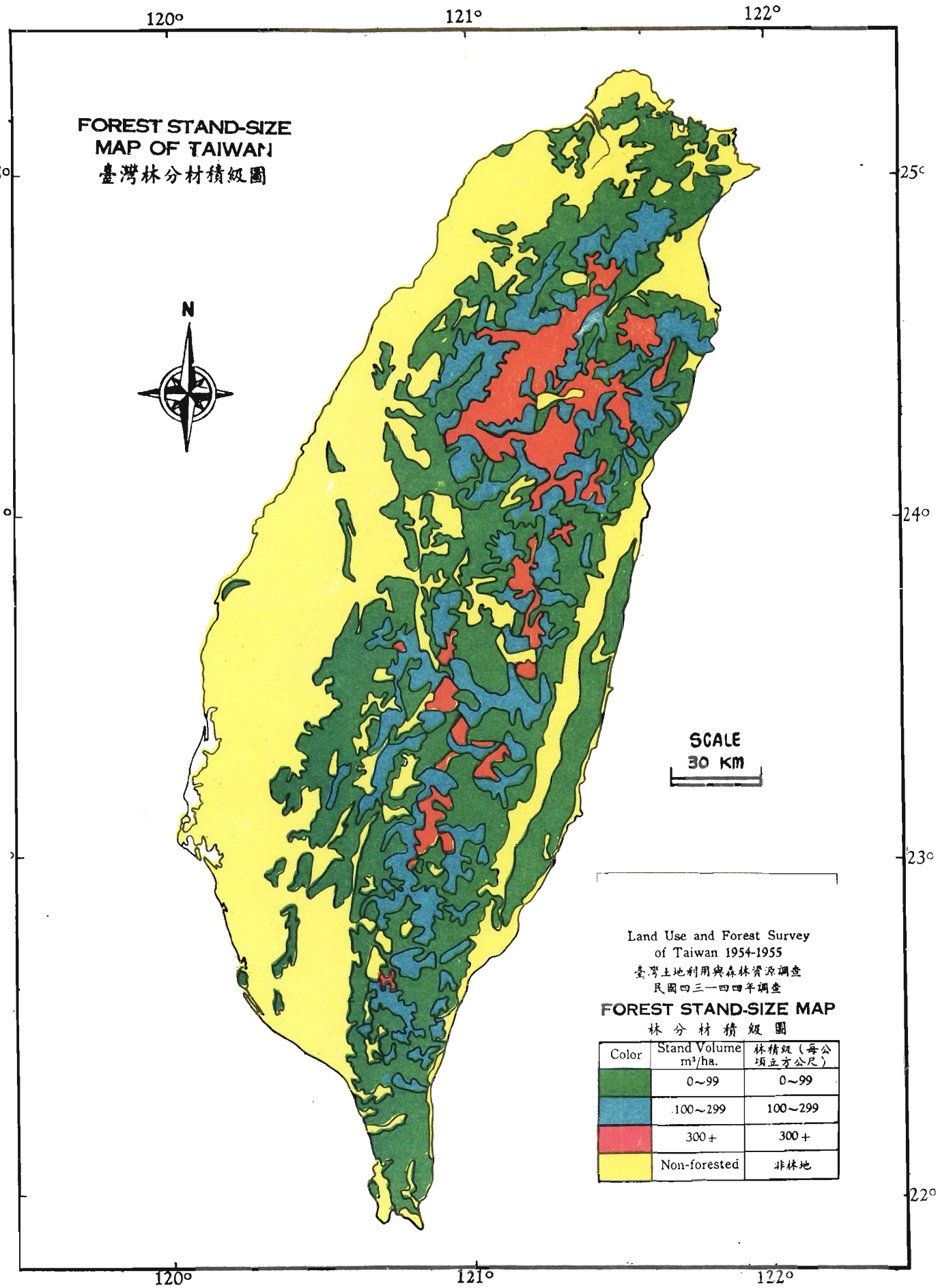


Figure 2 Forest stand-size map

HIGHLIGHTS

FORESTS COVER OVER HALF OF TAIWAN. Of the total land area 55.1 percent or 1,969,500 hectares are forested.

ALMOST THREE QUARTERS OF THE FORESTED LAND IS IN NATIONAL FOREST UNDER THE ADMINISTRATION OF THE TAIWAN FOREST ADMINISTRATION. Of 1,969, 500 hectares of forested land, over 1,409,000 hectares are owned by the national government directly under the management of the Taiwan Forest Administration. A considerable percentage of the remainder is also owned by the government but under the administration of the Land Bureau of the Provincial Department of Civil Affaires (Marginal Forest Land) and Hsien Governments (Aborigines Reservation). Publicly and privately owned forested lands constitute an insignificant portion. However boundaries of public lands are not marked, and trespass is common which is detrimental to the forest resource.

TAIWAN'S FORESTS CONTAIN 186 MILLION CUBIC METERS OF WOOD WITH 150 MILLON CUBIC METERS OF SAWTIMBER. However, of the total growing stock, only 93 million cubic meters are accessible. Broadleaved species constitute 70 percent and coniferous species 30 percent. ON THE COMMERCIAL FORESTED LAND (accessible unreserved forested land) THERE IS A TOTAL OF 83 MILLION CUBIC METERS.

TIMBER GROWTH AND DRAIN ARE ABOUT EQUAL ON COMMERCIAL FORESTED LAND. However the more valuable conifers are being depleted at the rate of over 600 thousand cubic meters per year. Most of the growth is in small hardwood trees.

MUCH OF THE ACCESSIBLE FORESTED LAND IS POORLY STOCKED OR STOCKED WITH NON-COMMERCIAL SPECIES. Of the accessible forested land 62 percent has less than 50 cubic meters per hectare. Most of this is not adequately stocked with commercial species. In addition, there are over 200, 000 hectares of accessible productive land now in grass or denuded. Taiwan has about one million hectares of land that is now producing only a small fraction of its capability.

IMPROVEMENT OF FOREST CONDITIONS CALLS FOR:

1. Planting of one million hectares of land now in grass, denuded or poorly stocked.
2. Locating and marking the boundaries of public land.
3. Research in the natural regeneration of commercial species and in management of the principal forest types.
4. Increased use of hardwood species.
5. Improved fire fighting facilities and initiation of protective measures against insects and disease.
6. In designing a forestry program for the production of an abundant supply of wood products, the manufacturing and marketing of these products must be taken into consideration. Improvement and expansion of these facilities as needed must be a part of the overall management plan. A working program for these purposes should include improvement of logging and sawmilling techniques, establishing and certifying product grades, tax relief measures for the plywood industry, and establishment of a foreign marketing service.

DESCRIPTION OF THE ISLAND[1]

GENERAL

Taiwan, with a population of about 10 million, is primarily a forest country of extremely rugged topography. The central mountain range divides the island and runs from north to south. To the east, the mountain range parallels the coast line and drops sharply into the ocean, while on the west the terrain slopes into broad alluvial plains extending along most of the coast. The mountains are high and steep, with the two highest peaks, the Tz'u Kao Shan to the north and Mt. Morrison in the central part, both reaching altitudes of slightly under 4,000 meters.

The principal mountain range is composed of slate, schist, gneiss and intrusive igneous rocks, and sandstone, limestone, shale and conglomerates lie under the foothills.

Because of inaccessibility, rough topography and unfavorable geological composition, the forest areas are largely unsuitable for agricultural purposes. The interior and high mountain areas are sparsely settled by natives (aborigines) who make a precarious existence, primarily from hunting, supplemented by spotfarming on the mountain sides, handicraft and, in some localities lumbering.

Forest plays an important role in conserving soil and water resources and protecting cropland in the low areas.

PAST HISTORY

During the former Chinese rule of Taiwan there was little concern for the forest except for the production of camphor on which the government established a monopoly in 1863. When the Japanese took over the island in 1895, they were immediately interested in its forest resources. The first step towards a forest exploitation program was one of land acquisition which was carried out by the newly established Forestry Section under the Industry Division. Farmers who owned forest land were required to show documentary proof of ownership. Lacking this, the government took possession of their forest. Likewise, large areas were acquired from the natives of the interior through a program of resettlement. The territories thus gained were classed as national forests in the sense of being government owned.

In 1897 the Forestry and Exploitation Sections were combined under the name of the Forestry Branch, mainly to deal with the natives in camphor production and land acquisition, and to establish forest ownership boundaries. In 1899 it began to administer the newly established government camphor industry. When the Exploitation Division was established in 1901, it took over the duties of the Forestry Branch and also began to sell government standing timber to private loggers. In 1905 the name was changed to Forestry Division.

Many changes in forest administration took place during the following

1 This chapter is primarily based upon "Forest Condition in Taiwan" by Paul Zehngraff, Forestry Consultant, JCRR.

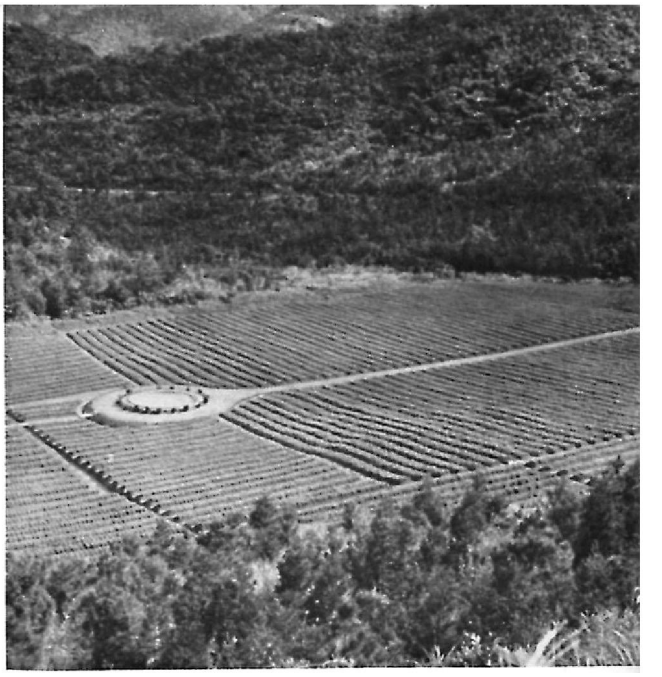
40 years. In general, however, the Regional Forest Office of the Governor General was the sole administrator of the so called special national forest areas on which the government operated three branch stations for the purpose of logging. The Forestry Division set the overall forest policy for the prefectural forestry sections which were responsible for the control of all regular national and prefectural forests and for encouragement of private forestry. In 1942 the Regional Forest Office was abolished, and the branch stations of the special national forests were transferred to the Forestry Division. The logging and milling equipment was transferred to the Taiwan Development Company, over bitter opposition by the government foresters. The following year, in line with the wartime policy of decentralization, all of the national forests were transferred to the prefectural forestry sections which continued to follow the policy laid down by the Forestry Division.

By 1942 the national forests contained 89.1 percent of the forest area and 95.6 percent of the timber volume of Taiwan. Private forests covered 10.1 percent of the forest area and 4.1 percent of the timber volume, while communities and prefectures owned the insignificant balance. About 470,000 ha. of national forests had been designated as special national forests by 1942. They included the three principal government timber producing areas, the Ali-shan, Taiping-shan, and Pasien-shan. These areas produced most of the timber in Taiwan, primarily coniferous sawlogs. There were several private operations of government owned timber, but all were on a smaller scale than government operations.

Three national parks were proposed in 1942 covering about 470,000 ha. mostly on national forest land, but have never been officially designated and used as national parks.

Forest management plans existed only on national forests. Up to 1936 such plans covering about 900,000 ha., had been prepared. By 1943 plans had been developed for a total of 1,000,000 ha. but these were never followed. A protection forest system, similar to that of Japan, covered 364,000 ha. in more than 500 units by 1942.

In spite of the rapid development of the logging industry, production



An abandoned national nursery re-established in 1953 with an area of 4 hectares. The chief species produced are Cryptomeria japonica, Cunninghamia lanceolata, Pinus luchuensis and American southern pines.

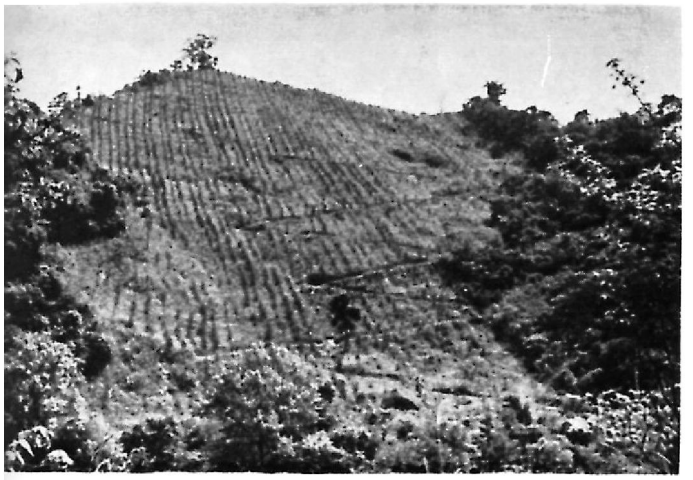
Teak is an importand exotic planting species in the South. A county nursery in Kaohsiung.

A recent windbreak plantation on the western sea-coast. Miscanthus planted as a pioneer which is followed by Casuarina in the succeeding year.

never came up to consumption, and large scale wood import was resorted to. The average domestic production for the period 1926 to 1941 was only 50 percent of consumption. Of the imported materials, 87 percent came from Japan. By 1940, production had nearly tripled, but so had consumption, and the import rate remained the same. Wood export which amounted to 15.4 percent of the production, or 7.7 percent of the consumption, was mostly in form of logs to Japan. A maximum timber production of about 481,000 m^3 was reached in 1955. The average timber production for the 16-year period 1926-1941 was about 245,000 m^3. This volume was in addition to fuel production which averaged 465,000 metric tons of fire wood and half-charcoal, and 55,000 metric tons of charcoal annually. The total wood drain, including all forest products, reached 1,870,000 m^3 tree volume in 1941. Two thirds of this came from the national forests.

From 1909 to 1941 a total of about 307,000 hectares had been reforested, more than three fourths of which was in private and prefectural forests. Most plantations were established in pure stands, and Formosan Acacia was the chief species planted. Cryptomeria and Cunninghamia were the most extensively planted conifers. Many exotic species were also introduced. Nurseries were small, mostly less than one half hectare each. By 1942 there were about 700 nurseries with a total area of 270 ha. Private nurseries numbered more than 300 and prefectural nurseries 240. The regional forest office maintained 35 nurseries for production of specialty trees and erosion control stock, while the prefectures operated 42 of their nurseries to provide stock for windbreaks and reforestation on private forests. The Monopoly Bureau operated 17 nurseries for production of camphor planting stock. The universities and experiment stations also operated nurseries for their own use. Prefectural nurseries were subsidized by the government (50 percent of stock production costs). Community nurseries received subsidies from both the prefec-

A Cryptomeria stand planted 30 years ago, ready for thinning.



Young plantation on cutover land.

20 years later.

ture and the government (1/3 of cost from each).

During and immediately after the war many of the plantations and windbreaks were cut and the nurseries abandoned. However, in recent years many of the nurseries have been re-established and new ones added and much progress made in reforestation and windbreak planting. Tables 1 and 2 show the recent progress made in these fields.

TABLE 1
RECENT REFORESTATION

Year	Government land (ha.)	All other land (ha.)	Total (ha.)
1946	1,108	1,079	2,187
1947	4,210	14,558	18,768
1948	5,925	2,939	8,864
1949	2,127	7,847	9,974
1950	4,455	7,062	11,517
1951	4,251	6,461	10,712
1952	6,660	3,352	10,012
1953	17,120	20,031	37,151
1954	16,253	27,204	43,457
1955	12,477	27,498	39,975
Total	74,586	108,031	192,617

*Source: Taiwan Forest Administration.

However only a small proportion of the plantations are in coniferous species. Up to 1951 less than 19 percent of all plantations were in coniferous species. Planting of coniferous species has been increasing recently, with 1,883, 5,780 and 11,894 hectares planted in 1952, 1953 and 1954 respectively.

TABLE 2 TREE NURSERIES AND PRODUCTION*

Yeas	No. of Nurseries	Area	Seedling Production		
			Conifers	Hardwoods	Tatal
		(ha.)		(Millions)	
1952	325	216	28	124	152
1953	327	200	55	121	176
1954	327	288	34	102	136

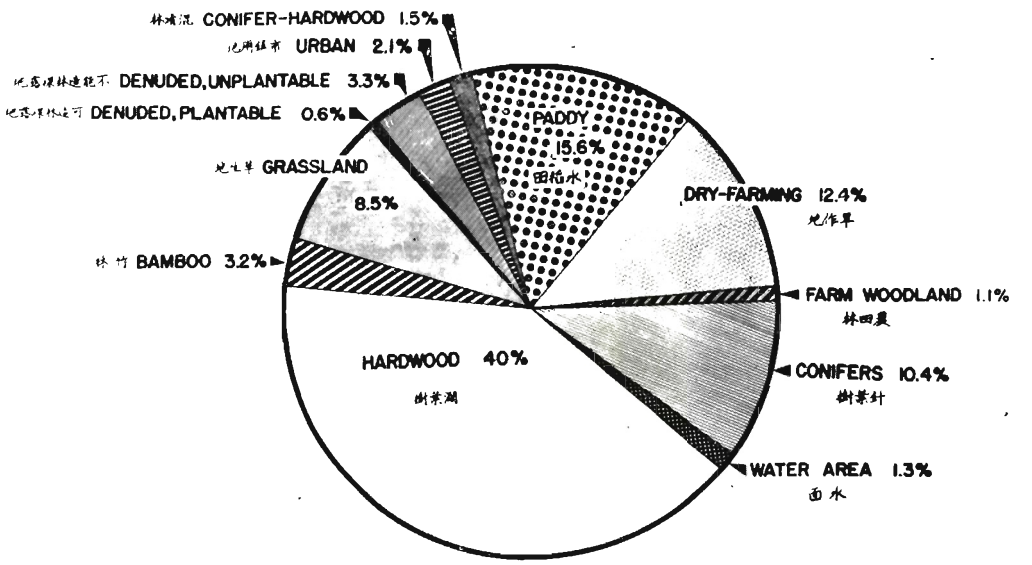
*Source: Taiwan Forest Administration

LAND USE

In the past, rather strict land-use policies were rigidly enforced. In line with the more democratic attitude of the Chinese Government, such policies have been largely abandoned since the restoration. Lack of enforcement of existing policies has increasingly encouraged unwise and short-sighted land-uses to the permanent detriment of public welfare.

TAIWAN LAND USE TYPES IN PERCENTAGE

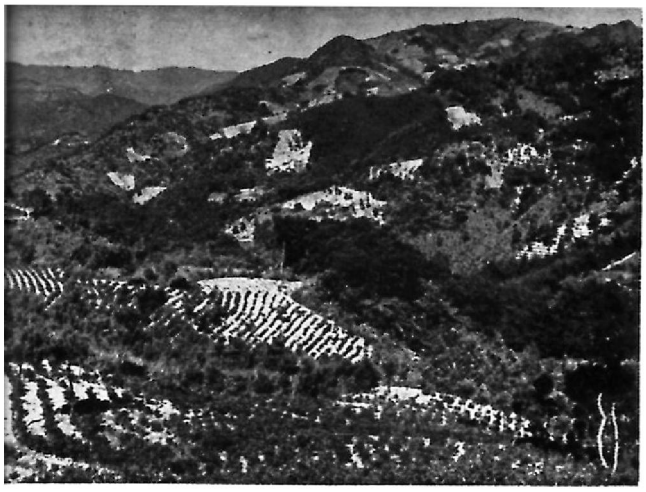
表覽一率分百型用利地土灣台



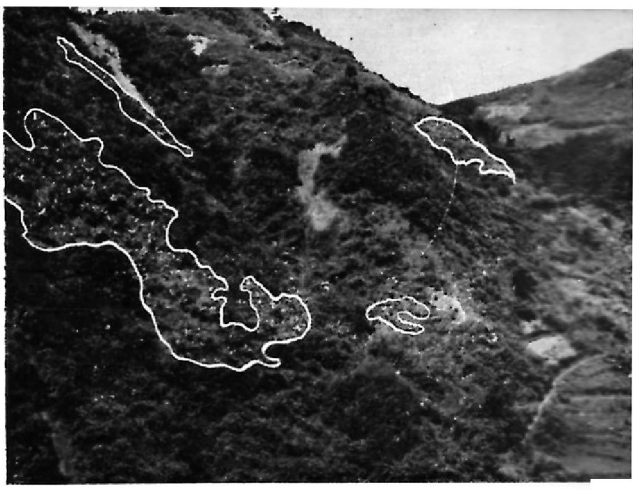
The unwise land-uses include indiscriminate clear-cutting and burning of steep slopes, regardless of ownership, for the cultivation of cash crops of which banana, citronella and pineapple are the most common. In the back mountains the same practice is followed by the natives for production of other food crops. Fires started for land clearing and other purposes often "get away" and rage uncontrolled over large areas, causing waste and destruction which renders the land nonproductive for generations to come.

The mountain soils as a rule are of poor quality and low fertility. The burning of forest vegetation is therefore done partly to obtain the temporary fertilizer benefits from the ashes. After a few growing seasons, this effect disappears and the user moves on to a new area, leaving the worn out area idle. This practice is used on national and other public lands as well as on private lands. Land-uses on national lands are under the control of the Bureau of Land Administration which is empowered to grant permission for use of idle land on a rental basis. Land willfully burned over by the potential user however is often classified as idle land.

In comparison with the bulk of mountainous areas in Asia, most of the mountains of Taiwan are still green and productive. This is partly due to favorable climatic conditions and partly to moderate use and high degree of protection in the past. However, the mountains of Taiwan are steep and most of them are of compositions which invite trouble when the forest cover is removed and the land used unwisely. As a result of indiscrimination and unwise land-use practices the exposed soil is



Competetion between land uses for forestry and agriculture is accute. Cultivation of agricultural crops has taken place on the hillsides due to pressure for land.



A Common practice in accessible areas is to clear forest land for banana plantation. Notice the exposed soil on the banana field (marked with white lines).

washed out during heavy rains and carried away by rapid mountain streams to be deposited elsewhere, causing flood and destruction, clogging of water reservoirs and irrigation systems and direct agricultural losses. Once the mountain side is broken, land slides and erosion continue at an accelerated rate. The costs of repair and artificial erosion control measures are high in comparison with the temporary financial gains from the cash crops. The financial losses to agricultural crops and lands below are considerably higher than the temporary gains from cultivation of mountain slopes, which afterwards are left non-productive, constituting a continuous threat to fertile lands below. Because of the steepness of topography and the violent nature of the rivers, certain areas already are beyond the possibility of economic repair and reclamation. In 1955, 117,400 hectares were placed in this class.

FOREST ZONES

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 3 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	4,000	3,500	4,000

From chart prepared by Taiwan Forest Research Institute.

Due to the geographic location of Taiwan and the extreme climatic variations of the island, forest species are numerous. Of the 200 commercially recognized species, broadleaved species number 154, coniferous species 20, and exotic species 26.

TABLE 4 FOREST ZONES WITH IMPORTANT COMMERCIAL SPECIES[1]

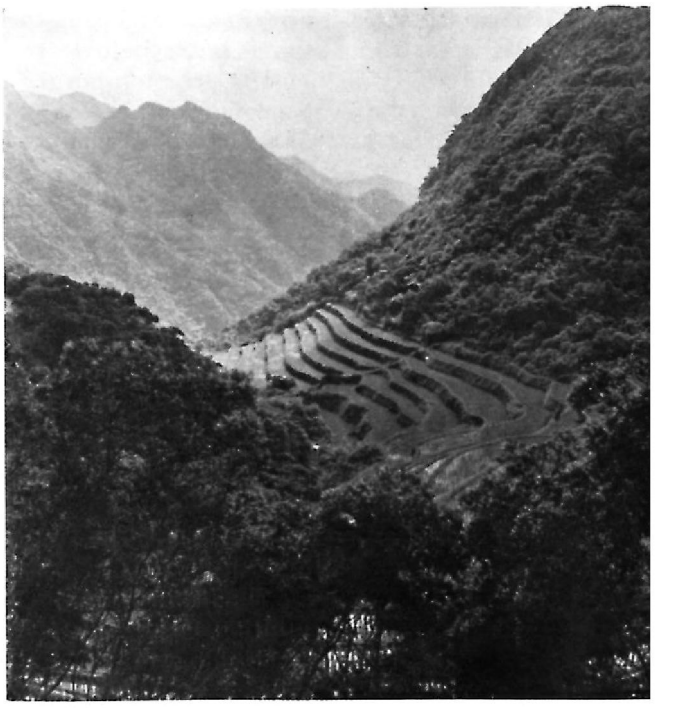
Tropical	Sub-tropical	Temperate	Frigid
Hardwoods	Hardwoods	Hardwoods	Conifers
Acacia confusa	Cinnamomum sp.	Quercus morii	Abies kawa-kamii
Machilus kusanoi	Zelkova formosana	Lithocarpus castanopsisifolia	
Machilus zuihoensis	Michelia formosana	Lithocarpus ternaticupula var. arisanensis	
	Phoebe and Noto-phoebe sp.	Conifers	
	Schima superba	Pinus armandi	
	Machilus sp.	Pinus taiwanensis	
	Castanopsis longicau-data	Pinus morrisonicola	
	Castanopsis stipitata	Pinus massoniana	
	Quercus gilva	Pseudotsuga wilsoniana	
	Quercus glauca	Taiwania cryptomerioides	
	Lithocarpus sp.	Chamaecyparis formosensis	
	Conifers	Chamaecyparis taiwanensis	
	Cunninghamia lanceo-lata[2]	Picea morrisonicola	
	Cunninghamia konishii	Tsuga chinensis	
	Libocedrus formosana		
	Cryptomeria japonica[2]		

1 From chart prepared by Taiwan Forest Research Institute.
2 Exotic species.

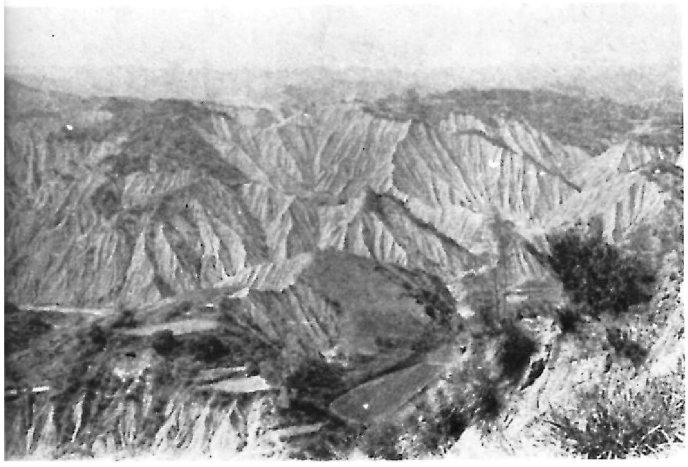
ADMINISTRATION

Following the Japanese surrender in 1945, the new Taiwan Provincial Government took over the administration of national forest land and most of the larger logging operations on such land. Since 1945 several changes in administrative organization and responsibilities have taken place, as well as frequent shifting of administrators and personnel.

At present, the Taiwan Forest Administration is responsible to the Taiwan Provincial Government, through the Provincial Department of Agriculture and Forestry, for administration of national forest land and, for logging operations on such land. The Provincial Government, in conformity with the present



Terrace is built on hillsides for growing rice if water is available.

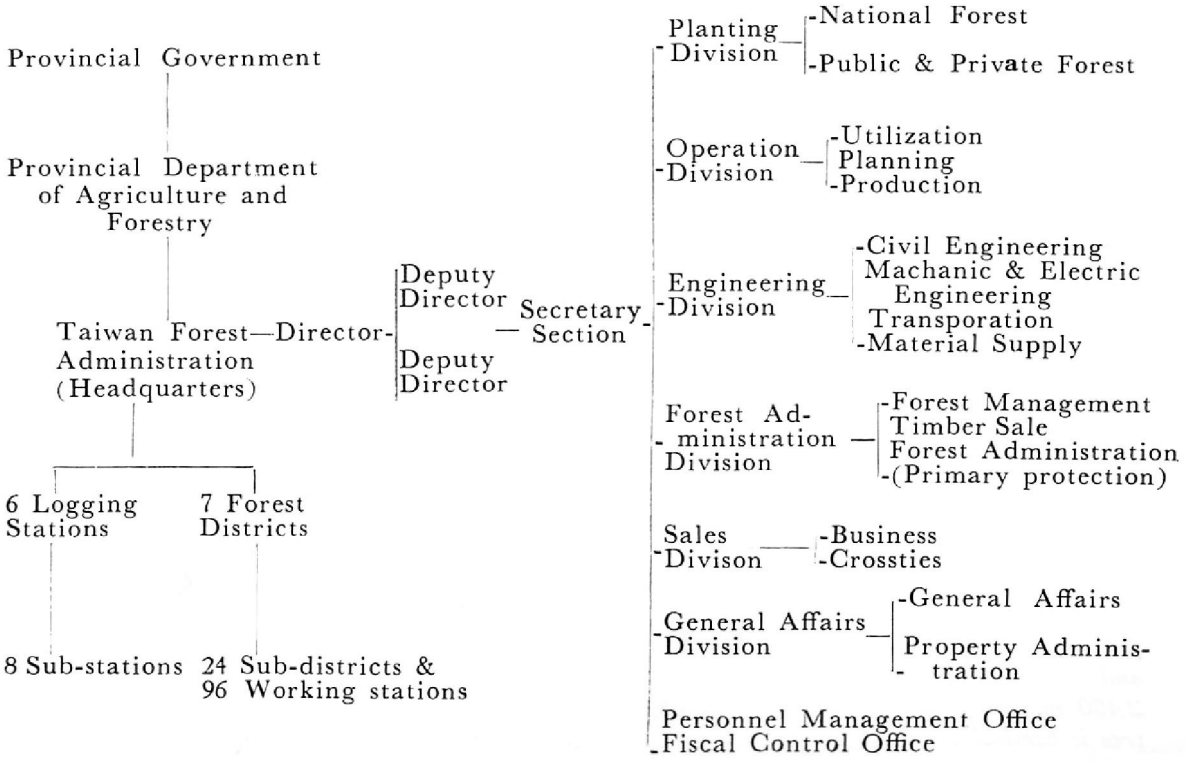


Some devastated areas are badly eroded.

economic condition, determines the forest policy, the amount of timber to be cut, disposal of revenue and appropriations for current administrative expenditures.

The Taiwan Forest Administration has its headquarters in Taipei. The national forest areas under its jurisdiction are divided into 40 working circles with size ranging from 7,835 to 96,456 ha. These areas are administered by seven forest district offices and six logging stations which range in size from 113,000 ha. to 365,000 ha. Under the district offices there are a total of 24 sub-district offices and 96 working stations in the field. The logging stations operate independently of the forest districts and of each other. They are responsible directly to the Forest Administration for the volume of timber produced and for reforestation of cut-over areas. In addition to logging, the logging stations operate sawmills, primarily for custom sawing and for the sawing of products needed for logging station maintenance purposes.

ORGANIZATION CHART OF THE TAIWAN FOREST ADMINISTRATION



FORESTED LAND AND TIMBEER RESOURCES

AREA

Of the total land area in Taiwan 55.1 percent or 1,969,500 hectares is forested (Table 11). Of this, conifers cover 18.9 percent, mixed stands 2.8 percent, hardwoods 72.5 percent, and bamboo 5.8 percent. Two-thirds of the forested areas is economically accessible (Fig. 3), with 30 percent or 391,000 hectares containing saw-timber stands (Table 19). However, hardwood and bamboo types occupy nearly 90 percent, leaving 8.5 percent occupied by the more valuable conifer types, the remaining parts being conifer-hardwood mixture. Of the 373,000 hectares in conifer types on Taiwan only 111,900 hectares or 30 percent are classed as accessible (Table 17).

Of the accessible land, 79 percent or 1,036,000 hectares (including bamboo) has volume less than 100 cubic meters per hectare, and 62 percent or 814,000 hectares (including bamboo) has volume less than 50 cubic meters per hectare (Table 20).

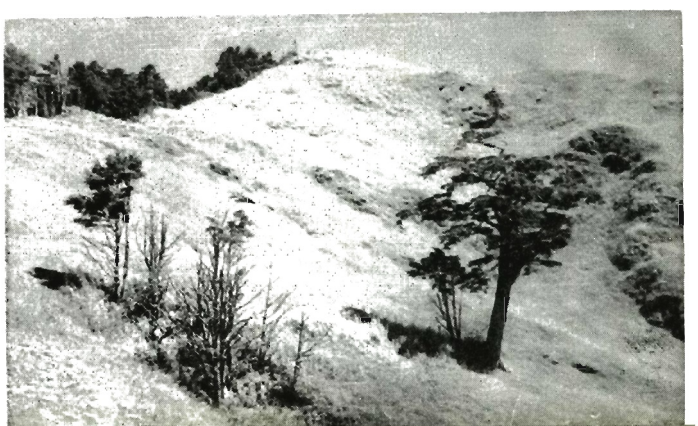
Of the total land area there are 325,000 hectares of grassland and denuded land that still have sufficient soil for growing trees (Table 11). Over 200,000 hectares are in accessible areas. The highest land use capability of most of this land is growing trees.

The forested land on Taiwan is fairly evenly distributed between four elevation classes, i.e. 0-599, 600-1199, 1200-1999 and 2000+ meters (Table 4). 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 M^3 or more per hectare while 60.6 percent of the stands above 2,000 meters have over 100 M^3 per hectare (Table 15).

FORESTED LAND BY ELEVATION CLASS AND VOLUME PER HECTARE CLASS*

Elevation Class (Meter)	Area in 1,000 ha.				Total (1,000 ha.)
	Less than 100 cu. m. per hectare	%	100 or more cu.m. per hectare	%	
0- 599	490.7	96.4	18.1	3.6	508.8
600-1199	391.3	86.4	61.4	13.6	452.7
1200-1999	331.1	62.4	199.9	37.6	531
2000 +	188	39.4	289	60.6	477
Total	1,401.1	71.2	568.4	28.8	1,969.5

Compiled from Detailed Table 15.



Huge area of high mountain grassland primarily caused by fire requires painstaking and expensive reforestation work (Elevation: 2,400 m. above sea level. The flat-topped tree is hemlock).

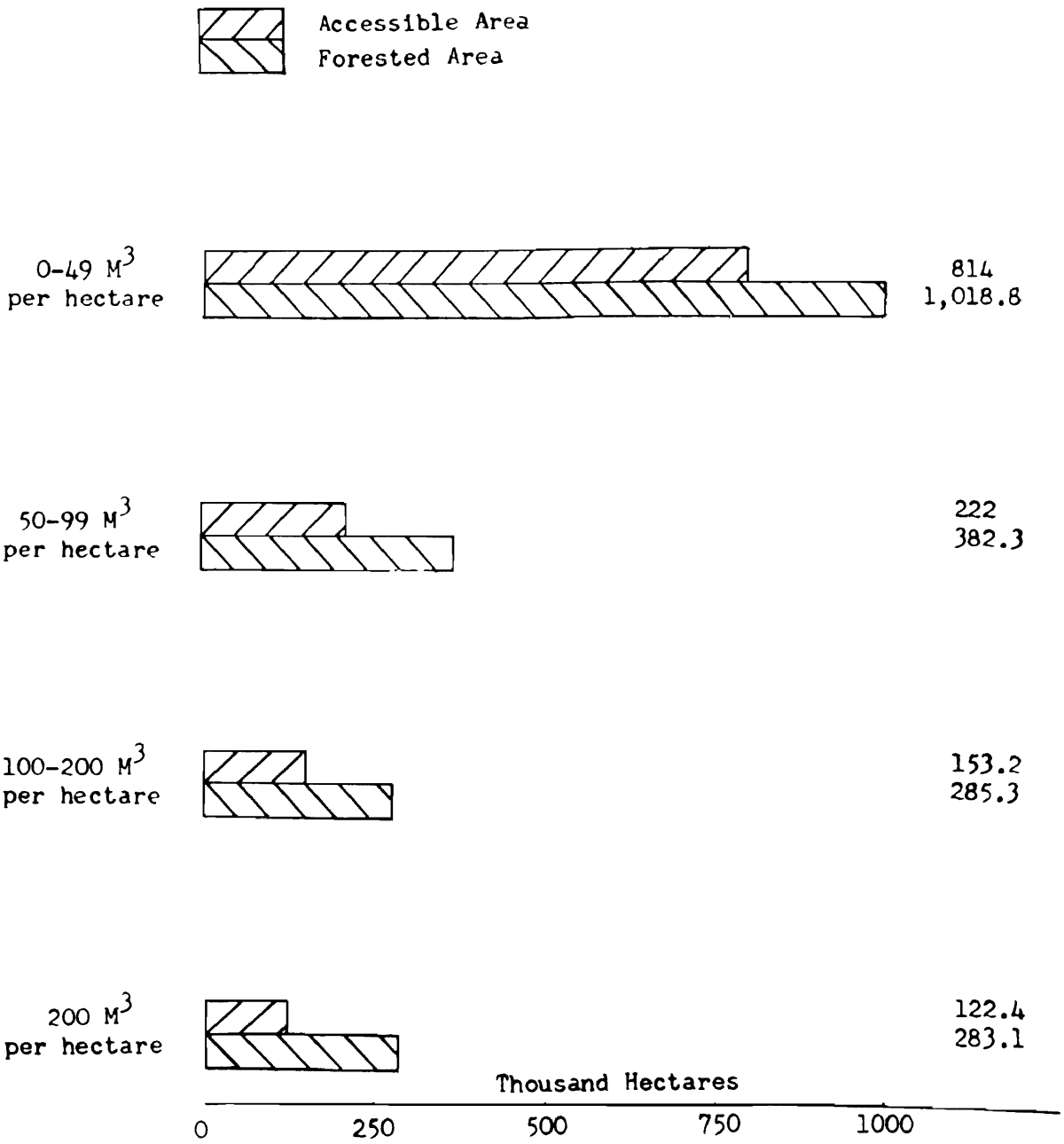


Figure 3 Forested Area by Volume Class per Hectare and Accessibility, 1955

Survey team members on the way to ground plots across a dangerous suspension bridge.

VOLUME

Taiwan has a total of 185,907,000 M^3 of growing stock of which 150,394,000 M^3 is in saw-timber trees (Table 27), and 140,093,000 M^3 is saw-log size material (Table 23). Coniferous species account for 52 percent of the growing stock and their saw-timber volume constitutes 60 percent of the total. Yellow and red cypress (Chamaecyparis formosensis and Chamaecyparis taiwanensis), the most valuable tree species on Taiwan, account for 30 percent of the coniferous growing stock volume with over 97 percent of their volume in saw-timber size trees (Table 24). A total of 1,490,000 M^3 of salvable dead cypress is included in the above volume (Table 23).

However, only slightly more than half (52.7%) of the total growing stock volume is classed as accessible (Table 29). Of this accessible growing stock only 30 percent or 28,909,000 M^3 is in coniferous species and 11 percent in red and yellow cypress. Of the total growing stock only 45 percent or 83,399,000 cubic meters is now available on commercial forested land.

The cubic volume of coniferous species is mostly in larger trees with 94 percent in saw-timber size trees. Hardwood species, although having a more even distribution by size class, still have 67 percent of their cubic volume in sawtimber trees (Table 15).

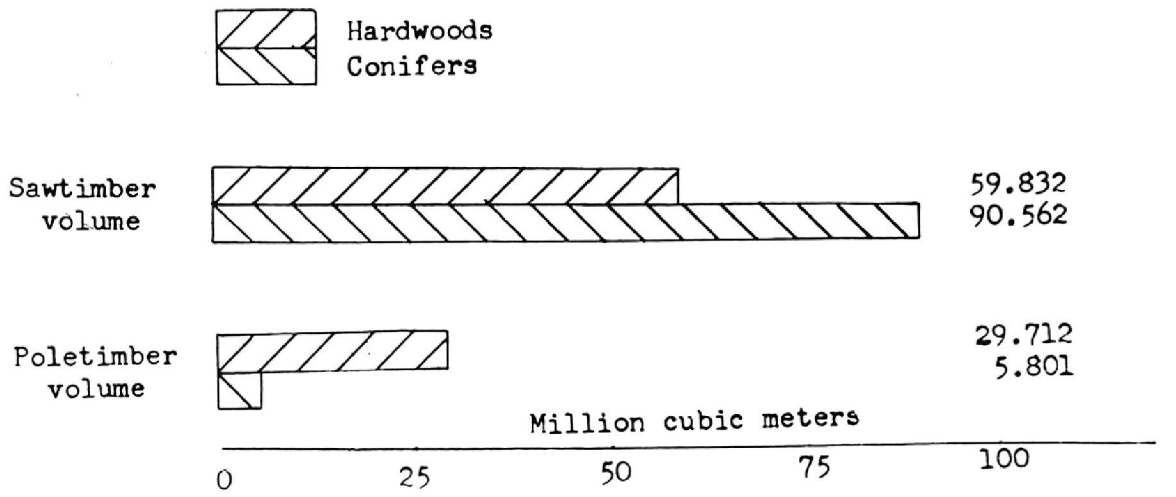


Figure 4 Growing stock volume by kind and class of trees on forested area, 1955

OWNERSHIP

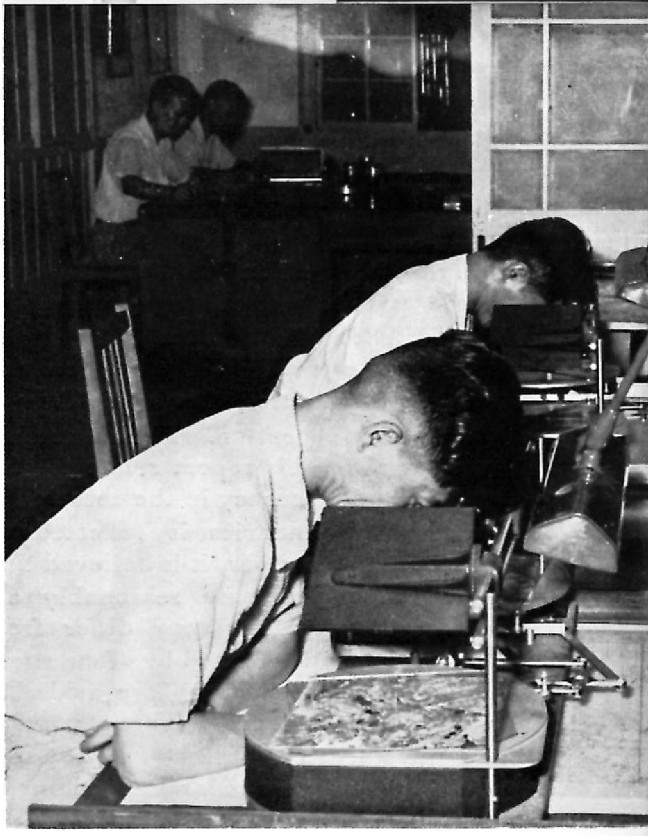
Nominally, the government owns most of the forested land and much of the nonforested land in Taiwan. However, in the more accessible mountain areas of Taiwan, land ownership has had little effect on land use. Boundaries of most of the various ownerships in the mountain areas never have been established on the ground. Maps, from the Japanese occupation days, have overlapping ownerships and some maps are missing.

After the retrocession of this island to China, the lack of boundaries and the population pressure has caused many farmers to move onto nationally owned land and establish use rights. Although the land still belongs to the government, the removal of the squatters is practically impossible from both the humanitarian and legal viewpoints.

Continuing but unsuccessful efforts are being made by various public agencies to induce the farmers to move off the nationally owned land, particularly since most of this land has not the capability for clean cultivation. Other and more successful efforts are resulting in reforestation of these lands by underplanting such areas as banana groves or by planting citronella grass areas with trees. However, the farmer still retains use rights and owns the trees. Arrangements for boundaries or use rights have not been made in most of these cases.

One reforestation method now in common use is to allow the farmers to clear nationally or publicly owned areas of brush and inferior tree species, cultivate them for 2 or 3 years and then plant trees. A tax of not less than 20 percent of the net product value are paid as rental when the trees are harvested.

The area of bamboo stands has been increasing rapidly. In addition to the stands planted by farmers, the bamboo species (Dendrocalamus) which is particularly good for food (bamboo sprouts) has been grown increasingly since the sprouts can be dried for export. Hardwood trees are cut to provide fuel to boil the sprouts before drying in the sun. Normally the hardwood trees nearest the bamboo and the centrally located boiling houses are cut for fuel. The bamboo quickly invades the areas formerly occupied by the hardwood trees that were cut for fuel. As more trees are cut for fuel each year, the bamboo area expands at an ever increasing rate. The bamboo belongs to the farmers and, since boundaries are not established, the farmers continually enlarge the area on which they claim land use rights, irrespective of actual ownership.



Aerial photographs are used for forest and nonforest inventory as well as for forest type and stand size and land use mapping.

Since the ownership boundaries are quite indefinite, data concerning ownership may be in error. However, an ownership and protection forest map was compiled, to the best of our ability within the resources available, for land under the jurisdiction of the Taiwan Forest Administration. The ownership data given in this report relate to this map. Any inaccuracy in the location of ownership boundaries is reflected in these data. However, it is believed that the map and data are reasonably accurate although they may differ from data previously reported by other agencies. Copies of this map are available in the Taiwan Forest Administration and the statistical data can be adjusted readily if any boundary inaccuracies are found.

National Forest land accounts for 72 percent of the forested land (Table 12) and contains 86 percent of the growing stock and 87 percent of the saw-timber volume on Taiwan (Table 27). The balance of the forested land and timber includes the aborigines reservation, marginal forest land, other public and private forests. Of the 302,883 hectares of designated protection forest (forested land only), 97.5 percent are on National Forested land (Table 14). Of the 113,900 hectares of bamboo stands, 26 percent, or 29,900 hectares, are on National Forest land (Table 14). All, or most, of these bamboo stands are claimed by private individuals.

National Forest land includes 301,800 hectares of land classed as nonforested by survey standards. Of this, 72,600 hectares are designated as protection forest area (Table 12). Over fifty thousand hectares, with 16,400 hectares in protection areas, are being cultivated (Table 21).

Grass now occupies 192,800 hectares of National Forest land (Table 21). However, almost 125,000 hectares of the grassland are now inaccessible or nonoperable. Most of the grassland is the result of shifting cultivation and forest fires.

GROWTH

The semi-tropical climate of the lower elevations of Taiwan is excellent for fast tree growth. However, the forest types in the lower elevations are mainly the less valuable hardwoods.

Taiwan has a net annual growth of 1.3% (Table 32 and 23) but it is mostly in small hardwood trees. Net annual growth in hardwoods is 3.2 percent. But net annual growth in conifers is minus one half percent (-0.5%) (Table 32 and 23). Gross annual growth for all commercial species in saw-timber size trees is almost balanced by annual mortality (Table 30).

The gross annual growth of saw-timber trees of coniferous species is 0.67 percent or 595,000 cubic meters while the gross annual growth of pole-timber trees, mostly plantation, is 6.6 percent, or 371,000 cubic meters (including sapling ingrowth) (Table 30, 31 and 24).

In hardwood species, the gross annual growth of saw-timber trees is 2.2 percent or 1,320,000 cubic meters, while the growth of pole size trees is 7.2 percent (2,146,000 M^3) (including sapling ingrowth) (Table 30, 31 and 24).

In terms of net annual growth the conifer saw-timber growth is a minus 0.8 percent (-728,000 M^3) while the conifer pole-timber is 4.1 percent or 239,000 cubic meters (Table 30, 31 and 24).

Net growth of hardwood saw-timber is 1.2 percent (737,000 M^3) while the net growth of hardwood pole-timber is 7.2 percent, or 2,125,000 cubic meters (Table 30, 31 and 24). Thus, we can see that the

net annual growth of hardwood species of pole-timber size is by far the predominant factor in timber growth in Taiwan.

However, much of the tree growth in Taiwan is not effective because of the inaccessibility of much of the forested land. Also, cutting is prohibited or limited by law on all protection forest land. Only 52.7 percent, or 97,575,000 cubic meters, on the accessible land is available for cutting (Table 29), and we can count on only 1,207,000 cubic meters as effective net growth of hardwoods on commercial forested land, while conifers have a net loss of 2,000 cubic meters annually (Table 34).

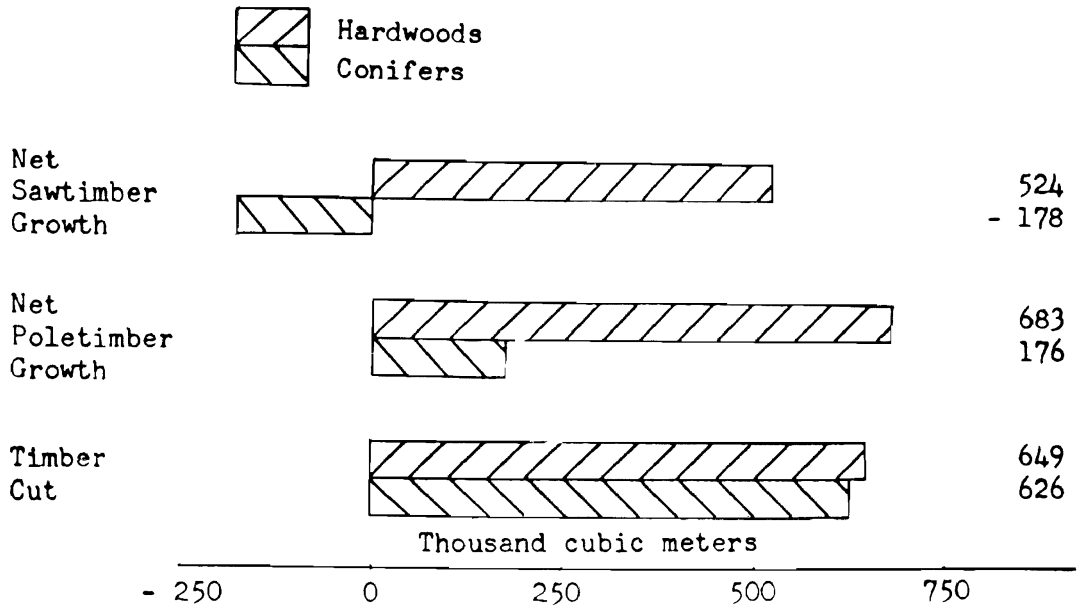


Figure 5 Net growth and timber cut by kind of trees on commercial forested land, 1955

TIMBER CUT

To obtain accurate statistics on annual timber cut has always been a difficult job requiring the use of various converting factors with subsequent possibilities of considerable error.

In this survey a new technique[2] involving the use of aerial photographs was used to obtain annual cut of 1,289,000 cubic meters. The difference between this figure and the timber drain of 1,233,692 cubic meters in 1955 as shown on Table 5, amounting to 55,308 cubic meters represents other miscellaneous uses, such as wooden vehicles, furniture, shoes, coffins, barrels, etc. This technique was verified by an independent study on fuelwood consumption made by the Rural Economics Division of the Joint Commission on Rural Reconstruction in cooperation with the Forestry Department of the National Taiwan University.

2 Use of Aerial Photographs in Estimating Drain. Bickford, C. Allen, 1953, U.S. Department of Agriculture. Station Paper 59, Northeastern Forest Experiment Station.

TABLE 5 CONSUMPTION OF TIMBER PRODUCTS, 1953, 1954, 1955

Item	Log Volume (cubic meters)		
	1953	1954	1955
1. Poles[1]	1,426	3,000	6,266
2. Crossties	61,603	32,377	19,173
3. Ship building	16,045	32,408	17,279
4. Mining timber	141,600	124,939	144,550
5. Pulp	31,540	30,330	24,400
6. Plywood	20,000	36,000	28,100
7. Shuttle and bobbin	5,000	5,000	5,000
8. Match	4,937	4,937	5,934
9. Camphor wood (excluding stumps and branches)	5,878	8,712	20,726
10. Timber for construction and special use	467,781	512,222	504,164
11. Fuelwood from growing stock	550,000	550,000	550,000
12. Fuelwood from non-growing stock[2]	2,281,000	2,281,000	2,281,000
Total timber consumption	3,586,810	3,620,925	3,606,692
Timber drain from growing stock[3]	1,233,310	1,172,925	1,233,692

1. Timber products for crossarms are included.
2. Nongrowing stock refers to waste wood, dead trees, branch wood and trees below 10 cm. in d.b.h.
3. Net import in log volume was approximately 72,500 cubic meters in 1953, 167,000 cubic meters in 1954, 92,000 cubic meters in 1955. Timber drain from growing stock = total timber consumption − fuelwood from non-growing stock—net import.

Further timber production and consumption data were obtained from the Taiwan Forest Administration as well as the Department of Reconstruction. These data were checked by a survey of Hsien Governments and the main timber using industries and organizations.

Foresters in Taiwan are well aware that production statistics reported in the past did not include an unknown amount of illegal cutting for sale and personal use, and of clearing for shifting cultivation. It is believed that we now have a more accurate measure of annual cut as the increased cut data reported here include the volume of illegal cut.

As shown in statistics (Table 32) cut plus mortality is depleting Taiwan's conifer stands by well over one million cubic meters per year. Hardwood stands have an increase of over two million cubic meters per year.

However, accessibility must be taken into account when considering growth and cut of forested land. Annual cut is carried out in accessible forested land only while mortality and growth occur on all forested land. Since cutting is generally prohibited by law on the protection forests, timber growth on them is not effective.

FOREST TYPE

Forest types vary according to elevation. The hardwood types generally occupy the lower elevations and conifers

Center rot is very common on logs from overmature virgin forests.

This particular big cypress tree, 3,000 years old and with DBH of about 11 meters, has been reserved for its scenic value.

predominate in the higher altitudes.

Conifer types cover 373 thousand hectares or about 19 percent of the forested area. However, as they grow at the higher altitudes on steep slopes, only 111.9 thousand hectares are accessible. Five conifer types are recognized. These types are all interassociated but the type is named for the dominant species present.

Cypress, the most valuable forest type in Taiwan, is found at elevations from 1500 to 2800 meters. Almost all of the area now covered by this type is in virgin stands of large trees varying in age from 200 to 2000 years. Eighty-two percent of the cypress growing stock is in trees 100 centimeters d.b.h. or larger. Stands are well stocked with 200 to 1200 cubic meters per hectare. Natural reproduction is sparse. It is not common after logging; where it does appear it is insufficient. Grass, brush and uncommercial bamboo usually take over the site. Planting is the customary method for renewing this type although

A virgin cypress stand at Tayuanshan.

Salvable dead cypress.

only a small amount of the logged-over areas have been planted and usually with faster growing species. The cypress type occupies 43,000 hectares but only 13,400 hectares are accessible.

The hemlock type covers the largest area and has the largest volume of all of the conifer types. However, since it is found at higher elevations of 2,000 to 3,000 meters and the wood is not as durable as cypress, it is less important in the forest economy. This type covers 133,000 hectares but only 17 percent or 23,300 hectares are accessible. A considerable amount of hemlock is used by the pulp and paper mill located at Lotung. Very little use is made of this species for construction purposes.

The virgin stands are old and usually in pure stands. The trees are thick but the volume per hectare is less than in cypress stands. Due to the high cost of logging and the low value of the products, not much logging of hemlock stands has been carried out. Brush, grass, and uncommercial bamboo take over the site after logging unless plantations are established.

The spruce-fir type grows in the highest mountains above 2,300 meters, and therefore is the most inaccessible timber in Taiwan. Less than 10 percent or 5,300 hectares is now accessible. The high cost has prohibited logging to any extent at present.

The pine types are found at high altitudes up to 3,000 meters and extend

(above) A natural cypress seedling overtopped by surrounding hardwoods. No release cutting or other similar treatments has been done in Taiwan.

(below) The most abundant and widespread coniferous species—Taiwan hemlock.

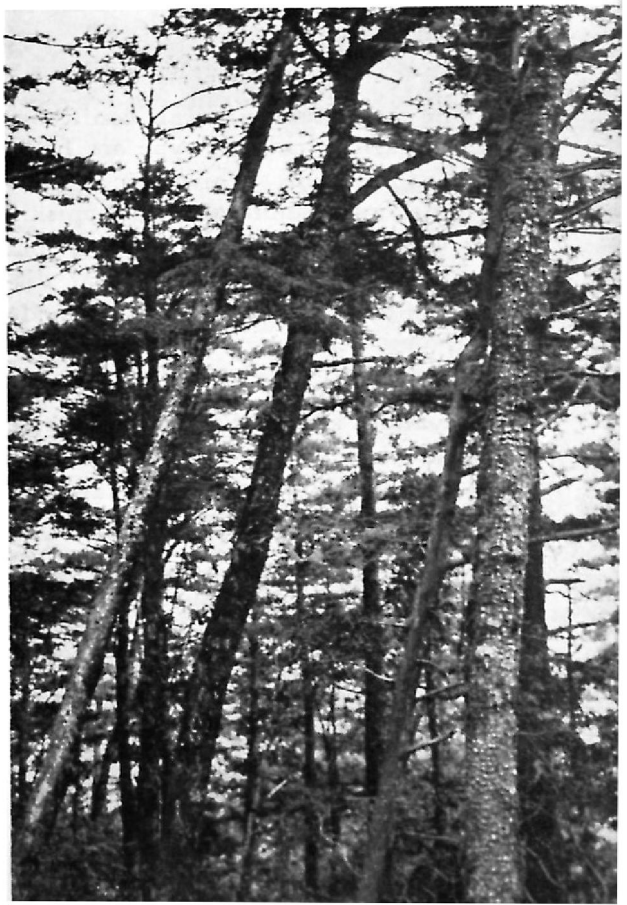
down to as low as 600 meters. The present stands are generally scattered but are the most accessible of the conifer types, and cover 23,900 hectares of accessible land. Several examples where the native pines seeded in following burns were noted by the survey crews. The use of controlled burning to obtain natural regeneration seems promising and warrants further investigation.

Plantations of Luchu pine have been successful at the lower elevation in the northern part of the island. The Luchu pine was introduced from the Ryukyu Islands and is a fast growing species. A few older plantations are found. One 30 year old plantation growing at an elevation of 1,300 meters, has trees 30 inches d.b.h. and with good height and form. The Luchu Pine plantations will soon provide a readily accessible wood supply for the pulp and paper mill located at Lotung.

Some of the pine species on Taiwan are suitable for turpentining but are not used for that purpose to any extent at present.

Other conifer types of importance are the Chinese fir and Japanese fir. Both are exotic species that have been extensively and successfully planted. Japanese fir grows best from 1,200 to 2,000 meters. Chinese fir has a wider range and grows well from 600 to 1,800 meters. The growth of both species is fast with the annual rate of 20 cubic meters per hectare being not uncommon.

Recently loblolly and slash pine from the United States have been planted rather extensively. A few older plantations have done well.



(*above*) *Fir is the dominant forest type on high mountain areas.*

(*below*) *Taiwan two-needle pine* (*Pinus taiwanensis*).

Fifteen-year old Luchu pine (Pinus luchuensis) plantation.

venty percent of the accessible volume is in hardwoods and over 40 percent of it is in trees of less than 40 centimeters in diameter at breast height. However, since they are not rot resistant and preservatives are applied to only a small part of Taiwan's wood products, they are of considerably less value than many of the more durable conifers.

The tropical hardwood forest type of 612,800 hectares, covering nearly 30 percent of the forested land and 44 percent of the accessible forested land, presents a serious land and forest management problem. This area probably has the greatest forest potential but with few exceptions it is contributing least on a hectare basis to Taiwan's national needs for timber. This great demand for timber has caused these accessible areas to be heavily overcut and badly managed.

Chinese fir (Cunninghamia lanceolata) plantation.

The important natural coniferous species classified in this type are Libocedrus formosana, Taiwania cryptomerioides, and Cunninghamia konishii. They are good in timber quality but exist only in spots due to natural distribution and destructive cuttings made in the past years.

Conifer-hardwood types are found at all elevations above 1,500 meters. Where they have been logged only the conifers have been removed, leaving many old and decadent hardwoods.

Hardwoods occupy three-fourths of the forested land of Taiwan. As they cover the lower elevations, usually less than 2,000 meters, they are more accessible than the coniferous species. Se-

Among the commercial species in this type, Acacia confusa is the most important and widely planted. It serves a good purpose in producing fuel for the population of the lowlands. Acacia is easily managed through cutting and sprouting. Camphor trees have been planted to a considerable extent by the government primarily on the east side of the island and are used for the production of camphor and camphor oil. Teak and mahogany are planted only to a limited extent on the southern part of the island. Both species require a deep, porous soil and are not suited for planting on the shallow mountain soils. Teak plantations formerly established were for the most part cut during World War II. These species are the most promising for planting in the lowlands of the South as no suitable coniferous species have been found

Temperate hardwoods.

One of the most valuable species—Cunninghamia konishii.

to date. Most of the remainder of this type have been subjected to shifting agriculture and have reverted to brush species. They are valuable only for low grade fuel and in protecting the mountain soil from erosion.

Much of this land should be reclaimed for forest production. In the northern half of the island Luchu pine and some American pine species show good promise even at the lowest elevations.

The sub-tropical hardwood type covers 565,800 hectares of which 385,000 hectares are accessible. It has been subjected to the same adverse treatment but to a lesser extent than the tropical types. It contains some valuable species such as the oaks. Most of the species, however, have little commercial value due to

A typical low grade tropical hardwood stand mixed with tree ferns.

short lengths and poor form. The rate of mortality is high. Past logging practices have removed the valuable species leaving the less valuable ones to regenerate.

Chinese fir, Japanese fir and pine when planted on these soils grow very well especially on the north slopes.

The temperate hardwood type appears to be a climax type. It is the least accessible hardwood type and the lumber value is low. It covers 248,700 hectares but only 100,600 of this is accessible.

The area in *bamboo type* has been increasing and now covers 113,900 hectares of which 106,900 hectares are accessible. Bamboo shoots are an important food item and the stems have many uses.

FOREST INDUSTRIES

The timber and paper industry is one of the important industries of Taiwan. A considerable amount of the population, 300,000 people or 3 percent, earn their living by logging, lumbering or manufacturing forest products. The value of timber and paper products was almost doubled between 1951 and 1955.

Notwithstanding its high forest capital, Taiwan has not been producing sufficient wood for its own use. The chief reasons are: (a) timber resources are located in mountains of difficult accessibility, involving high production and transportation costs, (b) a low degree of efficiency in logging operations and (c) poor "on the spot" utilization practices of the timber cut. Hence, importation of certatin forest products, such as railroad ties, pulpwood, poles and even lumber, has been considered cheaper than local harvesting.

TABLE 6 VOLUME[1] OF IMPORT AND EXPORT OF TIMBER[2]
1950-1954
(cubic meters)

Year	Import	Export	Net Import
1950	59,481	130	59,351
1951	45,780	994	44,786
1952	55,694	519	55,175
1953	48,779	1,764	47,015
1954	110,803	2,320	108,483
1955	67,388	7,639	59,749

1 Lumber volume
2 Compiled from information furnished by the Bank of Taiwan and the Custom House.

The Taiwan Forest Administration is a revenue producing government corporation. Since timber harvest is the main source of forest revenue, the present efforts of this agency are devoted primarily to logging. The Taiwan Forest Administration operates six logging stations which produce about one-half of the total timber cut reported by that agency.

TABLE 7 VOLUME[1] OF CUT[2]

Year	Forest Land	Operated by	Softwood cubic meters	Softwood percent	Hardwood cubic meters	Hardwood percent	Total[5]	Percent
1953	National	Government[3]	173,614	91.4	16,418	8.6	190,032	41.0
		Private[4]	42,411	26.5	117,638	73.5	160,049	34.6
	Other public & private	Other public & private	26,731	23.7	86,061	76.3	112,792	24.4
			242,756	52.5	220,117	47.5	462,873	100.0
1954	National	Government	207,592	87.9	28,516	12.1	236,108	49.5
		Private	37,282	24.4	115,236	75.6	152,518	32.0
	Other public & private	Other public & private	19,248	21.8	68,948	78.2	88,196	18.5
			264,122	55.4	212,700	44.6	476,822	100.0
1955	National	Government	218,713	90.0	24,672	10.0	243,385	50.6
		Private	22,855	19.1	96,921	80.9	119,776	25.0
	Other public & private	Other public & private	54,130	46.0	63,523	54.0	117,653	24.4
			295,698	61.4	185,116	38.6	480,814	100.0

1. Log and rough lumber volume (excluding fuelwood).
2. Source: Taiwan Forest Administration.
3 Logging conducted by logging stations.
4. Timber sale made by the Forest District Offices.
5. These figures do not include unauthorized and un-reported cuttings.

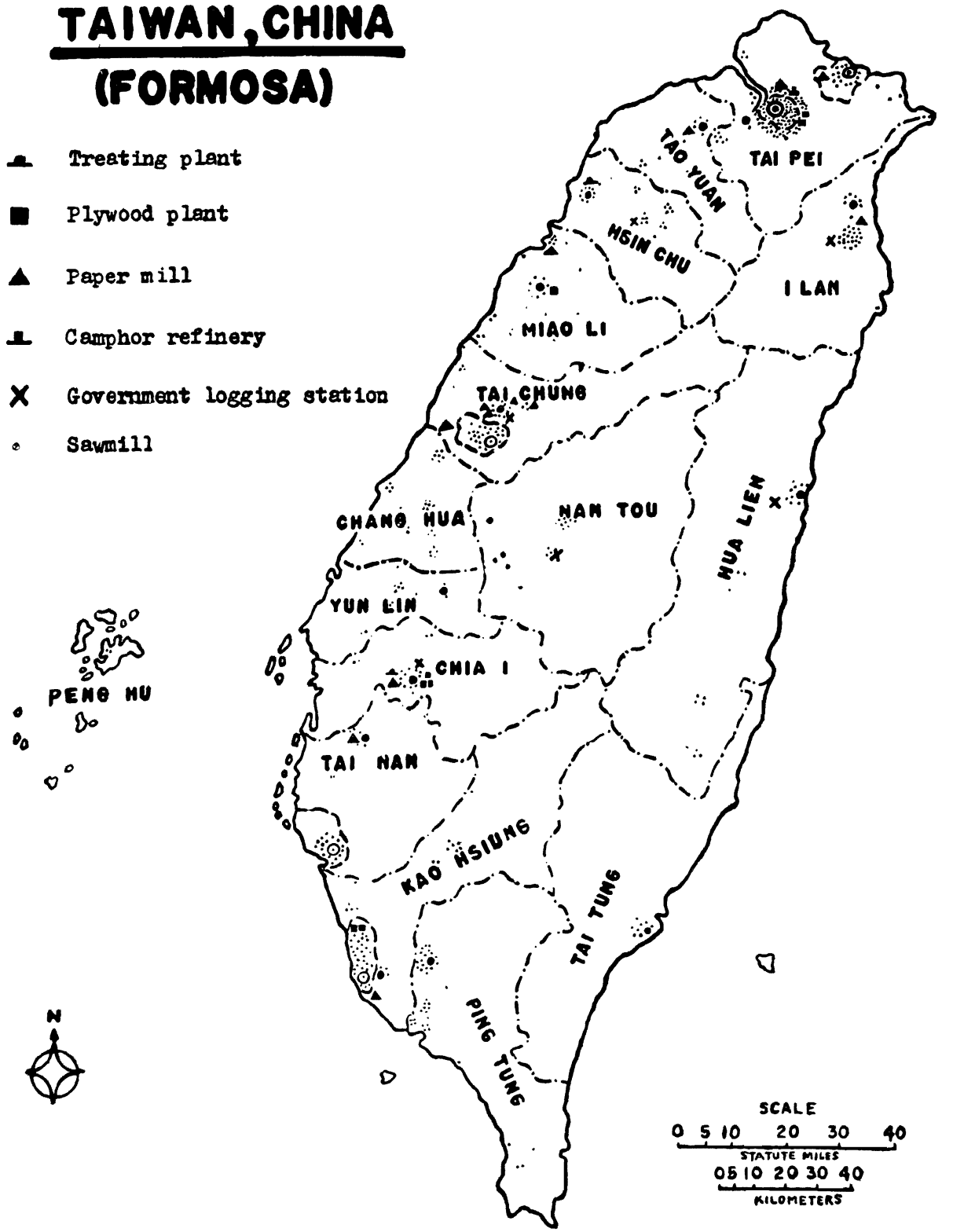


Figure 6 Map showing location of wood industries.

(BY COURTESY OF J. G. WHITE ENG. CORP.)

Most of the logging in Taiwan is done in the high, rugged areas of the central mountain range.

(BY COURTESY OF J.G. WHITE ENG. CORP.)

Most logging areas are reached by a series of three to five cableways.

Since practically all the high grade coniferous trees are located on national forests, and conifers are most profitably logged, government logging is concentrated principally on these species. In the past three years, approximately 90 percent of the timber produced at the government logging stations was coniferous species while hardwood species constituted three-fourths of the public and private timber production.

Reported timber production showed a gradual increase between 1950 and 1955. In 1950 it was 326,690 m^3 as against 480,814 m^3 in 1955.

In order to develop the wood using industries of Taiwan, the Japanese government invested huge sums of money in the construction of logging railroads and equipment in mountainous areas. An example of the transportation difficulties is the Alishan Logging Station on which operations began in 1913. The 65-kilometer railroad, connecting the station with the city of Chiayi, has a grade of 5 percent with 74 tunnels

Cableway operated by gravity has a loading capacity of five tons.

totaling more than 10 kilometers, three spiral sections, two switchbacks and 2.8 kilometers of bridges. On their 36-kilometer journey from Taiping-shan to the sawmill at Lotung the logs are transferred seven times over three aerial cableways and 4 narrow gauge logging railways before they are re-loaded on flatcars for their final journey to the mill. Consequently, transportation constitutes more than half of the cost of log production. Because of topographic conditions and the violent nature of the rivers in Taiwan, river driving of forest products is not possible.

The limited capacity of the aerial cableways (5 tons) makes it necessary to cut logs into short lengths and rip the larger ones before transporting them to the sawmills.

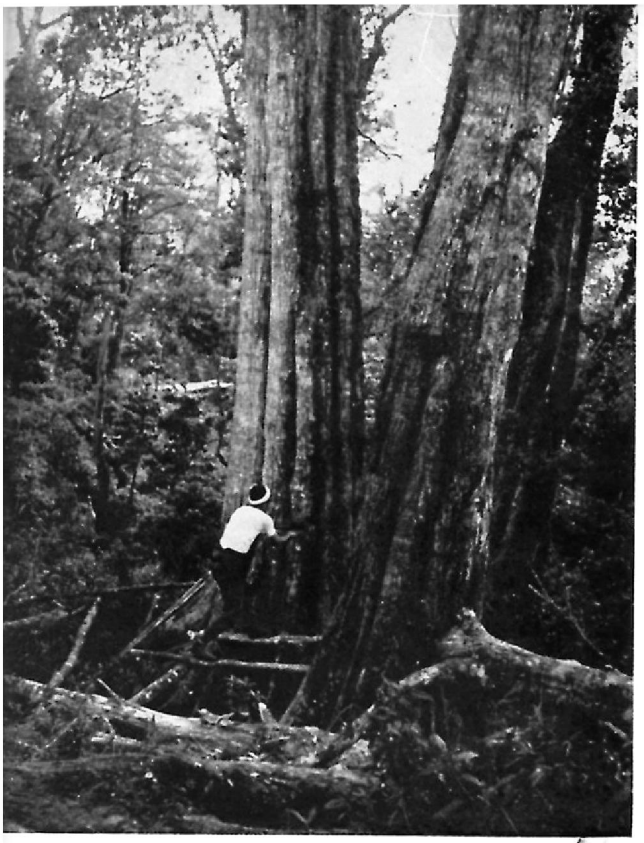
Felling and ripping are done with hand tools. Attempts to introduce power chainsaws have not been successful due to (1) the difficulty of using them under the steep and rough topographic conditions, (2) the local loggers are not mechanically minded, and (3) labor is cheap and plentiful.

Truck logging has been limited, with only 65 kilometers of truck roads now in use. However, 44 kilometers of high grade logging road is now under construction to open up a new area, Ta-Shueh Shan.[3] It will be the first complete truck logging operation on the Island.

Private logging operations on government land are confined chiefly to hardwoods. Partly because of lack of capital and partly because private operations are subject to government allocations of stumpage, these operations are, for the most part, small. Skidding is usually done by hand, using wooden

3 Source: Taiwan Forest Administration

The large logs are ripped in the woods to fit transportation facilities.



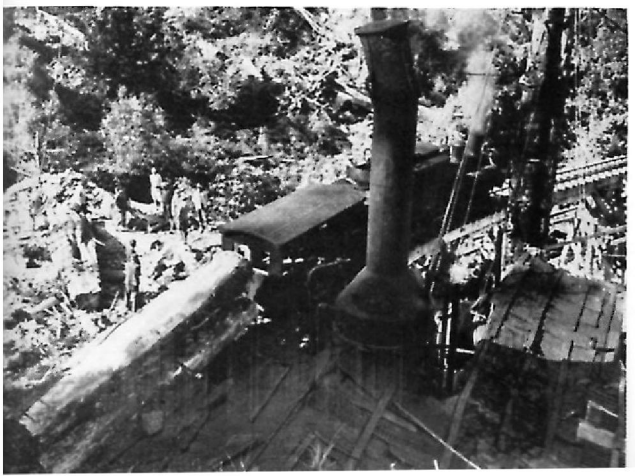
Felling with hand saw.

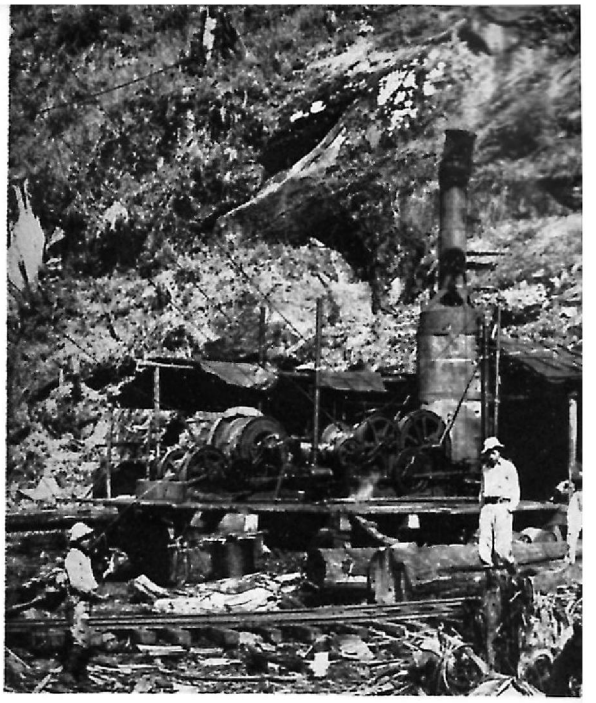
sleds pulled by one or more men. Logs are necessarily cut in short length (2-3 meters).

For longer distances narrow gauge (50 cm.) railroads are commonly used. The cars are pushed by men or women. In mountainous areas, light gravity-operated cableways are occasionally used.

According to the "Timber Sale Regulations on National Forest Land," each private logging operator must be registered with the Taiwan Forest Ad-

Logging railroad at the Alishan Logging Station.



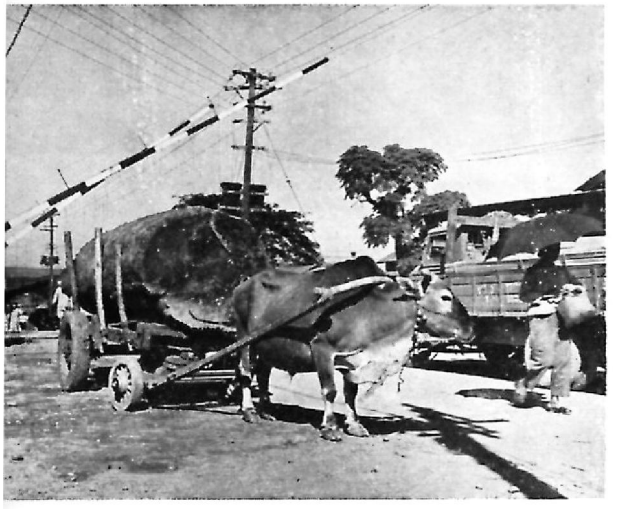


BY COURTESY OF J.G. WHITE ENG. CORP.)

Steam yarders over 20 years old still do a job in skidding large logs.

A yarding center.

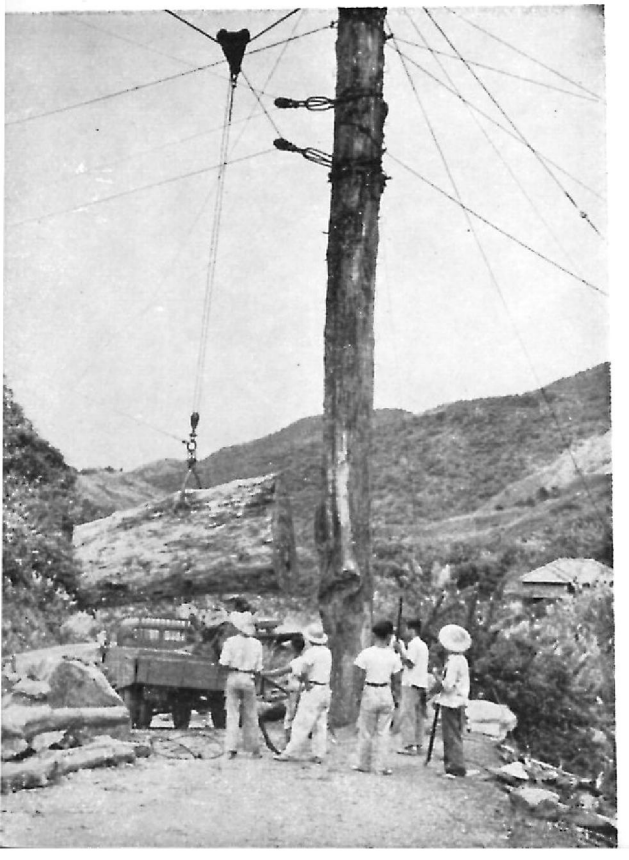
Logs are cut short (usually 2 meters) and tranported on wood sled pulled by man power.



ministration and officially approved before he can operate on national forest or other public land. At present only 70 logging operators out of 270 recognized by the Taiwan Forest Administration are conducting operations on national forest land. Five out of 54 fuelwood operators[4] are working on those areas.

SAWMILLNG

The 644 private sawmills on Taiwan sawed approximately 430,000 cubic meters of logs in 1954. The lumber produced was valued at NT$300,000,000.[5] One hundred and seven of the sawmills have a capacity of over 10,000 cubic meters a year of log volume.[6] However, most of the sawmills operate at much less than capacity due to the lack of logs. A typical electric powered mill has one 42-48 inch band headsaw with a cable powered carriage, two or three 38 inch band resaws with the logs pushed through by hand, and two or three swing-type circular saws for trimming. A total of 5,200 families are supported by the private sawmills.[7]



4 Source: Taiwan Forest Administration.

5,7 Source: Taiwan Industry Census sponsored by the Provincial Department of Reconstruction.

6 Source: Taiwan Chamber of Timber Industry

(*above*) *A government owned timber pond.*
(*middle*) *Ox-carts are also used for transportation.*
(*below*) *Loading of log on a truck.*

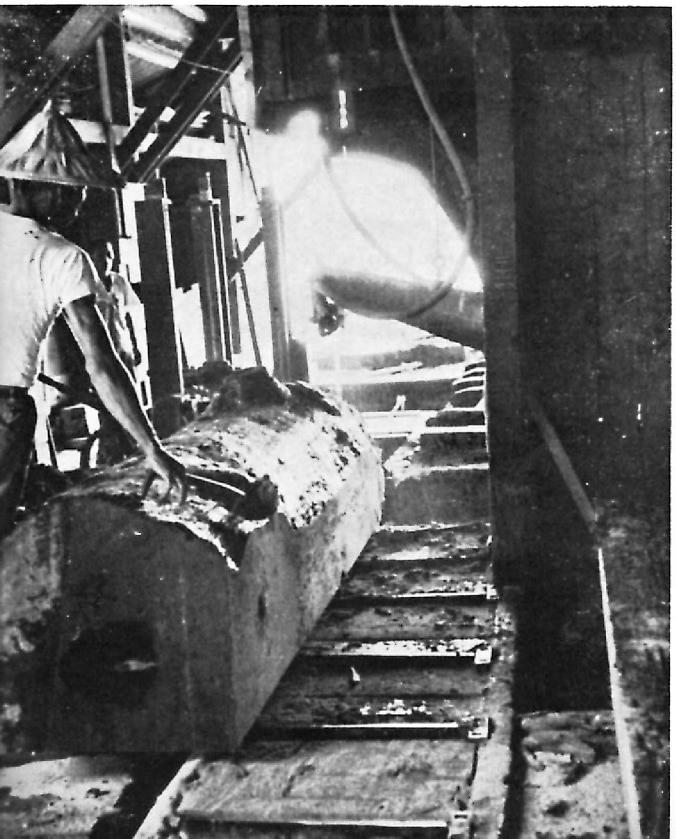
The 15 sawmills operated by the Taiwan Forest Administration produced 37,129 cubic meters of lumber in 1955. Members of 600 families are employed by these sawmills.[8]

PULP AND PAPER INDUSTRY

There are 58 paper mills on Taiwan.[9] However, five of them produce about seventy percent of the total paper production. Only one is a pulp producing mill, and this mill has been producing at about sixty percent of capacity due to difficulties of obtaining pulpwood.

The industry is carrying on an expansion program and, upon completion, will have an annual pulpwood requirement of approximately 56,600 cubic meters. At present they are using 24,400 cubic meters of pulpwood annually. Although much of the increased production will be bagasse pulp made from the stalks of sugarcane, there will still be a shortage of pulpwood.

A head-saw.



A table-type resaw.

Both pulpwood and pulp are being imported as well as considerable quantities of paper. To meet the increasing demand for paper products, much will depend on the success of the present program of planting pulpwood species in areas accessible to the pulp mill.

The industry employs some 5,530 people and produces products valued at NT$262,889,962[10] (actual sales) in 1954.

FUELWOOD

Fuelwood (including charcoal) production statistics are reported to the Taiwan Forest Administration by the logging stations, district forest offices and the hsien/city governments. In 1955 the reported amount was 150,297 cubic meters.

8 Source: Taiwan Forest Administration.

9 Source: Taiwan Industry Census sponsored by the Provincial Department of Reconstruction.

10 Source: Taiwan Industry Census sponsored by the Provincial Department of Reconstruction and Taiwan Pulp and Paper Corporation.

A swing type circular resaw.

However, the volume reported amounts to only a fraction of the actual amount used. Illegal cutting and the cutting of scattered trees for which a permit is not required as well as under-reporting from private lands to avoid taxes amounts to far more than the reported production.

According to the "Fuelwood Consumption Survey of Taiwan" conducted in 1954 by the Rural Economic Division of the Joint Commission on Rural Reconstruction in cooperation with National Taiwan University, the total annual fuelwood consumption was 2,829,000 cubic meters. Charcoal, in terms of firewood, constituted 30 percent of the total. The annual consumption per household averaged 1.8 cubic meters with 0.32 cubic meters per capita. This was almost half of the per capita consumption reported for Japan.

According to the Forest Resources Counter-Measure Council of Japan the annual fuelwood consumption per capita of Japan is 0.76 cubic meters. As Japan has a colder climate, more fuelwood is needed for heating purposes.

About 548,000[11] cubic meters, or less than 20 percent of the total, came from growing stock on forested land. Over 50 percent (1,538,000 cubic meters) came from branch wood, scattered trees, or trees less than 10 cm d.b.h.. Another 12 percent (344,000 cubic meters) was dead trees while the remainder (402,000 cubic meters) was sawmill waste, used lumber and other waste. The principal species used for fuelwood are Acacia confusa, Lagerstroemia subcostata, Euphoria longana, Trochodendron aralioides and Machilus Kusanoi.

Fuelwood is expected to remain the chief source of fuel for household needs. Future consumption probably will increase faster than the 3 percent population growth due to increasingly better economic conditions.

VENEER AND PLYWOOD

Within the last few years, a plywood industry has been developed on Taiwan. About 28,100 cubic meters of logs was used in 1955. However, only about 10 percent of the logs used are from the local forests. The other 90 percent are lauan logs (Philippine Mahogany) imported from the Philippine Islands. This is largely due to the high price of the domestic veneer logs. The lauan logs cost US$52 to $60 F.O.B. per thousand board feet. Besides transportation and insurance, the importer also pays taxes and custom duties of 62 percent. Despite cheap labor, the competition with Japan for world markets is very strong as the Japanese plywood mills obtain their logs duty free. The Chinese Government is considering tax refund measures for the export of plywood. If tax refunds are given, the plywood export business is expected to expand materially. Present production is about one-half of the total capacity of about 40,000 square meters per day for the eight plywood plants now in operation. Efforts are also being made to increase the quality of the plywood manufactured.

Cypress (Chamaecyparis sp.) is the only local wood used to a great extent in making plywood. Other species used to a very limited extent are Libocedrus formosana, Taiwania cryptomerioides,

11 The accuracy of this amount is supported by the volumle found by the drain survey conducted by the Land Use and Forest Resource project from duplicate aerial photographs taken several years apart When 550,000 cubic meters are added to domestic lumber consumption, the result gives a volume only 8-10 percent less than the aerial drain estimate Wood waste, etc would account for the difference.

A private plywood plant.

Michelia formosana, Machilus sp. and Camphora sp.

Almost 10 percent of the plywood used locally is for the construction of boxes for tea export. The remainder is used principally as construction materia!.

A total of 1,178 people were employed by the plywood industry with a total wage of NT$5,400,000 in 1954.[12]

TABLE 8 PLYWOOD PRODUCTION*

Year	Square Meters
1953	3,780,000
1954	5,640,000
1955	4,270,000

*Census conducted by the Survey Team.

TABLE 9 PLYWOOD EXPORTS AND LAUAN IMPORTS*

Year	Plywood Export	Lauan Log Import
	U.S. Dollars	
1953	72,102	147,379
1954	75,487	295,422
1955	62,804	369,142

*Source: Council of United States Aid, Bank of Taiwan and Custom House.

MATCH INDUSTRY

A total of eleven match manufacturing firms produce 21,600 tins annually.[13] Each tin contains 1,200 small boxes of matches. In making matches, wood is needed for both the match stick and for the small wooden boxes containing matches. The annual consumption of

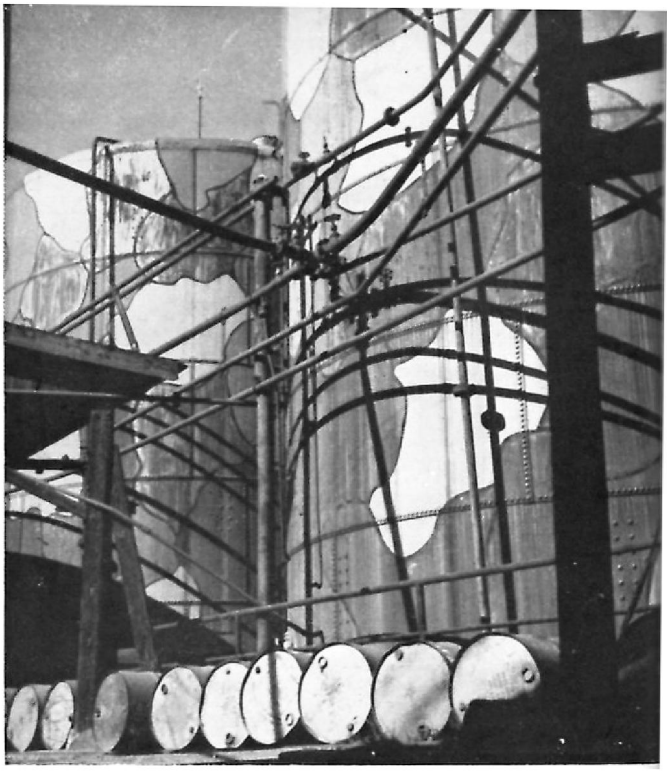
12 Source: Taiwan Industry Census sponsored by the Provincial Department of Reconstruction.

13 Source: Taiwan Industry Census sponsored by the Provincial Department of Reconstruction.

wood amounts to about 5,000 cubic meters.

Many tree species can be used for making match boxes but only a few of the local tree species have been found suitable for making match sticks. The preferred species for making match sticks are: Aleurites fordii, Sapium discolor, and Schefflera octophylla. Other species are sometimes used as substitutes but are not as satisfactory. However, there is a limited supply of all the usable species including the secondary ones. Therefore the match manufacturers import sandal splints and shavings from Japan and the United States to meet their needs.

This industry has provided jobs to 1,640 people[14] who have an estimated total of 8,000 dependents.



Camphor oil tanks at the Camphor Refinery in Taipei.

CAMPHOR[15]

Taiwan is one of the few countries in the world that produces natural camphor. It is extracted from the stump, bole and branches, excluding bark, of five varieties of Cinnamomum camphora. Three of the varieties growing in Taiwan are so low in camphor content, or so scarce as to be of little commercial value. Only two varieties, namely Ben-camphor tree and Fon-camphor tree, are extensively used for camphor extraction.

Small, crude stills are built in the forests for distilling the camphor from the wood. The wood is chipped usually by power chipper,[16] and placed in the still over a large pan full of boiling water. After the steam passes through the wood chips and extracts the oil, it is condensed and the camphor oil is separated by draining off water from the bottom. Part of the camphor crystallizes and part remains as oil. The crude oil and rough camphor are shipped from the scattered stills to the refinery in Taipei for refining.

After the oil is extracted, the wood chips are used as fuel for the camphor stills.

The production of each still depends on the abundance of camphor trees in the vicinity and varies from 140-400 kilograms with an average of 280 kilograms of rough camphor and crude oil a month. When the raw material in the vicinity of a still is exhausted, the still is moved along with the workers and their families.

Camphor production has been decreasing due to unfavorable foreign market price caused by huge amounts of camphor exports from the mainland of China and Japan. The local demand for camphor is very limited; about 80 percent of the production was exported in 1955.

14. Source: Taiwan Industry Census sponsored by the Provincial Department of Reconstruction.
15 Source: Taiwan Camphor Refinery.
16 Ninety-five percent of the stills have portable power chippers.

TABLE 10 CAMPHOR PRODUCTION AND EXPORTATION

Year	Camphor Products	Camphor Exported
	Kilograms	
1951	670,805	754,389
1952	586,692	329,152
1953	301,588	397,423
1954	470,100	151,845
1955	1,134,481	206,804

In 1955 a total of 70,905 cubic meters of wood[17] was used in the production of camphor. Forty-seven percent was from National Forest land, twenty-three percent from public forests, and the remainder from private forests. Future wood requirements will probably be about the same as in 1955 since no increase in production is expected in the near future.

The industry now employs 1,563 workers at the 484 stills in operation. Another 407 are employed in the refinery. The still "chiefs" are paid at an average of NT$4.56 for one kilogram of raw camphor and oil produced. Seventy percent of the payment plus one catty (0.6 kilogram) of rice for each kilogram of raw camphor or oil produced, goes to the workers as wage. The remaining 30 percent of the payment goes to the still chief. In addition, operating expenses, transportation and compensation are paid by the Camphor Refinery through the still chief.

Because of its importance as an export item (NT$5,284,800 in 1955) camphor was formally established as a government monopoly in 1899 and continued until November 1952. Currently the industry is under the control of the Government through the Taiwan Camphor Refinery, a part of the Taiwan Tobacco and Wine Monopoly Bureau which is an enterprise of the Taiwan Provincial Government.

CORK PRODUCTION

Cork oak (Quercus variabilis) grows at 600 to 1500 meters above sea level on Taiwan. A small industry of six private cork plants and a plant administrated by the Taiwan Tobacco and Wine Monopoly Bureau is based on the utilization of the bark of this tree. The main products consist of a glued cork board, an acoustic heat-resistand carbonized cork board for insulation, bottle cork and bottle cap cork. A small amount of raw material is imported by the private plants from Europe through Hongkong. The Monopoly Bureau purchases approximately US$50,000 worth of bottle cork and bottle cap cork every year due to the unsatisfactory quality of local bark as well as its high cost. The imported cork is more elastic and has a better natural color.

The bark of the cork tree is removed with an axe. The tree is divided into longitudinal sections about two feet in height. Starting with the top section the bark is peeled from around the tree. Usually two or three sections are obtained from the short trees which grow to a height of five to ten meters, depending on the site. The bark is removed during the late summer and early fall by aborigines in their reservations and by the permanent cork plant employees in other areas. However, the government's cork plant purchases the local bark through open bidding. They use the local bark only for carbonized boards.

The trees continue to yield bark but the quality of the bark decreases after the first debarking. Subsequent bark removals are at intervals of 6-10 years depending on the site quality. At present the original bark is worth NT$2.90 (US$0.12) per kilogram delivered at the plant while the secondary bark is worth NT$2.20. Approximately a million kilograms of bark is used each year. The total product value

17 Stumps and branches are included.

was approximately NT$1,500,000 in 1954, and NT$2,000,000 in 1955. Wages, totaling NT$390,000, were paid in 1954 to the approximately 75 families supported by the industry.[18]

WOOD PRESERVATION INDUSTRY[19]

The wood preservation industry is a relatively new development on Taiwan. During the Japanese occupation four small plants were started but they soon went out of business due to competition with plants located in Japan. The first preservation plant established after restoration was located at Lotung. Utilizing the equipment of the former Japanese plant located there, the plant used the open-tank process and treated only 9,750 cubic meters of poles and ties during the period of operation from 1951 to 1955.

In 1952, a modern plant using the pressure treatment was opened in Hsinchu and, in 1954, another plant was started at Chiayi. Both full-cell and empty-cell processes are used, depending on the characteristics of wood being treated. Coaltar creosote is applied to poles, crossties, and bridge, dam and ship building timbers. Malenit (chiefly a sodium-flouride and sodium dinitrocresolate mixture) is used for treating building lumber and structural timbers. Both of the preservatives are obtained from Japan.

The maximum capacity of the two plants is approximately 120,000 cubic meters of wood per year. One lot of 22,000 treated poles was exported to South Korea at the end of 1955. It is expected that the export of poles will increase.

The treating plants employ 130 men and paid a total wage of approximately NT$700,000 in 1954.[20]

SHIP BUILDING

There are 52 ship building firms on Taiwan most of which engaged in the construction and repair of wooden fishing boats. However, the largest firm normally builds steel ships. Annual consumption of timber varies from 10,000 to 20,000 cubic meters per year.[21]

FURNITURE MANUFACTURE

According to the Taiwan Industry Census, there were 1,914 furniture manufactures (wood, bamboo and cane) on Taiwan in 1954. The industry is composed of many small shops, often family units, scattered throughout the larger villages and cities. The shops are not mechanized and almost all work is done with hand tools. The furniture produced in 1954 was valued at NT$62,714,691 (actual sales) and it is estimated that some 3,500 families were supported by this industry.

HANDICRAFT: WOOD, BAMBOO, CANE

The handicraft industry is largely composed of small units, often family units, using only hand tools. The Taiwan Industry Census of 1954 indicates a total of 2,281 wood, bamboo and cane handicraft shops in Taiwan. Products were valued at NT$55,723,428 and about 5,000 families were supported by this industry.

18 Source: Taiwan Industry Census and Taiwan Tobacco and Wine Monopoly Bureau.

19 The Provincial Department of Reconstruction, Taiwan Timber Treating Co Ltd. and Chen Chang Timber Treating Plant.

20 Taiwan Industry Census sponsored by the Provincial Department of Reconstruction.

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SURVEY PROCEDURE

These estimates of land use areas, forested area and timber volume are based upon data obtained from a double-sampling survey, combining the use of aerial photography with ground sampling procedure.

AERIAL PHOTOGRAPHY

Twenty-four sample strips of aerial photography were flown in an east-west direction (at a right angle to the general topography). A random-systematic system of spacing placed the flight lines 10 miles apart. The photography was done with a 24-inch focal length lens with minus blue filter and infra-red film at an elevation of 20,000 feet with 1,500-3,000 feet between photo centers.

The basic statistical data of this survey were derived from the sample strip photography.

In addition to the sample strip photography, almost complete coverage of the island in 1/40,000 panchromatic, mapping photography taken in 1948 to 1952 was available. The mapping photography was interpreted and delineated into land use and forest cover types, problem areas, and stand-size classes. The delineated data were transferred to 1/50,000 topographic maps which are available to technicians for various types of land use and forest management planning. The delineated data on the 1/50,000 maps were condensed and placed in color on 1/250,000 topographic maps. These maps are small enough to be displayed on walls, and are of value for policy planning. The 1/250,000 maps were further condensed for inclusion in the analytical reports as well as for illustrative purpose in other publications.

The forest drain estimate was obtained by comparing sample plots on the duplicate aerial photographic coverage. When changes in forest volume classes were observed, the photographs were interpreted for the volume per hectare change and the volume of drain weighted by the lapse of time. This information was supplemented by drain observed on the ground sample plots to arrive at the over-all estimate of forest drain caused by timber cutting and land clearing.

PHOTO-INTERPRETATION

A large numder of plots (37,495) were distributed over the photographs. If the plot was forested, the photo interpreter classified the forest stand by forest type and volume class (based on stand height and density). Nonforested areas were classified by present use classes. In addition, all plots were classified by problem area classes (based upon depth, texture and erodible qualities of the soil as well as slope and aspect).

GROUND PLOT EXAMINATION

A total of 545 of the plots established on the aerial photographs were chosen from each stratum (based on volume for forest plots and problem area for non-forest plots) by random selection for examination on the ground. Forested ground plots were examined to establish a reliable average volume per hectare by volume classes from a tally of trees by species, diameter at breast height (1.37 meters) and merchantable height. Growth, cull, quality and mortality estimates were also made on the ground plots. Non-forested ground plots were examined to check the accuracy of the photo-interpretation and to estimate conservation measures needed and their costs.

COMPILATION OF DATA

Photo interpretation and field plot data were entered on punch cards by the Bank of Taiwan's Statistical Department. Tabulations were made from these punch cards to obtain the data set forth in this report.

ACCURACY OF DATA

Accuracy of the estimates is affected by two types of errors. One type of error involves human mistakes in measurement and judgment, and from limitations of method and equipment. Effects of this type of error—often referred to as reporting and estimating error—cannot be appraised mathematically, but constant attention was given to hold this type of error to a minimum by proper training and good supervision and by emphasis on careful work.

The second type of error is called sampling error which is subject to a mathematical evaluation of the probability of error. The sampling error comes from the use of sample to estimate the total. The size of sample is determined by the variability of the items sampled and the number of samples measured.

If no bias and no reporting errors are assumed, it is to be expected that the reported areas and volumes are within the indicated range two times in three and within the range of two sampling errors about 19 times in 20. Acreage and volume estimates of small numerical size can be expected to have larger sampling errors than estimates of large numerical size. Sampling errors for the principal items for Taiwan as a whole are given below as percentages of their respective totals:

Item	Percent
Forested land area	± 1.5
Total cubic volume	± 1.6

Area statistics by cover type, stand-size class, etc., reported in the tables herewith are subject to increasing sampling error as the class becomes finer and the area in a class smaller.

In general, the ranges in area sampling error shown below can be expected.

Class area in hectares	Approximate area sampling error in percentage
Less than 50,000	Variable, usually over 40
50,000 to 100,000	usually between 20-40
100,000 to 300,000	Usually between 10-20
More than 300,000	usually less than 10

DEFINITION OF TERMS

LAND

FORESTED LAND

Land that is at least 0.5 hectare in size and 36 meters wide with at least 10 percent of the area covered with tree crowns or commercial bamboo, or land that has at least 250 uniformly distributed trees of reproduction size per hectare. Open lands less than 0.5 hectare in size or less than 36 meters wide (except main roads and railroads) which are surrounded by forest are considered as forested land. Orchards, shade trees in cities or agricultural areas, and tree nurseries are not considered as forested land.

NONFORESTED LAND

Land that is at least 0.5 hectare in size and 36 meters wide with less than 10 percent of the area covered with tree crowns or commercial bamboo, or land that has less than 250 evenly distributed trees of reproduction size per hectare. Forests less than 0.5 hectare in size or less than 36 meters wide which are surrounded by nonforest are considered as nonforest land.

ACCESSIBLE FORESTED LAND

Forested land where logging and hauling could be done profitably at present with little additional investment in roads, railroads or logging and transportation equipment.

INACCESSIBLE FORESTED LAND

Forested land where logging and hauling could not be done profitably in the foreseeable future.

NON-OPERABLE FORESTED LAND

Forested land which is (1) incapable of yielding usable wood products because of poor site conditions, or (2) withdrawn from timber management due to excessive steepness of slope.

PROTECTION LAND

Land on which utilization of timber is usually prohibited or limited through existing statute, ordinance or administrative order for protection of soil and conservation of water.

UNRESERVED FOREST LAND

Forest land on which utilization of timber is not prohibited.

COMMERCIAL FORESTED LAND

Accessible unreserved forested land.

NATIONAL FOREST LAND

Nationally-owned land now under the jurisdiction of the Taiwan Forest Administration, including the National Taiwan University Experimental Forests, Taiwan Forest Research Institute Forest, Provincial College of Agriculture Experimental Forest, Taiwan Tea Corporation land now under the jurisdiction of Taiwan Forest Administration, and land formerly owned by private Japanese corporations.

OTHER LAND

Includes all lands not under the jurisdiction of the Taiwan Forest Administration. Included are private land and lands under the jurisdiction of county governments or Provincial agencies other than the Taiwan Forest Administration.

FOREST TYPE

Forest type is determined upon the basis of net cubic volume for tree stands with tree 10.0 cm. d.b.h. or larger. Other tree stands are classified on the basis of number of individual trees.

CONIFER TYPES

Forest stands with at least 75 percent of the net cubic live-tree volume (or number of trees) in conifers and not over 50 percent of the crown cover in commercial bamboo. The predominant conifer on the basis of net cubic volume (or number of trees) determines the type where conifer species are mixed.

Spruce-Fir

Conifer stands in which spruce (Picea morrisonicola) or fir (Abies kawakamii) is the predominant species on the basis of net cubic volume (or number of trees), singly or in combination.

Hemlock

Conifer stands in which hemlock (Tsuga chinensis) is the predominant species on the basis of net cubic volume (or number of trees).

Cypress

Conifer stands in which Taiwan cypress or Hinoki (Chamaecyparis taiwanensis) or Formosan cypress or Benihi (Chamaecyparis formosensis) is the predominant species, singly or in combination, on the basis of net cubic volume (or number of trees).

Pine

Conifer stands in which pine (Pinus sp.) is the predominant species on the basis of net cubic volume (or number of trees).

Other Conifer Type

Conifer stands in which coniferous species other than spruce, fir, hemlock, cypress or pine are the predominant species, singly or in combination, on the basis of net cubic volume. Such coniferous species include Libocedrus formosana, Taiwania cryptomerioides, Pseudotsuga wilsoniana, Cunninghamia konishii, Cunninghamia lanceolata, Cryptomeria japonica, Taxus chinensis, Podocarpus sp., and Juniperus sp.

CONIFER-HARDWOOD TYPE

Forested stands with more than 25 percent but less than 75 percent of the net cubic live-tree volume (or number of trees) in conifers, and not over 50 percent of the crown cover in commercial bamboo.

HARDWOOD TYPES

Forested stands with at least 75 percent of the net cubic live-tree volume (or number of trees) in hardwoods, and not over 50 percent of the crown cover in commercial bamboo. The natural hardwood stands are classified into three broad types depending upon the predominant species present, but changing in general with elevation and latitude.

Tropical Hardwoods

Natural hardwood stands usually below 300 meters of elevation in northern Taiwan or 600 meters in southern Taiwan in which some of the following species usually predominate:

1. Machilus kusanoi and zuihoensis
2. Liquidamber formosana
3. Mallotus sp.
4. Ficus sp.
5. Trema sp.
6. Schefflera octophylla
7. Sapindus mukorossi

Sub-tropical Hardwoods

Natural hardwood stands, usually on elevations between 300 and 1,500 meters in the north or between 600 and 2,000 meters in the south in which some of the following species usually predominate:

1. Machilus arisanensis
2. Engelhardtia formosana
3. Quercus gilva

4. Castanopsis longicaudata and C. stipitata
5. Shima sp.
6. Lithocarpus sp. except L. amygdalifolia

Temperate Hardwoods

Natural hardwood stands, usually above 1,500 meters in northern Taiwan or 2,000 meters in southern Taiwan in which some of the following species usually predominate:

1. Quercus morii
2. Trochodendron sp.
3. Illicium sp.
4. Actinodaphne sp.
5. Lithocarpus sp.

BAMBOO TYPE

Forest stands in which over 50 percent of the crown cover is made up of commercial bamboo. This includes Phyllostachys makinoi, Phyllostachys edulis, Dendrocalamus latiflorus, Bambusa stenostachya and other commercial bamboo species.

TREE CLASS

SOUND LIVE TREES

1. All live sawtimber-sized trees of commercial species with at least one 2-meter merchantable sawlog section, and at least 50 percent sound (30 percent in cypress) in the section extending from the stump to the point of minimum sawlog merchantability.

2. All live pole-sized or sapling-sized trees of commercial species that are of sufficiently good form and condition to indicate that they will eventually become sound sawtimber-sized trees.

3. All commercial bamboo.

SOUND DEAD CYPRESS

All dead sawtimber and pole-sized cypress (standing or down) with at least one 2-meter merchantable sawlog section, and at least 30 percent sound in the section extending from stump to point of minimum sawlog merchantability.

ROUGH CULL TREES

1. Live sawtimber-sized trees failing to meet the requirements for sound live trees; and with not over 50 percent of the gross volume to 8.0 cm. inside bark unsound due to rot.

2. Live pole-sized or sapling-sized trees which, mainly due to species, roughness, or shortness of bole due to poor site, are not expected to eventually become sound live sawtimber-sized trees.

ROTTEN CULL TREES

1. Live sawtimber-sized trees failing to meet the requirements for sound live trees; and with more than 50 per cent of the gross volume to 8.0 cm. inside bark unsound dut to rot.

2. Live pole-sized *or sapling-sized trees* which, mainly due to rot, are not expected to eventually become sound live sawtimer-sized trees.

DEAD TREES

All dead trees, sapling-sized or larger, of commercial species that died during the past year, and that were sound trees at the time of death.

SAWTIMBER-SIZED TREE

Trees at least 30.0 cm. d.b.h. (diameter at breast height or 1.37 meters above ground) outside bark. In the case of sound dead cypress trees for inventory measurements (not mortality), trees at least 30.0 cm. d.b.h. inside bark.

POLE-SIZED TREES

Trees at least 10.0 cm. d.b.h. but less than 30.0 cm. d.b.h.

SAPLINC-SIZED TREES

Trees at least 5.0 cm. d.b.h., but less than 10.0 cm. d.b.h.

SEEDLINGS

Trees at least 0.5 meters in height but less than 5.0 cm. d.b.h.

TIMBER VOLUME

GROWING STOCK

Net cubic volume of live sawtimber and live pole-timber trees from stump (0.3 m. above ground) to 8.0 cm. top diameter (of central stem) inside bark.

SAW-TIMBER VOLUME

Net cubic volume of sound sawtimber trees from stump height (0.3 m. above ground) to a minimum 8.0 centimeter top diameter (of central stem) inside bark.

Sawlog Portion

Net cubic volume of sound live saw-timber trees from stump height (0.3 m. above ground) to a minimum 20.0 centimeter top diameter (of central stem) inside bark.

Upper Stem Portion

Net cubic volume of the section in sound sawtimber trees between the top of the sawlog portion (20.0 cm. diameter inside bark) and the point on the main stem where the minimum diameter of 8.0 cm. inside bark is reached.

POLE-TIMBER VOLUME

Net cubic volume in sound live pole-timber trees from stump height (0.3 m. above ground) to a minimum 8.0 cm. top diameter (of central stem) inside bark.

LIMB VOLUME

Net cubic volume of all sound limbs in hardwood trees to the points where the minimum diameter of 8.0 cm. inside bark is reached.

GROWTH, MORTALITY AND CUT

TOTAL ANNUAL GROWTH

The increase in the cubic volume of growing stock during the current year.

MORTALITY, NORMAL ANNUAL

The net cubic volume of growing stock lost to the live-timber inventory during the current year through natural causes other than catastrophes such as large fires and insect or disease epidemics.

ANNUAL CUT

The net cubic volume of live sawtimber and poletimber trees cut or killed by logging, land clearing or cultural operations on commercial forest land during a specified year.

STAND-SIZE CLASS

SAW-TIMBER STANDS

Stands with a minimum net volume per hectare of 50 cubic meters and with at least half the volume in sawtimber trees.

POLE-TIMBER STANDS

Stands failing to meet the sawtimber stand specification, but at least 10 percent stocked with live pole-sized and larger trees, and with at least half the stocking in pole-sized trees.

SEEDLING-SAPLING STANDS

Stands not qualifying as either saw-timber or pole-timber stands, but having at least 10 percent stocking on trees and with at least half the stocking in seedlings and sapling-sized trees.

NONFORESTED LAND

LAND USE

The present use or cover types of nonforested land is classified as follows:

Use/cover	Description
Grassland	Tall or shoft grass excluding commercial bamboo groves.
Cultivated (cp) (Paddy)	Continuously cultivated land primarily managed for, or already having facilities capable of, paddy rice production,
Cultivated (Dry-farming)	All cultivated land other than Cp as described above, including all dry farming land under continuous, intermittent or shifting cultivation.
Farm woodland	Hedgerows, windbreaks and other wooded areas less than 0.5 hectare in size or less than 36 meters wide.
Urban or industrial	Urban or industrial areas including salt flats, villages, cemeteries, etc.
Water area	Water area including tidal flats, lakes, reservoirs, streams and rivers.
Denuded, Plantable	Bare lands such as sand dunes, denuded land and badly eroded land that are suitable for planting to trees.
Denuded, unplantable	Bare lands such as land slides, unstabilized alluvium and bare rocks that are not suitble for planting to trees.

PROBLEM AREA CLASS

Problem area classes were determined by the intensity of conservation problems confronting the use of nonforested land. They are based on such physical land conditions as slope, soil depth and texture, susceptibility to erosion and related data on these areas.

Problem Area Class I

Land with no appreciable conservation problem which can be continuously cultivated without any particular hazard to sustained productivity

Problem Area Class II

Lands with minor to moderate conservation problems which require moderate soil conservation practices to maintain the structure and productivity of the soil.

Problem Area Class III

Nonforest lands that are marginal. Continuous farming on these land will cause serious soil loss unless intensive treatment and conservation practices are followed. Proper future use and treatment must be based on physical and other related data for each individual case.

Problem Area Class IV

Lands in this class are not suitable for farming but should be kept under permanent vegetative cover for protection and production purposes. It includes lands with sufficient soil material for reforestation.

Problem Area Class V

Denuded lands which lack sufficient soil to support forest cover. Only by very expensive uneconomical measures can such lands be made productive.

TABLE 11 LAND AREA BY PRINCIPAL USE AND MAJOR FOREST TYPE

Land class	Area
	Thousand Hectares
Forested land	
Conifers	373.0
Conifer-hardwoods	55.3
Hardwoods	1,427.3
Bamboo	113.9
Total	1,969.5
Agricultural land	
Paddy	559.5
Dry-farming	445.0
Farm woodland	38.2
Total	1,042.8
Other land	
Grassland	305.1
Denuded, Plantable	20.1
Denuded, unplantable	117.4
Urban and industrial	74.1
Water area	47.0
Total	563.7
All lands	3,576.0

TABLE 12 FORESTED AND NONFORESTED LAND BY MAJOR OWNERSHIP

Ownership	Forested land	Nonforested	Total
		Thousand Hectares	
National forest			
Unreserved	1,114.7	229.2	1,343.9
Protection	295.2	72.6	367.8
Total	1,409.9	301.8	1,711.7
Other lands			
Unreserved	551.9	1,300.9	1,852.8
Protection	7.7	3.8	11.5
Total	559.6	1,304.7	1,864.3
All ownership	1,969.5	1,606.5	3,576.0

* Includes Aborigine Reservation and Marginal Forest Land.

TABLE 13 FORESTED LAND BY MAJOR FOREST TYPE

Forest type	Area
	Thousand Hectares
Conifers	
Spruce-fir	61.3
Hemlock	1.330
Cypress	43.0
Pine	70.2
Other conifers	65.5
Total	373.0
Conifer-hardwoods	55.3
Hardwoods	
Tropical hardwoods	612.8
Sub-tropical hardwoods	565.8
Temperate hardwoods	248.7
Total	1,427.3
Bamboo	113.9
All types	1,969.5

TABLE 14 FORESTED LAND BY MAJOR OWNERSHIP AND STAND-SIZE CLASS

Ownership	Saw-timber stands	Pole-timber stands	Seedling-sapling stands	Bamboo stands	Total
			Thousand Hectares		
National forest					
Unreserved	554	370	171	19	1,114
Protection	143	88	53	11	295
Total	697	458	224	30	1,409
Other lands					
Unreserved	93	163	213	83	552
Protection	—	2	5	1	8
Total	93	165	218	84	560
All ownership	790	623	442	114	1,969

TABLE 15 FORESTED LAND BY VOLUME CLASS AND ELEVATION

Volume class M^3 per ha.	Elevation in meter					Total
	0-599	600-1199	1200-1900	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

*Bamhoo included.

TABLE 16 FORESTED LAND BY COUNTY AND MAJOR FOREST TYPE

County	Forest type			Total
	Conifers	Conifer-hardwoods	Hardwoods & bamboo	
	Thousand Hectares			
Changhua	—	—	5.2	5.2
Chiayi	16.5	2.0	60.7	79.2
Hsinchu	10.6	3.1	80.1	93.8
Hualien	99.6	10.6	247.2	357.4
Ilan	19.1	2.5	118.1	139.7
Kaohsiung [1]	13.7	5.6	106.8	126.1
Miaoli	20.4	9.8	69.5	99.7
Nantou	120.3	9.1	139.7	269.1
Pingtung	1.7	4.3	153.7	159.7
Taichung [2]	33.6	0.3	71.5	105.4
Tainan [3]	2.7	0.3	71.6	74.6
Taipei [4]	10.6	0.9	133.2	144.7
Taitung	23.2	6.1	236.8	265.9
Taoyuan	1.0	0.7	33.4	35.3
Yunlin	—	—	13.7	13.7
Total	373.0	55.3	1,541.2	1,969.5

1 Includes Kaohsiung city.
2 Includes Taichung city.
3 Includes Tainan city.
4 Includes Taipei and Keelung city and Yangmingshan Administration.

TABLE 17 ACCESSIBILITY OF FORESTFD 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
Spruce-fir	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

TABLE 18 ACCESSIBILITY OF FORESTED LAND BY OWNERSHIP

Ownership	Operable			Non-operable	Total
	Accessible	Inaccessible	Sub-total		
	Thousand Hectares				
National forest					
Unreserved	632.8	421.3	1,054.1	60.6	1,114.7
Protection	153.7	126.2	279.9	15.3	295.2
Total	786.5	547.5	1,334.0	75.9	1,409.9
Other lands					
Unreserved	518.9	32.6	551.5	0.4	551.9
Protection	6.2	1.3	7.5	0.2	7.7
Total	525.1	33.9	559.0	0.6	559.6
All ownership	1,311.6	581.4	1,893.0	76.5	1,969.5

TABLE 19 ACCESSIBILITY OF FORESTED LAND BY STAND-SIZE CLASS

Stand-size class	Operable			Non-operable	Total
	Accessible	Inaccessible	Sub-total		
	Thousand Hectares				
Bamboo	106.9	6.3	113.2	0.7	113.9
Seedling-sapling	382.8	51.7	434.5	7.4	441.9
Pole-timber	430.3	159.6	589.9	33.5	623.4
Saw-timber	391.6	363.8	755.4	34.9	790.3
Total	1,311.6	581.4	1,893.0	76.5	1,969.5

TABLE 20 ACCESSIBILITY OF FORESTED LAND BY VOLUME CLASS

Volume class M^3 per ha.	Operable			Non-operable	Total
	Accessible	Inaccessible	Sub-total		
	Thousand Hectares				
00-49	814.0	173.4	987.4	31.4	1,018.8*
50-99	222.0	145.2	367.2	15.1	382.3
100-149	93.3	69.3	162.6	7.1	169.7
150-199	59.9	49.2	109.1	6.5	115.6
200-299	68.3	63.0	131.3	8.4	139.7
300-399	28.6	39.3	67.9	4.2	72.1
400-499	6.8	11.1	17.9	1.7	19.6
500-749	12.9	20.0	32.9	1.6	34.5
750+	5.8	10.9	16.7	0.5	17.2
Total	1,311.6	581.4	1,893.0	76.5	1,969.5

* Bamboo included.

TABLE 21 NONFORESTED LAND BY MAJOR OWNERSHIP AND USE

Ownership	Land use class						Total
	Cultivated*	Grassland	Urban and industrial	Denuded, plantable	Denuded, unplantable	Water area	
	Thousand Hectares						
National forest							
Unreserved	36.4	151.0	1.0	3.4	36.4	1.0	229.2
Protection	16.4	41.8	0.3	1.2	8.0	4.9	72.6
Total	52.8	192.8	1.3	4.6	44.4	5.9	301.8
Other lands							
Unreserved	989.0	110.6	72.4	15.5	72.3	41.1	1,300.9
Protection	1.0	1.7	0.4	—	0.7	—	3.8
Total	990.0	112.3	72.8	15.5	73.0	41.1	1,304.7
All ownership	1,042.8	305.1	74.1	20.1	117.4	47.0	1,606.5

* Includes farm woodlands.

TABLE 22 NONFORESTED LAND BY MAJOR OWNERSHIP AND PROBLEM AREA CLASS

Ownership	Problem area class*					Total
	I	II	III	IV	V	
			Thousand Hectares			
National forest						
Unreserved	—	18.7	15.4	160.0	35.1	229.2
Protection	—	—	5.0	57.4	10.2	72.6
Total	—	18.7	20.4	217.4	45.3	301.8
Other lands						
Unreserved	204.6	525.8	238.6	243.7	88.2	1,300.9
Protection	—	1.0	—	0.9	1.9	3.8
Total	204.6	526.8	238.6	244.6	90.1	1,304.7
All ownership	204.6	545.5	259.0	462.0	135.4	1,606.5

* See page 43 for description of problem area classes.

TABLE 23 NET VOLUME OF ALL TIMBER ON FORESTED LAND BY CLASS OF MATERIAL AND SPECIES GROUP

Class of material	Total	Conifers	Hardwoods
		Thousand Cubic Meters	
Growing stock			
Saw-timber trees			
Sawlog portion	140,093	85,916	54,177
Upper stem portion	8,956	3,300	5,656
Total	149,049	89,216	59,833
Pole-timber trees	35,369	5,656	29,713
Total	184,418	94,872	89,546
Other material			
Rough cull trees	23,302	3,020	20,282
Rotten cull trees	6,356	2,903	2,453
Hardwood limbs	11,280	—	11,280
Salvable dead trees	1,490	1,490	—
Total	42,428	7,413	35,015
Grand Total	226,846	102,285	124,561

* Sound dead cypress only.

TABLE 24 NET VOLUME OF SAW-TIMBER AND GROWING STOCK ON FORESTED LAND BY SPECIES OR SPECIES GROUP

Species or species group	Saw-timber	Growing stock
	Thousand Cubic Meters	
Conifers		
Cypress	27,985 [1]	28,691 [2]
Hemlock	29,245	31,804
Spruce and fir	18,368	19,793
Pine	12,062	12,485
Cryptomeria	72	379
Cunninghamia	685	805
Taiwania	357	362
Other conifers	1,788	2,044
Total	90,562	96,363
Hardwoods		
High value oaks [4]	1,637	1,728
Other oaks	13,086	17,682
Zelkova formosana	157	157
Camphor (Cinnamomum sp.)	528	529
Michelia	573	742
Machilus sp.	19,961	26,616
Acacia	—[3]	1,773
Other hardwoods	23,890	40,317
Total	59,832	89,544
All species	150,394	185,907

1 Includes 1,346,000 cubic meters of sound dead cypress.
2 Includes 1,490.000 cubic meters of sound dead cypress.
3 Negligible
4 Quercus gilva, Castanopsis longicaudata and Castanopsis stipitata.

TABLE 25 NET VOLUME OF SAW-TIMBER ON FORESTED LAND BY DIAMETER CLASS GROUP AND SPECIES OR SPECIES GROUP

Species or species group	Diameter class group (Centimeter)								Total
	30	40	50	60	70	80	90	100	
	Thousand Cubic Meters								
Conifers									
Cypress	599	486	754	355	1,182	860	725	23,044	27,985[1]
Hemlock	2,010	2,080	3,153	3,340	3,111	2,320	2,160	11,071	29,245
Spruce and fir	1,256	2,419	2,430	1,696	2,351	2,312	1,811	4,093	18,368
Pine	1,381	1,388	2,278	2,513	612	1,747	981	1,362	12,062
Other conifers	60	730	109	35	385	51	725	807	2,902
Total	5,306	7,103	8,724	7,719	7,641	7,290	6,402	40,377	90,562
Hardwoods									
High value oaks[2]	95	108	241	178	112	267	264	372	1,637
Other oaks[3]	2,744	2,198	1,968	1,796	1,117	1,470	439	1,354	13,086
Machilus sp.	4,279	5,120	3,160	2,813	2,365	866	875	483	19,961
Other commercial hardwoods	5,809	4,675	5,306	3,142	2,431	1,014	786	1,985	25,148
Total	12,927	12,101	10,675	7,929	6,025	3,617	2,364	4,194	59,832
All species	18,233	19,204	19,399	15,648	13,666	10,907	8,766	44,571	150,394

1 Includes 1,346,000 cubic meters of sound dead cypress.

2 Quercus gilva, Castanopsis longicaudata and Castanopsis stipitata.

3 Includes Zelkova formosana.

TABLE 26 NET VOLUME OF SAW-TIMBER AND GROWING STOCK ON FORESTED LAND BY STAND-SIZE CLASS

Stand-size class	Saw-timber	Growing stock
	Thousand Cubic Meters	
Saw-timber stands		
Conifers	87,887[1]	93,014
Hardwoods	48,802	66,068
Total	136,689	159,082
Pole-timber stands		
Conifers	2,676	3,349
Hardwoods	11,005	22,416
Total	13,681	25,765
Seedling-sapling stands		
Conifers	—	—
Hardwoods	24	1,060
Total	24	1,060
All stands		
Conifers	90,562*	96,363
Hardwoods	59,832	89,544
Total	150,394	185,907

* Includes 1,346,000 cubic meters of dead cypress.

TABLE 27 NET VOLUME OF SAW-TIMBER AND GROWING STOCK ON FORESTED LAND BY MAJOR OWNERSHIP AND STAND-SIZE CLASS

Ownership	Total		Saw-timber stands		Pole-timber stands		Seedling-sapling stands		Bamboo stands		Bamboo
	Saw-[1] timber	Growing[2] stock	Saw-timber	Growing stock	Saw-timber	Growing stock	Saw-timber	Growing stock	Saw-timber	Growing stock	(1000 pcs.)
	Thousand Cubic Meters										
National forest											
Unreserved	103,999	127,124	95,878	111,586	8,117	15,268	—	130	4	122	77,273
Protection	26,695	32,573	24,749	28,803	1,944	3,662	—	40	2	68	43,226
Total	130,694	159,697	120,627	140,389	10,061	18,948	—	170	6	190	120,499
Other lands											
Unreserved	19,662	26,130	16,062	18,693	3,582	6,747	—	161	18	529	334,556
Protection	38	80	—	—	38	70	—	4	—	6	3,970
Total	19,700	26,210	16,062	18,693	3,620	6,817	—	165	18	535	338,526
All ownership	150,394	185,907	136,689	159,082	13,681	25,765	—	335	24	725	459,025

1 Includes 1,346,000 cubic meters of sound dead cypress.

2 Includes 1,490,000 cubic meters of sound dead cypress.

TABLE 28 ACCESSIBILITY OF SAW-TIMBER VOLUME ON FORESTED LAND BY STAND-SIZE CLASS

Stand-size class	Operable			Non-operable	Total
	Accessible	Inaccessible	Sub-total		
	Thousand Cubic Meters				
Bamboo	23	1	24	—	24
Seedling-sapling	—	—	—	—	—
Pole-timber	9,442	3,577	13,019	662	13,681
Saw-timber	67,725	63,529	131,254	5,435	136,689
Total	77,190	67,107	144,297	6,097	150,394*

* Includes 1,346,000 cubic meters of sound dead cypress.

TABLE 29 ACCESSIBILITY OF GROWING STOCK VOLUME ON FORESTED LAND BY STAND-SIZE CLASS

Stand-size class	Operable			Non-operable	Total
	Accessible	Inaccessible	Sub-total		
	Thousand Cubic Meters				
Bamboo	681	40	721	4	725
Seedling-sapling	290	40	330	5	335
Pole-timber	17,784	6,735	24,519	1,246	25,765
Saw-timber	78,820	73,937	152,757	6,325	159,082
Total	97,575	80,752	178,327	7,580	185,907*

* Includes 1,490,000 cubic meters of sound dead cypress.

TABLE 30 ANNUAL GROWTH, ANNUAL MORTALITY AND ANNUAL CUT OF SAW-TIMBER ON FORESTED LAND

Item	Saw-timber		
	Conifers	Hardwoods	Total
	Thousand Cubic Meters		
Annual growth	595	1,320	1,915
Annual mortality	1,323	583	1,906
Net annual growth	-728	737	9
Annual cut			520
Annual change			-511

* Cypress species not included

TABLE 31 ANNUAL GROWTH, ANNUAL MORTALITY AND ANNUAL CUT OF POLE-TIMBER ON FORESTED LAND

Item	Pole-timber		
	Conifers	Hardwoods	Total
		Thousand Cubic Meters	
Annual growth	371	2,146	2,517
Annual mortality	132	21	153
Net annual growth	239	2,125	2,364
Annual cut			769
Annual change			1,595[1]

* Including sapling ingrowth

TABLE 32 ANNUAL GROWTH, ANNUAL MORTALITY AND ANNUAL CUT OF GROWING STOCK ON FORESTED LAND

Item	Growing stock		
	Conifers	Hardwoods	Total
		Thousand Cubic Meters	
Annual growth	802	2,724	3,526
Sapling ingrowth	164	742	906
Total annual growth	966	3,466	4,432
Annual mortality	1,455	604	2,059
Net annual growth	-489	2,862	2,373
Annual cut	626	663	1,289
Annual change	-1,115	+2,199	+1,084

* Cypress not included

TABLE 33 NET ANNUAL GROWTH AND ANNUAL CUT OF GROWING STOCK ON ACCESSIBLE FORESTED LAND

Item	Accessible forested land		
	Conifers	Hardwoods	Total
	Thousand Cubic Meters		
Net annnal growth			
Pole-timber	205	800	1,005
Saw-timber	-201	625	424
Total	4	1,425	1,429
Annual cut	626	649	1,275
Annual change	-622	776	154

TABLE 34 NET ANNUAL GROWTH AND ANNUAL CUT OF GROWING STOCK ON COMMERCIAL FORESTED LAND

Item	Commercial forested land		
	Conifers	Hardwoods	Total
	Thousand Cubic Meters		
Net annual growth			
Pole-timber	176	683	859
Saw-timber	-178	524	346
Total	- 2	1,207	1,205
Annual cut	626	649	1,275
Annual change	-628	558	-70