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forestry in china

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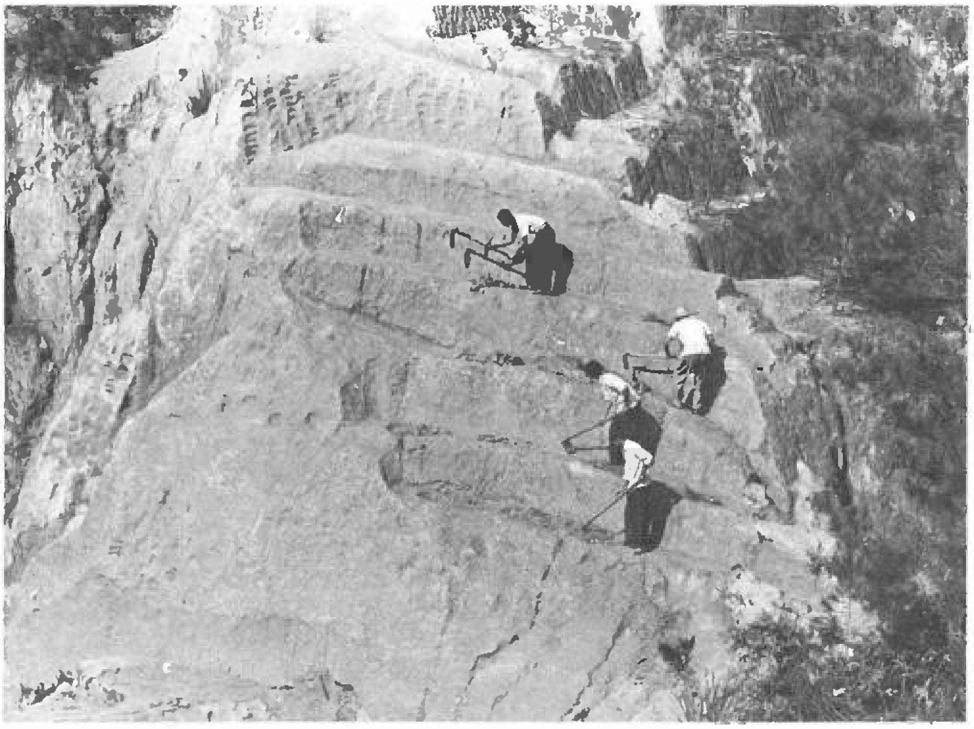
ACKNOWLEDGEMENTS

This study was commissioned by the Forestry Department of the Food and Agriculture Organization of the United Nations (FAO) with a view to amalgamate and update in a summarized form published and unpublished information obtained during FAO forestry missions and study tours to the People's Republic of China held from 1976 to 1980. In order to increase the study's coverage and thus the interest it may present, this information was completed by data from other sources, including in particular that obtained during numerous trips to China by members of the College of Forestry, Wildlife and Range Sciences of the University of Idaho at Moscow, Idaho (USA). The study is a joint effort of the principal author, Dr. John H. Ehrenreich, Dean of the College; Dr. Chi Wu Wang, Professor Emeritus; Dr. George Savage, College Managing Editor; Dr. Ernest Ables, Associate Dean; Dr. William McLaughlin, Associate Professor; Marilyn Sargent, and Albert Merkel, both Assistants to the Dean for International Programs. Information was also obtained from twelve other faculty members who made trips to China during the last three years. Most gratefully acknowledged is the information obtained from the Ministry of Forestry of the People's Republic of China and especially former Minister's Mr. Luo Yu-chan and Mr. Yong Wen-tao. Mr. P.R. Thomforde, a former staff member of FAO's Development Department, assisted generously with provision of information for the study.

While the scope of the study prevents it from going into great detail, especially when not dealing directly with forestry matters, it is hoped that the bibliography will facilitate further studies. It is realized that some aspects, in particular the "People's Communes System" and "Communication and Mass Mobilization," have a profound impact on forestry in the People's Republic of China.

Casuarina trees stabilize irrigation canal banks in southern China

Aerial view of the Yellow River valley. Trees are planted along the banks of irrigation canals to control erosion



Soil conservation and reforestation in Guangdong province.
These eroded slopes are being planted with pinus elliotti (right)

Erosion control. Making a check dam in Guangdong
province to arrest silt

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TABLE OF CONVERSION FACTORS
(Approximations)

Currency

1.00 yuan	= 0.60 US$ (1978)*
1.00 US$	= 1.66 yuan (1978)*

Temperature

°Fahrenheit	= 9/5 (°Celsius +32)
°Celsius	= 5/9 (°Fahrenheit -32)

Weight

1 kilogram	= 2.20 pounds
1 pound	= 0.45 kilograms
1 jin	= 0.50 kilograms
1 metric ton	= 2200 pounds
1 short ton (2000 pounds)	= 0.91 metric tons

Length

1 meter	= 3.28 feet
1 kilometer	= 0.62 miles
1 mile	= 1.61 kilometers

Area

1 mu	= 0.066 hectares
1 hectare	= 15.15 mu
1 rai	= 0.16 hectares
1 hectare	= 6.25 rai
1 square kilometer	= 100 hectares
1 square kilometer	= 0.386 square miles
1 square mile	= 2.59 square kilometers
1 hectare	= 0.004 square miles
1 square mile	= 259 hectares
1 hectare	= 2.47 acres
1 acre	= 0.40 hectares
1 square mile	= 640 acres

Volume

1 cubic foot	= 0.028 cubic meters
1 cubic meter	= 35.71 cubic feet
1 cubic yard	= 0.765 cubic meters
1 cubic meter	= 1.31 cubic yards

* 1978 currency exchange rates most accurately reflect the figures used throughout the text.

Chapter 1

BACKGROUND TO FORESTRY DEVELOPMENT

1.1 INTRODUCTION

The People's Republic of China, the world's third largest country, is home to 20 percent of the world's population. A population of 1000 million makes tremendous demands on the 122 million hectares (ha) of forests providing China lumber, fuel, rosins and dyes, medicines, paper, and a myriad of other forest products. Virtually all these products must be supplied from domestic raw materials; the balance of payments requirements set by the government allow few funds for purchasing forest products imports.

China's forests have undergone many changes throughout the country's long history. Harvesting, overgrazing and shifting cultivation have denuded vast areas where abundant forests once stood. However, in recent years, the potential yield of the forests has been fundamentally improved through the development of a multitude of new discoveries and techniques, coupled with the remarkable ability demonstrated by the Chinese government to educate and mobilize hundreds of millions of people to understand and participate in forestry activities.

The Cultural Revolution (1966 to 1976) severely impeded the momentum forestry programs had attained. Forestry education and research facilities were closed and faculty and researchers were assigned to other activities.

Now, the Chinese are energetically trying to restore the momentum of their forestry programs. They are participating in a number of cooperative educational and research programs. Vast reforestation efforts are underway. The national goal is to increase the combined forested areas, currently at 12.7 percent of the total land area, to 20 percent by the year 2000. Table 1-1 compares forest land area with other land use areas.

Table 1-1. China's land use (1978).

Category	Percent of the total area		Area ($x10^6$ ha)	
Arable land	10.5		100.0	
Irrigated land		4.9		46.8
Forest land	12.7		121.4	
Grassland	40.0		382.4	
Pastureland		23.0		220.0
Degenerated pastureland		4.8		46.0
Inland waters	1.7		16.7	
Lakes		0.7		6.3
Reservoirs		0.2		2.0
Reclaimable wasteland	3.5		33.0	
Barren land (mountains, deserts)	31.6		302.6	
TOTAL	100.0		956.1	

Sources: various 1979 Xinhua releases in Chinese and English.
Table from Smil (1981).

1.2 LAND AREA AND PHYSIOGRAPHY

As the second largest country in Asia, the People's Republic of China covers an area of 9,560,990 square kilometers (956,100,000 hectares). The country extends approximately 5000 kilometers (km) from east to west and 5500 km from north to south. It has the world's longest land boundary, with 28,072 km of borders shared with twelve countries and the cities of Macao and Hong Kong. In addition, China has over 5000 islands lying off the coast in the Yellow Sea, East China Sea and South China Sea (Figs. 1-1, 1-2).

China is a mountainous country. Most of the land consists of hills, mountains, plateaus, and desert basins (Table 1-2), (Fig. 1-5).

Table 1-2. Topographic features of China by percentage of total land area.

Mountains	33 %
Plateaus	26 %
Hilly Lands	10 %
Plains	12 %
Basins	19 %

1.2.1 Western China

(i) Two Regions

Western China can be divided into two distinctive regions - the Xizang-Qinghai (Tibet-Chinghai) Plateau in the south and the Xinjiang (Sinkiang)-Mongolia region in the north. The Xizang-Qinghai (Tibet-Chinghai) Plateau lies at an average elevation of 5000 meters (m) and is often called the "roof of the world." The Xinjiang (Sinkiang)-Mongolia region contains desolate mountains and two vast desert regions - the Taklimakan Desert in Xinjiang Autonomous Region and the great Gobi Desert in the central Inner Mongolia Autonomous Region. In all, Western China represents more than half of the total land area, but it contains less then 10 percent of the total population.

(ii) Mountains

Four major mountain ranges--the Himalayan, Kunlun, Tien Shan and Altai--extend throughout western China and form the watersheds for all of the principal rivers in the country.

Mount Everest, the highest elevation on earth at 8848 m, lies on the central range of the Himalayan mountain system on the border with Nepal. This system consists of three parallel ranges no more than 480 km wide. Perpetual snow and glaciers lie throughout the system.

Lying between Xizang (Tibet) and Xinjiang (Sinkiang) Autonomous Regions are the Kunlun Mountains. These mountains extend eastward and branch into three separate chains. The southernmost range, known as the Hengduan (Thanglha Ri), meets the Himalayas in northwestern Yunnan and western Sichuan (Szechuan) provinces and forms the watershed of the Chang (Yangtze) River. This area yields a substantial portion of timber. The central chain, known as Qin Ling, forms the watershed between the Chang (Yangtze) and the Huang (Yellow) Rivers; and the northern chain, known as the Altun and Qilian Shan, form the divide for the Huang (Yellow) River watershed.

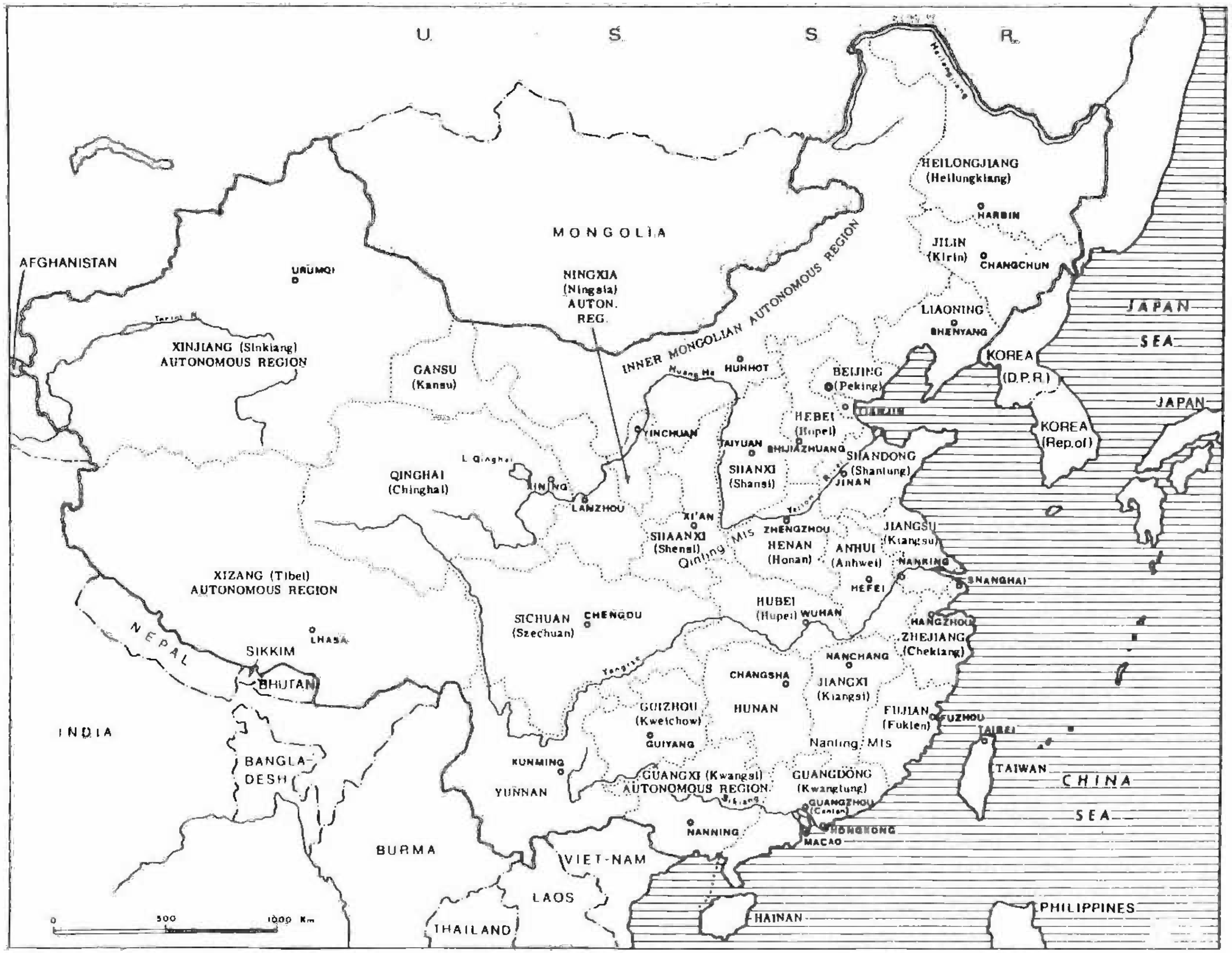


Figure 1-1. The People's Republic of China: Major Administrative subdivisions and capitals.

Figure 1-2. The People's Republic of China: Major topographical features.

The Tien Shan mountain system extends from west to east in a series of parallel ranges in central Xinjiang (Sinkiang) Province. The base of this system is approximately 1200 m, reaching an average height of 3600 m. Like the Himalayas, these mountains also have glaciers and areas of permanent snow. In contrast, the Turpan (Turfan) Basin in this same province lies 154 m below sea level.

Lying at an average height of 1800 m along the northwestern border with the USSR and Mongolia are the Altai Mountains. Named after the Mongolian word for gold, which has been found in these mountains, the area provides the basis for lumbering, mining and agriculture.

1.2.2 Eastern China

(i) Two Regions

Eastern China is made up of two areas known as Northeastern China and China Proper. China Proper includes the area of the country south of the Great Wall that stretches for 2400 km from the Gulf of Bo Hai (Chihli) to Gansu (Kansu) and Qinghai (Chinghai) provinces. More than 90 percent of the population is concentrated in these two segments and two-thirds of these are compressed into a restricted area of alluvial plains, which added together comprise only one-sixth of the land area of mainland China. These plains are characterized by fertile river valleys interrupted by low mountain ranges. Particularly large fertile plains lie in the coastal delta areas of the Liao, Huang (Yellow), Chang (Yangtze) and Sikiang (Pearl) rivers. Between these delta areas lie masses of hills and uplands, such as the Jilin (Kirin) hills, the uplands of the Liaoning (Liaotung) and Shandong (Shantung) peninsulas, the southeastern coastal hill land, and the hills of Guangdong-Guangxi (Kwangtung-Kwangsi) along the Sikiang River valley.

In the southwest the Yunnan-Guizhou (Yunnan-Kweichow) Plateau is dissected by a number of foundered lake basins and a series of parallel longitudinal river valleys and mountain ranges. This limestone area lacks a developed surface water supply and is deficient in good soils. It abounds with caves, sinkholes, and underground watercourses. There are also isolated stone pinnacles and steep hills.

(ii) Mountains

Two mountain systems unrelated to those in the West are jointly known as the Sinic Mountains. In the southeast, the Dongnan Qinling (Nan Ling) Mountains lie close to the Pacific coast. In the northeast the Da Hinggan Ling Mountains extend north and south near the border with Mongolia. The Sinic Mountains are heavily forested, especially in northernmost Heilongjiang (Heilungkiang) Province, and in the southern coastal Fujian (Fukien) Province.

(iii) Valley Plains

Lying between the mountains in northeastern China are valley plains, such as the Dongbei Pingyuan valley and the plain between T'ai Shan (1413 m) and Lao Shan (1035 m) in the peninsula of Shandong (Shantung).

1.2.3 Rivers

China's approximately 160,000 km of navigable rivers and inland waters are important to the overall transportation infrastructure. Two of the greatest rivers, the Huang (Yellow) and the Chang (Yangtze), originate only 80 km apart in southern Qinghai (Chinghai) Province (Fig. 1-2).

(i) The Huang (Yellow) River

The Huang (Yellow) River, the second largest in the country, is 4800 km long and drains an area of 1,554,000 square km. The course of the river can be divided into upper, middle, and lower sections. The upper section is full of rapids, and upstream navigation is practically impossible. The river's importance at this section lies in irrigation by means of big waterwheels. The middle section of the river is navigable for more than 650 km, and irrigation has been developed quite extensively in some parts. Its lower part is not navigable between Gansu (Kansu) and Shanxi (Shansi) provinces, as it flows through a rift valley with many gorges, rapids, and waterfalls.

(ii) The Chang (Yangtze) River

Sixty percent of China Proper is drained by the Chang (Yangtze) and its numerous tributaries. The Chang (Yangtze), by far the largest river, is 5209 km long and drains an area of over 1,813,000 square km. The Chang (Yangtze) can also be divided into three parts: torrential, seminavigable, and navigable. The middle course is seminavigable for 1500 km, but navigation is limited to specially made river steamers. The lower course, covering a distance of 1700 km, is navigable for both coastal and oceangoing vessels. It flows through a series of low, flat lake basins and marshes, which act as reservoirs in time of flood. Close to its mouth, the Chang (Yangtze) is divided into two channels by Ch'ung-ming Island. The southern channel has a deeper entrance and is closer to Shanghai, the leading port of China, from which oceangoing vessels can sail 1000 km inland.

(iii) Other Important Rivers

Other important rivers include the Huai, Min and Sikiang (Pearl) rivers. The Huai river is the largest river between the Chang (Yangtze) and Huang (Yellow) rivers and the only long river without a natural outlet; the Min river is navigable throughout most of its course. The Sikiang (Pearl) River, the chief river in Guangdong (Kwangtung), is China's fourth largest river. Forest products have historically been transported on these rivers.

1.3 SOILS

The soils can be classified into three main groups: the sweet soil of the north, the acid soil of the south; and the neutral, only slightly acid soil of central China. For a more specific identification of soil groups and group areas, see Figure 1-3.

The northern region has unleached or slightly leached soils rich in minerals but with little organic matter. The loess plateau in the western part of northern China consists of a vast area of eroded mountains and hills partially covered by extensive and deep, fertile, wind-laid silt created over many centuries by erosion. The tributary rivers of the Huang (Yellow) River flow across the loess plateau, contributing yellowish, muddy sediments and thus giving the river its name. The wind shifts silts from the loess plateau to the North China Plain.

Whereas climate and elevation are the major determinants of natural forest distribution in the arid West and the North; in southern and eastern China, the soil type becomes the major determinant. Since the soils in these areas are subject to leaching because of the hilly terrain and abundant rainfall, they are generally quite poor.

The most fertile areas containing a fair percentage of calcium and other soluble minerals are found on the plains along the rivers. For the most part, the productivity of the land depends more upon the climate than on the fertility of the soil. Deforestation has also caused acute soil-erosion problems. Because of the loss

Figure 1-3. The People's Republic of China: Soils (Chinese Geologic Survey). Key: 1 - Podzolic soil; 2 - Chernozem; 3 - Chestnut soil, brown soil; 4 - Sierozem and desert soil; 5 - Siero-korichnevyi soil; 6 - Korichnevyi soil and brown earth; 7 - Yellow-korichnevyi soil; 8 - Red and yellow earth; 9 - Red earth; 10 - Mountain steppe soil, mountain dark-korichnevyi soil; 11 - Mountain brown earth, mountain korichnevyi soil; 12 - Mountain yellow earth, mountain gray-brown earth; 13 - Mountain red earth, mountain podzolic soil; 14 - Mountain meadow soil, mountain steppe soil.

of surface soils, those areas which would normally be considered natural areas for forestry have a high proportion of exposed bedrock.

1.4 CLIMATE

Mainland China lies almost entirely in the temperate zone, chiefly between the tropic of Cancer and latitude 45° N, with portions of the three southernmost provinces within the tropics. Monsoonal climate is a major influence, with summers hot and humid throughout much of the country, and winters dry and unusually cool or cold for any given latitude. The concentration of rain in the summer months frequently results in torrential downpours and floods.

With great altitudinal and longitudinal range, the country has great climatic contrasts, especially in regard to length and severity of the cold season and in regard to the amount and distribution of rainfall (Figs. 1-4, 1-5). The north is much colder than the south in winter, has long, dry winters, and much of its rainfall is received in a short span in summer, with winter precipitation in the form of snow. The northwest experiences great seasonal extremes of hot and cold, and there is little rainfall and some desert. In the lower Chang (Yangtze) Valley, winters may have snow but are shorter and milder than in the north. There is more rainfall, and it is more evenly distributed. In the tropical and subtropical coastal area, annual rainfall is high; the winters are relatively warm but dry. Yunnan and part of Sichuan (Szechuan) province have distinctive climates. Yunnan, though partly in the tropics, has a temperate climate on its plateau, and the Red Basin of Sichuan (Szechuan) Province, being protected by mountains on the north, has a moist, warm climate throughout the year.

In winter, temperatures decrease rapidly from south to north. Average temperatures decline from 16°C, south of the Dongnan Qinling (Nan Ling) Mountains, to about 4°C, along the middle and lower Chang (Yangtze) Valley; and about -1°C, in southern Heilongjiang (Heilungkiang) Province, to -8°C, in northern Heilongjiang (Heilungkiang) Province. In summer the temperature is more uniform throughout the country, with a July mean of 27°C, but northern mainland China has much cooler nights and a shorter hot period than the southern regions.

Most rainfall occurs in summer, when the hot, moist air blows gently from the ocean toward the warm interior. Because of the topographical configuration, the amount of precipitation decreases from the south to the north, with an annual average of 1500 to 2000 millimeters (mm) in the Hsi River valley and the hilly land along the southeastern coast, 1000 to 1500 mm in the Chang (Yangtze) Valley, and about 600 mm over the North China Plain. Southeastern Heilongjiang (Heilungkiang) Province has about 750 mm of rain (see Fig. 1-4). Precipitation drops sharply northwestward to less than 250 mm in the interior. The late summer rain along the southeastern coast of the country is caused mostly by typhoon influence. Typhoons are also responsible for some cooling and provide a temporary relief from the prolonged summer heat, but they damage the forest.

1.5 POPULATION

1.5.1 Numbers and Growth Rates

Although demographers have argued for years about the size of China's population, in general it can be said that 20 percent of the world's population lives in China.

Chinese sources, who often refer to population in round numbers, have indicated a population of 1000 million at the end of the seventies, with an annual growth rate of 1.2 percent. The World Bank estimated the average population growth in China during the seventies at 1.9 percent, and the U.S. Bureau of the Census projected a population estimate of 1,041,532,000 in July of 1981, with an annual growth rate of 1.6

Figure 1-4. The People's Republic of China: Precipitation.

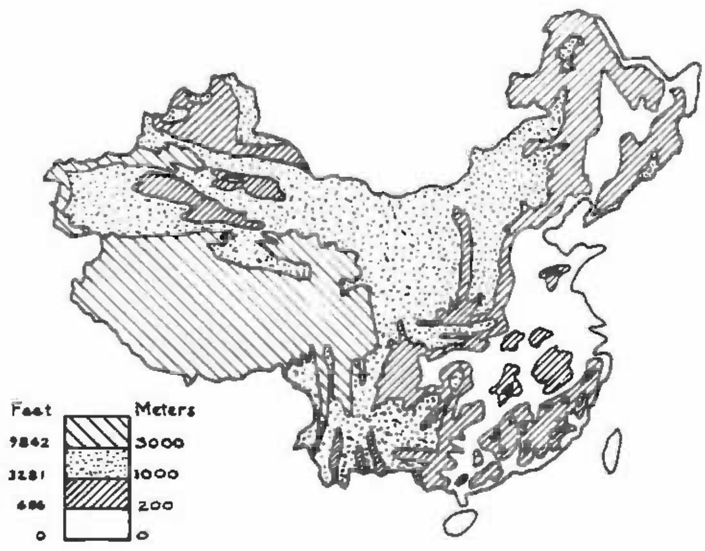


Figure 1-5. The People's Republic of China: Elevations.

percent. These figures may be more enlightening when stated as sheer numbers; in which case, the Chinese population is growing at an annual rate of approximately 12 to nearly 20 million inhabitants.

Even with the goal of zero population growth by the year 2000, the Chinese population is still projected to reach 1.239 billion (1239 million) by the beginning of the 21st century.

1.5.2 Population Control

The first official census was conducted in China in 1953. Chinese officials were somewhat surprised when the census showed a mainland population of 583 million, yet they were proud of their large source of national strength. In 1956 the government became actively involved in family planning efforts. Government support vacillated during the political upheavals that occurred over the ensuing decade. As a result, the annual growth rate peaked at 2.8 percent in 1968. Alarmed at knowing additional resources would have to be located and exploited to support the ever-increasing population, the government decided to reassert its population control efforts.

Today, the government encourages late marriage and a three-year lag between marriage and the birth of the first child. Couples pledging to have only one child receive a number of benefits, such as priorities to housing, education and employment, financial allowances, and additional retirement support. Those who have more than two children may lose parts of their annual wages and retirement benefits. If they hold a government post, they are subject to dismissal.

Free contraceptives, sterilization and abortions are widely available, and research is continuing on a once-a-month pill and also on male contraceptives. Population control efforts have met with considerable success in the urban areas. Programs in the rural areas have been hampered by the traditional belief that many children ensure a means of support for the parents when they grow old.

1.5.3 Age Distribution

Improved living conditions in China have resulted in longer life spans. According to the Chinese Public Health Ministry, in 1981 the average life span for males was 67 years and for females, 70 years. The age distribution has shifted slightly between 1953 and 1978 (Table 1-3).

Table 1-3. Age distribution in China (in %).

Age Range	1953 Census	1978 Estimates[a]
under 5 years	15.6	13.4
between 5 - 15	20.3	24.8
between 15 - 25	17.3	19.9
between 25 - 35	14.6	14.3
between 35 - 45	12.0	10.3
over 45 years	20.2	17.4
Total	100.0	100.1[b]

a) These estimates were prepared in March 1978 by U.S. Department of Commerce, Bureau of the Census, Foreign Demographic Analysis Division.

b) Error in total due to rounding.

1.5.4 Population Density and Distribution

The population density for the People's Republic of China as a whole is 109/sq km. This average figure may be misleading, since 90 percent of the population lives in Northeast China and China Proper on one-sixth of the total land area. The population in these areas is clustered along the coast and in the fertile river valleys. Large portions of western and northern China are uninhabited or only sparsely inhabited (Fig. 1-6).

Almost all of the major cities are located in eastern China. The capital, Beijing (Peking), has a population of almost 5 million. In all, however, only 13 percent of the population are urban residents. Chinese cities have not experienced the same growth that many other large cities around the world have. This is due in part to incentives to settle the countryside, attachments to homelands, and government relocation efforts. In fact, during the period 1959-69, the urban sector's growth rate actually decreased at a rate of 1 to 2%/year.

1.5.5 Basic Quality-of-Life Indicators

The People's Republic of China has a very impressive record in the area of quality of life when compared to other developing countries. The following table best compares several of the basic "quality of life" indicators (Table 1-4).

Table 1-4. Basic indicators.

Country and country group	GNP per person (dollars)	Annual population growth rule (percentage)	Adult literacy (percentage)	Net primary school enrollment (percentage)	Life expectancy at birth (years)	
	1979	1970-79	1976	1975 or 1977	1950[a]	1979
China	260	1.9	66[b]	93[b]	[36]	64
Low-income countries	210	2.3	39	56	[37]	51
Middle-income countries	1,420	2.4	72	71	[48]	61
Industrial countries	9,440	0.7	99	94	67	74

[a] Most 1950 data are estimated.
[b] 1979.
Source: World Bank 1981.

1.6 GENERAL ADMINISTRATION

1.6.1 Modern History

To understand more fully the organization of the Chinese government, it is important to look first at some recent events that have helped shape the present structure.

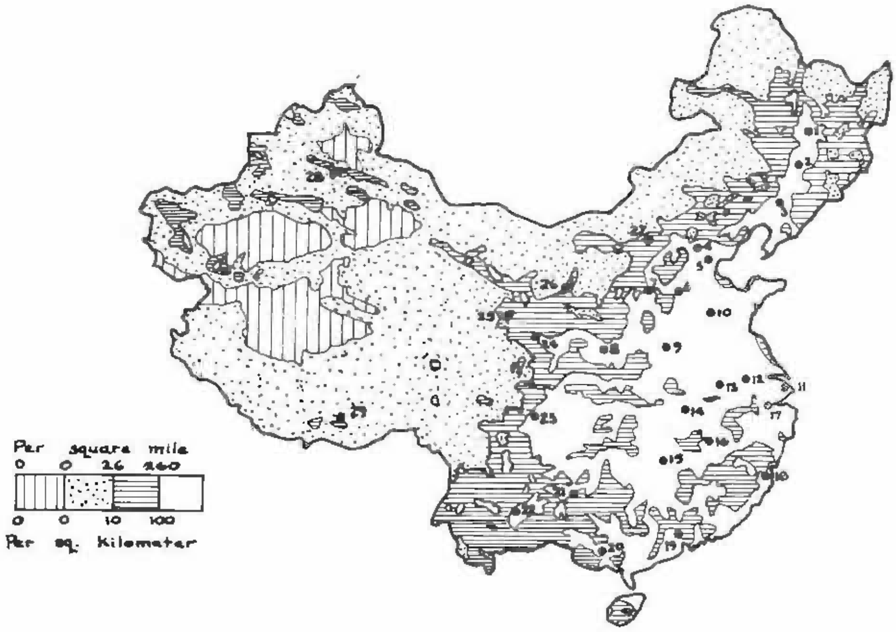


Figure 1-6. The People's Republic of China: Population distribution with major cities.

Key:

1.	Harbin	11.	Shanghai	21.	Guiyang
2.	Changchun	12.	Nanjing (Nanking)	22.	Kunming
3.	Shenyang	13.	Hefei	23.	Chengdu
4.	Beijing (Peking)	14.	Wuhan	24.	Lanzhou
5.	Tianjin	15.	Changsha	25.	Xining
6.	Shijiazhuang	16.	Nanchang	26.	Yinchuan
7.	Taiyuan	17.	Hangzhou	27.	Huhhot
8.	Xian	18.	Fuzhou	28.	Urumqi
9.	Zhengzhou	19.	Guangzhou (Canton)	29.	Lhasa
10.	Jinan	20.	Nanning		

1921 - The Chinese Communist Party (CCP) was officially founded.

October 1, 1949 - After almost 40 years of civil wars, the Communists established military control and Mao Tse-tung proclaimed the birth of the new People's Republic of China. The leadership set about to accomplish a number of tasks, including: dismantling the old bureaucracy and building the new structure, formulating a strategy of economic development, and transforming the society's values and institutions. In addition, a campaign continued to redistribute the land by eliminating all land deeds.

1953 - The First Five-Year Plan was instituted, allocating the major portion of investment to industry--particularly heavy industry--at the expense of other sectors of the economy.

1956-1967 - The First Twelve-Year Plan for agriculture was established, with forestry development included as an important component of the plan.

February 1957-1965 - As industrialization efforts became increasingly anemic, Mao made his famous "Hundred Flowers" speech in which he said, "Let a hundred sch ls of thought contend." As a result of his speech, three things occurred: (1) the investment in heavy industry was reduced; (2) economic control was decentralized; and (3) formation of communes began.

1958-1965 - As a result of disenchantment with the pace of national development and the feeling that agriculture did not have to be subservient to industry (that China could "walk on two legs"), Mao promoted the "Great Leap Forward." This movement resulted in feverish activity in all sectors of the economy; however, much of this energy was deployed wastefully, and it resulted in a decline in output and increase in shortages. In addition to these failures, a drought lasting from 1959-61 seriously hampered China's ability to feed its people. As a result, agriculture was given the highest priority in the economy.

1960 - Soviet advisors and technicians withdrew from the country. Year-to-year planning was instituted, and both agriculture and industry regained momentum, partly as a result of the introduction of industrial technology into the rural areas.

1965 - The depression following the "Great Leap" and the long droughts caused great concern for China's leaders. The movement of the "Great Leap Forward" was ended as the policy on economic development and the nation's leaders searched for ways to reinvigorate the economy of the nation.

1966-1976 - In an effort to reinstitute fundamental political principles, Mao led the "Great Proletarian Cultural Revolution." The movement, however, destroyed many careers and crippled many institutions. Universities and research centers were closed and their personnel reassigned, some becoming manual laborers. Courts ceased to function. Out of this movement came a policy of regional self-sufficiency brought on by the massive decentralization of industry.

October 1971 - The People's Republic of China became recognized as the possessor of the "China Seat" in the United Nations.

April 1, 1973 - The People's Republic of China became a member of the Food and Agriculture Organization of the United Nations.

1976 - The first organized group study tour consisting of 20 members from the Food and Agriculture Organization of the United Nations toured the PRC.

September 9, 1976 - Mao Tse-tung died and the "Great Proletarian Cultural Revolution" was ended.

November 1976 - An economic policy stressing the "four modernizations" was instituted, and the ideology of "Let a hundred flowers bloom" again pervaded the culture.

1977 - Domestic policy shifted to stress expertise and reward performance that led to economic growth. Academic entrance exams to universities were restored.

1978 - A new economic policy stressing modernization for science, industry, and agriculture was introduced. Political restrictions on scientists were lifted. Foreign economic policies were modified to permit direct foreign investment. The third plenum of the CCP Central Committee called for a strengthening of the legal system, liberalizing agricultural policies and instituting a new policy of "socialist modernization."

1979 - The revolutionary committee structure established during the Cultural Revolution was abolished. Artistic expression was given greater freedom.

1980 - New laws governing local governments and the legal system were instituted. The PRC became a member of the International Monetary Fund and the World Bank.

1981 - China continued its policy of improving future growth by modernizing the efficiency of its resource use through the development of science and technology. The World Bank loaned $200 million to the PRC to improve the quality of teaching and research and to strengthen the management of universities and the Ministry of Education. The government embarked on a program of adjusting the economic structure and reforming the basic economic system.

1.6.2 The Dual Government Structure

The government of the People's Republic of China is based on the structure of dual hierarchies consisting of the Chinese Communist Party (CCP) and people's congresses at all levels. Through this structure, ideas and plans move up and down the levels of authority between the people and the party and the people and government. The objective of this structure is mass involvement in planning.

(i) The Role of the Chinese Communist Party (CCP)

The CCP and the government - The Chinese Communist Party (CCP) establishes policy and its execution through a small group of leaders simultaneously holding high positions in both the government and the CCP. Every level of government has a corresponding CCP Committee involved in the planning and execution of policy.

Structure of the CCP (Fig. 1-7) - The CCP consists of two types of institutions: (1) committees and secretaries and (2) representative congresses and members' meetings. Formerly, power was controlled by the committees and secretaries and emanated from the top on down. Recently, this power has been in a state of flux. The national, provincial and county levels each hold CCP Congresses along with general membership meetings of primary organizations to elect their respective level's executive bodies and ratify the work of the executive committees. The executive bodies consist of committees and secretaries who conduct the daily work of the CCP. They hold an extensive amount of power since the Congresses meet infrequently.

At the national level, the Central Committee delegates its key decision-making powers to its Politburo. These powers are further centralized in the Politburo's standing committee. The executive power of the Politburo is exercised through a central CCP

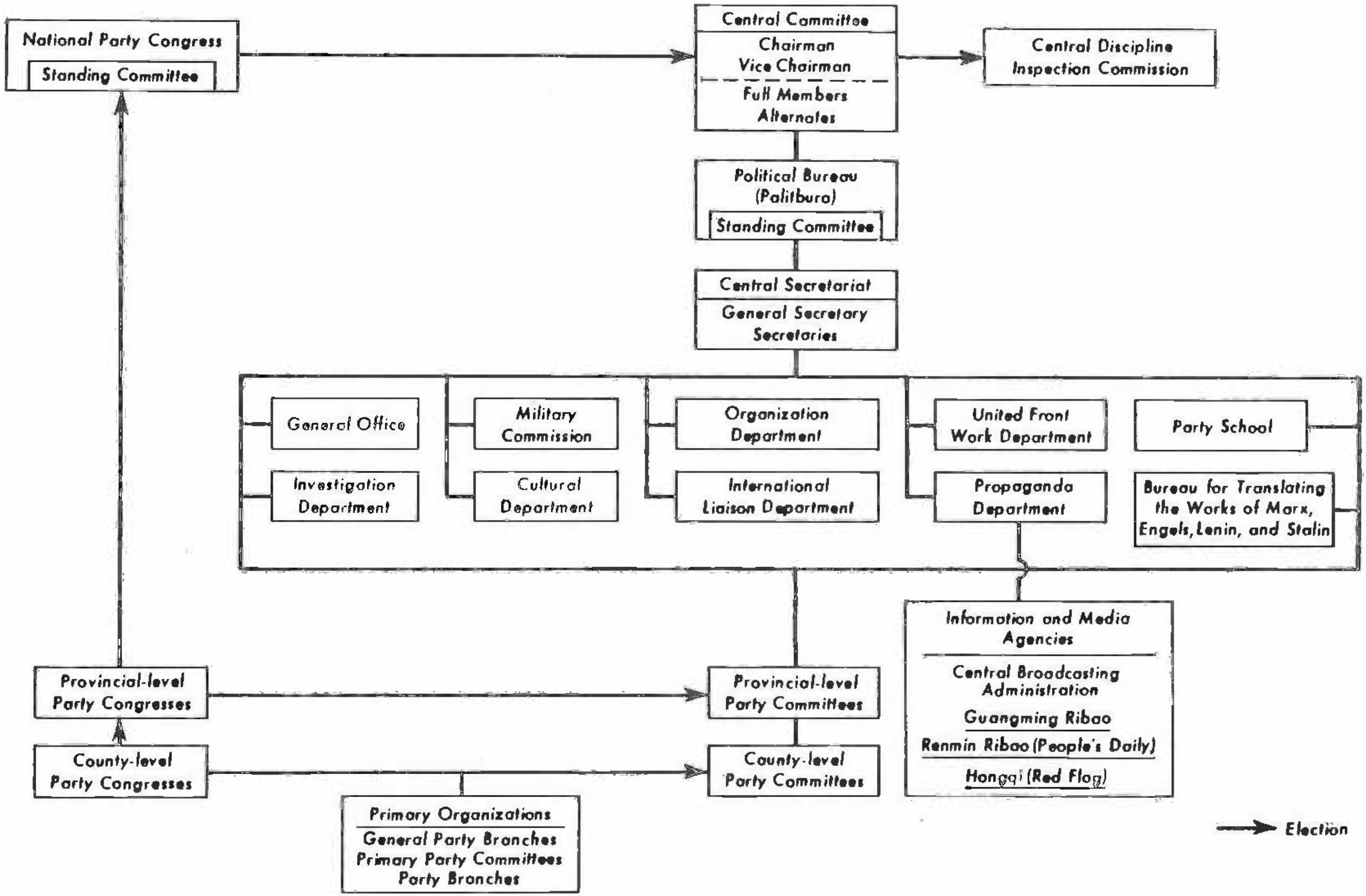


Figure 1-7. The People's Republic of China: Structure of the Chinese Communist Party.

bureaucracy consisting of a Secretariat and various departments that supervise state ministries and lower level Party organizations.

(ii) Government Organization (Fig. 1-8).

The 21 provinces, 5 autonomous regions (national minority areas) and 3 autonomous cities - Beijing (Peking), Tientsin and Shanghai (Fig. 1-1) - elect representatives to the highest level of state power, the National People's Congress (NPC). Representatives at this level hold office for five years. The congress elects its own chairman, who in turn chooses a premier. The premier nominates ministers who must in turn be approved by the NPC. The premier, vice premiers and ministers form the State Council.

Representatives at the province, autonomous region or autonomous city level serve in their respective congresses for a period of five years.[1] The 2000 counties, 170 cities and 100 autonomous counties and prefectures each have representatives who serve for a term of three years. The representatives of the 50,000 communes' people's councils serve for a two-year term.

Apart from those who have been officially deprived of their political rights for various crimes, all citizens over the age of 18 have the right to vote and to run for the entire hierarchy of people's congresses. Women enjoy equal rights with men. In 1975, women comprised 22 percent of the National People's Congress.

(iii) Legal Structure

The following paragraph from a publication by J.R. Townsend and R.C. Bush (1981) describes the legal structure in the PRC as it exists today:

> The legal structure has been revived in an effort to prevent the perceived injustices of the Cultural Revolution. Procuratorates, responsible for investigation and prosecution, and courts are functioning again for the first time since 1966. A program of codification has begun: a criminal code and criminal procedure statute was promulgated in early 1980, with various civil codes promised later. A serious shortage of lawyers and judges is only one of the obstacles to the emergence of vigorous legal institutions. Traditionally the rule of law had only limited application; even after 1949 the rule of Party and police was primary.

1.7 THE PEOPLE'S COMMUNES SYSTEM

1.7.1 Approximate Numbers

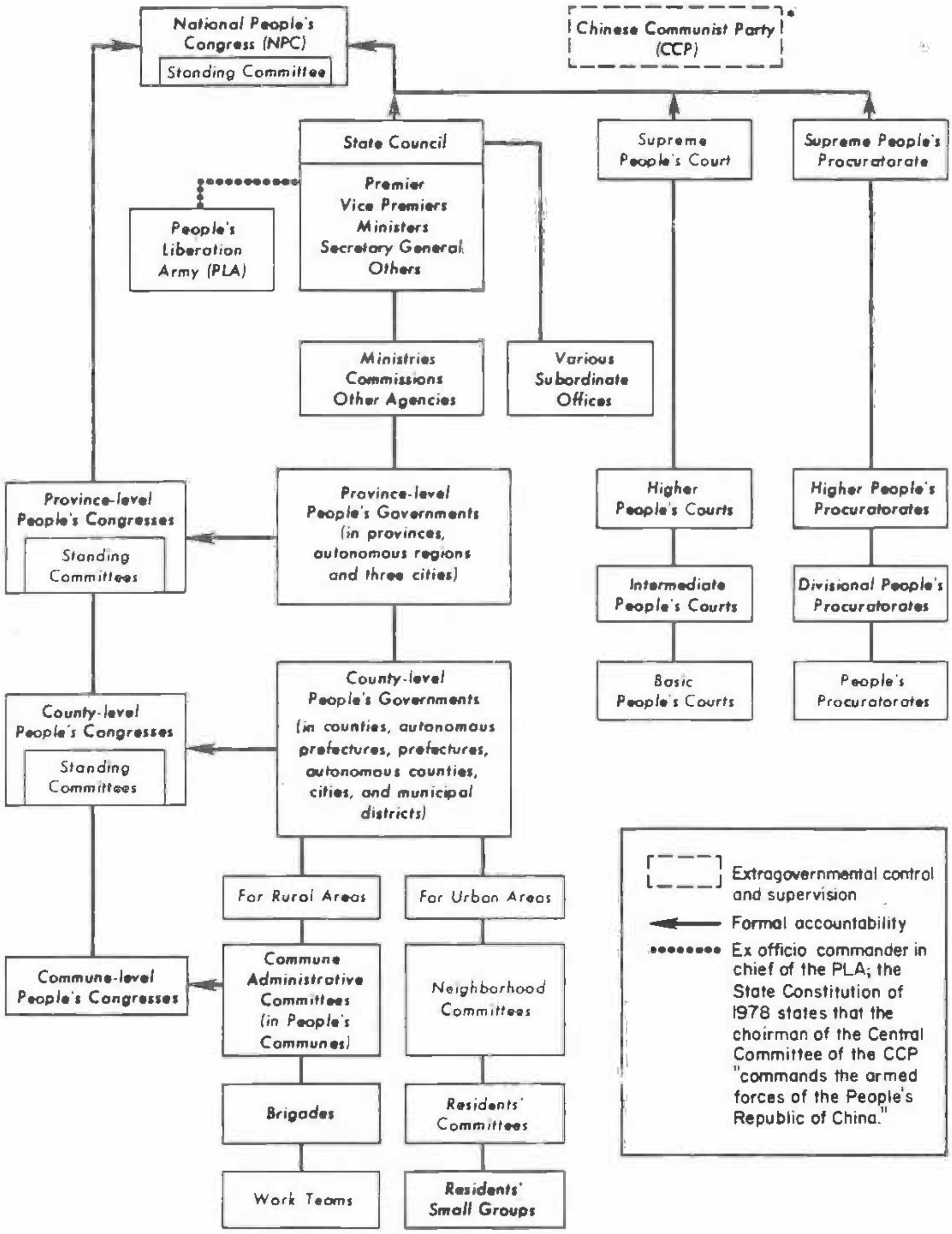
The basic unit of rural production, administration, planning and a socialist community life is the People's Commune. It corresponds by and large to the old market district of pre-revolutionary times (Hsiang). There are at present about 50,000 people's communes in China. The original number of about 27,000 communes in 1958-59 was increased to 77,000 after the consolidation measures of 1961 in order to have smaller, administratively more wieldy units, and then gradually again reduced by mergers whenever local economic experience showed that two or more very small communes could be operated more rationally on a larger scale.

1.7.2 Commune Structure

(i) Inner Structure: Brigades and Teams

The People's Commune has a two-tier inner structure (Fig. 1-8); it is subdivided into several brigades which organizationally correspond to the Advanced Agri-

[1] Each province is divided into approximately 8 prefectures, 80 counties and 2000 communes.



*Article 2 of the State Constitution of 1978 states: "The Chinese Communist Party is the core of the leadership of the whole Chinese people. The working class exercises leadership over the state through the Chinese Communist Party."

Figure 1-8: The People's Republic of China: Structure of the PRC Government.

cultural Producers' Cooperative of the pre-1958 stage. In most cases, the brigade is co-extensive with a larger village or group of smaller hamlets. The brigade is subdivided into several production teams which represent the historically grown hamlet, small village or part of a larger village. Teams consist of 6-50 households,[2] i.e., those which normally do their field work together (and have done so in the past); a team's cultivated area may range from 1 to 15 ha. The brigade groups several teams with about 50 to 400 households and 50-400 ha, but there are a few brigades which are not further subdivided into teams.

(ii) Division of Labor

There is a relatively clear division of labor among the three tiers of the commune system: the team manages crop work in the fields, small-scale animal husbandry (poultry and pigs), small-scale tree plantations and other operations closely connected with the farmers' daily routine. The brigades usually manage local irrigation and land improvement works, seed multiplication and testing, larger-scale animal husbandry. They also operate farm machines, repair and maintenance shops, small-scale and seasonal sidelines activities and rural industrial enterprises, and supply and retail stations (shops and warehouses); they undertake fish farming, agricultural, and forestry work. The communes are responsible for rural capital construction, labor deployment, full-time rural industries, large-scale land reclamation, and pilot and infrastructural projects.

1.7.3 Commune Government

(i) Levels and Functions

All three tiers are governed by the assembly of their members who elect their People's Congresses, and on the commune level the People's Council (40-200 representatives), who then elect the commune's People's Congress Committee. The committees, in charge of management, are composed of 5-9 members who are not professional administrators but who have productive professions which they continue to pursue during their tenure, and who must, after a given time, return to the rank and file to make room for new committee members.

The functioning of the Commune Congresses is supervised by the county (Hsien) authorities, whose Community Control Board controls the administrative practices, audits the financial management, and functions as a court of appeal in conflicts between commune organs. In each case, the local party cells, party committees and party secretaries act as foremost animating and guiding elements under the principle of "unified leadership" (among communal, administrative and party structures), which ensures close control and preeminence of the Chinese Communist Party (CCP) in decision-making at the village level.

(ii) Trade and Finance

The trade and supply cooperative - The Commune Congress controls the two most vital organs of the collective: the trade and supply cooperative and the finance and savings cooperative. Although both are called cooperatives, they are, in fact, administrative organs entirely dependent upon the instructions from the commune management. The first handles collection of the contractually due quantities of produce (quotas) for delivery to the county (Hsien) authorities, of grain amounts to be delivered in lieu of taxes, and of purchasing any above-quota quantities of produce that the collective or individual members want to commercialize. Inversely, it is also responsible for procuring the necessary production inputs for the brigades and teams, and for ordering and commercializing consumer goods from the state trading organization at the county (Hsien)

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2 Households may vary greatly in size and structure, but normally they average four to five persons. In addition to field work, each household also farms its "private plot." The plot equals an area of about 36 m^2 per family member.

level, to the individual members of the collectives through the stores and distribution points at the brigade level.

The finance and savings cooperative - The savings co-ops act as local branches of the People's Bank in collecting the credit assets of the collective and of individual members; the latter may have savings accounts. They accept payments and remittances from the Commune and its funds to the county (Hsien) authorities and the People's Bank and inversely handle loans from the latter to the commune.

(iii) Accounting

Revenue - The Communes' and Brigades' accountants work closely with those two cooperatives. The accounting is carried out in two categories: in kind and in money. Commune revenue is accounted in these two terms. Remittances are made from the gross revenue in the following order: to the tax account, to the quota delivery account, to the three commune funds and to working accounts. These transfers must be accepted by the commune members' assembly, usually twice a year. Once all production expenses are met and the necessary and statutory remittances are made, the assembly decides upon the distribution of the net proceeds. Usually this is done in two ways: (1) in kind, by giving each member first a basic amount of produce such as grain, sugar, cooking oil, cotton, etc., and distributing the remainder in proportion to the work points each member has earned during the period of account under study; and (2) in cash net proceeds through a similar distribution system.

Support of statutory funds - The three statutory funds to be supported by mandatory remittances from the collectives' gross revenue are: the welfare fund, from which the communes pay health, education and other social expenses; the reserve fund, which serves to defray unforeseen social costs, supports hardship cases, etc.; and the accumulation fund. From the latter, the commune pays for capital investments, be it in infrastructure, in agricultural capital equipment, or in expansion of productive capacity into other fields, i.e., rural small-scale industries. The level of remittance is theoretically freely mixed by the assembly, but the state, through its organs and the local CCP committee, ensures that the accumulation rate is not too low. In recent years, it was mentioned that in most well-run communes the accumulation rate was 10 to 12 percent (of gross revenue); in exemplary ones, it was said to exceed 20 percent and more.

1.7.4 Future Role of Communes

Under the "Communes" system, great economic and social achievements have been made. However, the county may become more important as a spatial synthesizer and arm of the state, as has already happened in research.

1.8 COMMUNICATION AND MASS MOBILIZATION

One of the truly unique characteristics of the Chinese system is its ability to educate and mobilize the masses. This process begins by giving all spheres of work, education, planning and policy a political context and is carried out by a variety of means pervading the everyday life of the Chinese people.

1.8.1 Mass Communication Techniques

(i) General Techniques

Mass communication techniques are used to create public awareness, particularly through radio and public address systems. Loudspeakers are situated not only in communes and production brigade areas, but also in the fields and factories. In addition, other mass communication techniques such as newspapers, posters, billboards, television, films and other mass media (theater, plays, exhibitions and public meetings) are used. Even the walls of houses are used for displaying painted slogans.

(ii) Slogans - Slogans are prevalently used for all forms of mass communication and are probably the cheapest and longest-lasting medium. These slogans are short and precise but have a profound impact on the people's minds. Some of the slogans relevant to forestry are:

(a) "Cover the country with trees and make it like a garden."

(b) "Agriculture, forestry and animal husbandry are interdependent, and none of them can do without the others; these three should be placed on an equal footing."

(c) "Adopt multi-purpose and fuller utilization of resources."

(d) "Use a combination of modern and traditional practices suited to local needs and conditions."

These slogans have, without a doubt, permeated the masses by creating public awareness of the important role of trees for water and soil conservation and timber for industrial and domestic needs.

1.8.2 Mass Education

There is also a system of mass education at the grass-roots level accomplished by a variety of means ranging from incorporation of the subject (i.e., forestry) into the curricula of primary and secondary schools, on to classes conducted for the benefit of production brigades and teams (e.g., short courses and field demonstrations).

Through these means, the public is made aware of the plans and goals of the government and what they themselves can do to ensure the accomplishment of those plans and goals.

1.9 THE ECONOMY

According to the World Bank Development Report 1981:

> China's economic structure and national income per person are similar to other low-income countries, but the physical quality of life of the bulk of the Chinese people is strikingly better than in most other low-income countries.
>
> Paradoxically, the income share of the poorest 40 percent of China's population--estimated at around 18 percent--is not very different from that of other low-income Asian countries. However, much of China's inequality results from regional economic differences. Within communes and cities, income inequalities are small, largely because poverty is collective. Moreover, the poor in China are, as the quality of life indicators show (see Table 1-3), far better off than those at similar income levels in most other developing countries.

1.9.1 Gross National Product

The Chinese central authorities do not acknowledge GNP calculations. They reject the concept of national accounts as computed in a market economy as misleading. Several estimates have, however, been made by China experts based on several assumptions about China's economic performance. Per capita GNP varies depending on assumptions of GNP and population.

The 1975 GNP of the People's Republic of China was estimated to range between 200 and 220 billion U.S. dollars, and growing at a rate of 7 to 8 percent a year. The 1975 per capita GNP (for a population of 870 million) was U.S. $230. The estimate of per capita GNP in 1976 by the Far Eastern Economic Review was U.S. $300. However, the World Bank estimated the per capita GNP for 1979 at U.S. $260.

Industry has now surpassed agriculture as the main contributor to GNP in the People's Republic of China, and industrial output is growing at 8 to 10 percent a year. However, agriculture remains the key sector (and the foundation) of the Chinese economy, supporting 85 percent of the population. Agriculture provides the bulk of export products and is the important supplier of industrial raw materials.

1.9.2 Economic Geography

The following map shows the location of the major industries throughout the PRC (Fig. 1-9).

1.10 LABOR FORCE

One of the resources China possesses in abundance is manpower. Massive efforts with the involvement of millions of peasants have gone into protection, afforestation, dune stabilization, shelterbelts, catchment afforestation, and dike consolidation. Mass approach is adopted even in research activities.

In China there appears to be little or no unemployment. Both sexes work, if able. The current total work force in China is estimated to be about 500 million and 80 percent of the employment is in rural areas.

1.10.1 Composition of the Labor Force

Between 1957 and 1975, China's labor force grew at a rate equal to, or perhaps slightly greater than, the rate of population growth. This growth produced a large increase in the supply of labor, most of which occurred in the countryside. Given the absence of large-scale open unemployment in either urban or rural areas during the 1970's, there can be no doubt that employment opportunities have also risen substantially between 1957 and the mid-1970's, and that the increase in demand for labor has also included a large rural component. The data in Table 1-5 point strongly to the conclusion that China's farm sector absorbed very large numbers of new workers between 1957 and 1975. This implication is confirmed by estimates of the level and growth of nonagricultural employment.

In 1978, China's state farms employed 5 million agricultural workers. Data from 18 of China's 29 province-level units showed that 17 million workers were occupied in 1977 in full-time projects involving building water conservancy projects, terracing hillsides, improving the soil and other basic measures for expanding the cultivated area and increasing per hectare yields. It is thus assumed that these categories, together with forestry, employed a total of 22 million persons in 1975, and that, as in the 1950's, full-time members of state farms and rural construction brigades continued to be classified as workers and employees.

1.10.2 The Forestry Labor Force

No figures are available on the total employment provided by forestry and forest industries. An estimate can, however, be based on averages from the figures made available from various units for logging, nursery, land preparation and planting, maintenance of manmade forests and wood processing (Table 1-6).

Figure 1-9. The People's Republic of China. Major industries and industrial areas.

Table 1-5. Composition of the Labor Force (in millions)

	1957		1975	
Sector	Size	%	Size	%
Agriculture *	231.53	84.5	329.04	76.7
Manufacturing and Services				
Industry and Construction	16.71	6.1	45.90	10.7
Commerce, Finance, Food & Drink, Personal Services	4.38	1.6	9.00	2.1
Transport & Communications	8.76	3.2	19.30	4.5
Health, Education & Culture	4.65	1.7	14.15	3.3
Government & Mass Organizations	3.01	1.1	6.00	1.4
Military	3.01	1.1	3.43	0.8
Salt & Fishing	1.91	0.7	2.14	0.5
Total, Manufacturing and Services	42.47	15.5	99.96	23.3
TOTAL	274.00	100.0	429.00	100.00

* Includes farmland capital construction, forestry, and water conservancy.

Source: Adapted from The Economist, February 16, 1980, p. 108.

Table 1-6. Estimates of employment provided by forestry and forest industries.

	Number of workers	% of total
Logging	165,000	7.6
Nursery and related operations	65,000	3.0
Land preparation and planting	665,000	30.6
Maintenance of plantation	20,000	0.9
	915,000	42.1
Wood processing	1,250,000	57.9
TOTAL	2,165,000	100.0

1.10.3 Compensation

(i) Wages

Even though wages (or in the case of collectives, remuneration based on work points) are based on skill and efficiency (i.e., according to work), conscious attempts are being made to reduce the conflict and gap between groups such as peasants and workers, mental and manual workers, etc.

In the state forestry farms, there are 8 different monthly salary levels which ranged from 33 yuan at the lower to 99 yuan at the upper limit. The level of an individual worker is judged by his peers as well as by his leaders, and depends on his skill, experience and attitude.

Forest workers (and their families) receive the same benefits as other workers (and their families) in respect to schooling, medical aid, transportation, work clothes, etc.

In the collectives (communes, brigades, and teams), the income is apportioned approximately 60 percent to members and 40 percent as tax to state, operational fund, accumulation fund, etc.

The wages in wood processing factories are also differentiated into several levels. In the Beijing (Peking) Multi-purpose Utilization and Timber Processing Factory, the average wage was 60 yuan plus a 5 yuan welfare benefit for bath and haircut. In the Kwang Huai Multi-purpose Timber Processing and Plastic Overlay Factory in Beijing (Peking), the average wages varied from 40 yuan for unskilled labor to 80 yuan for skilled labor.

(ii) Nonwage Compensation

Apart from the wages or share based on work points, the working class is entitled to a number of benefits or nonwage compensation--such as medical aid, recreation, organized pleasure trips, rations at fair prices, maternity leave, etc.

The state forest farms have a comprehensive welfare system. This includes accommodations for families and single persons, schools, shops, bathhouses, canteens, cinemas, libraries, recreation rooms, TV rooms, clinics, hospitals, barefoot doctors, medical aid,[3] safety regulations at work, 56 days leave in connection with childbirth, hardship allowance for loggers and forest workers in remote areas, nursery (day care) and kindergarten classes to look after children of working mothers, etc.

Workers in wood processing factories also enjoy privileges similar to those of workers in other industries. In cities and towns, housing (at least to a proportion of the workers) is provided by the municipality. In such cases, workers are provided with free bus transport. Young children are provided overnight facilities at schools in major towns, if no grandparents are living with the family.

The standard of living is still low but is quite secure. The state takes care of cultural, educational, health, housing and other social needs. Every year the state builds new apartments and dormitories for workers and educated youths, to replace the old ones. They also organize productive work for dependent teams.

The family houses of Pieh Hsui State forestry farms have two rooms and kitchen with a total area of about 45 square meters and are provided with a water supply. In the front and backyard of the houses, the residents grow vegetables, poultry, pigs, etc.

This may be compared with housing facilities in agricultural communes such as Tachai, Song Chow in Beijing (Peking), and Wu Sae in Shenyang, which are some of the most prosperous communes in the county, with an average family income of over 100 yuan per month.

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3 The medical aid program is really a cooperative scheme, where a nominal amount is to be paid by the workers for the medical facilities - normally 1 yuan per year per person, which entitles the entire family to health care.

(iii) Retirement Benefits

Normal retirement age is 60 years for men and 55 for women. At retirement, a worker receives a pension of 70 percent of his/her wages. After retirement, workers lead a pension-protected life.

In case of death before retirement, family is compensated and children are looked after.

1.10.4 Role of Women

The slogan, "Everything a man can do, a woman can do equally well," applies to forestry and forest industries in China.

There is a high percentage of women (mostly young) among forest workers and technicians. In Poli County (Heilongjiang/Heilungkiang), 109 women are included among the forest management staff of 446. In the Chu Chia Tien Nursery (Liaoning), out of 15 staff and workers, 13 are females, including the manager of the nursery. In Tao Yuan (Hunan) and Di Pai (Guangdong/Kwangtung), women's teams - "March 8 Brigades" - engage in afforestation work.

Women can be found even in logging and similar heavy jobs. In the Pieh Hsui Forestry Farm (Heilongjiang/Heilungkiang), the fallers were exclusively women, so, too, the tractor drivers. In the Di Pai Forestry Farm (Guangdong/Kwangtung), women are engaged in logging operations and billeting of logs.

In the wood conversion factories, approximately a third of the workers were women. In the Piecewood Factory in Tailin (Heilongjiang/Heilungkiang), the turnery unit where they make tea leaf cups, sickle handles, etc., from piecewood, is run exclusively by women workers.

1.10.5 Recruitment and Training

(i) Entry into the Work Force

Normally a youngster enters the work force at the age of 17 years, after graduating from senior middle school. One can enter the work force even after junior middle (14 years), but all youngsters are encouraged to complete senior middle. The student, on completion of school, can indicate his work preference - peasant, soldier or worker - and the exact nature of special work is allotted based on society's requirements, on aptitude, and on political consciousness.

(ii) Apprenticeship

In many industries (including wood based) new entrants to the permanent labor force must serve as apprentices before they can enjoy the benefits of regular worker status. An apprentice normally has to be over fifteen years of age, has to possess a primary school certificate, and be healthy and of no undesirable habits. The first few months of the apprenticeship are probationary. The new entrants are trained by experienced workers. The content of the training is decided entirely by the factory, which examines the apprentice at regular intervals. The worker training is supposed to last for about 3 years and may involve all or few of the workshops within a unit.

Education and training are integrated to provide production skills, political consciousness and leadership. The training, both at school and later, and the proper stratification of labor avoids absenteeism and unemployment due to the reluctance or inability of workers to handle the kinds of jobs that are available.

1.10.6 Mass Participation in Forestry

Article 3 of the Forest Regulation of 1963 states: "Revolutionary Committees at the various levels must strengthen propaganda and education in order to promote forest consciousness and forest education and mobilize the masses to properly protect forests and trees." The Chinese have successfully developed forest consciousness among the masses, by educating them on the material benefits of forestry. As part of developing forest consciousness, forest farms, communes and brigades organize exhibition halls. They also organize exchange visits for education and pooling of experience.

(i) Commune Participation

It is possible to draw the seasonal cooperation of up to 50 percent of the commune labor force for the implementation of afforestation programs. The scale of this labor input is indicated by such examples as the two shelterbelt systems in the Northwest. One of them, about 1500 km long and 12 m wide, was executed in 2 seasons (1955-56) by over 700,000 farmers from nearby communes. The other 800 km east to west and 500 km north to south, protecting 1.5 million ha of reclaimed farm land, was carried out in 3 seasons. In organizing the masses, the guideline adopted is: "In the busy season for agriculture, organize labor for agriculture; in the busy season for forestry, organize labor for forestry."

From autumn of 1957 on, afforestation was given the full benefit of mass labor, which became one of the outstanding characteristics of the "Great Leap Forward." According to Chinese sources, roughly 30 million ha were afforested in the two following years (half in industrial timber and half in shelterbelts and village fuelwood plantations). Most of these afforestation attempts failed. Subsequently, the defects and deficiencies were remedied and a new, concerted and massive attempt at afforestation was initiated. These attempts have yielded impressive results. The meticulous implementation of forestry plans, the sheer size of afforestation programs, and the amount of human effort that has gone into their achievement are all truly staggering.

(ii) Forest Farms

A "mass" approach is also adopted in regular management of forest farms. The commune logging and afforestation farm of Di Pai Commune (Guangdong/Kwangtung Province) draws teams for nursery work, logging, planting, etc., from the constituent brigades, in proportion to the forest area (hill area) in each brigade. The teams are provided accommodation in the farm. They are not paid any wages and they get their usual "work points" from their respective brigades.

Professional foresters and technicians provide guidance to the men and women carrying out afforestation and logging work. Aspects of silvicultural management are looked after by "professional teams."

(iii) Participation of Educated Youths

An aspect of mass mobilization is the involvement of educated youths and students in productive activities, including afforestation. The intention is to combine education with productive labor, mental with manual labor, and theory with practice.

Chapter 2

FOREST RESOURCES

2.1 CURRENT FOREST COVER

In 1949 when the People's Republic of China was established, the forest cover of the nation was only 8.6 percent of the total land area. Since then a large-scale afforestation program was carried out at both the state and the commune levels.

According to the latest forest survey, China now has 121.86 million hectares (ha) of fully stocked forests, about 12.69 percent of the total land area (Hsiung and Johnson 1981). It also has 15.63 million ha of thinly stocked forests, which is 1.63 percent of the total land area. These amount to a combined total forest cover of 14.32 percent of China's land area (Hsiung 1980). In addition, there are 4.51 million ha of new plantations. China has about .12 ha of forest land per capita, which is far below the average world level. It is also estimated that China has about 257.78 million ha, about 27 percent of its total land area, suitable for forests; about one-third of that still remains unforested (Table 2-1).

2.2 FOREST UTILIZATION

For the first time in China's history, all the forest lands, including natural forest lands, are under the management of a national forest system for production and regeneration. Natural forests and plantations are used nearly 80 percent for timber production, 7 percent for economic forests (commercial crops such as tung oil, rubber, fruit and medicines), 6 percent shelterbelts, 3 percent bamboos, and 4 percent other uses such as fuelwood.

Table 2-1. Utilization of forest land in China

	Million Hectares	Percentage of Total Land Area
Fully Stocked Forest	121.86	12.69
Thinly Stocked	15.63	1.63
Shrub Land	29.75	3.10
New Plantation	4.51	0.47
Nurseries	0.21	0.02
Land, Unforested	85.82	8.94
TOTAL	257.78	26.85

2.3 FOREST DISTRIBUTION

2.3.1 Natural Forest

Natural forest cover is limited in area and unevenly distributed. Large tracts of natural forest are preserved only in the remote frontiers of the northeastern province of Heilongjiang (Heilungkiang) and the southwestern provinces of Sichuan (Szechuan) and Yunnan, and eastern Xizang (Tibet). Many of these forests have never been exploited, and consist mostly of over-mature trees. According to Hsiung (1980), sixty-four percent (excluding Taiwan) of China's natural forest volume is concentrated in these two general border regions (Table 2-2).

The major natural forest areas are presented in Figure 6-1.

Table 2-2. Natural forest growing stock in China.

Heilongjiang (Heilungkiang)	25 %
Xizang (Tibet)	15 %
Sichuan (Szechuan)	14 %
Yunnan	10 %
The other 18 provinces and 4 autonomous regions	36 %
TOTAL	100 %

2.3.2 All Forests

The forest covers of the southern provinces are mostly of second growth and plantations. In general, the southeastern coastal provinces and Heilongjiang (Heilungkiang) have the highest forest cover (30 to 40 percent of land area in each province). The arid lands of Inner Mongolia, Ningxia (Ningsia), Qinghai (Chinghai), and Xinjiang (Sinkiang) have the lowest forest covers: less than one percent of land area. Distribution of forest covers in 22 provinces and 5 autonomous regions are listed in Table 2-3.

2.4 FOREST TREE SPECIES

2.4.1 A Broad Range of Species

China is particularly rich in tree species and endemic genera. The forest has over 3000 tree species, and 20 of the 30 genera of Pinaceae and Taxodiaceae in the world. The endemic genera include Cathaya, Cunninghamia, Fukienia, Glyptostrobus, Keteleeria, Metasequoia, Pseudolarix, and Taiwania. Ginkgo biloba still grows wild in China. In conifers there are 27 species of Pinus, 20 species of Abies and 19 of Picea. There are over 260 genera of broadleaf trees, and over 80 species of Quercus and 16 of Populus. Among other important broadleaf tree genera are Acer, Betula, Castanea, Castanopsis, Cinnamomum, Cyclobolanopsis, Fagus, Fraxinus, Juglans, Ormosia, Phoebe, Pseudosassafras, Schima, Sophora, Tilia, and Ulmus. Some of the important economic woody plants grown for food, oil and wax include Aleurites fordii, A. montana, Camellia oleosa, C. sinensis, Juglans regia, Morus alba, and Sapium sebiferum. In addition, there are nearly 50 kinds of commercial bamboos and many species of palms in cultivation.

Table 2-3. Percentage of forest cover in 22 provinces and 5 autonomous regions*.

THE NORTHEASTERN REGION	
Heilongjiang (Heilungkiang)	30-40
Jilin (Jirin)	20-30
Liaoning	10-20
THE NORTHERN REGION	
Hebei (Hopei)	10-20
Shanxi (Shansi)	5-10
Inner Mongolia *	1
THE EASTERN REGION	
Shandong (Shantung)	5-10
Jiangsu (Kiangsu)	1-5
Anhui (Ahnwei)	10-20
Zhejiang (Chekiang)	30-40
Jiangxi (Kiangsi)	30-40
Fujian (Fukien)	40-50
Taiwan	50-60
THE CENTRAL REGION	
Henan (Honan)	10-20
Hubei (Hupei)	20-30
Hunan	30-40
Guangdong (Kwangtung)	30-40
Guangxi (Kwangsi) *	30-40
THE SOUTHWESTERN REGION	
Yunnan	20-30
Guizhou (Kweichow)	10-20
Sichuan (Szechuan)	10-20
Xizang (Tibet) *	1-5
THE NORTHWESTERN REGION	
Shaanxi (Shensi)	20-30
Gansu (Kansu)	1-5
Ningxia (Ningsia) *	1
Xinjiang (Sinkiang) *	1
Qinghai (Chinghai)	1

Many introduced tree species have also become well established in certain parts of China. Examples include Pinus elliottii, P. taeda, Cedrus deodora, Taxodium distichum, T. ascendens, Carya illinoensis, Olea europaea (olive), Elaeis guineensis (oil palm), Platanus X acerifolia, Eucalyptus spp., Tectona grandis (teak), Robinia pseudoacacia, Cassia siamea, Albizzia falcata, Swietenia macrophylla (Honduras mahogany), Populus X canadensis, and Magnolia grandiflora.

2.4.2 Two Major Life Zones

China has two major life zones: the moist coastal area and the dry interior. A survey of the forests of China and a description of the vegetation in these two zones may be found in Wang (1961).

2.5 PHYTOGEOGRAPHICAL REGIONS OF CHINA[1]

2.5.1 Ten Phytogeographic Regions

On the basis of the major types of natural forests and other vegetation, 10 phytogeographical regions are recognized (Fig. 2-1, Table 2-4):

1. montane-boreal coniferous forest:
   a. larch forest,
   b. spruce forest of Xinjiang (Sinkiang),
   c. spruce-fir forest of the southwestern plateau;
2. mixed conifer and northern hardwood forest;
3. deciduous broadleaf forest;
4. mixed deciduous and evergreen broadleaf forest;
5. evergreen broadleaf forest;
6. rain forest;
7. wooded-grassland;
8. grassland;
9. desert;
10. alpine-tundra vegetation.

2.5.2 Locations

Forest regions - The forest regions are mostly located in the eastern part of China. They are primarily in the drainage areas of the Heilongjiang (Heilungkiang), Huang (Yellow), Chang (Yangtze) and the Pearl-Xijiang. These regions have annual precipitation of over 500 mm. With the exception of the extreme northeastern portion of the country, these regions are suitable for farming, and are densely populated.

Grassland-desert regions - The grassland-desert regions are located in the northcentral and western parts of China. This vast arid inland extends from Inner Mongolia to Xinjiang (Sinkiang) and Xizang (Tibet), and is primarily a land of plateaus and basins without outside drainage. Natural forests in these drier regions are limited to the high mountains and the fringe of rivers. The sparse population is concentrated in the isolated oases.

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[1] A much more extensive and detailed coverage of vegetation in China is found in Wang (1961).

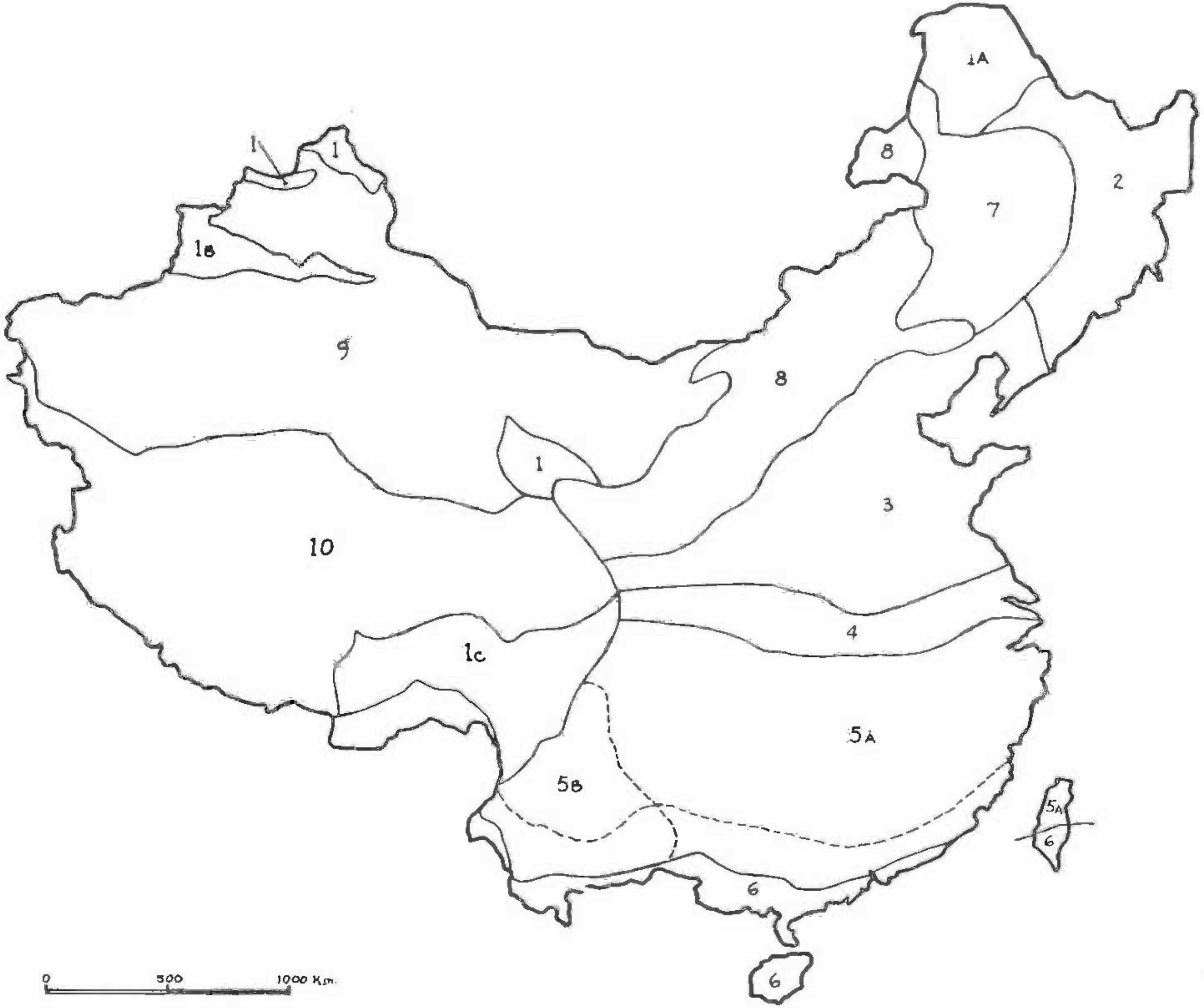


Figure 2-1. Phytogeographical regions of China; see also Table 2-4.

Table 2-4.

Phytogeographical Regions of China

Region	Location	Land use	Soil	Average elevation (m)	Annual precipitation (mm) and rainy season	Frost free season (day)	Annual mean temperature (°C)	Coldest month mean temperature (°C)	Warmest month mean temperature (°C)	Characteristic major plants	Minor plants
1. Montane boreal coniferous forest	A. Da Hinggan Ling Mtns, Heilongjiang (Heilungkiang) and Inner Mongolia	Forestry, reindeer, spring barley, potatoes (1 crop per year)	Podzolic forest soil, mountain gray-brown forest soil	450-600	360-500 (July-August)	60-100	-1.2 to -5.6	-28 to -38	15-20	Larix gmelini	Betula dahurica, Betula platyphylla, Pinus sylvestris var. mongolica, Populus davidiana
	B. Tien Shan; Altai Mtns.; Xinjiang (Sinkiang) Province	Forestry, summer pasture	Brown forest soil	1500-2800	400-500	60-100	-2 to -4	-14 to -26	18-22	Picea schrenkiana	Abies siberica Betula pendula, Larix sibirica, Picea obovata, Populus tremula
	C. Southwest plateau	Forestry, summer pasture	Brown forest soil	3200-4200	500-800	90-120	5.0 to 8.0	-8 to -15	20-24	Abies delavayi, Picea likiangensis.	Abies georgei, A. spectabilis, Picea purpurea
2. Mixed coniferous and northern hardwood forest	Hsiao Hinggan Ling Mtns., Changbaishan; Heilongjiang (Heilungkiang) and Jilin (Kirin) provinces	Forestry, wheat, sorghum, soybean. (1 crop per year)	Dark brown soil and brown forest soil, Gleys	400-1000	600-1000 (June - August)	110-160	2.0 to 8.0	-15 to -25	20-24	Acer, Betula, Fraxinus, Juglans, Maackia, Phelloden-dron, Ulmus, Pinus koraiensis, Tilia	Abies holaphylla, A. nephrolepis, Corylus, Picea jezoensis, Populus, Syringa, Taxus cuspidata
3. Deciduous broadleaf forest	Hills of Liaoning, Hebei (Hopei), Shanxi (Shansi), Sandong (Shantung), Henan (Honan), and Shaanxi (Shensi) provinces	Winter wheat cotton, corn (3 crops in 2 years)	Korichneogi forest soil, brown forest soil and Solonchaks	200-1200	500-750 (May - September)	160-240	9.0 to 14.0	2 to -14	24 to 28	Quercus accutissima, Q. aliena, Q. dentata, Q. liaotungensis, Q. mongolica	Acer, Carpinus, Castanea, Celtis, Fraxinus chinensis, Juglans, Juniperus, Ostrya, Pinus bungeana, P. densiflora, P. tabulaeformis, Thuja, Tilia

(Table 2-4, Cont.)

Region	Location	Land use	Soil	Average elevation (m)	Annual precipitation (mm) and rainy season	Frost free season (day)	Annual mean temperature (°C)	Coldest month mean temperature (°C)	Warmest month mean temperature (°C)	Characteristic major plants	Minor plants
4. Mixed deciduous and evergreen broadleaf forest	Huai River drainage to southern Shaanxi (Shensi) and Gansu (Kansu) provinces	Summer rice, winter wheat (2 crops per year)	Yellow-brown podzolic yellow korichneric	100-500	800-1400 spring, summer	210-250	15 to 18	1 to 2	26	Deciduous and evergreen oaks (Quercus glauca, Q. gracilis, Q. myrsinaefolia) Castanopsis sclerophylla, Cinnamomum, Lithocarpus glabra, Machilus, Phoebe, Pinus massoniana, Schima	Albizzia, Bamboos, Cunninghamia lanceolata, Dalbergia, Diospyros, Liquidambar, Pistacia, Platycarya, Rhus, Sassafras
5. Evergreen broadleaf forest	A. Chang Jian (Yangtze) and Sikiang drainage and Taiwan Province	Tea, tea oil, citrus, tung oil (2 rice and 1 winter crop per year)	Yellow podzolic, Rendzina	100-1000	1000-2000 spring, summer	250-330	18 to 21	2 to 12	27 to 29	Castanopsis, Lithocarpus, Pinus massoniana, Quercus glauca, Q. myrsinaefolia, Schima superba	Bamboos, Cryptomeria Cunninghamia lanceolata, Cupressus funebris, Machilus, Phoebe
	B. Yuman Province	1 rice (corn) and 1 winter crop	Red podzolic	1500-2200	900-1200 summer, fall	240-330	15 to 20	8 to 12	20 to 24	Castanopsis delavayi, C. hystrix, C. tribuloides, Lithocarpus microspermus, Pinus yunnanensis, Quercus delavayi, Q. glacoides, Schima wallichi	Anneslea, Bamboos, Cupressus duclouxiana, Keteleeria evelyniana, Machilus, Manglietia, Phoebe

(Table 2-4, Cont.)

Region	Location	Land use	Soil	Average elevation (m)	Annual precipitation (mm) and rainy season	Frost free season (day)	Annual mean temperature (°C)	Coldest month mean temperature (°C)	Warmest month mean temperature (°C)	Characteristic major plants	Minor plants
6. Tropical rain forest	Southern part of Fujian (Fukien), Taiwan, Guangdong (Kwangtung), Guanxi (Kwangsi), and Yunnan provinces and sea islands	Sugar cane, Hevea rubber (2-3 crops of rice per year)	Red and yellow lateritic soil	0-500	1200 in West to 3000 in East (May October)	Frost free	22 to 26.5	16 to 21	26 to 29	Annonaceae, Dipterocarpaceae (Dipterocarpus, Hopea, Shorea, Parashorea, Vatica) Lauraceae, Meliaceae, Moraceae, Myrtaceae, Sapindaceae	Dacrydium, Epiphytes, Rhizopora spp., Orchidacaea, Palmae, Podocarpus spp., Cyclanthacaea
7. Wooded grasslands	Northeastern part of Inner Mongolia, and Liaoning, Jilin (Kirin) provinces	Animal husbandry, wheat, sorghum, soy bean	Chernozems, Solenchaks, Ziero Korichnerie (loess)	400-1500	250-500 summer	90-160	-3 to 8	-7 to -27	18 to 25	Aneurolepidium chinensis, Filifolium sibiricum, Pinus sylvestris var. mongolica, Quercus mongolica, Q. liaotungensis, Stipa baicalensis, Ulmus pumila	Betula dahurica, B. platyphylla, Corylus spp., Pinus tabulaeformis, Populus tremuloides var. davidiana, Thuja orientalis, Tilla mongolica
8. Grassland	Eastern Inner Mongolia, Northern Shanxi (Shansi), and Shaanxi (Shensi) provinces to Northern Xingjiang (Sinkiang)	Animal husbandry, spring wheat, millet, oats	Black calcareous soil, chestnut calcareous soil, and brown calcareous soil	600-1300	150-400 summer	90-170	-3 to 8	-7 to -22	18 to 24	Allium, Artemisia, Cleistogenes, Stipa grandis, S. krylovii, S. spp.	Agropyron, Juniperus rigida, Lespedeza, Picea meyeri, P. wilsonii, Pinus tabulaeformis, Quercus mongolica, Thuja, Ulmus pumila

(Table 2-4, Cont.)

Region	Location	Land use	Soil	Average elevation (m)	Annual precipitation (mm) and rainy season	Frost free season (day)	Annual mean temperature (°C)	Coldest month mean temperature (°C)	Warmest month mean temperature (°C)	Characteristic major plants	Minor plants
9. Desert	Ordos and eastern Alashan of Inner Mongolia; Western Alashan to Tarim Basin of Sinjiang (Sinkiang); & Dzungari Basin of Sinjiang (Sinkiang).	Animal husbandry, irrigated agriculture in oasis. Rice, grape, melon	Gray-brown desert soil, brown desert soil Sierozem Solonchaks Solonetz	-154-1500	10-200 summer	90-200	4 to 12	-6 to -20	20 to 30	Artemisia, Calligonum, Ephedra, Haloxylon ammodendron, H. persicum, Nitraria, Populus euphratica, Tamarix spp.	Suffruticose shrubs (Salsola, Iljinea, Reamuria, Anabasis), & succulent shrubs (Suaeda, Atriplex, Kalidium, Halostachys)
10. Tibetan Plateau	Quinghai (Chinghai) and Xizang (Tibet)	Animal husbandry (yak), black barley	Alpine meadow soil, alpine grassland soil and alpine desert soil	4000-5000	50-500 (June - September)	0-50 (180 in valley)	8 to -10	0 to -20	5 to 16	Mountain shrub (Dwarf Rhododendron, dwarf salix, Caragana, Juniperus); Mountain meadows (Kobresia); Mountain grassland (Stipa, Artemisia); Mountain desert (Eurotia ceratoides, Carex moorcroftii, and Cushion plants).	Abies faxoniana, A. sutchensis, Ephedra gerardiana, Myricaria prostrata, Picea crassifolia, P. likiangensis, P. purpurea,

2.5.3 The Montane-Boreal Coniferous Forest

There are two major types of coniferous forest in the montane-boreal region. They are the larch forest of the northeastern provinces, and the spruce-fir forest of the Tien Shan-Altai ranges of Xinjiang (Sinkiang) and the southwestern plateau of Yunnan and Sichuan (Szechuan) provinces and eastern Xizang (Tibet). Other types of montane-boreal coniferous forest include the larch forest of the northeastern provinces and eastern Xizang (Tibet); the spruce forest of northeastern Inner Mongolia, the northeastern provinces and Qinghai (Chinghai) Province. Natural groves of ancient Abies spp. are found in high elevations of Guangxi (Kwangsi) (Lat. 25 N.) and Taiwan (Lat. 23 N.) provinces, both of which are below the tropic of Cancer.

(i) Larch Forest

The northeastern region - The larch forest of the Da Hinggan Ling mountain range in Heilongjiang (Heilungkiang) Province is composed of Larix gmelini. The forest elevations range from 450 to 1380 meters (m). In the lower elevations, larch is mixed with Pinus sylvestris var. mongolica, Quercus mongolica, and Betula dahurica. Picea koraiensis appears in the larch forest at higher elevations. Among the ground flora of the larch forest are many plants which are also common in forests of northern Europe and North America, including Vaccinium vitis-idaea, Sedum palmstris, Trientalis europaea, Maianthemum bifolium, and Linnaea borealis. When these forests are drastically disturbed, they are usually taken over by Betula platyphylla, B. dahurica and Populus davidiana.

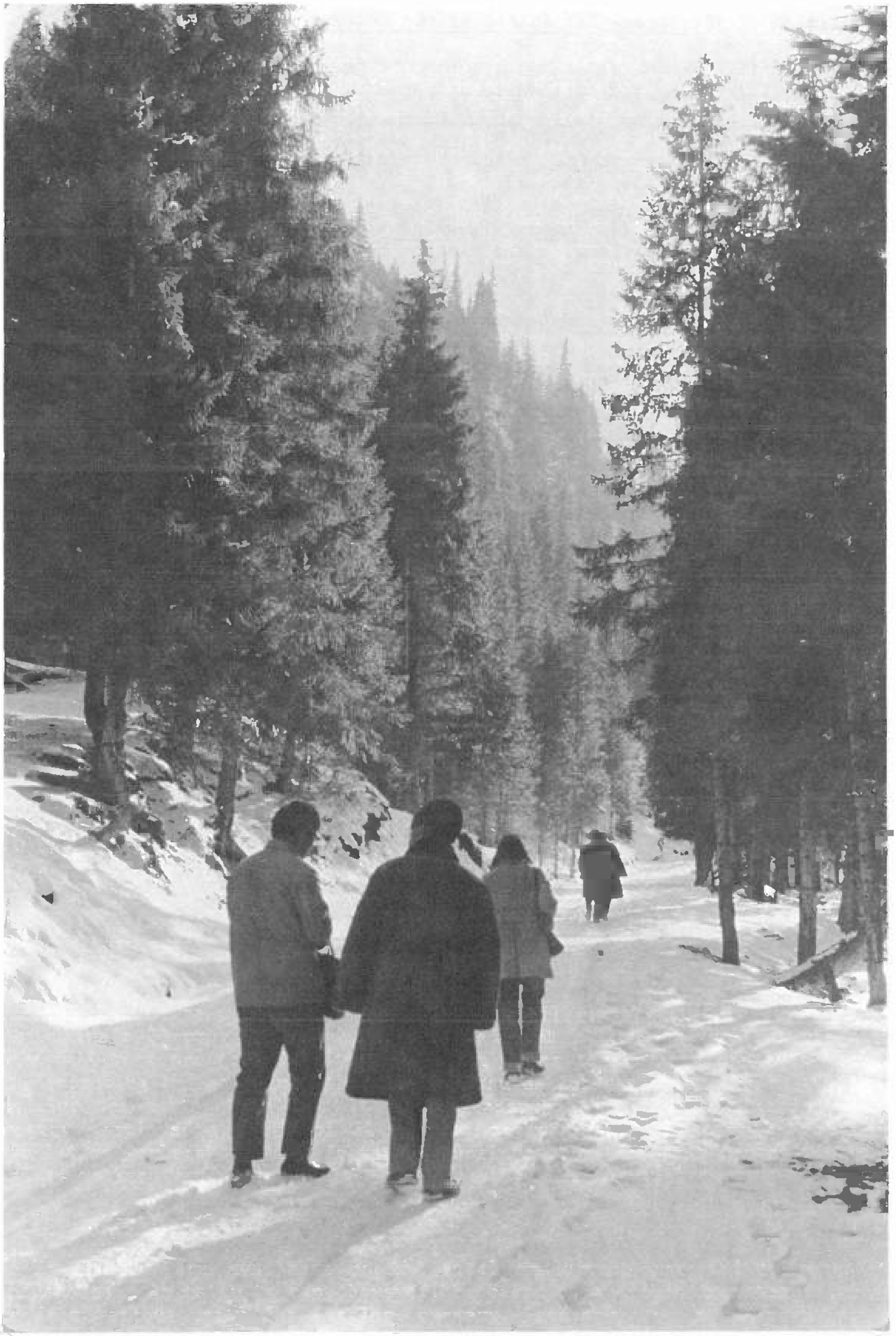
The growing season of the Da Hinggan Ling region is too short for agricultural crops, with the exception of spring barley and potatoes. Herds of reindeer are among the livestock kept by the minorities in the Hinggan. This region has large areas of inaccessible, undisturbed natural forests.

The northern, northwestern, southwestern regions - Other types of larch forests include the Larix principis-rupprechtii forest of Hebei (Hopei), and Shanxi (Shansi) provinces and Inner Mongolia; the Larix chinensis forest of Shaanxi (Shensi) Province; and the Larix potaninii forest of Gansu (Kansu) Province. They form pure forest and extend to the timberline. Larix griffithiana, L. himalaica, L. speciosa, L. potaninii var. macrocarpa are found in a narrow belt, 2800-3600 m, in eastern Xizang (Tibet).

(ii) The Spruce Forest of Xinjiang (Sinkiang)

The upper slopes (1500-2800 m) of the Tien Shan mountain range are covered with pure forest of Picea schrenkiana. This is located along the southern fringe of the Djungaria Desert basin. Below the forest belt are grassland (1300-1600 m), sagebrush (Artemisia spp.) (1000-1300 m), and desert (800-1000 m). Above the forest belt are open forests of spruce and other trees, including Larix sibirica, Populus tremula, and birches (Betula pendula, B. spp) and lush meadows (2800-3600 m).

The Altai mountain range, north of the desert basin, has a similar belt of coniferous forest. Larix sibirica begins to appear on the sunny slopes at 1200 m. The larch forms mixed forest with Picea obovata at elevations of 1300-2000 m. The minor forest components include Betula pendula and poplar (Populus spp.). Forests of Abies sibirica appear in moist areas of elevations between 1400-2300 m. It forms mixed forest with Pinus sibirica, Picea obovata, and Larix sibirica. Other types of spruce-fir forest of the arid regions include Picea meyeri-Picea wilsonii forest of the northern provinces, and Picea crassifolia forest of Gansu (Kansu) and Qinghai (Chinghai) provinces.



2-1: Picea schrenkiana, Xinjiang (Sinkiang) autonomous region

(iii) The Spruce-Fir Forest of the Southwest Region

Spruce-fir forest is a major forest type of the southwestern plateau from western Sichuan (Szechuan) and northwestern Yunnan to eastern Xizang (Tibet). It covers (3400-3800 m); Abies squamata-Picea likiangensis forest of western Sichuan (Szechuan) and eastern Xizang (Tibet) (3200-4200 m); and farther to the north, Picea crassifolia, P. likiangensis, P. purpurea-Abies faxoniana forest of the adjacent Qinghai (Chinghai) and Gansu (Kansu) borders (3600-4000 m).

In general, Tsuga (T. dumosa, T. chinensis) is a common minor component in the Abies forest at lower elevations in the south. Spruce is increasingly important in the northern part of the range.

2.5.4 The Mixed Coniferous and Northern Broadleaf Forest

(i) Location and General Description

This area covers extensive areas in the Hsiao Hinggan Ling and Changbeishan (Everlasting White) mountain ranges. This forest type is found at the lower elevations of 400-1000 m.

(ii) Composition

This type of forest is composed of Pinus koraiensis and a large number of deciduous broadleaf trees. The common northern broadleaved trees of this forest include maple (Acer pseudosieboldianum, A. mandshuricum, A. spp.); birch (Betula costalei, Carpinus cordata); Ash (Fraxinus chinensis); walnut (Juglans mandshurica, Maackia amurensis, Phellodendron amurense); poplar (Populus ussuriensis, P. koreana); elm (Ulmus propinqua, U. laciniata), and linden (Tilia mandshurica). Other conifers usually found in the mixed broadleaf forest are Abies holophylla and Taxus cuspidata. On the disturbed site the secondary growth is composed of white birch (Betula platyphylla) and aspen (Populus tremula var. davidiana).

A similar type of mixed northern broadleaf forest but without Pinus koraiensis extends to the northern provinces above the belt of deciduous oaks, and to the southwestern plateau below the Abies and hemlock.

2.5.5 The Deciduous Broadleaf Forest

(i) Location and General Description

The deciduous broadleaf forest covers the extensive hilly country in northern China from Liaoning to Shanxi (Shansi) and Shaanxi (Shensi) provinces. It is a kind of open forest composed of several species of deciduous oaks.

(ii) Composition

The common oak species of this region are Quercus mongolica, Q. dentata, Q. aliena, Q. acutissima, Q. variabilis, and at higher elevations, Q. liaotungensis.

Pinus tabulaeformis is usually associated with the oak forest. Other conifers of this region are Thuja orientalis and Juniperus rigida. On better sites and in the sheltered valleys, a number of other deciduous broadleaf trees are found in the oak forest. They include ash (Fraxinus chinensis), Carpinus spp., Ostrya spp., maple (Acer truncata, A. mandshuricum), linden (Tilia mongolica, T. mandshurica), Celtis koraiensis, chestnut (Castanea mollissima), Juglans mandshurica, and elm (Ulmus macrocarpa, U. spp.).

2-2: Northern broadleaf forest on the Northeastern College of Forestry Experimental Forest, Heilongjiang (Heilungkiang) Province.

2-3: Birch (Betula spp.) and other broadleaf species in the Northeast.

The lower slopes and the plains have long been under cultivation. The principal crops are winter wheat, corn and cotton. Among the most commonly planted trees, in addition to poplar (Populus spp.), willow (Salix spp.), and elm (Ulmus spp.), is black locust (Robinia pseudoacacia)--introduced from North America. Black locust is ubiquitous and firmly established on eroded slopes and abandoned fields. In the southern part of this region, evergreen oaks (Quercus glauca, Q. baronii) and other evergreen broadleaf trees (Machilus thunbergii, Lindera spp.) appear in the deciduous oak forest.

2.5.6 The Mixed Deciduous and Evergreen Broadleaf Forest

(i) Location

The mixed deciduous and evergreen broadleaf forest is located between the deciduous oak forest of the northern provinces and the evergreen broadleaf forest of the South in a continuous belt north of the Chang (Yangtze) River from the Pacific to Shaanxi (Shensi) and Gansu (Kansu) provinces. In the eastern section, it covers the lower slopes below 500 m, but it extends to 1800 m in the western inland.

(ii) Composition

This forest type differs from the deciduous broadleaf forests of the northern and northeastern provinces in the presence of a number of deciduous broadleaf trees not found in the deciduous oak forest and the mixed northern broadleaf forests. The deciduous broadleaf trees include Albizzia kalkora, Liquidambar formosana, Platycarya strobilacea, Dalbergia hupeana, Rhus chinensis, Pistacia chinensis, Diospyros kaki, and Sassafras tsuma.

Deciduous and evergreen oaks (Quercus) and related genera (Lithocarpus, Castanopsis) are the most important forest components. The common deciduous oaks are Quercus acutissima, Q. aliena, Q. variabilis, Q. fabri, and Q. glandulifera. The common evergreen broadleaf trees include Quercus glauca, Q. gracilis, Q. myrsinaefolia, Castanopsis sclerophylla, Lithocarpus glabra, L. henryi, and evergreen lauraceous trees (Cinnamomum camphora, Phoebe hearerі) and Schima superba.

The most common conifers are Pinus massoniana, and Cunninghamia lanceolata. Pinus massoniana is commonly planted on denuded slopes and Cunninghamia in sheltered valleys, coves and less harsh slope environments.

2.5.7 Evergreen Broadleaf Forest

(i) Location

Of all the forest regions in China, the evergreen broadleaf forest region is the most extensive and potentially the most productive. It is in this region that the Chinese forestry authorities implemented large-scale and long-term reforestation programs to establish a new "Southern Forest Production Base." The evergreen broadleaf forest covers the broad zones approximately south of the Chang (Yangtze) River to the Xijiang-Pearl River drainage, and from the coastal provinces of Zhejiang (Chekiang), Fujian (Fukien), Guangdong (Kwangtung), Guangxi (Kwangsi), and the lower elevations of Taiwan, to the southwestern provinces of Sichuan (Szechuan), Guizhou (Kweichow), Yunnan, and eastern Xizang (Tibet).

(ii) Composition

Major species - The evergreen broadleaf forest is rich in forest composition. The major forest components include over 40 species of evergreen oaks (Quercus, Cyclobalanopsis) and related genera (Castanopsis, Lithocarpus). The other important forest components include evergreen broadleaf trees of Theaceae (Schima, Hartia, Anneslea), Lauraceae (Machilus, Cinnamomum), Magnoliaceae (Manglietia, Michelia, Illicium) and Hamamelidaceae (Altingia, Bucklandia).

2-4: Mixed northern deciduous broadleaves and Abies nephrolepis (Rhododendron in left foreground).

Regional differentiation - Over such an extensive range, the forest components have regional differentiation. The eastern and the western sections of the forest have similar structure, but are represented by different regional species. The changes from the north to south are gradual. In general, there are more Quercus (Cyclobalanopsis) in the north, and more Castanopsis and evergreen broadleaf trees in the South.

The southeastern provinces - In the southeastern provinces of Zhejiang (Chekiang), Fujian (Fukien), Guangdong (Kwangtung) and Guangxi (Kwangsi), evergreen broadleaf forest is the major forest type below 1000 m. The forest of Zhejiang (Chekiang) in the northern portion of the range is composed primarily of Quercus (Cyclobalanopsis) glauca, Q. myrsinaefolia, Castanopsis schlerophylla, Lithocarpus glabra, and non-cupuliferous trees Schima superba, Phoebe sheareri, and Machilus thunbergii. The forest of Guangdong (Kwangtung), in the South, is composed primarily of Quercus nubium, Castanopsis fissa, C. fordii, C. fabri, C. fargesii, C. carlesii, Machilus panhoi, and Cinnamomum japonicum.

The most important coniferous trees in the southeastern provinces are Pinus massoniana, Cryptomeria fortunei, and Cunninghamia lanceolata. The introduced species, Pinus elliottii and P. taeda are successful in the lower slopes, and baldcypress (Taxodium distichum) is widely planted in the lower Chang (Yangtze) and Xijiang-Pearl River valleys and the delta regions.

The southwestern provinces - In the southwestern provinces, the evergreen broadleaf forests occupy the higher altitude. In the northern part of Yunnan the range is approximately 1600-2500 m, and in Sichuan (Szechuan), Guizhou (Kweichow) and the southern part of Yunnan the range is 600-1600 m. Deciduous broadleaf trees and Tsuga appear above this belt.

The forest components of the evergreen broadleaf forest of the Southwest, especially of Guizhou (Kweichow) and Yunnan, are different from those of the southeastern provinces. In the northern part of Yunnan, the important trees of this type are evergreen (Quercus delavayi, Q. glaucoides), other cupuliferous trees (Castanopsis orthocantha, C. delavayi), and Schima Wallichii. In the southern part of Yunnan, the important trees of this forest type are Castanopsis hystrix, C. indica, C. ferox, C. tribuloides, Lithocarpus microspermus, Phoebe nanmu, Schima noronhae and Anneslea fragrans. In southeastern Yunnan the most important evergreen cupuliferous tree is Castanopsis hystrix. Intermixed with the evergreen oaks are evergreen trees of Magnoliaceae (Manglietia fordiana) and Lauraceae (Machilus breisflora, M. yunnanensis).

Open growth of pine forest is the most common feature of the denuded slopes. In Sichuan (Szechuan) and Guizhou (Kweichow) the most common pine is Pinus massoniana, and in Yunnan, Pinus yunnanensis. The other important conifers of this region are Pinus armandi, Keteleeria evelyniana and Cuppressus duclouxiana. Several species of Eucalyptus are introduced to this region. The most commonly planted species include E. robusta, E. citriodora, and E. globulus.

Bamboo is highly productive and economically important. The planted groves and natural growth of bamboos have a combined area of 2.7 million ha. There are 26 genera and about 300 species of bamboos in China. The most important bamboo is Phyllostachys pubescens, which accounts for 70 percent of the bamboo area.

2.5.8 Rain Forest

(i) Location

The rain forest region constitutes a relatively small portion of the nation's land area, but it is of great economic importance. This is the only region in China where tropical trees and tropical crops can be planted.

Rain forest is distributed in the southern part of Guangdong (Kwangtung), Guangxi (Kwangsi), Yunnan and Taiwan Provinces, and the southeastern part of Xizang (Tibet). This is the narrow strip of frost-free land on the border of Vietnam, Laos, Burma and India. Most of the areas are located south of the tropic of Cancer, and below 500 m in elevation. But in Xizang (Tibet), rain forest extends to 38-29° Lat. N. and 1000 m in the protected valleys.

(ii) Composition

Dipterocarpaceae - In forest composition, the rain forest is similar to that of southeastern Asia. The crown layer of the Chinese rain forest is characterized by tall trees of Dipterocarpaceae. Dipterocarpaceae, the largest and the most important group of forest trees in tropical Asia, are found in China only in the rain forest region. It is represented by Dipterocarpus alatus, D. pilosus, D. tonkinensis, D. turbinatus, Hopea chinensis, H. hainanensis, H. mollissima, Vatica astrotricha), Shorea assamica, S. robusta and Parashorea chinensis.

Other groups of tropical trees represented in the crown layer include Sterculiaceae (Heritiera, Pterospermum, Sterculia), Meliaceae (Dysoxylm, Aglaia, Chukrasia, Aphanamixis) Moraceae (Artocarpus, Ficus), Sapindaceae and Tetramelaceae.

Under the crown layer the rain forest has one to two secondary tree layers, and then a layer of smaller trees and a ground cover of shade plants and ferns. The tree trunks are covered with epiphytic Bryophytes, orchids, ferns, and Gesneriaceae. Among the understories are different genera of palms (Arenga, Rhapis, Caryota, Phoenix, Pinanga) and tree ferns (Cyathea). The tangles of spring climbing palms (Calamus spp.) are the most characteristic and formidable of the undergrowth.

Mangrove - Mangrove is the natural coastal forest of Guangdong (Kwangtung), Guangxi (Kwansi), Taiwan and Fujian (Fukien) provinces, up to 27° 20". It covers extensive areas in Guangdong (Kwangtung), especially in eastern and northeastern Hainan Island. The best developed stand attains a height of 15 m. Mangrove (Kandelia candel) is successfully planted in the brackish water of southern Zhejiang (Chekiang) Province, outside its natural range.

The rhizophorous trees that characterize the mangrove are Rhizophora stylosa, R. mucronata (Taiwan), R. apiculata (Fujian), Ceriops tagal, Kandelia candel, Bruguiera gymnorrhiza, B. cylindrica and B. sexangula. Other trees in the mangrove include: Lumnitzera, Heritiera, Excoecaria, Aegiceras, Acanthus, and Avicennia. Casuarina equisetifolia is planted along the coast in a dense belt. Next to Pinus massoniana, the introduced tree Casuarina equisetifolia is the most extensively planted tree in Guangdong (Kwangtung).

Evergreen broadleaf - The coral islands of the Chinese tropical waters are covered with lush forest of evergreen broadleaf trees. The important trees are Pisonia grandis, Guettarda speciosa, Scaevola sericea, Messerschmidia agentia, and Cordia subcordata. Plantations and spontaneous growth of coconut palm (Cocos nucifera) are found in most of the islands.

Tropical crops - The rain forest region is the only place in China where Brazilian rubber (Hevea) can be produced. Hainan Island of Guangdong (Kwangtung), and the Shisonghana Autonomous Region of southern Yunnan have large acreages of rubber plantations. By the current process, 8 tons of wood are needed to cure 1 ton of rubber. The other tropical crops produced in this region include coconut (Cocos), Areca catechu, oil palm (Elaeis guineensis), Agave sisal, and a number of tropical fruits (banana, pineapple, papaya, mango, Litchi, Nephelium, and Averrhoa).

2.5.9 The Wooded Grassland Region

(i) Location

The wooded grassland occupies the broad areas of foothills and plains in the western part of the northeastern provinces and adjacent region in Inner Mongolia. This region is characterized by open stands of forest trees scattered among lush growth of tall grasses. The grasses are predominantly Aneurolepidicum chinense, Stipa baicalensis, and Filifolium sibiricum with admixture of numerous mountain meadow forbs (Trifolium, Vicia, Astragalus, Artemisia, Bupleurum, Alchemilla, Lathyrus, and Hemerocallis). This region is the most productive of China's pasturelands.

(ii) Composition

Northern section - The northern section of the wooded grassland is adjacent to the coniferous region of the Da Hinggan Ling mountain range. The elevation is 700 to 1200 m. The isolated groves of forest trees are white birch (Betula platyphylla), or mixed stands of white birch and aspen (Populus tremula var. davidiana), and in sandy areas, Pinus sylvestris var. mongolica.

Southern section - The southern section of the wooded grassland region occupies the plains of the northeastern provinces. It extends to the deciduous broadleaf forest region of the northern provinces. The general elevation of the plain is 200-300 m. This tall grass grassland is largely reclaimed, and becomes one of the great grainaries of China. On the foothills are deciduous oak (Quercus mongolica) and dense thickets of hazel (Corylus heterophylla, C. mandshurica). At higher elevations are black birch (Betula dahurica), aspen, linden (Tilia mandshurica), and other trees of the mixed broadleaf forest.

Inner Mongolia - In the grassland of Inner Mongolia, trees are limited to sheltered valleys. They include aspen, linden (Tilia mongolica), and birch (Betula platyphylla). On the open grassland there are occasionally lines of old elms (Ulmus pumila). They are generally associated with springs, lost rivers, or underground streams.

2.5.10 The Grassland Region

(i) Location

The non-forested regions are located in the northwest and comprise approximately half of China's land area. They are the grassland region, the desert region, and the Tibetan Plateau region.

In Inner Mongolia the eastern part is grassland and the western part desert. The best developed grassland of Inner Mongolia extends from Daqingshan (The Great Blue Mountain, 2000 m) to Lake Halum (600 m) region, a range of approximately 1500 m. East of the grassland are the forest regions and wooded grassland of the northeastern provinces, and west of the grassland are the deserts of Alashan and Xinjiang (Sinkiang). The centers of pastoral economy, Huhhot and Siliuhaote, and the majority of the Mongolian populations are located in this grassland belt.

(ii) Composition

The most abundant grass is Stipa grandis. Toward the western section of the range and on over-grazed areas, Stipa krylovii becomes increasingly important. The grasses of the sandy soils are several species of Agropyron (A. desertorum, A. cristatum). On the better site is the most palatable and productive yangcao or sheep grass (Aneurolepidium chinense). It is doubtful that the precarious harvest justifies the cultivation of this type of good pastoral land for field crops.

The grassland of the drier Vlanchap region, north of Huhhot, is composed mostly of Stipa gobica. Other common components are Stipa glareosa, S. klemengii, Cleistogenes songorica, and onions (Allium polyrrlinzum, A. mongolicum). This type of grassland extends to the Altai region in Xinjiang (Sinkiang).

The grassland south of the Daqingshan from Huhhot, Inner Mongolia, to Lanzhou in Gansu (Kansu) Province is different from that of Mongolian plateau. The grassland of this region is primarily composed of Stipa bungeana and S. purpurea, intermixed with Bothriochloa ischaemum, Agropyron spp., Potentilla chinensis, Affruticose shrubs Lespedeza (L. dahurica, L. hedysaroides, L. floribunda), and sagebrush (Artemisia capillaris, A. gmelinii, A. giraldii). This type of grassland extends eastward to northern Hebei (Hopei) and western Liaoning provinces.

The Ordos plateau (900-1500 m) is covered with moving sand with scanty vegetation. The loess plateau (800-1800 m) has an accumulation of 50-150 m of wind-borne deposits. On the foothills and dissected gullies of the loess plateau are thorny shrubs (Zizyphus sativa, Hippophae rhamnoides) and other shrubby plants (Vitex, Oxtryopsis, Tamarix, and Xanthoceras sorbifolia). On the upper slopes are patches of deciduous broadleaf trees and conifers similar to those of the deciduous broadleaf forest of the northern provinces. The common trees include Quercus liaotungensis, Pinus tabulaeformis, Thuja orientalis, Juniperus chinensis, and J. rigida. At higher elevations are aspen (Populus tremula), white birch (Betula platyphylla), and linden (Tilia mongolica), and 1700-1900 m on the northern slopes are spruce forest (Picea meyeri, P. wilsonii).

2.5.11 The Desert Region

(i) Location

The desert region occupies over one-fifth of China's land area. This region is characterized by desert basins intercepted by lofty mountain ranges, inland rivers without outside drainage, and dry valleys that descend to 154 m below sea level. The deserts are located in the Dzungaria Basin (300-500 m), and the Tarim Basin (800-1500 m) of Xinjiang (Sinkiang), the Tsaidaur Basin (2600-3000 m) of Qinghai (Chinghai), and the Alashan Plateau (1000-1500 m) and Ordos Plateau (900-1500 m) of Ningxia (Ningsia) and Inner Mongolia. The sand desert and the gravel desert have a combined land area of approximately one million square kilometers (sq km).

(ii) Composition

The desert vegetation has a distinct concentric pattern of distribution. The center and the lowest part of the desert basins are occupied by sand dunes, saline plants around salt lakes and lush dense gallery forest of poplar (Populus euphratica) and Tamarix spp. around fresh water lakes and rivers. Along the periphery of the desert basin is the belt of meadows and oases developed on fine deposits of the alluvial fans. Above this belt are desert scrubs on gravelly deposite of the piedmont. On higher slopes of the surrounding mountains are grassland and spruce forests.

Desert trees - On the open desert, Haloxylon ammodendron is the most conspicuous and widely distributed of the desert plants. It is a leafless small tree with green deciduous branchlets. It grows to 7 m in height (but usually only 2-4 m) and 60 cm in diameter. It forms dense "forest" from the Dzundaria, Tarim, and Tsaidam basins to the plateau of Alashan and in the sand desert, the gravel desert, and saline flats. On the stabilized and semistabilized dunes, Haloxylon ammodendron usually forms mixed stands with a related species, H. persicuux. The other desert shrubs usually associated with Haloxylon are species of Calligonum, Ephedra, Zygophyllum, Potaninia and Nitraria.

Shrubby and suffruticose plants - The most extensive types of desert vegetation are composed of shrubby and suffruticose plants forming pure or mixed stands in the desert basins and plateaus. The most important desert shrubs include Ephedra przewalskii, Zygophyllum xanthoxylon, Nitraria sphaerocarpa, Gymnocarpos przewalskii and Calligonum roborowskii). Calligonum is the most important shrub in the sand desert. The sand desert shrubs include Calligonum mongolicum, C. leucocladum, and C. rubicundum, and Ammodendron argenteum.

Sagebrush (Artemisia spp.) - Sagebrush is an important type of the desert vegetation. This type extends to the upper slopes. In the sand desert, Artemisia sphaerocephala is usually associated with the desert grass Psammochloa mongolica. The sagebrush, 1 m in height, occupies the lower part of the active sand dunes and sand flats; and Psammochloa, 0.5 to 1 m in height, occupies the upper part of the sand dunes. Both of them have extensive root systems. The long rhizome of Psammochloa extends to 40 m. The other sagebrush types are represented by Artemisia arenaria, A. santolina, A. terrae-albae, A. borotalensis, A. kaschgarcia, A. parvula, and other related genera (Brachanthemum, Asterothamnus, and Ajania).

Scrubs - In the desert basins there are large tracts of saline and calcareous deposits. Suffruticose scrubs and succulent scrubs of the family Chenopodiaceae are the typical vegetation types. The important suffruticose scrub plants are Reaumuria, Ceratoides, Salsola, Sympegma, Iljinia, Nanophyton, and Anabasis. The important succulent scrub plants are Halostachys, Atriplex, Suaeda, and Kalidium.

2.5.12 Alpine Tundra: The Tibetan Plateau Region

(i) Location and General Description

The Tibetan Plateau Region includes Xizang (Tibet) and Qinghai (Chinghai) provinces. With the exception of the southeastern part, this region is non-forested. The general elevation of the plateau is 4000-5000 m.

The southeastern part of this region is characterized by deep gorges, 2000-4000 m in elevation. On the slopes are coniferous forest at higher elevations and broadleaf evergreen forest at the bottom of the valleys. The vegetation of non-forested areas of the plateau is differentiated, from east to west, into three general types: (1) the mountain scrubs and meadows (4000-4500 m), (2) mountain grassland (4500-5000 m), and (3) mountain desert (5000-5500 m).

(ii) Composition

Mountain scrubs and meadows - The mountain scrub and meadow type is located in the eastern part of Xizang (Tibet) and the southern part of Qinghai (Chinghai). This type is higher in elevation than the adjacent coniferous forest region. The major components of the mountain scrubs are several species of dwarf evergreen Rhododendrons (R. litangensis, R. open-shawianum, R. thymifolium, and R. capitatum), several species of dwarf willows, Potentilla fruticosa, Caragana jubata, Spiraea angustata, and Juniperus spp.

The mountain meadows are primarily composed of several species of Kobresia (K. pygmaea, K. hunanis, K. capillifolia, K. kansuensis, K. prattii, K. tibetica) and Polygonum (P. sphaerootachynen, P. viviparum), and other forbs. The level eastern part of the plateau is characterized by meandering rivers and broad poorly drained valleys.

The swampy land, bogs, and wet meadows are composed of sedges (Carex lanceolata, C. muliensis, C. meyeriana) and wetland grasses (Deschampsia caespitosa, Elymus sinocompressus). On the well-drained slopes are the meadow grass Clinelymus nutans, and Stipa (S. caprillacea, S. aliena, S. purpurea, S. przewalskii).

In general, the mountain scrubs occupy the northern slopes and the meadows in the valleys, and the southern and upper slopes. There are occasional patches of coniferous forest in the sheltered valleys, composed of Picea crassifolia, P. likiangensis, P. purpurea and, on rare occasions, Abies faxoniana and A. sachalinensis.

Mountain grassland - The central part of Xizang (Tibet) and the western part of Qinghai (Chinghai) is an open grassland. This is an area of inland drainage with over 1500 salt lakes (Nor). The general elevation is approximately 4500-5000 m. The grassland is composed of scanty growth of Stipa spp. and sagebrush (Artemisia spp.). The grasses are mostly common species of Mongolia and Xinjiang (Sinkiang). The eleven species of Stipa known to this area include Stipa bungeana, S. krylovii, S. breriflora, S. glareosa, S. gobica, and the endemic S. subsessiliflora var. basiplumosa.

Sagebrush (Artemisia spp.) are an important component of this region. They include Artemisia salsoloides, A. stracheyi, A. minor, A. younghusbandii, S. duthreuil-de-rhinsii, A. moorcroftiana, and A. macrocephala. In the southern valleys, the common grasses are Aristida triseta, Pennisetum flaccidum, and Orinus thoroldii. A unique and important plant of this mountain grassland is a sedge, Carex moorcroftii. It covers extensive permafrost land of the northern region.

Mountain desert - The mountain desert type is located in the western and northwestern part of Xizang (Tibet) and the eastern part of Pamir. This is a land of salt lakes and dried up lake basins. The general elevation is above 5000 m, and the surrounding mountain ranges rise 6000-7000 m above sea level. Under the bleak conditions, the flora includes about 100 species of flowering plants. Most of the species are cushion and creeping plants. The most common plants are Ceratoides compacta (Chenopodiaceae, Hjania tibetica (Compositae), and Carex moorcroftii. The only woody plants in this region are two creeping shrubs, Myricaria prostata and Ephedra gerardiana. Both are endemic to this region, but are phylogenetically related to the deserts of Xinjiang (Sinkiang) and Mongolia.

2.6 AFFORESTATION

2.6.1 Extent of Afforestation Since 1949

During the thirty-year period since the founding of the People's Republic of China, 1949-80, nearly 30 million ha were afforested, of which 20 percent are state-owned and the remainder belong to the communes. Although most of the afforestation is by planting seedlings, some areas have been successfully aerial-seeded in the remote mountains of provinces such as Guanxi (Kwangsi), Yunnan, Sichuan (Szechuan), Hunan and Shaanxi (Shensi) with species such as Pinus massoniana, P. yunnanensis, and P. armandi. The annual area planted is said to exceed the forest area harvested. The forest cover of China increased to 12.7 percent in 1980.

In December 1981, the People's Congress passed a resolution introduced by Minister Yong Wentao requesting obligatory tree planting service whereby all able-bodied Chinese over 11 years of age are required to plant 3-5 trees every year (Anon., The United Journal 1981). The objective is to raise forest coverage to 20 percent by the end of this century and eventually to the national goal of 30 percent.

2.6.2 Types of Plantations

A primary purpose of forest plantations is industrial timber production. Other plantation purposes include shelterbelts and environmental protection, fuel production, bamboo production, and the production of edible oil, industrial oil and other forest products. The percentage of different types of plantations established during 1949-77 and of the nation's existing forest are shown in Table 2-5.

Table 2-5. Percentage of different types of plantations.

	Plantations, 1949-77
Timber plantation	66.5 %
Bamboo plantation	13.3
Non-timber tree crops	11.8
Shelterbelt and protective plantation	6.3
Fuel plantation	2.1
TOTAL	100.0 %

Source: Hsiung 1980.

2.6.3 Agro-forestry, Four-Around Planting, and Commune Plantations

(i) Agro-forestry

In the agricultural regions, trees are planted in a lattice pattern at regular intervals among row crops. This practice is especially common in the dry-farming districts of the northern and the northeastern provinces. Improved hybrids of poplar (Populus spp.) are extensively planted for this purpose. Other commonly planted trees include elms (Ulmus spp.), willow (Salix spp.), and ash (Fraxinus spp.). The compact rows of tall trees provide effective protection for the crop plants from the prevailing windstorms.

(ii) Four-Around Planting

In the densely inhabited areas, commune members are encouraged to plant trees in all spare spaces, such as around houses, around villages, around roads, and along canals and water courses. The "four-around" tree planting movement is carried out on a nationwide scale. A high proportion of new plantations established by communes in the "four-around" planting are devoted to other economic products and bamboo (Table 2-5). Some of the most important economic tree crops are tung oil (Aleurites fordii, A. montana), Thea oleosa, Sapium wax (Sapium sebiferum), tea (Camellia sinensis) and tea oil (Camellia oleosa). Other important forest products include rosin and shellac. The current annual production of rosin is 272,000 metric tons (MT). China potentially will be one of the world's largest producers and exporters of rosin.

(iii) Commune Plantations

The national policy is to rely mainly on the commune to plant forests. The state makes the overall plans and provides technical and managerial assistance. Members of the commune and production brigades are mobilized for large-scale afforestation. They also share the responsibilities of protection, fire control, regeneration and management.

Of the 30 million ha of land afforested in the last 30 years since 1949, six million ha are state owned. The rest belong to local communes. There are now 3900 state-owned forest farms and 220,000 forest farms owned by commune and production brigades.

On collectively owned land, the policy is that the communes, production brigades and groups of people own the trees they plant. In regions with excessive unplanted lands and shortages of firewood, it is permissible to give a certain amount of land to commune members for their private use. This means that the trees they plant and the forest products accumulated belong to the commune members in perpetuity.

2.6.4 The "Great Green Wall" and the Southern Forest "Production Base"

The post-revolution forestry administration implemented two major long-range national forestry projects: (1) The "Great Green Wall" project, or the "3-north" project, and (2) the establishment of a "Southern Forest Production Base."

(i) The "Great Green Wall"

The "Great Green Wall" project was initiated in 1978, with headquarters in Yinchuan of Ningxia (Ningsia) Autonomous Region (Province) in the arid heartland of China. The purpose is to plant drought-resistant trees and shrubs in a 6000-km-long shelterbelt system. This system extends along the woodland-grassland-desert fringe of the three northern regions: the Northern Region, the Northeastern Region and the Northwestern Region from Heilongjiang (Heilungkiang) Province on the Siberian border, through Inner Mongolia, to Xinjiang (Sinkiang) in Central Asia. For common woody plants used in the Northwest for arid-land planting and sand dune stabilization, see Table 2-6.

(ii) The "Southern Forest Production Base"

The establishment of a new southern forest production base is an ambitious move to shift the national sources of wood production to the southern provinces. In consideration of the shrinking acreage of natural reserves, primarily in the northeastern provinces, and the slow growth of the northern plantations, this southward shift of production base is the most promising alternative, and a project of high national priority.

This project redoubled afforestation efforts in the drainage of the Chang (Yangtze) and Sikiang (Pearl) and their tributaries, and in the southwestern provinces. This hilly region extends from the foothills of the Himalayas to the South China Sea. It has abundant rainfall and is practically frost free, a condition most conducive to the intensive management of fast-growing trees in short rotations. The expanding knowledge of tree improvement methods will further increase production potential.

2.7 PROTECTION OF FORESTS

2.7.1 Protection From Fire and Forest Pests

The protection of forests, both natural and plantations, is given high priority in China. The people are mobilized and organized to control fires and forest pests. Fire-breaks, lookout towers, transportation and communication lines, forest patrols, landing fields and aerial fire control brigades are all part of the system to protect forests from fire. In addition, surveys are regularly carried out to determine occurrence and predict development of populations of forest insects, as well as diseases. Both chemical and biological control systems are widely used at state, provincial and local levels. At the same time, an extensive program is underway to select tree species and varieties for pest and disease resistance.

2.7.2 Protection of Natural Ecosystems

China has a great interest in protecting natural ecosystems, rare and endangered tree species and even rare and endangered animals that occupy forest habitats, as well as other types of natural habitats. There are 63 natural areas that have been established or are in the process of being established throughout the country. There is also great interest in China in establishing a countrywide national and local park system. These topics will be more thoroughly discussed in Chapter 3.

Table 2-6. Common woody plants used in arid land planting and sand dune stabilization in the Northwest.

Species	Artificial Regeneration				Natural Regeneration		Natural Forest and Plantations												
	Seeding	Planting	Cutting	Division	Nat'l Seeding	Sprouting	1A	1B	1C	2	3	4	5A	5B	6	7	8	9	10
Caragana microphyllum	+	+			+	+					+					+	+	+	
Caragana korshinskii	+	+			+	+											+	+	
Elaeagnus angustifolia		+	+		+	+					+					+	+	+	
Haloxylon ammodendron	+	+			+	+											+	+	
Haloxylon persicum	+	+			+	+												+	
Hedysarum scoparium																	+	+	
Hippophae rhamnoides	+	+	+		+	+					+					+	+	+	+
Salix mongolica	+	+	+		+	+					+					+	+	+	
Tamarix chinensis	+	+		+	+					+					+	+	+		
Tamarix juniperina		+	+		+	+													
Tamarix ramosissima		+	+		+	+					+					+	+	+	

2.8 POTENTIAL FOREST PRODUCTIONS

2.8.1 Forest Volume, Volume Increment, and Consumption

China has about 9500 million cubic meters (m^3) of forest volume. The per capita forest volume is approximately 9.5 m^3. The average annual volume increment is 2.6 percent, or about 250 million m^3. This is about equivalent to the current annual consumption in China (Hsiung 1980).

2.8.2 Past Forest Exploitation

(i) Causes

Since the founding of the People's Republic of China in 1949, the exploitation of the remaining forest reserves was accelerated by the extension of road systems into hitherto inaccessible regions. Sixty thousand km of highways and 10,000 km of narrow-gauge railways were built in the state-owned forest areas. The removal of forest cover was especially severe during the "Cultural Revolution" when the national directive of "Grain Production First" was relentlessly pursued.

The annual timber output was raised substantially since 1949 from 5 million m3 in the early 1950's to over 45 million m^3 (Hsiung 1980). The need of forest products for fuel in rural areas, and the clearing of forest land for agricultural use further depleted the growing stock.

(ii) Results

From 1949-1978, the tropical forest of Hainan was reported to have been reduced since 1949 from 870,000 ha to 240,000 ha. The severity of forest destruction in the Thai Autonomous Region in southern Yunnan was reported in a June 1981 survey of 95 communes in eleven districts (counties). From 1949 on, the natural forest of the Autonomous Region was destroyed at the rate of 200,000 ha per year, of which 100,000 to 130,000 ha were cleared each year for land reclamation. The original forest cover was reduced from fifty percent of the land area in 1946 to 27 percent in 1980. Topsoil was washed away by the heavy rainfall of the tropics. Densely forested land was reduced to barren desert, with a resultant water shortage for rice field irrigation (Chao Pin 1981).

The high flood level of the Huang (Yellow) and Chang (Yangtze) rivers, and the increasing silt content of the Chang (Yangtze) reached unprecedented levels in 1981. The June 1981 Chang (Yangtze) flood innundated 52 counties (Hsien), and 2.5 million ha of farmland in Sichuan (Szechuan) Province (Chung 1981). This dangerous situation was attributed to large-scale removal of forest cover of drainage area in recent years.

2.8.3 Projections

(i) The Short Term

At the current rate of exploitation, the remaining forest reserve may be exhausted before the replanted and regenerated stands of the cut-over forests can be managed on a sustained yield basis. The short-term prospect of forest production is that China will have acute timber shortages in order to meet her increasing needs for at least the next quarter century.

(ii) The Long Term

In contrast, the long-term prospect of timber production in China is highly promising. The average annual timber volume production of China's fully stocked forests is comparable to that of the United States and is more than twice as high as that of Canada and Russia (Table 2-7).

Table 2-7. Average annual timber volume production: China, USA, USSR, Canada.

	CHINA	USA	USSR	CANADA
Land (square km)	9560	9363	22,400	9977
Commercial Forest Area (million ha)	120	198	792	314
Commercial Forest Volume (billions of m^3)	9.9	19.9	83.1	19
Annual Total Timber Growth Per Ha (m^3)	2.2	3.0	1.0	.99
Population (million)	914	220	260	23.9

Adapted from: American Forest Institute 1981.

China's population is about 1,000 million and only 12 percent of China's total land area is under cultivation. Because of the nature of the land the additional amount that can be put under cultivation is limited. Furthermore, it is estimated that 258 million ha, or about 27 percent of China's total land area, is suitable for forest growth. Forest production increase is vitally important to China's national economy. In consideration of the high increment rate of Chinese forests, and the traditional silvicultural practices of intense management of fast-growing trees in short rotations, China has the potential to become one of the world's leading timber producing countries in the coming century.

Chapter 3[1]

NATURE CONSERVATION, WILDLAND RECREATION AND WILDLIFE CONSERVATION

3.1 INTRODUCTION

The preservation of a spectrum of wildland areas allows a nation to maintain representative samples of ecosystems, to protect rare and endangered plants and animals, to protect areas of cultural heritage, to preserve scenic beauty, to maintain genetic reserves, to provide settings for education and research, and to provide areas for citizens to engage in wildland recreation.

Necessary to the accomplishment of these protections and provisions is an active role on the part of the government to ensure the existence of such areas. The central government of the People's Republic of China has assumed that role. Since 1949, they have established a substantial network of nature reserves, forest reserves, and wildlife sanctuaries (Figure 3-2; Tables 3-2, 3-3, 3-4), as well as wildland recreation areas and urban parks and gardens.

The breadth of activity in these areas, impressive as it may be, is even more impressive in light of the fact that of all forestry-related activities, the preservation and maintenance of natural and nature-related areas is the most recent.

3.2 NATURE CONSERVATION IN CHINA: FOUR ELEMENTS

The Chinese concept of nature conservation or the setting aside of wildland areas to be managed for preservation and recreation is in a stage of evolution. At least four elements seem to offer insights for understanding the most recent conception of nature conservation. These are the ancient idea of the Chinese garden, the more recent idea of natural protected areas, the promotion of an expanding tourism industry, and the realization that preserving environmental quality is a precondition to sustaining China's culture and environment.

3.2.1 The Chinese Garden Concept

(i) Philosophical Elements

The concept of the Chinese garden embodies the philosophies of Confucianism, Taoism and the Chinese version of Buddhism. As a philosophical concept, it represents not only a defined physical space, but also a mental or transcendental space. To better understand this ultimate illusion of the "natural," some of the impacts each of these philosophies has had on the development of the Chinese garden concept will be examined.

Confucianism - Confucianism stresses the virtues of the simple and the ancient. Particularly important to understand is the concept of harmony and the connection between the simplicity of the agrarian lifestyle and the Chinese garden. Man is seen as the "agent through which the abundant potential of nature could be fully realized" (Keswick 1978). This philosophy is not only reflected in the physical presence of rural style architecture, pavilions, terraces and croplands found in many Chinese gardens, but also in the very essence of the garden designer's approach to creating the "artificial natural."

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[1] This section written by Dr. William McLaughlin, Professor, University of Idaho.

Furthermore, the Confucian view of man as a social being is important in that it set the stage for gardens to be places for social gatherings (Moss 1965). Thus, spaces were designed to accommodate hunts, exhibits, plays, poetry readings and the social event of drinking tea.

Taoism - This philosophy presents man as one with nature in a constant search to find unity with the universe. This struggle makes man aware of the shifting patterns and cycles of nature, nature's polar opposites yin and yang, and the need to act not contrarily to nature, but harmoniously (Keswick 1978).

Accordingly, gardeners attempt to create shifting patterns and the cycles of seasons through their arrangements and choices of plantings and architectural structures. The rhythm of nature is created by varying sizes, shapes and entrances to spaces. These create an illusion of flow, as does one's movement along the intricately designed, hard-surfaced winding paths laid out to guide the visitor through the "natural" sequences of the garden.

Polar opposites are best depicted in the Chinese garden by the always present rock and water. The solid, rough, still rock is often aesthetically juxtaposed to permeable, silky, flowing water. Rock and water are important elements of nature and thus critical elements for inclusion in a Chinese garden.

To the Taoist the garden was the universe in miniature where man could experience solitude and the mysteries of nature. Walking through these artificial yet natural sequences of spaces was the equivalent of floating through time, the seasons and the wilderness of nature. In taking such a walk and/or creating such a place it was thought that individuals could find inner strength and perhaps even the immortality sought by Taoists.

Buddhism - Chinese Buddhism was a manifestation of many Confucianism and Taoist ideas, as well as a source of new traditions for the Chinese and their garden concept. For instance, the already sacred position held in society by mountains and rock was accentuated by the Buddhist notion of the universe arranged around a central mountain peak (Keswick 1978). Thus, the importance of creating artificial natural mountains and including rock in a garden is reinforced. Also, because mountains or high places were sacred, many gardens were built around a temple placed on a hilltop or mountain peak. This resulted in the de facto protection of many high places and their surrounding landscapes.

The Buddhists' reverence for mountains also led to the inclusion of the "mountain monastery" as an acceptable concept for a Chinese garden. This resulted in temples being built in gardens and the social acceptance of a group of individuals seeking spiritual quests. This consideration was quite different from the individualistic Taoist approach to gardens. It is, perhaps, this group-learning aspect that encouraged gardens to become acceptable places for poets, painters and scholars to gather. For the future it might suggest that environmental education for the masses would be a culturally acceptable use of Chinese gardens.

(ii) The Categories of Chinese Garden Settings

Three major, historical categories of garden settings underlie Chinese Gardens: (1) imperial gardens, (2) private gardens, and (3) temple gardens. The imperial gardens were those developed by China's political rulers, private gardens were those developed by individuals, oftentimes scholars and artists, and temple gardens were those in which a religious group and its purposes dominated.

Imperial gardens - The first imperial gardens were thought to be located in southern China. Based upon early (4th Century B.C.) descriptions in poetry and writings, these areas contained man-made lakes, paths, rock formations, and rural buildings.

3-1: Entrance to the Shanghai Botanic Gardens; the wall, the plants, the flowing lines are elements of the traditional Chinese garden.

3-2: Inside the Shanghai Botanic Gardens, rocks arranged around a pool provide seating and pleasant vantages from which to contemplate the typically Chinese combining of rock and water.

They were described as luxurious places symbolizing the wealth and power of the rulers. It was perhaps during China's first dynasty, the Xia Dynasty (2205-1766 B.C.), that imperial gardens began.

From that time, dynasty after dynasty developed imperial gardens. These were places seen by rulers as microcosms of their empires. They imported specimens of plants and animals from all over their empires to complement the artificial natural elements of gardens espoused by the traditional philosophies. Early garden activities are thought to include hunting, farming, gardening and mystical ceremonies. In fact, some suggest that the first gardens were hunting parks (Moss 1965). Over time, more sedate activities like walking, painting, and writing became important, as did social gatherings. Imperial gardens were being constructed as late as 1911 by the Qing Dynasty (1644-1911 A.D.). Today, some of these areas, like the Parks of the Sea Palaces in Beijing (Peking) still exist; others are being restored as tourist attractions and city parks.

Private gardens - While the imperial gardens evolved, so did private gardens. They were of predominantly two types: luxurious pleasure pleasure gardens often built by successful subjects of a ruler, and gardens developed as retreats and places to commune with nature. The latter represented the Taoist philosophical concept of a Chinese garden. Here the motivation of the gardener was not to display wealth, but rather, through creating the picturesque and natural, to search for inner strength and the ideals of love, desire, character and community. Many of these types of gardens were developed by great scholars and artists to draw attention to rulers' wastes and abuses of power and perhaps are most responsible for the merging of gardening and the arts, particularly landscape painting (Sun 1980). Today, some of these private gardens are now protected park areas. One example is Shou Xi Hu in Yang Zhou, where hundreds of small gardens initially developed during the Jin Dynasty (265-420 A.D.) were, after liberation, connected into one continuous city park area (Wu and Feng 1980).

Temple gardens - The third and final type of garden developed was the temple garden. These gardens were predominantly created as sacred or religious places. Since the two previously discussed garden types also reflect religious philosophies, the word predominantly is critical to understanding this class of gardens.

For the most part, these gardens and protected areas were set aside and designed by monks and other religious persons and groups. Usually they represented the essence of whatever philosophical and religious tradition they represented.

Contrary to what might be expected, these temples and their surrounding grounds varied from the extravagance of imperial gardens to the simple and the common. Today, many of these areas near urban centers represent the only remaining predominantly natural environments. In many areas they have become part of some city, county or provincial park system.

(iii) Summary

It is important to understand the roles philosophy and history have played in creating protected areas designated as Chinese gardens. The view of nature reflected by the gardens represents China's culture and its long evolution. This view of nature is taught in China's landscape gardening programs and is perpetuated by the many planners and designers presently responsible for managing and developing China's wildland recreation resources.

3.2.2 Natural Protected Areas

(i) Background

The initial concept of a nature reserve in China was to preserve natural ecosystems for scientific study, as benchmarks against which to measure change and as sources of gene pools. The first of China's nature reserves is reported to have been established in 1956 in Guangdong (Kwangtung) Province to protect the evergreen broadleaf forest (Wang 1980).

Today, China has established 63 natural protected areas, occupying .16 percent of the total area of the country. Perhaps more significant was the proposed expansion of the concept of nature reserves to the broader concept of natural protected areas. Under this concept, Wang (1980) suggests four classes of areas.

(ii) Four Proposed Classes of Areas

1. Areas that protect the whole landscape. This class would preserve large areas containing several ecosystems. Wildlife protection is envisioned as a key feature of this class.

2. Areas to protect special types of ecosystems. Smaller than areas in the first class, these would focus more on protecting a single ecosystem.

3. Areas to protect rare species of animals and plants. These areas, smaller than the first two classes, would focus on protecting single stands of trees and areas containing rare plant or animal species. The emphasis is more on protecting populations and sub-populations of plants and animals rather than the ecosystem.

4. Areas of tourism and recreation. These areas would include regions of natural scenery, areas having historic and cultural sites, and selected areas of old growth timber. These recreation and tourist attractions are seen in some cases as being a subdominant part of a natural ecosystem and in other cases predominantly artificial natural environments embodying the underlying ideas of the garden concept.

It may be argued that perhaps only the core area of a natural protected area can be preserved. However, a surrounding buffer area could be managed for such activities as timber harvesting and animal breeding. Experimental areas might also be set aside to allow local people's needs to be met. These areas could be cultivated and used to establish artificial ecosystems compatible with the landscape zone. It is in these areas that tourist and research facilities could be established (Wang 1980).

(iii) A Proposed National Natural Parks System

Under a proposed concept of national natural parks, areas with natural ecosystems, natural beauty and natural features may be preserved in China (Yen et al. 1980). The functions proposed for these areas include protecting unique natural ecosystems, providing places for scientific research, providing a setting for teaching students and the masses about ecology, and providing opportunities for human enjoyment by allowing tourists to visit the protected areas (Yen et al. 1980). This proposed natural national park concept focuses on natural ecosystems of national significance. Areas that are cultural sites, where the ecosystem is artificial, would not be included in the designation.

(iv) Functions of a National Park System

In the summer of 1980, sixty-four professionals throughout China attended a four-week course in Nanjing (Nanking) entitled Wildland Recreation Development and Planning. The course was sponsored by the Beijing College of Forestry, the Nanjing Technological College of Forest Products, the Shanghai Bureau of Parks and Gardens, the Chinese Ministry of Forestry and the College of Forestry, Wildlife and Range Sciences at the University of Idaho, U.S.A.. The professionals included faculty from colleges of forestry, agriculture and architecture, as well as park superintendents, managers and planners from parks throughout China. The dominant professionals represented were individuals trained in landscape gardening, a program offered through colleges of forestry in China.

A Survey - As a part of the course, a small group process was conducted to generate a list of reasons why China should establish national parks. Table 3-1 displays the twelve most important reasons developed by the class. It should be noted that this list represents the opinions only of the attending individuals.

Results: A Diverse Array of Activities - The results suggest that a diverse array of activities is perceived as being appropriate within national parks, one type of natural protected area. These would include natural resource production (timber, mining etc.), agriculture activities, recreation and tourism oriented activities, environmental education and scientific research, to mention a few. The similarities between the concept of the Chinese garden and reasons for setting aside national parks are striking. The evolutionary aspects of the orientation toward the "natural" is seen as one possible explanation. Meanings attached to spaces and places are very likely to be culturally dependent.

(v) Summary

The very fact that the government has set aside some natural protected areas and that scholars and governmental officials are discussing the idea of nature conservation is encouraging. Also of critical importance is the emphasis on ecosystem protection and the recognition of the difference between natural and artificial ecosystems. And, finally, it is interesting to note the diversity of legitimate reasons for nature conservation in China.

3.2.3 China's Expanding Tourism Industry

(i) Recognition of a Potential Market

In 1979, China received 960,000 tourists from abroad. Of these, 17 percent were foreign and 83 percent were "overseas Chinese."[2] By 1985, the number of international tourists is expected to reach nearly 2 million (Zhang 1980).

In 1954, a China International Travel Service was established, and ten years later, the Bureau of Travel and Tourism was established. The Administration of Travel and Tourism has been responsible for tourism since 1978. This agency has established offices in all provinces and autonomous regions and many municipalities, especially those with tourist attractions.

In addition to the expansion of the foreign tourism administration throughout China, tourism centers are being designated for planning purposes; the Chinese Civil Aviation Administration is expanding its international and national services; and schools and colleges to train guides, chefs, taxi drivers, administrative personnel, etc., are being developed in Beijing (Peking), Shanghai, Sichuan (Szechuan), Jiangsu (Kiangsu), Guangzhou (Canton), Guangdong (Kwangtung) and Shaanxi (Shensi).

(ii) Potential Effects of Tourism

The benefits of tourism are obvious. For example, it is likely that foreign currency will flow into China, internal transportation systems will be improved, new jobs will be created, and perhaps foreigners will gain a better understanding of modern

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2 "Overseas Chinese" is a term which, in China, is applied to all people of Chinese descent, regardless of citizenship.

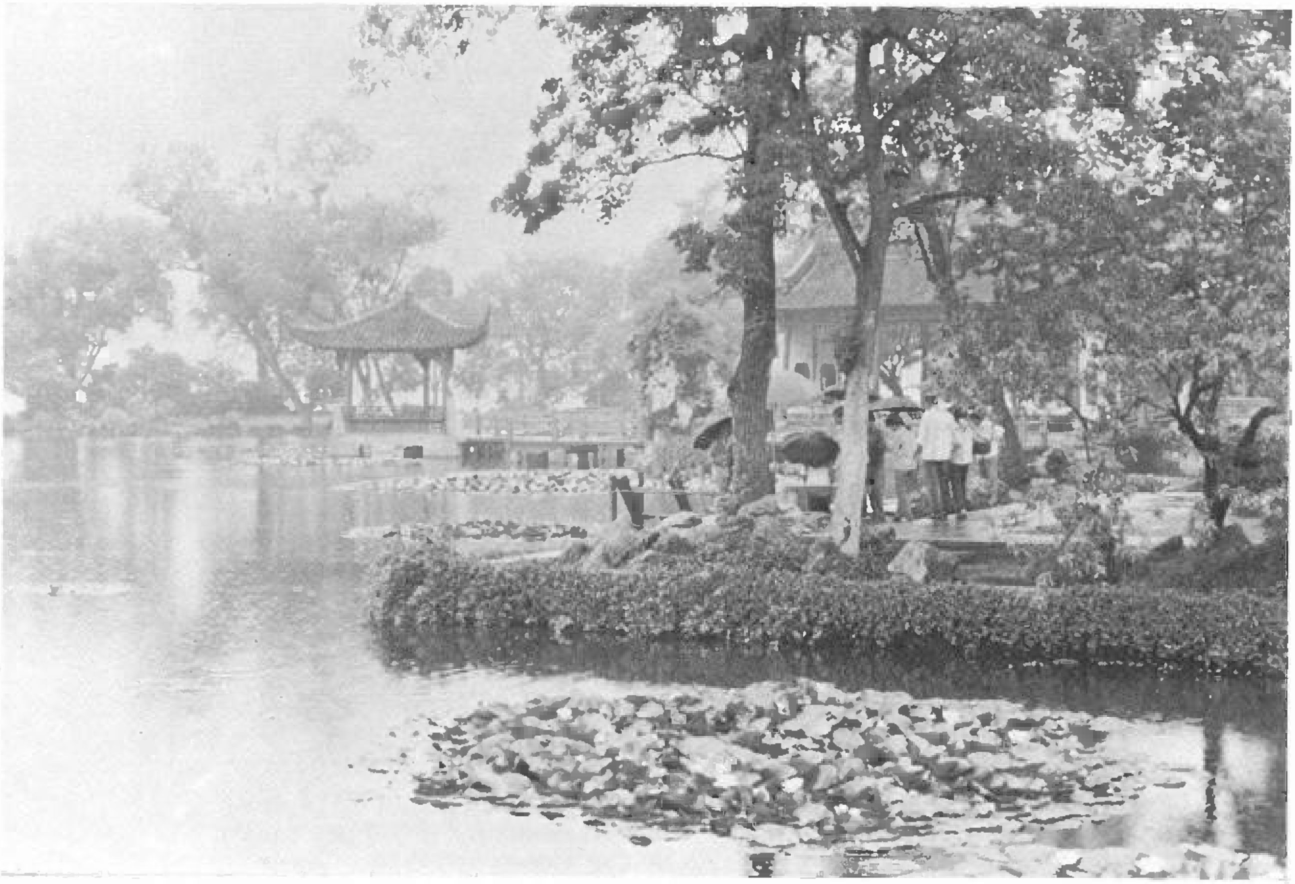
Table 3-1. Prioritized reasons for developing national parks in China[a].

Twelve Most Important Reasons	Individual Poll[b] (N=62)	Group Rating Points[c]
To protect and utilize natural resources	47	1443
To develop the industry of tourism	47	857
To meet the need of people for cultural life and to improve health	36	715
To help create a balanced ecology	27	575
To conduct natural science research	26	305
To protect ecology and develop agriculture	11	240
To benefit future generations	13	212
To enhance the communication and solidarity between people	12	140
To recognize that national parks are the trend for developing parks	6	107
To bring the interrelationship closer between man and nature	5	90
To bring natural science education to the general population/masses	7	60
To resolve the contradictions between people's needs for recreation and the limited recreation opportunities (city parks)	4	50

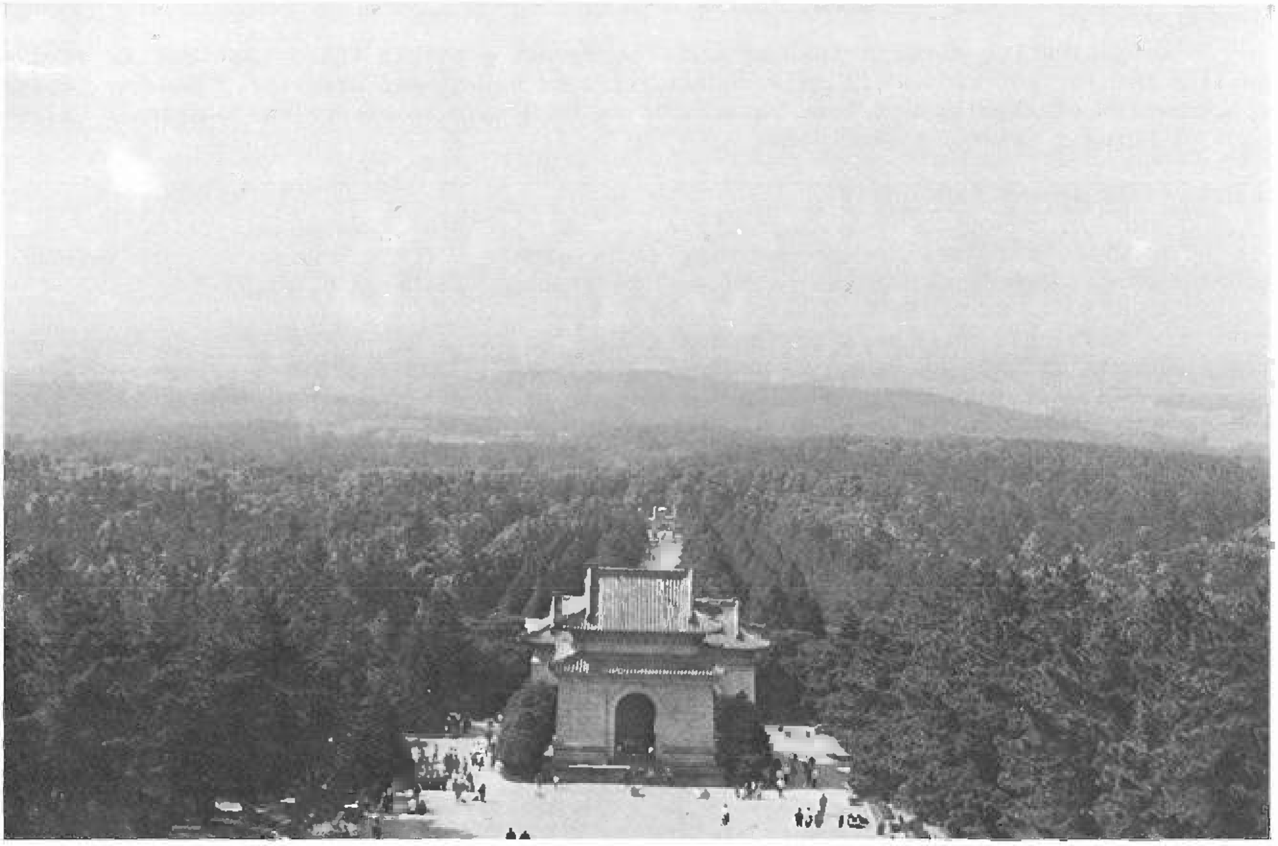
[a]Data were gathered from 62 park and recreation professionals who attended a course in National Park Development and Planning taught in the People's Republic of China in the summer of 1980. These reasons represent the views only of those individuals.

[b]The number in this column represents the number of individuals out

[c]Each individual had 100 points that could be allocated to the reasons which were felt to be most important. The points listed in the column represent the total number allocated by all individuals who participated in the exercise. The more points a reason receives the more important it is to the group.



3-3: A portion of the former Imperial retreat at West Lake (Hangzhou)--a place of pools, arcades, pavilions and nature paths.



3-4: A more strenuous recreation is offered by the 400-step stairway to the Sun Yat Sen Memorial in Nanjing (Nanking), a monumental structure which functions as a centerpiece for the forested park surrounding it.

China. However, international tourism also involves risks, including possibly less positive social impacts resulting from the introduction of foreign customs and behavior. Also, the new class of tourist worker will have to find a place in China's social structure. Most important to the preservation of natural areas is the restriction of numbers of international tourists to natural protected areas so that the very attractions which some tourists desire to see are maintained at an acceptable quality.

The appeal of China for the international tourist is likely to be high for many years to come. Thus, the emerging force of tourism should not be underestimated. Likewise, it is very likely that tourism has the potential to play a key role in the preservation and management of natural areas. Part of the attraction of China is its natural landscapes and unique wildlife.

(iii) Management of Tourism and Recreation Areas

Currently, foreign tourism and the agencies within China that manage it lie outside the jurisdiction of China's recreation land management agencies. However, close coordination of tourism and land management is necessary to ensure the continued existence of China's natural attractions.

3.2.4 Environmental Limits

China's natural environment is deteriorating. Land losses to soil degradation, erosion, deforestation and pollution are reaching alarming proportions.

That this awareness is causing change in China is evidenced by recently renewed efforts in afforestation, upgrading of farming practices, and research in forest genetics and soil stabilization. The investment of funds in these programs, along with recent newspaper articles and billboards in China's cities presenting the problems of air and water pollution, confirm that the government sees the magnitude of environmental problems it faces.

How this idea will be assimilated with the ancient idea that man is an agent to help nature reach its highest level of productivity is yet unknown. If a new environmental awareness is created in China, it may be a solid basis of popular support for an emerging nature conservation movement.

3.2.5 Conclusion

A concept of nature conservation does exist in China. It is truly Chinese in character. Its roots are found in the ancient idea of the Chinese garden, as well as in recent practices in the preservation of natural protected areas. Whether conservation of wildland ecosystems or over-utilization of these ecosystems to produce commodities like timber and recreation experiences occurs is likely to be greatly determined by forces outside of existing and potential natural protected areas. Some of these critical forces are economic and others social. For instance, in an economic sense, tourism will play a role, as will the continued industrial development of China and its accompanying pollution factor. An example at the social level is the need to feed people and thus use land resources for that purpose as opposed to setting aside lands to preserve natural ecosystems. China, with its population pressures and concern for quality of life and traditions, is considering the role it will play in the world nature conservation movement.

3.3 EXISTING AND POTENTIAL WILDLAND RECREATION RESOURCES IN CHINA

3.3.1 Classifying China's Wildland Recreation Resources

Wildland recreation resources can be classified in numerous ways. But in keeping with this chapter's focus on nature conservation, existing and potential wildland recreation resources in China will be presented according to a classification scheme based upon the extent and permanence of man's influence on a land area's natural ecosystem. Figure 3-1 illustrates the spectrum of existing and potential areas in China using this approach.

(i) Focus on the Natural Ecosystem

As with all classification schemes, there are certain types of recreation resources that may fit in several categories. In this case, cultural sites may be found in all of the areas listed. However, the focus here is on the integrity of the natural ecosystem, recognizing that cultural meanings associated with an area can further add to its attractiveness as a recreation site. Many cultural sites are important tourist attractions, but they lie outside the scope of what has been defined here as wildland recreation resources.

In addition, the city afforestation program in China, which is responsible for creating streets and avenues lined with trees, does not fit in the spectrum of existing and potential wildland recreation areas. This program is mentioned because it is often managed by city park bureaus and does represent a potential setting for passive recreation. The scope and goals of the program are beyond the focus of this chapter.

(ii) Scope of Discussion

Each of the eight classes of areas displayed in Figure 3-1 will be discussed in terms of distribution in China, accessibility to the Chinese public and foreign tourists, and jurisdictional responsibility. Examples will be given for each type of area.

3.3.2 Descriptions and Jurisdictions of Area Classes

(i) Unclaimed Wildlands

This category comprises lands unoccupied by crops, urban uses or any other developments. Some of these lands are seen as wastelands. No one is actively managing them. At present, jurisdiction does not seem to have been clearly assigned. Desert areas of northern and western China and other inaccessible areas of China fit this category.

(ii) Nature Reserves

In the strictest sense, this category comprises the areas shown in Table 3-2 and pictured in Figure 3-2. The purpose of these areas is to preserve representative single and multiple ecosystems of China. National jurisdiction for these areas is held by the Committee for Environmental Protection of the State Council and the Academy of Science's research institutes for botany and zoology, and the Bureau of Natural Protection in the Ministry of Forestry. In addition, local and provincial governments have set aside areas. All the areas, as the map shows (Figure 3-2), are in the eastern half of China. The greatest concentration of areas is in Sichuan (Szechuan) Province. Some are within reasonable distances of urban centers and others are rather inaccessible.

These areas are used for research and educational study and, for the most part, are closed to the public for recreation use. These areas certainly represent an untapped recreation potential.

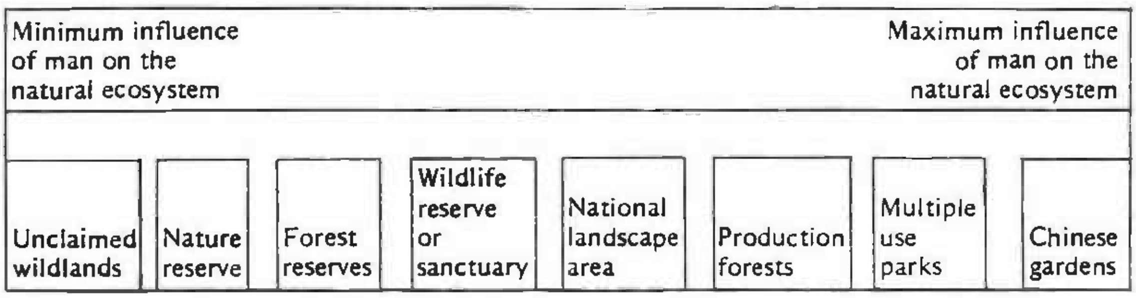


Figure 3-1. Spectrum of existing and potential wildland recreation areas in the People's Republic of China.

Figure 3-2. People's Republic of China: Natural Protected areas (Tables 3-2, 3-3, 3-4).

NATURAL PROTECTED AREAS
(adapted from Wang 1980)

Table 3-2. Nature reserves in China as of March 1980*

Map Number	Province	Natural Protected Area	Location (County or City)	Area (ha)	Purpose	Year Established	Administration	Personnel
1	Beijing (Peking)	Wei-Chang Natural Reserve	Wei-Chang, The Imperial Hunting Reserve, 40 miles north of Beijing	N.I.[a]	Natural forest, and the last natural colony of North China monkey	1958	Ministry of Forestry, Bureau of Forest Reserves, Beijing	N.I.
4	Inner Mongolia	Hanma-Hujin Daxinganlin Nature Reserve	Hanma and mid-Reminha River	480,000	Natural ecosystem (coniferous forest dominated by *Larix*)	Approved and demarcated by the State Council in 1958 and established in 1960.	N.I.[a]	N.I.
7	Jilin (Kirin)	Changbaishan Nature Reserve	Antu, Roushung, and Changbaishan	215,110 (strict protection: 132,235)	Natural ecosystem and northeast tiger, sika deer, Panax Schingseng, *Boschniakia rossica*, etc.	Approved and demarcated by Jilin Province People's Committee in 1960	Changbaishan Nature Reserve Management Bureau, Forestry Department, Jilin Province	250
13	Zhejiang (Chekiang)	Kaihua Gutianshan Nature Reserve	Kaihua-Xian	2,000	Natural forest; evergreen broadleaf forest	Re-approved by the Provincial Revolutionary Committee in 1975	N.I.	N.I.
26	Hubei (Hupei)	Shennongjia Nature Reserve	Shennongjia Forest District	2,000	Golden monkey, Davidia and other endangered trees and wildlife	Approved and demarcated by Hupei Province Revolutionary Committee in September 1978	Shennongjia Nature Reserve Administration Bureau	35

* Three areas in Taiwan - Yangmin-Shan Natl. Park (Fig. 3-2, No. 23), Mangrove Natural Protected Area (Fig. 3-2, No. 24), and Hengchun Natl. Park (Fig. 3-2, No. 25) are not included in these Tables.

a No Information.

NATURAL PROTECTED AREAS (CONT'D)

Table 3-2. Nature reserves (Cont'd).

Map Number	Province	Natural Protected Area	Location (County or City)	Area (ha)	Purpose	Year Established	Administration	Personnel
29	Guangdong (Kwangtung)	Zhaoqing Dinghushan Nature Reserve	Zhaoqing City	1,140 (strict protection 600)	Rain forest	Established in 1956; demoted in 1969; restored in 1975	Dinghushan Nature Reserve and Arboretum, Southern China Botanic Research Institute, National Academy of Science, Zhaoqing City, Guangdong Province	25
34	Guangdong (Kwangtung)	Chingjendong Nature Reserve	Luyuan-Xian	3,133	Subtropical forest and endangered wildlife	Approved and demarcated by Guangdong Province Revolutionary Committee in May 1976	Chingjendong Nature Reserve Management Office, Luyuan-Xian Forestry Bureau	5
37	Guangdong (Kwangtung)	Dongzhaigang	Qiongshan-Xian	2,600	Mangrove	Approved and demarcated by Guangdong Province People's Govern-ment in 1980	Dongzhaigang Natural Pro-tective Area Management Station	15
42	Sichuan (Szechuan)	Labahe Nature Reserve	Tianguan-Xian	12,000	Endangered wildlife	Approved and demarcated by Sichuan Province People's Committee in 1963; re-approved 1974.	Labahe Natural Protective Area Management Station, Sichuan Province and Tianguan-Xian Administration	8

Table 3-2. Nature reserves (Cont'd).

Map Number	Province	Natural Protected Area	Location (County or City)	Area (ha)	Purpose	Year Established	Administration	Personnel
43	Sichuan (Szechuan)	Baihe Nature Reserve	Nanping-Xian	20,000	Golden monkey and other endangered wildlife	Approved and demarcated by Sichuan Province People's Committee in 1963	Baihe Nature Reserve Management Station, Sichuan Province and Nanping-Xian Administration	8
45	Sichuan (Szechuan)	Wanglang Nature Reserve	Pingwu-Xian	27,700	Panda and other endangered wildlife	Approved and demarcated by Sichuan Province People's Committee in 1965	Wanglong Nature Reserve Management Station, Sichuan Province and Pingwa-Xian Administration	15
46	Sichuan (Szechuan)	Wolong Nature Reserve	Wenchuan-Xian	200,000	Panda, other endangered wildlife, and natural ecosystem	Approved and demarcated by the State Council in 1975	Wolong Nature Reserve Management Bureau, Department of Wildlife Protection, Ministry of Forestry, Beijing (Peking)	250
47	Sichaun (Szechuan)	Fongtungzhai (Dachygou) Nature Reserve	Baosing-Xian	40,000	Panda and other endangered wildlife	Approved and demarcated by the State Council in 1975	Management Station under Sichuan Province and Baosing-Xian Administration	17
48	Sichuan (Szechuan)	Tangjiahe Nature Reserve	Qingchuan-Xian	40,000	Panda and other endangered wildlife	Approved and demarcated by the State Council in 1978	Nature Reserve Management Station, Sichuan Province and Qingchuan-Xian Administration	20

Table 3-2. Nature reserves (Cont'd).

Map Number	Province	Natural Protected Area	Location (County or City)	Area (ha)	Purpose	Year Established	Administration	Personnel
49	Sichuan (Szechuan)	Mabian Dafengding Nature Reserve	Mabian-Xian	30,000	Panda, other endangered wildlife, and natural ecosystem	Approved and demarcated by the State Council in 1978	Mabian Dafengding Nature Reserve Management Station, Sichuan Province and Mabian-Xian Administration	15
50	Sichuan (Szechuan)	Maigu Dafongting Nature Reserve	Maigu-Xian	15,000	Panda, other endangered wildlife, and natural ecosystem	Approved and demarcated by the State Council in 1978	Maigu Dafongting Nature Reserve Management Station, Sichuan Province and Maigu-Xian Administration	8
51	Sichuan (Szechuan)	Jiuzhaigou Nature Reserve	Nanping-Xian	60,000	Panda, other endangered wildlife, and natural ecosystem	Approved and demarcated by the State Council in 1978	Jiuzhaigou Nature Reserve Management Station under Sichuan Province and Nanping-Xian Administration	20
52	Sichuan (Szechuan)	Xiaozhaijigao Nature Reserve	Beichuan-Xian	10,000	Panda and other endangered wildlife	Approved and demarcated by Sichuan Province Revolution Committee in 1979	Management Station under Sichuan Province and Beichuan-Xian Administration	8

Table 3-2. Nature reserves (Cont'd).

Map Number	Province	Natural Protected Area	Location (County or City)	Area (ha)	Purpose	Year Established	Administration	Personnel
55	Guizhou (Kweichow)	Fanjinshan Nature Reserve	Jiangko, Yinjiang and Sungtao Xians	36,700	Gray golden monkey, Davidia, other endangered trees and wildlife, natural ecosystem	Approved and demarcated by Guizhou Province Revolutionary Committee in 1978	Management Bureau under Guizhou Province and Xian Administration	60
56	Yunnan	Shiaomongyon (Mengyang) Nature Reserve	Jinghung-Xian	32,800	Rain forest, elephant, peacock and other wildlife	Approved and demarcated by the Yunnan Province People's Committee in 1958	Management Office under the Forestry Bureau of Xishuangbanna Autonomous Zhou	40
57	Yunnan	Mengluen Nature Reserve	Mongla-Xian	6,267	Rain forest, elephant, peacock and other wildlife	Approved and demarcated by the Yunnan Province People's Committee in 1958	Management Office under the Forestry Bureau of Yishuangbanna Autonomous Zhou	10
58	Yunnan	Mengla Nature Reserve	Mongla-Xian	6,233	Rain forest, elephant, peacock and other wildlife	Approved and demarcated by the Yunnan Province People's Committee in 1958	Management Office under the Forestry Bureau of Xishuangbanna Autonomous Zhou	10

Table 3-2. Nature reserves (Cont'd).

Map Number	Province	Natural Protected Area	Location (County or City)	Area (ha)	Purpose	Year Established	Administration	Personnel
60	Shanxi (Shansi)	Taibaishan Nature Reserve	Taibai, Maixian and Zhonzhi Xians	54,158.5	Natural ecosystem	Approved and demarcated by Shanxi Province People's Committee in 1965	Management Office under Shanxi Province Forestry Bureau	35
61	Shanxi (Shansi)	Foping Yueba Nature Reserve	Foping-Xuan	35,000	Panda and natural ecosystem	Approved and demarcated by the State Council in 1978	Management Bureau under Shanxi Province and the Ministry of Forestry	120
62	Gansu (Kansu)	Baishuaijiang Nature Reserve	Wensian	95,292	Panda, golden monkey, mountain sheep, other endangered wildlife and natural ecosystem	Approved and demarcated by Gansu Province Revolutionary Committee in 1978	Management Bureau under Gansu Province and the Ministry of Forestry	81 in 1979, planning to expand to 160

NATURAL PROTECTED AREAS (CONT'D)

Table 3-3. Designated forest reserves in China as of March 1980.

Map Number	Province	Natural Protected Area	Location (County or City)	Area (ha)	Purpose	Year Established	Administration	Personnel
5	Inner Mongolia	Beiyin-Aubao Forest Reserve	Beiyin-Aubao	N.I.	Virgin red bark spruce (Picea koraiensis forest)	Approved by Autonomous Region Revolutionary Committee in 1979	N.I.	N.I.
8	Heilong-jiang (Heilung-kiang)	Fenglin Forest Reserve	Yichuen, Wuying	18,400	Virgin forest of Pinus koraiensis; protected seed tree forest.	Demarcated in 1958; established 1963	Fenglin Forest Reserve Management Bureau, Forest Research Institute, Heilongjiang Province	56
11	Anhui (Anhwei)	Qinghiang-fong Forest Reserve	Huei-Xian	N.I.	Endangered trees and wildlife	N.I.	Management duties assigned to District Forest Research Institute	N.I.
12	Zhejiang (Chekiang)	Linan Xitianmushan Forest Reserve	Linan-Xian	2,000	Natural forest; evergreen broadleaf forest	Established 1962, Re-approved by the Provincial Revolutionary Committee in 1975	Management duties assigned to Tianmu-Shan Forest	N.I.

a No information.

Table 3-3. Designated forest reserves (Cont'd).

Map Number	Province	Natural Protected Area	Location (County or City)	Area (ha)	Purpose	Year Established	Administration	Personnel
14	Zheijiang (Chekiang)	Longquan Fengyangshan Forest Reserve	Longquan-Xian	2,000	Natural forest	Re-approved by the Provincial Revolutionary Committee in 1975	N.I.	N.I.
15	Zhejiang (Chekiang)	Taishan Wuyanlin Forest Reserve	Taishan-Xian	466	Natural forest	Established 1975; re-approved by the Provincial Revolutionary Committee in 1979	N.I.	N.I.
16	Jiangxi (Kiangsi)	Guanshan Forest Reserve	Yifeng-Xian	800	Natural evergreen broadleaf forest	Approved and demarcated by Yichuen District Forest and Reclamation Bureau in 1976	Management Station Yichuan District Forest and Reclamation Bureau	20
17	Jiangxi (Kiangsi)	Longnam Joulianshan Forest Reserve	Longnam-Xian	700	Natural evergreen broadleaf forest	Approved and demarcated by Ganzhou District Forest and Reclamation Bureau in July 1976	Management Station, Ganzhou District Forest and Reclamation Bureau	9
18	Jiangxi (Kiangsi)	Qianshan-Wuyishan Forest Reserve	Qianshan-Xian	1,400	Natural evergreen broadleaf forest	Approved and demarcated by Shonyau District Forest and Reclamation Bureau in 1977	Management Station, Shon-you District Forest and Reclamation Bureau	25

Table 3-3. Designated forest reserves (Cont'd).

Map Number	Province	Natural Protected Area	Location (County or City)	Area (ha)	Purpose	Year Established	Administration	Personnel
19	Fujian (Fukien)	Jianou Wanmulin Forest Reserve	Jianou-Xian	110	Evergreen broadleaf forest	Approved and demarcated by Fukien Province People's Committee in 1957; re-approved in 1976.	Jianou Xian Forestry Bureau	N.I.
20	Fujian (Fukien)	Nanjing (Nanking) Hexi Dadoushan Forest Reserve	Nanjing-Xian	20	Evergreen broadleaf forest	Approved and demarcated by Fujian Province People's Committee in 1963. Re-approved in February 1978	Fujian Province Science and Technology Committee	N.I.
21	Fujian (Fukien)	Sanming Shenkou Forest Reserve	Sanmingshi (City)	800	Evergreen oak forest	Demarcated by Fujian Province Forest Bureau in 1964	Administered by Experimental Forest, Fujian Provincial Forestry College	N.I.
22	Fujian (Fukien)	Wuyishan Forest Reserve	Jianyang, Chongan, Guangze-Xian	56,666	Natural ecosystem	Approved and demarcated by Fujian Province Revolutionary Committee in April 1979	Management office Fujian Province Government	100

Table 3-3. Designated forest reserves (Cont'd).

Map Number	Province	Natural Protected Area	Location (County or City)	Area (ha)	Purpose	Year Established	Administration	Personnel
27	Hunan	Mongshan Natural Forest Reserve	Yizhang-Xian	637	Evergreen broadleaf forest	Demarcated in 1958	Administered by the Mongshan Forest	N.I.
28	Hunan	Zhiyuenshan Forest Reserve	Shimming-Xian	66.6	Evergreen broadleaf forest	Demarcated by Shao-yang District Forestry Bureau in 1973	Administered by Zhiyuenxian Forest	N.I.
30	Guangdong (Kwangtung)	Ledong Jianfengling Tropical Forest Reserve	Ledong-Xian	1,635	Rain forest, long-arm monkey, peacock and other endangered wildlife	Established in 1960; re-approved by Province Revolutionary Committee in 1976	Jianfengling Tropical Forest Reserve Management Station, Jianfengling Forest Bureau	5
38	Guangxi (Kwangsi)	Longsheng Huaping Forest Reserve	Longsheng and Lingni Xians	13,918 (strict protection 4,166)	*Cathaya* and subtropical evergreen broadleaf forest	1961	Management Office under the joint supervision of Guangxi Province and local Science and Technology Committee	35
39	Guangxi (Kwangsi)	Guilin Miaorishan Forest Reserve	Xingan and Ziyuan Xians	1,559 (strict protection 720)	Rare conifers, watershed protection forest	Approved and demarcated by Guilin District Revolutionary Committee in 1976	Management Station, District Agriculture Committee	16

Table 3-3. Designated forest reserves (Cont'd).

Map Number	Province	Natural Protected Area	Location (County or City)	Area (ha)	Purpose	Year Established	Administration	Personnel
40	Guangxi (Kwangsi)	Tientangshan Forest Reserve	Rongxian	267	N.I.	N.I.	Administered by Tientangshan Forest	N.I.
41	Guangxi (Kwangsi)	Lungzhou Longgang Forest Reserve	Lungzhou-Xian	7,997	White-head monkey, limestone evergreen monsoon forest, and natural ecosystem	1979	N.I.	N.I.
53	Sichuan (Szechuan)	Jinfoshan Forest Reserve	Nanchuan-Xian	700 (tentative)	Cathaya and other endangered and valuable trees	Demarcated by Sichuan Province Revolutionary Committee in 1979	N.I.	N.I.
54	Sichuan (Szechuan)	Jinyunshan Area Forest Reserve and Scenic Area	ChungqingCity	1,600	Subtropical forest and natural scenic area	Approved and demarcated by Chungqing City Revolutionary Committee in 1979	Managed by Chungqing City Forestry Bureau	54

Table 3-4. Wildlife sanctuaries in China as of March 1980.

Map Number	Province	Natural Protected Area	Location (County or City)	Area (ha)	Purpose	Year Established	Administration	Personnel
2	Shanxi (Shansi)	LuyaShan Wildlife Sanctuary	Ningwu, Wuzhai, Keianxian	21,200	Endangered wildlife	N.I.[a]	N.I.	N.I.
3	Shanxi (Shansi)	Pangquan-Gao Wildlife Sanctuary	Wenhsui and Fangshan-Xian	8,000	Endangered wildlife	N.I.	N.I.	N.I.
6	Liaoning	Luda Snake Sanctuary (Snake Island)	Lueda City	N.I.	Snakes	1963	N.I.	N.I.
9	Heilong-jiang (Heilung-kiang)	Qiqihari Zhalong Crane Sanctuary	Qiqihare	42,000 (strict protection 2,000)	Red-crown crane, other species of cranes, and wet land ecosystem	Approved and demarcated by Provincial Forestry Bureau in 1976	Management Station, Forestry Dept. of Heilongjiang Province and Qiqihare City.	4
10	Anhui (Anhwei)	Wuhu Alligator Sanctuary	Guongde, Nanling, and Shuenqeng Xians	N.I.	Chang Jian (Yangtze) alligator	Approved and demarcated by Provincial Revolutionary Committee in 1977	N.I.	N.I.

a No information.

NATURAL PROTECTED AREAS (CONT'D)

Table 3-4. Wildlife sanctuaries (Cont'd).

Map Number	Province	Natural Protected Area	Location (County or City)	Area (ha)	Purpose	Year Established	Administration	Personnel
31	Guangdong (Kwangtung)	Dongfang Datian Wildlife Sanctuary	Dongfong-Xian	2,533	Hainan deer and natural forest	Approved and demarcated by Guangdong Province Revolutionary Committee in 1976	Datian Wildlife Sanctuary Management Station, Dongfong-Xian Forestry Bureau	5
32	Guangdong (Kwangtung)	Beisha Bangxi Wildlife Sanctuary	Beisha-Xian	333	Hainan deer and natural forest	Approved and demarcated by Guangdong Province Revolutionary Committee in 1976	Bangxi Wildlife Sanctuary Management Office, Beisha-Xian Forestry Bureau	5
33	Guangdong (Kwangtung)	Hainan Nanwanling Wildlife Sanctuary	Lingshui-Xian	933	Monkey and natural forest	Approved and demarcated by Guangdong Province Revolutionary Committee in 1976	Nanwan Wildlife Sanctuary Management Office, Lingshui-Xian Forestry Bureau	5
35	Guangdong (Kwangtung)	Heyuan Xingang Wildlife Sanctuary	Heyuan-Xian	2,500	Endangered wildlife and natural forest	Approved and demarcated by Guangdong Province Revolutionary Committee in 1976	Xingang Wildlife Sanctuary Management Office, Heyuan-Xian Forestry Bureau	5

Table 3-4. Wildlife sanctuaries (Cont'd).

Map Number	Province	Natural Protected Area	Location (County or City)	Area (ha)	Purpose	Year Established	Administration	Personnel
36	Guangdong (Kwangtung)	Bawangling Wildlife Sanctuary	Changjiang-Xian	2,000	Long-arm monkey	Approved and demarcated by Guangdong Province People's Government in 1980	Bawangling Wildlife Sanctuary Management Office, Bawangling Forestry Bureau	5
44	Sichuan (Szechuan)	Tiebu Wildlife Sanctuary	Yuoriqai-Xian	20,000	Deer and other endangered wildlife	Approved and demarcated by Abba Autonomous Zhou in 1964	Tiebu Wildlife Sanctuary Management Station, Sichuan Province and Ruoer-Xian Administration	8
59	Yunnan	Nangunho Wildlife Sanctuary	Lancang-Xian	N.I.	Elephant	Approved by the State Council in 1980	N.I.	N.I.
63	Qinghai (Chinghai)	Niaodao (Bird Island) Sanctuary	Qinghaihu (Kokonor)	7,850 (strict protection 2,721)	Migratory bird	Approved and demarcated by the Qinghai Province Revolutionary Committee	Management station under the Agriculture and Forestry Bureau of Qinghai Province	5

(iii) Forest Reserves

There are two major forest reserve areas. One is inaccessible virgin forests and the other is designated forest reserves (see Table 3-3). The designated reserves have been set aside to preserve representative samples of China's diverse forest ecosystem. The majority of these areas are in the southeastern part of the country (Figure 3-2).

Jurisdiction at the national level of these types of areas is held by the Committee for Environmental Protection of the State Council, the Ministry of Forestry's Bureau for Natural Protection Areas and the Academy of Science. The management of other reserves is usually assigned to the forestry bureau of a province or district. Once again, these reserves are used for scientific research and educational purposes. Wildland recreation management, at this time, is not taking place. In addition, some cities also have areas called forest reserves. The purpose and uses of these vary substantially.

(iv) Wildlife Reserves or Sanctuaries

These represent a third class of natural protected areas in China which have a potential for wildland recreation use. These areas are listed in Table 3-4 and pictured in Figure 3-2. These areas focus on preserving rare and endangered wildlife species. They are located throughout the eastern part of China with a major concentration of areas in the sub-tropics of Guangdong (Kwangtung) Province.

Jurisdiction over these areas is claimed by the same national agencies discussed in the two previous reserve categories. Provincial forestry bureaus oversee the administration of wildlife preservation areas.

A few of these areas allow the public to observe wildlife, but, for the most part, appreciative or consumptive recreational uses of the wildlife are not promoted. Tourist promoters are very interested in seeing these areas opened.

(v) Natural Landscape Areas

This designation protects natural scenery and famous cultural attractions predominantly natural in character. Areas such as Huangshan, Lushan, Taishan, the three gorges of the Chang (Yangtze) River, the Li River, Mt. Qomolangma, and the West Lake region are examples. These areas have been developed to support recreation use. In some cases, hotels and other tourist support services already exist. Many of these are managed and administered by provincial governments.

In addition to the recreation and tourism uses, the natural environments associated with these areas serve as sites for scientific study. These areas represent that point along the spectrum where man's impact becomes a subdominant and in some locations a codominant part of the recreation setting.

(vi) Production Forests

These areas are managed by the Ministry of Forestry and subordinate bureaus at the provincial and local levels for timber production. At present, most are located in northeastern China or southern China.

Public access is not now encouraged. These areas certainly have potential for forest recreation opportunities. But several potential management problems discourage recreation use. For example, wood is in very short supply in China, and opening up such areas may lead to problems, e.g., users gathering firewood. Chinese foresters have little or no training at present in recreation management; thus traditions of the profession have slowed the opening of areas to the public.

(vii) Multiple-Use Parks

These parks are best described as predominantly artificially created eco-systems that function as regional parks. Their proximity to urban centers provides a "natural appearing environment" to which many of China's urbanites escape if they desire to engage in wildland recreation.

These parks are mainly for the Chinese, but some of the more famous ones located in tourism cities receive a great deal of use by foreign tourists. These areas are an interesting combination of China's natural and cultural heritage.

One example of a multiple-use park is Xuan Wu Hu in Nanjing. Table 3-5 presents a listing of the uses at Xuan Wu Hu.

Table 3-5. Uses of Xuan Wu Hu - a multiple-use park.[a]

Individual Development	Commodity Exchange
Physical Exercise	Agriculture
swimming	pigs
boating	farm by-products
walking	Horticulture
roller-skating	fruit
calisthenics	flowers
sports	bunjin
Physical Relaxation	medicinal herbs
Aesthetic Appreciation	Aquaculture
viewing natural features	fish
viewing zoo animals	shrimp
viewing art	crab
enjoying performing arts	lotus root
dancing	pearls
Self-Education	Forestry
reading interpretive materials	timber
reading for pleasure	seedlings
studying	twigs (fuel)
Discovering and Exploring New Places	Concessions
	restaurants
Social Integration	tea houses
	souvenir shops
	photo venders
Improving Friendships	boat rentals
Increasing Family Togetherness	Admission Fees
Meeting New People	Sale of Zoo Animals
Courtship	Labor and Salaries
Transmitting Cultural Arts/Crafts	
concerts performances	**Environmental Maintenance**
calligraphy exhibits	
art exhibits	
flower exhibits	Watershed Management
bunjin exhibits	flood control
Transmitting Social Norms	industrial water supply
environmental education	Absorption and Breakdown of Air and Water Pollutants
youth camp	
collecting herbal medicines	Open Space
Settlement	Buffer to Nanjing Forest Reserve
fishing village	
worker housing	Biomass Production
athletic training center	Genetic Diversity
	Animal gene pool (zoo)
	Plant gene pool (nursery)

[a]This list reflects only those uses observed or verified by secondary data. There are undoubtedly others. Table adapted from Machlis et al. 1981.

(viii) Chinese Gardens

The last and most altered natural environment that serves as a "nature oriented" park is the traditional Chinese garden. Although the environment is nearly totally artificial, its arrangement and layout reflect the lines and processes of nature. More importantly to the Chinese and their traditions, the gardens are microcosms of real nature. These areas are found in nearly all cities of China. Some are private, but the vast majority are now operated by the local bureaus of parks and gardens.

In some instances, such gardens are but one component of a multiple-use park; in other situations, they stand alone as a type of wildland recreation area. The more famous gardens, like those in Suzhou (Suchow), are visited by locals and foreign tourists alike.

3.3.3 Conclusion

The diversity and potential of providing wildland recreation opportunities in China is nearly limitless. The vast majority of areas open for recreation at present are operated by provincial and local governments. A truly untapped recreation potential seems to exist in the reserves and sanctuaries of the central and provincial governments. Whether the scientists and resource managers administering these areas will open them up is yet unknown. However, with the pressures of tourism and the emerging park conservation movement, it is being considered.

3.4 WILDLAND RECREATION PARTICIPATION IN CHINA

3.4.1 General Classification of Participants

Any attempt to analyze participation in wildland recreation in China requires understanding that there are at least three distinct groups of participants: foreign tourists, "overseas Chinese" (people of Chinese descent living outside of Mainland China), and the indigenous Chinese people.

(i) Foreign Tourists and "Overseas Chinese"

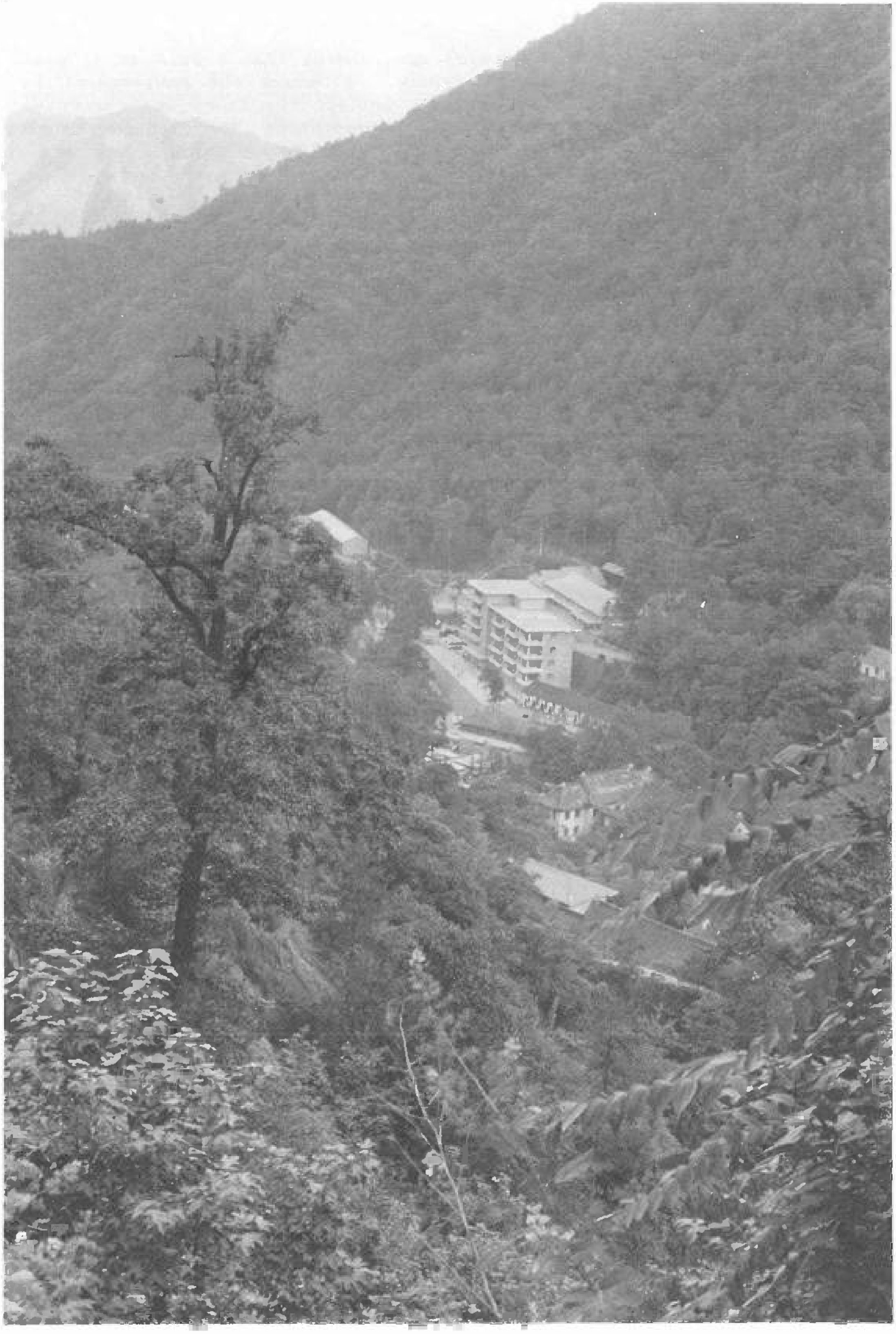
The number of these two groups allowed to enter the country is controlled by the Administration of Travel and Tourism which is under the Ministry of Foreign Affairs. The schedule of places each group will visit, the hotels in which they will stay and the prices charged are all regulated. Thus, participation rates and wildland areas that are impacted are definable. In a sense this demand is whatever the government desires to accommodate, and is, therefore, predictable. As previously noted, the government hopes to double the number of foreign tourists by 1985.

(ii) Indigenous Chinese

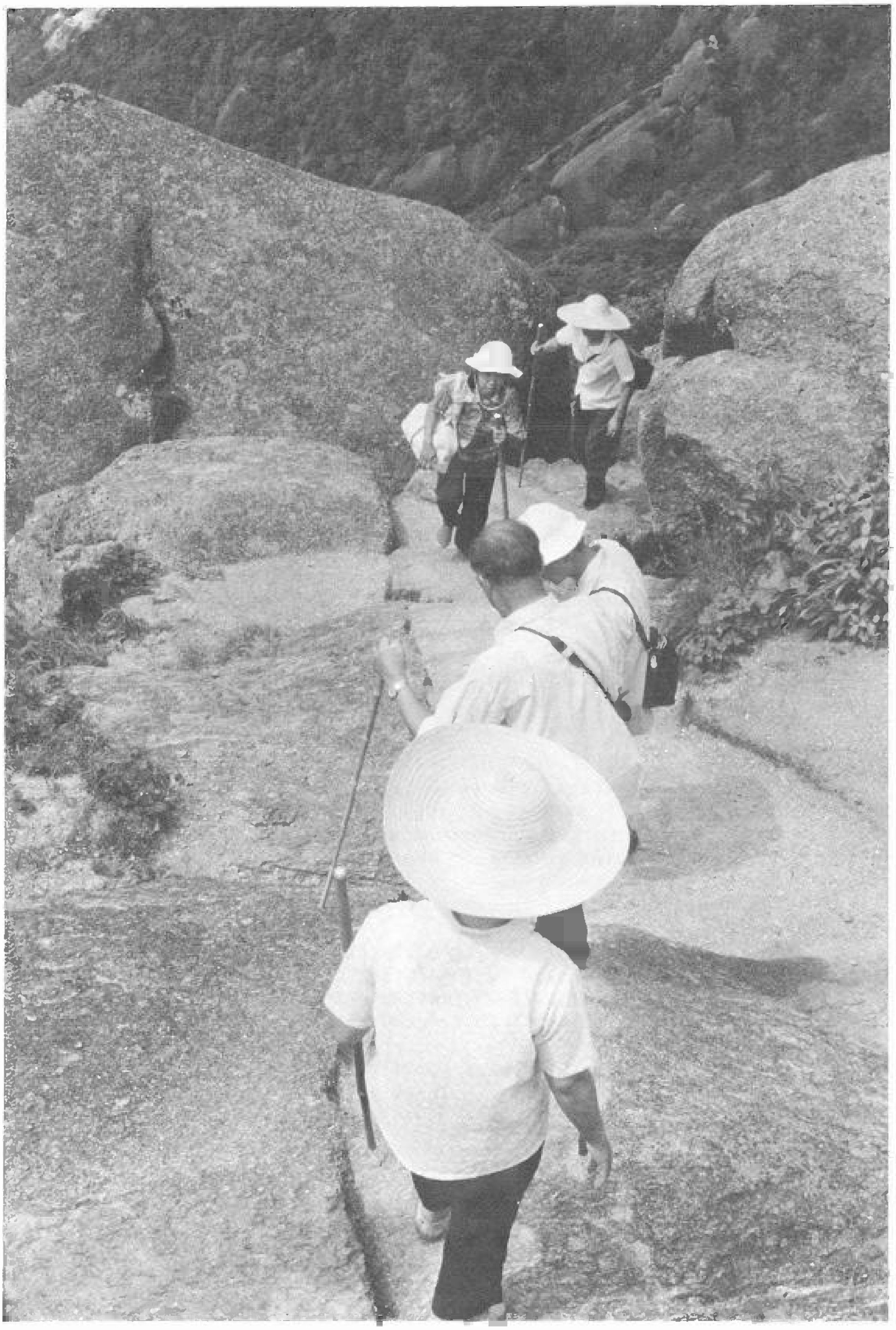
The third group, the indigenous Chinese, represents the greatest potential demand for wildland recreation in China. To understand this group and its potential impact on wildland recreation areas requires reviewing the group's present participation levels and preferred wildland recreation activities, identifying the barriers limiting areas, and determining the amount of time indigenous Chinese spend participating in wildland recreation.

3.4.2 Participation Levels and Preferred Wildland Recreation Activities of Indigenous Chinese

Interviews with park and recreation professionals and park visitors indicate an individual in China visits wildland recreation areas (mostly multiple-use parks at the county, city and provincial level) two to twelve times annually. Perhaps the motive



3-5: Looking down upon the "Heavenly Capital City" at Huangshan, a resort reached by climbing miles of nearly vertical trail consisting primarily of steps cut into the mountain rock.



3·6: The steep winding trail to Huangshan is the only access to the resort; all supplies, all wastes must be hand-carried up and down.

most often responsible for people visiting wildland areas is the social obligation to show out-of-town visitors (whether they be family or friends) the local scenic spots. This custom is one of many that influence Chinese leisure patterns.

(i) Recreation Activities

The most popular activities vary with age and sex. In a general sense, the older participants (over 50 yr.) use park areas for exercise in the early morning, for board games, talking, sitting and entertaining grandchildren. The middle-aged (35-50 yr.) engage in sightseeing, boating, picnicking, photography, hiking/climbing, swimming and other family oriented activities. Young adults (under 35 yr.) participate in the most physically oriented activities that a wildland recreation area offers. Some of the most popular activities are boating, hiking/climbing and team sports. Passive activities popular with this age group are sightseeing, photography, reading and studying, and courting.

In general, as women enter the middle-aged and older category, they prefer passive activities. Men, as they enter the older category, prefer passive activities. The exception to this is physical exercise, which is preferred most by individuals in the older category, regardless of sex.

(ii) Activity Patterns

Data collected at one particular multiple-use park, Xuan Wu Hu, in Nanjing (Nanking), offer some support for the general activity patterns developed from interviews with Chinese park professionals (Table 3-6). Of course, availability of an activity at a particular location will influence its selection as an important reason.

3.4.3 Barriers to Wildland Recreation Participation

(i) Availability and Location

To date, the majority of wildland areas that have been set aside are located in eastern China. This limits their environmental diversity to some extent, and their availability to some potential users; but, on the other hand, the vast majority of China's population is located in this sector of the country. In China, as everywhere, when people live near a particular area, they use that area more often.

(ii) Accessibility and Transportation

Directly linked to location is accessibility or available transportation to parks. Therefore, if an area is linked to population centers by rail or bus the likelihood of use increases. Furthermore, if an area is within walking or bicycling distance of a population center, access barriers are reduced considerably.

If a planned spin-off of foreign tourism, improved mass transportation, occurs, areas may well receive increased use. This, of course, assumes the transportation system developed for foreign tourists would also be available to the Chinese. At present this is not the situation in all cases.

(iii) Participant Income

Income is an additional barrier to recreation participation in China. In all cases, an entrance fee is charged to use parks and protected areas. In addition, transportation costs are a consideration when a potential user decides to participate in wildland recreation. At present, park fees and bus transportation costs are reasonably low relative to the average income. But for the middle and lower income brackets, disposable income is limited and, therefore, a trade-off is made when individuals opt to engage in wildland recreation.

Table 3-6. Reasons why people choose to visit Xuan Wu Hu (n=313).[a]

Reasons	Number of Individuals Listing Reasons[b]	Percentage of all Responses
Visit and play with friends	67	30.0
Viewing animals in the zoo	30	13.5
Viewing scenery	23	10.3
Spending time with family	20	9.0
Relaxing and resting	12	5.4
To take pictures	11	4.9
To go to the zoo	8	3.6
To exercise	8	3.6
Courting	7	3.1
Boating	7	3.1
Roller-skating	7	3.1
Studying or reading	4	1.8
Walking	3	1.4
Playing cards or chess	3	1.4
Participating in youth camps	3	1.4
Swimming	2	.9
To learn or explore the park	2	.9
Attending art performances and exhibitions	2	.9
Get out in the fresh air	2	.9
Play soccer	1	.4
Collect herbal medicines	1	.4
Total Responses	223	100

[a]The survey was constructed in English and translated into Chinese. Questions included frequency of visit, mode of transport, group type, age, and so forth. All were closed-ended except for the question dealing with why visitors came to Xuan Wu Hu, which was open-ended. Interviewers were park professionals and university professors attending a course at Nanjing (Nanking) Technological College of Forest Products. A training session was held to familiarize the interviewers with interview techniques.

The survey was conducted July 14, 1980. The park was divided into six zones, and interviewers were stationed throughout these zones. An interval sample was used; every tenth visitor to pass a station was interviewed. Each interviewer surveyed a maximum of 12 visitors and responses were recorded on a special coding sheet. Computer analysis of the closed-ended question data was by the Statistical Package for the Social Sciences. Answers to the open-ended question were translated into English and categorized by the authors.

[b]A person could list more than one reason or not answer the question; therefore, total responses are not the same as sample size.

Many of the local and regional natural park areas have certain days when no entrance fee is charged. During these times one cost barrier is eliminated and recreation opportunities are provided as a public good.

(iii) Available Leisure Time

The amount of leisure time the Chinese have to engage in recreation activities is limited. Urban dwellers usually receive one day off a week. For some segments of the work force, particularly factory workers, this day is different for groupings of factories within a city. In addition to the one day a week, three major holiday breaks are given: Spring Festival (3 days), National Day (2 days) and Labor Day (1 day). The worker is allowed to work on some days off to accumulate vacation days, thus allowing an extended period of free time. Husbands and wives do not always have the same days off, and all students receive Sundays off.

In rural areas, peasants work about 310 days a year. The same holidays apply, but rural workers seem to have more flexibility in scheduling weekly days off. In the countryside a worker is paid, or shares the equivalent in commodity production, only for each day he or she works.

College students and the most efficient and productive teams of workers sometimes receive special incentives in the form of free time. College students are now encouraged to travel during the summer months. This is done by reducing hotel costs in parks and having special transportation prices for them. Productive teams of workers are likewise awarded free trips to scenic spots and natural landscape areas. In both cases the government, by increasing available free time and reducing costs, encourages use of natural protected areas. The purpose of this is to expose citizens to the natural and cultural heritage of their country and, thus, to create a feeling of a united nation. In the past, it had been more difficult for the Chinese to travel and share cultures.

3.4.4 Conclusion

Participation in wildland recreation in China is controlled and moderated by many factors. Most are subject to change. The directions and types of change that result as China develops will dictate to a great extent what future recreation participation patterns will be.

It must be stressed that no broadly based scientific study of recreation participation is known to have been conducted in China. Thus, data reported in this section must be interpreted with this constraint in mind.

3.5 CURRENT LEVELS OF GOVERNMENT MANAGEMENT OF WILDLAND RECREATION AREAS

3.5.1 Decentralized Management

Wildland recreation areas in China are presently administered by all levels of government: central, provincial, municipal, autonomous regions, prefectures, counties and cities. This decentralization poses a problem for developing a system of national areas. The central government and local/regional levels of government carry out different management functions for wildland areas presently being used for recreation or having potential for such use.

3.5.2 Central Government

Currently, very little land is being managed by the central government for recreation. The Ministry of Forestry through its Bureau for Natural Protected Areas controls land areas that could be managed for wildland recreation opportunities. Much of this land is forested or undergoing afforestation and is located throughout China.

Some of it is near urban population centers, but most is in rural areas. Various other agencies manage lands that also have potential for wildland recreation opportunities. These include the State Council's Committee for Environmental Protection and the Chinese National Academy of Science Institutes for Botany and Zoology. Numerous other ministries and their bureaus also control land, but they are of lesser importance to the nature conservation cause.

3.5.3 Local and Regional Governments

Most local and regional jurisdictions listed above (3.5.1) have bureaus of parks and gardens. These bureaus, along with the one responsible for planning (urban, rural and regional), are under the Construction Committee existing at each level of government jurisdiction. This committee approves all development plans, whether for parks, housing or industrial facilities. It is also responsible for allocating funds for the construction of facilities in approved plans. Therefore, proposals for wildland recreation areas must compete for funding with all other development projects. A value of this centralized planning approach is that land development is coordinated and interdependent land uses are better integrated.

For example, some cities and regions have been designated as tourism centers via the planning process. As a result, their development goals reflect this policy decision. This means that projects which will enhance tourism receive priority. Thus, this centralized planning is very important and effective for building China's tourism industry. It also offers a possible avenue for preserving and developing the recreation potential of wildland areas nearby such centers.

(i) Management Policy

The construction committees, the bureaus of parks and gardens and park managers are the key policy makers at the local and regional level. Because no specific laws establish the majority of wildland recreation areas in China, most policy about how a system and a particular unit of land will be managed is decided via the planning process. At first this suggests that areas with similar environmental and jurisdictional characteristics would be managed very differently, and to some extent this is the case. But balancing this is the fact that most of the park planners are trained in the Chinese garden tradition. The result is that this traditional force tends to set the boundaries of what is possible within park areas. Only recently has a more natural ecosystem approach to park development entered the picture. Thus, in a very real sense development policy is influenced by the tradition of the Chinese garden concept.

(ii) Administration, Management and Operations

The day-to-day administration, management and operation of parks are the responsibility of the bureau of parks and gardens at both the local and regional level. The size and scope of a particular bureau's park system determines its administrative components. Bureaus in larger cities and provinces are likely to have units to carry out the following responsibilities: maintenance and operation of a nursery, maintenance of public trees, management of parks, gardens and zoos, conducting plant and wildlife research, planning and design, producing education materials and general administration (purchasing, personnel, etc.).

At the next administrative level each park or unit of the system is controlled by a manager. Managers are usually trained professionals in the area of landscape gardening, horticulture, planning, engineering or the biological sciences. Depending upon the size and type of area, staffs vary in numbers and training.

The key positions of power within a bureau seem to be the director, park manager and planners, in that order. However, one cannot forget the important role the Construction Committee plays in development of park areas.

(iii) Financing

Operations and maintenance - The operations and maintenance of most areas are financed from fees charged to enter a park or to use a particular facility (e.g., boats). Commodity production (aquaculture, horticulture, agriculture, etc.) within the park, sales of trees grown in a park systems nursery and operations of various other concessions by the park or bureau create additional funds for operating parks. For example, in a national landscape area like Huangshan, operated at the provincial level, funds are generated by the hotels, hot springs, swimming pool, restaurants, and other tourist services operated by the park. In a multiple-use park like Xuan Wu Hu in Nanjing (Nanking), concessions include tea houses, souvenir shops, photo booths and boat rentals. Further adding to revenues, Xuan Wu Hu produced 530,000 kilos of fish in 1979, which were sold to nearby markets. As the examples suggest, rather diverse sources provide the pay for the management of parks.

Construction projects - Financing for construction projects comes either from generated savings after operations and maintenance costs are covered or from funds allocated to the park by a Construction Committee. This latter method is nearly always used to obtain at least a portion of the construction costs.

(iv) Planning

The planning process - A generalized version of the planning process followed for improving an existing park or developing a new one is as follows. First, a team of park planners, engineers and other needed experts create an initial design. Second, the area manager reviews the design and offers suggestions. Third, the design team holds meetings with other designers and in some cases obtains citizens' comments. When citizens are involved, a book is provided for them to write down their comments, or in some cases the design team is available to talk with citizens. The fourth step consists of the design team attempting to incorporate the inputs it received into its original proposal. The fifth step is the redrawing of the sketch plan for the area. The sixth step involves the area manager taking the plan to the director of the bureau for final approval.

Obtaining government approval - The remaining steps focus on acquiring governmental approval external to the Bureau of Parks and Gardens. The first of these requires the director of a park and garden bureau to present the plan to the appropriate construction committee. The construction committee then reviews the plan in terms of the overall plan and planning goals of a city or region. If a local construction committee approves the plan, it most often must go on to at least the provincial level. In rare cases when funds for development of the plan are expected to be requested from the central government, the plan approval of its construction committee is sought. Following this process of plan approval, actual construction funds must be sought for the project.

The approved plan becomes the critical element in determining the kind of setting that will be developed and preserved. Thus, the influence of planners in the development of China's natural protected areas should not be underestimated.

3.5.4 Conclusion

As previously suggested, the management of wildland resources for recreation purposes is at present dominated by local and provincial governments. Currently, the Chinese garden tradition is the strongest influence in the development of these areas and only recently has an ecological approach emerged for consideration. In this respect and in view of increasing tourism, the agencies involved in park financing may well decide to shift emphasis from maximum resource development and protect, perhaps by use limitations, China's unique natural areas. Additionally, officials may well consider increasing and strengthening, at the central government level, the coordination between the tourism industry and protected areas land managers.

3.6 THE FUTURE OF NATURE CONSERVATION AND WILDLAND RECREATION MANAGEMENT IN CHINA

The future of nature conservation and the management of forest and other lands for the purpose of providing wildland recreation opportunities will certainly be affected by emerging and existing resource conflicts (i.e., timber and mining production vs. recreation), economic issues (i.e., capital for industrialization vs. park development), and social issues (i.e., population pressures) in China. The complexity of these issues and their interrelatedness are important considerations for China's future nature conservation movement. It is possible to suggest activities that would interest Chinese government officials, park managers, forest managers and academies involved in nature conservation.

3.6.1 Educating and Training of Wildland Recreation Management Professionals

Interest exists in developing professionals in wildland recreation management. At present, few schools train students specifically in this area. There is a need for development of two and four-year undergraduate college programs for existing park administrators and managers, as well as for in-country education programs for existing professionals.

To further enhance the development of professionals in China, additional up-to-date scientific information in areas such as recreation behavior, recreation management and recreation resource protection would be helpful. Publication exchanges with other countries through universities and colleges, as well as international organizations and governmental outlets, would also be useful.

3.6.2 Developing a Governmental Structure to Protect Natural Areas

There is also interest in examining other governmental structures for developing and protecting natural areas, as well as exploring the ramifications of various natural area classification systems. Also of interest are the necessary administrative organization and structure to manage and operate protected areas.

3.6.3 Cooperating in Recreation Research

At present, the Chinese have conducted little research in the area of wildland recreation. Exchange of scientists to assist in the development of a research agenda would be useful. Researchers could also assist in the development of graduate programs, cooperative research programs and programs to update the research skills of academicians and researchers. Both social science and biological science research skills are needed.

3.6.4 Inventorying Recreation Resources

Methods of inventorying recreation potential and the ultimate selection of lands for preservation is another area of interest to China. Recreation inventory systems and methods for conducting them, such as remote sensing and computer mapping and analysis would be helpful in accomplishing this task.

3.6.5 Understanding the Role of Tourism in Development

China, like so many countries, is interested in using natural protected areas to stimulate rural development. As a result, methods for studying the social, economic and physical impacts of tourism on China's protected areas and rural communities is an area where knowledge and expertise would be useful. This seems to be particularly important if China's many and varied cultures and unique ecosystems are to be preserved.

3.6.6 The Chinese and the World Nature Conservation Movement

World nature conservation groups and their members throughout the world recognize the high quality and uniqueness of resources that exist in China. However, it would be useful if additional environmental education programs depicting China's resources could be developed for the Chinese people and for citizens of all nations. Professional exchanges and attendance at international meetings by Chinese professionals dealing with wildland recreation will further assist the mutual understanding of all people interested in nature conservation.

3.7 WILDLIFE CONSERVATION IN CHINA[3]

3.7.1 Distribution of Wildlife

(i) Habitat Varieties

China contains a great diversity of plant and animal species, habitat types, and ecosystems, some of which are unique. There are three main bioclimatic regions. The eastern half of the country is lower in elevation and under the climatic influence of oceanic air masses. Forests occupy the east and range from conifer stands in the northeast to tropical rain forests in the south. The northern and northwestern parts of the country are higher in elevation and influenced by continental winds and rain shadows of mountain ranges. This is an area of steppes and deserts, dominated by the vast Gobi Desert, an inhospitable expanse of land covered with gravel and small boulders. The western and southwest parts of China are dominated by high mountains and plateaus of the Himalayan chain. Habitats vary from tropical forests in valley floors to barren tundra. The average elevation of the Xizang-Qinghai (Tibet-Chinghai) Plateau is about 5000 meters (m).

(ii) Fauna Varieties

As might be expected in a land of such great ecological diversity, there is a rich variety of animal life. Vertebrates are represented by 3700 species, including 480 mammals and 1110 birds.

Interior plateau - It is not surprising that at one time large herds of ungulates and predatory carnivores, comparable to those of the savannahs of Africa, inhabited the interior plateau of China. This region, comprised of Inner Mongolia, Gansu (Kansu), and Xinjiang (Sinkiang) provinces, is a steppe that changes into harsh desert to the west. Inhabitants include two species of gazelle (*Procapra gutturosa*, *Gazella subgutturosa*), Bactrian camels (*Camelus bactrianus*), the wild ass (*Equus hemionus*), the grey wolf (*Canis lupus*), and a variety of smaller species including several kinds of wild cats. Mountain ranges provide habitats for goral (*Naemorhedus goral*), wild sheep (*Ovis ammon*), roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), and common leopard (*Panthera pardus*).

Northeast forested region - The northeast forested region has many genera and species common to northern Europe and North America. Reindeer (*Rangifer tarandus*) and moose (*Alces alces*) are circumpolar in distribution, while red deer, roe deer and wild boar (*Sus scrofa*) occur throughout Eurasia. China has at least a dozen kinds of deer in a variety of habitats throughout the country. Those in the northeast include the red deer, roe deer, musk deer (*Moschus moschoferus*), and Sika deer (*Cervus nippon*). The best known large carnivore is the Northeast tiger (*Panthera tigris altaica*), a forest

[3] This section contains material written by Dr. Ernest Ables, Miss Susan Chen and Professor Xiao Qian-Zhu, and accepted for publication by The Wildlife Society and *Oryx*.

dweller of Heilongjiang (Heilungkiang) and Jilin (Kirin) provinces. Black bear (Selenarctos thibetanus), and brown bear (Ursus arctos) also inhabit forests of this region.

Southwestern mountain region - The southwestern mountain region, including Xizang (Tibet), contains an extremely diverse variety of animal life. Sichuan (Szechuan) Province alone, home of the giant panda (Ailuropoda melanoleuca), contains half of China's mammal species and one third of her bird species (Hung-Shou Pen 1962). In these mountains one finds goat-antelopes, the serow (Capricornes sumatraensis) and the goral (Naemorhedus goral), animals that seem to be in evolutionary transition. In this region one also finds the common red fox (Vulpes vulpes), the wild red dog (Cuon alpinus), common leopard (Panthera pardus), blue sheep (Ovis ammon), takin (Budovcas taxicolor), golden monkey (Rhinopithecus bieti), and 2-3 subspecies of tigers. Further south at lower elevations are elephant (Elephas maximus) and gaur (Bibos gaurus). On the Tibetan plateau are Yak (Poephagus grunniens), snow leopard (Unica unica), Tibetan antelope (Pantholops hodgsoni) and Tibetan gazelle (Procapra picticaudata).

(iii) Bird Distribution

There is little information on bird distribution, except that richness of bird fauna closely corresponds to that of mammals. The rain forests of Yunnan Province contain a spectacular variety of birds, including green peafowl (Pavo muticus) and hornbills (Anthracoceros spp., Buceros spp.). Of the 15 species of cranes in the world, China has 8. The largest breeding colony of red-crowned crane (Grus japonensis) in China occurs in Qiqihari Zhalong Crane Sanctuary in northeast Heilongjiang (Heilungkiang) Province.

3.7.2 Present Status of Wildlife

Only 11 percent of China's land is arable, and most of the country is either hilly, mountainous, arid to semi-arid, or situated on high plateaus. The majority of fertile land is located in the east around the Huang (Yellow) and Chang (Yangtze) River Basins. Therefore, about 90 percent of China's human population is concentrated in the eastern half of the country. It is in this region that wildlife has suffered the greatest losses.

(i) The Heavily Populated East

Centuries of human activities - agriculture, timber harvesting, and hunting - have reduced wildlife populations in eastern China and in populated river valleys to near extinction. What remains of wildlife in these areas are hidden in inaccessible natural sanctuaries, some of which have been authorized as nature preserves. As one tours cities or visits the countryside in eastern China, the almost total absence of bird life is immediately apparent. Although the Père David's deer (Cervus davidianus) exists in captivity, its natural habitat in the Huang (Yellow) River Valley has been obliterated. Perhaps there remains a chance to reintroduce this deer in the wild near the Great Wall in northern Hebei (Hopei) Province.

One wildlife species surviving precariously in the East is the Chinese alligator (Alligator sinensis), small populations of which live on and south of the Chang (Yangtze) River in southern Anhui (Anhwei) and Jiangsu (Kiangsu) provinces. Current numbers of the Chinese alligator are difficult to determine, but a count made in Anhui (Anhwei) Province in 1976 revealed 120 of the animals, 240 less than revealed by a similar count in 1956. The decrease in alligator population is attributed to loss of habitat, the effects of herbicides and fertilizers, and to the fact that local fish and duck raisers have considered them harmful and have killed them freely. However, the Chinese alligator has been officially designated a First Class Protected Animal, and the people are being educated to its rarity and relative harmlessness (Zhujian 1981).

(ii) The Northeast Forested Region

The largest single species populations of wildlife remain in the northeast forested region, where inhospitable climate limits human activities. In northern Heilongjiang (Heilungkiang) Province, rather large herds of red deer, plus abundant tracks, licks, and spoor, were observed during the summer of 1980. Also observed in many separate forest stands in this part of China were spoor, and other evidence of roe deer, musk deer, black bear, wild boar, and badger (Meles meles). Forests are alive with bird life, and small mammals such as voles and shrews inhabit the forest floor. Not all species have fared well in this region, however. Caribou herds that once ranged into these forests are extinct in the wild and remain only in domesticated herds.

(iii) The Mountainous Southwest

The greatest diversity of wildlife is found in the southwest because the high rugged mountains provide a variety of habitats and limit man's access. Reports indicate some problems with poaching and human encroachment in this area. However, there may be habitats in near pristine condition in this part of China.

(iv) The Northwest Arid and Semi-arid Region

In the 1950's large herds of gazelle were reported in Inner Mongolia. Today these herds are greatly reduced due to competition with domestic livestock and uncontrolled hunting. On both sides of the border separating Inner Mongolia from The Mongolian People's Republic, gazelle are hunted from vehicles and shot with semi-automatic weapons; but in the buffer zone between the two countries, wildlife species are hunted much less and the largest populations are reported in this zone.

Few biologists have had an opportunity to visit the northwestern desert region. In 1977, Professor Li Bo travelled the length of Inner Mongolia and into the Bogda Shan Mountains of northern Xinjiang (Sinkiang) Province. He reported that wildlife numbers were greatly reduced because of human encroachment throughout this area. Two-humped camels still occur in stream valleys along the northern perimeter of the great Taklimakau Desert. Gore and Dale (1980) reported that at higher elevations in the Tian Mountains of this region, herdsmen carry rifles to protect their livestock from wolves and leopards. More recent information on the northwest mountain ranges substantiate the presence of these predators. Some of these northwest mountain ranges are in pristine condition.

3.7.3 Values and uses of Wildlife

(i) Traditional uses

The single most important factor affecting wildlife conservation in China is the traditional utilization of wild animals for medicinal purposes, meat, and skins. Although China's cultural heritage is adorned with wildlife, as seen in art and architecture, the Chinese people have always had an utilitarian attitude toward wild animals. Several species of deer supply important medicinal and industrial products. Deer antlers are harvested and sold throughout southeast Asia for their aphrodisiac properties. Deer farmers have discovered that velvet antlers (the most valuable) can be cropped twice per year. When cut off at the proper stage of development, a velvet antler will rejuvenate itself. Wild red deer of both sexes are harvested in June in Heilongjiang (Heilungkiang) Province. Antlers of males are at their most economically valuable stage at this time, and fetuses of females are near term and provide a variety of medicines for treatment of reproductive maladies of human females. The musk of musk deer is used for at least 30 medicinal purposes and as a base for expensive perfumes in Europe. The diversity of medicinal uses of deer musk is great. It is used to treat sore throats, rheumatism, and especially chills and fever in humans, plus a variety of ills in domestic livestock.

Tigers, symbolic of strength and courage throughout Chinese culture, are highly valued for the rejuvenating properties of their bones and blood (Shafer 1968). The knee bones of tigers are believed to cure rheumatism and arthritis, as are the bones of leopards. Tigers and other cats are also prized for their beautiful pelts, around which a substantial export trade has developed. Gall bladders of the Asiatic black bear are used to treat eye disorders and their foot pads are considered a delicacy. Other wild meats, such as monkey, are a delicacy in many parts of China. At least 56 species of birds have been identified to have high economic value (Cheng Tso-hsin 1964).

(ii) The Problem of Attitude

Wildlife has historically not been regarded benevolently in China. Certain wild animals have always been regarded as enemies of civilization because they destroyed crops, preyed upon domestic livestock and poultry, or attacked people. Some were even viewed as forces of evil and darkness. The savage tribes which inhabited lands beyond China's borders were labelled as bird people, snake people, etc. (Shafer 1968).

Today, this attitude towards wildlife has not disappeared completely, even among those responsible for managing the country's wildlife. The elimination of wild animals regarded as harmful to man or man's livelihood is a common occurrence. Sparrows were almost eliminated during an official campaign to rid the country of four pests (mice, flies, mosquitos, and sparrows). People responded to the call for eradication by chasing and killing sparrows mercilessly. Possibly other sparrow-sized birds in both urban and rural areas became the objects of this campaign. Today, wherever people live, birds are scarce. Part of this scarcity of birds may be due to pesticides, which are reportedly used in heavy amounts.

Carnivores have likewise been persecuted heavily. They are considered serious predators on domestic livestock and economically valuable wildlife species and cause injury to man. Leopards are shot, trapped, and poisoned around deer farms. Black bear are feared by people in the forested areas of northeast China. Some workers carry shotguns when they go into the forests as protection against bears and wild boar. Sign of both bear and boar were indeed common in some areas, but the actual danger seems more often imagined than real. Nevertheless, bear are shot on sight.

(iii) Protection and Preservation of Wildlife

Traditional utilitarian attitudes toward wildlife can have a negative effect on this resource. But, on the other hand, these traditions and attitudes have led to the protection of selected wildlife species in China. The categories of protected species are those that are rare and endemic to the country, and those that are economically valuable.

Wildlife Farming - In addition to granting protected status to certain species, the government is advocating farming of wildlife. Red deer and Sika deer are being kept and bred in deer yards, especially in Jilin (Kirin) and Heilongjiang (Heilungkiang) provinces, to ensure a supply of antlers in velvet. Musk deer farms have been established to extract musk without harming or killing the deer. These deer farms serve dual purposes: to provide supplemental income to the collectives and to reduce pressures on populations in the wild. On a larger scale, natural areas have been set aside in Shaanxi (Shensi) Province for the propagation of roe deer. Each year, over 10,000 deer in this area are harvested and the meat exported to West Germany. Local hunters are recruited for the harvesting period. The money earned becomes extra income for the local people. Therefore, domestication and breeding of wild animals in captivity can be viewed as a means of reducing the conflict between the increasing demand for animal products and the dwindling supply of animal resources. Economic incentives through material returns earned from game farms and future savings of gene pools in the wild are one of the major underlying factors of wildlife conservation in China.

Rare and Endemic Species as Tourist Attractions - The Chinese also see values in their rare and endemic species. Not only are these animals important to the cultural heritage, e.g., panda and tiger, but they are also tourist attractions. At present, natural areas are being assessed for their potential to attract foreign tourists. One of the resources being evaluated is the wildlife residing in these natural areas. These wildlife species attract tourists and research funds. For example, the participation of the World Wildlife Fund in giant panda research and the proposal for a nature center next to panda habitat have reinforced the protection of the panda. Unfortunately, the answer is more uncertain for species which have not demonstrated their value to society.

3.7.4 Administration and Management

(i) A New Emphasis on Conservation

During recent years, China has taken great strides in the conservation of her wildlife resources. This is reflected in official government policies and actions. In 1980 China joined the International Union for the Conservation of Nature and Natural Resources (IUCN) and agreed to adhere to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). In September 1980 a new Wildlife Policy Act was formulated that stressed rational use and conservation of wildlife. Parts of this act closely resemble a similar document of the IUCN.

(ii) Conservation and Industrialization

China has embarked on a very ambitious economic development plan to industrialize the country. Conservation has been given a place within the framework of this plan. In essence, conservation is being promoted on a utilitarian platform. The government of China considers utilization of wildlife a valid argument for its conservation. Therefore, commercially important species will play a major role, and management of wildlife at present is oriented strongly toward economically valuable species. However, it is not just economic considerations that are influencing conservation efforts. Scientific and ecological values of wildlife are a part of the country's wildlife conservation plan, as well. Endangered, rare and endemic species are receiving special emphasis. Sixty-three protected areas ranging from 15 hectares (ha) to 480,000 ha have been established. About half of these areas were set aside for the protection of the giant panda and its habitat. In the future, China plans to increase the number of protected areas to 300, or about one percent of the nation's area. The Chinese are also well aware of the need for conservation of genetic resources.

(iii) The Lack of Clearly Defined Authority

Administrative authority and responsibility for wildlife conservation seems to be in a state of flux. Government departments compete with each other for control. Until recently, authority for management of all wild birds and mammals in China was under the jurisdiction of the Ministry of Forestry. In 1981 the State Council formed the Committee for Natural Environmental Protection, which includes wildlife. A Bureau of Wildlife Protection was created within the Ministry of Forestry and given authority and responsibility for large animals. The 1980 Wildlife Policy Act placed 145 species on three lists according to the degree of protection to be given. These lists include both birds and mammals, large and small.

(iv) Regulatory Authority

Regulations governing harvests of wild birds and mammals are set jointly by the Ministry of Forestry and by the respective provinces. Deer and fur-bearer farms are managed by both the central government and by local communes.

3-7: An example of China's--and one of the world's--endangered species, a Northeast tiger stares from his cage in the Harbin Zoo, Heilongjiang (Heilungkiang) Province.

(v) Management of Free-Ranging Wildlife

There are only three major approaches to actual management of any free-ranging wildlife resource: 1) direct manipulation of animal populations, 2) manipulation of the habitat, and 3) protection of the animal and its environment. Of these approaches there is manipulation of numbers through harvest regulations and predator control, and habitat protection through establishment of preserves. However, planned habitat manipulation seems almost nonexistent. The most significant wildlife populations in China are in forested regions, which are managed almost exclusively for timber production. Although beneficial effects for wildlife from forest practices are not planned, they do occur; e.g., in northern Heilongjiang (Heilungkiang) Province excellent populations of red deer can be observed in areas of clear-cuts.

3.7.5 Wildlife Research

(i) Authority for Wildlife Research

Research on wild birds and mammals and their habitats is yet inadequate throughout significant portions of the country. Authority for wildlife research is shared by the Research Institute of Zoology within the Academy of Natural Science, and by the forestry schools within the Ministry of Forestry. The Research Institute of Zoology has responsibility for small birds only. The newly authorized Wildlife Department in the forestry school in Yunnan Province has been given responsibility for game birds, while fur animals are the responsibility of the Wildlife Department of the Northeast Forestry Institute at Harbin. Clearly, a significant segment of the wildlife resource has yet been left out.

(ii) A Limited Scope of Wildlife Research

Wildlife research is not restricted to the above government agencies. Faculty at nonforestry educational institutions, as well as members of other organizations, are engaged in limited research. A member of a teacher's college in Harbin is conducting a nesting ecology study of the red-crowned crane. Researchers in the Beijing (Peking) Natural History Museum are engaged in limited ornithological research. It seems, however, that no bird banding is being conducted, and banding is considered basic to ornithological research.

The research program of the Department of Wildlife Management of the Northeast Institute of Forestry at Harbin is still limited. In recent issues of the Journal of the Northeast Forestry Institute, only two of the 47 articles addressed wildlife. These two studies include a taxonomic description of a new species of hare (*Lepus*) and an ecological study of the Siberian marmot (*Marmota Sibirica* Raddle), a species of economic importance.

The surgical removal of part of the musk gland from the musk deer has, so far, been successful only in China, and details of this study are yet lacking.

(iii) New and Proposed Research Projects

Chinese scientists are initiating some wildlife research projects in China with international organizations and scientists from other countries. One of these projects is the giant panda study funded by the World Wildlife Fund and China (Schaller 1981). Attempts are also being made to initiate cooperative studies on the red-crowned crane, the northeast tiger, and the remarkable complex of smaller cats in China.

(iv) Problems and Possibilities in Research

As in many countries, research in China is presently hampered by a lack of funds requisite to bolster and extend methodology and techniques and to provide for the

3-8: An Asiatic black bear cub attempts to escape from its captors, foresters on the Northeastern College of Forestry Experimental Forest, Heilongjiang (Heilungkiang) Province.

necessary within-country travel. In some cases, organizational structures may have to evolve to facilitate more fully China's increasing wildlife research needs and to aid scientists in sharing the results of their research. Similarly, as China's scientists and those of other countries inevitably find commonalities of interest, Chinese agencies and organizations may well adopt methods loosening the restrictions on international research within China.

3.7.6 Wildlife Education

China now has only one active wildlife department, the Department of Wildlife Management in the Northeast Institute of Forestry at Harbin in northeastern China. Another wildlife program, located in the forestry school near Kunming in Yunnan Province adjacent to Tibet, is scheduled to become operational in 1983.

(i) The Current Restriction to Forestry Schools

Wildlife management education in China is offered only in forestry schools and is considered a part of forestry education. An education in biology/ecology can be obtained at institutions other than forestry schools, but the orientation is usually toward classical zoology, emphasizing systematics, zoogeography, or natural history.

(ii) The Department of Wildlife Management at Harbin

Background and curriculum - The Northeast Institute of Forestry at Harbin was established in 1952 and offers various specialties, as explained in Chapter 5. Three of these areas are biologically oriented: silviculture, forest protection, and wildlife. The Department of Wildlife Management began its program in 1962. Currently the department has 150 undergraduates, 2 graduate students, 4 faculty with professional titles, and 25 instructors. Each entering class is limited to 30 students.

As with all colleges in China, the student must pass The National College Entrance Exam. There are 2610 classroom hours in required subjects. Matriculation during the first 2 years comprises the usual general subjects of mathematics, physics, chemistry, biology, and social sciences.

During the second 2 years, studies involve applied subjects and reflect the orientation of Chinese wildlife management (i.e., heavy emphasis on deer and furbearer farming). There is a strong emphasis on field orientation and application. Many upper division classes spend considerable time in the field.

Foreign language studies, which begin at the primary school level, continue throughout college. For many years the required foreign language was Russian; now it is either English or Japanese.

The Chinese wildlife student's curriculum has little room for electives. Only about 7 percent of required classroom hours are free to be filled with other subjects. This may be more of a problem of course availability than of curriculum rigidity. A feature of interest in the curriculum is that all subjects are taught within the Forestry Institute. This characteristic permeates all of higher education in professional areas in China.

Upon graduation, the wildlife graduate will be assigned an appropriate job by the government. Typical places of employment are the Ministry of Forestry, Ministry of Foreign Trade, zoos, universities, local or provincial forestry bureaus, or research institutes.

Effects of the cultural revolution - All higher education in China suffered immeasurably during the years of the Cultural Revolution. At the Northeast Institute of Forestry, the entire faculty moved to the school forest from 1968 to 1973. Students were enrolled again in 1973.

In the late 1970's, some significant developments in wildlife conservation and management education occurred. Government and educational leaders instituted a new wildlife management program in the Yunnan College of Forestry, developing short courses and extension activities in wildlife, promoting wildlife research, and encouraging wildlife professionals to obtain further education in other countries.

Modernization efforts - Strong emphasis is being placed on updating the educational system at the Institute in Harbin. This task is being accomplished by self-improvement of faculty in residence, by importing expertise from abroad, and by sending faculty to other countries for education, experience, and training. Efforts are being made to update the literature on wildlife management principles and techniques. A major weakness of the wildlife faculty at the Institute was lack of education in wildlife ecology, but this is now being corrected.

3.7.7 Obstacles and Conflicts

Several obstacles confront China's wildlife conservation efforts. The use of economic rationale as a basis for wildlife conservation is perfectly viable, but some kind of management strategy will have to be formulated to promote rational utilization and conservation of wildlife resources.

(i) Lack of Scientific Data and Trained Experts

Lack of scientific data and trained experts in wildlife ecology and management are major obstacles in China today. In one respect, China is already far ahead of other countries in the rational use of wildlife resources. The technology for domestication of wild animals is fairly well established. A commune, with help from the government, can set up animal farms with a minimum of difficulty. In addition, the market infrastructure already exists for various animal products.

Preservation of a gene pool in the wild, however, will require more data on population dynamics and natural history of the species. The survival of those rare and endemic species will depend largely on the wise management of their habitats. The establishment of parks and reserves for the protection of these species will require information on home-range size, migration patterns, and so on. More wildlife biologists will have to be trained to conduct research. More managers will have to be produced to manage these areas. The department in Harbin graduates 30 wildlife biologists a year, not nearly enough to meet the country's increasing demands for wildlife managers, biologists, administrators and teachers.

(ii) Disregard for Protected Areas and Species

Another obstacle to conservation in some areas is the disregard by the local people for protected areas and protected species. Utilitarian attitudes towards wildlife can be a mixed blessing. These attitudes can be manipulated to promote conservation, or they can become an obstacle for conservation. Several hundred thousand people hunt in China. Hunting for commercial purposes is well established (Greer 1976). Over the years, teams of hunters from collectives shoot selected species to supplement their diet and income. Wildlife has always been a resource for the local people to exploit. Consequently, the establishment of protected areas simply transformed many of these legitimate hunters into poachers. In areas far from the central government, poaching is widely accepted, since it provides protein and extra income to the community. For example, poaching occurs regularly in Changbaishan Nature Reserve, a Man in the Biosphere Reserve. During the Cultural Revolution, at least 10 tigers were shot in and around this reserve. The local people are quite candid about this activity, and the above example is not unique to Changbaishan. It is reported to be repeated in many parts of China. Indeed, wildlife managers in China consider poaching one of the major wildlife conservation problems.

In addition, predators are still persecuted, regardless of their endangered and protected status. Farmers continue to kill those animals that raid their crops and livestock. Evidently, tradition and attitudes are difficult to change.

China will have to find ways to sell conservation to the local people if she hopes to succeed in conserving her dwindling wildlife. People will have to be educated on the values of wildlife conservation. Perhaps the economic rationale will be the most persuasive tool in changing traditional practices and attitudes.

(iii) Conflicts of Interest

Conflicts of interest over wildlife resources in China, as in most countries, can undermine the conservation effort. Direct conflicts of interest could occur between the Ministry of Forestry and the Ministry of Trade. The trade of animals and animal products is regulated by the Ministry of Trade, which has specific quotas to meet. A classic example is the trade in endangered cat skins. All species of felids found in China have protected status, both within the country and internationally by the CITES convention, but the Ministry of Trade maintains quotas for pelts of these cats. The existence of these quotas creates a market which could encourage poaching of these endangered cats. Perhaps when the wildlife departments of the Ministry of Forestry become more well established, the necessary steps will be taken to enforce protection and eliminate the incentive to kill endangered wildlife. If China intends to adhere to the CITES convention, the trade in protected birds and mammals will have to be controlled.

Conflicts of interest may also arise among researchers and zookeepers. Most zoo directors and scientists advocate wildlife conservation in China. But, since rare and endemic species of wildlife are major attractions in zoos, many zoos pay high prices for a live specimen. Similarly, scientists, in their zest to collect wildlife species for research, have inadvertently contributed to the demise of rare and endangered forms. Both parties have thus contributed to creating a market for the exploitation of endangered wildlife.

Chapter 4

POLICY AND PLANNING

4.1 GENERAL ASPECTS

4.1.1 "Walking on Two Legs"

Placing politics in command, China aims to build the country through self-reliance, hard struggle, diligence and thrift, and to lessen gradually the differences between workers and peasants, between towns and villages and between mental and manual work. The key to the process of development is the treatment of underdevelopment as a whole and not piecemeal. An essential characteristic of the planning policy is "walking on two legs"[1] instead of hobbling along on one.

4.1.2 Planning: The Total Approach

The Chinese believe that the economic system should serve man, and should be appropriate to the total approach to life. Grain is taken as the key link and other developments are planned around it. Each aspect of development is linked closely with other aspects of national economy.

(i) Use of Slogans

The general model of planning is conveyed to the common man in the form of a series of consistent and meaningful slogans (e.g., "Take agriculture as the foundation and industry as the leading factor"; "Adopt multi-purpose and fuller utilization of resources"; "Use combination of modern and traditional practices suited to local needs and conditions"; "Achieve industrial development with a mixture of small, medium and large units; Consider small and medium units as the main"). The planning philosophy, strategy and even operational aspects have all been turned into slogans, mostly as exhortations, directives or sayings of Chairman Mao, e.g., "Combine proletarian politics with productive labor"; "Grasp revolution and promote production"; "In agriculture, learn from Tachai."

The effect of sloganization is a simplicity which educates and arouses the masses.

(ii) Decentralization

Another notable aspect of Chinese planning is decentralization. The February 1957 speech of Mao--"Let a hundred flowers bloom and a hundred schools of thought contend."--invited uninhibited criticism and enabled extensive decentralization of all activities.

The policy of decentralization has given a substantial amount of autonomy to the communes. The communes are seen as the principal tool through which China accomplishes its rural economic development. To accomplish this task, the communes have been given substantial financial and administrative autonomy and have in essence taken over many aspects of the economy and daily social life.

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1 "Walking on two legs" is an expression which means simultaneous use of two methods or systems of different origin, efficiency, etc. (e.g., indigenous and modern technology) in order to obtain the maximum benefit from all resources available.

4.1.3 Planning Structure

(i) The "Down-Up-Down" System

The overall responsibility for planning lies with the Central Planning Commission of the government and the Provincial Planning Bureaus assisted by the Central Statistical Bureau and Provincial Statistical Offices. In the process, a great deal of balancing and target setting has been delegated to the provinces and regions with the center restricting itself mainly to a coordinating role. There is, however, sufficient monitoring and backfeeding to give the center adequate control over the lower echelon's decisions. The system is sometimes referred to as the "down-up-down" system.

The provincial planning and economic bodies are subordinate to the provincial governments (administrative committees), which have the right to intervene in the planning process and to reset the targets, correct aspects of policy and generally supervise the formulation of detailed plans.

(ii) Time Schedules and Guidelines

The planning exercise takes place simultaneously within two time schedules: five year[2] and annual, the latter being a clarification and detailed treatment of the longer term plan. In addition, there are some long term and perspective plans in selected fields (e.g., 12-year plan for agriculture).[3] The work of the planning commission is based on two sets of guidelines - the General Line and Planning Directives. These guidelines include: (1) putting politics in command; (2) rejecting profit as the major criterion of efficiency; (3) adopting optimality as a decision-making criterion with reference to the national economic goals; (4) ensuring that enterprises have not only an economic, but also a social function; (5) ensuring that wages are imposed and not based on marginal productivity or profitability; (6) ensuring fair distribution of goods by rationing; and (7) promoting regional and local self-sufficiency (Henle 1974).

(iii) Planning Levels

The planning exercise also takes place on two levels. The first (of the Five-Year Plan) mainly involves the government, the planning commission, the sectoral ministries, and provincial economic bodies, and is initiated at least 18 months ahead of the starting date of the plan.

The second (of the annual plan) mainly involves the enterprises and communes and usually starts at least one year ahead of time, and in practice requires about 3 to 5 months, proceeding in 3 stages. The first two stages are simultaneous and consist in the sending down of a draft plan of requirements from the sectoral ministry via the provincial organs to the enterprises and communes, which then send their proposals upward to the center. Both parties then participate in a series of conferences; the delegates from the ministries meet with heads of enterprises and/or communes to reconcile the two drafts. These meetings take place at provincial/county (hsien) levels. Once the final draft has been agreed upon, intermediary level bodies reformulate its contents for implementation.

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[2] The first Five-Year Plan was launched in 1953.

[3] The setting up of a long-term land use plan, a device introduced by an increasing number of communes, has also been encouraged, and the plan is brought into line with the overall and long-term planning goals of the state.

(iv) Effects of the Two-Level System

The decentralization and involvement of lower levels have helped to develop self-reliance. While the provinces and communes are delegated far-reaching powers in managing enterprises under their territorial jurisdiction, budget centralization ensures that no unplanned investment takes place - except the utilization of small funds as well as local accumulation funds for technical improvements and rationalization. These funds also supplement centrally allocated budget resources.

Broad masses indicate their ideas through their collective on all areas of development. These need not necessarily be in formalized reports and can be done orally. In order to aid in this process, workers in various fields meet in conference to discuss long-range plans. The ideas are pooled and decisions made centrally.

Within the commune, the plan is considered by both the brigade and the team committees. Communes give due weight to the decisions of the brigades and the brigade to those of teams. In practice, this means negotiations at each level, with the party organs acting as arbitrators to ensure that the competitive advantages of each collective and of sister collectives on the same level are fully utilized.

4.2 FORESTRY POLICY CONSIDERATIONS AND DEVELOPMENT

Forestry is regarded as an essential component of a balanced economy. Due in part to environmentally degrading practices, China has taken purposeful action to restore environmental health, placing great emphasis on tree planting.

4.2.1 Early Forestry Guidelines

Following Liberation, it was felt that guidelines were needed for afforestation work to establish productive as well as protective forests. Guidelines were also needed for exploitation of the existing natural forests and for management of forest resources in general.

When the Ministry of Forestry was established in 1950, Liang Hsi, a knowledgeable and experienced forestry professor at Nanjing (Nanking) University, became the first Minister of Forestry. He drew up a program and guidelines concerning:

1. protective afforestation for erosion control of sloping terrains aiming at watershed rehabilitation, stabilization of moving sands in more arid regions, particularly in northwest China, and shelterbelt plantations to protect crops against dry winds;

2. harvesting of natural forests, especially in regard to rich forest areas of the northern provinces (Heilongjiang/Heilungkiang, Jilin/Kirin and Inner Mongolia);

3. productive afforestation with fast-growing species which had potential for producing raw materials for industrial and construction purposes.

After the ministry was firmly established, the guidelines were further detailed in the "Directive on Mass Afforestation, Cultivation of Forests and Protection of Forests," which was accepted by the State Council in September 1953.

The "Directive" was focused on providing guidance to the collectives mobilized for large-scale afforestation of wastelands and bare hills and tree planting in and around villages for shelterbelts and along roads, canals, and river banks. A high priority was given to building a qualified infrastructure to give professional guidance and supervision (in forest protection and management) to the mass afforestation movement.

An Afforestation Fund was established in 1954. Within its terms, both state and commune forest farms set aside part of their revenue for afforestation purposes. Each province established a fund, and the central government developed an afforestation budget designed to supplement the funds of lower income units.

Before the end of 1955, a national conference on forestry was held and a forest development program was mapped out as an integral part of the Twelve-Year Plan for Agricultural Development covering the period 1956-1967. In view of rapidly rising wood requirements by the industrial, transportation, mining and communications sectors, it was planned that at least 100 million ha should be afforested during this period. Mao Tse Tung made an appeal to the people: "Cover the country with trees and make the country gardenlike!" The afforestation program focussed on both the establishment of protective forests and the establishment of plantations of fast growing species of high economic value and the so-called "industrial" species (producing oils, such as tung oil, tea oil and other products).

4.2.2 Problems Confronting Early Afforestation Efforts

It could not be expected that the state infrastructure, which had practically to be built up from nothing, would function properly within a few years. A number of problems arose during the course of early afforestation efforts.

(i) Lack of Technical Expertise

Collectives mobilized to do the mass afforestation work lacked expertise in afforestation work, particularly in areas with poor soil conditions, such as denuded hillsides. The collectives had been encouraged to rely on themselves in regard to seed collection and selection, nurturing seedlings in nurseries and forest planting--"the Three Selfs." Unfortunately, without technical guidance, these programs often met with a number of difficulties. For example, in Hunan Province, contour lines had been planted which were not horizontal, eventually causing severe erosion. Similar problems occurred in Guangdong (Kwangtung) Province, where nursery beds had been laid downslope without terracing. The older plantations of Pinus massoniana in both these provinces had to be totally replaced due to bad stem form, poor stocking and unhealthy appearance. Inadequate care and protection of plantations once they were established were evident. Plantations were heavily pruned, particularly in densely populated areas where coal and other sources of energy were not common, and people had to rely on gathering fuelwood from the forests.

Since the scientific and technical apparatus was still being developed, it could not provide the necessary guidance and supervision for mass afforestation work, particularly in seed collection and selection, nursery practices, and planting techniques.

(ii) Unclear Lines of Responsibility

Another factor contributing to the neglect and inadequate protection of the young forest plantation was vague or improperly delineated lines of responsibility.

The large-scale tree planting in and around villages for shelterbelts and along roads and canals was more successful, since the soil there was generally better than on the eroded hillsides and because the ownership of the land and hence the responsibility for the care and protection of the plantations was clear. Supervision by the local leadership could be more intensively and easily provided around the villages than for plantations in the hilly areas.

(iii) Labor Shortage

The Northern Region suffered a shortage of labor for extensive afforestation, tending, thinning and other management activities, as well as for forest exploitation.

This led to an increasing drive for mechanization. The problem of accelerating mechanization of forest operations and the improvement and rationalization of processing of wood and other forest products, including fuller utilization of waste products, occupied Chinese foresters.

(iv) Incomplete Forest Inventory

Planning the exploitation of the existing forest resources required a reasonably accurate inventory, as the possibility for overcutting was very great, particularly in view of the large, increasing demand for timber since cessation of timber imports in 1950. A special organization was established by the ministry in 1954 to conduct a forest inventory. In view of the urgency, the forest survey was scheduled to be finished not later than 1962, but this turned out to be too ambitious. Since the forest resources of high economic value were in Heilongjiang (Heilungkiang), Jilin (Kirin) and East Inner Mongolia, priority was accorded to these areas.

(v) Results of Early Afforestation Problems

These and other problems led the government to slow afforestation work and to devote more attention to the technical and managerial aspects. Early in 1963, a special deputy minister was appointed to deal with the management of forest plantations.

When the People's Republic of China started to reconstruct the country, only 8.6 percent (82.22 million hectares (ha)) of the total land area (956.1 million ha) was covered by forests. Now 12.7 percent of the land area is under forest.

4.3 FOREST PROTECTION POLICIES

4.3.1 Laws and Regulations Governing Protection of the Forests

(i) Decree of 1963

In order to reconfirm the policies as outlined in the "Directive of 1953" and to reinforce the measures which had been taken to ensure proper implementation, on May 27, 1963, the State Council promulgated a National Decree: "Regulations Governing the Protection of Forests." The general principles laid down in Chapter I of this Decree were as follows:

Article 1. These regulations are made for the purpose of protecting forests, guarding against forest fires, reckless timber cutting, and diseases and pests, so as to promote forestry production.

Article 2. Forests owned by the state and the collective, and forests owned by individuals are all protected by these regulations.

Article 3. People's councils at all levels should strengthen propagandistic education on loving and protecting forests and should motivate the masses to do a good job of protecting forests and trees.

The decree also addresses "Organization of Forest Protection," "Forest Management," "Fire Prevention and Fighting," "Prevention and Control of Diseases and Pests," and "Awards and Punishment."

The decree further states that detailed measures for implementing these regulations shall be instituted and promulgated by the Ministry of Forestry. However, the people's councils of various provinces, autonomous regions, and municipalities directly under the central authority may institute their own methods of implementation based upon these regulations, and detailed measures of implementation incorporating the concrete conditions of their own localities.

Through this method of local control, people are made aware of not only the need to care for the trees, but also of the punishments against those who commit forest felonies. Those people caught committing minor infractions are subject to criticism by members of the commune, production brigades and production teams. Attempts to rehabilitate the lawbreakers are carried out by re-education. These methods serve to promote the cause of forestry throughout the country.

(ii) The Forestry Act of 1979

The Forestry Act of the People's Republic of China was adopted in principle by the sixth session of the Standing Committee of the Fifth National People's Congress, February 23, 1979 (a translated copy of the 1979 Act is in Appendix 3). The general principles of this Act are as follows:

Chapter 1: General Rules

China's forest resources are classified into five categories: protection forests, timber forests, economic forests, firewood and charcoal forests, and special use forests. Forests, for the most part, "shall come under the socialistic ownership of the whole people and the socialistic collective ownership of the laboring masses." It also encourages a national effort in "building" forests at all levels by all people.

Chapter 2: Forestry Management

Responsibility for the country's forestry operations, including overseeing local forestry development and all forestry management organizations, is given to the Ministry of Forestry. An enforcement authority is created to ensure that management goals are being met and to require the development of long-range plans at all levels for the development of forestry. This chapter also sets priorities for forest development, e.g., by requiring construction and mining projects in forested areas to get prior approval from the Minister of Forestry and to construct roads before undertaking other capital construction projects. The Act also creates a timber tax, administered by the Ministry of Forestry, to be used for reforestation as well as for "building" new forests.

Chapter 3: Forest Protection

Chapter 3 creates agencies to oversee forest protection and to provide personnel to patrol the forests, prevent acts of damage, or deliver forest law violators to security departments. Also required are the development of fire prevention rules, facilities and suppression programs, including personnel organization. Firewood cutting, grazing, quarrying or any destruction in land reclamation forests are prohibited. The state and revolutionary committees are directed to protect and conduct research on animals and plants, and to create organizations for forest pest treatment and control.

Chapter 4: Tree Planting and Afforestation

This chapter addresses forest "building" and establishes the goal that 30 percent of China's land area should be forested. Revolutionary committees are instructed to develop plans for "building" forests for various land conditions, management objectives, and people's needs. Investigations will be made to see if planned goals and time frames are met. Reforestation will occur the same year or the following year of a harvest. High priority is given to developing high quality planting stock from improved seed tree sources and nurseries.

Chapter 5: Logging and Forest Utilization

All harvests will be well planned and controlled; the number of trees felled are not to exceed the number of seedlings grown that year. Timber harvesting on other than state lands must be approved by the appropriate revolutionary committee. All harvesting must be conducted according to state regulations; only regeneration cutting will be allowed in protective forests; no cutting is to be allowed in forests set aside for ecological protection. Organizations will be established to control and manage production of all wood products. The shipment of lumber or any forest product out of the production county, province, or autonomous region requires a permit from the respective forestry department. Lumber sizes and grades will be gradually standardized, and processing should be placed on a supply and demand basis.

Chapter 6: Awards and Penalties

The revolutionary committees at all levels are charged with encouraging and rewarding significant contributions; guidelines are given to help determine which units should be rewarded. Commendations will be awarded to those units which follow sound management practices, have made outstanding achievements in protection and production, and have carried out educational and research efforts. Also included are guidelines for moral and material rewards for individuals who have shown outstanding enthusiasm in helping obtain the state's forestry goals and objectives. Disciplinary actions are also provided for individuals who are poor leaders, defy policies and laws, or have in any way violated the priorities set by the Ministry or by the revolutionary committees.

Chapter 7: Appendix

Authority is given to the Minister of Forestry with approval by the State Council to develop details for implementation of the Act. Revolutionary committees at various levels are required to develop measures for enforcing the Act.

4.3.2 Resolution of Conflicting Interests

The conflicting interests among forestry, animal husbandry, agriculture and fuelwood needs placed tremendous pressures on the forests. The 1963 regulations were necessary to protect the forests against a number of encroachments, including fire, particularly in areas where fuel gathering and grazing were common. In general, plantation-forest areas had all access strictly controlled. To ensure the effectiveness of these regulations and measures, appropriate organizations needed to be set up. With the establishment of large scale plantations, mostly monoculture stands, the growing danger of pest and disease attack was recognized, as well as the need for research in this field.

(i) Integrated Use of Forest Land

The government, realizing that a rational land use policy must be formulated to resolve the conflicting interests of agriculture, forestry and pasture animal husbandry, undertook a comprehensively planned approach to the problems in these areas. In short, the government developed a policy of integrated use of forest land.

Pasture animal husbandry - For example, the autonomous regions (homelands of minority groups) still practiced extensive pasture animal husbandry, often with deleterious effects on forest land. Since these pasture animals are often the mainstay of a group's livelihood, a special policy was adopted by the government to solve this problem. During the First Five-Year Plan, 5,910,000 ha of forest land were closed to grazing. A national campaign was launched to encourage pig production to gradually replace free-grazing cattle and goats. This strategy has helped protect the forests. As a result, annual burning of grazing land to improve grass production has stopped; forest fires have been minimized, and hill forests have a better chance to regenerate.

Interplanting - This policy has also led to agricultural crops being interplanted in newly cleared afforestation areas until the forest plantation closes its canopy. This agrisilvicultural system - which is also being practiced in several other countries - is practiced particularly in the densely populated areas where labor is plentiful, such as Hunan and Guangdong (Kwangtung) provinces. In some areas in Hunan, intensive methods of tree planting in afforestation work have been applied, using chemical fertilizers, as well as organic and green manure.

Priority given food crops - As a related point of interest, since arable land for food crops is limited, nonfood crops are not allowed to expand at the expense of food crops. For instance, the increasing demand for textiles is partly met with rayon made from wood pulp to minimize as much as possible the expansion of cotton cultivation on farm lands. The Chairman of the Multipurpose Timber Processing Factory in Mutangkiang estimates that the annual production of 1800 metric tons (MT) of rayon grade pulp is equivalent to cotton production of 5300 ha.

(ii) Forest Products and Use

While food production must be given highest priority in a heavily populated country like China, the government decided that forests in hilly and mountainous areas would not be sacrificed for agricultural purposes in view of the key role forests were playing in improving the environment, as well as in providing materials for industrial needs. Furthermore, so long as fuel requirements for domestic and industrial use could not be fully met with other sources of energy, fuelwood remained indispensable. Therefore, China, a timber-deficient country, has pursued a policy of full utilization of wood in processing industries.

4.3.3 Protection Against Overcutting

The Forestry Act of 1979 established a policy of limiting timber harvest to the amount of the current annual forest increment. This law was established to prevent the overcutting and degradation of the forest that had occurred in the past. However, further consideration is being given to the question since the current annual increment is difficult to calculate accurately and does not necessarily equal the optimal cut that considers standing volume, its composition, future growth potential and life expectancy. A more flexible policy of optimality would include harvesting more than the annual increment in the overmature stands and less in the overcut forests.

4.3.4 Forest Fire Protection

(i) Fire Protection Systems

During the 1950's, a system of fire protection units was established the responsibilities of which included developing a network of special fire roads, watchtowers and a communication system. In the richest forest resources area in the Northeast, the government established aerial control stations with an airborne fire control brigade.

At the ministry and provincial levels, there are offices of "Fire Prevention and Control." These offices promote fire prevention and train the members of the county level "forest fire defense systems."

(ii) Fire Protection Problems and Prevention

Problems - Forest fire fighting has been complicated by a number of factors. Many of the richest forest areas are either remote or inaccessible by land. These overmature stands are most susceptible to severe fire destruction, since the forest floor cover has accumulated dried grasses, needles, twigs and leaves for years. Aerial fire control is constrained by a small number of planes with a large area to cover.

Emphasis on fire prevention - Because of the problems surrounding fire fighting, the government has strongly emphasized fire prevention. Prevention programs are promoted through mass media campaigns and mass mobilization of the people to cooperate with prevention efforts. Each forested province, prefecture, county and commune makes its own special regulations regarding forest fire prevention, and, as a result, a number of prefectures, counties and communes have not had any forest fires for over 20 years.

4.3.5 Protection Against Pests and Diseases

As with fires, the major emphasis regarding protection of the forests against pests and diseases lies in a campaign of prevention against outbreaks. This policy includes two major components: (1) selection of pest-resistant species, and (2) a mixture of species in afforestation plantations. Efforts are made to forecast epidemics. When an outbreak does occur, both biological and chemical control methods are used. The Chinese prefer to use as few chemicals as possible, resorting instead to the predominant use of biological control methods to fight outbreaks.

4.4 FORESTRY PLANNING

Responsibility for planning forest development rests with a number of agencies at various levels, and generally follows the same planning process elaborated on earlier in this chapter (4.1.3). The highest planning agency is the State Planning Commission. The commission is responsible for determining a national tree planting program, assessing wood requirements for industry and calculating the annual national harvest cut. The Ministry of Forestry is in charge of supplying information to the commission. This information is based on a collation of forecasts prepared at provincial level by teams of specialists from the forestry bureaus in charge of mapping, forest inventory and production forecasting.

When a goal is agreed upon by the State Planning Commission and the Ministry of Forestry, the ministry calls a meeting in Beijing (Peking) for all provincial forestry bureau directors. They discuss the feasibility of the planting and felling program and determine each province's allocation. Within their respective provinces, the forestry bureau directors, in turn, consult prefectures, counties and communes to discuss and allocate the planting and felling programs. The ministry, in turn, engages in a similar process involving state-owned forests to determine planting and felling programs.

4.4.1 Forestry Planning in Heilongjiang (Heilungkiang) Province

Due to the major role that forestry plays in Heilongjiang (Heilungkiang) Province, the forestry planning process is somewhat different from that of other provinces.

In May and November of each year, the Heilongjiang (Heilungkiang) Provincial Planning Commission meets and determines forestry goals, sets transportation and forest cutting guidelines and directs the harvested timber to industries or administrative units. Forestry development planning has to be synchronized with other developments. The details of synchronization and integration may vary, e.g., Tai Lin is a very important forestry county and is almost autonomous. It refers to the provincial bureau only for broad objectives and for the purpose of having its objectives coordinated with those of other areas. The Tai Lin Forestry Bureau has devised an overall unified production plan.

4.4.2 Development Planning

A national conference of forestry workers is organized once every 3 to 5 years, to discuss forestry development problems and long-range planning, which must be facilitated by short-term plans and programs.

Development planning considers local conditions in determining the type and mix of forestry, agriculture and animal husbandry. The exact nature of forestry, timber felling, shelterbelt forestry, etc., is also determined by local conditions. In addition, goals are also set for planting trees of economic value throughout the country. All local areas are expected to strive toward self-sufficiency in small-sized timber production; however, they may purchase larger-sized timber for local construction needs.

Outside the major timber producing areas of the northeast and south-central regions, the main orientation of the massive forestry effort in the countryside has been in the direction of protection afforestation to support agriculture and production afforestation to reduce dependence on "imports" of timber from other areas of the country. Emphasized are dune fixation, shelterbelts, river bank stabilization, dike consolidation and watershed afforestation. "Four around" forestry is practised in the plains to provide farmers with fuelwood and small timber.

Integration of forestry with other forms and aspects of land use have influenced the policies and plans of forestry development in China. This includes industrial forestry (chestnut, walnut, tea oil),[4] afforestation, shelterbelt, and agro-forestry.

4.4.3 Forest Industry Planning

Forest industry planning is the responsibility of the Ministry of Forestry. The Ministry of Light Industry is also concerned with industries such as pulp and paper. Industrialization is achieved by a combination of small, medium and large units - the emphasis being on small and medium-size units. Multi-purpose utilization is the universal rule.

Forest industries and enterprises are organized based on large forest areas. Forestry farms are organized in areas suitable for forestry. The state plans distribution of logs for processing. The self-reliance policies of China are now attaching greater importance to small-scale, multi-purpose woodlots and their utilization than was the case in the 1960's.

While the model as such is relevant and appealing to masses, the cooperative spirit of implementation is the crucial factor in the success of China's planning. Appraisals and comparisons are frequently made, to ensure the proper implementation of the plan.

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4 Throughout China, forestry is taken as encompassing not only timber trees but also orchard trees and economic crops (namely: tea oil, tung oil, nut trees, forest orchards, bamboo groves), and this influences the people's attitude towards forestry. The conflict of interest inherent in agriculture and forestry have been overcome by this view and by the integrated system of planning.

4.4.4 Statistics

(i) Macro Statistics

The Chinese planning system needs an adequate statistics base for continuous analysis and evaluation, even if such figures are not published. In the forestry sector, particulars concerning forest growing stock volume, increment, etc., for the entire country are not available in any collected form. The same is true of forest products production, trade and consumption.

The few statistics given are mostly percentile increases over previous years or occasionally refer to a reference year which has primary source material. Since China has been host to a large number of forestry delegations since 1972, these figures have been quoted in some reports. Otherwise, the sources of country data are the estimates of different agencies or individual China specialists. Some such estimates are subjective.

(ii) Micro Statistics

On the other hand, statistics at lower levels are available and are readily given. In the forestry sector, the area of forest, area of plantations, survival rates, spacings, volume of growing stock, thinning yields, growth statistics, management statistics, labor inputs, costs, prices, etc., are given for lower units and plantations. To some extent the afforestation figures get confusing due to planting of shelter rows of "four around" forestry - since it is sometimes included and sometimes not.

4.4.5 Projections about Outlook

Projections about future outlook or goals are only vaguely given for the country and the provinces; whereas, the smaller units usually give goals for planting, afforestation, logging, extraction, timber production, etc., both in the short run and the long (1990) run.

At briefings, authorities usually make general statements to the effect that China plans to increase the area under forest cover to 20 percent by the year 2000 and to 30 percent over the long-run, and that there are still large areas of barren land to be afforested. They also state that the forestry mechanization level is not sufficient, that forest road density is not high, and that multi-purpose timber utilization efficiency needs improvement. Not much more than this is usually given officially regarding future plans for forestry.

Chapter 5

FOREST ORGANIZATION, RESEARCH AND EDUCATION

5.1 ORGANIZATION OF FOREST ADMINISTRATION

The organizational structure of forest administration in the People's Republic of China has changed several times over the past three decades, reflecting policy changes by the government. For example, in the early years following the founding of the People's Republic of China in 1949, forestry came under the direction of two ministries - the Ministry of Forestry and the Ministry of Exploitation. Later, the Ministry of Exploitation was merged into the Ministry of Forestry. In 1971, the Ministry of Forestry was absorbed by the Ministry of Agriculture in an effort to better coordinate agricultural and forestry activities. In 1978, the National People's Council adopted a new constitution allowing, among other changes, the elevation of forestry, once again, to a ministerial level (Fig. 5-1).[1]

5.1.1 The State Council

The National People's Congress, the highest level of public representation, elects the members of the State Council based on recommendations from the Chinese Communist Party's Central Committee. The State Council consists of a Premier, 13 Vice Premiers and approximately 40 Ministers and Commissioners. This cabinet is the highest level of power in the government structure, although it is subordinate to the guidelines of the Chinese Communist Party.

The State Council maintains authority over 10 commissions, one of which is the State Planning Commission.

5.1.2 The State Planning Commission

As the highest formal planning authority in the government, the State Planning Commission directs annual, five-year and long-term planning for each sector of the economy (including forestry). Each sector must have its budget guidelines established by the Commission.

The State Planning Commission works with the Ministry of Forestry and local planning bureaus and the provincial, prefecture and county levels to establish budget guidelines for forestry throughout the country.

5.1.3 The Ministry of Forestry

(i) General Responsibilities

The Ministry of Forestry is in charge of formulating national forest policy and regulation. The ministry is responsible for all nationally-owned forests--approximately half of all the forested land in the country (See Section 5.1.7 (i) for a more in-depth discussion of forest ownership.). In addition, the ministry has direct jurisdiction over the Academy of Forest Science (the fountainhead of forest research) and the six major forestry colleges.

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[1] In early 1981, the Ministry of Forestry began a reorganization. In early 1982, Minister Yong Wentao was replaced by current Minister Yang Zhong.

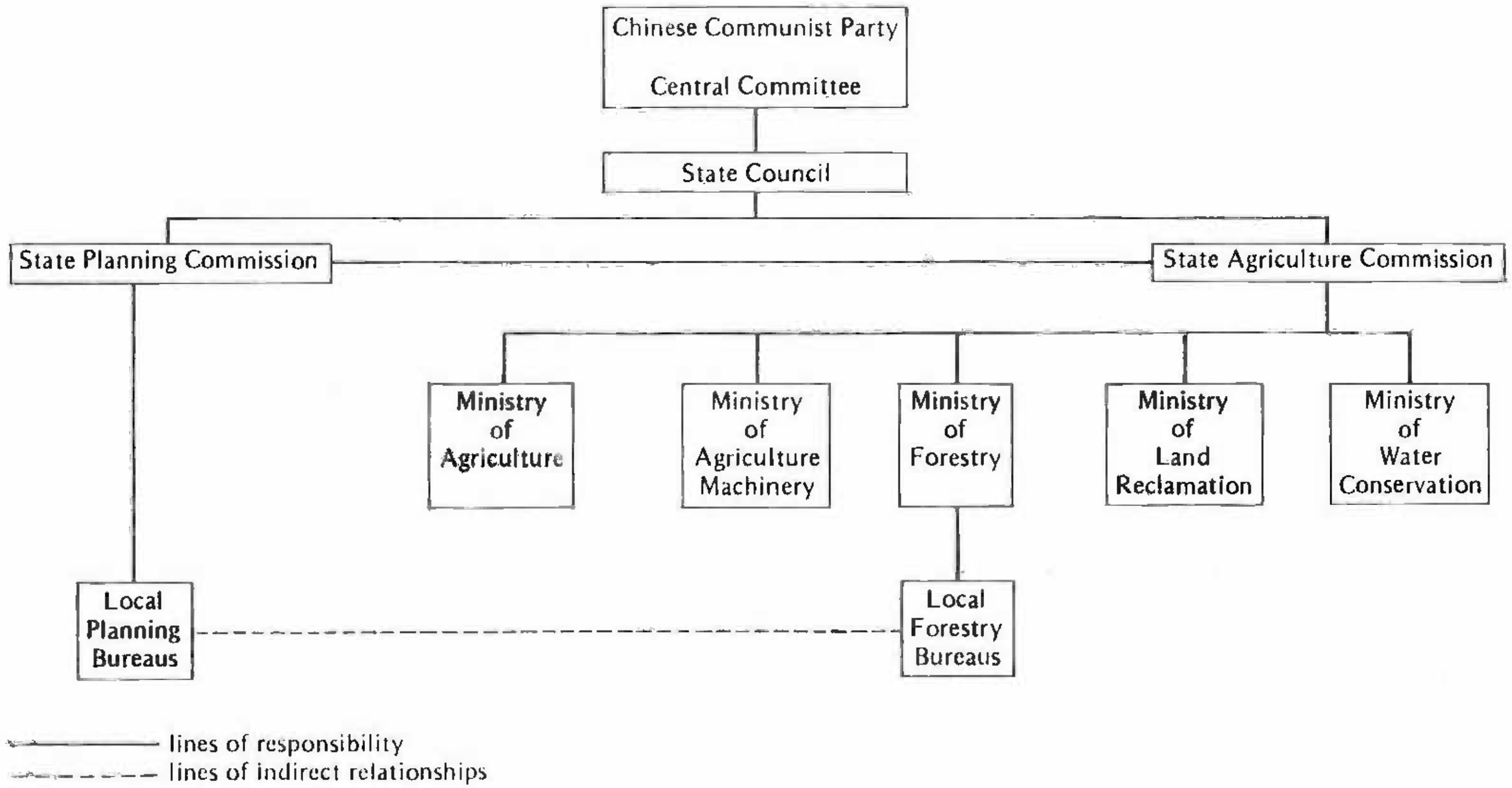


Figure 5-1. Organizational relationships with the Ministry of Forestry.

The Ministry of Forestry works closely with the other ministries which are under the State Agriculture Commission: Agriculture, Agriculture Machinery, Land Reclamation, and Water Conservancy. The Ministry, of course, also coordinates with other ministries and commissions.

(ii) General Organization

The Minister of Forestry is assisted by eight deputy ministers in the following areas--one each in Forest Industry, Forest Management, Planning and Finance, and Research; two each in Administration and Maintenance of Plantations, and Machinery and Material Supply (Table 5-1, Fig. 5-2). These deputy ministers oversee the following Bureaus and Offices of the Ministry (Table 5-1).

5.1.4 The Bureaus of Forestry

In almost all of the provinces, prefectures and counties, there is a Bureau of Forestry administratively responsible to the respective level governments, but technically responsible through the hierarchical structure to the Ministry of Forestry. The structure of each varies greatly, depending upon the amount of forest resources at each level. In areas where forestry is of minor importance, it is often combined with agriculture.

The Bureau of Forestry at each of these three levels is in turn responsible for allocating national planting and felling targets, advising and guiding the communes, and distributing a total of 100 million yuan per annum in state aid to the collective forests. This state aid, in combination with contributions from the communes, is used to buy equipment and establish new plantations.

The provincial bureaus of forestry have the additional responsibilities of production forecasting, forest survey and inventory and control of the provincial forest research institutes. The county bureaus of forestry maintain a permanent staff in charge of the management of the state forests--including the ability to employ collective labor to engage in forestation efforts.

5.1.5 The Communes

The approximately 50,000 communes in the People's Republic of China are divided into production brigades and production teams. These groups are responsible for the local management of the trees--the effort of which varies according to the amount of forest resources in the area. These groups are involved in the "four-around" planting policy by planting trees around their houses, villages, roads, rivers and canals. They are also involved in shelterbelts, afforestation of bare mountains, sand dune stabilization, intercropping (agrisilviculture) and even plantations of fast-growing trees for timber production.

5.1.6 Heilongjiang (Heilungkiang) Province

Heilongjiang (Heilungkiang) Province produces more than one-third of the industrial wood used in China. Because of the major role that forestry plays in the province, the structure of the forest administration is quite unique. The Provincial Minister of Forestry is located at the Provincial Bureau of Forestry in Harbin. In addition, there are bureaus of forestry not only at the prefecture and county levels, but also at the commune level. In the rural areas, the entire civil administration is incorporated within the forestry administration; together they are responsible for the management of factories, hospitals and schools.

Table 5-1. Bureaus and Offices of the Ministry of Forestry.

Bureaus

Seed and Nursery Bureau

Afforestation Bureau

Forestry Education Bureau

Science and Technology Bureau

Foreign Affair Bureau

Personnel Bureau

Forest Products Industry Bureau

National Forest Bureau

Wood Production Bureau

Finance Bureau

Planning Bureau

Information Bureau

Machinery Bureau

Material (Supply) Bureau

Offices

Office for Endangered Animals

Office for the Three-North (N,NE,NW) Protective Forest Project (Yinchuan, Ningxia/Ningsia Region)

Office for the Southern Forest Production Base Project

Office for the Southwestern Forest Production Base Project

5.1.7 Forest Management

To further clarify the responsibility and authority of various organizations over the forests and trees of China, it is important to classify the forests and trees two ways: by ownership and by function.

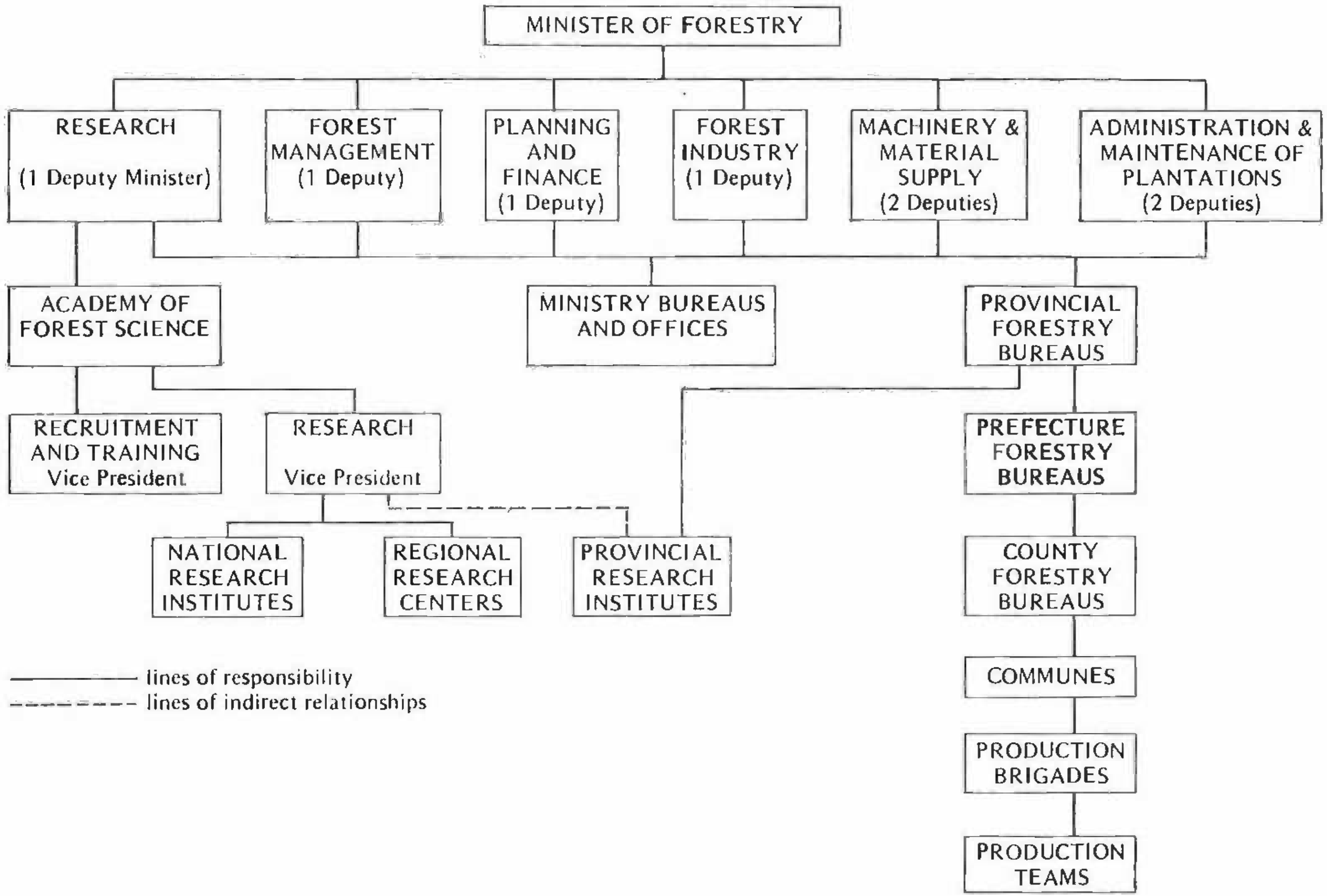


Figure 5-2. Organization of the Forest Administration.

(i) De facto Ownership

State-owned forests - Approximately half of the area in forests is owned by the state. For the most part, these areas are overmature, unexploited reserves located in northern Heilongjiang (Heilungkiang) Province, on Hainan Island, in south-central China and throughout the Xizang-Qinghai (Tibet-Chinghai) Plateau in southwestern China. In addition, the Ministry of Forestry also maintains guardianship over some afforested areas and some plantations.

Heilongjiang (Heilungkiang) Province forests - Of the 18 million ha of forested area in Heilongjiang (Heilungkiang) Province, 12.5 million ha are owned and managed by the semiautonomous forest administration under the direction of the Provincial Minister of Forestry. The remainder of the forests in this province are located in inaccessible areas in the north and belong to the state.

Collectively-owned forests - These forests are owned and managed by the rural communes, although they often receive advice and assistance from the state, province or county forestry bureaus. Forestry is highly integrated with agriculture and other endeavors of the commune. Usually they develop integrated plans, including "four-around" plantations, shelterbelts, watershed management, plantations for food and non-wood products, and even plantations of fast-growing species for timber production (for further discussion of this see Chapter 8). For many communes in northeast and southern China, the revenue from forest products now makes up half or more of the total income of the commune.

Urban forests - In major cities as well as small towns there is almost a line of forest bordering the roads; green walls and parks are also thickly planted. Trees are planted for amenity, climate, air pollution control, shade and wood production. These trees do not usually fall under the jurisdiction of the Bureau of Forestry; instead, they are managed by the various departments of Civil Administration.

(ii) Functional Classification of Forests

The following table illustrates the division of forests according to their function.

Table 5-2. Classification of forests by function.

Function	Percentage	Area Million hectare
1. Timber producing	80	96
2. Non-timber tree crops (tung oil, tea oil, etc.)	7	9
3. Shelterbelts	6	8
4. Misc. (such as fuelwood, amenity)	4	5
5. Bamboo	3	4
Total	100	122

5.2 RESEARCH

5.2.1 Background

(i) Early Efforts

Prior to 1950, forestry research was confined to only a few nurseries and laboratories. In the early 1950's effort was concentrated on summarizing the knowledge of Chinese forestry, especially in the silviculture of Chinese fir (Cunninghamia lanceolata), bamboos, tea oil (Camellia oleifera), and tung oil (Aleurites fordii).

In the middle 1950's, scientific research was greatly intensified. The Research Institute of Forestry was enlarged and in 1958 renamed the Chinese Academy of Forest Science. Associated with the academy were ten institutes and research stations.

(ii) Effect of the Cultural Revolution

The Cultural Revolution resulted in a serious disruption of research from 1966 to 1976. The institutes were dissolved and many researchers sent to do other work. Some research activities were combined with the Academy of Agricultural Sciences. Several colleges and universities were closed or had their faculty removed and some books and equipment destroyed. For example, the Beijing (Peking) Forestry College was moved to southwest China (Yunnan Province) and enrollment of students was suspended for seven years.

(iii) Post-Cultural Revolution Activities

In 1978 the Academy of Forest Science was reestablished under the Ministry of Forestry. Research institutes were reformed and research has been expanding rapidly in many areas, including: resource inventory, silvics of important forest species, genetic improvement, and forest entomology and pathology.

5.2.2 Organization

(i) Academy of Forest Science

Organization - The Academy of Forest Science, located in Beijing (Peking), is the focal point for forestry research in China and comes under the jurisdiction of the Ministry of Forestry. The Academy has seven institutes or departments located in Beijing (Peking): the Institutes of Forest Research, Wood Utilization Research, Forest Mechanics, Forest Economics Research, and Information (Literature) Research; and the Departments of Administration, and Library and Herbarium. In addition, there are three specialized research institutes located throughout the country that administratively fall under the jurisdiction of the Academy. They are: (1) the Wood Chemistry Research Institute at Nanjing (Nanking) in Jiangsu (Kiangsu) Province; (2) the Subtropical Research Institute at Fuyang in Zhejiang (Chekiang) Province, and (3) the Tropical Research Institute on Hainan Island in Guangdong (Kwangtung) Province. There are also two major research stations located outside Beijing (Peking): (1) the Forest Machinery Research Station at Dailing in Heilongjiang (Heilungkiang) Province, and (2) the Lacquer Research Station in Quangxi (Kwangsi) Autonomous Region. There are also several new field stations being established throughout China. See Figure 5-3 on the organization of the Academy of Forest Science.

The Institute of Forest Research - The Institute of Forest Research is the largest department of the academy, with 244 employees out of a total of about 600 employed by the academy. The department is divided into 14 branches: (1) Botany; (2) Ecology; (3) Entomology; (4) Exotic Introduction; (5) Genetics, Tree Breeding and Provenance; (6) Management, Inventory and Statistics; (7) Mensuration; (8) Non-timber Commercial Species; (9) Pathology; (10) Physiology; (11) Shelterbelts and Sand Fixation;

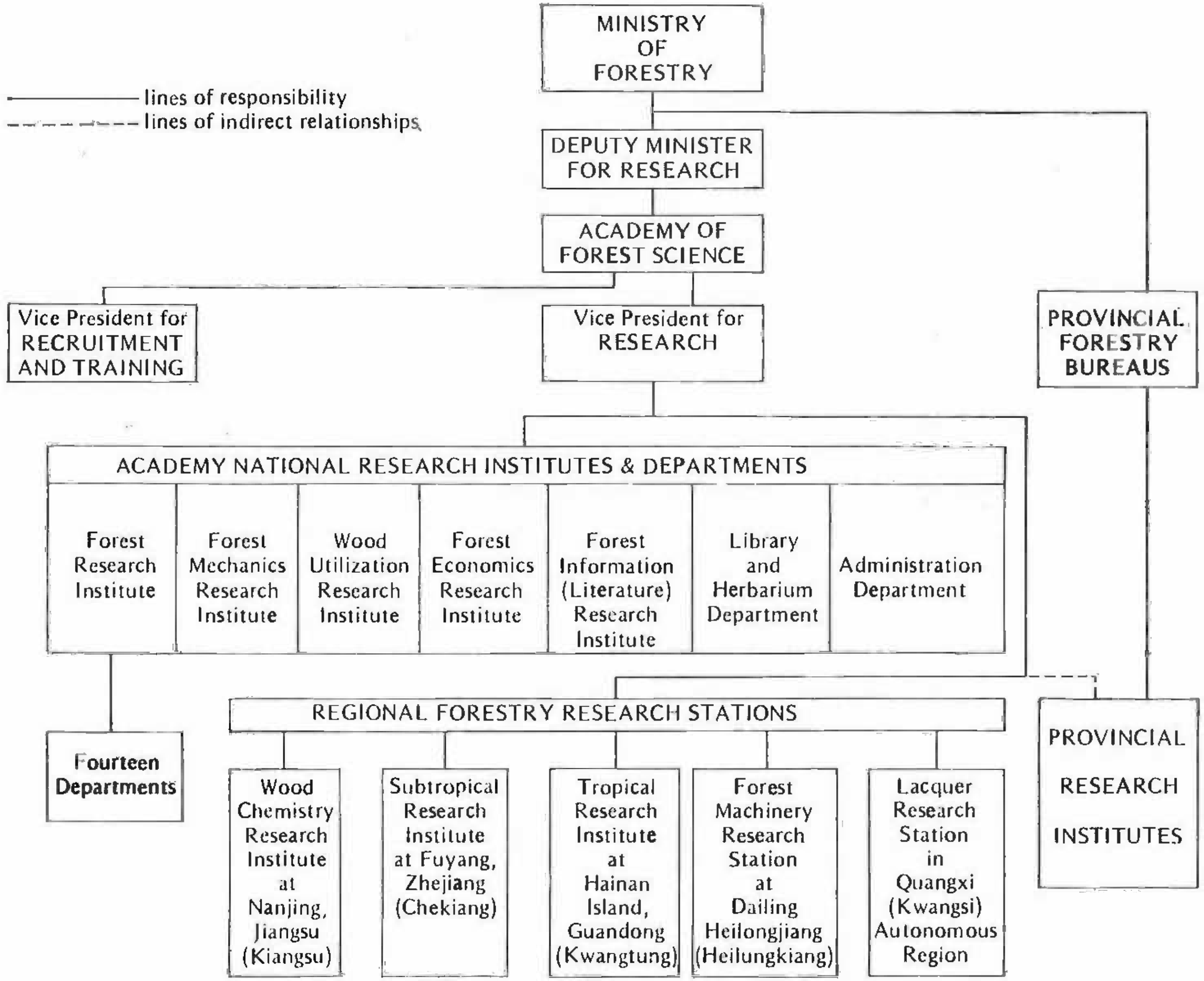


Figure 5-3. Organization of the Academy of Forest Science.

(12) Silviculture; (13) Soils and Site; (14) Urban Planting and Environmental Protection. In addition, the institute has a number of silvicultural field stations located throughout the country. The Academy of Forest Science is responsible for both basic and applied research, while the provincial institutes are usually concerned with more applied research immediately applicable to their areas.

(ii) Other Research Organizations

The provincial research institutes - These institutes fall under the jurisdiction of the provincial bureaus of forestry; most provinces have research institutes. In Heilongjiang (Heilungkiang) Province, where forestry plays a major role, there are 24 research or experiment stations under the jurisdiction of the county bureaus of forestry. Although the academy has considerable influence over the research conducted by the provinces, it does not have authority over them. The academy exerts its influence by calling periodic meetings of the provincial research institute directors to coordinate research efforts. Special meetings are also called to coordinate research efforts on a particular subject and to communicate research findings to foresters throughout the country.

Facilities in agricultural colleges - Some forestry colleges and forestry departments in agricultural colleges also conduct research, particularly at the main forestry colleges supported by the Ministry of Forestry.

Chinese Academy of Science - Basic research in forestry-related subjects is also conducted by the Chinese Academy of Science. Some of these research areas are taxonomy, botany, physiology, ecology and soils.

5.2.3 Formulating Research Projects

(i) Preference for Basic Research

Obstacles to applied research - Many researchers in China, as throughout the world, prefer to develop basic research projects in which they are personally interested. This preference for basic research is further reinforced by a number of difficulties encountered when a scientist attempts applied research in the field. First and foremost, there is a shortage of trained technical support staff to assist the scientist. Second, travel to the field sites can be extremely difficult. Not only is there a shortage of vehicles, but also a shortage of official drivers, since few Chinese have learned to drive. Travel is also constrained by the long distances between the laboratories and the fields.

Political influence - Since the Cultural Revolution in 1966, researchers have been regarded as an elitist group. In an attempt to keep research from becoming too academic, political instead of scientific directors have been appointed to head research institutions. These directors seldom have any scientific background and, as a result, have no basis on which to decide the relative benefits of a research project. Some people feel these directors favor those projects they feel will give China worldwide recognition.

(ii) Determining Research Direction

The Ministry of Forestry plays a major role in the formulation of forestry research policy and strategy of the Academy of Forest Science. The academy, in turn, exerts considerable influence over the direction of forestry research throughout the country. Since the academy is responsible for calling national and provincial meetings to discuss research, they are thus able to control the timing and direction of those discussions.

Beijing (Peking) Conferences - Top officials of the provincial research institutes and the provincial forestry bureaus are invited periodically--usually every other year--to meetings conducted by the Academy of Forest Science to discuss the research policy and strategy of the provinces. These meetings are usually rather large, which makes actual discussion difficult. However, they allow enough time for the academy to identify the major areas of research each province will undertake.

Interprovincial meetings - The academy occasionally calls meetings of several provinces to discuss the direction of research in a particular field and to exchange information and promote collaboration.

The academy may occasionally ask a provincial research institute to conduct research on an area unrelated to the concerns of the province, but usually the institute devotes its efforts to local problems and conditions.

In the end, the research programs undertaken by the provincial research institutes appear to take into account the desires of the academy and of the provincial, prefecture and county forestry bureaus.

5.2.4 Research Undertaken Since the Cultural Revolution

The Cultural Revolution ended in 1976. Since that time, research has been undertaken with renewed vigor. The following paragraphs describe some of the research that has taken place since 1976.

(i) Basic Data Collection

Basic data on forest soils are well advanced. Although many plants and animals in the remote mountainous regions have yet to be named, China seems to be well advanced in taxonomic efforts. Basic research on the physiology and biochemistry of forest species is starting in research institutes and colleges throughout China.

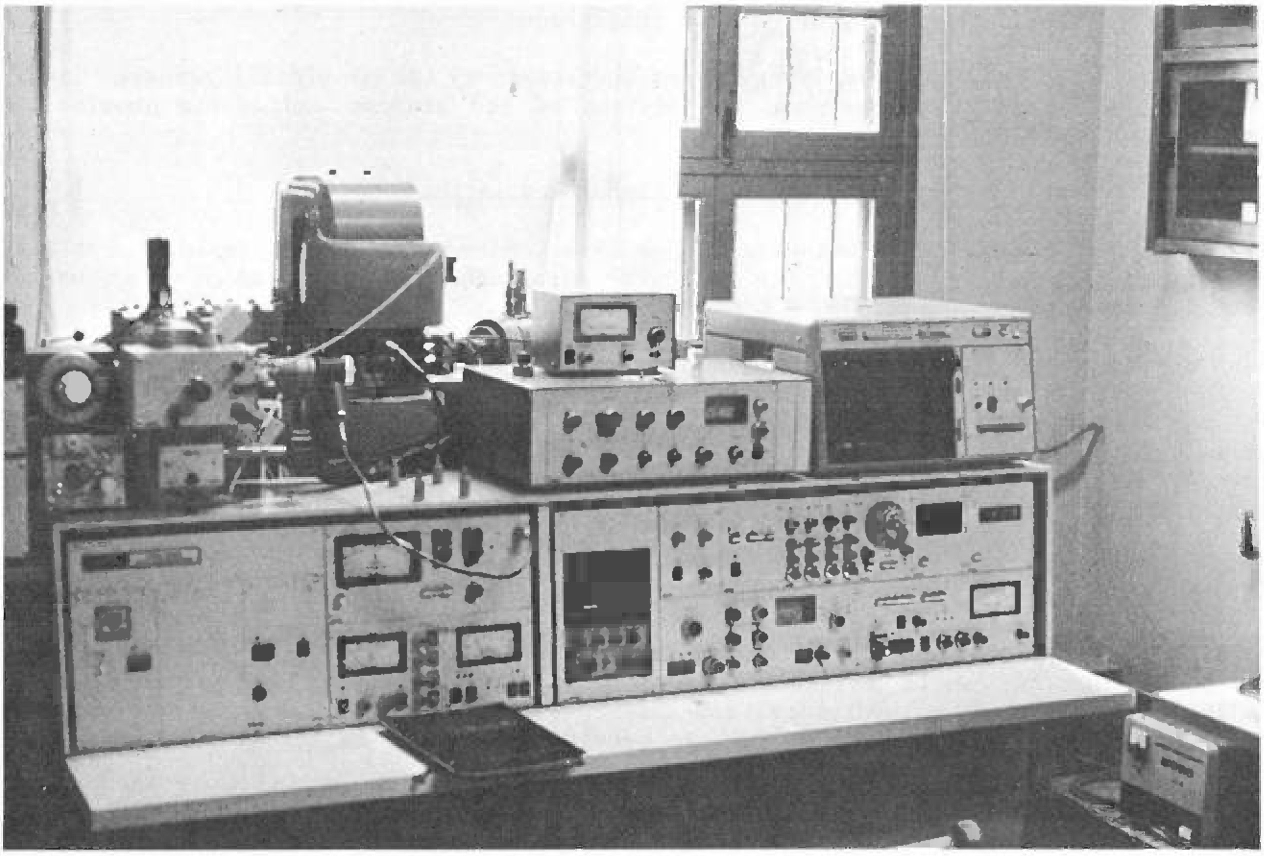
(ii) Resource Inventory

The main forest regions of China were inventoried by teams of Chinese scientists between 1950 and 1966. The teams were made up of silviculturists, dendrologists, ecologists, soils scientists, and botanists. Stations were established to collect data on climate, hydrology, and soils. Volume and yield tables were developed. Reports published from this research are proving invaluable in forest planning today.

(iii) Silvics

Studies of the silvics of the timber species of China are advancing. Several monographs on species and genera are available. Of special note is China's work with bamboos. In 1981 Wen-Yue Hsiung, of the Nanjing (Nanking) Technical College of Forest Products, published Bamboo Research. This book summarizes much of the knowledge of bamboo in China and includes papers on taxonomy, anatomy, ecology, and the silviculture of bamboo.

Studies are focusing on both native and exotic species, including Cunninghamia lanceolata, Pinus massoniana, P. koraiensis, P. yunnanensis, P. tabulaeformis, P. armandi, P. sylvestris var. mongolica, Sassafras tsumu, Cupressus spp., Funebris sp, Fokienia hodginsii, Biota orientalis, Paulownia elongata, P. catalpifolia, P. fortunei, Paulownia tomentosa, Populus tomentosa, P. simonii, P. euramericana, Robina pseudoacacia, Elaeagus angustifolia, Larix spp., Picea spp., Fraxinus spp. and Tilia spp.. One of the most commonly planted trees in central China, Metasequoia glyptostroboides, is under study to describe its silvics.



5-1: Gas chromatograph and electron microscope used for research at the Nanjing (Nanking) Technological College of Forest Products.

(iv) Genetics and Tree Improvement

Much of the current technology of forest genetics in China has been learned from reading foreign scientific literature and applying the knowledge gleaned to developing techniques for use in China. Selection and breeding of improved varieties are major activities of the forestry sector. Both native and introduced species are being studied. Major exotic genera include Populus, Eucalyptus, Acer, and Pinus.

Provenance testing - Provenance testing has been a major effort since 1977. A few tests were established before this year, but most of the records, as well as the tests themselves, were destroyed during the Cultural Revolution. The Academy of Forest Science reports provenance tests are established or planned for the following species: Pinus massoniana, Pinus sylvestris var. mongolica, Pinus taeda, Pinus caribaea, Pinus tabulaeformis, Pinus elliottii, Pinus armandi, Ulmus pumila, Cunninghamia lanceolata, Paulownia spp., and Robinia pseudoacacia.

New seed sources - New seed sources of the exotic species are being brought into China, especially for Pinus taeda, Pinus elliottii and Pinus caribaea, which prove very promising as they outgrow native species, especially on seed orchards, and seed collection areas are needed. A Pinus elliottii clonal seed orchard was established in Guangdong (Kwangtung) Province in 1964. A Cunninghamia lanceolata clonal seed orchard was established by Hangzhou City and produces about 130 kilograms (kg) of seed each year. Seed production areas not considered natural stands or established plantations receive a low priority in China.

(v) Tissue Culture

Tissue culture receives intense interest in China. Many of the major forestry research centers have ongoing experiments with tissue culture. Populus spp., Ulmus spp. and Cunninghamia lanceolata receive the most interest, but Taxodium distichum, Paulownia tomentosa, Sapium spp., Catalpa spp. and Eucalyptus spp. also are being studied.

Principal work here involves members of the Populus, Salix, Cunninghamia, Camellia, and Paulownia genera. Bamboos are also studied. Products of the work are being utilized throughout the forestry sector, often being vegetatively propagated for widespread use. Widespread use of imported hybrids such as Populus euramericana has been observed in China.

(vi) Introductions

In tropical and subtropical regions, several promising species are under investigation. These include Khaya senegalensis, Tectona grandis, Swietenia macrophylla, Mesua ferrea, Acacia auricumiformis, A. mearisii, and Eucalyptus spp..

Orchard species for production of fruits, nuts and oils are important. Olea europea was introduced very early. Other genera of importance are Carya and Juglans, both for nuts and wood. Wu Chung Lun of the Chinese Academy of Forestry published a book titled Exotic Trees and Shrubs in China (1981) which summarized the data on introductions in China.

(vii) Forest Entomology and Pathology

Extent of research - Chinese scientists are doing a considerable amount of entomology and plant pathology research. This research is being done by the Forest Research Institute, the Subtropical Forestry Research Institute and the Tropical Forestry Research Institute of the Academy of Forest Science, by various provincial forest research institutes, by the colleges of forestry, by botanical garden research stations and even city tree research institutes.

Biological control - Research has stressed basic taxonomic and biotype studies, monitoring and forecasting of epidemics and population changes, and studies of control methods. Research emphasis of control has generally been on biological control methods, rather than on use of pesticides and fungicides. This is due in part to a philosophy of concentrating on the use of natural as opposed to artificial materials, partly because of the large labor supply and partly because of the nature of the petro-chemical industry. Chinese research efforts on developing biological control methods have been enhanced by lack of constraints or regulations as occur in many countries. The degree of control of the pine moth Dendrolimus punctatus, which is the most serious forest pest in China, is a remarkable success story for biological control.

Biological control research in the past has focused on Trichogramma dendrolini, a small wasp that parasitizes insect eggs, and two microbials, Beauveria bassiana and Bacillus thuringiensis. Results have been so successful that these control agents are now used on a large-scale basis. Other parasites and predators are still in the experimental or small-scale use stage. There is also research on use of insectivorous birds. Some research is also being done on development of synthetic pheromones for monitoring changes in pest populations and for control through mating disruptions. Most recently, research is focusing on integrated pest management methods.

Integrated pest management - It appears that China is shifting from reliance on single control strategies to a research policy stressing studies using silviculture as a foundation for insect and disease control in an integrated pest management control context. The opportunities for integrated pest management methods should increase as foresters proceed in studies of suitabilities of tree species for particular habitats and site conditions and their development of strategies for mixed plantations (For more information on entomology and pathology, see Chapt. 6 and the publication by McFadden (1982).).

5.2.5 Research Needs

In an article published in the Journal of Forestry (Aug. 1981), Wu Chung Lun, of the Chinese Academy of Forest Science, summarized some of China's forest research needs. An excerpt from that article follows:

> SUGGESTIONS
>
> In order to speed up forestry development in China, suggestions on forest science are proposed.
>
> 1. Research institutes at experiment stations should be kept in stable condition, and permanent plots or other samples should be preserved. Major changes should not be made without careful consideration and discussion. Research workers should be employed as continuously as possible.
>
> 2. Scientific cooperation among institutes and personnel is very important and necessary in tackling the key problems efficiently. Research fields and projects in institutes at different levels should be different. Generally speaking, the Chinese Academy of Forestry, forestry colleges, and certain research institutes of provinces and autonomous regions should give more attention than local institutes do to basic sciences such as tree physiology, forest ecosystems, wood science, and technical problems over a wide range.
>
> 3. Experimental forests to demonstrate modern management should be established in each province and autonomous region. With the several forest regions in mind, the Academy of Forestry has established four experimental forests (or stations). It is also essential that each research institute in provinces or autonomous regions set up one or more experimental forests, stations, or farms. In addition, experimental forests are needed for each forestry college and department.

4. Basic research should be strengthened, especially in physiology, ecology, soils and sites, and wood technology, and also in mechanization of both silvicultural practice and product manufacture.

5. Experience in both ancient and recent forestry should be summarized.

6. Provision of modern scientific instruments should be facilitated. Such facilities as phytotrons, electron microscopes, computers, and remote-sensing equipment are indispensable if China is to catch up in forest science.

7. Literature, other information, and research personnel should be exchanged with foreign countries. In my judgement, our government will surely encourage such exchange by governments, institutes, and schools. Good international cooperation and information exchange will help accelerate the modernization of Chinese forestry.

5.3 FORESTRY EDUCATION

5.3.1 Relationship between Forestry Education, Extension and Research Programs

Because of the mass nature of forestry education, it is difficult to draw a line between forestry education and extension programs in China. Research is closely linked to these programs.

In most state demonstration forestry farms, research plots have been established which are used for problem-solving as well as for teaching new forestry techniques to the masses. Moreover, research is included in the curricula of all forestry education institutions. The staffs of both educational and research institutions visit communes from time to time to give on-the-spot training or to carry out research programs. There is, thus, close coordination between research workers and the grass-roots level, where much of the research is taking place.

The education system is related to the ownership patterns of forestry in China. Most of the forests, other than those owned by highway and railway authorities and the state-owned demonstration farms, are owned and managed, and their products sold, by the masses. This explains why China has undertaken such an extensive education program.

5.3.2 Levels of Education

Forestry education and training in China may be conveniently divided into two distinct levels of training, as outlined below:

1. professional forestry education, where students study forestry at colleges for four years;

2. vocational technical training, which is divided into two levels, i.e., secondary forestry school training, where students study for two years, and lower-level technical training for one year.

5.3.3 Professional Forestry Education

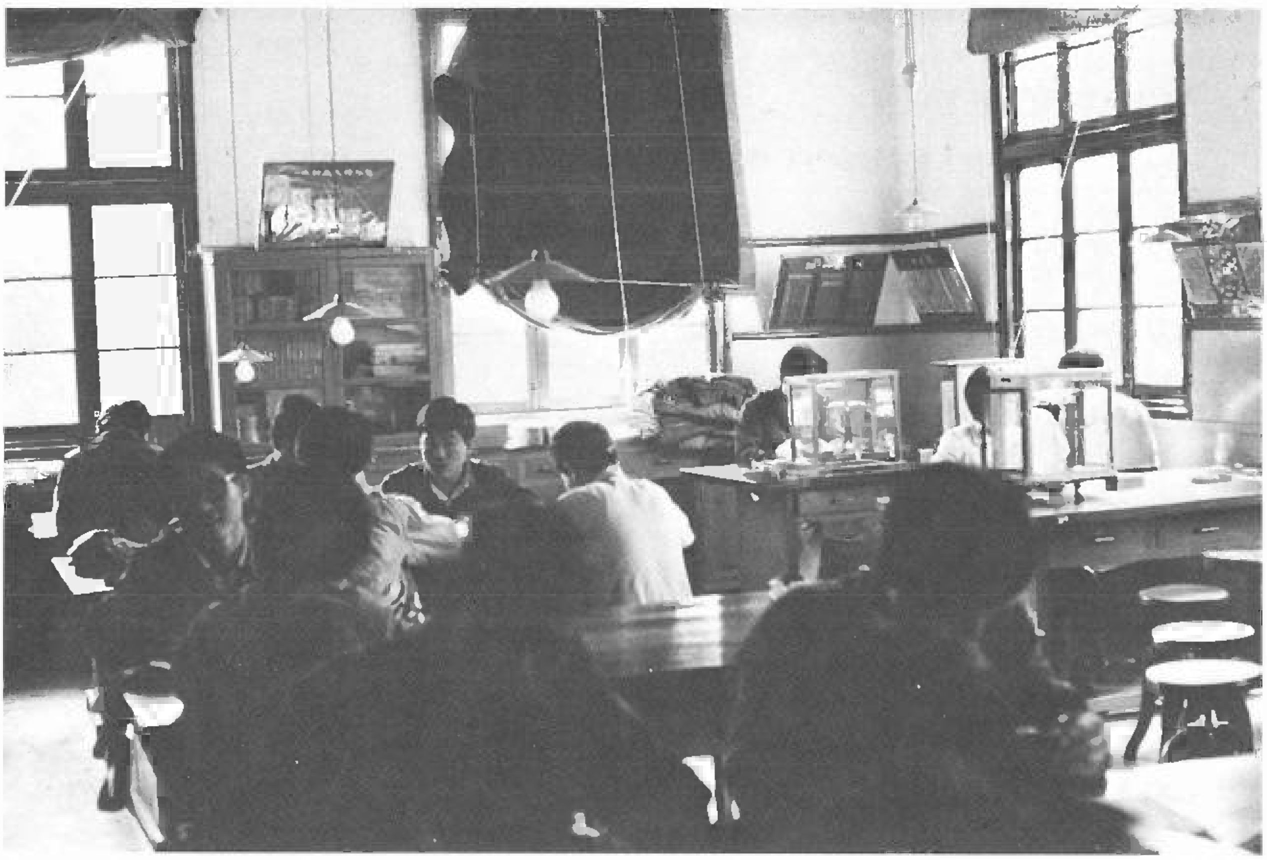
Professional forestry education in China is available at two levels: the 4-year professional education and the 3-year graduate program. Professional forestry education is offered in the independent forestry colleges and forestry departments affiliated with agriculture colleges. The entrance requirements, with the exception of those during the period of Cultural Revolution, include a combined 12-year pre-college education in middle school and primary school, and a highly competitive college entrance examination.

5.3.4 Forestry Colleges and Departments

There are eleven independent forestry colleges and seventeen forestry departments. With the exception of Qinghai (Chinghai), a province with scanty forest resources, college level forestry education is offered in every province and autonomous region. In each of the six geographic regions of China, there is a "major" forestry college under the direct jurisdiction of the Ministry of Forestry. The forestry colleges and departments of the six regions are listed as follows:

Table 5-3. Forestry colleges and forestry departments (* major forestry college).

THE NORTHERN REGION	
(1) Beijing College of Forestry *	Beijing (Peking)
(2) Forestry Department, Beijing Agricultural College	Beijing
(3) Forestry Department, Tienjing Agricultural College	Tienjing
(4) Hopei Forestry Technical College	Yi-hsien, Hopei (Hebei)
(5) Forestry Department, Shanxi Agricultural College	Taiyuan, Shanxi (Shansi)
(6) Forestry College of Inner Mongolia	Huhhot, Inner Mongolia
THE NORTHEASTERN REGION	
(7) Northeast College of Forestry *	Harbin, Heilongjiang (Heilungkiang)
(8) Jilin College of Forestry	Jilin, Jilin (Kirin)
(9) Forestry Department, Shenyang Agricultural College	Tunglin, Shenyang, Liaoning
THE EASTERN REGION	
(10) Nanjing College of Forestry Industry *	Nanjing (Nanking), Jiangsu (Kiangsu)
(11) Forestry Department, Anwhei Agricultural College	Sanhogi, Anhui (Anhwei)
(12) Zhejiang College of Forestry	Liwan, Zhejiang (Chekiang)
(13) Forestry Department, Shandong Agricultural College	Jinan, Shangdong (Shantung)
(14) Fujian College of Forestry	Nanping, Fujian (Fukien)
(15) Forestry Department, Communist Labor University	Nanchang, Jiangxi (Kiangsi)



5-2: Students at work in a wood chemistry class, Nanjing (Nanking) Technological College of Forest Products.

THE CENTRAL REGION

(16) The South-Central College of Forestry *	Shupu, Hunan
(17) Forestry Department, Henan Agricultural College	Zhengzhou, Henan (Honan)
(18) Forestry Department, Hwazong Agricultural College	Wuhan, Hubei (Hupei)
(19) Forestry Department, Guandong Agricultural College	Guanghon, Guandong (Kwangtung)
(20) Guangxi Forestry College	Yibien, Guanxi (Kwangsi)

THE NORTHWESTERN REGION

(21) The Northwest College of Forestry *	WuGong, Shaanxi (Shensi)
(22) Forestry Department, Gansu College of Agriculture	Langhow, Gansu (Kansu)
(23) Forestry Department, Ningxia Agriculture College	Yinchuan, Ningxia (Ningsia)
(24) Forestry Department, August Eighth Agriculture College	Wulumutzi, Xinjiang (Sinkiang)

THE SOUTHWESTERN REGION

(25) Yunnan College of Forestry *	Kunming, Yunnan
(26) Forestry Department, Sichuan Agriculture College	Ya-An, Sichuan (Szechuan)
(27) Forestry Department, Guizhou Agricultural College	Guiyang, Guizhou (Kweichow)
(28) Forestry Department, Xizang Agriculture-Animal Husbandry College	Lingtze, Xizang (Tibet)

5.3.5 Student Enrollment

Since 1949, more than 60,000 professional foresters have graduated from 4-year forestry colleges and forestry departments. But no new students were admitted between 1966 and 1972, and during the first post-Cultural Revolution year of 1977. There was no formal forestry instruction during the 10-year Cultural Revolution (1966-1976). The 1972-76 classes of "labor-farmer-soldier" students were recruited for their revolutionary activities and were admitted without adequate academic qualifications and entrance examination scores. Graduates from this period have required remedial training before beginning a professional career.

The first post-Cultural Revolution class of forestry students was admitted in 1978 by open entrance examination. In 1980, some 8500 students had been enrolled through competitive examination and had received or are receiving forestry educations at the eleven forestry colleges. The Beijing (Peking) College of Forestry and a few of the other leading colleges garner new students on a nationwide basis, and prepare their graduates for nationwide service. Graduates from provincial colleges and departments are usually assigned local employment.

5.3.6 Forestry Curriculum

(i) A Standardized Curriculum

All forestry colleges and forestry departments have a silviculture curriculum. Usually the only curriculum in most of the forestry departments, it includes a fixed set of required courses taught and studied with the aid of an approved synopsis or standard textbooks. The system assures a basic level of competency.

(ii) Curriculum Composition

The Chinese silviculture curriculum is essentially similar to that offered in many foreign countries. Instructions are given in eight 5-month semesters. Summer field courses are usually required. Certain options, such as wood utilization and landscape architecture, usually require an additional year of instruction and internship. The Chinese silviculture curriculum requires courses and credit-hour distribution generally similar to those of other countries. Of all the credit-hours in the Chinese system, 93.4 percent represent required courses; only 6.6 percent of credit hours are open to electives (Table 5-4). While the college level entrance students are, in general, more proficient in mathematics than entrance students from some countries, quantitative sciences such as computer analysis and modelling have not yet been introduced in the Chinese forestry curriculum.

A tabulated description of the Chinese curricula is listed in Table 5-4.

(iii) Options/Specialties Among Colleges

Flexibility within Chinese forestry instruction is possible at the department level and in the options available within each department. The leading forestry colleges of the six geographic regions offer a wide range of curricula, and each has its academic specializations and regional interests. The departments and options of the leading forestry colleges in Beijing (Peking), Nanjing (Nanking), and Harbin are listed in Table 5-5.

Table 5-4. Average undergraduate curriculum distribution percentages, 1980.

Physical Education	2.5
Humanities	8.6
Social Science	8.6
Math, Chemistry, Physics	15.0
Basic core course	25.4
Specialized courses	23.2
Electives	6.6
Other	10.1
	100

Table 5-5. Departments (roman numerals) and options (arabic numerals) of the three major forestry colleges.[1]

Beijing (Peking) College of Forestry

I Forest resources
1. Silviculture
2. Forest protection
3. Soil and water conservation
4. Forest economics

II Utilization
1. Wood manufacturing
2. Wood chemistry
3. Forest mechanics

III Urban forestry
1. City planning
2. Urban forest planting and landscape

Nanjing (Nanking) College of Forestry Industry

I Forest resources management
1. Silviculture
2. Forest pathology and entomology

II Forest utilization
1. Wood manufacturing
2. Plywood

III Wood chemistry

IV Forest mechanics
1. Woodworking machinery
2. Forest machinery

Northeastern College of Forestry

I Forest resources management
1. Silviculture
2. Forest protection
3. Forest economics

II Forest utilization
1. Wood manufacturing
2. Wood chemistry

III Forest mechanics
1. Woodworking, machinery design and manufacturing
2. Forest machinery design and manufacturing
3. Forest machinery, operation and maintenance
4. Forest industry, electrification and automation

IV Forest wildlife

V Logging

VI Bridge and road building

---

[1] Figures are approximate and drawn from unofficial sources.

Under this system, the better forestry colleges accept only better qualified students and offer them a wider range of career selection. All forestry students study common, required core courses, and each option includes a definite set of required courses.

Generally, forestry departments in colleges of agriculture or provincial forestry education programs do not have a wide range of subjects or courses. Most of these programs relate to silviculture with emphasis on agrisilviculture.

(iii) Instructional Methods

The teaching duties of a forestry course in the leading colleges are borne by a "teaching group" of professors, lecturers, and instructors. Lectures are given by individual members of the group for assigned sections of the course according to a jointly prepared course outline or lecture notes. Students receive copies of the course outline or, usually, a mimeographed copy of "Jiangyi," or lecture notes, even when textbooks are available. In China, a primary duty of good professors is to prepare lecture notes and distribute them to the students. The students are not required to take notes for the materials repeated in the lectures.

5.3.7 Faculty and Graduate Programs

(i) Faculty Distribution

In 1980 there were 2700 faculty members in the eleven forestry colleges. The faculty of the three colleges in Beijing (Peking), Nanjing (Nanking), and Harbin in 1979 are listed as follows (Table 5-6).

Table 5-6. Faculty of the three major forestry colleges.[1]

College	Depts.	Options	Full profs.	Assoc. profs.	Instructors	Teaching assts.
Beijing (Peking)	3	9	6	20	200	50
Nanjing (Nanking)	4	7	7	20	200	60
Northeastern	6	12	5	56	200	80

1 Figures are approximate and drawn from unofficial sources.

(ii) Faculty Problems

Age - Many professors received their graduate educations in foreign countries; many are alumni of leading American, European or Russian universities. They are recognized and respected scientists in their specialized fields and have had creative careers. But many are approaching, if not over, retirement age. Partly because of the years of isolation and the Cultural Revolution, there are relatively few well-educated professors in the younger and middle-aged brackets.

The thinning rank of aging professors has indicated to the authorities the need for graduate programs and, on a short-term basis, the desirability of academic exchange and advance studies abroad.

The need for increased graduate offerings - Beginning in 1954, nondegree graduate study was available at several of the forestry colleges, but this study ceased in 1966. In 1978, after the Cultural Revolution, regular 3-year graduate programs leading to the equivalent of a master's degree in forestry were initiated. The programs are offered in several options by the leading forestry colleges and forest research institutes.

The desirability for graduate study abroad - Study abroad has historically been a part of the Chinese forestry education program. During the 1950's and 1960's, many Chinese studied in Russian universities. Now, after years of isolation, the desirability for academic exchange and graduate studies abroad is greater than ever. The Chinese intend to modernize as rapidly as possible. Obviously, foreign study would expedite their modernization plans. Since the Cultural Revolution, China is again encouraging education abroad, although the number studying abroad in forestry is relatively low compared to some areas of science and technology.

However, more important is the next generation's education. The number of professors and assistant professors in the three leading forestry colleges of Beijing (Peking), Nanjing (Nanking), and Harbin has increased substantially from that of 1979 (Table 5-7). However, most of new professors and assistant professors were promoted from the instructor rank, and are former students of the same department and the same option of the same college. The result is a limited professional perspective which can be most immediately alleviated by foreign graduate studies for promising young faculty members and graduate students.

The Ministry of Education, therefore, has adopted the policy that the major emphasis on studies abroad at government expense will be placed on graduate level studies. The ministry feels that the Chinese undergraduate program is relatively good and, further, that it is more economical and efficient to emphasize the one or two-year graduate level program. There are a large number of Chinese students at both the undergraduate and graduate levels who are sponsored by friends or relatives abroad.

5.3.8 Vocational Technical Training

(i) General Description

To reach the national goal of creating and managing a forest cover for 20 percent of China's land, an area of 191 million hectares, by the year 2000, many forestry technicians will be needed. The vocational schools and their graduates will play an important role in achieving this goal.

There are 32 secondary and a number of technical schools for various forestry related training. These schools are generally supported by provincial or community administrations or by production units and usually offer a one or two-year program. The schools enroll middle-level graduates and some students from lower grades, for one to two years of vocational training. Selection is based on:

- experience in forestry work;
- aptitude for, or interest in, forestry work;
- and a high level of political consciousness.

Upon graduation, the students are generally assigned employment in the local region.

(ii) Secondary Forestry Schools

A number of counties administer secondary forestry schools. As of 1980, there were 32 secondary forestry schools located throughout China. These secondary forestry schools offer two-year courses in forestry.

(iii) Technical Training

Technical training normally consists of a one-year training program. On 7 May 1966, Chairman Mao stated that scientific experiment, together with class struggle and the struggle for production, was one of the three great revolutionary movements which were of theoretical and practical significance in implementing policies oriented towards socialism. Institutions in every discipline were set up in which instruction emphasized all three. As in other disciplines, forestry schools were established to produce lower-level forest technicians who would be going simultaneously through the three movements in their learning. These schools came to be known as the 7 May forestry schools.

The 7 May forestry schools administer short courses covering a period of one year. The students in such an institution spent one day a week in the classroom and the rest of the days in the field doing productive work as well as carrying out some research or observation work.

5.3.9 Continuing Education

Continuing education may be divided into three major programs, as outlined below:

1. training by demonstration where communes, production brigades and teams may learn from the experience gained in state farms established for the purpose;

2. training by way of visits of farmers to some identified model farms or communes, or tours of technicians, researchers and political cadres to communes where they discuss and exchange information on problems facing the individual communes visited;

3. spot training programs for individuals in the field, normally accompanied by seminars or workshops.

(i) Training by Demonstration on State Forestry Farms

Training of the masses by way of demonstration is a widely used and effective training method in China. In a county where forestry is important and commune members are supposed to carry out large afforestation programs, the state selects a representative place and establishes a forest farm there.

These forestry demonstration farms are not only meant for training the neighboring production brigades and teams, but are also production-oriented, carrying out a number of experimental research programs, and are supposed to be self-sufficient.

For example, there is a state-run forestry demonstration farm in Leichow County in Guangdong (Kwangtung) Province. The state Forestry Bureau in Leichow County was established in 1954 and currently administers ten forestry farms scattered throughout the county with a total area of 69,000 ha. This bureau also runs a forestry research institute. Through the initiative of this bureau and the research programs carried out by it, the surrounding communes and production brigades have been able to learn and copy new methods of afforestation and soil and water conservation, and, as a result, forestry and its role in water and soil conservation has become a major contributory factor to the agricultural and general economy of the whole county. As a result of integrated planning and improved agro-forestry practices, the yields of the land have almost doubled, leading to increased revenue and greater prosperity for once impoverished areas.

(ii) Training by Means of Visits and Tours

This method of learning from the experience of others by visits of farm workers to identified model farms and communes has come to be very widely used, not only in agriculture but also in all fields of development.

For example, a group of workers engaged in afforestation programs in one production brigade will arrange to visit another county or commune which has been identified as carrying out better forestry practice in one way or another. Such a group will try to learn the new technique practiced in the area visited so as to apply it to themselves.

In addition, through the three-in-one method outlined in the section on technical training, groups of technicians, researchers and political cadres carry out tours to particular communes and production brigades where they review the progress of forestry programs and teach the members new management methods.

(iii) Spot Training Programs

The spot training method differs from that of demonstration in that it mainly involves fewer individuals and it concentrates on specific items or subjects encountered in the field. The people involved in spot training methods are frequently professional or vocational forestry graduates assigned to a provincial forestry bureau or to a county or commune forestry department or team.

For example, a group of unskilled workers engaged in either nursery work or planting root cutting may be given on-the-spot training in the best nursery and planting techniques. This is usually followed by discussion seminars or practical workshops where the technicians and the workers discuss the problems concerning the new techniques. This method normally turns unskilled workers into very skilled personnel in the particular line of work in which they are engaged.

On the whole, the average Chinese is much more knowledgeable about forestry than the average person in any other country. This general awareness is only possible through the integrated nature of their training programs and also through the interdependent nature of agriculture, forestry and animal husbandry which, in fact, forms the basis of the Chinese economy and way of life.

5.4 FORESTRY EXTENSION

Extension in China is seen as a means of achieving increased production through mass participation and thereby raising the social and economic well-being of the community and of the entire nation.

Forestry extension is practised in a very pragmatic way. In provinces with relatively important forestry activities, forestry extension centers are established at each administrative level. These may take the form of a forestry institute at the provincial and county level or simple forestry technology stations manned with technicians at the commune level. In Hubei (Hupei) Province, 60 percent of the communes were reported to have their own forest technology stations.

5.4.1 Extension Techniques

Three interesting features of extension techniques, some of them unique in themselves, are described in the following paragraphs.

(i) Political Line

Mass communication - Most spheres of work and activity have been given political content in China. Chairman Mao's thoughts on forestry and its interdependence with agriculture and animal husbandry, enunciated by him in 1958, have been disseminated to the masses through a system of mass communication, using particularly radio and public address systems which are much in evidence in practically all the production brigades in China. Loudspeakers are noticeable not only in commune and production brigade areas, but also in the fields and factories. Thus, there is a smooth and effective flow of information between the people at the top levels and the masses. The stress given to the need for "four-around" integrated planting of trees along roads, along rivers and canals and around houses and villages, together with the call to modernize China scientifically before the end of the century, have without doubt permeated the masses by creating public awareness of the important role of trees for water and soil conservation and for timber, industrial and domestic needs.

Regulations - There are also regulations, promulgated by the State Council, governing the protection of trees. These regulations are communicated to the people by the revolutionary committees. The people's committees at all levels also may make their own regulations in consultation with the citizenry, to meet local needs. All these regulations are communicated to the public by extensive use of the mass media, such as radio, newspapers, posters, billboards, films, as well as through plays, exhibitions and public meetings. There is also a system of mass education at grass-roots level whereby classes are conducted for the benefit of members by party cadres and appropriate forestry department personnel.

Through these means, the people are made aware not only of the need to care for trees, but also of awards and punishments concomitant upon the care--or lack of it--accorded trees. Persons committing minor misdemeanors are subjected to criticism by the commune, production brigade or production team members, and rehabilitation is attempted by re-education of the errant member.

(ii) Motivation

Motivation is important in extension work. The new lines of policy and large-scale implementation comprise the foundations of national reconstruction. Motivation, therefore, was born out of a will to construct the future. This tremendous motive force has compelled the Chinese people at all levels physically to move mountains, as exemplified by Chairman Mao's story of "The Foolish Old Man who Moved Mountains." Such examples and simple slogans emphasizing government policy (i.e., "Cover the country with green trees"), catch the interest of the people and motivate them.

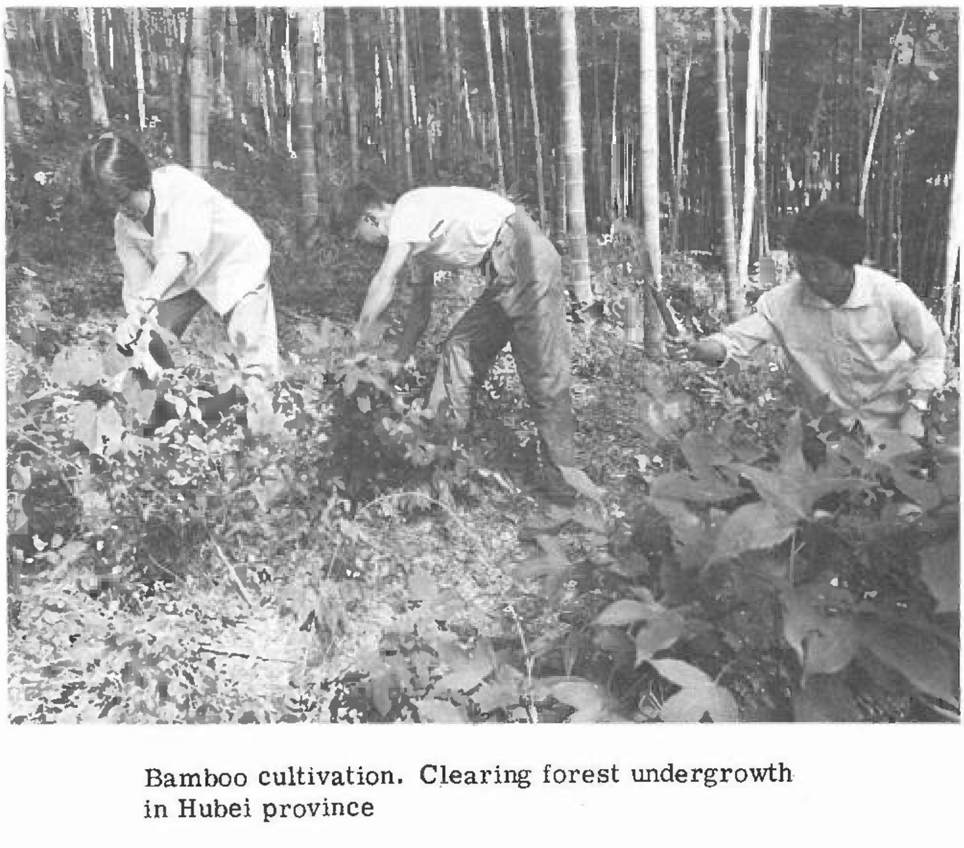
From the beginning, the emphasis has been placed on self-reliance and hard work, and because of this, agricultural production is reported to have progressively increased and exceeded targets in many areas. Similarly, forestry has played an important role in achieving this goal, and the people have become fully aware of the interrelationship between forestry and agriculture.

(iii) Mass Mobilization

Through extension, men, women, the young and old, at all levels, have been directed in accordance with Chairman Mao's teaching to "go all out to mobilize the masses." The results are often impressive. A notable example is the Ming Reservoir, where the late Premier Chou En-lai joined the masses in reconstruction work.

Extension work involves the semi-mechanization or mechanization of forestry operations. Transport of planting materials, etc., is now largely motorized in many areas. This trend will free some people to devote greater attention to other types of work.

Workers tend bamboo shoots at one of many bamboo groves in Zhejiang province



Bamboo cultivation. Clearing forest undergrowth in Hubei province

Bamboo forest industries. Tops of bamboo stems (phylostacchys pubescens) cut and ready for transport to a furniture factory

Making furniture from pinus massoniana wood in Hubei province

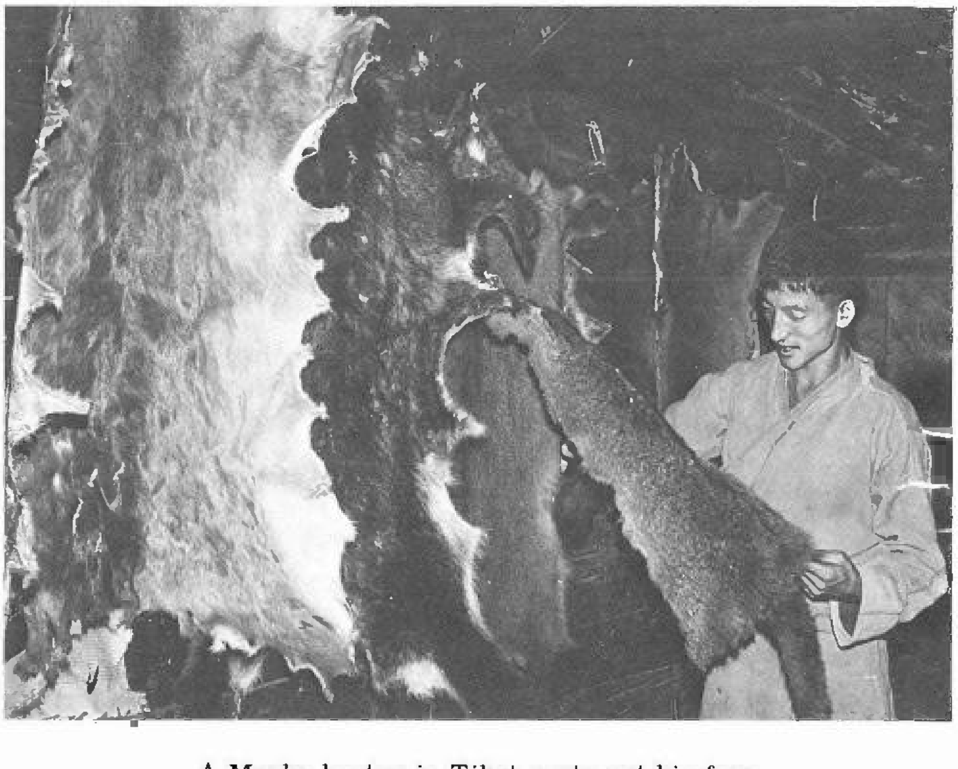
Tending a pinus elliotti plantation in Hubei province

The Chief of the Silviculture Bureau in Hubei province
demonstrates the use of a chain saw for forest workers
at a plantation of pinus cunninghamia

Adding mulberry leaves to silkworm trays in Guangdong province

Three-month-old seedlings at a Paulownia tree nursery in Hubei province

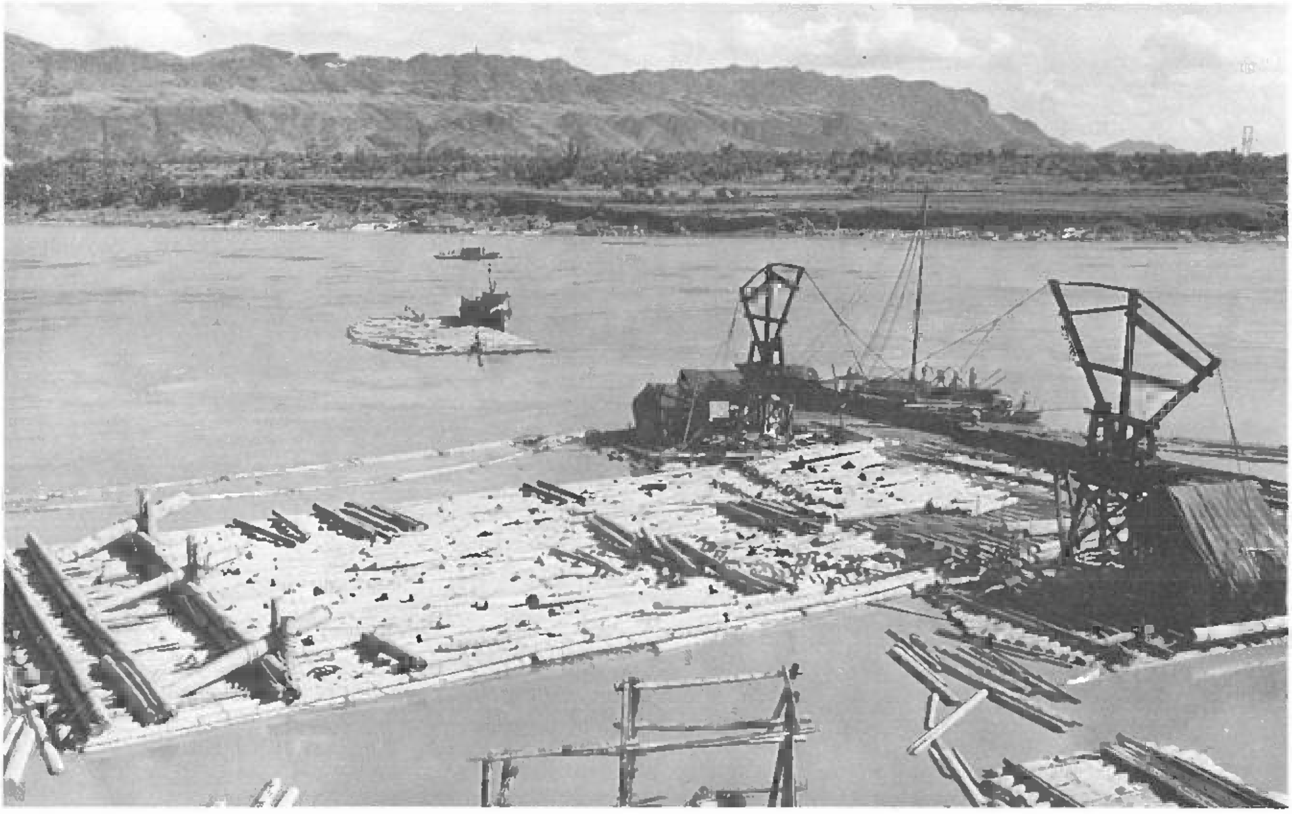
Collecting resin from pinus elliotti in Guangdong province



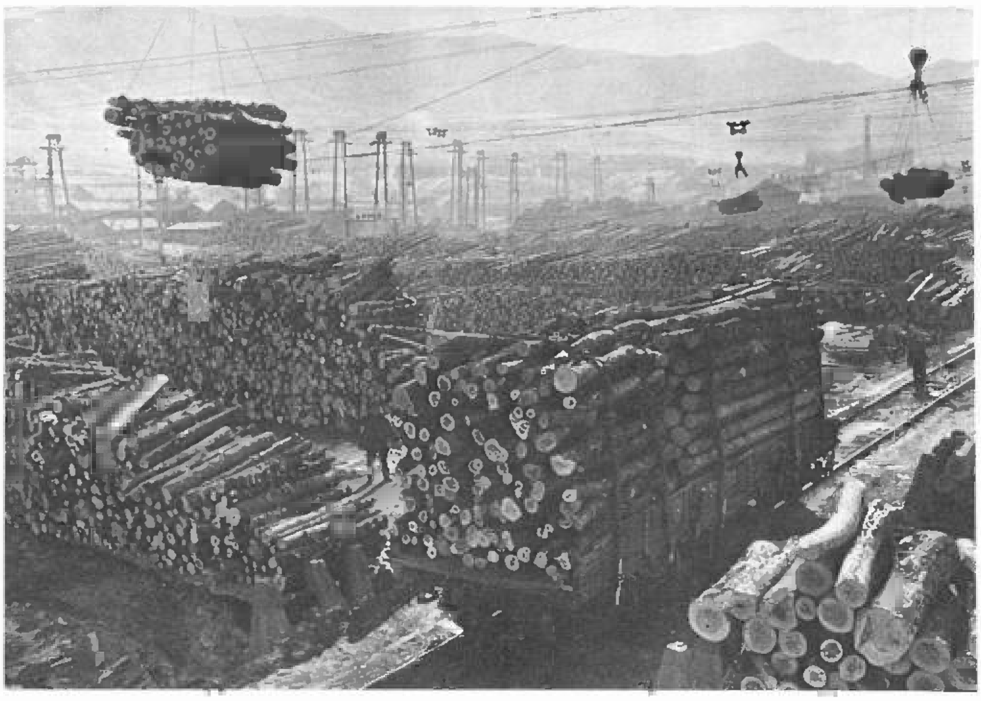
A Menba hunter in Tibet sorts out his furs

Basketry at a village industry in the bamboo forests of Hunan province

Furniture factory using pinus cunninghamia wood in Hubei province



Floating timber on the Yangtze River



Loading logs onto railway cars at a depot in northern China

The manager of a resin factory in Guangdong province checks containers ready for shipment to Japan

Chapter 6

SILVICULTURE, LOGGING AND TIMBER TRANSPORT

6.1 SILVICULTURE

For years prior to 1949, great damage was caused to both natural and man-made forests. Since the establishment of the People's Republic of China, the forests and forest land of China are for the first time under effective national control. Their use and management have become an integral part of the planned economy. The state forest enterprises and the forest felling and tending farms operated by communes and production brigades have assumed the tasks of timber production and forest regeneration and management. The policy of "taking silviculture as the foundation and integrating harvesting with tending" has been adopted.

China has limited amounts of natural forest, and a large portion of the remaining reserves were subject to utilization following the vast extension of the road systems in the last 30 years. The major efforts of Chinese forestry include large-scale afforestation projects in the denuded regions, the great national shelterbelt planting project, and the establishment and management of forest plantations.

Silvicultural practices are traditional and are characterized by (1) intensive management of fast-growing trees in short rotations, (2) multiple-purpose plantations of economic trees for the production of forest by-products and timber, and (3) mixed planting of several tree species, mixed planting of trees with agricultural crops, and thinning and harvesting at intermittent intervals. In essence, the approach is basically agricultural: tilling, sowing, planting, and harvesting. The methods involve labor intensive techniques of trimming and debudding, grafting, rooting of branches and trunks, and division of roots, rhizomes and stumps. The remaining natural forests, on the other hand, are not under intensive management, and are regenerated by natural and artificial means with varying degrees of success.[1]

6.1.1 Natural Forests

Natural forests once covered almost half of China. However, after centuries of exploitation and clearing land for cultivation, the surviving forests are limited mainly to the more inaccessible regions. The remaining natural forests of major economic importance are located in the northeast, mainly in Heilongjiang (Heilungkiang) and Jilin (Kirin) provinces and part of Inner Mongolia; and in the southwest, principally in the mountains and plateaus of eastern Xizang (Tibet). There are areas of old growth, mixed broadleaved/coniferous forests still remaining in the central and northwestern parts of the country, which have not been exploited because of difficulty of access. Modern transportation has only recently extended to these previously inaccessible frontiers. Efforts are directed toward judiciously exploiting these primeval forests, regenerating them by artificial and natural means, and managing them on a sustained yield basis. The natural forests of China are presented in Figure 6-1.

(i) The Northeast

The northeast region contains approximately 60 percent of China's total timber reserves, and at present most of the large wood processing plants are located there or in nearby cities. Virgin forest remains only in the less accessible higher elevations of the horseshoe-shaped region formed by the eastern margin of the Mongolian plateau, the Hsiao and Da Hinggan ranges and the Changbaishan massif. Lower elevations have been

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[1] For silvicultural practices and plantations of major forest trees and for economic woody plants and their products, see Tables 6-9 through 6-12, end of this chapter.

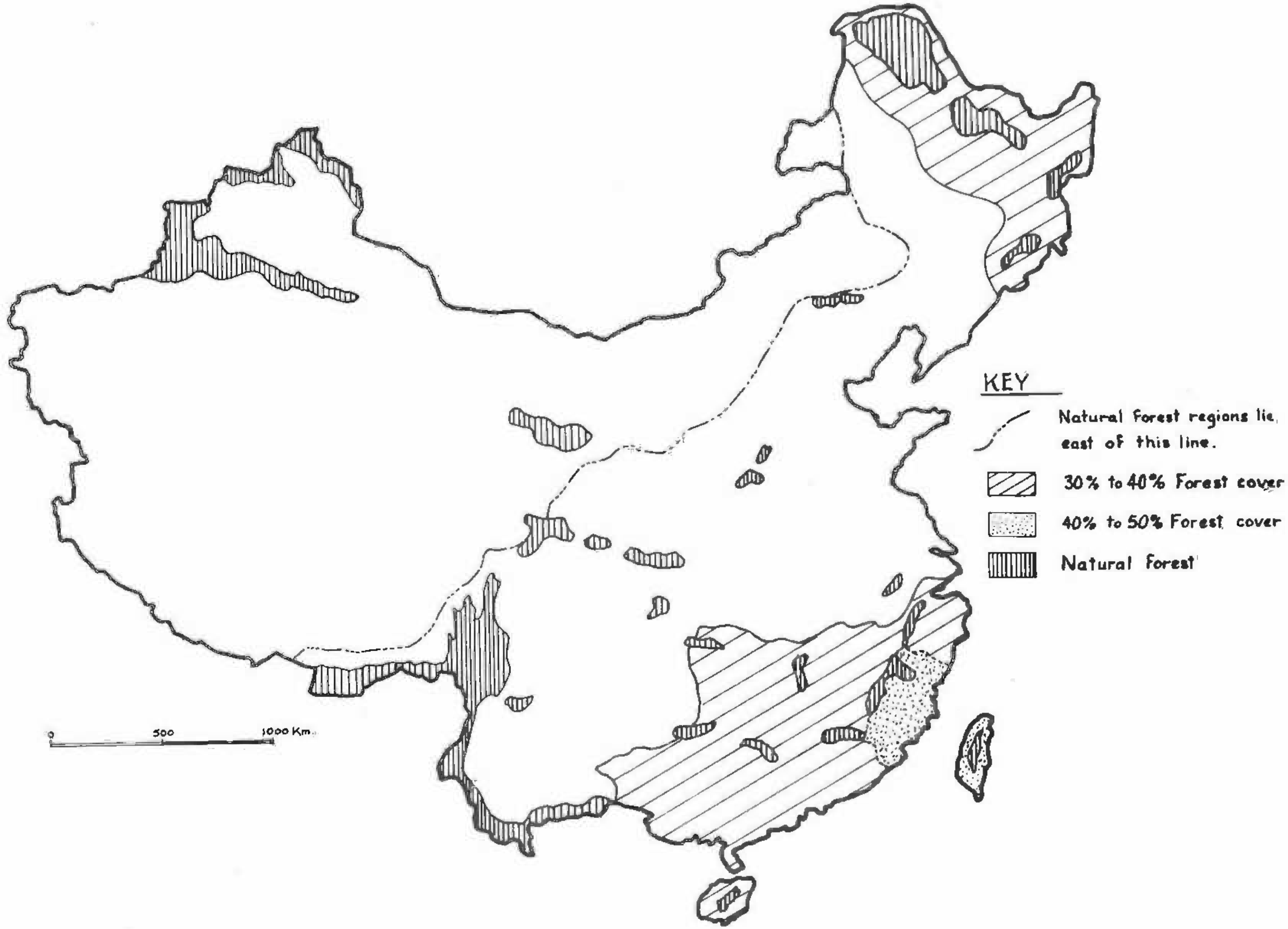

Figure 6-1. The People's Republic of China: Natural Forest Regions.

6-1: Mixed broadleaves and conifers on the Northeastern College of Forestry Experimental Forest, Heilongjiang (Heilungkiang) Province.

6-2: Mixed northern broadleaves--birch (Betula spp.) and maple (Acer spp.)--in Heilongjiang (Heilungkiang) Province.

reduced to shrubs and slopes with sparse plant cover. The plains of this region are intensively cultivated and densely populated.

The main silvicultural problem in the northeast revolves around cutting and regenerating these old growth forests. Red pine (Pinus koraiensis) is currently the most important commercial species in this area. There are at least 20 other commercially important species in coniferous and broadleaved-coniferous forest types. "Selective" cutting is currently practiced on the majority of areas harvested, and "natural regeneration" is relied upon in many areas. However, selection cutting is falling into disfavor because of misapplication and because the forest types do not seem to respond satisfactorily to this type of silvicultural system. Often noncommercial species tend to take over in preference to the desired commercial species, and regeneration is difficult. Therefore, the preferred system is now clearcutting followed by planting.

Even with planting and other special attention, it is difficult to get the desired species to dominate the young stand. This is particularly true in the broadleaved-coniferous mixed forest because birch and other species quickly invade the cut-over areas and compete with the planted trees. In these stands, the ash and basswood, which are so important for the furniture industry, are not being replaced, and an adequate future supply of these woods is in doubt.

(ii) The South and Southwest

In the southern and southwestern provinces (Figure 2-1, Regions 5A, 5B, and 6), intensive farming in irrigated fields is highly productive in the river plains and valleys. This general region has abundant rainfall and a long growing season. On the surrounding hills the cut-over areas and abandoned fields of shifting cultivation are soon overgrown with tall grass and shrubs. At present, the hilly regions of the south and southwestern provinces have considerable cover of secondary growth. With adequate protection, especially fire control, the natural cover of evergreen broadleaf trees can be readily restored.

To date, silvicultural research has not yet progressed sufficiently to provide adequate guidelines. There seems to be much research in the basic plant science areas to provide information fundamental to silviculture. However, more applied research in species trials, regeneration, stand establishment and stand management, including thinning and fertilization, is needed as background to solving the silvicultural problems in natural stands.

6.1.2 Man-made Forests

Afforestation, considered the foundation of forestry activity in China, is carried out in massive proportions to balance the growth and the cut. By any measurement, the performance and achievement in afforestation is staggering. Afforestation activity is being carried out in state farms and in people's communes as well as by agencies such as those in charge of railways, roads and cities, according to their situation and needs. China has afforested nearly 30 million hectares (ha) since 1949. In general, about 80 percent of the plantations belong to the communes and 20 percent to the state.

According to Hsiung (1980), 66.5 percent of all plantations are for timber production, 6.3 percent for shelterbelts and protection plantations, 13.3 percent for bamboo plantations, 11.8 percent for nontimber plantations of economic crops and 2.1 percent for fuelwood plantations.

(i) Quick-Growing Timber Plantations

Characteristics - The aim of this type of plantation is to provide timber for industry, housing, various uses in factories and agriculture and coal mines. In spite of the great number of species encountered, some of the most important quick-growing species used for timber production are: poplars (Populus spp.) in northern China; Cunninghamia lanceolata, Paulownia spp., Sassafras and Pseudosassafras spp. in central and southern China, and eucalypts (Eucalyptus spp.) and Casuarina spp. in southern China, especially in Guangdong (Kwangtung) Province. Other species include native trees such as Pinus koraiensis, Larix spp., Pinus sylvestris var. mongolica, and Pinus massoniana. In addition, many introduced species and some species of bamboo are used in these plantations. The silvicultural characteristics of some of these species are discussed in a later section of this chapter.

Establishment - Site preparation has undergone several improvements since the first plantations were created. Initially, shallow ploughing was done and shallow holes wer dug. Since then, site preparation has been the subject of much research work because of the low rate of survival. At present, all over China, the method of "three deep" is adopted, i.e., the site is deeply ploughed to a depth of at least 40 centimeters (cm) from the soil surface, a hole is dug 60 cm long and 40 cm wide, and the seedling is then planted deep with two-thirds below the soil surface. Hole planting is, in some locations, replaced by trench planting. Instead of a hole, a trench 50 cm deep is dug. This method is said to preserve the soil moisture better. Deep planting promotes a good development of the root system and prevents sprouting from the root collar, which occurs with some species where shallow planting is done.

After planting, intercropping is sometimes practiced in place of weeding. Shallow ploughing takes place in the second or third year after planting, and deep ploughing to a depth of 0.40 meters (m) or 0.50 m is undertaken in the fourth or fifth year. In the meantime, a ditch is dug between rows 50 cm away from the root collar wherein grasses or legumes are buried to increase the soil's organic content. Such a ditch is about 60 to 70 cm wide and 70 cm deep.

Growth and harvest - At the beginning, close density was adopted. This density might be as high as 6000 plants per ha. Several spacings have been tried: 1.3 x 1.3 m (5800 plants/ha), 1.5 x 1.5 m (4350 plants/ha), 2 x 2 m (2500 plants/ha) and 1.3 x 2.6 m (3000 plants/ ha). The high density affects tree growth, a fact acknowledged by Chinese foresters. At present, a spacing of 1.3 m x 2.6 m is most favored, as it allows a quick canopy closure for some species such as Cunninghamia lanceolata at year six or seven, which in turn permits a thinning of 50-percent intensity so that the final stand has only 1500 trees/ha. Rotation os some species, such as Cunninghamia lanceolata and Paulownia spp., is from 20 to 30 years.

(ii) Afforestation of Bare Mountain Watersheds

Afforestation of bare mountains is part of the integrated land-use plan at all levels. This type of activity is undertaken either in the context of protection or production forestry. Production plantations are carried out either to enrich secondary forest areas with species producing timber, fuelwood or some other commercial product, or to replace old, unsatisfactory plantations, especially of Pinus massoniana. Protection plantations are used primarily for regulating streamflow, improving water quality and controlling erosion to benefit adjacent agricultural areas. The practice in the past for either production or protection plantations has involved clean cultivation, removing old stumps and existing vegetation. This method has typically caused a lot of erosion during the early years of establishment. New soil and water conservation principles have, however, reduced the losses and at the same time increased tree growth.

Under these new principles, slopes of more than 15 percent are normally designated for forests. Slopes from 15 to 35 percent are usually terraced and pit-planting is done on slopes greater than 35 percent. The planting terraces and trenches are shaped to ensure better water conservation, and drainage of excessive water is also provided for. The terraces and pits also retard downward movement of the loosened soil. The frequent practice of intercropping with legumes and other crops provides additional soil cover and further helps stabilize the soil. Generally, three to four-year-old seedlings, two to four meters tall, are hand planted and fertilized.

The following species are commonly used in bare mountain-watershed plantations:

In Liaoning Province:	Populus chifungensis, P. simonii, P. nigra, P. pyramidalis, P. canadensis, P. pekinensis, Salix spp., Ulmus pumila, Amorpha fruticosa, Robinia pseudoacacia, Pinus tabulaeformis.
In Henan (Honan) Province:	Paulownia fortunei, Populus spp., Salix spp., Ulmus pumila, Platanus orientalis, Diospyros kaki, Ziziphus jujuba, Melia azedarach, Toona sinensis, Populus tomentosa, Populus dakuanensis, Paulownia lankanensis.
In Hubei (Hupeh) Province:	Cunninghamia lanceolata, Pinus massoniana, Larix koreana, L. sibirica, L. principis, Pseudosassafras laxiflora, Glyptostrobus pensilis, Pterocarya stenoptera.
In Hunan Province:	Paulownia spp., Populus spp., Salix spp., Cunninghamia lanceolata, Pinus elliottii, P. massoniana, Pseudosassafras latifolia, Toona sinensis, Aleurites montana, A. fordii, Camptotheca acuminata, Osmanthus fragrans, Sapindus mukurosi, Cinnamomum camphora, Podocarpus macrophylla, Acer davidii, A. mono, Platanus orientalis, P. acerifolia, Taxodium distichum, T. ascendens, Ligustrum lucidum, Sassafras tsumu, Magnolia grandiflora.
In Guangdong (Kwangtung) Province:	Alstonia scholaris, Michelia alba, Acacia confusa, Aleurites moluccana, Bombax malabaricum, Melaleuca leucadendron, Chukrasia tabularis, Ficus retusa, F. lancor, Casuarina equisetifolia, Eucalyptus exserta, E. citrodora, E. "leichow no. 1" (a local race of E. citriodora), Artocarpus heterophylla.

(iii) Shelterbelts and Sand Dune Stabilization

Shelterbelts are grown in most parts of China, but especially in the northwest to control sand dunes and desert encroachment. China's "Great Green Wall," a shelterbelt 6000 kilometers (km) long and about 100 m wide, is the most ambitious shelterbelt undertaken.

Characteristics - Poplars (Populus spp.) and willows (Salix spp.) are very commonly used in shelterbelts, particularly in north and central China. Pinus massoniana and P. tabulaeformis, Ulmus spp., Robinia pseudoacacia, Paulownia spp., Cunninghamia lanceolata, Casuarina equisetifolia and Eucalyptus spp. are also quite common.

Establishment - Usually one year before planting the site is prepared by deep ploughing and harrowing. Planting stock, usually from cuttings or seed from selected parents, is transferred from the nursery when plants are 2 to 4 m tall. Some of the tree planting methods are:

Slip planting - Normal cuttings of branches of poplar (Populus spp.) are planted beneath the surface, with only the tip emerging, at an acute angle to the soil surface. This is suitable for sandy areas subject to strong winds.

Pit planting - Two pits are dug; the soil from one pit is put into the other; the plants are planted and the soil is then firmed.

Furrow planting - Rectangular furrows are dug; seedlings are planted and buried.

Open-hold (pit) planting - This is a common method for planting farmland shelterbelts. A pit 30 x 30 x 60 cm is dug and planted with seedlings.

The planting distance for poplars (*Populus* spp.) used to be very close (1.3 x 1.3 m), but this has been changed to 2.5 x 2.5 m and 2 x 2.5 m (rows are 2 m apart) to allow for mechanization of tending operations. For *Paulownia* spp. shelterbelts in Henan (Honan) Province, single rows are spaced 50 to 70 m apart and plants 4 m apart in the rows. In multi-row belts, plants are normally staggered to give triangular-shaped compartments.

Culture - Early efforts at planting shelterbelts had only limited success. To improve survival, guidelines were given that required plantation work to be divided at the rate of 30 percent to planting and 70 percent to tending the seedlings after planting. Weeding is usually done three times during the first two years and once or twice during the third and fourth years of the plantation. The rates of survival are, therefore, usually very high (90-95 percent). Intercropping of shelterbelts has now largely replaced such intensive weeding operations. The belts are intercropped with agricultural crops, usually legumes (sweet potato, peanuts, etc.), for the first two or three years. The system has two advantages: weeding becomes unnecessary and food is produced.

Farmland shelterbelts are usually irrigated at the same time as the crop fields, normally three times a year. Organic manure is applied at the rate of 2-5 metric tons (MT)/ha of belts, normally when the crop fields are manured.

Shoot pruning is done to favor the strongest leading shoots. Buds are also removed from the shoot to produce a strong leader stem. Protection against pests and diseases is carried out when necessary.

In coastal shelterbelts, the species most commonly used is *Casuarina equisetifolia*. It is grown from seed, most commonly sown in January and February. The seedlings are transplanted in March-April into soil blocks covered with straw. Tap roots are cut when they are transplanted. The seedlings are planted out in July-September. Before planting, the roots are pruned. The spacing is 2 x 2 m and pits are of 40 x 40 cm. No manuring is applied. Every year five rows are planted toward the sea. The rotation period ranges from 10-15 years depending upon growth conditions and plan requirements. The yield is 45 cubic meters (m^3)/ha, which is about 4-5 m^3/ha/year. Each year 40 ha are cut and the area is immediately replanted. The wood is used for fuelwood and for constructing houses, large boats and even furniture.

Growth and harvest - As one example, the growth rates presented in Table 6-1 were given for Chieng County in Liaoning Province:

Table 6-1. Growth rates of poplars in a shelterbelt.

Planting date: 1966
Measurement date: 1976

Species	Average Height (m)	Average Diameter (cm)
Populus canadensis	18.8	20.2
P. pekinensis	16.4	19.3
P. pyramidalis	16.1	17.1
P. simonii	11.3	13.5

In another belt of Populus canadensis planted in 1966 and measured in 1976, average height was 21 m and average diameter was 20.5 cm. The total volume of 1 km of this belt 10 m wide (equivalent to 1 ha) was 563.3 m^3, or an average increment of 56.33 m^3/ha/year. Measurements for Ulmus pumila in this belt were 11.2 m and 14.5 cm for average height and diameter, respectively.

The rotation for poplars (Populus spp.) has been fixed at 20 years, after which belts are usually clear-felled. Successive belts are planted adjacent to the old shelterbelts at a distance of 8 to 10 m, eight to ten years before clear-felling of the older belt for utilization. The successive belts will assume the protective function of the old belts. This type of belt management was introduced as a means of practicing clear-felling instead of selective felling within belts.

(iv) Four-around Plantations

Four-around plantations refers to planting along roads, along rivers and canals, around houses and around villages. This is sometimes referred to as "environmental forestry" or "amenity forestry," but it also has a direct effect on the economy of the commune because the trees also produce timber, fuelwood, fruit, fodder and organic manure.

Characteristics - Planting of one or two rows on either side of roads is common, although there are sometimes complete belts of trees six to ten rows deep along some major roads and rivers. Such plantings are also common in cities, large and small, along roads as well as parks and recreation areas. Trees are always seen around individual dwellings in communes and around villages. Major species used in four-around planting varies from north to south, depending on whether it is along a river or in a large city. In northern China, willow (Salix spp.), poplar (Populus spp.) and Pinus massoniana are perhaps most common in four-around plantings, while in central China Paulownia spp., Robinia pseudoacacia, Sassafras spp., Pseudosassafras spp., Platanus orientalis, Thea oleosa and Melia spp. are most common. In southern China Casuarina equisetifolia, Eucalyptus spp. and Cunninghamia lanceolata are the most common trees.

Establishment - Trees are planted by hand labor, most commonly 2 m apart in a row and 2 m between rows. Close planting appears to be a common practice. On roadsides, plantings are often mixed. In northern China the inner row of trees may often be Pinus massoniana and the outer rows either poplar (Populus spp.) or willow (Salix spp.). Spacing between rows of poplar (Populus spp.) or willow (Salix spp.) may be only 1 m, compared to 2 m between rows of pine (Pinus massoniana) and poplar (Populus spp.). Generally, three to four-year-old seedlings 2 to 4 m tall are used for outplanting in four-around plantings. In urban plantings, trees up to 8 m tall are used in outplantings. Trees are often planted in pits 2 m in diameter and 1.2 m deep. Shading and watering of planted seedlings is common. Survival percentage is reported to be about 95 percent.

Culture and harvest - Trees are, of course, intensively cared for in cities and villages, but they are also cultured in roadside areas. In some cities trees are pruned so that the branches on either side of the road are trained toward the center of the road until they touch each other. This shades the roads and assists in controlling pollution effects. Trees are often intercropped for production of food crops. Even without intercropping, the trees are often irrigated, the soil weeded and ploughed and fertilized. A thinning after three years and a ten-year rotation are common. Depending on the type, trees are fully utilized, even in the cities, for fuelwood, timber or whatever product can be made from them.

6.1.3 Production of Planting Stock

For about the last 30 years, a tremendous amount of resources and effort has been devoted to afforesting the country. Throughout this period, natural regeneration has been of secondary importance. Early afforestation efforts were not highly successful due to a variety of problems ranging from lack of attention to seed selection to the use of low-quality planting stock to damage caused by extreme cutting of lower branches for firewood. Today those dealing with afforestation are cognizant of these problems and, through closer state control, are working toward more successful establishment of trees by improving seed quality, raising seedlings for large-scale afforestation projects in centralized nurseries, using higher-quality planting stock and educating the masses to the importance of trees and the need to protect them.

(i) Seed Collection

The bulk of seed collection is now organized by the Ministry of Forestry through seed centers. The centers either purchase surplus seeds from the production brigades operating the state or commune nurseries or by directly employing collecting teams.

In addition, seed orchards and stands have been established to produce seeds from superior species. Many of these orchards are unique in their establishment for multiple purposes. Not only are they used to bear seeds, but they are also managed to produce wood products. This is accomplished by not pruning the seed trees, as is sometimes done in other countries. Instead, they may harvest several selective cuttings on a given plantation and then convert it to a seed orchard. Because the trees are planted so closely together (5000 per ha), the growth rates are not particularly impressive. Other problems with this type of multiple use management of seed orchards involve the harvest of some of the best trees for wood and the difficulty of collecting seeds from the newly converted seed trees due to their height.

However, in recent years the establishment of orchards exclusively for the production of seeds has been initiated. By grafting older wood onto younger understock, a very high success rate (over 90 percent) has been achieved with the establishment of clones. For example, in 1973, a seed orchard was established in Heilongjiang (Heilungkiang) Province to produce seed from superior Larix gmelini and Larix gugensii. Four years later, the trees bore fruit, and in 1980, 17 percent were producing cones. Seeds were selected from the orchard trees based upon the individual tree's rate of growth, quality of fiber, absence of disease and quantity of seed cones borne (Dickerman et al. 1980).

(ii) Nurseries

Literally thousands of nurseries throughout China produce bare-root and containerized tree seedlings. In addition to the small nurseries at many communes, the state also maintains nurseries for seedling production.

State and commune nurseries tend to be very labor intensive. Irrigation is done by means of trenches between the beds instead of by overhead sprayers. Although some chemical weed killers are applied, weeding is usually done by hand. All cultivation is also done by hand. Site preparation is usually done by machine; however, containerized seedlings are usually planted in deep hand-dug holes. Seedlings are then transplanted as either bare-root or in containers.[2] Bare-root seedlings of Larix gmelini and Larix gugensii have shown rapid growth rates when planted in good soil with 3 x 5-m spacing.

The following information on Cunninghamia lanceolata is an example of how some of these practices are used. After the seed has been collected in October, it is broadcast sown directly into the nursery bed the following April. Seventy five kilograms

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2 Containerized seedlings can be transplanted after only 100 days in the nursery. Poplars are planted as rooted cuttings when they are one year old.

(kg) of seed are usually required for each ha of nursery bed, with an average germination of 40 percent. The young seedlings are thinned four times until they reach a density of 90 seedlings/square meter (m^2) at the time of transplanting.

Commune nurseries - The small commune tree nurseries are often located on land previously used for low productivity agriculture. These nurseries often produce seedlings that are phenotypically inferior and, because of poor soil and low intensity care, more variable than the seedlings produced in the state nurseries. Due to these problems, the small nurseries prefer to raise easily propagated trees such as Populus spp. and Salix spp. species and cultivars. Although each commune produces seedlings only for local use, they are so prevalent that they have contributed a significant portion of the trees used in the past for afforestation programs throughout the country.

State nurseries - The larger state nurseries often produce a higher-quality planting stock due in part to better practices and more intensive care. Inorganic fertilizer is seldom used; instead, they prefer to rely on large amounts of organic manure. Intercropping is a common practice. For example, the nursery at Jangutai covers in excess of 7 ha and intercrops with Chinese cabbage. This intercropping practice serves a dual function--the cabbage provides a low-cover windbreak for the seedbeds and provides food when the cabbage is harvested. The nursery produces over 3 million Pinus sylvestris seedlings annually, which are planted as 1-1 stock, and also 100,000 poplars (Populus spp.) of 12 varieties.

Large-scale nurseries are located in the cities and also throughout the provinces. The Tung Pei Wong Nursery in Beijing (Peking) raises 40 percent of the one million seedlings planted each year in the city. Of the seedlings produced each year, 62 percent are deciduous trees, 9 percent are evergreen trees and 6 to 7 percent are fruit trees. Populus tomentosa is predominantly planted throughout the city. This nursery, established in 1952, covers 160 ha and has a staff of 265 workers. Other cities have similar nurseries.

The Dailing nursery in Heilongjiang (Heilungkiang) Province covers an area of 20 ha with a seedbed density of 300 seedlings/m^2 on the 15 ha of seedbeds. The growing stock is about 25 million, with an annual production of eight million seedlings. Pinus koraiensis, raised as 2-1 stock[3], represents 40 percent of the annual production. The Pinus koraiensis seed is stratified for 12 to 18 months in underground pits prior to planting of the seeds. Larix dahurica is planted as 2-0 stock and accounts for 30 percent of the annual production. Abies spp. planted as 2-1 stock, and Pinus sylvestris var. mongolica planted as 2-0 stock, account for 10 percent of the annual production. The remaining 20 percent is Populus spp. Seeds of the conifers are either sown in rows or broadcast. During the cold winter, all seedlings are covered with soil.

China plans to further expand and improve her nurseries to fill the increasing requirements projected for the future.

(iii) Genetics

Throughout China, government officials and research scientists are dedicated to advancing and refining their programs in genetics and tree improvement. The Chinese consider that a number of areas may be further improved upon, and they are taking steps in this direction. Today, genetic principles are applied for selecting species adaptable to various parts of the country. However, because a number of regions still prefer the predominant use of a particular species, new infestations of pests and diseases may severely threaten the potential of the tree resources in these areas. The Chinese plan to undertake further research to improve selection programs for better form, growth and resistance and also to broaden their genetic base.

[3] 2-1 stock: 2 years in the seed bed and 1 year in the transplant bed.

Research - The Academy of Forest Science is in charge of coordinating all research on genetics and tree improvement; however, little of this is basic research and much of the research has never undergone replication tests. Current innovative programs on the production of planting stock include research on: pollinating Populus spp., clonally propagating Cedrus spp. and Populus spp. for urban forests, increasing the cooking oil yield from tea-oil shrubs, provenance testing the adaptability of a number of quick-growing species, including Pinus elliottii and Pinus taeda, and hybridizing Populus spp. and Eucalypts spp.. Current research also addresses organic fertilization and nitrogen fixation, rubber tree selection and culture, tree improvement programs for Phyllostachys spp., Cunninghamia lanceolata and Pinus massoniana and many others.

The Academy of Forest Science has identified a number of species that are either included in provenance studies or will soon be. They include:

> Masson's pine (Pinus massoniana), Scotch pine (Pinus sylvestris var. mongolica), White elm (Ulmus pumila), Loblolly pine (Pinus taeda), Slash pine (Pinus elliottii), Armand pine (Pinus armandi), Chinese fir (Cunninghamia lanceolata), Caribbean pine (Pinus caribaea), Poplar (Populus spp.), Chinese pine (Pinus tabulaeformis), Empress tree (Paulownia spp.), Black locust (Robinia pseudoacacia).[4]

Continued refinement of genetic and tree improvement programs to develop better planting stock will help fill the country's long-term forest resource requirements.

6.1.4 Forest Protection

(i) Problems

Fuelwood gathering - Among the problems that affect good silvicultural practices in China is the heavy utilization of plantations for fuelwood gathering. In some plantations all of the litter has been picked up, and removal of lower branches for fuelwood has been so severe that only a small crown remains at the top of the trees. Such severe removal may not only affect the growth of the tree and the future quality of wood, but this type of pruning can also increase susceptibility to insects and disease. In some areas new fuelwood plantations will provide the energy needs of rural people and relieve pressure on plantation trees grown for timber or other specific uses. In addition, plantations such as four-around and shelterwood are used not only for industrial wood and environmental control and amenity purposes, but in many cases serve an important role in providing fuelwood for rural villages. In some parts of the country, the government is also making coal available to people to help relieve the pressure of fuelwood gathering on commercial plantations.

Plantation density and composition - In some plantations trees are so closely spaced that growth is stagnated. In other cases, the stands consist of only one species, which may result in the plantation being more susceptible to losses from insect and disease attacks. Moreover, the planting stock in some of the older plantations often came from the same basic source or from unknown sources of poor quality. In any of these cases, the trees' susceptibility to insect and disease attack are increased. Natural stands of mixed species are relatively free from these kinds of problems and are not subject to the same types of infestations.

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4 Krugman, S.L., et al. 1981. Forest genetics and tree improvement programs in the People's Republic of China: 1981. (Administrative Report), p. 9.

Much is being done in China to alleviate these plantation problems. Silvicultural guidelines call for intensive management of plantations, which includes proper thinning and pruning and in many cases fertilization. Efforts are being made to obtain better planting stock from known seed sources. Plantations of mixed species are now being used in many areas. Even in established pure stands, other species are being interplanted to create mixed stands.

(ii) Forest Fires

In 1963 the State Council issued national regulations on forest protection, including a series of related rules and measures stressing prevention. The Offices of "Fire Prevention and Control" in the Ministry of Forestry and at provincial levels promote forest fire prevention through massive social work and use of mass media. As a result, many Prefectures/Counties/Brigades have not had any forest fires for nearly 20 years. In each forest area special rules/regulations for forest fire prevention are issued responding to local conditions. During high fire-risk seasons, the use of the forests may be restricted locally. Joint county "forest fire defence systems" also exist. In remote areas, fire watchtowers are erected. In northeast China aerial control stations, including airborne fire-fighters, combat fire losses.

Many of the inaccessible, overmature natural forests of the northeast and the southwest have large amounts of fuel per ha and are very susceptible to wildfires. Their inacessibility often makes it difficult, if not impossible, to get teams of fire fighters into the areas, even if the fires are detected early.

(iii) Insects and Disease

Silvicultural approach - Silvicultural practices, of course, vary with stand types, local conditions and management objectives. In China, natural stands and plantations are managed for a variety of products such as logs, pulpwood, poles, and fuelwood, as well as watershed protection, with local needs determining the major emphasis. Insect and disease problems have led to work on the development of silvicultural systems which meet the primary management goals and still hold the incidence and severity of insect and disease outbreaks to acceptable levels.

Major forest insect pests - The most important economic insect pest occurring throughout the coniferous forests, particularly the man-made forests, is the pine tip moth (Dendrolimus spp.), which attacks several genera of conifers, particularly Pinus spp. and Larix spp. The pine tip moth is capable of completely defoliating a tree, and two successive years of defoliation can kill the tree. It is estimated that nearly two million ha are damaged each year by pine moths. Larch casebearer (Coleophora laricella), the bark beetles (Ips subelongata and Blastophagus piniperda), gypsy moth (Lymantria dispar) and pine bast scale (Matsucoccus matsumurae) are also among the serious conifer pests (McFadden et al., 1981).

Among other important insects, a leaf roller, Polychrosis cunninghammiacola, attacks Chinese fir (Cunninghamia lanceolata), and a defoliator, Biston marginata, attacks Camellia oleifera. Bamboos (Phyllostachys spp.) are commonly damaged by Algedonia coclesalis and a locust, Ceracris kiangsu. Poplars (Populus spp.) are damaged by wood borer, Saperda populnea, and a defoliator, Clostera anachoreta. Willows (Salix spp.) and some poplars (Populus spp.) are attacked by Melolopha anachoreta, Leucoma candida, Anophophora chinensis and Batocera horsfieldi (McFadden et al., 1981).

Major forest diseases - Some of the more common diseases of forest trees in China are: damping off, caused by Pythium debaryanum, Rhizoctonia solani and Fusarium spp., which affect seedlings of Pinus spp., Populus spp. and Cunninghamia lanceolata; blister rust of Pinus spp. caused by Cronartium ribicola; needle cast of Pinus spp. and Larix spp. caused by Lophodermium pinastri; witch's broom of Paulownia fortunei caused by Mycoplasma spp.; Larix rot caused by Guignardia laricina, a fungus which affects several species of Larix spp.; fungus staghead disease of Phyllostachys spp. caused by Leptosphoeria spp.; root rot of conifers and broadleaf trees caused by Armillaria mellea; Tung wilt disease caused by a fungus, Fusarium spp., affects Tung oil (Aleurites spp.) trees such as Aleurites fordii; chestnut blight caused by Endothia parasitica attacks Castanea spp.; and Dutch elm disease affects Ulmus spp.

Among other diseases, Glomerella ungulata affects Cunninghamia lanceolata and Abies spp.; Balansia tabe affects Phyllostachys spp.; Phytophthora cinnamoni affects Robinia pseudoacacia; Colletolrichum camelliae affects the oil tree Camellia oleifera, and Cylospora chrysosperma affects Populus spp.

(iv) Control of Forest Pests

Integrated pest management approach - Insects and disease have a major negative impact on forest productivity in China. Currently, China is evolving from reliance on single control tactics to a policy of using silviculture as the foundation for a strong program in integrated pest management. For instance, in some areas new tree species have been added to break up pure stands. Work is also being done to select genetic stock that is resistant to the major pests. In addition, pest control techniques are being developed that are compatible with integrated pest management procedures. This means careful application of pesticides which, in addition to controlling certain target pests, might also reduce natural parasites and predators. Furthermore, as foresters in China develop more information on which tree species or combination of species are best suited for particular habitat and soil-site conditions, the opportunities for silvicultural or basal integrated pest management will increase.

Biological control - Although pesticides are still being used extensively as part of the integrated pest management program, the main emphasis today is on biological control of forest pests. This is in part due to the nature and distribution of the forest, but more particularly because of the conviction that biological control can be effective and is the best alternative. Synthetic pheromones are being explored as another possible tool for the integrated pest management program for monitoring changes in pest population density and for insect control via mating disruption.

The main natural control agents used in China are Trichrogramma dendrolimi, a small wasp that parasitizes insect eggs, and two microbes, Beauveria bassiana and Bacillus thuringiensis. Most other parasites and predators are used on a relatively small scale or on an experimental basis, although about half of the two million ha of forest land currently being treated receives the above mentioned biological control methods and about half receive some chemical insecticide. The plan is to increase the relative amount of biological control methods, although there may be problems in greatly increasing production of the biological agents.

The Chinese have isolated numerous viruses from at least 30 different insects. These include granulosis viruses, cytoplasmic polyhedrosis viruses and nucleopolyhedrosis viruses. However, some of these viruses have adverse side effects and production problems have yet to be worked out.

In the Nanjing (Nanking) area, bird predation is recognized as a major factor in pest control. Some 27 species have been said to feed on Dendrolimus punctatus. The warbler, Parus major Linne, is said to be one of the main feeders on this insect. It is estimated that in 16 days two birds could consume 2000 Dendrolimus spp. larvae. Although these figures are interesting, it is difficult to interpret them in terms of control over large areas.

6.1.5 Silviculture of Major Species

As discussed above, silviculture in China is more strongly oriented toward plantation forestry and agroforestry than toward natural stands. However, many of the procedures and methods used in either man-made or natural forests are based on studies of individual tree species under both types of forests. A discussion of the silviculture of a few of the major species will, therefore, also be helpful in understanding current silvicultural practices in China. Some silvicultural characteristics of additional species are noted in Tables 6-2 and 6-3. For tabular summaries of silvicultural practices and plantations of major forest trees and of commonly planted woody plants and their products, see Tables 6-9 through 6-12, pages 180-187, this section.

The following forest trees are discussed in this chapter:

1. Chinese Fir (Cunninghamia lanceolata)
2. Massons's Pine (Pinus massoniana)
3. Scotch Pine (Pinus sylvestris var. mongolica)
4. Red Pine (Pinus koraiensis)
5. Larch (Larix spp.)
6. Poplar (Populus spp.)
7. Paulownia (Paulownia spp.)
8. Sassafras (Sassafras spp.)
9. Eucalyptus (Eucalyptus spp.)
10. Casuarina (Casuarina spp.)
11. Tea-oil (Thea oleosa)
12. The bamboos (Phyllostachys spp.)

(i) Chinese Fir (Cunninghamia lanceolata)

Chinese fir (Cunninghamia lanceolata), or Sa-Mu as it is often called in China, is one of the most important timber trees in China. In timber volume it constitutes a large percentage of the nation's commercial timber production. It has been cultivated in China for over ten centuries. The silviculture of this indigenous conifer is a highly developed art.

Fast growth - The mature tree is over 30 m in height and often over 3 m in diameter. In plantations the average annual growth of 20-year and younger trees is approximately 1 cm in diameter, 1 m in height, and 1 m^3 in volume. In the better stands, the annual growth is twice as much. In Nanjing (Nanking) District of Fujian (Fukien) Province, a 37-year-old plantation of the Xiho commune was reported to have a total growing stock volume of 1170 m^3/ha (Anon., Silviculture of Major Trees in China, 1978).

Range of cultivation - Chinese fir is widely cultivated in 16 provinces from Taiwan to Yunnan. The range is approximately 102-122^o latitude and 22-34^o longitude. It appears in pure plantations or in mixed stands with Masson's pine (Pinus massoniana) and the common bamboo Phyllostachys pubescens. The center of Chinese fir cultivation is the hilly country of the southeastern provinces. This is the Xijiang (Sikiang) and Chang (Yangtze) River divide, and the nation's southern commercial timber production base. The greatest concentration of Chinese fir plantations is in the southern part of Zhejiang (Chekiang) and Fujian (Fukien) provinces, the northern part of Guangdong (Kwangtung) and Guangxi (Kwangsi) provinces, and southwestern Hunan and southeastern Guizhou (Kweichow). In the last 30 years, the range of Chinese fir plantations was expanded to southwestern Yunnan and tropical Hainan Island. It was also planted as far north as Shandong (Shantung) Province.

In the new planting areas, special consideration has to be given to the selection of proper strain of Chinese fir and suitable sites.

Altitudinal range - Chinese fir also has a wide altitudinal range. In the main production region of the southeastern provinces, Chinese fir is mostly planted on the low hills below 240-300 m in elevation. The altitudinal limit is lower (180-240 m) in the eastern and the northern regions, and is higher in the southwestern plateau. In western Sichuan (Szechuan) (Omei Mountains), Chinese fir extends to 1800 m, and in northeastern Yunnan (Hweijai District) to 2900 m.

Geographic variation - Chinese fir rotation periods vary considerably among geographic regions. The plantations are mostly managed for short rotations of about 20 years. In the southern regions, the rotation age is as short as 15 years. The purpose is to produce round logs during the period of fast juvenile growth. The performances of 20-year plantations in different areas, given in the following table (Table 6-2), are based on above-average stands.

Table 6-2. Geographic variation of Chinese fir Plantations (20-year height, diameter and stem volume).

Region	Province	(District)	Latitude	Height (m)	diam. (cm)	Stem Volume (m^3)
Lower Chang Jian (Yangtze) Valley	Anhui (Anhwei)	(Hoshan)	31-32	10.63	14.08	0.0860
	Anhui (Anhwei)	(Chimen)	29-30	13.30	14.30	0.1013
Middle Chang Jian (Yangtze) Valley	Hunan	(Hwetung)	27-28	14.90	16.50	0.1696
	Hunan	(Jianghwa)	25	16.20	16.70	0.1773
	Guizhou (Kweichow)	(Jienping)	26-27	14.00	16.40	0.1611
South-eastern Coast	Fujian (Fukien)	(Pingnan)	26-27	16.22	18.70	0.2487
	Fujian (Fukien)	(Jienno)	27	17.80	18.50	0.2229
Southern Provinces	Guangdong (Kwangtung)	(Yuenan)	23-24	7.30	14.60	0.0580
	Guangdong (Kwangtung)	(Shenyi)	22-23	8.00	10.40	0.0390

Site conditions - Chinese fir is primarily planted in the evergreen broadleaf forest regions of the southeastern and southwestern provinces, a region of abundant rainfall and high humidity. The major Chinese fir regions have an annual precipitation of 800 to 2000 millimeters (mm). The rainfall is evenly distributed. The dry season, with less than 40 mm monthly precipitation, is less than three months long. The monthly relative humidity is 80 percent.

The range of Chinese fir plantations follows approximately the 6-10°C January isothermal line. The annual mean temperature of the Chinese fir region is 15-23°C. There are considerable genetic variations in cold-resistance among the different geographic seed sources of Chinese fir. The fine Chinese fir plantation (1000 m elevation) of Lushan in Jiangxi (Kiangsi) Province has a January mean temperature of 1.2°C and annual extreme minimum temperature of -16.7°C.

In site selection, the general rule in the Chinese fir region is to plant tea-oil (Thea oleosa) plants on the sunny slopes, Masson's pine (Pinus massoniana) on the ridges, and Chinese fir only in the shaded valleys. The best growth is found on deep, well-drained soil with pH of 4.5-6.5.

Chinese Fir plantations - Traditional Chinese fir plantations are planted with year-old seedlings. Thinning is seldom practiced and often there is no pre-commercial intermediate thinning. Chinese fir logs as small as 5-cm diameter have commercial value and a ready market.

The spacing in initial planting depends upon the site. The traditional rules include wide spacing for good site, close spacing for poor site, wide spacing for gentle slopes, close spacing for steep slopes, wide spacing for valleys and lower elevations, and close spacing for higher elevations.

The spacing also depends upon the final product. For short-rotation (15-20 years), wide spacing is used. For longer rotation to produce larger logs, to obtain early return, and to increase total production by harvesting a crop in early thinning, denser spacing is used. In areas that are more accessible, have adequate labor, and a good market for small-diameter logs, dense planting is recommended.

In practice, 1410 to 1830 seedlings per ha are planted in the valleys and at lower hillsides, and 1830 to 2505 seedlings per ha on the upper slopes. The spaces between seedlings are often interplanted with crops or with tung-oil (Aleurites fordii) or tea-oil (Thea oleosa) trees in the early years. The purpose is to use interplanting as a silvicultural practice to control weeds.

Spacing and tree growth - The relationship between planting density and tree growth is presented in Table 6-3. The table shows that a density of 2000-2500 plants per ha seems to favor a better growth and can enhance Cunninghamia lanceolata timber production. Depending on the intensity of cultivation methods, total production per ha of C. lanceolata varies from 250 m^3 to 350 m^3 (including the volume of thinning products estimated to be of 40-50 m^3/ha) for a 20 year rotation. Clearcutting is used to harvest the area.

Table 6-3. Relationship between density and tree growth of Cunninghamia lanceolata.

	Aver. Hgt. (m)	Aver. Diam. (cm)	Standing Vol/ha (m^3)	Remarks
Plot 1:				
Before thinning in 1974	7.1	8.9	74.25	Planted in 1965 - density 6000 plants/ha in 1974 before thinning to 2650 plants/ha.
Measurements in 1976	8.5	10.6	110.25	
Increase in volume in 2 years			36.00	
Plot 2:				
Measurements before thinning in 1974	7.4	9.0	62.85	Planted in 1965 - same density of 6000 plants/ha thinned in 1974 to 2200 plants/ha.
Measurements in 1976	8.5	10.9	111.60	
Volume increase in 2 years			48.75	

Table 6-3 (continued).

	Aver. Hgt. (m)	Aver. Diam. (cm)	Standing Vol/ha (m^3)	Remarks
Plot 3:				
Measurements in 1974	4.9	6.5	44.80	Planted in 1976 - density 6000 plants/ha. In 1974, trench dug along contour line 0.70 m wide and 0.70 cm deep. 75 t of green manure applied + 2.250 t P_2O_5 + 750 kg calcium/ha in trench and covered with soil. Thinned to 2250 plants/ha.
Measurements in 1976	6.6	8.5	82.80	
Volume increase in 2 years			38.00	

Source FAO 1978.

Chinese Fir sprouts - Chinese fir sprouts vigorously from stumps after harvesting. The stand can be regenerated by sprouts. The sprouts are also utilized for planting. There is a unique means to improve log quality and growth by the use of seedling sprouts. The 1-year-old seedlings planted in the new plantations are partially severed just above the ground surface and bent back to the ground at the end of the first year after planting. The vigorous sprouts developed from the established root system the following spring grow faster and produce a longer branchless bole than the original seedlings.

Intensive management - *Cunninghamia lanceolata* is increasingly being grown in intensively managed plantations of 20 to 25-year rotations. Under these conditions, it is necessary to fertilize, or the second generation trees may produce a lower yield. Sometimes intercropping with legumes is used to provide the fertilizer; or, if other crops are used for intercropping, fertilizer may be applied to the trees at the same time it is applied to the crops. Early flowering of five or six-year-old trees may indicate poor sites and a need for fertilization.

Even though disease and insects are not currently regarded as serious threats to *Cunninghamia lanceolata*, increasing interest is being directed at developing mixed plantations should some disease or insect epidemic specifically injurious to *Cunninghamia lanceolata* occur. Two broadleaved species used in mixed plantations are *Robinia pseudoacacia* and *Sassafras* spp. Mixtures of strips have been successful, as both the broadleaved species and *Cunninghamia lanceolata* can be managed on a 20 to 25-year rotation. In the second generation, *Cunninghamia lanceolata* can be planted on strips previously occupied by the broadleaved species and vice versa.

(ii) Masson's Pine (*Pinus massoniana*)

Masson's pine (*Pinus massoniana*) is the most widely distributed and the most abundant of all Chinese pines. Of all the growing stock of timber trees in the southern provinces, Masson's pine, or horse-tail pine as it is sometimes called in China, constitutes about half of the total volume.

Afforestation uses - *Pinus massoniana*, a pioneer tree, regenerates readily by natural seeding and it is frequently used to afforest denuded hills. Therefore, it is easily established by planting or by direct seeding, even on unfavorable sites. It is also widely planted because it is quick growing, produces good timber, and is generally used as fuel. Valuable in paper and fiber industries, Pinus massoniana is also the major Chinese source of turpentine and rosin. China is one of the world's largest turpentine and rosin producers.

Distribution and habitat - Pinus massoniana grows to a height of 40 m and a diameter of 1 m. It is widely distributed in the southeastern part of China. Extensive areas of natural growth and plantations occupy the lower slopes, generally below 600-800 m. In the coastal province of Fujian (Fukien) and the western provinces of Sichuan (Szechuan) and southern Gansu (Kansu), it grows at elevations up to 1200 m.

In the natural range of Masson's pine, the mean annual temperature is 13-22°C, and the annual precipitation is 800 mm. The pine is not cold hardy and suffers frost damage at temperatures of -13°C.

Masson's pine is adaptable to a wide range of soil types, from the yellow podisols of the lower Chang (Yangtze) foothills to the laterites of Hainan Island. The soil is generally acidic (pH 4.5-5.5). Masson's pine can not be used on alkaline-saline and water-logged soil.

Plantations and natural stands - Plantations are mostly planted with 1-year seedlings during the wet season. The spacing is generally 1.5 m x 1.5 m. Closer spacing is used for fuel production. The lower limbs are frequently pruned at 3 to 5-year intervals for local fuel supply.

Scattered growth of Pinus massoniana covers large patches of lower hills, open slopes, and bare ridges. Natural forests of Masson's pine can be substantially expanded and improved with proper silvicultural management, especially fire and insect control.

Silvicultural management - Pinus massoniana is noted for quick growth but poor form. Poor tree form primarily results from systematic removal of good timber form trees and the natural regeneration by seed trees of poor form trees. Tree form can be improved by selection thinning in both plantations and natural stands. Seed orchard and seed production areas are established for the production of improved seeds.

Fire and insect control are important in the management of Masson's pine. The most serious damage is caused by Dendrolimus punctatus infestation. The interplanting with evergreen broadleaf trees is practiced as an effective means to minimize fire and pest damage. Slash pine (Pinus elliottii) has been successfully introduced to the southern provinces. It is more resistant to Dendrolimus spp. Pinus elliottii outperforms Pinus massoniana on good sites, but is not adaptive to poor sites, such as mountain ridges and upper slopes.

(iii) Scotch Pine (Pinus sylvestris var. mongolica)

Zhangzhi-Sung is the Chinese name for Scotch pine (Pinus sylvestris var. mongolica). This species is noted for its distinct cinnamon (Zhangzhi)-like fragrance. The natural range of Scotch pine is in the northeastern provinces of Heilongjiang (Heilungkiang), Jilin (Kirin), and the autonomous region of Inner Mongolia. A valuable tree for afforestation, it is widely used in large-scale arid land planting and windbreak projects in the Northern Region (Beijing (Peking) to Inner Mongolia), the Northeastern Provinces (Heilongjiang (Heilungkiang), Jilin (Kirin), and Liaoning); and the Northwestern Region (from Ningxia (Ningsia) and Gansu (Kansu) to Xinjiang (Sinkiang)).

Natural forest - Natural forests of Scotch pine are found in the northern part of the Da Hinggan Ling (the Greater Hinggan Mountains) at elevations of 300 to 900 m. It occurs mostly on the sunny slopes at higher elevations and is associated with Pinus pumila. The best stand attains 30 m in height and 1 m in diameter.

In Inner Mongolia there are natural forests of Scotch pine in Hailaer and Hunghwargi. This is a region of stabilized sand dunes and a primary seed source for large-scale afforestation and windbreak projects in arid regions. Natural forests of Scotch pine are also found in the Hsiao Hinggan Ling (the Lesser Hinggan Mountains) and Jilin (Kirin) Province. In the Lesser Hinggan Mountains, Zhangzhi-Sung is associated with larch (Larix gmelini) and birch (Betula spp.) on the lower slopes (200-400 m).

Cold hardy and drought resistant - Scotch pine is exceedingly cold hardy. In the natural habitat and in the planted areas, it survives -50°C winter temperatures. It is also adaptive to the short growing season of the northern regions.

Scotch pine is also very drought resistant. Among the 30 species of conifers and broadleaf trees included in a sand field planting test in Zhanggaitai, Liaoning Province, Scotch pine proved to be the best tree for this purpose. The 20-year growth results in this test are as follows:

	Height (m)	Diameter (cm)
On sand flat between sand dunes	8.5	12.7
On active sand dunes	7.45	9.2

Sand dune stabilization - Scotch pine develops an extensive root system in the seedling stage. In the natural habitat, the soil is neutral to slightly acidic. A field planting test in Heilongjiang (Heilungkiang) Province revealed that Scotch pine seedlings can be planted on slightly alkaline-saline soil (pH 7.6-7.8).

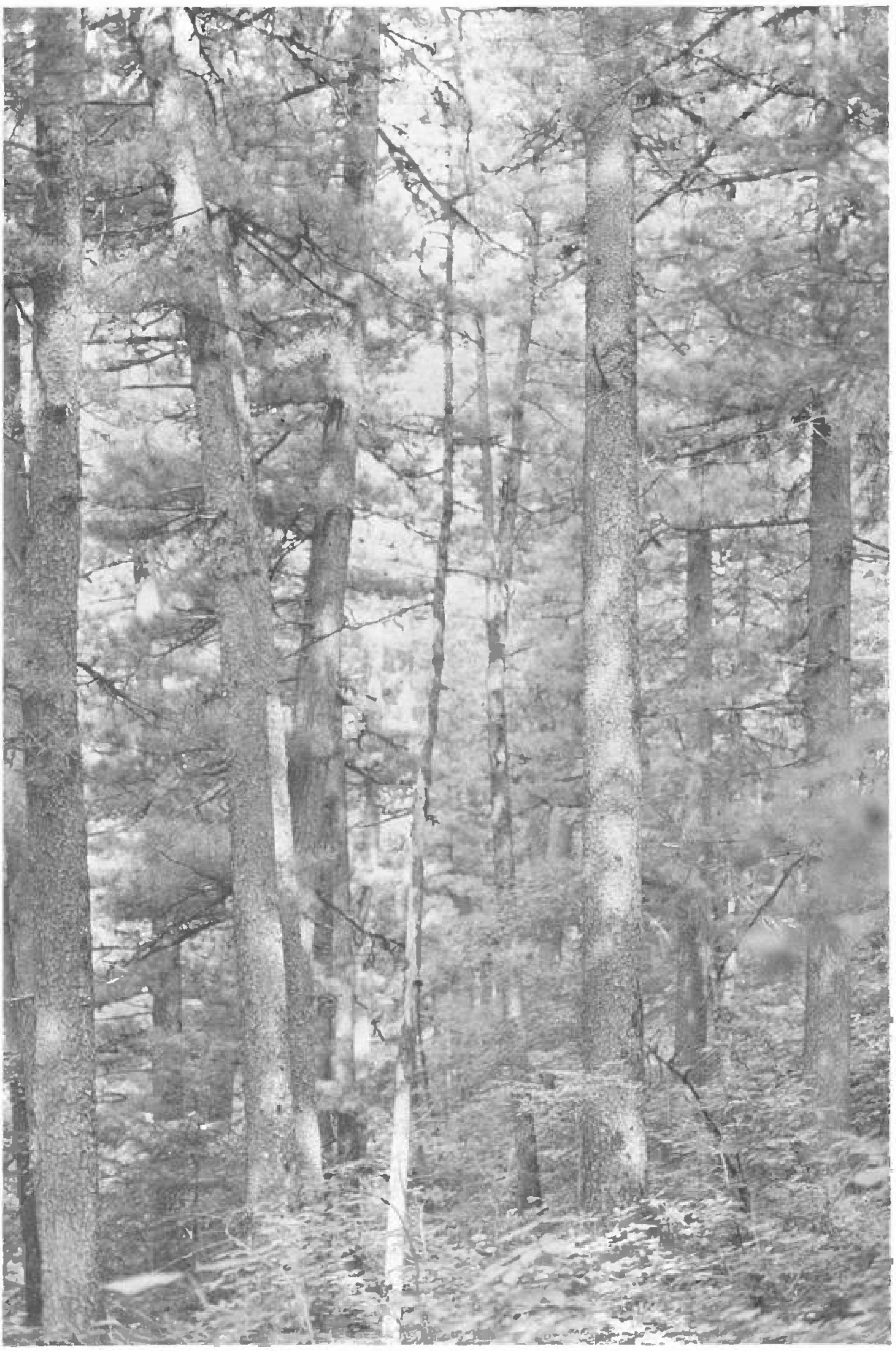
In another test in Zhanggaitai, active sand dunes were stabilized by forests of Scotch pine. This pine is also successfully used in afforestation in the arid areas of northern Shaanxi (Shensi), Inner Mongolia, and Xingjiang (Sinkiang).

The most successful method of sand dune stabilization developed in the Liaoning test is the use of Scotch pine in combination with desert shrubs. In the first year, parallel bands of Lespedeza spp., a low shrub of the pea family, are planted on the sand. Each band includes two rows of 1-year, top-pruned seedlings. Direct seeding was also tried with success. Two-year-old seedlings of Scotch pine are planted between the bands of shrubs 2 to 3 years after the initial planting of shrubs. Willow cuttings (Salix mongolica) and seedlings or direct seeding of Caragana microphylla, and sagebrush (Artemisia spp.) were also tried for initial planting, with considerable success. Planting of Scotch pine seedlings in deep pits in sand is absolutely necessary for survival.

(iv) Red Pine (Pinus koraiensis)

The Chinese call Pinus koraiensis red pine, or hung-sung. The natural range of red pine is limited to the eastern part of the northeastern provinces. This tree is widely known for its large edible seeds.

In the primeval forest, red pine reaches 40 m in height, 1.5 m in diameter, and over 500 years in age. The tree is characterized by a straight and clean bole extending above the general canopy of the associated mixed north broadleaf trees. The common broadleaves include maple (Acer spp.), birch (Betula spp.), linden (Tilia spp.), wild walnut (Juglans spp.), ash (Fraxinus spp.), and Phyllodendron spp.



6-3: Pinus koraiensis (red pine) approximately 40 meters tall, Heilongjiang (Heilung-kiang) Province.

6-4: Foresters lend scale to the Pinus koraiensis (red pine) pictured on the preceding page.

Natural distribution and variation - The natural distribution of *Pinus koraiensis* coincides approximately with the mountain ranges of Changbeishan (Ever White Mountains) and the Hsiao-Hinggan Ling (The Lesser Hinggan Mountains). It extends from 49°20' in eastern Heilongjiang (Heilungkiang) Province to 40°45' in Liaoning.

Within this wide latitudinal range are considerable variations in site condition and in geographic seed sources. In the Dailing district of Heilongjiang (Heilungkiang) Province in the north, the annual mean temperature is -2°C, and the growing season is 150 days (May to September). In the Canhokao district of Liaoning Province in the south, the mean annual temperature is 5° to 8°C, and the growing season is 180 days (April to early October). Of the 20-year red pine plantations in the two stations, the trees of the southern plantations are 50 percent taller and 30 percent thicker than those of the northern plantations.

Artificial regeneration - In the last 30 years, as new road systems have been constructed, more of the primeval forests are being harvested. The cut-over land is regenerated mostly by artificial means. The common practice is to plant 2 to 3-year-old seedlings, spacing them at 4400 trees per ha, and in less accessible areas, at 3300 per ha.

Red pine can be grown on many different plantation sites. However, it is difficult to establish red pine in water-saturated soils, and the tree will not grow well on shallow, rocky soils or on highly calcareous sites. Red pine requires a minimum growing season of 100 frost-free days and a minimum of 50 cm of precipitation, but it can tolerate extreme winter temperatures.

In the northern region, red pine seedlings are not damaged by winter temperatures as severe as -50°C. Terminal buds and young shoots are hardened long before the killing frost. The most serious damage is caused by rodents, which, without proper control, can destroy young plantations.

Height and diameter growth - The Chinese have managed red pine plantations for over 80 years. Their experience with red pine management indicates that sawlogs can be produced in 30-40 years.

Growth of plantation red pine is slow during the first 10 years. The mean annual height growth is below 0.4 m. Height growth begins to increase after the twelfth year to a mean annual height measurement of 0.50 to 0.65 m, until the thirtieth year, when height growth rate begins to decline. The most rapid height growth occurs in the sixteenth year.

Diameter growth is likewise slow during the first 10 years. The mean annual diameter increment from the eleventh to the twenty-sixth year is 0.75 to 1.40 cm. The most rapid diameter growth occurs from the twelfth to fourteenth year. Diameter growth rate begins to decline after the twenty-sixth year.

Plantations vs. natural stands - Distinct differences are evident in growth and tree forms between red pines in plantations and those in natural stands. The following is a comparison in 40-year growth.

Table 6-4. Comparisons of red pine (Pinus koraiensis) growth in plantations and natural stands.

	Average Height (m)	Average Diameter (cm)	Volume per ha (m^3)
40-year red pine plantation, Cauhokao, Liaoning Province (Note: 1020 trees per ha)	15.6	20.9	255.71
40-year natural red pine forest, Hsiao Hinggan Ling, Heilongjiang (Heilungkiang) Province (Site II Class)	5.57	4.98	44.09

The above comparison in quantity growth is only approximate. The differences in seed sources and environments have not been taken into consideration. However, it is obvious that red pines in the natural forest are severely suppressed in the early years.

Tree form - The difference in tree forms of red pine is striking. Trees in plantations have straight clear boles, but in the plantations multiple-forking conditions may develop at an early stage. The red pines in the Canhokao plantation of Liaoning Province begin to show multiple forking at age eleven. The percentage of multiple forked trees increased to 13.1 percent at age 21 and to 48 percent at age 31. The percentage of multiple-forked trees increases with further increase in age.

The multiple-forking condition results from damage to terminal shoots or terminal buds. Damaging factors include insects, diseases, rodents, and abnormal climatic conditions. This situation is glaringly similar to the pine weevil infestation of eastern white pine (Pinus strobus) plantations of eastern United States.

The eastern white pine also grows in natural conditions in mixed stands with deciduous broadleaf trees.

Mixed plantations - In natural forests, multiple-forking conditions of red pine are not observed until the trees are 80 to 120 years old. The young red pines are naturally regenerated in mixed stands with deciduous broadleaf trees. To improve the tree form of red pine, mixed plantations are encouraged at a red pine-broadleaf ratio of from 9:2 to 4:2. The hardwood species selected include wild walnut (Juglans spp.) and ash (Fraxinus spp.) for the gentle and moist slopes; linden (Tilia spp.) and Phyllodendron spp. for the shaded slopes and deep moist soil; and maple (Acer spp.), poplar (Populus spp.) and birch (Betula spp.) for the sunny slopes.

To improve the genetic quality of tree form, red pine of improved tree form can be obtained by progeny testing and selection from the natural red pine populations. The tree form progeny selection can be conducted in conjunction with provenance tests to obtain the best geographic seed sources for planting locations.

(v) Larch (Larix spp.)

Larch (Larix spp.) forests constitute about 25 percent of the growing stock of all coniferous forests of China. There are four geographically isolated larch (Larix spp.) forest regions, and ten distinct important Larix species. Among them, the Hinggan larch (Larix gmelini = L. dahurica) forest of the Hinggan Mountains in Heilongjiang (Heilungkiang) is the most extensive and, economically, the most important.

The natural forests of Hinggan larch (Larix gmelini) appear mostly in pure stands. Their main range is in the Da Hinggan Ling (Greater Hinggan Mountains) region, 49° 10' in the north, to a southern limit of 2° 30' lat. N. The mature natural stand on a good site attains a height of 30 m and a growing stock of 300 m^3 per ha. Pure larch forest is also found on shallow gravelly soil and on permafrost land. It is usually the only forest tree of the swamps. The stagnated growth of old swamp larch forest has a stock volume of 90 m^3 per ha.

Five habitat types - Five habitat types of Larix gmelini forest are recognized. The Larix gmelini-Pinus pumila type of the high elevations (1100 - 1500 m) is generally reserved for watershed protection. The Larix gmelini-moss (Itylocomium-Pleurozium) (800-1350 m) and the Larix gmelini-Ledum (450-1000 m) types are mostly on the northern slopes of the Da Hinggan Mountains. Natural regeneration is rare on the dense moist floor coves, but the presence of Picea koraiensis seedlings indicates the possible trend of succession. The Larix gmelini-Quercus spp. type is concentrated in the lower slopes (450-600 m) of the southeastern part of the Da Hinggan. Under the tall canopy of Larix gmelini forest (18-25 m) there is a secondary tree layer of Quercus mongolica (8-18 m). The lowland and swamp Larix gmelini forest is a distinct feature of the Hsiao Hinggan Ling (Lesser Hinggan Mountains) region. It is characterized by extensive tall Larix gmelini forests in the valleys and stagnated old Larix gmelini stands in the bogs. Under the first tree canopy of tall Larix gmelini there is usually a secondary tree layer, Pinus koraiensis, Picea koraiensis, and Abies nephrolepis, and to a lesser extent, Betula platyphylla.

Natural regeneration - In forest management, natural regeneration is found to be difficult on the forest floor of mosses in the higher elevations and of the sedges of the lowland-swamp type. Furthermore, because the natural larch (Larix spp.) forest has a good seed crop only once every five to six years, the cut-over or artificially thinned larch (Larix spp.) forests are easily replaced by the prolific white birch (Betula platyphylla), a pioneer species. Open ground is necessary for successful natural regeneration.

In general, the larches (Larix spp.) are found on poor sites of diverse origins, from the talus and moraines above the timberline, the burned over areas, sunny land sites, and eroded slopes, to the permafrost land and bogs. The cataclysmic origin of larch (Larix spp.) forest is documented in the case of Larix olgensis.

Cataclysmic origin - Larix olgensis is the major component of the larch (Larix spp.) forest of the Hsiao Hinggan Ling region. The extensive natural forest of Larix olgensis of this region ranges from 170-200 years old. This is a region of active volcanic activity; the last eruption was in 1702. In the volcanic deposits are carbonized logs of Picea jezoensis and Picea koraiensis. The Hsiao Hinggan Ling region is located in eastern Heilongjiang (Heilungkiang) and Jilin (Kirin) provinces, and is lower in elevation than the Da (Greater) Hinggan.

Major Larix spp. forests - In addition to Larix spp. of the northeast provinces, the other major Larix spp. forests in China and their components are the Larix spp. forests of the northern provinces (Larix principis-rupprechtii), the Larix spp. forests of Xinjiang (Sinkiang) (Larix sibirica), the Larix spp. forests of the southwestern plateau (Larix potaninii, L. griffithii, L. himalaica, and L. speciosa).

Natural forest of Larix principis-rupprechtii is now found in Hebei (Hopei) and Shanxi (Shansi) provinces at 1600-2600 m. Formerly, this species had a wider range. This species is widely used in afforestation, and has been planted successfully in Inner Mongolia. Larix sibirica is an important forest resource of Xinjiang (Sinkiang). The growing stock of the natural forest is generally 200 m^3 per ha, but reaches 596 m^3 per ha in the fully stocked mature stand. The southwestern plateau has scattered patches of Larix spp. forest from southeastern Gansu (Kansu) Province to the headwaters of the Huang (Yellow) River to Xizang (Tibet). The larch tree belongs to a distinct section multiseriales of the Larix genus. The most productive natural stand has a growing stock of 500 m^3 per ha.

(vi) Poplars (Populus spp.)

Poplars (Populus spp.) are a distinct group of forest trees highly important to Chinese forestry. In natural conditions, the aspen poplars (Populus spp.) cover extensive areas mostly at the higher elevations, and the desert poplars (Populus spp.) form gallery forests of the great desert basins. In plantations, the selected clones of indigenous and introduced species, their multitudinous inter-specific and inter-provenance hybrids, and their vegetatively propagated clones and cultivars greatly increased biomass production. The selective breeding of poplars is one of the major projects of the Beijing (Peking) National Academy of Forestry.

Aspen poplars (Populus spp.) - The aspen poplars (Populus spp.) of China are an integral part of the circumpolar population of Populus tremula of Europe and Populus tremuloides of North America. In China Populus tremula var. davidiana is ubiquitous in the forest clearings and the cut-over and burned-over areas of larch (Larix spp.) and Pinus koraiensis forest, and northern broadleaf forest of the northeastern provinces and inner Mongolia, and in the similar conditions of the deciduous broadleaved forest, spruce (Picea spp.) and spruce-fir (Picea spp.-Abies spp.) forest of the northern and the southwestern provinces.

In the Altai and Tien Shan mountains (1550-2000 m) of Xinjiang (Sinkiang) the aspen poplar is Populus tremula. There are usually spruce seedlings (Picea schrenkiana) under the canopy.

Desert poplars - In the desert basins of Tarim and Dzimgana, in the far West, the gallery forests of Populus spp. are formed along rivers and streams, on river deltas, and in oases along the periphery of the desert. The most important poplar is Populus euphratica (P. diversifolia). In favorable conditions it reaches 20 m in height and one m in diameter. Populus euphratica extends deep into the desert of Alashan and to the western parts of inner Mongolia.

Populus pruinosa usually occur in mixed stands with P. euphratica. It has a less extensive range than P. euphratica. P. alba, P. canescens and P. laurifolia form natural forest along mountain streams in Xinjiang (Sinkiang). The ancient buildings along the silk road have massive beams of white poplar.

Poplar (Populus spp.) plantations - Several species of indigenous Populus spp. are components of the natural forests in the northeastern provinces (Populus koreana, P. ussuriensis), in the northern provinces (Populus tomentosa, P. suaveolenesis, P. cathayana), in central and eastern China (Populus adenopoda, P. simonii, P. purdomii), and in the southwestern plateau (Populus lasiocarpa, P. yunnanensis). They rarely form pure forests in nature over extensive areas, but several of the Populus spp. are widely planted and are far more productive in plantations.

Populus cathayana was widely planted from the northern provinces to the plateau of Qinghai. At 23 years, the best plantation has a growing stock of 800 m^3 per hectare. Populus pseudo-simonii is a natural hybrid of P. cathayana and P. simonii. It is widely planted in the northeastern provinces. The growing stock reaches 400 m^3 per hectare at 23 years.

Exotic poplars - Inter-species crosses were used effectively in the breeding of Populus spp. In addition to the hybrids between indigenous species, numerous promising combinations were obtained in the crossing of Chinese Populus spp. with exotic

6-5: Populus spp. shelterbelt in Inner Mongolia.

species and with introduced clones. Two important exotic sources were used in hybridization with Chinese poplars. They are Populus nigra var. italica, the black poplar of southern Europe, and Populus x euramericana, a hybrid between the European black poplar and Populus deltoides of the Mississippi Valley.

Hybrid poplars are commonly used in the "four-around" plantings in all the spare spaces. They are also used in windbreaks, for interplanting with row crops, and with other trees and shrubs. The most common and successful combinations in the mixed planting of Populus spp. are with black-locust (Robinia pseudoacacia) and the shrub Amorpha fruticosa. Successive crops of grain, fodder, fuel, and timber are harvested at intervals from the windbreak-protected field.

(vii) Paulownia spp.

Paulownia spp. is a valuable and exceedingly quick-growing tree. Merchantable timber is harvested in five to eight years. It is extensively planted in the great plain of the northern provinces intermixed with row crops. Generally, Paulownia spp. is planted in rows 50-70 m apart as windbreaks and for agroforest production.

Paulownia spp. has a deep rooting system which can go as far as 2 m deep, and does not harm food crops whose root system is localized in the upper 50 cm of soil layer. Soil preparation for planting is similar to that for Populus spp. plantations. Seedlings are raised in the nursery from cuttings and usually planted after one year.

On irrigated sandy soil, a four-year-old Paulownia fortunei may have a diameter of 70 cm, a height of 10 m and 5 m of clear bole. On a favorable site, eight-year-old Paulownia fortunei may have a diameter of 170 cm. At ten years of age, it is not unusual to obtain a diameter of 45-50 cm. A rotation of 8 to 10 years is common, and production with this rotation can be in the order of 12 m^3/ha/year.

The commonly planted Paulownia spp. includes the following seven species:

1. Paulownia elongata (Lankao Paulownia)
2. P. catalpifolia (Catalpa-leaf Paulownia)
3. P. tomentosa (Tomentosa-leaf Paulownia)
4. P. glabrata (Glabrous-leaf Paulownia)
5. P. fortunei (White-flower Paulownia)
6. P. fargesi (Sichuan Paulownia)
7. P. kawakami (Taiwan Paulownia)

The growth of four species of Paulownia spp. are tabulated in the following table (Table 6-5). These four species grow under uniform growing conditions. They are planted in Yen-Chen District of Shangdong (Shantung) Province as highway shade trees. They were spaced at 5 m between individual trees of Populus tomentosa.

Table 6-5. Eight-year growth of four species of Paulownia under uniform growing conditions.

	Height (m)	Mean Trunk Height (m)	Diameter (cm)	Disease Occurrence (%)
Paulownia elongata	10.0	3.60	24.1	22
P. catalpifolia	9.3	3.80	22.0	38
P. tomentosa	7.5	3.00	12.4	5
P. glabrata	7.2	2.74	14.7	0

Paulownia spp. can adapt to a wide range of varying climatic conditions. Some species thrive at temperatures as low as -18°C and as high as 40°C. Paulownia spp. also thrive at elevations between 10 to 1600 m above sea level. However, the species requires a deep, friable and well-drained soil. The water table should be at least 2 m below soil surface for good growth.

The effect of water table on Paulownia spp. growth is presented in Table 6-6.

Table 6-6. Soil water levels and Paulownia growth.

Soil Water Level (meters below ground surface)	Tree Age	Total Tree Height (m)	Annual Height Increment (m)	Total Diam. (cm)	Annual Diam. Growth (cm)	Total Volume (m^3)	Annual Volume Growth (m^3)
1.5	6	8.16	1.36	12.04	2.0	0.0289	0.0048
2.5	6	8.00	1.33	19.00	3.2	0.1134	0.0189
3.4	5	6.00	1.20	20.00	4.0	0.0915	0.0183

Paulownia spp. wood is useful for building and furniture manufacturing. The leaves are used as animal feed; the bark and flowers provide ingredients for traditional medicine. With a production of 12 m^3/ha/year, Paulownia spp. is a cash crop widely used in agricultural diversification. However, a disease assumed to be caused by a virus affects large numbers of Paulownia spp. trees. The disease has been successfully controlled, either by physical operation, which consists of cutting the attacked branch and burning it, or by injecting an antibiotic solution. Prevention is now possible by dipping rooted cuttings into an antibiotic solution before planting.

(viii) Sassafras (Sassafras spp.)

Local foresters have placed Sassafras tsumu, Pseudosassafras laxiflora and Pseudosassafras latifolia under the designation of Sassafras. Phenotypically they look almost alike, but the leaves are shaped differently.

Sassafras are local species found at high elevations in Hubei (Hupei) and Hunan Provinces. They perform very well when adapted to lower elevations. In Hubei (Hupei), Pseudosassafras laxiflora reached a height of 16-20 m and a diameter of 10-15 cm after 14 years. In Hunan, Sassafras tsumu planted in 1973 had a maximum growth per year of approximately 4 m in height and 1.5 to 2 cm in diameter. An eight-year-old Sassafras in the province reached 14 m in height and 18 cm in diameter. Despite its good performance, Sassafras is not yet used in any large-scale plantation, except in Hunan Province, where large blocks of hundreds of ha of Sassafras can be observed.

Site preparation includes ploughing, digging a deep hole 1 m wide and 1 m long and planting 1-0 stock nursery seedlings. Planting is done in spring. Spacing is usually 2 m x 3.3 m. Density at planting is 1500 plants/ha. After planting, Amorpha fruticosa (Legum.) is intercropped as green manure. Amorpha fruticosa leaves are harvested two or three times a year and buried in the stand to increase soil organic content and improve soil structure. Thinning is done at 4-5 years, which leaves 900 plants/ha. Thinning products are all utilized to meet the requirements for small-diameter woods. All trees thinned are uprooted and roots used as stumps for further planting.

At 15 years of age, Sassafras may reach 25 cm in diameter and have a straight bole of 15 m. Rotation is approximately 15 years. Production at felling may be as high as 400 m^3/ha, which is a production of 30-35 m^3/ha/year. Clear-cutting is practiced and subsequent regeneration is by planting.

(ix) Eucalyptus (Eucalyptus spp.)

Early introduction - Eucalyptus globulus was introduced to Yunnan in 1896. This is the earliest record of introduction of this group of unique and highly valuable Australian trees to China. It was most likely reintroduced from the French Mediterranean littoral.

Eucalyptus citriodora and E. camaldulensis were later introduced to China at the turn of this century. Since then, over one hundred species have been introduced and systematically tested. In the early years Eucalyptus spp. was planted as interesting ornamental, and later as roadside shade tree. In the last 30 years since liberation, Eucalyptus spp. was widely planted in 15 southern and southwestern provinces and regions, and was used in forest plantations over extensive areas in 6 provinces and regions: Guangdong (Kwangtung), Guangxi (Kwangsi), Fujian (Fukien), Jiangxi (Kiangsi), Sichuan (Szechuan), and Yunnan.

Planting of Eucalyptus spp. - One-year seedlings raised in the nursery are planted at a density of 4500 plants/ha and are thinned to 3000 plants/ha at age five, to 1500 plants/ha at year seven and to 900 plants/ha at year 10 or 12. Volumes harvested at each commercial thinning are, respectively, 24 m^3/ha, 21 m^3/ha and 24 m^3/ha, leaving a standing volume of 120 m^3/ha. Thus, at twelve years old, total production is 189 m^3/ha, i.e., a mean annual increment of 15.75 m^3/ha/year. It is expected that by the end of the rotation, growing stock per ha will be in the order of 300 m^3/ha.

Managed under a 25-year rotation, Eucalyptus spp. provides pulp, poles, fuelwood, building material, craftwood and foliage for oil and tannin extraction.

Eucalyptus globulus - E. globulus is an exceptional tree. It may reach heights of 50 m at age 30. Stands of coppice origin may grow 4.5 to 5.5 m per year. Even though E. globulus lacks the qualities of a good timber tree, it can be easily used for pulp, fuelwood, craftwork and poles. It has a good life in the ground, often up to 15 years. This species appears to do well in areas with abundant rainfall and long frost-free seasons.

E. globulus in the southern provinces is usually grown from seed or coppice. In nurseries, the seed is usually broadcast sown and seedlings then raised in shade. At 9 to 12 months they are usually planted out, currently with 2-m spacing. Thinnings occur at 5 years, then at 3 to 5 year intervals until the trees are harvested at 20 to 30 years old. Subsequent crops are then coppice grown. Although E. globulus doesn't have a high quality wood, its rapid growth rates appear to justify plantation establishments.

Of the numerous Eucalyptus species originally introduced to China, nine species are now planted on a large scale. The eight species are as follows: Eucalyptus botryoides, E. camaldulensis, E. citriodora, E. exserta, E. globulus, E. maidenii, E. viminalis, and the Chinese local race, Eucalyptus leichow number one. Other potentially promising species include E. tereticornis, E. angustifolia, E. grandis, and Eucalyptus congo number twelve.

Eucalyptus viminalis is most cold resistant. The other species that have been successfully planted in Shaanxi (Shensi), the northern limit for Eucalyptus spp., are E. robusta, E. botryoides and E. camaldulensis.

Eucalyptus citriodora - Eucalyptus citriodora will take the place of E. globulus on drier, nutrient-poor sands and severly eroded hills. But it will not do well in areas with low rainfall. This species does not attain the height of Eucalyptus globulus, only 30 m-35 m. Crown form is poor, but mature timber is of a higher quality than E. globulus.

This species' wood is used in construction, for railroad ties and tool handles, pulp, craftwood and fuel. Oil of citronella can be extracted from the leaves. Thus, this species is often an all-purpose basis for a commune industry.

Plantations of E. citriodora are grown and treated in a similar way as E. globulus. While this species is not yet widespread, it shows promise due to its tolerance of low nutrient soils.

Leichow plantations - On Leichow Peninsula, 52,000 ha have been planted with eucalypts. More than 60 species have been tried, but only three are actually used in large-scale plantation: E. exserta, E. citriodora and E. leichow no. 1. Other species such as E. tereticornis, E. grandis and E. saligna perform well in diameter growth, but their boles are not as straight as those of the three former species. E. botryoides, E. argophlora, E. toriellana and E. pilularis are only of marginal interest.

Under the particular conditions of Leichow Peninsula, where there is no rain for eight months of the year and where the compact, sandy, red soil is subject to severe erosion, E. exserta, E. citriodora and E. leichow no. 1 now constitute a highly profitable undertaking with their excellent growth and their full utilization.

The total growing stock of 52,000 ha of Eucalyptus spp. is 1.84 million m^3, of which 150,000 m^3 are harvested annually. Two-thirds of the harvested volume is timber and one-third thinning products, which provide also 7.5 MT of leaves/ha to be used in oil and tannin extraction. Oil content of Eucalyptus spp. leaves is 0.7 percent for E. exserta and 1.2 percent to 1.7 percent for E. citriodora. Tannin content is generally eight times higher than that of oil. After oil and tannin extraction, what remains of the leaves is used as organic manure.

The 1986 plan fixes a target for growing stock at 3 million m^3, of which 400,000 m^3 will be harvested every year. Of the 400,000 m^3 cut, about 250,000 m^3 will be timber. Such a plan implies that Eucalyptus spp. will be planted on the remaining 17,000 ha still to be used by the Leichow State Forestry Bureau and also on the expanded forest areas on waste and barren lands.

The reafforestation with Eucalyptus spp. in Leichow Peninsula is impressive and successful. But since the prosperity of the whole area depends mainly on Eucalyptus spp., increased attention must be paid to the potential problems insects and diseases can cause, especially Phorocantha spp.

(x) Casuarina spp.

Casuarina spp., introduced in the early years of this century, was extensively planted along the southern coast and on coral islands of tropical waters. Three species of Casuarina spp. were introduced with equal success: Casuarina equisetifolia, C. cunninghamia, and C. glauca.

Casuarina spp. are used primarily and successfully for windbreaks, sand stabilization, and as protective forest for coastal farms. Thousands of miles of Casuarina spp. tree belts are planted in the provinces of Guangdong (Kwangtung), Fujian (Fukien), Taiwan and the Autonomous Region of Guangxi (Kwangsi).

Planting of Casuarina - One-third of Nanshan Island (4034 ha) is planted in C. equisetifolia as a coastal windbreak 57 km long and from 1 to 5 km wide. Raised in nursery beds, the young seedlings are transplanted after two months to a basket 10 cm in diameter and 15 cm in depth. After four or five months in the basket, the roots are dressed before planting the seedlings in holes of 40 cm x 40 cm x 40 cm. The rate of survival is about 80 percent. July, August and September are the best months for planting, as the young seedlings will have the benefit of the rains during these months. C. equisetifolia grows very well in coastal sand.

A four-year-old plantation shows an average diameter of 5-7 cm and an average height of 7-8 m. C. equisetifolia plantations are managed under a 10-15 year rotation. The yield is about 45-50 m^3/ha, which is a production of about 4 m^3/ha/year. Plantation cost, including tending, amounts to 120 yuan/ha.

Wood production and improvement - The C. equisetifolia plantation on Nanshan Island annually harvests 2100 MT of firewood, which is marketed outside the island, in addition to more than 10,000 m^3 of timber, which is sold to the state. In 1976, the total income from forestry was 700,000 yuan, in addition to the increased income from food grain production under windbreak protection (1.4 MT previously; now 4.8 MT). Since Casuarina spp. serves a dual purpose of providing timber and supporting agriculture while growing under harsh, windy conditions, it has great potential for future expansion.

Nanshan Island is implementing a tree improvement program for C. equisetifolia. Superior trees are selected from which seeds are to be collected for further plantation. Coppice from stumps is no longer allowed to develop, as the people prefer to uproot stumps and replace coppice with genetically improved seedlings.

(xi) Tea-oil (Thea oleosa)

This species has been widely planted throughout the southeastern provinces. As a deep-rooted intolerant species, it does best on red and yellow soils with pH of 4.5-5.5. It grows best on hills at an elevation of 800 m, but it can thrive almost anywhere if the soil is deep and rainfall is above 700 mm per year. Clean land cultivation at 30-40-cm depth with inversely sloped terraces is essential. On lands with a slope of more than 15 percent, the width of terraces is about 2-3 m, while on slopes less than 15 percent they can be as wide as 4-5 m. Generally, the trees are planted with a spacing of 3 x 3, 4 x 4 and 5 x 5-m distance, giving between 500 and 900 trees per ha. January to March are the best months for planting. Direct sowing is sometimes practiced.

T. oleosa is a small, slow-growing tree, but it can bear fruit from about age eight to nearly 100 years. During its early years, T. oleosa can grow under the shade of a timber tree cover crop such as Pinus massoniana, thus allowing progressive conversion of the stands occupied by the latter species without uncovering the soi. Intercropping is sometimes used to provide better soil moisture while increasing income.

Pruning and trimming are used to develop maximum crown, in addition to developing maximum fruit-bearing capacity. Pruning of the lower branches is started 3-4 years after planting to increase the height. At a height of 60 cm the tree is topped off, keeping three main branches. The following prunings train the remaining branches to spread at an angle of about 60°, making them even and uniform. After three years, a second pruning is carried out to form the tree ultimately into an umbrella shape with a hollow inner part to expose it to proper sun and air penetration when it is at the optimum fruit-bearing stage.

Colletetsichum camelline, Caprodium theae, Eupractus pseudoconspersa and Chremonia adsitarsis are the major pests and diseases of T. oleosa.

(xii) Bamboo

Bamboo plantations and natural growth have a combined area of 3.3 million ha in China. They constitute approximately 2.7 percent of all the forest land. A total of 3 million MT of bamboo is reportedly harvested every year (Hsiung 1974).

Bamboo is a high-yield, short-rotation crop. A bamboo plantation can be harvested by thinning every year, and regenerated naturally with ease. In a country with a severe wood shortage, bamboo is used in many ways as a wood substitute. It is extensively used in paper making. One ton of bamboo produces 1/3 ton of paper pulp, or 1/4 ton of rayon pulp. It is valuable as fuel and as food, and in innumerable household uses. Bamboo is exceedingly important to the nation's economy.

Fast growth and high yield - Bamboo is quick growing. Under ordinary plantation conditions, an emerging bud of mao-chu (Phyllostachys pubescens) grows to a stalk (culm) 20 m in height and 10 cm in diameter in about two months. The first season's growth is useful for pulp. The 5-6 year stalk is ready for final harvest. A 0.33 to 0.66 ha plantation managed by annual selective thinning and natural regeneration can produce 23 to 30 MT of stalk per ha per year, far surpassing any quick-growing trees in yield for this region.

Phyllostachys pubescens - Mao-chu (Phyllostachys pubescens) is the most widely planted bamboo in China and economically the most important. Of all the over 200 species and varieties of Chinese bamboos, mao-chu occupies over 70 percent of all bamboo plantations. Mao-chu was introduced to Japan in 1736 and became the most important bamboo in that country. It is successfully planted from the southern island of Kyushu to 41° 45' lat N. in Hokkaido. This introduced bamboo now constitutes 32.9 percent of all bamboo plantations in Japan, and 50.2 percent of bamboo production.

In China, mao-chu is widely planted in the southern provinces (Figure 2-1, regions 4 and 5A), from 24° to 32° lat. N., and from 102° to 122° long. E. It is concentrated in Zhejiang (Chekiang), Jiangxi (Kiangsi), and Hunan provinces. Over 60 percent of all mao-chu plantations are located in this region. This is the central and the major region of bamboo plantations in China. The three bamboo regions in China are presented in Table 6-7.

The three bamboo regions - The natural distribution of bamboos in China is from Hebei (Hopei) and Liaoning to Hainan (18°-35° lat. N.), and from Taiwan to Xizang (Tibet) (92-122° long. E.). There are distinct geographic differences. Generally, the northern species are hardy bamboos of the monopodial type. The monopodial bamboo produces a single stalk (culm) from the node of the rhizome. In the southern bamboo region, species are mostly of the sympodial type. This bunch type has stalks in dense clusters. All three types of bamboos--the monopodial, the sympodial and the amphipodial or the mixed type--are found in the central bamboo region.

In the northern region, natural bamboo groves are mostly confined to the sheltered valleys. According to the historical record, however, there were extensive natural areas of bamboo in southern Shandong (Shantung), southern Henan (Honan), southern Shaanxi (Shensi), and southeastern Gansu (Kansu) (Figure 2-1, region 4). The hardiest species is the monopodial bamboo Phyllostachys bambosoides. It is successfully planted in the vicinity of Beijing (Peking) (40 lat. N.). Other monopodial species and amphipodial species are also found in the southern part of this region (Table 6-7).

The central bamboo region is located mainly in the hilly region of the Chang (Yangtze)-Xijiang (Pearl) water divide (Figure 2-1, region 5A). This region is the most important bamboo producing area, with extensive areas of mao-chu (Phyllostachys pubescens) plantations. In this region the utilization of bamboo products and the management of bamboo plantations are highly developed. Intermixed with P. pubescens are other species of monopodial bamboos and bamboos of the amphipodial type. The sympodial type of bamboos becomes increasingly important toward the south.

Table 6-7. Bamboo Species and locations.

	Location	Lat. N.	Ann. Temp. (C)	Jan. Temp. (C)	PPT (MM)	Major Species	Other Bamboos
The Northern Bamboo Region (monopodial bamboos)	SE Gansu N. Sichuan S. Shaanxi S. Henan Hubei Anhui Jiangsu S. Shandong S. Hebei	30 to 37^{o}	12 -17	-4 to 4	500 to 1200	Phyllostachys bambosoides (monopodial bamboo)	Monopodial bamboos Phyllostachys pubescens P. nigra var. henonis P. makinoi P. bambosoides var sulphurea P. congesta P. nigra Amphipodial bamboos Pleioblastus amarus Indocalamus fargesii Ginarundinaria nitida S. faberi S. fangiana
The Central Bamboo Region (monopodial and amphipodial bamboos	SW Sichuan N. Yunnan Guizhou Hunan Jiangxi Zhejiang NW. Fujian	25 to 30	15 to 20^{o} C	4-8 C	1200 to 1800	Phyllostachys pubescens (monopodial bamboo)	Monopodial bamboo P. bambosoides P. nigra var. henonis P. makinoi P. congusta P. propinqua P. dulcis P. vivax Amphipodial bamboos P. amarus Indocalamus tessellatus Indocalamus latifolius Sympodial bamboos Sinocalamus affinis S. distegius, S. farinosus Bambusa rigida Bambusa multiplox
The Southern Bamboo Region (Sympodial bamboos)	Taiwan S. Guandong S. Guanxi S. Yunnan	S. of 25^{o} Lat. N.	20 -22^{o} C	Above 8^{o} C	1200 to 2000 mm	Bambusa pervariabilis B. sinospinosa B. textilis Sinocalamus latiflorus Sinocalamus oldhami Sinocalamus giganteus	Sympodial bamboos Sinocalamus beecheyanus var. pubescens Sinocalamus oldhami Sinocalamus beecheyanus Schizostachyum pseudolima Lingnania chungii Bambusa rigida Amphipodial bamboo Pseudosasa amabilis

The southern bamboo region includes the southern peripheries of China south of 25° lat. N. from Taiwan, to the southern part of Guangdong (Kwangtung), Guangxi (Kwangsi), and Yunnan provinces (Figure 2-1, Region 6). This is a low and hilly region. Bamboo is a major local product. In the low valleys and along rivers, dense thickets of tall bamboo are dominant features of the landscape. They are composed of several species of sympodial bamboos. On the higher elevations there are several species of monopodial and amphipodial bamboos in extensive plantations. They include the famous "fishing-pole" bamboo, Pseudosasa amabilis, an amphipodial bamboo. It has been exported from the Wheigee commune to North America and Europe in quantity for over a century.

The high mountain bamboo - Although the bamboo plantations and commercially managed natural stands are on the plains and in lower slopes generally under 800 m, there are vast areas of bamboo at higher elevations. The high mountain bamboos form dense evergreen thickets 1-3 m in height. They extend to 3500 m in Yunnan, Sichuan (Szechuan), and Gansu (Kansu) (Sinarundinaria mitida, S. clumgii) and to above the timber line of Abies kawakami forest in Taiwan (Yushania niitakayamensis). For miles they cover the upper slopes and mountain ridges in a dense continuous mantle. In addition to the useful materials produced, they are invaluable for watershed and soil protection.

6.2 LOGGING

Harvesting is one element of an integrated forest management plan--"Take silviculture as the foundation and integrate harvesting with tending."

Log requirements for the processing factories are planned by the state well in advance and allocated through a series of discussions between the state and the local administrations. The annual cut is determined more by these requirements then by any silvicultural management plan. At present, this is reasonable for many forested areas in the northeast and southwest, since these forests are overmature and contain most of their volume in large diameter classes. When these areas have been harvested, which will be many years in the future, the annual cut will be brought into balance with sustained yield management.

6.2.1 Utilization

In China the entire tree is often utilized, including leaves, twigs and branches. Leaves and branches support local fuel and agricultural needs. Large branches are turned by mobile chippers into salvage materials suitable for pulp. Smaller branches and twigs are used for the manufacture of fiberboard. Chinese foresters report that their logging efficiency varies between 85-90 percent (i.e., waste is only 10-15 percent). Even cull logs are harvested, transported, sorted and shipped off for processing.

Manpower is used year-round, since the Chinese log not only in the summer, but also in the winter when the snow aids the skidding operations.

6.2.2 Types of Cuttings

In China, both selective cutting and clearcutting techniques are used. The range of ages of the trees in a given stand determines which cut will be used. Selective cutting is often done in a series of separate partial cuts. For the first harvest, a haul road is cut every 50 m, with care taken not to damage the border trees. The second cut involves removing the old and overmature trees lying next to the haul roads. With the third cut, the mature and overmature trees inside the stand are harvested. After the third cut, trees are planted throughout the site. Although planting may sometimes not be necessary since there are seed trees remaining in the stand, it does alter the regeneration, providing an opportunity for more desired stand, composition and perhaps a better growth.

Clearcutting is often done in strips ranging from 50 to 200 m and 800 m long.

6.2.3 Mechanization and Productivity

The degree of mechanization in the harvesting process has increased in a series of steps. Between 1949 and 1952, only rudimentary logging was carried out and productivity averaged 70 m^3 per man per year. With the introduction of mechanization to the harvesting operation, productivity increased to 159 m^3 per man per year during the years 1953-1957. It is reported that at the end of this period, 57 percent of harvesting operations had been mechanized. Between 1958 and 1965, productivity increased to 184 m^3 per man per year, and 75 percent of the operations were reported as mechanized at the end of that period. In the years since the end of the Cultural Revolution, mechanization has proceeded at a rapid pace. Productivity is said to be as high as 260 m^3 per man per year, and the degree of mechanization is reported to be as high as 97 percent. However, some harvesting operations activities still appear to be labor intensive. For instance, there appears to be excessive manpower when trucks and tractors have two men in the cab, although this may be for safety or training purposes.

6.2.4 Equipment Used

Depending on the terrain, and other factors, different types of logging equipment are used: chainsaws, crawler tractors, rubber-tired skidders, winches and cables, skylines, etc. Most of the equipment is manufactured made in China, but some is imported.

(i) Chainsaws

Axes and power chainsaws are used for felling and bucking. Three types of chainsaws are produced in China. One is similar to a Russian electric model and is now out-of-date. It has a frame handle and a saw blade that can be tilted so that the logger doesn't have to bend down to use it. Another is a conventional type of chainsaw weighing 10 kg with 1.5 kg of fuel. It has a 38 HP motor which operates at 4500 revolutions and a 44 cm blade length. The fuel mixture consists of 15 parts gasoline to 1 part oil.

The Pieh Hsui Forestry Farm uses two of the conventional saws described above; however, only one saw is used each day, while the other is under maintenance or repair. Minor repairs are usually handled in the field, but large repairs have to be done in the workshop. The chainsaw is hand oiled and has to be sharpened hourly. Each chain lasts approximately one month. One of these chainsaws can cut 10,000 m^3 per year. At Pieh Hsui, the felling in one case was done by a team of two women who can fell 62-80 m^3 (average diameter: 42-50 cm) in an eight-hour day. Limbing is still done by hand saw.

(ii) Skidders

In northeast China, tractor skidding is preferred, while in southern China, cable systems are more suitable for the mountainous terrain. Logs are usually skidded downhill to the valley floor, requiring less work for the skidders.

Two types of skidders are used. One is a crawler tractor with a 50 HP engine. It costs approximately 18,000 yuan and has a skidding capacity of 8-10 m^3 in the winter.

The other mode is an 80 HP wheel tractor with a skidding capacity of 10-15 m^3 in the summer and 20 m^3 in the winter. The price for this wheel tractor with bulldozer is 20,000 yuan. Both models are manufactured in Harbin.

6-6: Skyline rig at work in the Northeast (Heilongjiang (Heilungkiang) Province).

6-7: A landing of birch (Betula spp.) logs in Heilongjiang (Heilungkiang) Province.

(iii) Loaders

There are two known operations for loading logs. The first uses a Spartree loader made in Tailin. This machine has a 50 HP diesel engine and costs 5000 yuan. Logs are also loaded using a winch-operated overhead cable system strung across the road.

6.2.5 Pre-Transport Processing

In certain areas, logging is done in tree lengths of 20, 25 or 30 m. In other places, logs are cut in standard lengths of 4, 5, 6 or 8 m, and are usually trucked to a sorting yard where they are frequently bucked to fit railway cars, then sorted by species, grade and size for supply to processing factories. This may be counter productive for the fullest utilization by some factories, since logs are often again butted off to accommodate short lathes or other processing equipment at the particular factory. Some logs are chemically treated with preservative, but few measures are taken to protect against checking and staining in storage. In the north, however, logs can be stored without serious deterioration. Logs are usually not debarked before they are transported.

Red pine (*Pinus koraiensis*), which makes up a large percentage of the total harvest in the northeast, is shipped great distances to wood processing factories in China. One of the outstanding qualities of this species is that the logs deteriorate very little during the long periods often involved in storage and transporting.

6.3 TIMBER TRANSPORTATION

The transportation infrastructure remains a weak link in China's forest economy. The mountainous topography in most of the heavily forested provinces presents a major barrier to accessing the areas to be harvested. In addition, the distances are great between wood-harvesting and wood-processing areas. Logs are usually transported on inland waterways or roads to depots where they are loaded onto rail cars and shipped to their final destination. Table 6-6 gives estimates (Richardson 1976) for the volume of timber transported on major inland waterways and roads and by major railroad routes.

Table 6-8. Timber volume by major transportation media.

Media		% of Volume Handled
Inland waterways		13
Roads		28
Railroads		59
	Total	100

6.3.1 Inland Waterways

Wood and wood products have historically been transported throughout the country on inland waterways. There are approximately 161,000 m of navigable rivers that all run in an easterly direction. The two greatest semi-navigable rivers, the Huang (Yellow) and the Chang (Yangtze), originate only 80 m apart in Qinghai (Chinghai) Province in central China.

The Huai River lies between the Huang (Yellow) and Chang (Yangtze) Rivers and is the only long river without a natural outlet. Other important semi-navigable rivers located in eastern China include the Min River, which is navigable for most of its course, and the Sikiang (Pearl), which is China's fourth longest river and the chief river in Guangdong (Kwangtung) Province. A more detailed discussion of these rivers is covered in Chapter 1.

6.3.2 Roads

Of the 800,000 km of roads in the country, at least fifty percent are dirt roads which tend to become impassable during rainy weather. With the expansion of all-weather roads, previously inaccessible forests are being brought into production. Since 1949, over 60,000 km of logging roads have been built in the state forests. Logs are usually transported by logging trucks from the harvest area to the railway depot.

6.3.3 Railroads

Although totaling only 44,000 km of track, the railroads form the most important means for transporting wood and wood products throughout the country. Of the 30,000 km of track laid since 1949, 10,000 km have been laid in state forest land, and this expansion is continuing. With the new railroad in Xizang (Tibet) Province, every province is now linked by rail. There are approximately 215,000 railway cars in use, and every year some 18,000 new freight cars and 250 new locomotives are produced. Although capacity does not always equal demand, the system appears to be very efficient, even though logs must be shipped over very long distances before reaching their predetermined locations (Figure 6-2).

6.3.4 Ports

Shanghai, Tianjin, Tsing Tao, Wham Pao and Dalian are major ports through which logs, timber and wood products are either imported or exported.

Table 6-9. Silvicultural practices and plantations of major forest trees;
+ refers to major areas; - refers to peripheral areas (see Figure 2-1);

Conifers	Artificial Regeneration				Natural Regeneration		Natural Forest and Plantations												
	Seeding	Planting	Cutting	Division	Nat'l Seeding	Sprouting	1A	1B	1C	2	3	4	5A	5B	6	7	8	9	10
Abies fabri		+			+				+					+					
Abies holophylla		+			+					+									
Cedrus deodara		+									-	+	+						
Cryptomeria fortunei		+	+			+					-	+	+		-				
Cunninghamia lanceolata		+	+	+		+					-	+	+		-				
Cuppressus duclouxiana		+			+	+			+					+					
Cuppressus funebris		+			+							+	+	+					
Dacrydium pierrei		+			+														+
Fokienia hodginsii		+											+	+					
Larix gmelini		+			+		+												
Larix leptolepis		+			+						+	+							
Larix olgensis		+			+					+									
Larix potaninii		+			+				+										
Larix principis--rupprechtii		+			+			+		+						-			
Larix sibirica	+	+			+			+											
Picea asperata		+			+				+		-	-							
Picea crassifolia		+			+			+	+						+				
Picea schrenkiana	+	+			+			+											
Picea koraiensis		+			+			+		+							+		
Pinus armandi		+			+				+		+	+	+						
Pinus bungeana		+			+						+	+	+						
Pinus caribaea		+													+				
Pinus elliottii		+									-	+	+		-				
Pinus fenzeliana		+			+								+		+				
Pinus khasiana	+	+			+									+	-				
Pinus koraiensis		+			+					+									

Table 6-9 (continued).

Conifers	Artificial Regeneration				Natural Regeneration		Natural Forest and Plantations												
	Seeding	Planting	Cutting	Division	Nat'l Seeding	Sprouting	1A	1B	1C	2	3	4	5A	5B	6	7	8	9	10
Pinus massoniana	+	+			+						-	+	+		-				
Pinus sylvestris var. mongolica	+	+			+		+			+						+	+		
Pinus tabulaeformis	+	+			+						+						+		
Pinus taeda		+									-	+	+		+				
Pinus taiwanensis	+	+			+								+						
Pinus thunbergii	+	+									+	+							
Pinus tonkinensis	+	+			+										+				
Pinus yunnanensis	+	+			+									+					
Podocarpus nagi		+			+								+						
Pseudolarix amabilis	+	+			+								+						
Taxodium ascendens		+	+		+			-	-		-	+	+		+				
Taxodium distichum		+	+					+	+		-	+	+		+				
Taxodium mucronatum		+	+					+	+			+	+		+				
Thuja (Platycladus) orientalis		+						-	-		+	+					+		

Table 6-10. Silvicultural practices and plantations of major forest trees; + refers to major areas; - refers to peripheral areas (see Figure 2-1).

Deciduous broadleaf	Artificial Regeneration				Natural Regeneration		Natural Forest and Plantations												
	Seeding	Planting	Cutting	Division	Nat'l Seeding	Sprouting	1A	1B	1C	2	3	4	5A	5B	6	7	8	9	10
Acer truncatum		+									+	+							
Ailanthus altissima		+		+							+	+	+			+	+		
Alnus cremastogyne	+	+			+								+	+					
Alnus nepalensis		+			+	+								+					
Betula pendula	+	+			+													+	
Burretiodendron hsienum		+			+	+									+				
Camptotheca acuminata		+											+	+					
Catalpa bungei		+	+	+							+	+							
Catalpa duclouxii		+	+	+		+							+	+					
Catalpa fargesii		+	+	+							+	+							
Cedrela (Toona) sinensis		+		+							+	+	+	+		+			
Cedrela (Toona) sureni		+		+									+	+					
Chukrasia tabularis		+											+	+	+				
Dalbergia odorifera		+	+										+		+				
Fraxinus americana		+																+	
Fraxinus mandshurica		+				+				+									
Fraxinus sogdiana		+									+							±	
Fraxinus velutina		+									+	+							
Gleditsia sinensis		+									+	+	+	+					
Gmelina hainanensis		+	+										+		+				
Juglans mandshurica	+	+			+	+					+	+							
Liriodendron chinense		+	+										+	+					
Melia azedarach		+		+							+	+	+						
Melia toosenda		+		+									+	+					
Paulownia catalpifolia		+	+								+								
Paulownia elongata		+	+								+								
Paulownia fargesii		+	+										+	+					
Paulownia fortunei		+	+										+						

Table 6-10 (continued).

Deciduous broadleaf	Artificial Regeneration: Seeding	Planting	Cutting	Division	Natural Regeneration: Nat'l Seeding	Sprouting	1A	1B	1C	2	3	4	5A	5B	6	7	8	9	10
Paulownia glabrata		+	+								+	+							
Paulownia kawakmi		+	+										+						
Paulownia tomentosa		+	+								+	+							
Phellodendron amurense		+								+	+								
Pistacia chinensis	+	+									+	+	+	+					
Platanus acerifolia		+	+									+	+						
Populus alba		+	+								+					+	+		
Populus boleana			+													+	+		
Populus canadensis			+				+			+	+	+			+	+			
Populus cathayana		+	+							+	+					+	+	+	+
Populus euphratica		+																+	
Populus euramericana cv-robusta			+								+								
Populus euramericana cv-sacran			+								+	+							
Populus euramericana cv-1-214			+								+	+							
Populus koreana		+	+							+									
Populus nigra var. italica X cathayana			+							+	+						+	+	
Populus nigra var. thevestina			+								+					+	+	+	
Populus nigra var. thevestina X simonii			+															+	
Populus pseudosimonii (Simonii X P. cathayana)			+				+			+						+			
Populus simonii		+	+				+			+	+	+		+		+	+		
Populus simonii X cathayana			+				+			+					+				
Populus simonii X nigra			+				+			+	+								

Table 6-10 (continued).

Deciduous broadleaf	Artificial Regeneration				Natural Regeneration		Natural Forest and Plantations												
	Seeding	Planting	Cutting	Division	Nat'l Seeding	Sprouting	1A	1B	1C	2	3	4	5A	5B	6	7	8	9	10
Populus simonii X nigra v. italica			+							+	+	+				+	+	+	
Populus tomentosa			+	+							+	+				+	+		
Populus ussuriensis		+	+							+									
Populus yunnanensis			+											+					
Pterocarya stenophylla	+	+				+						+	+	+					
Quercus acutissima	+	+			+	+					+	+	+	+		+	+		
Quercus variabilis	+	6			+	+					+	+	+	+		+	+		
Robinia pseudocacia		+	+	+		+					+	+				+	+		
Salix alba			+		+													+	
Salix babylonica			+								+	+	+						
Salix capitata			+							+						+			
Salix matsudana			+								+	+				+	+		
Sassafras tsumu		+	+			+							+	+					
Sophora japonica		+								+	+	+	+	+					
Tectona grandis			+																
Terminalia hainanensis		+												+	+				
Tilia amurensis		+			+	+				+	+								
Ulmus laevis		+									+						+	+	
Ulmus macrocarpa	+	+				+					+	+				+			
Ulmus pumila	+	+				+				+	+	+				+	+	+	
Zelkova schneideriana		+										+	+	+					

Table 6-11. Silvicultural practices and plantations of major forest trees;
+ refers to major areas; - refers to peripheral areas (see Figure 2-[illegible]);
* indicates introduced species.

Evergreen broadleaf	Artificial Regeneration				Natural Regeneration		Natural Forest and Plantations													
	Seeding	Planting	Cutting	Division	Nat'l Seeding	Sprouting	1A	1B	1C	2	3	4	5A	5B	6	7	8	9	10
Acacia confusa		+				+							+		+				
*Albizzia falcata		+				+									+				
*Anthocephalus chinensis		+													+				
Calophyllum inophyllum	+												+	+	+				
*Cassia siamea	+	+				+									+				
Castanopsis kawakamii	+	+		+	+	+							+		+				
Castanopsis hystrix	+	+		+	+	+							+	+	+				
*Casuarina equisetifolia		+													+				
*Casuarina cunninghamia		+													+				
*Casuarina glauca		+													+				
Cinnamomum camphora	+	+				+							+	+					
*Enterolobium confortisiliqum		+											+		+				
*Eucalyptus spp.		+										+	+	+	+				
Erythrophloeum fordii		+											+		+				
*Grevillea robusta		+											+	+	+				
Homalium hainanensis		+													+				
Hopea hainanensis		+													+				
*Khaya senegalensis		+	+			+									+				
Mangifera persiciforma		+													+				
Manglietia hainanensis		+													+				
Michelia macclurei		+				+							+		+				
Mytilaria laosensis		+											+	+	+				
*Ochroma lagopus		+													+				
Ormosia hosiei		+										+	+						
Phoebe bournei		+											+	+					
Schima superba		+			+	+							+	+					
Schima wallichii		+				+								+					
*Swietenia macrophylla		+				+									+				
Syzygium cumini	+	+													+				
Vatica hainanensis		+			+										+				

Table 6-12. Commonly planted economic woody plants and their products (see Figure 2-1); * indicates exotic plants.

Species	Deciduous	Evergreen	Forest Product	1A	1B	1C	2	3	4	5A	5B	6	7	8	9	10
Acacia catechu	+		tannin, medicinal									+				
*Acacia mearnsii		+	tannin, medicinal							+	+					
Aleurites fordii	+		industrial oil						+	+	+					
Aleurites montana	+		industrial oil							+	+					
Areca catechu		+	nuts									+				
*Amorpha fruticosa	+		forage, osiers					+	+				+	+		
*Anacardium occidentalis		+	nuts, timber									+				
Artocarpus heterophyllus		+	timber, fruit									+				
Camellia oleifera		+	cooking oil						+	+	+					
Canarium pimela		+	cooking oil, nuts timber									+				
*Carya illinoensis	+		nuts, timber						+	+						
Castanea dandoensis	+		nuts, timber				+	+								
Castanea henryi	+		nuts, timber							+	+					
Castanea mollisima	+		nuts, timber					+	+	+	+					
Cinnamomum cassia		+	medicinal							+	+	+				
Cleidrocarpon cavalerei		+	cooking oil									+				
*Cocos mucifera		+	cooking oil									+				
Cornus walteri	+		cooking oil					+	+	+	+					
Dalbergia balansae	+		wax							+	+	+				
Dalbergia obtusifolia	+		wax							+	+	+				
Dalbergia szemaoensis	+		wax								+	+				
Elaeagnus molhs	+		cooking oil						+							
*Elaeis guineensis		+	cooking oil									+				
Eriolaena malvacea	+		wax								+					
Eucommia ulmoides	+		medicinal						+	+	+					
Fraxinus chinensis	+		wax, timber					+	+	+	+					
Ginkgo biloba	+		nuts, timber					+	+	+						
Hevea brasiliensis	+		rubber									+				
Illicium vernum		+	spice, timber							+	+	+				
Juglans regia	+		nuts, oil, timber					+	+	+	+				+	
Juglans sililato	+		nuts, oil timber								+					
Listera chinensis		+	fiber, leaf									+				
Litchi chinensis		+	fruit, timber									+				
Lycium barbarum	+		medicinal					+						+		
Magnolia officinalis	+		medicinal, timber						+	+	+					
Mangifera indica		+	fruit, timber									+				
Morus alba	+		fruit, silk				+	+	+	+	+	+		+	+	
*Olea europaea		+	cooking oil						+	+	+					
Pistacia vera	+		nuts, cooking oil												+	
Prunus amygdalus	+		nuts, cooking oil												+	
Rhus verniciflua	+		latex					+	+	+	+	+				
Salix purpurea	+		osiers					+	+					+		
Sapium sebiferum	+		wax					+	+	+	+					
Thea sinensis		+	tea						+	+	+	+				
Torreya grandis		+	nuts, timber							+						
Trachycarpus fortunei		+	fiber, leaf						+	+	+	+				
Xanthoceras sorbifolia	+		cooking oil					+					+	+		
Zanthoxylum bungeanum	+		spice					+	+	+	+					
Ziziphus jujuba	+		fruit					+	+							

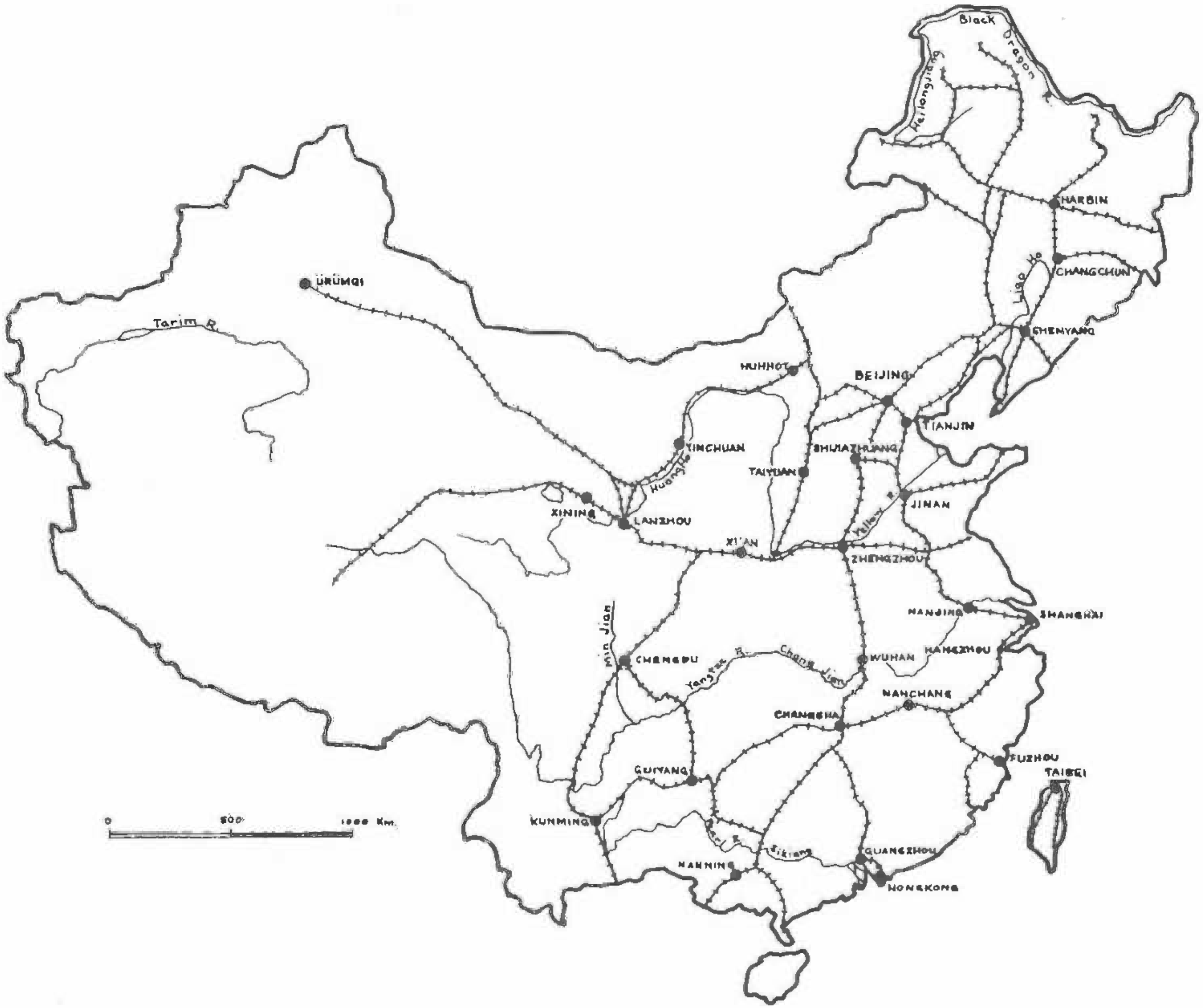


Figure 6-2. People's Republic of China: Major railroad routes and rivers.

Chapter 7

FOREST PRODUCTS UTILIZATION

7.1 GENERAL BACKGROUND

Although per capita wood consumption is relatively low, the size of the population puts tremendous pressure on China's forest products industry. This is particularly so considering that this industry is still in the process of being consolidated, coordinated, and directed. However, the Ministry of Forestry, often in concert with the Ministry of Light Industry, is creating an industry that now produces a vast range of forest products--from saw logs to medicines--and simultaneously is creating a network to support that industry: education, training, research, design, marketing (even exporting).

7.2 DEVELOPMENT OF WOOD PROCESSING INDUSTRY

The development of the wood-processing industry in China has assumed a varied course similar to the development and history of China in the twentieth century. There were periods of great advancement and times when progress slowed. It therefore becomes practical to divide the history into separate periods, as follows:

(i) the pre-liberation period (pre-1949): the wood processing industry was primitive;

(ii) liberation, Russian technical assistance, and the "Great Leap Forward" (1949-1960): wood processing was nationalized, consolidated and mechanized;

(iii) construction and economic consolidation following the "Great Leap Forward" (1960-1966);

(iv) impact of the cultural revolution on industry (1966-1976);

(v) the current period of progress.

Table 7-1. Evolution of forestry industries.

	Production in 1000 m^3					
Products	Before 1949	1957	1966	1976	1978	1980
Lumber (m^3)	3,375	10,241	11,171	10,000	11,000	13,000
Plywood (m^3)	7	70	203	184	268	300
Fiberboard (m^3)	--	--	62	170	393	--
Particleboard (m^3)	--	--	13	26	37	--

7.2.1 The Pre-Liberation Period (pre-1949)

In the years before 1949, the wood processing industry in China was very unsophisticated. Mechanization was scarce; even sawing was done by hand in some places. Most of the industrial activity was done in the interest of foreign powers. This led to the exploitation of many of the virgin forests in northeast China.

Wood-processing plants were generally located in the coastal cities where shipping facilities were available and in the northeastern provinces. The main product was sawn timber, most of which was exported. Often little more than a collection of wood workshops, most sawmills had waste recovery rates of less than 10 percent. Little attention was focused on more complete utilization of available residues.

7.2.2 The Period of Consolidation (1949-60)

Most industries were nationalized at this time, including all wood-processing plants. The immediate aim for forest industry was consolidation. Accordingly, mills were mechanized and reorganized into integrated productive units.

During the first five-year plan (1953-58), many wood-processing plants were established. Many of these plants, including equipment and technologies, were provided by Western Europe, Sweden and Russia. By the end of the five-year plan, annual sawn timber production had increased two and a half times over the pre-liberation period, and plywood production increased sevenfold. The guidelines for the restructuring and expansion of wood processing plants were:

(i) Processing should be done at the source to cut down transport costs.

(ii) Existing plants were to be renovated with the addition of modern equipment. Because of limited funds, a mixture of local ingenuity and foreign techniques was often adopted.

(iii) New factories would be built to increase production and to manufacture products of high quality. The small and older existing plants would assume back-up roles.

(iv) Relocation of wood-processing plants would produce a better regional balance.

Generally, plants set up at this time were better planned and integrated. Utilization of wastes and residues was also given priority. Fiberboard and particleboard plants, as well as wood pulpmills, were built to convert residues into products, and it is estimated that by the end of this period, about 25 percent of wood wastes were being utilized. Although these achievements were a great improvement, they by no means brought the industry up to the standard achieved in some other countries.

7.2.3 The Period Following the Great Leap Forward (1961-65)

The Russians withdrew their cooperation by the end of 1960, and the wood industry was badly affected. Scheduled plant imports, vital for continued reorganization of the industry, were either postponed or did not arrive at all. Prompted by these kinds of problems, the "hard struggle and self-reliance" campaign was intensified on all fronts, including industries.

Machinery and plants required for the wood-processing industry were manufactured in the country. Many plants developed auxiliary workshops which not only service and maintain the machinery of the plants, but, in some cases, even produce the machinery. Also, many new wood-based plants came into operation utilizing the milling wastes generated by sawmills, and wood-based panel production increased greatly. Therefore, in spite of many problems, the wood-processing industry expanded during this period.

7.2.4 The Cultural Revolution Period (1966-76)

The turmoil of the Cultural Revolution hampered the growth of production during this decade. Frequently shifting policies led to repeated disruptions of established development plans. The negative impact upon both production and progress slowed the rates of growth in all major sectors.

7.2.5 The Current Period

Since 1976, the government has returned to the "Four Modernization" policy. Under this policy, science and technology, both national and foreign, are being used as tools for economic progress. All Industries, including the wood-processing industry, are responding well to the new incentives and production is increasing rapidly. Most wood-processing mills are developing far-reaching plans for further production efficiency over the next few years. Increased utilization of presently unused or inadequately used residues will be a major factor. The demand for wood is currently greater than the supply; and steel, cement and plastics are therefore increasingly being used as wood substitutes. However, this may change in the future, as the wood supply increases as a result of the massive afforestation efforts in China during the past decades.

7.3 DESIGN AND LOCATION OF WOOD PROCESSING PLANTS

The general principle is to process the log close to the point of production, whenever possible. This can result in significant savings in transportation costs. In addition, it is then easier to integrate the operations such as combining lumber production with the production of chips, pulp, plywood and other wood-based boards. Another common policy is to combine small and medium-sized enterprises with a large one.

Wood-processing plants can now be grouped into two broad classes: (1) plants that have been formed from the consolidation of groups of smaller workshops with varying degrees of reconstruction, and (2) plants that have been newly constructed closer to the source of raw material. Thus, the goal of wood industry development is to expand production by constructing new industries and redesigning older established plants on a regular sequence as defined by the priorities of national development.

In 1980, there were 209 sawmills and 244 wood-based panel plants located throughout China under the jurisdiction of the Ministry of Forestry. In addition, there are also wood-processing plants under the jurisdiction of other ministries, as well as those under the administration of some provinces and autonomous regions. For instance, there are 2100 furniture mills under the administration of the Ministry of Light Industry, and most of these mills have their own small sawmill.

7.3.1 Reconstructed Mills

Mills falling into this category are usually located in or around the larger coastal cities, where the old established wood factories existed prior to 1949. They can be found in Beijing (Peking), Tianjin (Tientsin), Shanghai and Guangzhou (Canton). Such mills can also be found in the northeastern provinces of Heilongjiang (Heilungkiang), Jilin (Kirin) and Liaoning, where they were reconstructed mainly from old mills originally constructed by the Japanese.

7.3.2 New Mills

(i) New Mill Locations

New mills are usually found in areas where forest resources are readily available and where no previous mills have existed to process the logs. For example, in the western part of the province of Heilongjiang (Heilungkiang), six new processing plants were constructed. These plants were established along branch railway lines (designed to carry forest and agricultural products from the zone) laid north and south from the main Chinese northeastern railway. The forests supplying these plants are close by and have resources to supply them for a period sufficient to amortize the investment.

(ii) Mill Equipment

China now manufactures many kinds of wood-processing mill equipment, including complete fiberboard mills. Also, equipment capability has been improved by adopting air and hydraulic pressure, optical, photoelectric and data control techniques.

7.3.3 Wood Preservation Mills

Wood preservation is important in China. Because of the climatic ranges from cold temperate to warm tropical zones, there are many kinds of organisms that are harmful to wood, such as fungi, termites and wood-boring beetles. Wood storage and preservative treatment work is done by the Ministry of Forestry, as well as by railway, construction and communications organizations. For instance, eight wood preservation plants have been built by the railway agency. Research on preservatives is being strengthened; so, too, is research on technological processes for treatment of wood products such as sleepers, electrical posts, wooden bridges, pitprops and construction wood.

7.4 SAWMILLS

7.4.1 Sizes and Technology Used

It is reported that sawmills have been classed into three different sizes based on annual production with a two-shift operation (FAO 1979, FAO 1981). Large mills produce about 200,000 cubic meters (m^3)/year; medium mills produce 100,000 to 200,000 m^3/year, and small mills produce less than 100,000 m^3/year. These production figures seem rather high, however, since no descriptions of individual mills in various reports list production figures of this magnitude. Three types of headrigs are used: band saws, gang saws, and circular saws.

About 40 percent of all industrial roundwood is sawn into lumber and more than half of the lumber is processed by sawmills located near the larger forested areas. A large percentage of the wood-processing industry is located in Heilongjiang (Heilungkiang) Province, where sawmills are usually equipped with bandsaws. The mills here usually do not combine sawmilling with chip production, but such enterprises exist in southern China. In Heilongjiang (Heilungkiang), some mills combine band saws and gang saws, and some mills use multiple band saws of twin and quad types. The present trend favors multiple band sawmills.

7.4.2 New Sawmill Construction

In Heilongjiang (Heilungkiang) Province, a new sawmill, using a twin band saw as main headsaw, is now under construction. Log input per shift is 72,000 m^3, with the main equipment comprised of 11 sawing units. The sawmill's covered space is 4300 square meters (m^2). Annual output is 50,000 m^3/year per shift, working 360 days per year. Production is 2.7 m^3 per worker per shift, or 820 m^3 per worker per year, calculated on the basis of workers within the sawmill shop. The total investment for this sawmill is 2.43 million yuan, of which 650,000 yuan (26.7%) is for construction and 1.5 million yuan (61.7%) is for equipment (FAO 1979).

New sawmill techniques are currently being developed in China using twin bandsaws for small logs, twin horizontal double bandsaws, multiple bandsaws and chipping saws. Ripping with milling and cutting machines and scale measuring with photoelectric scanners are also being studied and developed (Wang 1981).

7.4.3 Productivity and Efficiency

(i) Toward Increased Mechanization

China has developed industries founded on intensive utilization of manpower. However, the mechanization of enterprises will diminish manpower requirements. Currently, sawmill productivity is often still relatively low. Until recently, the government's objective was to utilize fully all available manpower, which sometimes depressed per capita production levels. Now, however, it is felt that using mechanization to increase productivity will free workers for other equally valuable activities.

(ii) Present Productivity

Productivity now varies from .5 m^3 to 3.0 m^3 man/day, but with increased mechanization and better management of workers, productivity may increase to 7 to 10 m^3 man/day.

(iii) Lumber Drying Productivity

Currently, only about 15 to 20 percent of lumber in China is dried in dry kilns. Most lumber is air-dried or delivered green to users. Since much of the lumber is shipped long distances for use by specialized enterprises in China, deterioration can result. Efforts are being made to increase drying productivity and improve drying techniques by automation.

7.4.4 General Observations

Several general conclusions can be drawn concerning China's sawmill industry.

1. The Chinese are highly efficient in terms of volumetric yield, utilizing 50 to 75 percent of the exploitable volume. The major proportion of the ligneous wastes is used as raw material in other industries, but a small proportion is used locally as firewood. In addition, green wastes containing bark are used in the production of fiberboard, while green wastes with an absence of bark are used to manufacture particleboard.

2. The energy consumed in the operation of these sawmills is comparable to that of similar mills in other industrialized countries.

3. All sawmills have maintenance shops in charge of the daily preventative maintenance such as checking, cleaning and lubricating. In addition, the shop operators are in charge of saw sharpening and saw maintenance.

4. A number of mills have not been designed for the most efficient layout of machinery. Poor layout interrupts the normal flow process, which is further disrupted by a lack of specialized conveyors to handle dust, chips, and other by-products.

5. When lack of debarking machines occurs, a lower quality product results, as well as excessive wear and tear on the saws and machinery. In some plants, logs are laboriously debarked by hand.

6. The policy of maximizing the use of labor in industry has in many cases resulted in less than optimal productivity. To satisfy the increasing demand for wood products, it is considered necessary to increase the amount and efficiency of machinery used and to transfer labor into other activities where capital intensive projects are neither efficient nor feasible.

7.5 FIBERBOARD MILLS

7.5.1 Size and Production Capacity

In China, fiberboard mills, like sawmills, are classified by extent of output. The one large mill in the country has a capacity of 18,000 metric tons (MT)/year. Medium-sized mills produce about 5000 MT/year, and small mills have capacities less than 2000 MT/year. There are wet, dry and semi-dry process mills in China, producing both hardboard and softboard. A Chinese-designed, medium density fiberboard mill with an annual capacity of 10,000 (m^3) is now under construction. There are now more than 240 fiberboard mills in China. Total fiberboard mill capacity for China is more than 530,000 MT per year.

7.5.2 Wet-Process Fiberboard Mills

Two types of wet-process fiberboard plants with capacities of 2000 and 5000 MT per year have been designed and are being built in China. Since 1968 more than 200 of these kinds of plants have been established and are in operation. This type of plant is well suited to conditions in China where available raw material sources from forests or mill residues are widely scattered. The technological process involves chipping with a disk chipper, soaking chips with water, continuous cooking in the pipeline, defibrating, refining, pulp diluting, concentration-regulating, mat-forming, hot pressing with a multi-opening hot press and heat treatment. Many of these mills have been locally modified and updated, resulting in greatly increased production capacities. Detailed descriptions of equipment, operations and production of these types of mills have been previously reported (FAO 1979, Chian 1981).

7.5.3 Dry-Process Fiberboard Mills

A Chinese-designed, dry-process fiberboard mill was constructed in Shanghai in 1970. Other dry-process mills are being designed. One small dry-process mill under design will have a production of 2000 MT per year of .925 m by 2.134 m fiberboard sheets. This mill will require a raw material input of 6000 m^3 of wood residues, 20 MT of paraffin, 2.9 MT of sulphuric acid, 1.8 MT of ammonia (25%), 54.4 MT of alum and 2358 MT of coal; a labor input of 98 workers, of which 92 are production workers; and an energy input of about 700 kilowatt hours (KWH) per ton of board and 18.1 MT of water per hour to produce a steam supply.

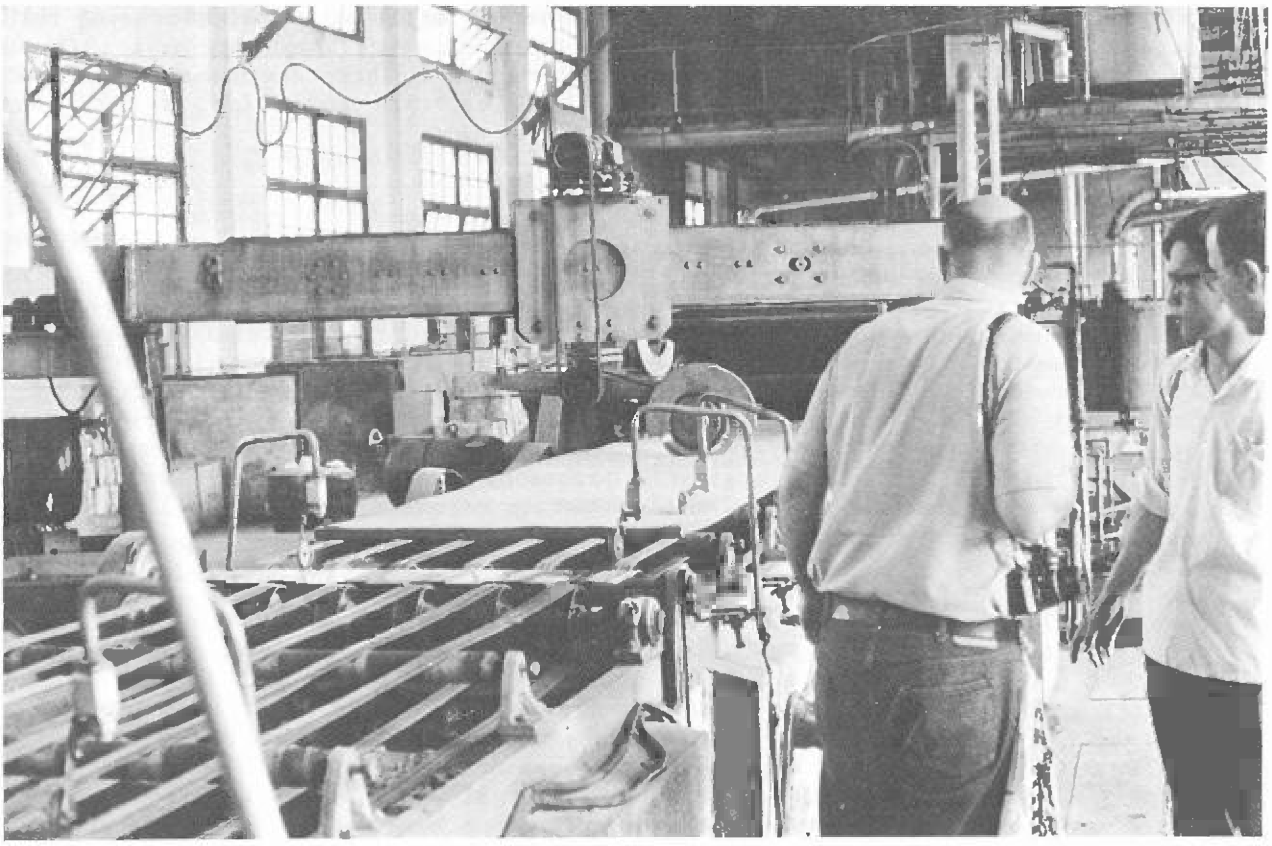
7.5.4 Productivity

Productivity per worker increases proportionally to the capacity of the mill. For example, in one mill with a capacity of 2000 MT/year, the productivity averaged 63 MT/man-year. A similar type mill of 3500 MT/year capacity had an average productivity of 130 MT/man-year (Wang 1981).

7.5.5 Quality Control and Utilization

(i) Quality Control

There are standards for quality directed by the government. The evaluating rules are as follows:



7-1: Fiberboard mats being cut, Nanjing (Nanking).

First Quality - To be evaluated as "first quality," fiberboards must have a specific weight (density) of 900 kilograms $(kg)/m^3$ and a thickness of 3.2 millimeters (mm), with an allowable error of plus or minus .3 mm.

Second, third and fourth quality - Panels within these quality categories must have a specific weight (density) of 800 kg/m^3.

First and second quality fiberboard comprises 87 percent of total production.

Efforts undertaken to improve quality - Since the manufacture of fiberboard began, a number of steps have been taken to improve the quality of the final product. Researchers have conducted extensive studies on raw material characteristics and their reactions to various water emulsifying agents and other chemicals. Research and development of new equipment and technological processes have also been major factors leading to increase in quality and productivity.

(ii) Utilization

Fiberboard is used primarily for furniture, cabinets and packing boxes, but it is also used for building, woodwork (interior doors with plywood covers, etc.) and portable (mobile) homes.

7.6 PARTICLEBOARD PLANTS

7.6.1 Particleboard Production

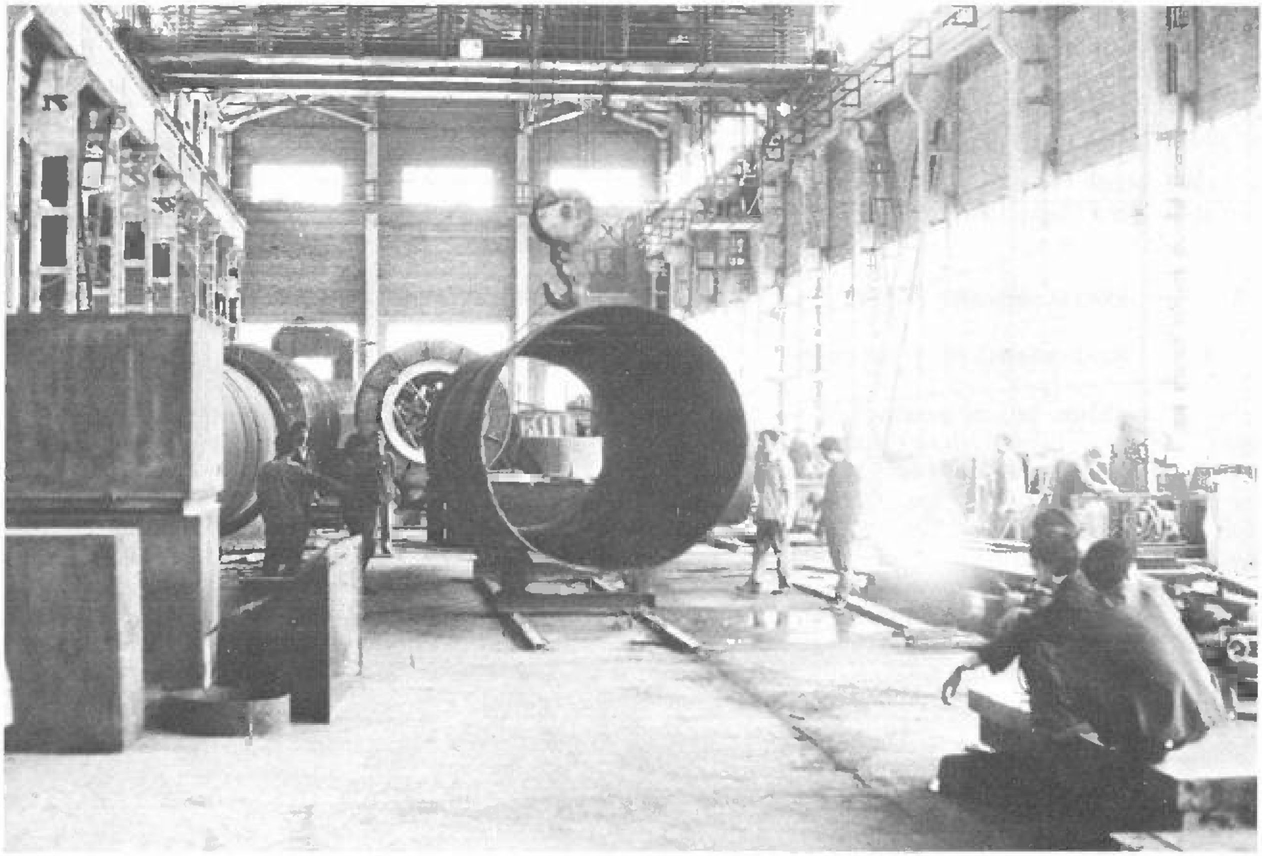
China began producing particleboard in the early 1960's to meet the requirements of the wood industry in general and the furniture industry in particular. However, production is not as great as that of either fiberboard or plywood (see Table 7-2) for two reasons: (1) special tools made of tungsten carbide are required for cutting, along with special machinery required to manufacture the particleboard into furniture; and (2) only recently has China begun to produce the special glues (urea-formaldehyde or phenol-formaldehyde) required for quality particleboard production. China presently has the capacity to produce particleboard at the rate of 60,000 m^3/year.

Table 7-2. Production Comparisons.

	1966	1978
Fiberboard	62,300 m^3	393,000 m^3
Plywood	203,000 m^3	268,000 m^3
Particleboard	13,000 m^3	37,000 m^3

7.6.2 Production Inputs

To produce particleboard, sawmill waste (chips, slabs) and round logs from thinnings are used as the primary raw material. About two-thirds of the basic raw material is *Pinus koraiensis*, with the remaining third comprised of *Betula* spp., *Tilia* spp., *Populus* spp. and occasionally wood from various conifers. A typical mill which produces 2300 m^3 a year, working three shifts operating 300 days/year, requires 3680 m^3 of wood, 136 MT of glue, 1.4 MT of hardener and 13.5 MT of paraffin wax. Of a total of 53 workers, 50 are directly involved in the production process. In addition, 321 kwh and 1 MT of steam are required to produce 1 MT of particleboard.



7-2: The source of much of the machinery used in China's wood processing industry--the Kunming Wood Base Panel Machinery Factory, Yunnan Province.

7.6.3 Current Productivity

Particleboard manufacturing has a relatively low productivity in China: 12 m^3/man/year (290 days a year), or 0.04 m^3/man/day (FAO 1981).

However, particleboard manufacture is very useful to developing countries with limited funds, because this forest product requires a relatively modest investment. Building a particleboard plant in China covering 1100 square meters (m^2) of floor space is reported to cost 860,000 yuan. Also, particleboard manufacture uses wood waste, and thus adds value to forest raw materials.

7.6.4 Efforts Undertaken to Improve Productivity and Quality

Factory research departments, in collaboration with research institutes and college laboratories both in China and abroad, are actively engaged in developing and improving both the equipment and techniques used in the production of wood-based boards. For example, in 1978 a flat-pressing process plant with a capacity of 50 m^3/day was designed and built. Testing is also being done on an imported turnkey particleboard mill which has an annual capacity of 30,000 m^3 using the flat-pressing process.

In the 1970's, complete plants were imported to produce a variety of decorative, colorful laminates using thin paper and PVC (polyvinyl chloride) film overlays. Designs are printed directly onto the surface of wood-based boards and micro-veneers using rolling presses. Research continues on the development of gloss and matt finishes and decorative laminates that do not require a surface overlay.

New equipment and techniques, in combination with refined, more abundant synthetic resins and surface treatments, have all contributed to the improved quality and quantity of wood-based boards produced in China today.

7.6.5 Wood-Based Board Adhesives

The development of the wood-board panel industry in China has coincided with improved adhesive technology. The use of synthetic resin adhesives has increased rapidly since their introduction into China in the late 1950's and early 1960's. Soybean and blood-based adhesives were used almost exclusively prior to that time.

(i) Synthetic Resin Adhesives

A wide variety of synthetic resin adhesives is presently used by the wood-based panel industry. These adhesives are produced primarily at plants attached to the wood-processing operations. The major portion of the synthetic resin production in China is urea-formaldehyde, which is used for both plywood and particleboard manufacture. It is estimated that 80 percent of the plywood adhesives used are synthetic resin, of which 80 percent is urea-formaldehyde and 20 percent phenol-formaldehyde. Essentially all particleboard panels are manufactured using urea-formaldehyde resin adhesives. Also introduced into China in the 1950's and 1960's were a variety of other synthetic resins: melamine resin, phenol-formaldehyde impregnating resins, "tego film" and polyvinyl acetate. It is estimated that the annual consumption of synthetic resin adhesives in the wood-based panel industry is 40,000 MT.

(ii) Adhesives to Improve Panel Surfaces

The development of techniques to improve panel surfaces led to the introduction of modified melamine resins, binary polymer resin adhesives, "EVA" hot melt adhesives, and rubber-base adhesives during the 1970's. The development and introduction of melamine resin paper laminates during the 1960's and the later introduction of new varieties of decorative laminates, including decorative paper and PVC (polyvinyl chloride) film overlays and direct printing onto the surface of the wood-based panels, are attempts to increase the use of wood-based panels for products such as furniture, building decoration and cabinetry. It is estimated that the annual production of wood-based panels is about 10 million m^2 (Wang 1981).

7.7 PLYWOOD MILLS

7.7.1 Classification

Plywood was the first wood-based board to be produced in China. Plywood mills are classified according to production output and amount of machinery in the mill. There are 11 large plants in China, each with a production capacity between 10,000 and 20,000 m^3 per year, with equipment consisting of three hot presses and three or more peelers. Medium-sized plants produce between 5000 and 10,000 m^3 using two presses and two peelers. The small-sized plants produce less than 5000 m^3 per year using one press and one peeler. Many of these mills still have a significant amount of manual operations.

7.7.2 Plant Production

(i) Large Mills

The data for a large plant having a capacity of 10,000 m^3 per year could be represented as follows: the log input is 25,000 m^3/year in 306 working days of two shifts. The number of workers is 403, of whom 349 are production workers. The installed power is 395 kwh, and 1090 MT of glue are required per year. A water supply of 9 MT/hr and a steam supply of 5.2 MT/hr are required. Power per worker is 1.1 kwh and productivity is 29 m^3 per worker per year. To build a mill with 7082 m^2 of floor space requires an outlay of about 2.68 million yuan.

(ii) Small Mills

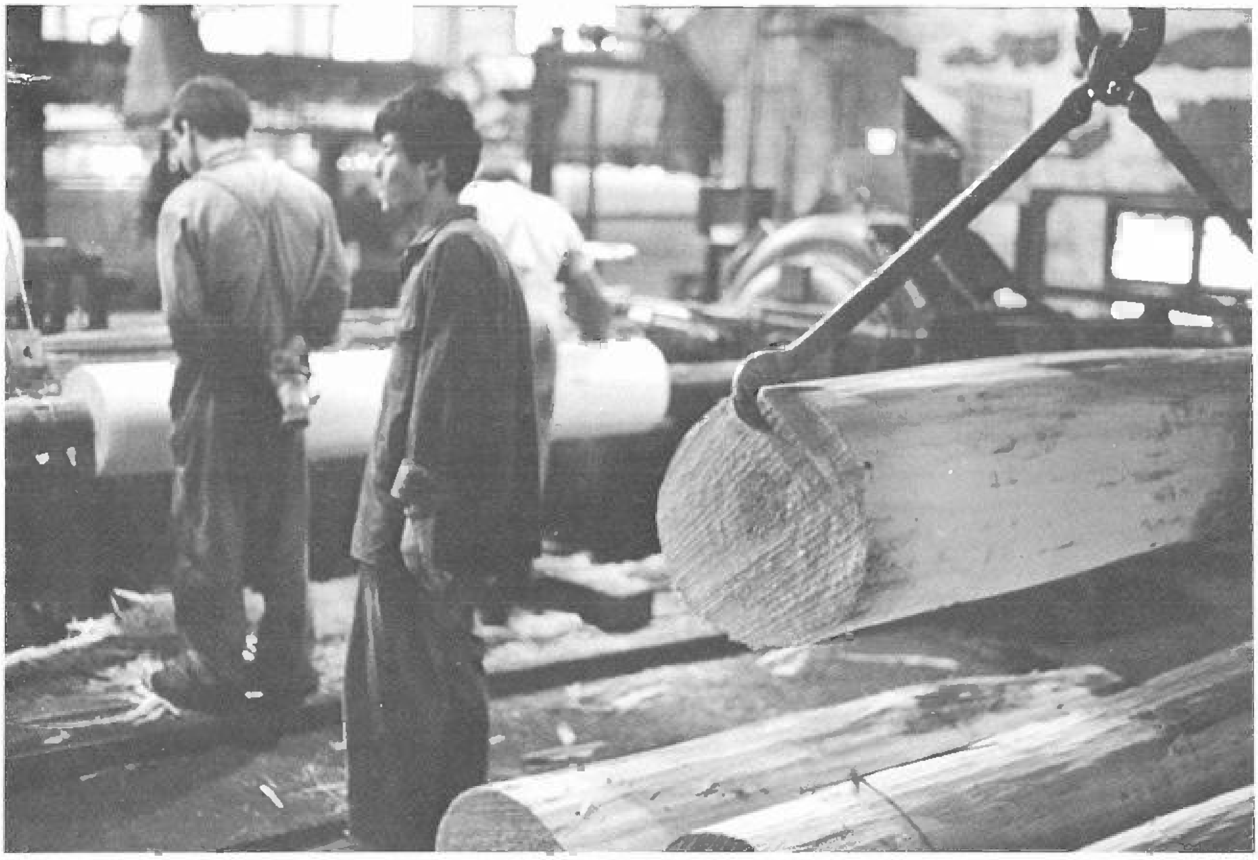
On the other hand, a small plant producing only 1000 m^3/year typically would require the following inputs: 2700 m^3 of raw material per year, 280 working days of one shift per day and a work force of 40 people, of whom 38 are production workers. The power requirement is 70 kwh, and annual glue usage is 118 MT. A water supply of 1.8 MT/hr and a steam supply of 0.7 MT/hr are required. Productivity is 26 m^3 per person per year, and the installed power is 1.8 kwh per worker. It costs 135,000 yuan to build a mill covering 670 m^2 of floor space.

7.7.3 Blockboard

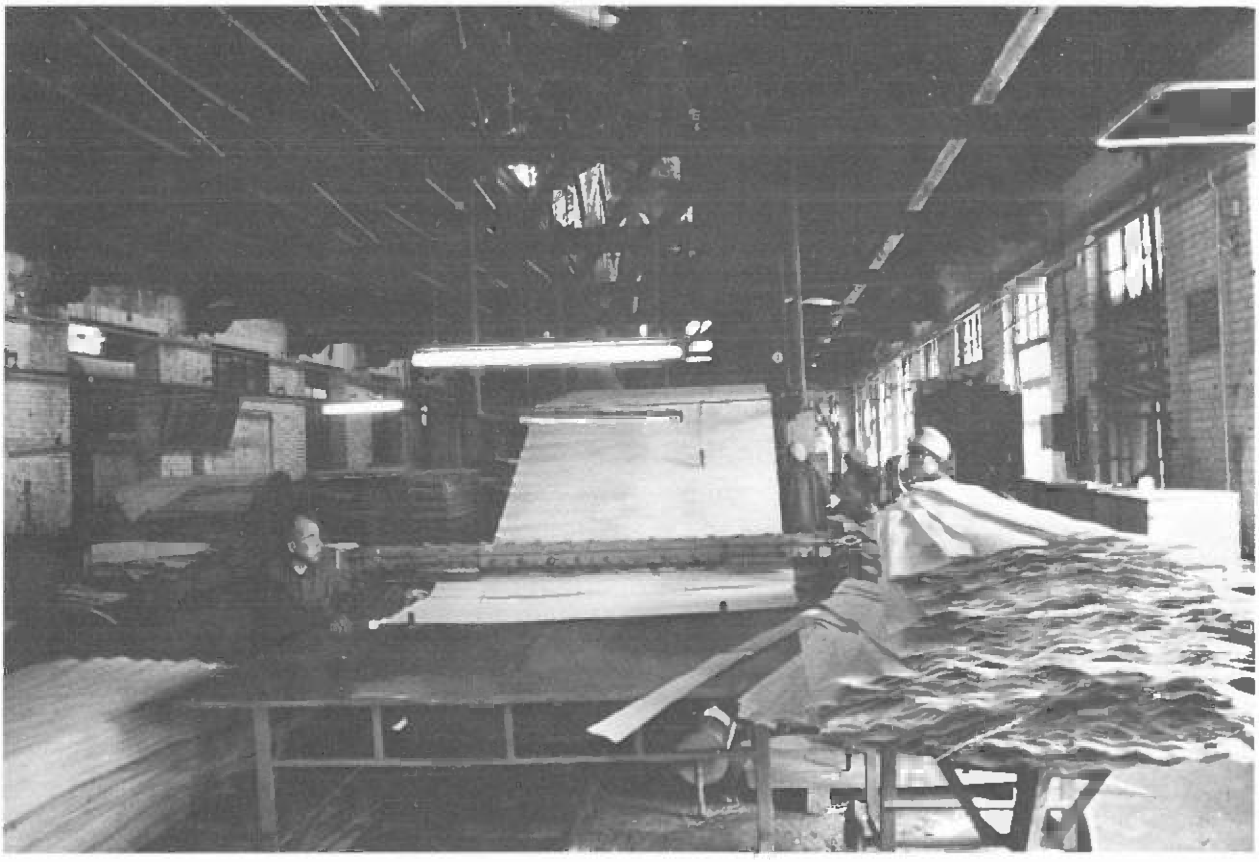
In addition to producing panels, plywood is also made into blockboard. In 1980, seventy factories manufacturing tabletop board produced a total of 6.3 million pieces. Productivity is quite high in these mills. The cores are frequently made from flitches and small pieces of wood that are joined together, or cores are sometimes manufactured from a paper honeycomb structure. The top and bottom of the core structure are then laminated with either a veneer or plastic overlay to form the finished product.

7.7.4 Productivity

Through expansion, replacement of old equipment with locally manufactured equipment, and new mills, plywood production has been increased by more than 50 percent in the last 14 years. Total annual production in 1980 amounted to 300,000 m^3. The main plywood product is a thin panel. A great deal of labor is put into veneer-jointing and splicing; therefore, productivity on a per worker basis is relatively low. Productivity ranges from 40-50 worker hours per m^3 of plywood in some mills, to 60-70 worker hours per m^3 in other mills (Wang 1981). However, volumetric yield is high in relation to the low quality and small diameter (30-40 cm) of peeler logs used. In addition, the quality of the plywood produced is quite satisfactory for the products it is ultimately used in.



7-3: Peeling logs in a Shanghai plywood factory.



7-4: Ply cutting, Shanghai.

Many of the plywood mills are being updated and improved. For instance, in the mid-1960's, China began producing jet veneer dryers which made possible continuous operation of peeling, reeling, drying and clipping. Glue-spreading, lay-up, prepressing and hot pressing operations are also being organized as one production line in some mills.

7.7.5 Species Used

The major species used in the production of plywood include: ash (Fraxinus mandshurica), birch (Betula spp.), poplar (Populus spp.), linden (Tilia spp.), Masson's Pine (Pinus massoniana), walnut (Juglans spp.), oak (Quercus spp.), camphor (Cinnamomum camphor) and teak (Tectonia spp.). To a limited extent, imported species are also used.

7.7.6 Final Destination of Products

Plywood is distributed to other sectors according to selected species, face qualities, gluing type and product.

Plywood board is used for boxes, packaging, construction, shuttering for concrete formwork, furniture, decorative panels used in railroad cars and modern houses, clock cabinets and musical instruments. Basswood plywood board is exported to Cuba, Hong Kong, Japan, The United Kingdom, Tanzania and Zambia.

Plywood blockboard is used to manufacture doors, sewing machine tabletops, furniture and travel trailers.

7.8 WOOD-BASED PULP MILLS

7.8.1 Pulp and Paper Manufacture

Generally, most paper in China is manufactured from straw produced by agriculture, but wood is also used. There are more than 1000 paper mills in China using straw, with the smallest having a capacity of less than 1000 MT/year, the large mills having a capacity of more than 100,000 MT/year. A number of small pulp and paper mills have been built in Heilongjiang (Heilungkiang) Province to utilize fully the wood resources to manufacture paper, paperboard and rayon pulp. In the future in the province, the production of rayon pulp will become necessary to meet the needs of a growing population's demand for cloth.

7.8.2 Typical Small, Rayon-Dissolving Pulp Mills

(i) Mill Description

The operation of these mills may be illustrated through one such mill in Heilongjiang (Heilungkiang). This mill is a small capacity, high grade, special purpose pulping plant which is part of a wood-processing complex producing sawnwood, fiberboard, charcoal, and carboxmethyl cellulose. The designed output is 2000 MT of bleached dissolving pulp per year. However, current annual production is 3000 MT in 330 working days per year using three shifts. Wood consumption is 15,000 m^3/year. The plant annually consumes 1050 MT of caustic soda, 250 MT of sodium sulphite, 33 MT of sodium bisulphite, and 300 MT of chlorine. The installed power is 977 kwh. A water supply of 260 MT/hour and a steam supply of 3.3 MT/hour are required. The work force is 254 people, of whom 243 are production workers. The total capital outlay for a pulp mill with 5913 m^2 of floor space is 2.67 million yuan.

The mill was designed and made in China and completed in 1965. The main equipment consists of a chipper, four spherical digesters--two for prehydrolysis and two for alkaline kraft cooking--bleaching vats, rotary filters, centricleaners, beaters used

7-5: Chest-of-drawer bases, Nanjing (Nanking) Furniture Factory.

7-6: Scrap and waste material awaiting reconstitution into fiberboard, Peking (Beijing).

for bleaching, a fourdriner-type sheeter and roll-type bowl dryer. The last item is a sheet cutter and baler which was made in the factory maintenance shop.

(ii) Raw Materials

Residues of slabs, offcuts and branch wood of several species of deciduous broadleaves are used in the mill. Hand debarking of this residue material is carried out in the mill's wood yard; the material is then conveyed by belt to the chipper. The species most commonly used are birch (Betula spp.), ash (Fraxinus spp.), elm (Ulmus spp.), linden (Tilia spp.) and poplar (Populus spp.). The actual mix of species varies with the log supply available.

7.8.3 General Equipment Maintenance

Daily preventive maintenance consisting essentially of greasing, checking oil levels, cleaning, and adjusting traction cables is undertaken by the machine operators.

Repairs, including the fabrication of new parts and the construction of supplemental machinery, are done by the mechanical engineering group assigned to each production unit and each industrial complex. The central mechanical engineer for the factories is in charge of annually scheduling a 3 to 4-week period, for most factories, during which worn parts are replaced and any major maintenance is done.

7.9 LABOR AND WORKING CONDITIONS IN INTEGRATED WOOD INDUSTRIES

7.9.1 Recruitment

(i) Two Systems

By the state - Recruitment of workers can take one of two routes. The first requires the industry to file a formal application with the government, showing its labor needs. This system is normally used when the industry wishes to recruit graduates from universities, technical colleges, or other training schools.

It is the government or province, then, that recruits from the institutions. In addition, the government distributes young workers entering the labor force to the various mills, according to their respective requirements and the jobs available.

It should be noted that some graduates who have had working experience before enrolling at the university or technical colleges will return to their previous employers. These will not be affected by the distribution process.

Many of the workers recruited under the system described above are usually qualified technical or professional employees. Therefore, they are placed in responsible positions when they return to or take up employment with the industries.

By the industries - This second recruitment process, unlike the first, is controlled by the individual mills or plants themselves. Before they can do this, however, formal permission must be given by the state. If the request is granted, the industry recruits the approved number of individuals. These recruits are generally unskilled people from nearby communes.

(ii) Social Aspect of Job Creation

The social aspect of job creation is important. Many plants seem overstaffed at the factory floor level. Also, because the welfare of the workers is a priority, there are large numbers of employees who work in the canteens, medical clinics, kindergartens, cleaning, and gardening services of the plants. Since everybody is employed in productive work with a visible purpose, morale is high. Because the labor cost is low, the lowered level of per worker productivity caused by many workers can, without strain, be accommodated.

7.9.2 Training

(i) Apprenticeship

Apprenticeship training is available in the wood-processing industries. Workers who join the industries after completing their secondary school or tertiary institution studies are employed for three years as apprentices. At the end of the three-year period, the apprentices take an examination. Those who pass become permanent employees, while those who do not have a chance to repeat their apprenticeship courses.

(ii) Additional On-The-Job Training

The value of additional training for workers is not overlooked. It is understood that productivity, efficiency, and quality of any staff can be improved by further schooling. In the wood-processing industry there are primarily two methods of accomplishing this.

Short courses--The first method is through short courses, usually arranged and taught by the personnel of the various mills at the mill site. The aim of such courses is to increase the employees' knowledge of various aspects of their jobs. In addition, these course help workers better understand their role in attaining the objectives of the mill and of society.

Institutional training--The second method of giving additional training is to send the most capable and promising employees to institutions such as universities and technical colleges. For example, the Northeast Forestry Institute at Harbin will usually give enrollment priority to such people. On successful completion of training, the graduate returns to employment and may take up a more responsible position.

There are strong incentives for workers to improve their knowledge on the job, since pay scales are tied to training results.

7.9.3 Wages and Other Social Benefits

(i) Wage Scales

All employees, ranging from the manager on down, are paid according to an eight-grade, wage-scale structure. The manager may be, although not necessarily, paid at the highest level - grade 8 - at approximately 100 yuan/month. A highly skilled factory technician may be paid more than the manager of the factory. Remarkably, this does not seem to interrupt the management structure.

At the lowest level, the salary ranges between 35-45 yuan per month. The average salary overall is 65-75 yuan/month (Table 7-3). While all wages are based on this scale, slight differences may occur among mills and among provinces. Compensation over and above regular wages is paid in the form of monthly bonuses to employees whose output and quality of work are outstanding. As far as it is known, these wages represent net take-home pay.

A normal work week is eight hours a day, six days a week. Various subsidies are given to defray transportation costs, with less compensation going to workers who live close to the plant. Subsidies may also be given to cover purchase and maintenance of bicycles.

Table 7-3. Shanghai Wood Industries Wage Scale (1978).

Grade	Yuan
1	38
2	44
3	51
4	59
5	68
6	78
7	90
8	104

(ii) Housing

Some housing is provided by industries for their employees. Rent for these houses is either free or is so low that it does not exceed 5 to 10 percent of the renter's monthly earnings. Some industries located on large tracts of land will supply land available near the factory, in addition to electricity and water, for those employees who want to build their own houses.

(iii) Medical Care

It is considered a primary task of management to provide free health services for employees and their families. This is done by the establishment of health clinics staffed by trained and qualified people on the mill sites.

In addition, some mills have agreements with big hospitals in their local areas to provide care to employees who are seriously ill and also for delivery services for pregnant employees.

(iv) Education

Education from kindergarten through secondary school is free of charge and compulsory. Many factories provide educational facilities, staffed with trained, qualified teachers, for the children of their employees. In the cities, the employees' children may be sent to schools run by the Ministry of Education if the factory does not have its own school.

(v) Leave

Employees are entitled to take up to four different types of leave, depending upon the circumstances and their sex.

Vacation leave - The state has decreed that workers who meet output, attendance norms, etc., are granted up to 12 days annual leave on full pay. Currently, not all workers get full annual leave, but one of the objectives of the government is to extend this provision to all deserving employees. Efforts to meet this objective are hampered by a lack of vacation facilities.

Sick leave - All employees are entitled to a maximum of six months' sick leave on 100-percent salary. After six months, 80 percent of their monthly salary is paid while they are on sick leave.

Maternity leave - A pregnant employee is given full pay while on leave for two weeks before the expected delivery of her baby and up to a maximum of eight weeks postnatal leave. During her hospital stay, all medical care is provided free.

Special leave - Leave is also granted when an employee must attend to family problems.

7.9.4 Safety

(i) Safety Hazards

Hazards and risks are inherent in the forest products industry, and China's industry is no exception. China lags behind some of the industrialized world with the provision of such safety equipment as protective clothing, boots, gloves, and eye and ear protection. In many plants, machine guards and protection against building hazards, such as floor openings, are inadequate by standards accepted in some industrialized countries. Some areas of plants using toxic solvents have inadequate ventilation. Machine operators seem to handle their machines carefully, and groups of workers operating unguarded guillotines and circular saws, without any interlocked safety controls, move very carefully to avoid injury. Low accident rates can be attributed, in part, to good worker morale, a high interest in work output, and the absence of pressure from overseers. In discussions on safety, managers stressed that an important factor in reducing accidents is the safety training given workers. While this does not overcome the problem of unguarded circular saws, guillotines and so on, in hazardous situations it undoubtedly must reduce the incidence of accidents.

(ii) Probable Causes of Hazards

Three reasons for the relatively slow development of safety protection in China can be readily identified.

Tradition - Chinese industry in pre-revolutionary days was notorious for its almost total disregard for the welfare and safety of its workers.

Lack of equipment - At the current level of development of Chinese industries, there is simply a lack of basic protective equipment. The light footwear worn by factory workers, for example, gives little protection against falling objects. Management has found it difficult to give priority at this time to providing hard boots for sawmill workers. Safety helmets (hard hats) are used to a minor extent, and those that were seen were of a woven bamboo basket construction which seemed inadequate by modern standards. Screens and safety glasses are rarely seen, probably because of shortages of these items.

Isolation from safety developments - A major factor contributing to the lack of safety devices and policies is probably the long isolation of factory management and technical staff from world developments in industrial safety.

7.9.5 Incentives

The wood-processing industry has a rather elaborate incentive system involving bonuses. The system includes material and moral motivations.

(i) Material Incentive

Payments beyond regular wages provide the material incentive. These payments go to employees whose work during a given month has been up to or above the standard set by the mill management. Appraisals are based on production and the quality of the product, and are awarded at the end of each month. This incentive is an effective one and can encourage many employees to become more productive. However, it is not clear if the system is industry-wide or localized. The system of the Kwang Hua Timber Mill in Beijing (Peking) is certainly effective. The average wage for this factory was 61 yuan/month within a range of 33 to 95 yuan. The typical bonus per month was 5.5 yuan/

month for management, 6 yuan/month for maintenance workers, and 7 yuan/month for production workers.

(ii) Moral Incentive

Unlike the monetary system, this program does not involve payments to employees. Instead, the moral incentive system relies on recognition for those deemed to be outstanding workers and includes publicity on notice boards and/or announcements on the radio for outstanding workers ("industrial heroes"), etc. Photos of outstanding workers are displayed in factory show windows. However, the most effective incentive system seems to require the monetary system in addition to the moral incentive system, since only a select few can receive the "moral bonus."

(iii) An Example of Incentive System Results

It is not possible to show how these incentive systems affect such variables as quality, output, labor productivity, etc., in wood processing industries. However, the following table taken from the Beijing Review No. 34 illustrates how a factory in Beijing (Peking), upon implementation of an incentive system, experienced an increase in output, quality and productivity (see Table 7-4).

Table 7-4. Incentive System's Effect on Productivity.

1st Quarter of 1978	Compared with State Quota	Compared with 1st Quarter of 1977
Output	31.5 percent higher	109 percent higher
1st class products	7.8 percent higher	11.2 percent higher
Labor productivity	11.8 percent higher	100 percent higher

These figures illustrate how the incentive system can encourage workers to improve their productivity and efficiency.

7.10 ORGANIZATION AND MANAGEMENT OF ENTERPRISES

7.10.1 Organizational Structures

There are two kinds of organizational structures. Figure 7-1 shows the typical organization for a small factory, and Figure 7-2 shows the organizational structure used in most medium to large enterprises.

7.10.2 Planning Considerations

(i) Development Planning

The Chinese development planning objectives are similar to those of any enterprise: to assess demand, to attain full production potential, to define production techniques, and to coordinate supplies, production and sales. The major difference lies in the Chinese pursuit of state goals versus the pursuit of profit goals by free market enterprises.

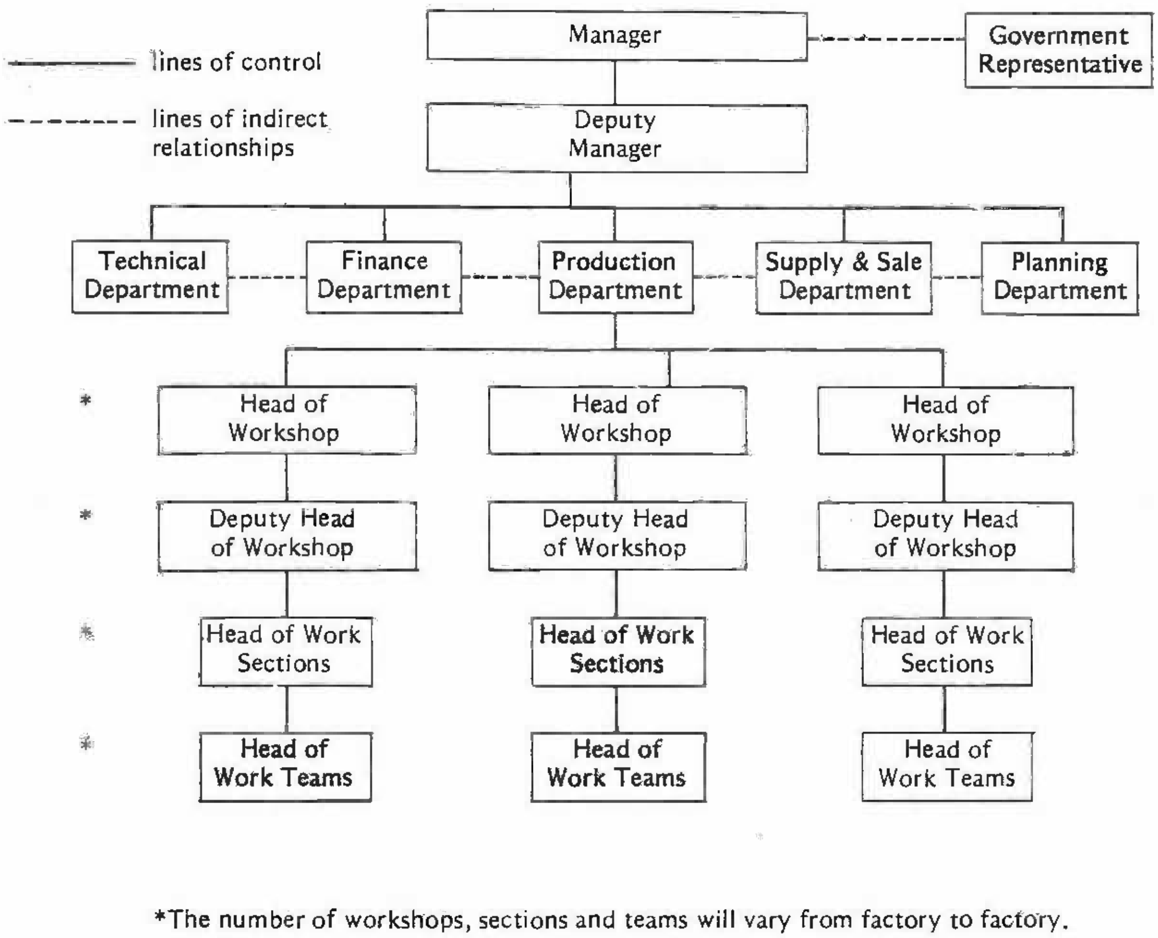


Figure 7-1. Organization of small factories.

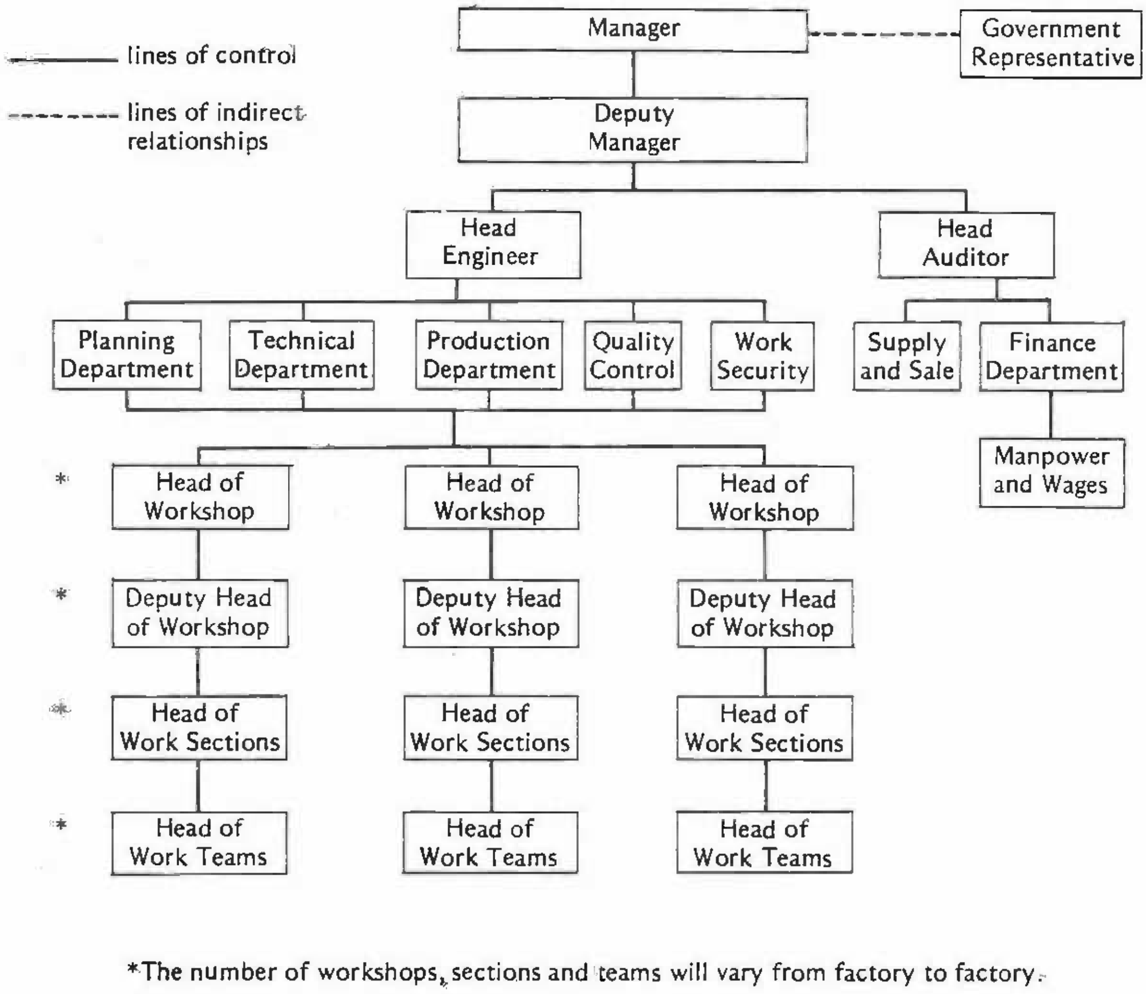


Figure 7-2. Organization of medium to large factories.

(ii) Strategies

The strategies used to attain these objectives are as follows:

1. analyze the social/governmental parameters and directives to determine enterprise direction and scope;

2. bring worker/technician productivity into line with "projected profits" (in China called "interest");

3. identify and eliminate or ameliorate those elements which retard the pursuit of management objectives;

4. utilize manpower, raw materials, and financial resources fully and efficiently;

5. maintain full production;

6. engage in consistent research and development to improve methods, and thus to fulfill government plans more quickly and completely.

(iii) Development Plan Content

Typically, development plan content comprises a long-term plan, an annual production plan and a plan for operations. The annual production plan is of most immediate importance. This is the program which mobilizes employees of the enterprise to a stated goal. It takes into account production criteria (manpower and technology) and financial requirements. In general, it defines objectives for sales and research and development. It also includes provisions for repair and maintenance of equipment, provisions for wages and investment, and provisions for transport, for finance, and for future construction and development.

(iv) Development Plan Elaboration

Submitting factory needs to the government - Once they are identified, the different needs are submitted to the government. Those needs include:

- raw materials (logs, chips, etc.);
- consumption (energy, glue, tools, accessories);
- number of workers in the firm (analysis of needs in manpower with respect to different working positions;
- working capital;
- level of quantity and quality of different products.

Approval/disapproval - The general rules or guidelines for planning are established by the government. The factory will determine a project plan in accordance with these guidelines and then submit it to the appropriate government authorities. The project is then approved or disapproved. If it is rejected, the project plan is revised and re-submitted. When the project is accepted, the enterprise uses a three-stage process to put the plan into action.

Preparation - Government authorities set guidelines based upon the balance sheet indicating the factory's performance during the past fiscal year. The new targets for the upcoming year are then set by the planning department.

Elaborating the development plan project - The project is then developed by the appropriate departments in collaboration with other associated departments. New rules for production are determined, economic effects are computed--occasionally refined--and commitments to the plan are defined. The plan project is submitted to the congress of worker representatives and is adopted or occasionally modified by the congress. It is then submitted to the enterprise manager. With his approval, the project is submitted to the authorities.

Upon approval by the government, the plan becomes a public law to which the enterprise must adhere.

Application and control of the development plan - The planning department is responsible for the administration of the different phases of the plan with the collaboration of each department of production, quality control and finance.

7.10.3 Production Management

Reports about ongoing production are prepared by the production department and provide a necessary management tool. These reports are indispensable, not only for managing the supply of raw materials and coordinating the management of other associated functions (storing, shipping, etc.), but also for the early detection of problems that could hinder the accomplishment of production goals.

7.10.4 Technical Management

Effective management of raw material and manufactured products requires the development of production processes that realize the largest economic return with greatest possible efficiency.

It is important to improve the technical knowledge of the workers with regard to equipment, processes, characteristics of products, etc. In order to increase productivity, effective management also involves planning for preventative maintenance, day-to-day repairs and major repairs.

7.10.5 Quality Control

Quality control is checked by special groups, supervised by a member of the technical service. Their duties include:

- control daily the quality of products;
- establish a close collaboration between research institutes and the enterprise and thus ensure that the enterprise is informed about new improved techniques;
- determine objectives, principles, and general plans for improving quality;
- occasionally--with the help of other technical groups and in accordance with the general operational plan--reorganize production processes to increase productivity.

7.10.6 Financial Management

Capital is controlled by the financial management department. This department also manages the economic and financial activity of the enterprise according to financial provisions established in the operational plan.

Factories establish monthly accounts for each of the different sectors defined as a profit center. The income of the general enterprise is given the highest priority. An informed work force participates in finding ways to eliminate waste and improve economic return.

7.10.7 Management of Supplies and Sales

All raw materials and other consumable materials are distributed among industries by government bureaus following the operational plan.

The products of a firm are sold according to government orders and prices. The firm has no right to enter into the market by itself and must rely on official government organizations for marketing functions.

7.11 PRODUCT MARKETING

Marketing is done exclusively by the government, the sole owner of production means. There is no competition among producers. The government has designed a distribution network subject to operational plans set by the central government.

7.11.1 The Export Market

Exporting all industrially produced goods is carried out by a government corporation: the China National Machinery and Equipment Import and Export Corporation in Beijing (Peking), which has a branch in Shanghai and agencies in Hong Kong and Macao. Export prices are determined by the government.

7.12 PRODUCT IMPROVEMENT

Product improvement is directed by the government and assisted by continuing collaboration between research centers and factories. Factory managers are constantly concerned with product improvement, and one function of a factory's quality control section is to seek possibilities for improvement. The workers are likewise encouraged to participate. There are, as well, periodical investigations of product quality by government agents.

7.13 SPARE PARTS

Maintenance shops in forest industry factories are equipped not only for making repairs, but also in some cases, especially in large plants, for making supplemental materials and spare parts.

Some specific pieces must be brought to the factories from other sources (ball-bearings, electrical material, pneumatic and hydraulic parts). However, careful organization and skillful management of stocks of these elements protect production lines from lasting breakdowns.

The government determines the productive life of a factory and its equipment and usually assigns them long amortization periods. Under these conditions, it is necessary to provide industries with well equipped, competently staffed maintenance shops.

7.14 ENERGY SOURCES

China is energy self-sufficient and, indeed, enjoys substantial reserves of coal and petroleum. However, the Chinese have begun energy conserving industrial practices. For example, the Nanjing (Nanking) Fiberboard Plant recycles waste oil from local refineries and the plant's vehicles into a new oil-burning boiler. The availability of energy supplies for the forest industry--as well as all other industries--is assured for some time to come.

7.15 GENERAL CONCLUSIONS

1. In the forest products industries, very high priority is accorded to recovery and recycling of waste material.

2. China has become self-sufficient in the manufacture of wood industry machinery, to the extent that 20 percent of machinery production is exported.

3. In the foreseeable future, China is expected to experience a growing demand for wood products, which will necessitate considerable technological progress. An example is the current need for high-quality particle panels in the furniture industry.

Chapter 8

FORESTRY IN RURAL AND COMMUNITY DEVELOPMENT

8.1 RELATIONSHIP OF AGRICULTURE AND FORESTRY IN CHINA

8.1.1 Integrated Planning

About eighty percent of China's population lives in rural areas and the economy is predominantly agriculture-oriented. The national strategy adopted was to "take grain production as the key link and ensure an all-round development in agriculture." Forestry has not only served as a support to agriculture in achieving this goal but, in the process, has developed into a strong and viable segment within a system of integrated planning. Chairman Mao highlighted China's strategy when he said, "Agriculture, forestry and animal husbandry should be interdependent and none of them can dispense with the others; these should be placed on equal footing."

Throughout history, China has been stricken by a series of natural calamities, and is now determined to tame rivers, regulate water systems, reverse soil erosion, and establish a more favorable climatological balance. Forestry has played a major role in accomplishing these objectives. Moreover, through afforestation, China has not only attempted to create a physio-biotic environment favorable to agriculture, but has also ensured a steady income to strengthen its collective economy and to enable procurement of capital goods to bring about technological advancement. In working toward these goals, China has effectively utilized the labor of large masses of people, whose productive energies have been directed towards the creation of a land and water conservation system which is a model for developing nations.

8.1.2 Integrated Development

Integration of forestry and agriculture, which has taken place at all levels in China, has had a positive impact. The collectives have implemented integrated plans concerning mountains, rivers, farmlands, forests, roads and communication systems for integrated development of agriculture, forestry, fisheries, livestock and related occupations. Some advantages of integration are:

(1) rational utilization of land for agriculture, forestry and related activities for land productivity;

(2) intercropping in man-made forests, between tree lines;

(3) raising fodder crops and grazing in forests;

(4) growing food, fodder, and medicinal and oil trees as part of forestry and the development of nontimber forestry;

(5) complete utilization of forest resources without any waste - as industrial wood, fuel, charcoal or manure;

(6) providing additional revenue for collectives to undertake investments and to increase reserves;

(7) stabilize soil and produce a more favorable environment.

Major elements of the forestry support for agriculture program are: "four around" plantation, shelterbelts, sand dune stabilization, coastal windbreaks, watershed management, afforestation of bare mountains, plantations of quick-growing species for timber production, and forestry for food and nonwood products.

8.2 "FOUR AROUND PLANTATION"

"Four around plantation" refers to planting along roads, along rivers and canals, around houses and around villages for production, protection, and/or amenity forestry. The success of the People's Republic of China in tree planting is attributable to an "up and down" planning system and to effective mobilization of the masses.

In every commune, "four around" tree planting is an integral part of economic activity, and tree planting is everybody's business. This is reflected as one of the national aims popularly referred to in the country as the "five ones." These are: one man - one hundred trees, one pig, one mu (.066 ha) of irrigated land, one thousand jin (1 jin = .5 kilograms) increase in food production, and one mu - 1100 jin of food grains. This program, which encompasses both the rural and urban sections of the country, has persuaded 1000 million Chinese that tree planting will contribute to their collective and individual well-being. As a result, today the Chinese people are the most tree-conscious people in the world.

8.2.1 Roadside Planting

(i) Rural Roadside Planting

Anyone traveling by state highways, secondary roads and dirt roads, in the hills and in the plains, is invariably struck by the amount of tree planting that has taken place everywhere. Although the trees planted along state highways belong to the Department of Highways, many roads within a commune, and the trees lining them, belong to the communes themselves.

Planting one row of trees on either side is most common; however, two or more rows on each side are also often planted. At times, complete belts of trees six to ten rows deep are planted along the roadway.

In the northern parts of China, planting willow (*Salix* spp.), poplar (*Populus* spp.) and *Pinus massoniana* is most common. However, poplar (*P.* spp.) is a much favored tree for roadside planting in the countryside, since it grows fast and straight and provides timber, fuelwood, fodder and substance for organic manure. Five- to 6-year-old poplars (*P.* spp.) reach a height of 15-20 meters (m) and an average diameter of 15 to 20 centimeters (cm). *Paulownia fortunei*, *Robinia pseudoacacia*, *Sassafras tsuma*, *Platanus orientalis*, *Pseudosassafras* spp., *Thea oleosa*, *Aleurites fordii*, *Melia* spp. are commonly observed along the roadsides in the central provinces. In some areas the tree belts on either side of the road are underplanted with a green manure crop like *Amorpha fruticosa*, which is usually cut back annually for fodder or for its long slender shoots which are used for baskets. In southern China, the roadside trees are generally in one or two rows and are mostly *Casuarina equisetifolia* and *Eucalyptus* spp.

(ii) Roadside Plantings in Cities

Urban forestry has been undertaken on an impressive scale in cities large and small. Besides providing aesthetic values, roadside planting meets practical aims, such as air quality, pollution control and shade. Immediately following liberation, revegetating of urban areas was begun and continues to receive high government priority. This effort has helped to modify the urban environment and even to provide additional wood supplies. Many millions of trees have been planted for this purpose. In Beijing (Peking) alone, a million trees a year are planted in boulevards, parks and other areas. As the visitor drives into the city from the new Beijing (Peking) Airport, he does so on a completely shaded road of some 25 kilometers (km), with long belts of mixed forests or tree plantations on both sides of the road--willow (*Salix* spp.), poplar (*Populus* spp.) and *Pinus massoniana* are planted three or more rows deep and are underplanted with *Amorpha fruticosa*.

8-1: Populus spp. line the highway from the Beijing (Peking) Airport into the city.

8-2: Hundreds of sycamores (Platanus spp.) grown from a single clone shade the pleasant streets of Nanjing (Nanking)

8-3: Urban forestry nursery in Xian, Shaanxi (Shensi) Province

In Shanghai, urban planting proceeds on a scale comparable to that in Beijing (Peking). The trees are produced in urban nurseries. Usually, three- to four-year-old seedlings, 2 to 4 m tall, are supplied for outplanting. Normally a production plan is made each year, linking production of all nurseries with the requirements of the city. Priority is given to raising seedlings for roadside plantings or parks. A lower priority is given to raising ornamental seedlings and experimenting with new species.

As would be expected, the major species used for urban planting vary from north to south and east to west. In the North, in cities such as Harbin and Shenyang, Populus spp. cultivars, P. simonii, P. pseudosimonii and Salix spp. are most common. In the South, in cities such as Nanjing (Nanking), Platanus acerifolia is perhaps the most widely planted species, although recent plantings of Ulmus pumila, Magnolia spp., Metasequoia spp., Populus tomentosa and Populus hybrids are evident. Further south, in Guangzhou (Canton), Casuarina equisetifolia, Eucalyptus spp., Pinus massoniana, Cryptomeria japonica, Cunninghamia lanceolata and other species are important.

8.2.2 Planting Around Houses and Villages

Tree planting around individual dwellings in the communes and around villages has been emphasized. A very good example of "around village" planting is at Pengchuang Production Brigade in Yanling removed the 400-meter-long mud wall around the village, moved 38,000 cubic meters (m^3) of earth and planted 50,000 trees around the village. Mainly, poplar (Populus spp.) was planted, with 2 x 2-m spacing. Trees were even irrigated and the soil worked by ploughing under the tree belts. A thinning after three years and a ten-year rotation are planned. Such examples of planting and tending of trees around houses and villages are numerous. Trees planted in an individual's compound belong to the individual, trees lying outside such compounds belong to the village.

8.2.3 Riverside and Canal-side Planting

The monumental examples of harnessed rivers, afforested hill and mountain watersheds and improved farmlands bear ample testimony to the contribution of forestry to the national goals of stabilizing waterways and developing agriculture. Everywhere, riverside and canal-side planting bear evidence to the massive post-liberation reforestation programs launched to protect soil from wind and water erosion.

(i) The Huang (Yellow) River Example

The Huang (Yellow) River, the second largest in China, is an outstanding example of riverside planting. During the past 2500 years, the Huang (Yellow) River broke its banks 1500 times, causing untold human misery. Some 1.6 billion tons of silt are deposited annually by the Huang (Yellow) River. Every year the riverbed rises by 10 cm, and in some places the river is more than 10 km wide.

Following liberation, top priority was given to controlling the Huang (Yellow) River; soil conservation measures were undertaken in the catchment area, and some 100,000 people living along the river were mobilized to construct supplementary dikes over some 700 km at intervals of 200-500 m, and to plant trees on the banks and on reclaimed soil. The main species planted here was willow (Salix spp.). Of the 1900 million trees planted under the "four around" forestry program in Henan (Honan) Province, a large proportion is along the Huang (Yellow) River. As a result of this work, no damage has been recorded in recent years. Even in the peak flood year of 1958 (some 22,000 m^3/sec of water flow), no breaches of the dikes occurred.

(ii) Other Examples

In Chifeng County, Liaoning Province, trees have been planted over 920 km along six rivers and 21 irrigation canals. In Xianning Prefecture of Hubei (Hupeh)

Province, trees have been planted 10 to 50 rows deep on either side of the Chang (Yangtze) River over 324 km. Salix spp., Populus spp., and Paulownia spp. are the main species planted along rivers and canals.

8.3 SHELTERBELTS

The shelterbelt systems of China are legends, unmatched in magnitude anywhere in the world. Over the centuries, poor agricultural and forestry practices resulted in the loss of considerable areas of formerly productive land to water and wind erosion. Since liberation, shelterbelt establishment has been one of the cornerstones of reclaiming agricultural lands and increasing agricultural productivity. China's "Great Green Wall" is undoubtedly one of the most ambitious protection-afforestation projects ever undertaken. The "Great Green Wall," a shelterbelt nearly 6000 km long which covers about 1.6 million hectares (ha), is intended to serve as a protective barrier around the Gobi Desert and other barren areas subject to wind erosion.

8.3.1 Planning and Establishment

As all other forestry practices in China, shelterbelts are an integral part of agricultural, animal husbandry, forestry, and water conservancy planning. Tree belts have been established on farmlands, along roads and rivers and in sand dune areas to protect the land and the people from wind and water erosion.

(i) Shelterbelt Disposition

Usually main belts run from 45° to right angles to the prevailing winds, with width varying from 8 to 22 m, and consist of from 4 to 13 rows of trees. On irrigated farmlands, the main belts run at right angles to the irrigation canals while the secondary belts parallel the irrigation canals at right angles to the main belts. Secondary belts usually have a spacing of about 400 m, to form a network of squared farm plots, each about 400 x 400 m. At the same time, roads and irrigation canals are arranged in such that they lie between shelterbelts. However, in some areas such as Chachia Production Brigade, Henan (Honan) Province, belts are spaced much more closely, 100-200 m apart, to adequately protect the loose sandy soils of the area.

(ii) New Shelterbelts

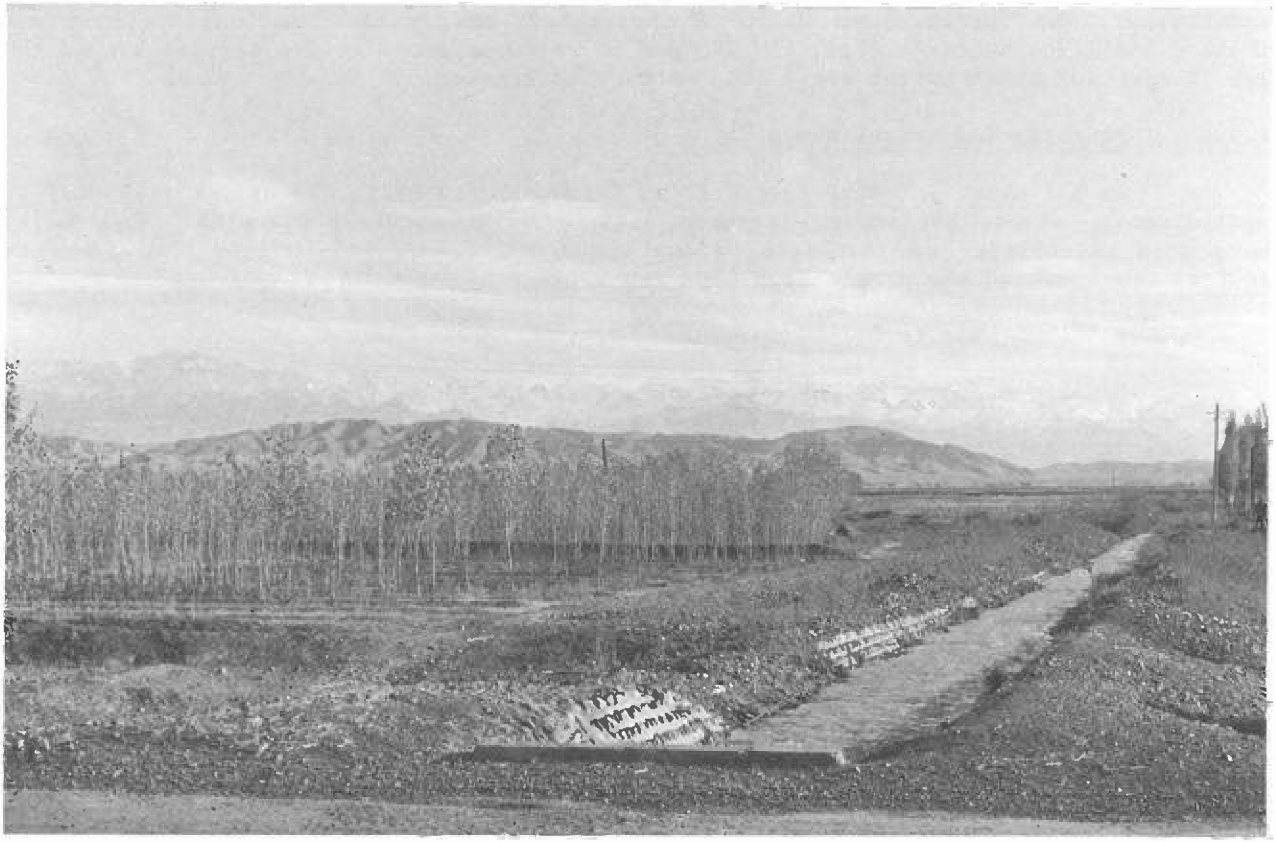
New belts are usually planted adjacent to the old shelterbelts at a distance of about 8-10 m, eight to ten years before clear-felling of the latter for utilization. The successive new belts take over the protective function of the old belts so that clear-felling instead of selective fellings within the belts can be practiced.

(iii) Shelterbelt Structure

The structure of belts varies according to the damage caused by wind-blown sands. Three types of structures are: 1) ventilated structure where area is very windy; 2) thin structure for belts close to the river, where sand damage is serious; and 3) close structure for fruit gardens and for protection from sand dunes. Establishment and culture of various species of trees for shelterbelts are discussed further in Chapter 6.

(iv) Shelterbelt Species

Poplars (Populus spp.) constitute the main species for shelterbelts in Chifeng County (Liaoning Province). The following broadleaved and coniferous species are also used: Populus simonii, P. pekinensis, P. pyramidalis, P. canadensis, P. nigra, Salix spp., Ulmus pumila, Amorpha fruticosa, Robinia pseudoacacia and Pinus tabulaeformis. In Henan (Honan) Province, Paulownia fortunei is the main species, spaced very widely.



8-4: Canal-side planting of Quercus spp. in Xinjiang (Sinkiang) Autonomous Region.

8-5: A carefully wrought pattern of latticed windbreaks protects a commune in northern China.

(v) Shelterbelt Cost

In one example, the cost of establishing a belt of 1 km with a spacing of 2.5 x 2.5 m (approx. 1 ha) was given as 15-20 worker-days or 15-20 yuan. This includes labor costs for digging planting holes and for weeding three times during the first year, but does not include land preparation before planting and tending operations after the first year, which are all done by machines; nor does it include nursery costs. Machine costs, using a 15 hp tractor for cultivation and weeding, were given as 0.20 worker-days/ha.

8.3.2 Shelterbelt Research

(i) A Need for Massive Efforts

Following liberation, it was realized that agricultural goals could not be met unless massive efforts were made to stabilize and reverse the loss of agricultural lands due to wind and water erosion. Therefore, a high priority was given to developing methods to carry out successful shelterbelt systems. Research was initiated at the national level under the direction of several ministries, including those which are members of the Agricultural Commission: the ministries of Forestry, Water Conservancy, Land Reclamation, and Agriculture. Research efforts were also directed at the provincial and commune levels. In addition to efforts directed toward specific parts of the shelterbelt problem, shelterbelt experiment stations were instituted in various parts of the country.

(ii) Experiment Stations: Jangutai

The Shelterbelt Experiment Station at Jangutai is one such station. Located approximately 200 km northwest of Shenyang in Liaoning Province, this station, begun in 1952, now has a staff of 43, 19 of which are "scientific workers." Two of the major tasks of this station are to determine how to stabilize shifting sands and how to build shelterbelts.

The station is located on the eastern edge of a large blowing sand, desert area. Three hundred years ago this was a rich agricultural area. But poor agricultural (and forestry) practices resulted in the area being gradually taken over by shifting sands that engulfed even the villages. One village was forced to move three times during the last 100 years.

Research results - Initial efforts focused on developing methods for stabilizing sand and building shelterbelts. Many of the early efforts proved unsuccessful, but gradually successful methods were evolved. To date some 240 ha of shifting sand has been stabilized, and 1330 ha of stabilized dunes have been afforested in the experimental area. The experiment station has also assisted with the stabilization of an additional 380 ha of sand, planted 250 ha of pines and built 183 ha of shelterbelts in the area near the station. This effort has provided protection for a total of 1121 ha of farmland. Agricultural production had increased 2.5 times in some protected areas. In Jangutai, it was evident that a productive agricultural economy, including vineyards (*Vitis* spp.) and small but impressive orchards of pears (*Pyrus* spp.) and apples (*Pyrus* spp.), has been successfully established.

Stabilization and windbreak species - Extensive trials demonstrated that the sands could be stabilized with low shrubs. After the shrubs had anchored the sands, trees could be established. Trials of many shrub species were made and resulted in the selection of five: *Lespedeza bicolor*, *Caragana microphylla*, *Artemisia halodendron*, *Amorpha fruticosa* and *Salix flavida*. Over twenty species were also tested to determine which could be used most successfully for afforestation and shelterbelts in the region. Five species were selected for planting on upland sands (*Pinus sylvestris* var. *mongolica*, *P. tabulaeformis*, *P. densiflora*, *Populus pseudosimonii*, and *Maakia amurensis*), and two species have been selected for lowland sites (Ulmus pumila and Populus pekinensis). Populus pseudosimonii is the most important species used in windbreaks or shelterbelts in the Jangutai region. It has been found that it is most effective if the main shelterbelts (8-12 m wide) are established at 300-m intervals at right angles to the prevailing winds. Secondary belts (6 m wide) are planted parallel to the wind at 500 m apart.

8.3.3 Benefits of Shelterbelts

Although shelterbelt forestry is accepted in China as prerequisite to increased agricultural crops, it is difficult to quantify its benefits, especially when it has indirect, associated and induced benefits and multiplier effects. The total contribution of forests can be understood only through the concept of attributability. What is involved in attributability of forestry is the overall contribution of forestry to agriculture, livestock, fishery, industry, ecological balance, hydrology, energy (fuelwood) and amenities. The beneficial effects are enormous, though not entirely quantifiable.

(i) Improving Agricultural Productivity

Chang Ku Tai: An example - One of the benefits attributable to shelterbelts and stabilization has been the difference in the productivity of land. For example, in Chang Ku Tai People's Commune in Liaoning Province, grain yields have more than doubled; and the protected land can now be harvested annually, instead of as formerly on rotation. Tai Chen Fang is a village in Chang Ku Tai People's Commune which had to move 3 times due to shifting sands. It is now a production brigade in the People's Commune.

By site improvement due to afforestation in Chang Ku Tai, agricultural productivity has increased 6-fold, in some places up to 14-fold. The number of cattle has increased 4.4 times, horses 2.2 times. The number of sheep doubled. Once a desert, the area now supports even a fruit garden of 2.5 ha with 48 varieties of apple (Pyrus spp.), 20 varieties of pear (Pyrus spp.), and 22 varieties of grapes (Vitis spp.) in reclaimed wasteland. What has been achieved is not only land reclamation but its continued productivity and ecological balance.

Chu Chou County: An Example - Afforestation has favorably affected agriculture in Chu Chou County, Hunan Province. In 1975 yield amounted to 7.5 metric tons (MT) of food grains per ha, which was double that of 1965. There were also corresponding increases of pigs, poultry, and other products. Similar increases have been obtained in Fu Kou County of the same province following planting of 74 million trees; 50,000 ha of land were brought into cultivation.

Turfan County: An Example - In Turfan County in Xinjiang (Sinkiang) Autonomous Region there is an oasis within the Gobi Desert. Before liberation, the size of the oasis decreased steadily due to constant wind erosion and sand-drift. Today, there are more than 1400 km of forest shelterbelts which form an effective, integrated system of farmland protection from wind and sand. The area of the oasis is now twice the size of pre-liberation days, and the production of food, cotton and hides has tripled since 1949.

Creating a positive attitude - Obviously, all improvements in agricultural productivity can not be attributed to afforestation alone; other factors can claim a share of the credit. Even communes without significant afforestation programs have had great improvements. For example, Wu Sae Commune of Shen Yang Municipality, Ta Chai Brigade and Song Chow People's Commune of Beijing (Peking) Municipality. But the areas where afforestation had to be the first step are places where, due to reckless deforestation in the past, the forces of nature had caused very serious damage. A noteworthy aspect of this work is that the farm worker can measure the increased yield behind the shelterbelts and can see new lands being brought under cultivation. This has created a favorable attitude towards protective afforestation.

(ii) Supply of Timber and Fuelwood Requirement

Lack of fuelwood had been a severe problem in many parts of China. Fuelwood produced from shelterbelts and other plantations has done much to reduce this problem. It is estimated that on the average more than 1 m^3 of firewood is needed each year per person. Since there are only .12 ha of forests per person in China, and these produce an average 2.6 m^3 per year, there is not sufficient wood to meet fuelwood requirements. Moreover, natural forest stands are not usually located where the densest populations are located. Therefore, fuelwood supplied by shelterbelts and other plantations is very important for many areas of rural China.

The Tungfanghung Production Brigade harvested 3000 m^3 of fuelwood from shelterbelts between 1966 and 1976 for its own requirements, as well as for supplying other brigades. Thus, dung, previously used for fuel, was preserved for fertilizing the crop lands. During this time, the brigade's income from forestry of 319 thousand yuan, mainly from the sale of timber to the state, enabled the brigade to purchase agricultural machinery, fertilizers, irrigation equipment and other implements necessary to agricultural development.

(iii) Improvement of the Microclimate

Shelterbelts not only improve the environment for agricultural crops, thus increasing their yields, but also can help regulate the microclimate. Wind speed is reduced behind shelterbelts, thus affecting all microclimatic factors to the benefit of the growing crops. The following table compares some effects in two sites (Table 8-1).

Table 8-1. Effects of shelterbelts on the microclimate.

Effects of Shelterbelt	Chifeng County, Liaoning Province 4 rows, 8 m wide, 20 m high *Populus* spp.	Yu County, Henan (Honan) Province 1 row, 40 m apart, 20 m high *Paulownia* spp.
Wind speed reduction	58%	14-30%
temperature reduction (spring and summer)	1°C	0.4-2.2°C
temperature increase (autumn and winter)	1°C	0.4-2.0°C
Evaporation reduction	38%	12-25%
Relative humidity increase	7%	13-20%
Grain yield increase	30-50%	13-17%

Shelterbelts can increase agricultural productivity by extending the growing season for crops, by protecting seeds and seedlings from burial by sands and fine soil, and by allowing harvesting to be done in autumn without the wind shattering fruits and seeds. The favorable effects of shelterbelts are greater in areas of severe climatic conditions.

8.4 SAND DUNE STABILIZATION

Afforestation has been extensively used in China to reclaim sand dunes, which are otherwise wasted, and sterile land which encroach upon productive lands, destroying crops and dislocating villages.

8.4.1 Levelling of Inland Dunes

Sand dune problems are commonly found in the desert sands of the north and northwestern interior of China. The dunes are formed by sand which are blown from the desert to cover cultivated lands, canals, roads, and villages. Many sand dune problems are caused by past misuse of the land.

(i) Sand Dune Stabilization in Northwest China

Background - The Wushenchao Commune in Wushen Banner, Inner Mongolia, comprises an area of 1600 square kilometers (km^2), more than half of which is covered by shifting sand dunes. Rainfall in the region is low, averaging only 317 mm yearly, and is concentrated in heavy rainstorms from July to September. Sandstorms are frequent during the dry season, with wind velocities up to 25 meters per second. Driven by strong northwestern winds, the sand dunes advanced southeastward, encroaching upon the only 544 km^2 of usable pasture. In 1958, a mass movement began to stabilize the sand dunes and to create pastures from otherwise useless land.

Initial efforts - The first step was to plant rows of vigorous, drought-resistant species such as yukao (Artemisia ordosica) and sand willow (Salix microstachya) on the lower one-third of the windward side of the sand dunes. Smaller shrubs and grasses were planted between the rows. These plantings established ground cover of up to 50 percent and, consequently, reduced the sand-carrying capacity by at least 20 times. On upper levels of the dunes, where there was no protective plant cover, wind forces were sufficient to level off the dunes in only two to three years. As soon as a small section was leveled, it was also planted with yukao (Artemisia ordosica) and willow (Salix spp.).

At the same time, sand willow (Salix michrostachya) and dry willow (Salix spp.) were planted on the land between the dunes which had groundwater at shallow depths. These were planted with a 5- by 5-m spacing, and were underplanted with forage species such as white sweet clover (Melilotus albus) and purple alfalfa (Medicago sativa) to allow for grazing and to provide added soil amelioration.

The results - This strategy of planting grasses, shrubs, and trees provided a ground cover of more than 70 percent and effectively checked the sand dune movement in only 5 years. However, continued surveillance was necessary for the first several years. Because of the aridity and strong sand storms, the death of a single shrub on the windward slope of the dunes could leave wind gaps which could destroy substantial areas of established ground cover. To prevent this, a four-stage "cultivate-plant-replace-protect" measure was adopted. "Cultivate" refers to the cultivation of rows of Yukao (Artemisia ordosica) and willow (Salix spp.) at various parts of the shifting sand dunes; "plant" refers to the planting of grasses and shrubs between the rows to strengthen further the wind resistance of the yukao (Artemisia ordosica) and willow (Salix spp.); "replace" refers to the urgent planting of new shrubs and trees wherever wind erosion gaps occurred in order to prevent further deterioration of the plant cover; and, "protect" refers to the prohibition of fuelwood cutting and grazing for several years, until the plants were well established. It should be noted that protection does not imply the total disuse of the areas for many years. For example, once forage species were planted on the between-dune areas, grazing was permitted at all times other than the growing season.

8-6: Sand dune stabilization project in Ninxia (Ningsia) Autonomous Region.

8-7: Tree planting on the grassland of Inner Mongolia.

Benefits - By 1975, a total of 16,000 ha of unproductive shifting sand dunes had been brought under control. In addition to the benefits of sand-stabilization and increased forage production, the growth of trees for fuelwood and other uses has greatly increased. The fast-growing willows (*Salix* spp.) have a high economic value; they may be cut for wood once every 6 to 8 years with an average yield of 1300 trees per ha. As a result, the focus of this sand-stabilization project has shifted from increasing forage production to maximizing wood values.

(ii) Sand Dune Stabilization in North-Central China

In Min Chin in Gansu (Kansu) Province there were serious sand movements engulfing 6000 villages. After liberation, 30,000 ha were afforested, resulting in the protection of 130,000 ha for growing grass and 20,000 ha set aside for farming. As a result, grain yield has doubled and pastures greatly improved.

(iii) Sand Dune Stabilization in Northeast China

Background - In the past, Chifeng County, Tungfanghung Production Brigade and Taipingti Commune in Liaoning Province were known for their poverty. Precipitation here is very low, ranging from an annual average of 300 to 400 mm, with an evaporation rate four times the annual precipitation. Southwest winds in summer and northwest winds in autumn and winter are the prevailing winds, with an annual average speed of 4 meters per second, rising to maximum velocities of 29 meters per second. In any given year, there are 100 to 150 days of very strong winds, of which 45 to 71 days are days with maximum wind speed. As a result, thousands of ha of sand dunes exist. For example, in Tungfanghung Production Brigade alone there were 20,000 sand dunes; each of these covered between 0.1 to 0.5 ha.

Efforts and results - The people of Tungfanghung Production Brigade were mobilized to level the dunes by moving two million m^3 of sand. After being leveled, the land was flooded to enrich the sand with silt deposits. This manmade soil has reached a depth varying from 0.30 to 1 m within ten years; nitrogen has increased 4.1 times, phosphorus 1.3 and potassium 1.4 times. This development was completed by establishing shelterbelts around the fields and linking the land with irrigation pumps and a canal system. The grain yield has more than tripled. Wind damage is completely eliminated. In fact, in 1963 very strong winds occurred in the neighborhood, covering the land with six inches of sand, but those lands treated by development measures were not affected at all.

In Paichuang Production Brigade in Yu County in Liaoning Province, similar climatic and environmental conditions existed, producing the same effects. Here 800,000 m^3 of sand were moved and the dunes converted into land suitable for agricultural crops in the same way and with similar success.

8.4.2 Coastal Windbreaks

(i) The Problem

A great effort has also been put into sand stabilization in coastal areas of China. Nanshan Island (Guangdong (Kwangtung) Province), originally composed of ten islands which have been linked together, has an area of 122 km^2 and a population of 51,000. Before 1949, this island was characterized by shifting sands and sand dunes and was barren and treeless. The area was often struck by typhoons and very strong winds which blew almost all year-round. Between 1929 and 1949 the sea encroached some 2 km, and 120 ha of cropland were covered by sand. Agricultural production was, predictably, extremely poor.

On Nanshan Island 57 km of coastal windbreaks have been established in the last 20 years to protect the island from the northeast winds which blow sands onto the farmlands, and from summer typhoons and sea tides which annually destroyed the arable land and houses. Before the establishment of coastal windbreaks, the island suffered badly from heat and typhoons.

(ii) Soil and Climatic Conditions

The soils are sandy and the climate subtropical, with an average annual temperature of 23.6° Celsius (C), an absolute maximum temperature of 37°C and an absolute minimum temperature of 2°C. Average annual rainfall is 1,400 to 1,600 mm, and there are two distinct seasons: a dry season from October to April and a rainy season from May to September.

(iii) Stabilization Process

Tree planting started in 1953, and by 1954, 19,300 trees had been planted. However, the survival rate was low because of lack of experience. In 1956, large-scale plantations were initiated through mass mobilization; by 1964 some 3933 ha of land had been planted with *Casuarina*. This rate of planting continued, and by 1976 the island had a total of 57 km of coastal windbreaks covering 4034 ha of land.

(iv) Benefits

The windbreaks are from 1 to 5 km wide, and give total inland protection from sand and tidal water. As a result, wind speed has been reduced by 60 percent, daily average temperature by 0.2 to 8.3°C, ground surface temperature by 1.3 to 2.0°C, evaporation by 12.5 percent and relative humidity has increased by 7 percent. Yield of agricultural crops increased from 1.27 metric tons (MT)/ha before 1949 to 4.35 MT/ha in 1976. Furthermore, 2200 ha of land have been reclaimed by linking the islands, 1200 ha of which have been used for agriculture.

Before the establishment of the windbreaks, fuelwood had to be transported to the island. After 1964, the windbreaks began supplying wood. Timber was sold to the state, and in addition, timber for 20,000 new houses was also made available to commune members. At present, more than 10,000 m^3 of timber are supplied to the state and 1900 MT of fuelwood to neighboring cities annually. The species used is *Casuarina equisetifolia*. The revenue of the island from forestry is about 700,000 yuan per year.

The cost of establishing one ha of coastal windbreaks, including nursery, is about 120 yuan. The rotation period ranges from 10-15 years, depending upon growth conditions and plan requirements. The yield is 45 m^3/ha, which is about 3 to 5 m^3/ha/year. Each year 40 ha are cut and the area is immediately replanted. The wood is mainly used for constructing houses as well as large boats and furniture.

8.5 WATERSHED MANAGEMENT

8.5.1 Background

Population pressures and consequent intensive land-use patterns have accelerated soil loss and land deterioration, resulting in impoverished crop lands and the conversion of millions of square kilometers (km^2) to unproductive deserts. Of equal importance to the loss of land productivity is the loss of soil cover and the subsequent reduction of the soil reservoir--the principal means by which water and erosion are controlled on watershed lands. The results have been increased floods and shifting stream beds, accompanied by water and silt damage to prime agricultural land, irrigation structures, reservoirs, settlements, and communication networks.

Because of these problems, afforestation of bare mountains or mountains with sparse vegetation cover is given high priority in China. The hydrological effects of afforestation in hilly areas are recognized in controlling erosion and regulating streamflow. In addition, afforestation has been extensively used in China to reclaim sand dunes which are otherwise wasted and encroach upon adjacent productive lands, destroying crops and dislocating villages. Regardless of whether the main objective of afforestation is water quality improvement and erosion control or production forestry, the principles of soil and water conservation are considered very important and given high priority in the integrated planning procedure. As water is the key to food production, many projects center around the development of irrigation and flood-protection systems which, along with the massive tree-planting program and management methods and techniques, will have a long-term beneficial effect on the hydrological regime of the watersheds.

8.5.2 Magnitude of the Problem

Two of the most important watershed problem areas in China are the Huang (Yellow) and the Chang (Yangtze) River drainages. The Huang (Yellow) River drainage, which probably receives the most attention, drains an area of 752,000 km^2. Of 277 counties in the watershed, 138 face serious erosion problems. Silt carried to the Huang (Yellow) River equals 1,600 million MT per year, causing the riverbed to rise 10 cm per year in the lower reaches, where it is already 3-8 m above the surrounding ground surface (Roberts 1980). Large floods are mainly produced by rainstorms during July and August. Ninety percent of the total sediment comes from 40 percent of the total drainage area--the middle section of the Huang (Yellow) River which is overlain by loess.

In North Shaanxi (Shensi) province, an area of about 80,000 km^2 contributes an estimated 50 percent of the silt in the Huang (Yellow) River. The most severe erosion in this area occurs on the 15,000 km^2 of the northwest loess plateau, where gullies range from 150 m to 200 m deep, and where the density of gullies is greater than 5 km per square kilometer (Roberts 1980). A related problem in this region is that of sand dune encroachment. The depredation of protective vegetation cover on grasslands, plus frequent flood deposits of sediment eroded from upland slopes, has resulted in extensive areas of shifting sand dunes common in the north and northwest interior.

8.5.3 Actions Taken to Reverse Damage

In China watershed management problems are generally understood and steps have been taken to find solutions. Priorities include: 1) the development of a strong data base with which to assess soil and water conservation measures, 2) soil conservation practices such as afforestation of bare mountains and marginal farmland, 3) construction of silt-saving and water-storage ponds and dams, and dikes to contain major rivers.

(i) Developing a Data Base

After liberation, the need to implement integrated land-use planning to conserve the nation's soil and water resources was well recognized. However, sufficient data upon which to base these plans were lacking. Little scientific data existed for precipitation and streamflow volumes, or soil erosion and sedimentation rates. This information is essential for assessing the impact of land-use changes. A "grass-roots" movement was promoted within the masses to gather local hydrologic data; the movement continues today. Information on local hydrologic conditions, weather patterns, wind speeds, natural vegetation cover, etc., have been systematically recorded by production brigades, communes and county offices.

Currently, 456 hydrometric stations throughout the country make year-round measurements of climatic and hydrologic parameters (Long and Xiong 1981). These are supplemented with numerous hydrologic and soil conservation experimental stations located in regions with the most serious soil erosion and sedimentation problems. For instance, the Huang (Yellow) River Conservancy Commission, Zhengzhou, has a research institute with numerous experiment stations doing research and gathering data. The

8-8: Terrace planting for erosion control in the loess region.

hydrometric and experimental station network has provided a thousand-fold increase in data, providing the basis for the development and management of both land and water resources.

(ii) Examples of Experiment Stations and Data Obtained

The Chaba Gully Experimental Basin, with an area of 187 km^2, was established in the gullied hilly loess region of the Middle Huang (Yellow) River drainage to study storm runoff and sediment generation. Within the basin, nine hydrometric stations have been set up and measurements of runoff have been made on 14 experimental plots. Soil moisture, evapotranspiration, water balance and meteorological data have been collected, and provide valuable information for improving the understanding of the soil erosion process as well as for surface runoff production within the region.

A runoff experiment station has been established at Zizhou on the loess plateau of the Huang (Yellow) River basin to study the processes of runoff and soil loss and to estimate the effectiveness of various soil and water conservation measures. Experimental plots have been established to: 1) study the dynamics of soil and water losses and the benefits of soil conservation practices, 2) study the separate effects of slope angle, slope length, vegetation cover and cultivation method on loss of soil and water, 3) determine effects of field works, e.g., terraces and earth banks on sediment detention, and 4) investigate interactions of soil erosion and water loss from ridge slopes and gully slopes. Measurements include precipitation, soil erosion, runoff outflow, evaporation, infiltration, soil moisture, soil fertility, and crop output.

Along the Lower Huang (Yellow) River, eight hydrometric stations have been set up to measure water and sediment discharge along the river course, and 101 channel reaches are surveyed repeatedly each year. Experimental stations have been established to study the fluvial processes and the transport capacities within certain representative channel reaches. Routine measurements are supplemented by reconnaissance investigations to determine the total quantity of water and sediment withdrawn for irrigation, and to investigate the distribution of rare storms and peak discharges, the detention effect of check dams, and the relationship of sedimentation to structural failures.

In addition, systematic reservoir surveys have been undertaken in a number of large and medium-sized reservoirs several times per year. The inflow and outflow of water and sediment are measured at hydrometric stations, and the status of density currents, bank stability, groundwater depths, depths of reservoir deposits, and flow conditions are also monitored. These provide a better understanding of the physical laws of sediment movement and deposition in the reservoirs.

(iii) Land-Use Transformations

In the last decade, sweeping changes have begun in the distribution of land uses as part of a program to control erosion and increase crop production efficiency. A land capability classification has been adopted for delineating areas for agriculture and permanent vegetation cover (forests and grasslands). All lands with a slope of up to 15° and a suitable soil are reserved for agriculture, while those with a slope of over 15° are reserved for forests, as are lands with a slope of up to 15° and poor soil. Tree planting over areas with serious erosion hazards is given high priority (See Chapters 2 and 6). The conversion of marginal and steeply sloped cultivated lands (especially those used for winter wheat production) to forests and forage lands have had a significant impact on the control of erosion and regulation of streamflow. In addition, the expected return from timber and forage produced is usually well above that from the crops previously grown on marginal lands.

The Loess Plateau of the Huang (Yellow) River - An example of the changing pattern of land use is found on the loess plateau of the Huang (Yellow) River. Only about 3 percent of the original forest vegetation remains on the loess plateau. The forest, once thickly covering the hills and valleys and providing soil protection, has been destroyed to make space for crops. What little remains is unevenly distributed and found mostly in rocky waste places.

Cultivation extends from the river valleys through gully bottoms to terraces and open hillsides of up to about 35-percent slope. Virtually the only remaining natural vegetation occurs on the side slopes of steep gullies. Farming on steep slopes is often carried to the very edge of gullies. Uncontrolled rills in cultivated fields lead to concentrations of water which converge at the heads of gullies and accelerate active cutting.

Soils of the plateau have generally good infiltration rates (0.5 - 1.0 mm per minute) and an absorption capacity of 44-48 percent. However, water retention is only about 20 percent; clay content generally runs 15-20 percent, so the soils expand when wetted. The soils are easily eroded and gully formation is rapid.

The Transformation Plan - The transformation plan for the loess plateau involves the following changes for the land presently occupied by agriculture, forestry, and forage production: agricultural land to decrease from 62 percent to 26 percent, forested land to increase from 27 percent to 41 percent, and forage production land to increase from 11 percent to 33 percent. To carry out this program, the per man production of irrigated land and suitable uplands have been increased to maintain crop yields as marginal lands are being converted to forest and forage production. Increased crop production is accomplished by better application of fertilizers, selection of high-yield varieties, and use of soil and water conservation practices. For erosion control, both biological and mechanical methods are used in conjunction with the program for overall land-use transformation.

(iv) Soil Conservation Practices

Conservation farming and erosion control practices vary for different slopes and soil conditions. For example, on slopes of up to 15° with arable soils, land is leveled into terraces shaped to ensure better water conservation and decrease down-slope movement of loosened soil, while providing for adequate drainage of excess water. On slopes greater than 15° with soils not suitable for farming, planting pits are used for afforestation.

Since the time of the destruction of the original native forests, the principal site for native species of vegetation has been on the steep sides of eroded gullies, and it was on such sites that the first tree plantings were made to control erosion. In general, the erosion rates on cultivated slopes are much lower than those in the gullies. As a result of upslope erosion, the overland flow from cultivated fields carries sediments which act to scour the sides of the gullies, thus greatly increasing erosion rates within the gullies. Farming conservation measures and conversions to forest are both effective in reducing the upslope erosion rates by increasing infiltration rates and, thereby, decreasing overland flow. The improved slope conditions act, in turn, to decrease gully erosion by spreading (rather than concentrating) overland flow, and by decreasing the sediment load in runoff which reduces the scouring effect on the gullies. Table 8-2 shows that sediment yields from forested and grass loess watersheds is far less than from gullied loess watersheds.

Table 8-2. Mean annual sediment yields of representative stations in different physiographic regions of the middle portion of the Huang (Yellow) River.

Physiographic region	River	Station	Drainage area (km^2)	Depth of runoff (mm)	Average sediment concentration ($g\ l^{-1}$)	Sediment yield ($t\ km^{-2}\ year^{-1}$)
Gullied-hilly loess area	Yehe	Yean	3208	47.1	311	14400
Gullied loess plateau	Puhe	Bajiazui	3522	35.9	145	5190
Loess terrace	Zhuhe	Sujiadian	840	83.2	18.9	1400
Hilly loess area with forest	Huluhe	Zhangcunyi	4715	23.0	4.94	128
Rocky mountain with forest	Wenyuhe	Wenyuhe	1876	131	0.12	15.3
Hilly sandy area	Xiliugou	Longtouguai	1145	25.0	125	3130
Sandy grass land	Dusitu	Kushuigoukou	8321	1.5	10.0	15.9
Hilly grassland	Kundulun	Atashan	879	16.2	56.9	917

Source: Long and Xiong 1981.

The long-term objective in gully control is the establishment of permanent vegetation cover. However, areas such as gullies where vegetation will not grow effectively due to the severity of erosion require mechanical measures. Small check dams at the mouths of gullies are commonly constructed to stop or slow discharge in the channels and to allow sediments to accumulate behind the dams. This accumulation decreases the gradients of the gully floors, and allows permanent vegetation to become established. Stabilized gully bottoms, in turn, aid the stabilization of the steeper gully sides, since the toes of the side banks are at rest. Construction of gully check dams, along with small reservoirs, ponds and dams on eroding streams has been done wherever possible. These structures help to increase channel storage capacities and decrease channel gradients, resulting in fewer floods and in improved subsoil water movement.

8.5.4 Benefits of Integrated Watershed Management

(i) Some Examples

China provides an excellent example of an integrated effort to combine biological treatments and mechanical methods to tame rivers and protect flood-prone areas. In past decades, roughly 6.7 million ha of arable land were prone to flooding about once every five years, and 70 percent of this land was perennially waterlogged. Including soil and water conservation principles in agricultural and forestry development prevented or at least reduced floods and lessened the effects of droughts, which alternated frequently with floods.

In the Huang (Yellow) River basin a huge effort was made to harness the river and restore the upper catchments. During a 20-year period, to 1972, 380 million m^3 of earthwork dikes were completed on the Lower Huang (Yellow) River by a seasonal labor force of 300,000 to 400,000 people. During the first phase of the project, one quarter of the total expenditure was devoted to efforts to check excess surface runoff and soil erosion on upland slopes and to detain silt by building reservoirs on the tributaries of the middle reaches of the Huang (Yellow) River. Since research indicated that the large silt-detaining reservoirs would silt up almost immediately without upland watershed management practices, afforestation and the building of small check dams were stressed to halt sheet and gully erosion.

Soil and water conservation measures undertaken on the upland loess plateau in Shanxi (Shansi) province from 1949 to 1963 were reported to have reduced by 23 million tons the amount of silt washed away annually into the Huang (Yellow) River. The success of this project has been, since the early sixties, a national example of the astonishing results obtained by integrated efforts in water and soil conservation, agriculture and forestry.

In Taoyuan County, 21 floods and eight droughts occurred from 1949 to 1958. Starting in 1959, a program combining the control of rivers and mountains with afforestation was undertaken to control waterlogging and droughts. This has been accomplished through a wide array of measures: the closure and protection of the upper catchment reaches, the construction of five multi-purpose dams and one reservoir, the planting of 105,000 ha of trees, the building of 132 small impoundments and 15 small reservoirs, the construction of 23,000 small farm ponds, the straightening of the river course in 45 places and the strengthening of the embankment along 40 km.

The effect of this work has been to reduce sediment from 7100 MT/km^2 to 3350 MT/km^2. There is now a storage capacity of 620,000,000 m^3 of water which can provide irrigation for a drought of 110 days. Food grain output has increased from 120,000 MT in 1970 to 180,000 MT in 1976, largely due to irrigation.

(ii) Other Benefits

In some cases, productive plantations are made to enrich existing secondary forests with species producing quality timber or edible oil or to replace unsatisfactory *Pinus massoniana* plantations. In earlier afforestation, the land was clean cultivated, all stumps uprooted and existing vegetation completely eliminated. This clean cultivation, with or without terracing, caused substantial soil erosion and deep gully formation. Practicing the new soil and water conservation principles has reduced the losses and increased tree growth.

8.6 TREES AND SHRUBS AS FUELWOOD FOR ENERGY

8.6.1 Background of Fuelwood Needs and Supplies

China has a substantial need for increased fuelwood production, especially in rural areas. About 80 percent of China's population lives in rural areas and accounts for about 40 percent of the nation's total energy consumption. About 70 percent of rural energy consumption is used for cooking and heating. Over four-fifths of the rural energy comes from traditional fuel, of which fuelwood is the major component. Fuelwood use in rural areas consists mostly of trees, branchwood, residues and shrubs from natural forests, as well as plantations (timber production plantations, protective forests, economic plantations and four-around plantations).

China has made substantial progress in the last few decades in increasing fuelwood production. It is generally recognized, however, that there is still a shortage of fuelwood, especially in rural areas, and appropriate plans are being made to further increase fuelwood supplies. This can be seen in the attention given to fuelwood in the 1979 Forestry Act (See Chapter 4 and Appendix 4) and the importance placed on fuelwood production in national and local planning activities.

8.6.2 Current Situation

As noted in Chapter 2, China has made tremendous strides in increasing tree cover since 1949. Available data imply that no less than 26 million ha have been added between 1949 and 1980 to China's forest land. However, there are still only about .12 ha of forests per person in China, and the need to increase fuelwood production persists. Moreover, the forests are unevenly distributed, and even though the fuelwood needs have been met in some areas, there are still needs in other areas; and the process of deforestation continues in many areas, especially in the large, state-owned forest areas of the northeast (Heilongjiang (Heilungkiang), Jilin (Kirin) and Liaoning provinces, and part of Inner Mongolia) and Yunnan and Sichuan (Szechuan) provinces.

Provisions for the supply of fuelwood are being integrated into forestry development mainly in the following ways: (i) fuelwood may be supplied from "four around" plantings (plantings along roads, along rivers and canals, around homes, and around villages); (ii) fuelwood may be supplied from larger collective protective, timber, or fruit, nut, and oil forests; (iii) grass and brush fuel may be gathered by local farmers during certain periods or from certain sections of areas that have been closed off for natural regeneration; (iv) fuelwood may be supplied from forest plots specifically designed for fuelwood production and (v) in some cases, small-size timber from state-owned forest areas has been collected and supplied to rural communities by the state.

Four around afforestation projects have been pursued in many parts of China, but particularly on the plains. The projects are usually designed primarily for protective purposes, but timber, fuelwood, fruit or other products may often be obtained from the trees. In some cases, private plantings by individuals around their homes may be especially important as a source of fuelwood; e.g., in Hunan Province four around plantations sometimes provide as much as 60 percent of the fuelwood needs of individual families.

In many larger collective afforestation projects, fuelwood trees may be interplanted alongside other types of trees. Also, local farmers may be often allowed to enter local forests to remove dead trees, to prune branches, or to pick up miscellaneous wood for use as fuel.

"Fengshan yulin" is the Chinese system for closing the mountains to allow natural regeneration of forests and land cover; access to local uncultivated areas is restricted to enable vegetation to recuperate. However, supervised fuelwood gathering is still allowed, although it may be restricted to certain areas which are changed in rotation, or it may only be allowed during certain seasons. It is prohibited to pull up grass by the roots or cut young trees or valuable bushes.

In 1976 collective fuelwood plots covered about 3.7 million ha and have been promoted primarily in the northern and northwestern parts of China, in areas where adequate supplies of coal and biomass fuels have been difficult to obtain, but expanses of uncultivated land suitable for forestry development are available; e.g., in Hubei (Hupei) Province, 70 to 80 percent of the firewood requirement is supplied by plantations and household plots, and 20 to 30 percent by stems of agricultural crops.

In general, Chinese reports indicate that fuel shortage and abuse of forest resources by rural fuel gatherers persist in some areas. The practices have often serious implications for plantation management, in that the people have a vested interest in the early mortality of newly planted trees and, also, they disfigure established trees by reckless pruning. Mutilated and unsightly saplings, even in the forest-rich areas of the Northeast, bear witness to the nature of these (abuse) practices. Concerning the practice of supplying firewood from four around plantations, a report from Guangdong (Kwangtung) Province states that in some areas people in great need of fuel have torn off the bark of the trees along roads and dug up the roots for firewood. Over the years, the Chinese government has issued increasingly strict regulations concerning forest protection as a way to control abusive tree felling and mutilation. As an important corollary, emphasis is being placed on further development of alternative household fuels, such as coal or biogas, and greater attention is given to the development of forest plots specifically for fuelwood production. The 1979 Forestry Act and directives on forestry work issued by the Central Committee of the Chinese Communist Party and the State Council in 1980 and 1981 all call for greater efforts in building collective fuelwood lots. The directive, issued on March 8, 1981, states that in places where there are shortages of firewood, priority in afforestation work should be given to the planting of fuelwood trees, and trees planted on private plots will belong to commune members forever, with the right of inheritance.

During most of the 1970s (and the Great Leap Forward), the fundamental policy for rural development was self-reliance or "zili gengsheng". In China's rural areas, local units were encouraged to adopt a "do-it-yourself" approach. A central aspect of the Chinese concept of local self-reliance is local participation in development: the planning, control, funding and management of local development projects are largely delegated to local units.

Taken as a whole, the policy of local self-reliance supported by the Chinese science policy appears to have provided a very effective framework for the rapid popularization of decentralized renewable energy systems. The speed of development and the creativity of local people in overcoming local obstacles were truly remarkable. However, the policies prevalent during the early and middle 1970's also involved disadvantages and caused a series of problems. Concerning the policy of local self-reliance, the wide application of the policy--in both forestry and forest industry--caused a lack of proper integration, and pushed the rural economy in a cellular direction. With the stress on local self-sufficiency associated with the policy, specialized development relying on interdependence was deemphasized, and inadequate attention was given to local comparative advantage, coordination between localities, and economic efficiency. In the specific case of the development of small-scale, decentralized enterprises, local self-reliance often led to technical deficiencies, waste through duplicated effort (caused by poor coordination), a lack of standardization in technology, and mismanagement. However, in the field of wood-based energy, these disadvantaged were felt much less than in otheas, since especially fuelwood must be produced close to the place of consumption because it is a low-unit-value, bulky material which cannot stand high transportation cost. Moreover, since 1976, the dominant political attitudes in China have changed drastically, bringing widespread reform of government policies. The role of the technocratic guidance in development has been strongly reaffirmed, and China's new leadership has established a new policy for scientific and technological development, which places special emphasis on the strengthening of China's capabilities in advanced scientific work, and, thus, the achievement of a better balance between the advanced and centralized sphere and local sphere in technological development. Below, the fuelwood situation is briefly reviewed under four different headings according to their respective characteristics.

(i) Natural Forests

The natural forest areas of the Northeast and the Southwest have traditionally provided substantial amounts of fuelwood. Reports indicate that high quality logs were used for fuel in the past. However, inhabitants of these areas now fill their fuelwood needs from logging residues, such as branches and defective logs, and from silvicultural residues, such as thinnings or prunings.

(ii) Fuelwood Forests in Remote Areas

In areas lacking such natural forest resources, it is more difficult for local populations to obtain adequate fuelwood to meet the existing needs. In spite of the fact that there are an estimated 3.2 million hectares of fuelwood forests (both natural and planted) in China, these forests are often located far away from communities in need of fuelwood. In some of the remote mountain areas there are some secondary coppice forests of broadleafed trees which are classified as fuelwood forests. Where no fuelwood forests exist, the people use shrubs such as Vites negundo, Ziziphus jujuba, Lespedeza bicolor, and Hippophae rhamnoides. However, even these fuel sources are not available in many areas. Straw has been and continues to be used in such areas, with fuel uses competing for straw with the pulp industry. In other areas, the use of straw as fuel reduces the amount of plant residues for composting and use as organic fertilizer.

(iii) Fuelwood Forests in Agricultural Areas

The fuelwood situation in some agricultural areas such as north China is especially serious. For instance, of 55 counties in Hebei (Hopei) Province, only seven can provide an estimated 70 percent of their fuel needs from wood and straw. An additional eleven counties can meet only 40-70 percent of their existing needs with the remaining 37 counties meeting less than 40 percent. These fuelwood deficits must be met by other means, such as coal. Coal, however, is transported over long distances, requiring a great deal of manpower and capital. Therefore, in some areas the people spend much of their time searching for biomass fuels of various kinds, including digging out the roots of trees, shrubs and herbaceous plants (Shen 1981).

(iv) Fuelwood Forests in Dry Areas

Populations inhabiting the peripheral regions of the desert northwest are especially hard hit for lack of adequate fuel. In Gansu (Kansu) Province, most of the people lack adequate fuel at least for part of the year. With low yields in agricultural production, the amounts of straw are also limited. To meet the urgent need for fuel in this area, manure is often used, thereby denying the land of this source of natural enrichment. Severe soil erosion is being encountered in these areas, largely due to heavy biomass removal (including roots and herbaceous plants) brought about by the need for fuel.

8.6.3 Fuelwood Species

China's vast land base and extremely large number of plant species permit the utilization of many species with good to excellent potential as fuel. Over this large territory, the appropriate combination of species and silvicultural techniques can result in substantially increased production of fuelwood. In general, the species selected for large-scale fuelwood plantations are Pinus massoniana, populus spp., Eucalyptus spp. and Paulownia spp.

(i) South China

In south China such species as Cassia siamea, Eucalyptus spp., Casuarina spp., Pinus massoniana and Acacia confusa have been found to be excellent for fuelwood forests. These species, especially Pinus massoniana, can form a base for successful fuelwood production. This pine has proven to be very adaptable to a wide range of conditions, including those of south China, where it has been grown in high density fuelwood plantations for some time.

Other species mentioned above have an excellent potential for fuelwood due to their high sprouting capability and equally high energy content. Large areas of China, especially in Leizhou Peninsula of Guangdong (Kwangtung) Province have been planted into Eucalyptus spp. forests where no forests existed prior to 1949. In areas where such plantations exist, fuelwood supply does not appear to be a problem. In the same province, Casuarina spp. shelterbelts have been successfully planted along the sandy seashores where they play an important role in farmland protection while providing fuelwood for the local communities.

The climatic factors, precipitation and soils of southern China are favorable for rapid tree growth; therefore, many areas have been able to meet fuel needs through afforestation programs. As an example, Cassia spp. fuelwood plantations in southern Yunnan Province have played a critical role in supplying fuel needs for people inhabiting nearby areas.

(ii) Central and North China

Black locust (Robinia pseudoacacia), Quercus acutissima, Pinus tabulaeformis and Quercus variabilis are examples of the species used for fuelwood plantings which thrive in central and north China. In the Nanyang Perfecture of Henan (Honan) Province, black locust fuelwood plantations are common. Black locust is characterized by excellent adaptability and high sprouting ability. The wood of this species also has a rather high density and high energy content per unit volume. Fuelwood from black locust originates from cutting small trees or from pruning larger trees. On a good site the cutting rotation is about three years. In some regions black locust is managed as small-sized timber forests, with fuelwood obtained from thinning and pruning.

Man-made black locust forests have been created in hilly areas of Jiaonan County in Shandong (Shantung) Province where historically no forests have existed. These plantations are often mixed with pine (Pinus tabulaeformis), with both species heavily utilized for fuelwood. These locust-pine forests have done much to reduce fuelwood supply problems in these regions. An estimated 80 thousand MT of fuelwood are harvested each year in these areas. Local populations use the two species in combination with straw and herbaceous plants to meet their fuel needs.

Large poplar plantations in the Yanlin County of Henan (Honan) Province are also heavily utilized as fuelwood. Poplars (Populus spp.) have been especially successful in shelterbelts which, as by-products, produce fuelwood. Rapid growth and adaptability have made several species of poplars especially popular. The cutting cycle for various species of poplar (Populus spp.) is about 20 years, after which clearcutting takes place. The following data indicate that substantial growth is recorded in Chifeng County, Liaoning Province, by various species of poplar (Populus spp.).

Table 8-3. Growth rates of poplars in a shelterbelt.

Planting date: 1966
Measurement date: 1976

Species	Average Height (m)	Average Diameter (cm)
Populus canadensis	18.8	20.2
P. pekinensis	16.4	19.3
P. pyramidalis	16.1	17.1
P. simonii	11.3	13.5

In another belt of P. canadensis planted in 1966 and measured in 1976, average height was 21 m and average diameter was 21.5 cm. The total volume of 1 km of this belt 10 m wide (equivalent to 1 ha) was reported to be 563.3 m^3 or an increment of 56.33 m^3/ha/year.

(iii) Northwest China and Inner Mongolia

The sandy deserts of northwest China and Inner Mongolia, with their harsh climates and low annual precipitation, present difficult growing conditions. This large land base has an annual precipitation of 300-400 mm, severely limiting plant growth. However, in these relatively thinly populated areas, the possibilities for fuelwood production still exist, utilizing such shrubs as Caragana microphylla, Tamarix chinensis, Amorpha fruticosa, Salix mongolica, Hippophae rhamnoides, to mention a few. In the southern parts of these areas, black locust can be successfully grown.

The shrub species noted yield an estimated 7-15 MT of fuelwood per hectare per year. All species noted have excellent sprouting capability and high fuel value. Plantings of these shrubs result in fuelwood production in 3-4 years under the northwest climatic conditions and can be reharvested every 2 to 3 years. Some, such as Amorpha fruticosa and Salix mongolica, may be harvested once each year. The Xiaoyaogou production brigade of Lianchen County in Inner Mongolia has 100 ha of Hippophae rhamnoides shrub plantation, of which they harvest 25 ha per year, producing nearly 170 MT of fuelwood, which entirely meets their annual needs. In some areas of Shaanxi (Shensi) Province, Caragana microphylla is harvested for fuel, providing all the fuel needs of the local populations and in a few cases even producing a surplus of fuel for sale. In many cases, these shrubs also produce forage for livestock as well as helping in soil and water conservation.

8.6.4 Development of Fuelwood Energy

The need for fuelwood in rural China is about one m^3 per individual per year; however, the total fuelwood supply is estimated to be about 150 million m^3, of which 70 million m^3 come from the forests, and 80 million m^3 are rural fuelwood. Since there is currently only about .12 ha of forests per individual in China, and because these forests are unevenly distributed, there is a great need to increase fuelwood supplies. It is estimated that there is a demand for approximately 400 million MT of fuelwood per year, while the current supply of fuelwood is about 80 million MT (Shen 1981).

The target for the end of this decade is to produce 150 million MT. Of this, 60 million MT are to come from plantations, 16 million MT from productive forests, 15 million MT from natural shrublands, and 56.5 million MT from small woodlots and scattered trees. Current estimates indicate about 3.2 million ha of fuelwood forests; the goal is to plant an additional 10 million ha of fuelwood forests by 1970, bringing the total to 13.2 million ha.

The state and local planning authorities are also formulating policies to encourage increased fuelwood production. For instance, in addition to planting collective fuel forests, rural communes and brigades are being encouraged to plant private fuel forests or trees. In those regions which have barren hills and where additional fuelwood is still needed, each family is allocated a certain amount of barren land for planting fuelwood trees or shrubs. The fuelwood and fodder from these areas belong to the commune members for their own use. In other areas, the state may provide financial assistance to communes and brigades which undertake afforestation. This policy will stimulate planting of trees and shrubs which will assist in soil and water conservation and may provide fodder and fuelwood. In addition, opportunities may occur to expand the introduction of imported species and varieties with fuelwood potential in many parts of China. Experience now being rapidly obtained in many parts of the world with similar climatic conditions to those of various parts of China is being examined in regard to fuelwood production. The variety of plant and tree species adaptable to Chinese conditions is large. Much potential exists for substantially increased fuelwood production from native species, supplemented with imported varieties.

China is making great strides in meeting the rural energy needs by such activities as those mentioned above. Integrating efforts to increase fuelwood supplies with, on the one hand, forestry development and, on the other hand, the use of other energy sources--e.g., marsh gas, hydraulic electrogenerating from small power stations, coal from small mines in rural areas, solar energy, geothermal energy, and wind energy--will also help meet rural energy demands.

8.7 PLANTATION OF FAST-GROWING TREE SPECIES FOR TIMBER PRODUCTION

8.7.1 Planting

Tree planting is part of integrated land-use planning, on the same footing as agriculture and animal husbandry. The basic principle behind tree plantation in China is to organize the masses and encourage them to act in a spirit of self-reliance, that is, to collect seeds, raise the seedlings and do the planting themselves. China has had outstanding success in getting the masses to be tree conscious and to get them to participate not only in agroforestry, where they can see direct, early benefits to themselves (such as the "four around" program), but also to participate in establishing plantations of fast-growing trees for timber production. The principal aim of this type of plantation is to provide timber for industry, including coal mines and various uses in factories, housing and agriculture.

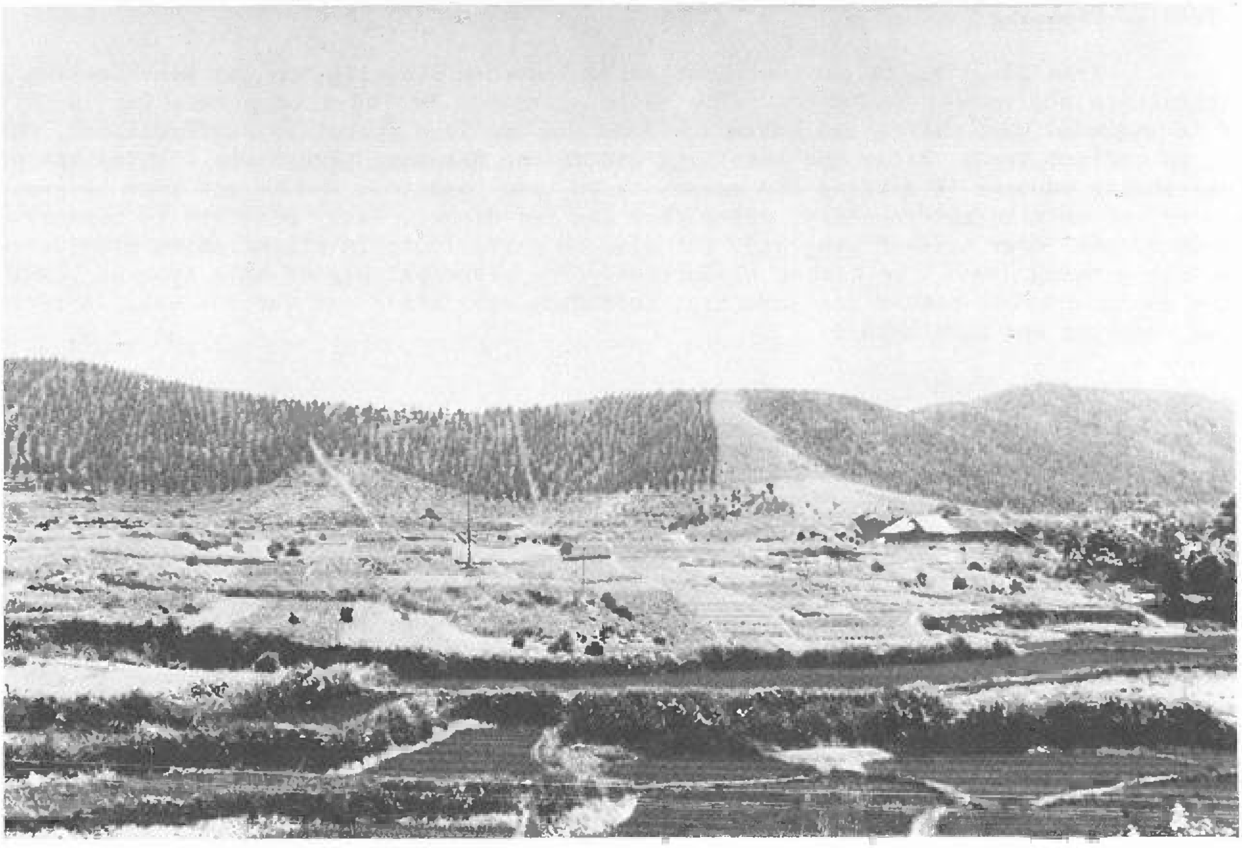
8.7.2 Species Used

In spite of the great number of species encountered, the most important quick-growing species used for timber production are: *Populus* spp. in North China; *Cunninghamia lanceolata*, *Paulownia* spp., *Sassafras* and *Pseudosassafras* spp. in Central and South China, and *Eucalyptus* spp. and *Casuarina* in South China, especially in Guangdong (Kwangtung) Province.

Poplars (*Populus*) are one of the main species used in plantations and shelterbelts in North China because they are faster growing. Some of the commonly used poplars (*Populus* spp.) and other associated broadleaved species are: *Populus simonii*, *P. pekinensis*, *P. pyramidalis*, *P. canadensis*, *P. nigra*, *Salix* spp., *Ulmus pumila*, *Amorpha fruticosa*, *Robina pseudoacacia*. A coniferous species often associated with poplars is *Pinus tabulaeformis*.

Cunninghamia lanceolata is one of the most prized species for reforestation in eastern China. In some areas, use of this species may constitute more than half the total areas replanted. *Paulownia fortunei* is one of the most commonly used species of *Paulownia* spp. used in central and southern China for windbreaks or in plantations in agricultural diversification with row spacing of 50 m to 70 m apart. In Henan (Honan) Province, plans called for areas totaling 1,380,000 ha to be planted to *Paulownia* spp. by 1980. *Paulownia* spp. is widely used as a cash crop in agricultural diversification. The timber is good for building and furniture manufacturing; the leaves are commonly used as an animal feed, and the bark and flowers are utilized in medicines.

Sassafras tsuma, *Pseudosassafras laxiflora* and *Pseudosassafras latifolia* are usually planted in higher elevations in Hubei (Hupeh) and Hunan provinces, although some are used at lower elevations. In spite of its good growth, *Sassafras* spp. is not commonly used in large-scale plantations except in Hunan Province, where blocks of several hundred hectares can be found. *Amorpha fruticosa* is frequently used in intercropping as a green manure. Thinning products are all utilized to meet the people's requirements for fuelwood and some other products.



8-9: Hillside afforestation in northeastern China.

Eucalyptus exerta and E. citriodora, including E. leichow no. 1, are the eucalypts most commonly grown in large-scale plantations in southern provinces, although more than 60 species have been tried. In Leichow Peninsula, for instance, the State Forestry Bureau has planted 52,000 ha to Eucalypts (Eucalyptus spp.) out of a total of 69,000 ha of land under its administration. The plan calls for 3 million m^3 of growing stock by 1986. Of this amount, 400,000 m^3 will be harvested every year, and of this 250,000 m^3 will be for timber. To meet this goal, the bureau is expanding current plantations to include additional barren lands.

Casuarina equisetifolia is one of the more common species planted in southern China as a cash crop species to be grown in harsh, windy conditions. It has been successful both in timber production and in support of agriculture. For instance, on Nanshan Island C. equisetifolia is planted on 4034 ha as a coastal windbreak 57 km long and varying in width from 1 to 5 km. This area is one-third of the total land area of the island.

8.8 TREE CROPS YIELDING IMMEDIATE CASH RETURNS

8.8.1 Fruit Trees

In China fruit trees such as Apple (Pyrus spp.), citrus (Citrus spp.), pear (Pyrus spp.) and Chinese date trees (Ziziphus jujuba) are used in forestry as well as in agriculture. For instance, the Paichuang Production Brigade, Henan (Honan) Province, removed 32 sand dunes and levelled 27 waterlogged areas between dunes, thus gaining 630 ha of cultivable land. As soon as the land was levelled, one-third of the area was planted with forest trees, one-third was cultivated with fruit trees and one-third was reserved for agricultural crops.

In Taoyuan County, Hunan Province, chestnut trees are envisaged as one of the several species to be planted in what is locally termed "industrial forestry," aiming at producing nonwood products of quick, perennial and high return. As another example, in Yu County, Henan (Honan) Province, plans have been made to plant 6300 ha with apple (Pyrus spp.) trees and another 6300 ha with walnuts (Juglans spp.).

Traditionally, the Chinese "date" is a special product used in medicine and as a cooking delicacy. The Chinese date tree (Ziziphus jujuba) is now widely planted on newly conquered sand dunes, and is seen throughout many provinces in central China. As an example, the Chachia Production Brigade, Yanling County, Henan (Honan), started planting Z. jujuba in 1964 on about 55 ha of new land levelled from sand dunes. A thirteen-year-old "date tree" measures 10 m in height and 10 cm in diameter. Z. jujuba is planted with a spacing of 10 m x 5 m, at a density of 200 plants per ha. The average yield in dried dates is about 240 kg/ha, usually sold to the state for processing and export. The production brigade received an income of about 150 yuan per ha from only 200 plants. In addition to the income from "date trees," agricultural intercropping of peanuts and/or maize may easily produce five or six MT of food, which is the norm established in Henan (Honan) Province. Income from Z. jujuba and connected forestry activities represents 25 percent of the total income, which includes return from foodcrops, pig-raising and sideline activities. The total area planted with Z. jujuba is not known with accuracy, but it can be estimated to be one-third of the cultivated area in Henan (Honan) Province.

Another fruit tree prized in Chinese forestry is Diospyros kaki. Dried D. kaki fruits are an export item. All over China, D. kaki is planted in the same way as Z. jujuba. The land between rows is intercropped with maize and other crops. This fruit tree plays in important role in the rural economy. D. kaki is also planted along roadsides and as shade trees in the city streets. D. kaki is also frequent, though not abundant, in natural forests. The fruit from natural forest trees is not large in size, but the trees are preserved to provide supplementary items in the diet of the local people.

8.8.2 Oil-bearing Trees and Shrubs

(i) General

Some of the more common oil-bearing trees and shrubs are Aleurites fordii, A. montana, Sapium sebiferum (Fam. Euphorbiaceae) and Thea oleosa (Fam. Theaceae). A. montana and A. fordii are commonly planted along roadsides, canals or dwellings for family needs, but small plantations of S. sebiferum can also be seen. A. fordii is sometimes interplanted with pine as a special intercrop for a period of eight to ten years, which is the life span of A. fordii. After ten years, A. fordii is cut. At the same age, pines would have their crown sufficiently developed to cover the soil against erosion. In rural zones, where electricity may not be available, tung oil is used for lighting.

(ii) Agroecology of Thea Oleosa

Thea oleosa is very adaptable and has been planted over thousands of hectares. It can be planted between 98°40' and 121°40'E longitude and 22°42' - 34°34 N latitude, where there is an annual average temperature of 15 to 22°C, annual average precipitation of 700 to 2400 mm and relative humidity of 70 to 85 percent. It grows best on hilly areas at 800 m above sea level, but prefers sunny sites with 4.5 to 5.5 pH and deep soil. However, it can thrive almost anywhere, provided the soil is deep and annual rainfall is above 700 mm.

Thea oleosa is a slow-growing small tree, but has a long life and excellent cropping capacity up to 200 years. Fruit-bearing starts at the age of eight and goes on as long as 80 to 100 years. The fruit contains 1 to 6 seeds, each of which contains about 30 percent edible oil. The oil, which can be stored ten years, represents 70 percent of total edible oil consumption in China. It can be used as a lubricant, is rust-resistant, and is also used in the treatment of skin diseases. The outer part of the seed can be used as tannin, or as active carbon; the remainder is used for fertilizer. Constant flowering is good for bee-keeping. The timber is solid and is largely used for agricultural tools.

Although Thea oleosa has been planted in China for more than 300 years, there were only about 10,000 ha of scattered plantations mixed with weeds and shrubs prior to 1949. The yield was only 20 to 30 kilograms (kg) of oil per ha. However, from 1949 to 1958, existing plantations were improved and consolidated. Soil preparation was carried out and the gaps were filled through regeneration. Through these operations alone the oil production was doubled. Then from 1958 to 1960, Thea oleosa cultivation received strong support from the government, and the area of Thea oleosa was substantially increased. Since 1970 Thea oleosa has been treated as a horticultural crop with all rational management practices including farming of consolidated plantations in large blocks, intercropping with agricultural crops, intensive cultivation consisting of one deep ploughing every three years and one shallow ploughing every year, siting of Thea oleosa plantations on terraces to preserve soil, water and fertilizer, fertilizing, pruning, pest and disease control and grafting for quality and yield increases.

(iii) Benefits of Thea oleosa

As a result of this intensive management, the oil output has been increased by as much as 100 to 120 kg per ha, as against an output of 20 to 30 kg per ha before 1949. In addition to oil, an average of 225 kg per ha of oil cake are obtained. The total oil and oil cake bring in an income of about 160 yuan/ha/year.

The importance of Thea oleosa in integrated land use management is listed as follows:

(1) As an economic cash crop, T. oleosa, once established, can grow and thrive for 100 years or more, assuring a sustained income.

(2) As a shrub which can survive in a wide range of climatic conditions, it has watershed management benefits.

(3) During establishment, T. oleosa can grow under a cover crop of forest trees, thus allowing progressive conversion of the stands without any uncovering of the soil.

(4) It contributes oil cake for the development of animal husbandry (pig raising) which in turn provides refuse (dung) for agricultural fertilizer.

(5) The fact that T. oleosa flowers during five months in winter (October to February) makes it a valuable forage for bee-keeping.

(6) Pruning and trimming, which are necessary cultural operations to develop maximum crown, and rejuvenation by coppice provide fuelwood or wood for handicrafts.

(iv) Thea oleosa Culture

Two varieties - There are two distinct varieties of T. oleosa: a small-fruit variety and a big-fruit variety. The small-fruit variety has small leaves and dense foliage, a very thin pericarp around the seed, 1 to 3 seeds in each capsule, maturing in early October, an oil content of 30 percent, and high resistance to disease. The big-fruit variety has bigger leaves; each fruit consists of 5 to 6 seeds, maturing at the end of October; oil content is 25 percent; this variety has medium resistance to pests and disease. Plantations of the big-fruit variety occupy 95 percent of the total T. oleosa plantation area, but because of cross-pollination and site differences, the oil content of individual trees shows great variation. For this reason, great emphasis has been put on selection of plots, fruit, seeds and, above all, plants.

Planting practices - Careful site selection, land preparation and close planting are the major rules to be followed. Being a light-loving species and deep rooted, T. oleosa requires red and yellow soils with pH of 4.5 to 5.5. Clean land cultivation at 30 to 40 cm depth with inversely sloped terraces is essential. On land with a slope of more than 15 percent, the width of terraces is 2 to 3 m, while on slopes less than 15 percent, terraces can be as wide as 4 to 5 m. The general practice is to plant the trees with a spacing of 3x3, 4x4 and 5x5-m distance, which gives between 500 and 900 trees per hectare.

Planting season - Nursery-grown and carefully selected seedlings are used in plantation for higher survival rate and fast growth as well as greater yield. January to March are the best months for planting. Direct sowing is also practiced.

Intercropping - Intercropping is used as a care and maintenance practice, to give the plantation a better structure, to provide better soil moisture, and at the same time reduce the planting cost by increasing income. During the last two years, 1000 ha of plantations have been intercropped, which have produced 3600 MT of food grains and other crops. In addition to soybean and sweet potatoes, a special grass has been grown, whose rhizomes contain additional edible oil. To increase and maintain the soil fertility, the dead leaves of these crops are mixed with manure, especially pig manure. Most forestry farms raise pigs to obtain the required manure. For its multiple use and high return, T. oleosa can be regarded as another "miracle tree" in Chinese forestry.

Pruning - Pruning of the lower branches is started 3 to 4 years after planting. At a height of 60 cm the tree is topped off, keeping three main branches. The following prunings aim at training the remaining branches to spread at an angle of about 60° and making them even and uniform. After three years, a second pruning is carried out with the same objectives and ultimately to form the tree into an umbrella shape with a hollow inner part, in order to expose it to proper sun and air penetration when it is at the optimum fruit-bearing stage. Dead, diseased, overgrown, lower and slanted branches are pruned.

Pests - Colletetsichum camelline, Caprodium theae, Eupractus pseudoconspersa and Chremonia adsitarsis are the major pests and diseases of T. oleosa.

8.8.3 Other Products from Trees

The Chinese people are well known for their skill in making use of everything. This skill has also been observed in finding many nonwood products of forest trees.

(i) Medicine and Cosmetics

Cinnamomum camphora once grew well in more or less pure stands in Hunan Province. These stands were decimated because of their timber, which is very prized in Chinese tradition as "coffin wood." For centuries, the Chinese have known how to extract camphor from young leaves, twigs and resin, for use in traditional medicine and cosmetics. C. camphora is now returning to Chinese forestry as a plantation species along roads and canals, but not yet as a full-scale plantation species. Currently, only small patches of C. camphora can be observed in full plantations.

(ii) Soap and Wine

Sapindus mukurosi is a fairly common but not abundant species in tropical and subtropical forest formations. It is an understory species in natural forests and is not prized for timber or fuelwood. However, S. mukurosi is one of the 149 species raised in the Changsha City Nursery, which produces some 3.8 million plants per year. Out of this number, S. mukurosi and Osmanthus fragrans represent 10 percent of the seedlings produced. S. mukurosi is known as a "soap fruit tree." In fact, the fruit provides a liquid detergent when it is macerated in water. Clothes soaked in this water can be washed as they are with soap. Osmanthus fragrans and Hovenia dulcis provide raw material for wine making. O. fragrans is utilized for its flowers and Hovenia dulcis for its berries. In natural forests, all the above trees are preserved.

(iii) Air Pollution Detection

Cedrus deodara, Pinus massoniana and Cunninghamia lanceolata may be planted individually or along roadsides for their role as indicators of air pollution by sulphur dioxide or chlorine. The Changsha city nursery has found that they are sensitive to the presence of sulphur dioxide and chlorine, whereas other species such as Pittosporum tobira, Magnolia grandiflora and Poncirus trifoliata are resistant to sulphur dioxide, and Ligustrum lucidum, Photinia serrulata and Nerium indicum are resistant to chlorine.

(iv) Non-Wood Production Research: Dianbai

An illustration of the Chinese skill in the diversification of non-wood production is given by the Soil and Water Experimentation Station in Dianbai County. The soil there is a compact, yellow, sandy soil subject to heavy erosion. Eucalyptus exserta and Casuarina equisetifolia, which perform very well elsewhere, do not grow well on this type of soil. Traces of gully erosion can be seen in several places. The climate is dry; rain occurs only with the typhoons. Eucalyptus and Casuarina show a very poor growth with a thin stem and a diameter of 4 to 5 cm after ten to twelve years of age.

After several years of research, Livistona chinensis was introduced on 1300 ha of land in this area. Livistona chinensis is a palm with fan-shaped leaves arranged in a rosette. Leaf exploitation begins after six years. A full hectare of L. chinensis can yield 60,000 leaves per year. L. chinensis is used as a fiber source in rope-making, mat-making, basket handicraft, etc. Income from leaves amounts to some 400 yuan/ha/year, which is very high. The life span of L. chinensis is about 100 years or more. L. chinensis is thus seen not only as a suitable species for covering the soil entirely for a long time, but also as a species which ensures a continuous and sustained income.

L. chinensis is interplanted with three other species: Piper nigrum, Litchi chinensis and Averrhoa carambola. In addition to interplanting, intercropping with cassava, soybean and peanuts is also practised during the first two years. Yield of Piper nigrum at year six is about 800 to 900 kg/ha, whereas the yield of Litchi chinensis can be 8.2 MT/ha and Averrhoa carambola (star fruit) 27 MT/ha. Other fruit trees have also been tried, such as jackfruit and mango. Mango yields only 1.4 MT per ha in a good year and jackfruit 5.4 MT. The most interesting combination seems to be Livistona chinensis and A. carambola. After six years of age, A. carambola will be dominant and a two-story stand is formed with Livistona chinensis as the understory. L. chinensis can grow under shade without diminishing its yield in leaves.

The Chinese seem to favor the combination of Livistona and Averrhoa, as this provides the highest income. A. carambola is a popular fruit, rich in juice and vitamins, which can be used as a preserve or in pastry.

8.9 INTERCROPPING (AGRO-SILVICULTURE)

Intercropping between rows of trees is extensively practiced in China. It is essentially a tending operation which promotes good growth of young trees and at the same time produces food and additional income. The soil between rows of trees is usually cultivated for the first two or three years after planting, whether the trees are planted in shelterbelts, along rivers or around villages. Depending on silvicultural requirements, soil conditions and needs of the people, intercrops planted may be watermelon, soybeans, peanuts, sweet potatoes, oil seeds, grains or green manure.

8.9.1 Benefit of Intercropping

The multiple land-use concept has found its application throughout China in the agro-silvicultural system. It not only enhances tree growth, but provides additional sources of food, fodder and green manure. It also eliminates the problem of weeding between rows of trees and the build-up of fire hazards. Since initiation of the agro-silviculture system, the Chinese report no incidents of fires in these plantations.

Crop output per ha may be 6 to 7 MT of sweet potatoes, maize or peanuts, if ideal conditions are met. It may be only one or two MT on average soil combined with medium skill in management. In Zhuzhou County (Hunan), intercropping in Thea oleosa plantations gave 3.6 MT of food/ha. Of course, the amount of food crops per hectare of intercropping varies depending on soil quality, cultivation intensity and availability of irrigation, but considering the above mentioned yields and the millions of acres on which this practice is carried out, the contribution to the total food needs of China is great indeed.

8.9.2 Examples of Intercropping

(i) Associations with Paulownia spp.

In Henan (Honan) Province, Paulownia is intercropped with cereal grains such as wheat, as well as tobacco, colza (rape seed), beans and soja. Intercropping is begun at the time of plantation establishment and also in old plantations where the trees are properly spaced. In new plantations, the one-year-old saplings may be spaced at 5 by 5 m with crops planted in between, or the trees more closely spaced in rows with several meters between rows. The crown of Paulownia spp. is less dense than that of some species of trees used in intercropping and, therefore, can allow cropping for a longer period of years.

Crop yields from intercropped Paulownia spp. plantations were reported as from 1500 kg/ha to 2000 kg/ha for wheat, from 1500 kg/ha to 1800 kg/ha for colza (rape seed), from 900 kg/ha to 1200 kg/ha for beans, and from 900 kg/ha to 1200 kg/ha for soja.

In addition to improving soil and climatic factors, Paulownia spp. yields green leaves (which contain about 3.3% nitrogen in dry matter) for fodder or green manure. Paulownia spp. was reported to produce 12 m^3/ha/year of wood. It can be harvested at 12 to 15 years. The wood produced may be used as fuelwood for the collectives or sold for forest products. Wood is sold at the price of 140 to 200 yuan/m^3 to the state and at as much as 300 yuan/m^3 on the free market. Wood sold to the state provides the cash income to allow the collectives to purchase tractors, trucks, fertilizer or other necessary items for further development. Income from such sales may compose 20 percent to more than 50 percent of the total collective income.

(ii) Association with Cunninghamia spp.

Intercropping of 76 ha of new Cunninghamia spp. plantations in the Xianning State Forestry Farm produced 82 MT of grains, or 1.1 MT/ha. In another farm, a 335-ha Cunninghamia spp. plantation intercropped with grains and oil seeds provided an income of about 20,000 yuan.

In another intercropped Cunninghamia spp. plantation of 413 ha in one production brigade in Echeng County (Hunan Province), total intercrop production was 2450 MT of grains, watermelon and vegetables, providing 50 percent of the production brigade's total income. Output per ha was 5.9 MT. Not only did intercropping provide a substantial income, but the survival rate of Cunninghamia spp. was reported to be 5 percent higher than that of non-intercropped plantations and plant height was one-third higher.

(iii) Association with Pinus elliottii

In a forest farm in Zinzhou in Hubei (Hupei) Province, plantations of Pinus elliottii were grown with wheat and colza for five years until the crown cover completely closed. Annual height growth of Pinus elliottii in adjacent non-intercropped areas was only 0.4 m with diameter growth being 0.61 cm, while trees in the intercropped area had a height growth of 0.65 m and a diameter growth of 1.17 cm. The revenues from the grain was sufficient to cover the cost of the plantation as well as the cost of maintenance.

(iv) Associations with fruit trees

In Chao An Commune in Guangdong (Kwangtung) Province, citrus (Citrus spp.) trees are grown in combination with groundnut, rice and wheat. The citrus (Citrus spp.) plants grow in one-meter-wide raised beds. On these beds, between two citrus (Citrus spp.) plants, 3 rows of groundnut are sown at a spacing of 20 x 50 cm on the one-meter-wide bed, utilizing the 2.5-m space between the citrus (Citrus spp.) plants. On both sides of the 1-m citrus (Citrus spp.) and groundnut beds are 1.5-m furrows. In these furrows the rice/rice/wheat sequence (3 crops during the year) cropping system is followed. Each year the citrus (Citrus spp.) beds are widened and raised with earth obtained from deepening the furrows. The furrows are deepened and narrowed. Thus, rice or wheat and groundnut occupies 80 percent of the land in the first year, 60 percent in the second year, and 30 percent in the third year.

8-10: A common sight in China - deciduous broadleaf trees interplanted in a wheat field.

(v) Intercropping and Integrated Land Use

In Taoyuan County, Hunan Province, integrated land-use planning was implemented as part of an extensive, successful erosion control project. This project included the building of a network of water reservoirs integrated into a comprehensive irrigation system, to bring water to lands at different elevations, and the reafforestation of 52,000 ha of watersheds. In this county, grain output per ha is very high, and three crops a year are grown: two crops of rice from May to September plus one crop of wheat from October to the beginning of May. The rain output is now more than 22.5 MT/ha. Here, intercropping aims at producing more green manure than food. A yield of 18 MT/ha of green manure is common. This green manure will be used for both feeding pigs and fertilizing the soil. Refuse from pigs will fertilize crops and fish ponds. Taoyuan is known for its integrated activities in agriculture, forestry and animal husbandry, which all support each other.

Since intercropping has been practiced here, no forest fires have been recorded; complete weeding through intercropping has been achieved. There has been no build-up of fire hazards. On the contrary, the soil has become more friable and capable of retaining more moisture and thus of ensuring a better growth and a higher tree survival rate.

8.10 CONCLUSIONS

To sum up the relationship between forestry and agriculture in one word is easy--integrated. By far the major work of forest management is associated with agriculture. Most plantations are established by farmers. Tree nurseries, while not consistently producing extremely high quality stock, are owned and run by agricultural communes.

China is probably the world leader in this type of forestry, pioneering methods and establishing systems that can serve as examples to the world. Sand dune stabilization is integrated into agriculture, not set apart as a problem for the conservationist or watershed manager. The use of shelterbelts to protect and increase farm production is well advanced in China. Many more examples are readily visible.

Much of the success of China in these endeavors must be attributed to the fact that the Chinese have identified the need to integrate forestry into agriculture and have made and enforced real commitments to the goal of agro-forestry.

Appendix 1

English names of selected tree species found in China (FAO) 1978).

Acacia confusa	Acacia
Acer davidii	David's Maple
Acer mono	Mono Maple
Acer negundo	Ash-leaved Maple; Box Elder
Ailanthus altissima	Tree of Heaven; Ailanthus
Aleurites fordii	Tung-oil Tree
Aleurites moluccana	Candle-nut Tree
Aleurites montana	Chinese Wood-oil Tree
Alstonia scholaris	Scholar Tree; Devil's Tree
Amorpha fruticosa	Bastard Indigo
Artocarpus heterophylla	Jackfruit
Arundinaria spp.	Bamboo; Cane
Averrhoa carambola	Carambola; Star Fruit
Biota orientalis (syn. Thuja orientalis)	Chinese Arbor-Vitae
Bischofia javanica	Java Bishopwood; Red Cedar
Bombax malabaricum	Silk-Cotton Tree
Camptotheca acuminata	Camptotheca (anti-cancer tree)
Canarium album	Chinese White Olive; White Almond
Castanea henryi	Henry's Chestnut; Henry Chinkapin
Castanea mollissima	Chinese Chestnut
Castanea seguinii	Seguin Chestnut
Casuarina equisetifolia	Horsetail Casuarina or Beefwood; She-Oak; Australian Pine
Cedrela sinensis (syn. Toona sinensis)	Chinese Mahogany; Toona Cedar
Cedrus deodara	Deodar Cedar
Chukrasia tabularis	Indian Red Wood
Cinnamomum camphora	Camphor Tree
Citrus spp.	Citrus Fruits
Crataegus pinnatifida	Chinese Hawthorn
Cryptomeria japonica	Japanese Cedar; Cryptomeria
Cunninghamia lanceolata	Chinese Fir; China Fir
Cupressus funebris	Chinese Weeping Cypress; Mourning Cypress
Dendrocalamus spp.	Giant Bamboos
Diospyros kaki	Chinese Persimmon; 'Kaki' Persimmon
Elaeagnus angustifolia	Oleaster; Russian-olive
Eucalyptus citriodora	Lemon-scented Gum
Eucalyptus exserta	Bendo Gum
Eucalyptus grandis	Rose Gum
Eucalyptus Leichow No. 1 *	Eucalyptus Leichow No. 1
Eucalyptus saligna	Saligna Gum; Sydney Blue Gum
Eucalyptus tereticornis	Forest Red Gum
Ficus lancor	Spotted Fig
Ficus retusa (syn. F. microcarpa)	Chinese Banyan; Malay Banyan
Fraxinus chinensis	Chinese Ash
Fraxinus mandshurica	Manchurian Ash
Gingko biloba	Maidenhair Tree; Gingko
Glyptostrobus pensilis	Chinese Swamp Cypress; Chinese Water-Pine
Haloxylon ammodendron	Common Dulse; Dulse
Hovenia dulcis	Japanese Raisin Tree
Juglans mandshurica	Manchurian Walnut

* a race of E. citriodora

Juglans regia	Common Walnut
Keteleeria davidiana	David Keteleeria
Larix dahurica	Dahurian Larch
Larix koreana	Korean Larch
Larix principis rupprechtii	Prince Rupprecht's Larch
Larix sibirica	Siberian Larch
Ligustrum lucidum	Glossy Privet
Liquidambar formosana	Sweet Gum; Formosan Gum
Litchi chinensis	Litchi
Livistona chinensis	Chinese Fan Palm
Magnolia grandiflora	Laurel Magnolia; Bull Bay
Mangifera indica	Mango
Melaleuca leucadendron	Punk Tree; Cajeput-oil Tree; River Tea Tree; Paper-bark Tree
Melia azedarach	Persian Lilac; Chinaberry
Metasequoia glyptostroboides	Dawn Redwood
Michelia alba	White Jade Orchid Tree; White Michelia
Morus alba	White Mulberry
Nerium indicum	Indian Oleander
Osmanthus fragrans	Fragrant-Olive; Kwai-Fah
Paulownia fortunei	Fortune's Paulownia or Fox-glove Tree
Paulownia lankanensis	(Variety of Paulownia or Fox-glove Tree)
Photinia serrulata	Chinese Photinia
Phyllostachys spp.	Bamboo
Pinus armandii	Armand's Pine
Pinus elliottii	Slash Pine
Pinus massoniana	Masson's Pine
Pinus sylvestris	Scots Pine
Pinus tabulaeformis	Chinese Pine
Pinus taeda	Loblolly Pine
Pinus yunnanensis	Yunnan Pine
Piper nigrum	Black Pepper
Pittosporum tobira	Japanese Pittosporum
Platanus acerifolia	London or European Plane
Platanus orientalis	Oriental Plane
Podocarpus macrophylla	Japanese Yew; Kusamaki; Buddhist Pine
Poncirus trifoliata	Bitter or Trifoliate Orange
Populus canadensis	Hybrid Black Poplar; Carolina Poplar
Populus chifungensis	Chifung Poplar
Populus dakuanensis	Dakuan Poplar
Populus nigra	Black Poplar
Populus pyramidalis (syn. P. italica)	Lombardy Poplar
Populus simonii	Simon's Poplar
Populus tomentosa (syn. P. pekinensis)	Chinese White Poplar
Populus yunnanensis	Yunnan Poplar
Prunus spp.	Stone-fruits (Plums, Cherries, Peaches)
Pterocarya stenoptera	Chinese Wing-nut
Pyrus spp.	Pome-fruits, including Pears
Quercus acutissima	Sawtooth Oak
Quercus mongolica	Mongolian Oak
Quercus variabilis	Oriental Oak
Robinia pseudoacacia	Black Locust
Salix spp.	Willows
Sapindus mukurosi (or mukurossi)	Chinese Soapberry
Sapium sebiferum	Chinese Tallow Tree
Sassafras spp.	Sassafras

Schima confertiflora*	Gugertree
Sophora japonica	Pagoda Tree
Tamarix chinensis	Chinese Tamarisk
Tamarix pentandra	Tamarisk
Taxodium ascendens	Pond Cyprus
Taxodium distichum	Bald Cyprus
Thea oleosa (syn. Camellia oleifera)	Tea-oil
Thea sinensis (syn. Camellia sinensis)	Tea
Tilia mandshurica	Manchurian Linden
Ulmus laciniata	Manchurian Elm
Ulmus pumila	Dwarf or Siberian Elm
Ziziphus jujuba	Jujube Tree; Chinese Date
Ziziphus spinosa	Thorny Jujube (wild)

Note: English names of tree species vary in many cases from one country to another. In the above list an attempt has been made to select comprehensive or definitive list.

Appendix 2

LIST OF SELECTED TREE SPECIES FOUND IN CHINA WITH

INDICATION OF MAJOR DISTRIBUTION PATTERN AND USES (FAO 1978)

Species	Distribution Areas			Major Uses in Planting						
	North	Central	South	Timber Forestry	Fuelwood	"Four Around" Forestry	Shelterbelts, windbreaks	Urban Forestry	Industrial Forestry	Coastal Afforestation
Acacia confusa			x		x	x		x		
Acer davidii		x		x				x		
Acer mono		x						x		
Acer negundo	x	x						x		
Ailanthus altissima	x	x	x	x						x
Aleurites fordii		x	x		x	x			x	
Aleurites moluccana			x					x		
Aleurites montana		x	x		x	x			x	
Alstonia scholaris			x					x		
Amorpha fruticosa	x	x	x		x				x	
Artocarpus heterophylla			x					x	x	
Arundinaria spp.		x	x			x	x		x	
Averrhoa carambola			x			x			x	x
Biota orientalis		x		x				x		
Bischofia javanica		x		x						
Bombax malabaricum			x					x		
Camptotheca acuminata		x		x	x	x		x		
Canarium album			x						x	
Castanea henryi		x	x	x					x	
Castanea mollissima		x	x						x	
Castanea seguinii		x	x						x	
Casuarina equisetifolia			x	x	x	x	x	x		x
Cedrela sinensis	x	x				x		x		
Cedrus deodara	x	x		x				x		
Chukrasia tabularis			x	x	x					
Cinnamomum camphora		x	x	x				x	x	
Citrus spp.	x	x	x						x	
Crataegus pinnatifida		x								x
Cryptomeria japonica		x		x				x		
Cunninghamia lanceolata	x	x		x						
Cupressus funebris		x		x				x		
Dendrocalamus spp.		x	x	x					x	
Diospyros kaki		x	x			x		x	x	
Elaeagnus angustifolia	x									x
Eucalyptus citriodora			x	x	x		x		x	x
Eucalyptus exserta			x	x	x		x		x	x
Eucalyptus globulus			x	x	x		x		x	
Eucalyptus grandis			x	x	x	x	x			
Eucalyptus leichow No. 1			x	x	x		x		x	x
Eucalyptus saligna			x	x	x	x	x			
Eucalyptus tereticornis			x	x	x	x	x			
Ficus lancor			x					x		
Ficus retusa			x					x		

Species	Distribution Areas			Major Uses in Planting						
	North	Cen-tral	South	Timber Fores-try	Fuel-wood	"Four Around" Fores-try	Shelter-belts, wind-breaks	Urban Fores-try	Indus-trial Fores-try	Coastal Affores-tation
Fraxinus chinensis	x			x	x					
Fraxinus mandshurica	x		x							
Gingko biloba		x	x					x	x	
Glyptostrobus pensilis		x	x	x						
Haloxylon ammodendron	x						x			
Hovenia dulcis	x	x							x	
Juglans mandshurica	x	x		x					x	
Juglans regia	x	x				x		x	x	
Keteleeria davidiana		x	x	x				x		
Larix dahurica	x			x				x		
Larix koreana	x			x				x		
Larix principis ruppr.		x		x				x		
Larix sibirica		x		x				x		
Ligustrum lucidum		x		x	x					
Liquidambar formosana		x	x				x	x		
Litchi chinensis		x	x						x	
Livistona chinensis			x					x	x	
Magnolia grandiflora		x	x					x		
Mangifera indica			x			x			x	
Melaleuca leucadendron			x	x	x			x		x
Melia azedarach		x	x	x	x		x			x
Metasequoia glypto-strobo ides	x			x						
Michelia alba			x	x			x	x		
Morus alba		x	x			x			x	
Nerium indicum		x						x		
Osmanthus fragrans		x	x					x	x	
Paulownia fortunei	x	x		x		x	x	x		
Paulownia lankanensis	x	x		x		x	x	x		
Photinia serrulata		x						x		
Phyllostachys spp.		x		x		x			x	
Pinus armandii			x	x						
Pinus elliottii		x	x	x						
Pinus massoniana	x	x	x	x	x					
Pinus sylvestris		x		x				x		
Pinus tabulaeformis		x		x	x					
Pinus taeda	x	x	x	x	x					
Pinus yunnanensis			x	x						
Piper nigrum			x						x	
Pittosporum tobira		x						x		
Platanus acerifolia		x		x				x		
Platanus orientalis		x		x				x		
Podocarpus macrophylla		x	x	x				x		
Poncirus trifoliata		x						x		
Populus canadensis	x	x		x		x	x			
Populus chifungensis	x	x		x		x	x			
Populus dakuanensis	x	x		x		x	x			
Populus nigra	x	x		x		x	x			

Species	Distribution Areas			Major Uses in Planting						
	North	Cen-tral	South	Timber Fores-try	Fuel-wood	"Four Around" Fores-try	Shelter-belts, wind-breaks	Urban Fores-try	Indus-trial Fores-try	Coastal Affores-tation
Populus pyramidalis	x	x		x		x	x			
Populus simonii	x			x		x	x			
Populus tomentosa	x			x		x	x			
Populus yunnanensis			x	x		x	x			
Prunus spp.	x	x				x		x	x	
Pterocarya stenoptera		x	x	x	x	x		x		
Pyrus spp.	x	x				x		x	x	
Quercus acutissima		x	x	x						
Quercus mongolica	x			x						
Quercus variabilis	x			x						
Robinia pseudoacacia	x	x	x	x	x	x	x			
Salix spp.	x	x	x			x	x	x		
Sapindus mukurosi		x	x			x			x	
Sapium sebiferum		x	x						x	
Sassafras spp.	x	x		x	x	x		x		
Schima confertiflora			x			x				
Sophora japonica		x	x			x	x	x		
Tamarix chinensis	x				x					x
Tamarix pentandra	x				x					x
Taxodium ascendens		x	x	x				x		
Taxodium distichum		x	x	x				x		
Thea oleosa		x	x				x		x	
Thea sinensis		x	x						x	
Tilia mandshurica		x		x		x		x		
Ulmus laciniata	x	x		x			x	x		
Ulmus pumila	x	x		x			x	x		
Ziziphus jujuba		x							x	
Ziziphus spinosa		x	x						x	

Appendix 3

List of selected woody plants found in China (supplements FAO 1978 (Appendix 1)).

Abies delavayi
Abies fabri
Abies georgei
Abies holophylla
Abies faxoniana
Abies nephrolepis
Abies sachalinensis
Abies sibirica
Abies spectabilis
Abie squamata
Acacia auricumiformis
Acacia catechu
Acacia confusa
Acacia mearnsii
Acer mandshuricum
Acer pseudosieboldianum
Acer truncatum
Acanthus spp.
Aegiceras spp.
Agave sisal
Aglaia sp.
Albizzia falcata
Albizzia kalkora
Alnus altissima
Alnus nepalensis
Altingia sp.
Anacardium occidentalis
Anneslea fragrans
Anthocephalus chinensis
Aphanamixis
Artocarpus spp.
Avicennia spp.
Areca catechu
Betula costalei
Betula dahurica
Betula pendula
Betula platyphylla
Bruguiera gymnorrhiza
Bucklandia spp.
Burretiodendron hsienum
Calophyllum inophyllum
Camellia oleifera
Camellia oleosa
Camellia sinensis
Caragana jubata
Carpinus cordata
Carya illinoensis
Castanea dandoensis
Cassia siamea
Castanopsis carlesii
Castanopsis delavayi
Castanopsis fargesii
Castanopsis ferox
Castanopsis fissa
Castanopsis fordii
Castanopsis hystrix
Castanopsis indica
Castanopsis kawakamii
Castanopsis orocantha
Castanopsis sclerophylla
Castanopsis tribuloides
Casuarina cunninghamia
Casuarina equisetifolia
Casuarina glauca
Catalpa bungei
Catalpa duclouxii
Catalpa fargesii
Cathaya spp.
Cedrela sureni
Celtis koraiensis
Ceriops tagal
Chukrasia sp.
Cinnamomum camphora
Cinnamomum cassia
Cinnamomum japonica
Cleidrocarpon cavalerei
Cordia subcordata
Cornus walteri
Corylus heterophylla
Corylus mandshurica
Cryptomeria fortunei
Cuppressus duclouxiana
Cyclobolanopsis
Dacrydium
Dalbergia balansae
Dalbergia hupeana
Dalbergia obtusifolia
Dalbergia odorifera
Dalbergia szemaoensis
Dipterocarpus alatus
Dipterocarpus pilosus
Dipterocarpus tonkinensis
Dipterocarpus turbinatus
Dysoxylum
Elaeagnus molhs
Elaeis guineensis
Entrolobium comfortsiliqum
Erythrophloeum fordii
Eucalyptus camaldulensis
Eucalyptus globulus
Eucalyptus maidenii
Eucalyptus robustus
Eucalyptus viminalis
Eucommia ulmoides
Excoecaria
Fagus spp.

Appendix 3 (continued).

Ficus spp.
Fokienia hodginsii
Fraxinus americana
Fraxinus sogdiana
Fraxinus velutina
Gleditsia sinensis
Gmelina hainanensis
Grevillea robusta
Guettarda speciosa
Haloxylon persicuux
Hartia spp.
Heritiera sp.
Hevea brasilensis
Homalium hainanensis
Hopea chinensis
Hopea hainensis
Hopea mollisima
Illicium vernum
Juglans ormosia
Juglans silillato
Juniperus chinensis
Juniperus rigida
Kendelia candel
Keteleeria evelyniana
Khaya senegalensis
Larix chinensis
Larix gmelini
Larix griffithiana
Larix gugensii
Larix himalaica
Larix leptolepis
Larix olgensis
Larix potaninii
Larix speciosa
Lindera spp.
Liriodendron chinense
Listera chinensis
Lithocarpus glabra
Lithocarpus henryi
Lithocarpus microspermus
Lycium barbarum
Maackia amurensis
Machilus breisflora
Machilus panhoi
Machilus phoebe
Machilus thunbergii
Machilus yunnanensis
Magnolia officinalis
Mangifera persiciforma
Manglietia fordiana
Manglietia spp.
Melia toosenda
Messerschmidia agentia
Mesua ferrea
Michelia macclurei
Mytilaria laosensis
Ochroma lagopus
Olea europaea
Ormosia hosiei
Ostrya sp.
Parashorea chinensis
Paulownia catalpifolia
Paulownia elongata
Paulownia fargesii
Paulownia glabrata
Paulownia kawakami
Paulownia tomentosa
Phellodendron amurense
Phoebe bournei
Phoebe nanmu
Phoebe sheareri
Picea asperata
Picea crassifolia
Picea jezoensis
Picea koraiensis
Picea likiangensis
Picea meyeri
Picea obovata
Picea purpurea
Picea schrenkiana
Picea wilsonii
Pinus bungeana
Pinus caribaea
Pinus densiflora
Pinus fenzeliana
Pinus khasiana
Pinus koraiensis
Pinus sibirica
Pinus taiwanensis
Pinus thunbergii
Pinus tonkinensis
Pisonia grandis
Pistacia chinensis
Pistacia vera
Platycarya strobilacea
Podocarpus nagi
Populus adenopa
Populus alba
Populus boleana
Populus canescens
Populus cathayana
Populus davidiana
Populus euramericana
Populus euphratica
Populus koreana
Populus laurifolia
Populus pekinensis
Populus pruinosa
Populus pseudosimonii
Populus purdomii
Populus suaveolensis
Populus tremula
Populus tremuloides
Populus ussuriensis
Prunus amygdalus
Pseudolarix amabilis
Pseudosasa amabilis
Pseudosassafras latifolia

Appendix 3 (continued).

Pseudosassafras laxiflora
Pterocarya stenophylla
Pterospermum spp.
Quercus aliena
Quercus baronii
Quercus delavayi
Quercus dentata
Quercus fabri
Quercus glandulifera
Quercus glauca
Quercus glaucoides
Quercus gracilis
Quercus liaotungensis
Quercus myrsinaefolia
Quercus nubium
Rhizophora spp.
Rhizophora apiculata
Rhizophora mucronata
Rhizophora stylosa
Rhododendron spp.
Rhododendron capitatum
Rhododendron litangensis
Rhododendron open-shawianum
Rhododendron thymifolium
Rhus chinensis
Rhus verniciflua
Robinia pseudocacia
Sassafras tsumu
Schima noronhae
Schima superba
Schima wallichii
Shorea assamica
Shorea robusta
Sibiraea angustata
Sterculia spp.
Swietenia macrophylla
Syringa sp.
Syzygium cumini
Taiwania sp.
Taxodium ascendens
Taxodium distichum
Taxodium mucronatum
Taxus cuspidata
Tectona grandis
Terminalia hainanensis
Thuja spp.
Thuja orientalis
Tilia mongolica
Toona sinensis
Torreya grandis
Trachycarpus fortunei
Tsuga chinensis
Tsuga dumosa
Ulmus spp.
Ulmus laevis
Ulmus macrocarpa
Ulmus propinqua
Vatica astroicha
Vatica hainanensis
Xanthoceras sorbifolia
Yushania niitakayanensis
Zanthophylum bungeanum
Zelkova schneideriana

Appendix 4

The Forestry Act of the People's Republic of China

(Adopted in principle by the sixth session of the Standing Committee of the Fifth National People's Congress on 23 February 1979)

Chapter One: General Rules

Article 1. Being important resources of the country, forests can provide the timber and various forestry products needed for the economic construction of the State and the livelihood of the people; can adjust climate, contain and reserve water resources, conserve soil and water, offer protection from wind and stop drifting sand and guarantee the development of agriculture and animal husbandry; and can prevent and control air pollution, protect and beautify the environment and promote the people's health in body and mind. This Forestry Act is hereby formulated for the specific purposes of speeding afforestation, strengthening forest protection and forestry management, and rationally exploiting and utilizing forest resources.

Article 2. Forest resources include trees, bamboo and wooded lands as well as all plants and animals within the boundaries of forestry areas. Forests are classified into the following five categories, in accordance with their different uses: (1) Protection forests: Forests that mainly serve the purpose of protection. These include water and soil conservation forests, water resources containment forests, forests that offer protection from wind and stop drifting, sand, farmland and pasture protection forests, river bank protection forests, road protection forests and national defence forests. (2) Timber forests: Forests that are used mainly for the purpose of producing timber and bamboo. (3) Economic forests: Trees that are used mainly for the purpose of producing fruit, edible oil, industrial raw material and materials for medicine. (4) Firewood and charcoal forests: Tall trees and shrubs that are mainly used for the purpose of producing fuels. (5) Forests with special uses: Forests and trees that are used mainly for environmental protection, scientific experiments and other special purposes. These include experimental forests, parent plant forests, environmental protection forests, landscape forests, trees at scenic spots, historical sites and sacred places of the revolution, and forests within natural resource protection areas.

Article 3. In accordance with the stipulations in the Constitution on the system of ownership of the means of production for the present period, forests shall come under the socialist ownership of the whole people and the socialist collective ownership of the labouring masses. Trees planted by people's commune members around their houses or in places designated by the production teams shall be owned by the individual commune members. Trees planted by offices, organizations, PLA units, schools, factories, mines, agricultural and pastoral farms and other units in the places designated by the local revolutionary committee shall be owned by the respective units. Ownership of trees by the State, the collective or the individual shall be protected from encroachment. State-owned forests cannot be transferred to a collective or non-forestry units; collective-owned forests cannot be transferred to an individual; and trees that belong to a commune, a production brigade or a commune member cannot be commandeered.

Article 4. Counties, communes and production brigades in a forestry area shall practise the principle of taking forestry as the key link and ensuring all-round development. Designation of a forestry area county and of a forestry area commune or brigade shall be determined by the revolutionary committee of the province, autonomous region or directly administered municipality concerned.

Article 5. In forestry building, the principle of taking administration as the foundation, building and managing forests simultaneously, more building than felling, combining exploitation and culturing, and multi-purpose use shall be practised.

Article 6. The fundamental tasks of forestry building shall be: Vigorously carry out tree planting and afforestation constantly to expand forest areas and the amount of trees in reserve; strengthen forest protection, uphold the principle of rational exploitation and felling, and prepare for reproduction in good time; speed up the development and building of forestry areas, improve forest management, increase the production potential of forests, and rationally use forest resources; and strengthen forestry science and education, train forestry technicians, enhance scientific research and speedily modernize forestry production.

Article 7. It is the glorious obligation and right of the people of the whole country to plant trees, carry out afforestation and take care of and protect forests. All localities shall organize the masses to plant trees and carry out afforestation on tree-planting day each year and other such times as appropriate for tree planting in each respective area. Revolutionary committees at all levels shall constantly carry out propaganda and education in the need to love and protect forests and arouse the masses to protect forests and trees.

Chapter Two: Forestry Management

Article 8. The Ministry of Forestry, established under the State Council, is responsible for the country's forestry operation. To oversee local forestry development, forestry management organizations shall be established under the revolutionary committees of the provinces, autonomous regions, municipalities directly under the central government, autonomous prefectures, counties, autonomous counties, and municipalities. Specific companies or corporations for enterprise management may be established with regard to forest seeding, survey, planning, capital construction, timber production and processing, forest industrial production, supplies, and manufacturing, maintenance and repairs of machinery and equipment.

Article 9. The state procuratorial organs will assign one to three forestry inspectors to each country's forestry department in forested areas, state forestry bureaux and state forests. These inspectors, whose functions and duties shall be defined uniformly by the state procuratorial organs, will not give up their production jobs and are responsible for inspecting the implementation of state forestry policy and decrees. The revolutionary committees of the provinces and autonomous regions will set up public security bureaux and police stations in major forested areas and establish a forestry police to strengthen security and protect the forests according to actual needs.

Article 10. Revolutionary committees at all levels will strengthen forestry management. The state forestry bureaux and state timberyards manage state forests. Government organs, civic bodies, PLA units, schools, factories, mines, farms and ranches manage the forests they develop. Collective forests will be managed by timberyards and professional teams from communes and production brigades or by personnel assigned by communes and production brigades.

Article 11. The state forestry bureaux and state timberyards are managed at different levels. State forestry bureaux in major forested areas are under the leadership of the Ministry of Forestry or the forestry departments of the provinces or autonomous regions where these bureaux are located. Large state forests are under the leadership of forestry departments in provinces, autonomous regions or in the municipalities directly under the central government. All state forestry bureaux and state forests shall be managed as enterprises. State forests whose primary business is afforestation will be examined as are enterprises under construction. A review of investment results shall cover the entire production period prior to the start of logging. The period will include the time for the cutting, seeding, planting, caring and protecting processes.

Article 12. Forestry departments in provinces and autonomous regions may establish forest companies in areas with relatively dense forests owned by collectives and, in order to give guidance to communes and production brigades on how to develop forestry production, may adopt such economic measures as signing contracts with the local communes and production brigades.

Article 13. The State and the revolutionary committees at all levels will draw up long-range plans for the development of forestry. Forestry departments at various levels shall conduct periodic surveys of forest resources, as stipulated by the State, so as to collect the most up-to-date information on the forests. The state forestry bureaux and state timberyards shall formulate forestry management programmes in accordance with the long-range plans for the development of forestry and shall forward their programmes to their superior departments for approval before putting them into effect. The forestry departments advise communes, production brigades, government organs, civic bodies, PLA units, schools, factories, mines, farms and ranches on matters pertaining to forestry development planning.

Article 14. Engineering units whose construction or mining projects call for use of forest land or felling of trees in forest areas shall seek prior consultation with the appropriate forestry management office and submit a report to the revolutionary committee of the concerned province, autonomous region or municipality directly under the central government for prior approval. Use of 1000 mu of forest land or more must be approved by the Ministry of Forestry and the trees felled shall be turned over to forestry management units for disposal. Compensation shall be made by the construction units for the land thus used and or trees felled.

Article 15. To improve forestry management and expedite road construction in forested areas, investments in road construction in state-owned forest areas will have priority over other capital construction projects in these areas. Road construction in forested areas owned by collectives will be financed by the local people or by the local people and the government jointly.

Article 16. To take into account the characteristically long production cycle for forestry production and to compensate for lost forest resources resulting from past excessive cutting over a long period, a fixed forest culture fee shall be levied on the selling prices for timber, bamboo and other forestry products, and forest culture funding system shall be established. Forest culture funds shall be used mainly for the purpose of preparing deforested land for reproduction and may also be used to build new forests. The funds shall be used under the supervision of the Ministry of Finance and the banks. There shall be two separate funds, for the culture of state forests and for collective forests. The state forest culture fund shall be managed by the forestry departments of provinces, autonomous regions and directly-administered municipalities. The Ministry of Forestry shall have the power to adjust the use of this fund. Regulations on the management of the culture fund for collective forests shall be determined by the revolutionary committees of the respective provinces, autonomous regions and directly-administered municipalities. Coal industry and paper manufacturing industry departments may set aside from their funds certain amounts of forest culture fees on the basis of coal and paper output to use to build forests providing timber for mine shaft props and the raw materials for manufacturing paper. Specific regulations for levying forest culture funds shall be formulated by the Ministries of Forestry and Finance.

Chapter Three: Forest Protection

Article 17. Organs in charge of forest protection shall be established by the departments concerned under the organization of the revolutionary committees of the respective provinces, autonomous regions, directly-administered municipalities and forestry area countries and in accordance with actual need. Grassroots mass organizations for forest protection shall be set up by communes and brigades, as well as by state-operated forestry, agricultural and animal husbandry farms, factories and mines in forestry areas. Joint forest protection organizations shall be established in forestry areas stretching across administrative boundaries under the leadership of the revolutionary committees concerned. Communes and brigades, and state-operated forestry, agricultural and animal husbandry farms, factories and mines in forestry areas shall, under the leadership of county revolutionary committees, define their boundaries of responsibilities for forest protection, and have full or part time forest protection personnel appointed. The main functions and responsibilities of forest protection personnel: (1) Carry out patrols. (2) Prevent all acts that may damage forests. (3) Deliver those who set forest fires and other elements who violate law by damaging forests to the local public security departments.

Article 18. Revolutionary committees at all levels and all departments concerned shall be required to adopt effective measures to prevent forest fires and protect forest safety: (1) They shall determine forest fire prevention periods. During them safety rules against all activities in open fields in forestry areas that involve the use of fire and that may cause fire must be laid down and rigidly observed. (2) Various facilities to protect forests from fire shall be constructed in forestry areas. For state forest areas that cover large areas, civil aviation departments shall establish professional airborne forest protection contingents to carry out forest protection from the air. (3) When there is a forest fire, forces must be immediately organized to work hard to put it out. Vigorous support shall be rendered by local PLA units, and commercial, grain, public health and other departments. During the fighting of a forest fire, the transport and communications facilities belonging to the railway, highway, waterway transport, aviation and posts and telecommunications departments may be used on a priority basis. (4) It is necessary to determine the causes of forest fires, ascertain losses, trace the sources responsible and handle such cases sternly. (5) The State shall offer treatment to those who are injured or allowances to the families of those who lose their lives in fighting forest fires.

Article 19. Destruction of forests for land reclamation or side-line production is strictly prohibited. If a forest has been destroyed, the unit or personnel that destroyed the forest should restore it within a set period of time. Cutting firewood, grazing livestock or quarrying in young forests, in mountainous areas marked off for forest cultivation, in forests that provide protection against wind and prevent sand from drifting, or in forests reserved for special uses is prohibited.

Article 20. The State and revolutionary committees of all provinces, autonomous regions and municipalities directly under the Centre should designate habitats of rare animals and plants as natural preservation areas and set up organizations to strengthen preservation management and carry out scientific research.

Article 21. Personnel entering forest areas must observe the following stipulations: (1) During forest fire prevention periods all stipulations regarding forest protection and fire prevention must be observed. (2) Causing damage to forest trees, roads, rivers or engineering facilities which serve forestry is not allowed. (3) Herdsmen must strengthen supervision of their livestock to prevent damage to forest trees. (4) Hunters must observe the stipulations regarding hunting control.

Article 22. Revolutionary committees at all levels must, in accordance with actual needs, set up organizations for forest pest prevention and treatment so as positively to prevent and treat forest pests, determine those forest tree seeds and seedlings which should be quarantined, designate those areas which should be quarantined and protected, carry out the quarantine of forest tree seeds and seedlings and prevent contamination by and the spread of dangerous pests.

Chapter Four: Tree Planting and Afforestation

Article 23. The State and revolutionary committees at all levels should draw up plans and fulfil forest building tasks within the specified periods of time in accordance with the following stipulations:

60 (1) The forest-covered area in the whole country should be 30% of the country's total area. All provinces, autonomous regions and municipalities directly under the Centre as well as autonomous prefectures, counties and autonomous counties should make an account of their forest-covered areas. Such areas in counties in mountainous areas should generally exceed 40%; in counties in hilly areas they should generally exceed 20% and on plains they should generally exceed 10%.

(2) Various kinds of protective forests should be built in agricultural and pastoral areas, in areas with serious water loss and soil erosion and disastrous winds, on both sides of railways, highways, rivers and ditches, around reservoirs and along sea coasts and lakes.

(3) The State and all provinces, autonomous regions and municipalities directly under the Centre should build new timber and economic forest bases in a planned way. Those provinces and autonomous regions where forests are scarce must strive to become self-sufficient in timber. All production brigades and production teams that meet the necessary conditions should build firewood and charcoal forests, according to actual needs.

(4) Those cities and industrial and mining areas that meet the necessary conditions should build garden forests and environmental protection forests with the view of providing each person with a tree-covered area of not less than 5 sq. m. on the average.

(5) In planting trees and building forests, technical rules and procedures should be strictly carried out to ensure the survival and growth of forests. In forest building and renovation covering large areas, it is necessary to pay attention to renewing tree seeds and building hybrid forests.

Article 24. Revolutionary committees at all levels should draw up plans for forest building on suitable barren mountains and barren land and set a time limit for such forest building. In the case of state-owned barren mountains and barren land suitable for forest building, if for no valid reason, forest building has not been completed within the prescribed time, it is necessary to investigate and determine the responsibility of the leadership concerned. As for collectively owned barren mountains and land suitable for forest building, the State should make the necessary arrangements for forest building, while the proceeds from the forest should go to the units that build it.

Article 25. Tree planting and forest building on both sides of railways, highways, rivers and ditches, around reservoirs, near industrial and mining areas, offices, schools and PLA barracks, as well as on agricultural and livestock farms should be carried out by the units concerned within the time set by the local revolutionary committees.

Article 26. After felling a forest, renovation should be carried out the same year or in the following year, in accordance with state stipulations.

Article 27. Cultivation and felling of state-owned forests and the transformation of low-yield forests should be included in state plans, and should be managed according to the conditions the forest are in so as to promote rapid growth and a bumper harvest of forest trees.

Article 28. Forestry departments at all levels must vigorously popularize fine-quality, fast-growing seedlings, establish seed-tree forests and seed gardens, cultivate good-quality and sturdy seedlings and plant forests with only fine-quality seedlings.

Chapter Five: Logging and Forest Utilization

Article 29. Felling of forests must be well planned. In both local and state forests, the number of trees felled each year should not exceed the number of seedlings grown that year. Both state and local lumber production must be reflected in state and local plans. No felling outside plans shall be permitted. Felling in state forests should be carried out by state forestry bureaux and logging stations according to state plans. Felling in collectively owned forests should comply with state guidelines and with contracts signed between the unit owning the forest and the forestry department concerned. When a commune or brigade wants to cut trees for its use in commune or brigade-owned forests, prior approval must be obtained from the county revolutionary committee if the annual felling exceeds 10 cubic meters of lumber. When an office, organization, PLA unit, school, factory, mine, farm or livestock farm wants to cut trees for its own use in forests owned by unit itself, prior approval must be obtained from the forestry department of the province, autonomous region or municipality directly under the Centre if the annual felling amounts to over 100 cu. m. of lumber.

Article 30. Felling of forests must comply with the following regulations: (1) Felling of timber forests must be carried out in compliance with state regulations to ensure proper operations. (2) In protective forests such as forests for environmental protection and for landscape improvement and seed-tree forests, no cutting other than for regeneration purposes is permitted. (3) No cutting of any nature should be permitted in forests intended for ecological protection. The forestry departments have the authority to sanction any violations of the above regulations.

Article 31. The forestry departments should set up special organizations to control and manage the production of bamboo and lumber products, firewood and charcoal. Complying with the principle of making proper use of waste lumber materials, the forestry and supply and marketing departments may also work out joint plans - subject to approval by the planning commission of the province, the autonomous region or the municipality directly under the Centre - for setting up agencies for the production and marketing of bamboo and lumber products, firewood and charcoal. No unauthorized units or individuals may enter a forest to cut trees or process and buy lumber.

Article 32. To ship lumber of finished and half-finished bamboo or lumber products to localities outside the producing county, one must first obtain a transport certificate to be issued by the county's forestry department. For shipments of such products to localities outside the province or autonomous regions, one must obtain a transport certificate issued by the provincial or autonomous regional forestry department.

Article 33. Efforts should be made actively to develop the multiple use of lumber and build, in forest areas, lumber processing plants and chemical plants using lumber as raw material so as to promote the utilization of forestry resources and lumber.

Article 34. Lumber for construction purposes must be gradually standardized. Lumber processing enterprises in forest areas should process lumber based on the demand and supply of lumber materials in specific localities, while lumber processing enterprises in cities should centralize processing and unify supply.

Chapter Six: Awards and Penalties

Article 35. The State and revolutionary committees at all levels should provide moral encouragement or material rewards, in accordance with the significance of contributions, to the following meritorious units: (1) Units which have conscientiously implemented forestry policies and principles, fulfilled state plans in an all-round way and achieved advanced domestic levels in major economic and technical targets for three consecutive years. (2) Units which have made outstanding achievements in forest protection and have been free of forest fires for three consecutive years. (3) Units which have achieved high production, good quality and low cost in nursing seedlings and fulfilled seedling nursing tasks for three consecutive years. (4) Units which have fulfilled all afforestation plans ahead of schedule at low cost and with high quality and speed. (5) Units which have distinguished themselves by cultivating forests in a timely way, actively improving low-yield forests, achieving rapid tree growth and increasing lumber production. (6) Units which have distinguished themselves by persistently felling trees and reafforestation in a rational and timely manner. (7) Units which have distinguished themselves by actively developing consolidated forest utilization, saving lumber and constantly raising lumber utilization. (8) Units which have distinguished themselves by popularizing education and carrying out scientific forestry research.

Article 36. Moral as well as material rewards should be given by the State or revolutionary committees at all levels, based on one's contribution, to any of the following meritorious individuals: (1) An individual who has worked in a basic-level forestry unit for more than 15 years, has cherished forestry and scored remarkable achievements. (2) An individual who has introduced inventions or made major innovations in production, teaching and scientific forestry research. (3) An individual who has firmly guarded his production post, observed labor discipline and rendered meritorious services in fulfilling production targets. (4) An individual who has played an exemplary role in enforcing law and implementing forestry policy and made remarkable achievements in resolutely struggling against violations of law. (5) An individual who has bravely and unswervingly fought forest fires and achieved remarkable results. (6) An individual who has rendered meritorious service in preventing and averting accidents, and prevented the State and the people from suffering a major loss of property.

Article 37. Disciplinary actions of varying degrees, including dismissal of an offender from public office, should be taken against state workers who are found delinquent in one of the following aspects: (1) Those who are incompetent in leadership and have caused damage to forestry production. (2) Those who have defied policies, laws, rules and regulations in forestry and caused damages to forests or serious waste of lumber. (3) Those who have failed to fell trees and reafforest according to state laws. (4) Those who have illegally used funds earmarked for forest cultivation. (5) Those who have resorted to deception and submitted false reports on achievements.

Article 38. Those who have destroyed trees in rural and urban areas, around houses and villages and along roads and waterways should be asked to grow three trees for each one they destroyed or pay a fine.

Article 39. Those who have committed not so serious a violation of the Forestry Act should be asked to make compensation for the losses or pay a fine and turn in any illegally obtained property; those who have seriously violated the act should be punished by law if they are involved in any one of the following acts: (1) Starting a forest fire; (2) destroying a forest for the purpose of land reclamation or for the development of sideline production or animal husbandry; (3) collecting firewood, grazing flocks and gathering pebbles and stones in a young forest, in a mountain area which has been marked off for forest cultivation, in a forest built for protection against sandstorms and holding sand dunes in check, or a forest built for any other special purpose; (4) violating regulations covering natural preservation or hunting control; (5) entering forest areas without authorization to procure lumber, bamboo, firewood, charcoal or finished or semi-finished wood or bamboo products; (6) illegally taking lumber or felling trees, or stealing or looting lumber; (7) carrying out speculative and profiteering activities in lumber markets; (8) violating the forestry act, disobeying advice, and assaulting personnel guarding forests; (9) becoming seriously delinquent in work, thus causing damage to a forest.

Article 40. Those who wilfully start a forest fire in order to destroy a forest, organize a gang to destroy a forest or kill personnel guarding a forest should be severely dealt with and punished by law.

Article 41. In any violation of the Forestry Act committed under the direction of a unit's responsible person, actions should be taken not only against the offender but also against the responsible person; the latter should be seriously dealt with based on the nature of the case.

Chapter Seven: Appendix

Article 42. Details concerning the implementation of the Forestry Act shall be formulated by the Ministry of Forestry with the approval of the State Council. Specific measures for enforcing the Act should be formulated by the revolutionary committees of the various provinces, autonomous regions and municipalities directly under the Centre.

Appendix 5

Natural Protective Areas, 1980
(Adapted from Wang 1980)

Region	Province	Natural Protective Areas	Land Area (Hectare)		Personnel	
Northern Region		(5)	509,200	(3)*		
	Beijing (Peking)	1				
	Shansi (Shansi)	2	29,200	(2)		
	Inner Mongolia	2	480,000	(1)		
Northeastern Region		(4)	275,510	(3)	310	(3)*
	Liaoning	1				
	Jilin (Kirin)	1	215,110	(1)	250	(1)
	Heilongjiang (Heilungkiang)	2	60,400	(2)	60	(2)
Eastern Region		(16)	62,932	(9)	154	(4)
	Anhui (Anhwei)	2				
	Zhejiang (Chekiang)	4	2,466	(2)		
	Jiangxi (Kiangsi)	3	2,900	(3)	54	(3)
	Fujian (Fukien)	4	57,566	(4)	100	(1)
	Taiwan	3				
Central Region		(16)	48,017	(16)	129	(11)
	Hubei (Hupei)	1	2,000	(1)	35	(1)
	Hunan	2	703.6	(2)		
	Guangdong (Kwangtung)	9	15,240	(9)	55	(7)
	Guangxi (Kwangsi)	4	23,741	(4)	39	(3)
Southwestern Region		(18)	547,500	(17)	551	(16)
	Sichuan (Szechuan)	13	477,000	(13)	431	(12)
	Guizhou (Kweichow)	1	36,700	(1)	60	(1)
	Yunnan	4	43,800	(3)	60	(3)
Northwestern Region		(4)	192,300	(4)	228	(4)
	Shaanxi (Shensi)	2	89,158.5	(2)	142	(2)
	Gansu (Kansu)	1	95,292	(1)	81	(1)
	Qinghai (Chinghai)	1	7,850	(1)	5	(1)
TOTAL		63	1,635,460.1	(52)	1,372	(38)

* Number of natural protective areas reporting land area and personnel information.

Appendix 6

Major forest insect pests in China (McFadden et al., 1982)

Insects	Susceptible tree species	Location
Dendrolimus punctatus	Pinus massoniana P. elliottii	Southern Provinces
D. spectabilis	P. tabulaeformis P. thunbergii	Liaoning and adjacent Provinces
D. sibiricus	Larix spp. Pinus koraiensis P. sylvestris	Northeastern Provinces, Inner Mongolia, Hebei
Pyrrhalta aenescens	Ulmus pumila	Hebei, Henan, Shanxi, Shandong and Inner Mongolia
Ambrostoma quadriimpressum		Northeastern area and Inner Mongolia (eastern)
Aprocheima cinerarius	Populus spp.	Henan, Hebei, Shanxi, Inner Mongolia, and Xinjiang
Stilpnotia salicis	Populus spp. Salix matsudana	Northeastern area
Ocneria dispar (Lymantria dispar)	Xylosma congestum Salix spp. Betula japonica Larix spp. Malus mill. Pyrus linn.	Northeastern area
Phycita pryeri	Pinus spp.	Northeastern area
Polychrosis cunninghamiacola	Cunninghamia lanceolata	Southern Provinces
Ceraeris spp.	Phyllostachys spp.	Jiangxi, Fujian, Hunan and Sichuan
Algedonia coclesalis	Phyllostachys spp.	Zhejiang, Hunan, Jiangxi and Sichuan
Coleophora laricella	Larix spp.	Northeastern Provinces
Anoplophora glabripennis	Populus spp. Salix spp. Ulmus spp.	Hebei, Henan, Shandong, Shanxi, Shaanxi, Inner Mongolia, and Anhui
Saperda populnea	Populus spp.	Liaoning, Hebei, Inner Mongolia, Shandong, and Shanxi

Major Forest Insect Pests in China (Cont'd.)

Semanotus bifasciatus	Cunninghamia lanceolata	Southern Provinces south of Yangtze River
Matsucoccus matsumurae	P. massoniana P. thunbergii	Liaoning, Shandong, Jiangsu, Zhejiang
Lymantria xylina	Casuarina spp. Robinia pseudoacacia Rterocarya stenoptera	Fujian, Guangdong, Guanxi
Euproctis pseudoconspersa	Camellia fordii	Southern and central Provinces below Yangtze River
Blastophagus piniperda	Pinus spp. Larix spp.	
Ips subelongatus	Larix spp.	Heilongjiang, Jilin, and Inner Mongolia
Odontotermes formosanus	Cunninghamia lanceolata Pinus massoniana	Provinces in central and south China

Appendix 7

List of forest insect viruses discovered in China (1980) (McFadden et al. 1982).

	Common names of insects	Scientific names	Kinds of visuses
1.	Looper	Acidalia carticcaria	NPV[1]
2.	Smaller tea tortrix	Adoxophyes privatana W.	GV
3.	Grape hornworm	Ampelophaga rubiginosa	NPV
4.	Red-costate tiger moth	Amsacta lactinea C.	GV
5.	Elm looper	Apocheima cinerarius	NPV
6.	Tung-oil tree geometrid	Buzura suppressaria	NPV
7.		Bhima undulosa	NPV
8.	Poplar caterpillar	Clostera anachoreta	GV
9.	Oriental moth	Cnidocampa flavescens	NPV
10.	Giant bagworm	Cryptothelea variegata	NPV
11.		Culcula panterinaria	NPV
12.		Dasychira abietis S.	PV
13.		Dasychira glaucinoptera C.	PV
14.	Pale tussock moth	Dasychira pudibunda	NPV
15.	Masson-pine caterpillar	Dendrolimus punctatus	NPV,CPV
16.	Tehchang-pine caterpillar	Dendrolimus punctatus tehchangensis	NPV
17.	Pine lappet caterpillar	Dendrolimus spectabilis	CPV
18.	Oil pine caterpillar	Dendrolimus tabulaeformis	CPV
*19.		Euproctis flave	NPV
20.	Tea tussock moth	Euproctis pseudoconspersa	NPV
21.	Mulberry tussock moth	Euproctis similis	PV
*22.	Fall webworm	Hyphantria cunea	NPV
23.		Lebeda nobilis	NPV
*24.		Leucoma candida	NPV
25.	Satin moth	Leucoma salicis	NPV
*26.	Elm tussock moth	Ivela ochropoda	PV
*27.	Gypsy moth	Lymantria dispar	NPV, CPV
28.		Lymantria xylina	NPV
*29.	Lackey moth	Malacosoma neustria testacea	NPV
*30.	Green cochlid	Parasa consocia	PV
31.	Chinese cochlid	Parasa sinica	NPV,GV
32.	Yellow-tipped prominent	Phalera assimilis	NPV
33.		Seopula subkumctaria	PV
34.		Thosea baibarana	NPV
*35.	Flattened eucleid	Thosea sinensis	NPV

* Viruses collected by Division of Forest Entomology, Forest Research Institute, the Chinese Academy of Forest Science.

1 NPV = nucleopolyhedrosis virus; GV = granulosis virus; PV = polyhedrosis virus; CPV = cytoplasmic polyhedrosis virus.

Appendix 8

Major forest diseases in China (McFadden et al. 1982).

Diseases	Susceptible tree species	Location
Fusarium oxysporum Rhizoctonia solani	Pinus sp. Larix sp.	all over the country
Mycosphaerella larici-leptolepis	Larix sp.	provinces in northeast
Guignardia laricina	Larix sp.	
Cronartium ribicola	Pinus koraiensis	Heilongjiang and Jilin
Glomerella cingulata	Cunninghamia lanceolata	southern provinces
Colletotrichum camelliae	Camellia oleifera	southern provinces
Leptosphaeria sp.	Phyllostachys pubescens	Zhejiang, Guanxi, and Hunan
Mycoplasma	Paulownia sp.	Shandong, Anhui, Henan, and Shaanxi
Cylospora chrysosperma	Populus sp.	northeastern area

Appendix 9

Some forest products and the benefits they provide (FAO 1978).

Nature of product	Type of product or species	Time lapse between planting & harvesting	Life span benefit	Kind of benefits Main	Secondary
Food	Nuts - cashew, chestnut, Macadamia, Pistachia	Short to medium	Very long if protected	Nut	Fuelwood, poles, shade, fodder
	Nuts - brazil, pine, hazel, Canarium	Medium	"	Wood, fuelwood, shade	Nut
	Fruits - jakfruit, mango, Durio, Garcinia, Ficus, Tamarindus	Medium	"	Fruit	Wood, shade, fodder
	Palm	Medium if cultivated	Very long for fruit and oil	Fruit, oil, edible heart	Leaves for fuel and roofing
	Fungi	Short	Renewable source if cultivated	Mushroom	
	Animal protein	-	Renewable if protected and managed	Meat and fish	
Fodder	Acacia, Prosopis, Albizia	Short	Medium	Fodder	Poles, fuelwood, bee forage
Forest products providing employment or cash	Bamboo (also crop diversification)	Very short	Renewable by planting and good management	Raw material for industries, handicrafts, handmade paper	Shoots for food, forage
	Resin tapping	Medium to long	Sufficiently long if resources renewed after timber exploitation	Employment	Further employment if rosin & turpentine industry follows

Some forest products and the benefits they provide (Continued).

Nature of product	Type of product or species	Time lapse between planting & harvesting	Life span benefit	Kind of benefits Main	Secondary
	Tasar silk	Short	Forever if vegetation protected	Income by harvesting silk	Fuelwood, employment if silk industry follows
Forest products which increase land productivity by diversification	*Acacia senegal* (also crop diversification)	Short	Renewable by planting and good management	Gum arabic	Fodder, fuelwood, poles, soil improvement
	Medicinal and other economic plants	Short if planted	Very long if planted	Income and employment	Impact on health (medicinal)
	All species which provide bee forage as well as wood, nuts or fruits			Income and employment, honey	Impact on nutrition
	Thea oleosa	Medium	Very long	Oil, oilcake for animal feed	Bee forage, wood for handicrafts

Note: The species and products mentioned above are examples only.

Appendix 10

Government guidelines for the forest industry*

The government-imposed guidelines summarized below represent projections of the productivity of China's forest industries during the next ten years.

Sawmills

- Productivity: 2.8 m^3/man/year
- Mechanization level: 7 kwh/man
- Financial amortization time: 3 years
- Technical amortization time: 20 years

Fiber Panel Factories

(i) Production Capacity

Production capacity varies with the size of each plant:

- Small enterprises: less than 10,000 t/year
- Medium enterprises: from 10,000 to 20,00 t/year
- Large enterprises: more than 20,000 t/year

(ii) Example of Production Controls

Capacity:	2000 t/year by 3 teams working 300 days/year
Raw materials:	
- wood	6000 m^3/year
- paraffin	22,000 kg/year
- charcoal	2600 t/year
- ammonia water	2 t/year
- sulphate of aluminum	60 t/year
Consumptions:	
- steam	3.5 t/h
- water	20 t/h
- electricity	700 kwh/t of fiber panels
Installed power	1670 kwh
Workers	92 persons
Work area	2300 m^2
Investment	± $1200 U.S., including 75 percent for machines
Mechanization level	8.4 kw/h/person
Financial amortization time	5 years
Technical amortization time	25 years

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* From (FAO 1981 China).

Cellulose Paste Factories

The following controls, and those in the above section, are established for a single unit of production-transformation to be integrated in an industrial wood complex.

Capacity:	2000 t/year with 3 teams working 300 days/year
Raw materials:	
- wood	15,000 m^3/year
- kali	1050 t/year (at 100 percent)
- natium sulphide	250 t/year (at 60 percent)
- liquid chloride	190 t/year
Consumption:	
- water	260 m^3/h
- steam	3.5 t/h
Installed power	977 kwh
Number of workers	254 persons, including 243 laborers
Level of mechanization	4 kwh/person
Covered area (buildings)	5914 m^2
Productivity	8.2 t/man/year
Investment	± $1,780,000 U.S., including 60 percent for equipment
Financial amortization	6 years
Technical amortization	25 years

Appendix 11

CLIMATIC CONDITIONS OF REPRESENTATIVE STATIONS

Region	Station (Province)	Altitude (m)	Latitude (N)	Longitude (E)	Annual mean precipitation (mm)	Annual mean temperature (c)	Absolute minimum temperature	Absolute maximum temperature	Frost free season (days)
Montane boreal coniferous forest	Genho (Heilongjiang)	979.9	50:41	121:57	427.4	-5.7	-49.2	35.6	0
	Huma (Heilongjiang (Heilungkiang))	177.4	51:43	126:39	456.6	-2.1	-46.3	38.0	30
Mixed coniferous and northern hard-wood forest	Harbin (Heilongjiang (Heilungkiang))	[illegible]	45:41	126:37	526.6	3.5	-38.1	35.4	96
	Yichuen (Heilongjiang (Heilungkiang))	231.3	[illegible]:43	128:54	636.[illegible]	0.3	-43.1	34.4	60
Deciduous broadleaf forest	Beijing (Peking)	31.2	39:48	116:28	584.0	11.6	-27.4	40.6	146
	Xian (Shaanxi(Shensi))	396.9	34:18	108:56	604.2	13.3	-20.6	41.7	150
Mixed deciduous and broadleaf forest	Nanjiang (Jiangsu(Kiangsu))	8.9	32:00	118:48	1013.4	15.4	-13.0	40.5	210
	Hanchung (Shaanxi(Shensi))	508.3	33:04	107:02	903.9	14.3	-8.4	36.9	184
Evergreen broadleaf forest (eastern part)	Hangzhou (Zhejiang(Chekiang))	[illegible]	30:19	120:12	1246.6	[illegible]	-9.6	38.9	206
	Changsha (Hunan)	44.9	28:12	113:04	1450.2	17.3	-9.5	39.8	263
Evergreen broadleaf forest (western part)	Guiyang (Guizhou(Kweichow))	1071.2	36:35	106:40	1128.3	15.2	-7.8	35.4	207
	Kunming (Yunnan)	1891.4	25:01	102:41	1034.4	[illegible]	-5.4	31.2	233
Rainforest	Guangzhou (Guangdong(Kwangtung))	6.3	23:03	121:41	1622.5	19.7	0.9	37.6	365
	Jionghung (Yunnan)	552.7	21:52	112:20	1461.2	26.4	[illegible]	41.0	365
Wooded grassland	Changchun (Jilin(Kirin))	236.8	43:54	125:13	571.6	[illegible]	-36.5	38.4	94
	Duolum (Inner Mongolia)	1245.4	42:11	116:28	373.7	1.6	-36.4	33.7	88
Grassland	Huhhot (Inner Mongolia)	1063.0	40:49	111:41	414.7	5.8	-31.[illegible]	36.9	92
	Lanzhou (Gansu(Kansu))	1517.2	36:03	103:53	331.5	8.9	-21.7	36.[illegible]	165
Desert	Wulumuqi (Xinjang(Sinkiang))	653.5	43:54	87:28	194.6	[illegible]	-32.0	40.9	[illegible]
	Jiuquan (Gansu(Kansu))	1477.2	39:46	98:31	82.[illegible]	6.9	-27.6	36.1	84
Alpine meadow	Lhasa (Xizang(Tibet))	3658.0	29:42	91:08	463.3	[illegible]	-16.5	27.0	123
	Changdu (Xizang(Tibet))	3240.7	31:11	96:59	499.2	7.4	-18.7	[illegible]	93
Alpine	Kereh (Xizang(Tibet))	4278.0	32:30	91:08	60.[illegible]	0.2	[illegible]	25.7	0

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A botanist checks the growth of "Hequeteng", a liana, in the Dinghushau Nature Reserve.

Pinus cunninghamia in Hunan province demonstrates the Chinese watershed management policy: tree plantation on the slopes with agriculture in the valleys