

THE DISTRIBUTION OF WOODY PLANT REGIONS OF CHINA.

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INTRODUCTION

In the preceding issue of *TAIWANIA* I discussed the distribution of woody plants in China (Lee 20). In this paper I wish to consider the factors affecting the distribution of the woody plants.

Botanists, plant geographers and many foresters have divided the natural vegetation types of China into from 5 to 18 or even as many as 26 different types and regions. This discrepancy in the classification is dependent upon the different bases that the various authors have used. C. K. Merriam⁽¹⁰⁾ classified the distribution of vegetation by simply basing it upon the temperature as the controlling factor and neglecting the moisture, soils and other factors. W. Koeppen⁽⁷⁾ has, in addition to temperature, stressed the importance of such edaphic factors as, moisture and soils. The former method is more simple; the latter is more complex. When other edaphic factors are considered this results in producing more kinds of vegetational types. Thus, Merriam⁽¹⁰⁾ has made the laws of temperature, control the geographic distribution of terrestrial animals and plants, and Koeppen⁽⁷⁾ has made his world vegetation maps based upon edaphic factors. Livingston and Shreve⁽⁹⁾ in their studies found that the distribution of vegetation as related to climatic condition so manifold in its effects, as to render it an almost hopeless task to define the relation between climates and plants. Many other plant geographers have reconstructed the distribution of the original vegetation upon the basis of climatic, precipitation, soil types and other factors. Veatch⁽¹⁹⁾ Sampson⁽¹²⁾ and others have used soil maps as a basis for the mapping of the original forest vegetation. Their methods were based upon the assumption, that vegetation types possess a distributional equivalence to the soil types.

Regarding the floristic regions of China Handel-Mazzetti⁽⁴⁾ has recognized eight floral regions:

1. The northeastern Chinese and Korean provinces of mixed forests.
2. The desert of the southern Gobi.
3. The northern Chinese Loess-steppe Area.
4. The middle Chinese-Japanese Laurel Area.
5. The tropical Chinese region.
6. The highlands and the high mountains of Yunnan and western Szechuan.
7. The eastern Tibetan Grasslands.
8. The upper Burma and western Yunnan monsoon region.

Walker's⁽¹⁶⁾ classification agreed with Handel-Mazzetti's work and recognized eight floral divisions, namely:

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1. Northeastern China,
2. Gobi desert region,
3. Loess region,
4. Middle China,
5. Southern China,
6. Southwestern Yunnan,
7. Highlands of western China,
8. Grassland of Tibet, including the grass lands of Sikang and Tsinghai.

In addition to these eight floral regions Walker named two more areas: (1) The Tsaidam Swamp and surrounding plain of Tsinghai province, (2) The southern fringes of Tibet and Sikang which are drained by the five rivers: namely, the Indus, Tsangpo, Nu-Kiang, Lantsang-Kiang and the Yangtze. In the protected valleys the climate is mild and the vegetation is rich.

T. N. Liou⁽⁸⁾ also proposed eight floristic regions: namely, 1. Manchuria, 2. North China, 3. Mongolia, 4. Central China, 5. South China, 6. Tibet, 7. Eastern China, 8. Yunnan and Kweichow.

K. S. Hao⁽⁵⁾ suggested similar floristic divisions of the regions and based them upon the prevalence and characteristics of the plants in the regions.

Regarding the forest zones Wang Cheng⁽¹⁷⁾ classified the forest regions attempting to correlate forest types with habitat factors. His classification was simply based upon Mayr's method⁽¹¹⁾ by using the average temperature of May, June, July and August, (the four months of the growing season) to determine the 6 forest zones.

C. L. Wu⁽¹⁸⁾ in 1950, with special reference to the natural distribution of Pinus, has recognized 12 forest regions in China.

Teng⁽¹³⁾ has classified Chinese forests into 18 regions.

Thorp⁽¹⁴⁾ in his geography of the soils of China has made a soil map of China and shown a very good coincidence of the soil groups with that of the vegetational groups of China, however he failed to interpret them ecologically.

P. S. Hwang⁽⁶⁾ has, in part upon soils, divided Chinese vegetation into 26 divisions.

S. S. Chien⁽¹⁾ has recognized 7 major and 5 lesser zones of vegetation in his phytogeographical regions of China.

The object of this study is, thus, to classify the Chinese forest regions based upon the prevalence in species and varieties and their special habit of growth, using the forest trees studied in the Arnold Arboretum of the Harvard University as a basis and to correlate them with the habitat factors and to determine the distribution of woody plant regions of China.

STUDIES ON THE EDAPHIC CONDITIONS OF CHINA

1. Soil conditions

According to G. B. Cressey⁽³⁾ "The soils of China are largely a by-product of

climate and natural vegetation. Geological parent materials place their initial stamp on young soils, but as time goes on, the composition, texture, and profile of mature soils take on environmental characteristics that increasingly reflect temperature, rainfall, drainage, and the accumulation of organic matter "In classifying the infinite complexity of Chinese soils, two great groups appeared: (1) To the north of the Hwai River, where rainfall diminishes, soils tend to be rich in lime and soluble plant nutrients, porous, and friable and easily permeated by water. With limited rainfall there is but little opportunity for ground water to leach out of the soil and thus has resulted in a grassland cover of vegetation, humus accumulation is more rapid than beneath a forest growth. (2) While in the Yangtze Valley and to the south, many soils are leached, heavy textured, more or less stiff and less fertile except where renewed by flood deposits. Throughout China soils tend to be low in organic matter and many are deficient in plant nutrients. Soils of North China are chiefly pedocals, or calcium carbonate accumulating types, where well developed on the uplands. They include chernozems, chestnut-brown soils, and light-colored desert soils. Low-land soils of mature characteristics include Shachiang and saline soils.

South China and a pedalfer or non-liming soils, namely from their aluminium and iron, "AL" and "Fe". Upland well-developed varieties include podzolic soils, and red and yellow earths. On low land with poor drainage, various paddy soils are formed, either with or without podzolization. Chernozems occur chiefly in the grassland of northern Manchuria, Inner Mongolia and north-eastern Tibet.

Chestnut-colored soils have an A horizon which varies from dark to light brown, largely in terms of humus content. In Inner Mongolia, north-eastern Manchuria, Sinkiang, rainfall is inadequate, so a short grass type of vegetation has resulted.

The soils of the loessial parts of Shansi, Shensi, Honan, and Kansu require a special classification since they are derived from parent material of high lime content and are subject to constant renewal by wind work. They are low in organic matter but rich in plant nutrients. In general they represent imperfectly developed very high-colored chestnut earths. Some soils in the drier areas or scanty of vegetation are yellow-gray earths. Beneath the loess are reddish shales, which have given rise to local areas of red soils.

Gray and yellow-gray desert soils are common in short grass and brush areas of Mongolia and Sinkiang.

Shachiang soils are unique, although apparently similar to some of the Indo-Gangetic Plain and those in Texas, they occupy large parts of the eastern lowlands in Shantung, Honan, Anhwei and Hopei. These soils are poorly drained and have a subsoil horizon of lime and iron manganese concretions. The lime is not all derived from the leaching of an A horizon but probably comes from the ground water.

Saline and alkaline soils are wide spread in North China, even in the Hwang River delta from Shanghai to northern Manchuria. Soils containing the concentrations

of sodium chloride, with some sodium sulphate and sodium bicarbonate are very common.

There are three other soils which are either limy or nearly neutral. One is the Shantung brown soil, much eroded but resembling the brown forest soils of the Mediterranean region. Pears, persimmons and other fruit trees are common. Purple-brown soils are common in Szechuan and Yunnan, and in parts of Hupei, Kiangsi, and Hunan. These are derived from high colored Cretaceous and Triassic formations, some of which may in turn be fossil pedocals. Since the erosion of those soft rocks is rapid, the soils are relatively immature. In some way they relate to the gray-brown podzolic soil type. In these areas Tung Oil trees develop well. The third type is the rendzina, best developed in Kwangsi and Kweichow but found even in Manchuria. Rendzines are dark colored warm climate soils with imperfect profiles, which in color and humus somewhat resemble temperate chernozems and chestnut soils, they are covered with grass.

Red and Yellow soils are developed in areas of over 40-inches of rainfall and with little or no freezing weather. Red soils involve lower humidity and usually higher temperature than yellow soils. Each was developed in a topography where erosion was at a minimum.

Cressey⁽³⁾ has recognized nine soil regions of the country, three of which are large areas of primary soils and six composed exclusively of secondary soils.

1. The upland soils of the redsoil region are rather lateritic in character, with heavy clay subsoils, and occur with a rainfall of over 50 inches, and subtropical temperatures. Nearly all of the agricultural development is on the alluvial soils of the included valleys, the upland soils eroding very severely when cleared. They are naturally forested.
2. The Claypan Soil Region receives a rainfall of 40-50 in. with hot summers and cold winters. The soils are reddish brown with a very dense clay subsoil. Terrace and bottom lands are farmed. The hill lands are too severely eroded. They are naturally covered with forests, which have been almost wholly removed.
- 3, 5, 6. The soils of the middle Yangtze Flood Plains, the lower Yangtze Delta, and the Hwai River valley are generally non-calcaeous, their characteristics being determined mainly by the mode of accumulation and origin of soil material. The soils are generally silt loams, clay loams, and clays and are very deep.
4. The Brown soil region has 20 to 30 inches of rain, with hot summers and cold dry winters. The hills are severely eroded, most of the soil being on terraces and bottoms. Soils are generally brown in color with a clay subsoil, but conditions are quite variable within quite limited areas. The natural cover has all been removed but was probably grass, brush, and sparse woods.
4. Alluvial soils of the northern plains include the flood plains of numerous minor streams and also the present flood plains of the Yellow River. They are deep

and fine textured, calcareous and generally saline. They are poorly drained and subject to severe flooding. Wheat and kaoliang are the major crops.

8. The Sajony Soils occupy the great central plains area and are characterized by the presence of an horizon of lime concretions or Sajong in the subsoil. They are quite calcareous and somewhat saline and are generally poorly drained. Wheat and kaoling are the common crops.

Thorps⁽¹⁴⁾ an American pedologist, who was at one time in the employ of the National Geography of China, has published in his geography of China a tentative map of the vegetation groups in China. If his vegetation map is compared with his soil map, the coincidence of soil groups and vegetation groups, as might be expected, are very obvious. His desert vegetation steppes and saline vegetation formation of halophytes and salt-tolerant species are natural units of vegetation. But such vegetation groups are grasses and brushes, with some trees. Forests on higher mountains are deciduous and coniferous forests could not be in close coincidences, therefore his map may be said to be incomplete and can not be applied to the whole of China.

T. W. Hwang⁽⁶⁾ in his "Regions of natural vegetation in China" includes a map of vegetation for the whole of China based in part upon soil and has revised the major division of vegetation groups into 26 vegetation regins. It is rather difficult to use a soil map as a basis for the reconstruction of vegetation types, because their assumptions are simply employing the boundaries of soil types for corresponding vegetation. In actual practice, however, it is not as simple as the theory sounds. Furthermore the boundaries of soil types as drawn are still quite arbitrary.

2. Precipitation

According to Cressey⁽³⁾ there are three main types characterizing China's climate and precipitation:

- (1) The northeast and center type—having short summers and severe winters, with moderate rainfall.
- (2) The southern type—having long hot summers and mild winters, with adequate rainfall.
- (3) Mongolia and the interior type—is a land of desert and steppe.

According to China's physiography Tsinling is the climatic dividing line. Its height decreases eastward from the border of Szechuan and Shensi to Honan and Hupei i. e. from 3000 m. to 1500 m. East of that is Anhwei with lower mountains, therefore the temperature of lower Yangtze Valley is much lower and the differentiation of climate between north and south is not so radical, while the climate of the upper Yangtze Valley and of the north side of Tsinling and the south side of this range is essentially different, because Tsinling can overshadow and protect the cold winter northwest currents from blowing to the south side of this range, resulting in two distinct types of vegetation and two separate vegetation regions.

With regards to the precipitation:—the south-eastern portion of China belongs to south-east monsoon region. During the summer and the remaining half of the year there are more south-easterly winds carrying an abundance of oceanic moisture, and during the winter and the following months the more north and north-westerly winds blowing southeastwardly from the dry cold continent carrying very little moisture in the air, and therefore the precipitation of north and central China falls mostly during three months of June, July, and August, and the rest of the year is rather dry. Thus the Yellow River basin has a dry climate and Yangtze River basin has a moist climate, for example Kaifeng in Honan has only half the precipitation of Hankow, even though both are nearly on the same latitude.

Precipitation of West Yunnan and Szechuan and South-west Tibet comes mostly from Indian Ocean. Above 20% of the precipitation in Hunan, Kiangsi, Kweichow falls in the Spring; while in Shansi, Honan, Hopei, and Shantung above 40% falls in the summer, that of the maritime provinces—Shantung, Kiangsu, Chekiang, Fukien, Taiwan, and Kwangtung with more changeable seasonal distribution, usually has above 30% in the summer. The changing seasonal distribution of precipitation south of the Yangtze River is usually small, less than 20% and the north-west is more changeable always above 35%, so there are more droughts of floods occurring in that region.

According to Chinese climatologist Dr. K. C. Chu,⁽²⁾ the climatic regions of China have been divided into nine regions and these regions have been corrected by Dr. C. W. Tu,⁽¹⁵⁾ into eight regions as follows:

1. **Chang-Pei-Shan and Hai-lung-kiang region**

Including all of the North-eastern provinces except the western portion of Hin-An-Ling; the average monthly temperature drops below zero Centigrade for 5 months. It varies very much from the south to north. The winter season is severely cold. All the rivers are frozen. Precipitation decreases from the southeast toward the north-west. In the Chang-Pei-Shan area the precipitation is above 700 mm. annually and in Hin-An-ling area is only 300 mm. Over 80% of the rain falls during the summer season. This region is divided into 3 sub-regions:

- a) Hin-An-Ling sub-region.—Climate is very similar to that of Siberia. The growing season of the year is not more than 100 days. Annual precipitation is 400 mm.
- b) Kuangtung grass-land steppe sub-region.—The average annual temperature is about 5°C. The annual precipitation is about 600 mm. The winter season is the longest and the average temperature is below zero for about 5 months. The summer season is about 2 months with temperature of above 20°C.
- c) Chang-Pai-Shan sub-region.—The climate is that of a grassland but the growing season is shorter and rainfall is higher than that of the plains. Annual precipitation is from 700 to 1000 mm. Forest growth is luxurious.

2. Mongolian Region

Including Outer and Inner Mongolia, west of Da-Hin-An-Ling, and Sinkiang. The climate of this region, lying in higher latitudes and from the seas, is dry and cold. Precipitation is very scarce. This region is sub-divided into sub-regions.

- a) Desert sub-region: Including the Gobi desert and Da-li-mu and other basins. The precipitation here is the least, and there is practically no vegetation.
- b) Desert steppe: Scattered belts around the desert, only *Tamarix* is found to exist.
- c) Grazing grassland sub-region: Border of Outer and Inner Mongolia, with grazing grassland vegetation. Precipitation is about 200 mm.
- d) Cultivated grassland sub-region: Including the west part of Da Hin-An-Ling and a large portion of Inner Mongolia. Precipitation is 250–350 mm.
- e) Montane sub-region: Including the Altai mountains and other high elevations, their slopes facing the Arctic Ocean, with elevation about 2000 m. and the annual precipitation of 400–500 mm. Forests are luxuriously developed.

3. North China region

Its northern boundary is the Great Wall, and its southern boundary is Huai River, and west to the Wei River. Average annual precipitation is about 500–600 mm. but exceedingly variable, in different years, due to the physiographic variations. This region is sub-divided into 2 sub-regions:

- a) The North China plain sub-region: Including the Yellow River alluvial plain, Shantung peninsula and the eastern portion of Shansi. Precipitation is rather heavy, average annual rainfall is about 600 mm. The distribution of the summer thermal-line are quite regular.
- b) The loess-steppe sub-region: Including Shensi, the eastern portion of Kansu, and a large part of Shansi. The elevation is rather high, the temperature is more variable, especially so during the winter season. Precipitation is rather scarce, the annual average is below 500 m.

4. Central China region

This region includes most of Kiangsu, Chekiang, Anhwei, Kiangsi, all of Hunan and Hupeh, and the Szechuan basin. The annual precipitation is about 1000 mm. That south of the Hwai River is 800 mm. and that of the hilly country to the south of the Yangtze river is often as much as 1200 mm. This region may be divided into 4 sub-regions, namely: (1) the Lower Yangtze River portion, (2) The Middle Yangtze River portion, (3) the Szechuan basin sub-region, and (4) The Hang-chow bay sub-region. The differences between the 4 sub-regions are in temperature, precipitation and elevations.

5. South China Region

This region includes the southern portion of Chekiang and Kiangsi and Fukien. The climate of this region is chiefly sub-tropical. The mean annual temperature is

22°C, there is no snow, the summer is about 8 months long. The average annual precipitation is 1500 mm. and that of the hilly parts of the region exceeds 2000 mm. During the Summer-Fall season, typhoons often hit this area bringing torrential rainfalls. This region is sub-divided into the following 3 sub-regions:

- a) The south-east coast sub-regions: Including east Chekiang, and parts of Fukien and Kwangtung. Most of the rain falls in June and August. Foochow has most of its rainfall in December. Tropical plants are not present.
- b) The Si-Kiang (West River) Basin sub-region: Includes Kwangtung, Kwangsi and the southern part of Kiangsi. Precipitation is 200-300 mm., the rainy season lasts very long, with most of the rains falling from June to September in Kwangtung and falling from May to August in Kwangsi.
- c) Taiwan and Hainan Island sub-region: Hainan and Taiwan Islands have an annual mean precipitation of 1750-2000 mm. and both have an abundance of tropical plants.

6. The West China Region

This region includes the high plateau of Yunnan, Kweichow, and the Szechuan basin's surrounding the mountains, and Tsinling mountains. The region consists of mountains and plateaus, therefore the physiographic feature is the most important factor in relation to the amount of precipitation. In the valleys the rainfall is rather small, averaging about 1500 mm. and on the tops of mountains it usually reaches 2000 mm. annually. The western part of Szechuan and Sikong have the highest-precipitation. This region is divided into three sub-regions:

- a) Tsinling mountain sub-region: Temperature is rather low, rainfall smaller, especially along the northern slope averaging about 1000 mm, but the highest peaks have a rainfall of 3000 mm. annually.
- b) Si-K'ong mountaneous sub-region: Includes the cross-valley of Sikang and the western portion of Szechuan. This sub-region has the highest precipitation with about 3000 mm. annually.
- c) The South-western Plateau sub-region: Includes the plateau of Yunnan and Kweichow, and the mountains of south Szechuan with elevations of 1000 to 2000 mm., the climate is mild. Precipitation is below 1500 mm. Kweichow has higher precipitations and south Yunnan and the the upper Red River basin, is a drier region.

7. Tibet (Si-Tsang) Region

This region includes most parts of Tibet, Tsinghai, and Sikang with an elevation of above 4000 meters plateau. Cande's mountain is the southern boundary of the eastern section and Himalya is the southern boundry of the west section protecting the south-west monsoons from blowing inward, therefore the annual precipitation of this region is not quite 100 mm. The climate of this region is noted for its

scarce rainfall, and low temperature with only mosses, liverworts and cold resisting shrubs growing here. Solar radiation is very intense, evaporation is very high, and the wind velocity is strong. This region may be divided into 3 sub-regions:

- a) The Northern portion of Tibet: A dry and cold desert.
- b) The Western portion of Tibet: Bordering northeast India. There is rather high humidity and frequently low pressures occur causing some rainfall, especially on the mountains.
- c) Tsinghai sub-region: This is lower in elevation, of about 1000 m. Rainfall is more than that in Tibet but the temperature is lower.

8. South-eastern Tibet Region

This region includes the Ja-Ru-Tsang-Pu River valley district though the elevation is rather high yet it is subjected to the attack of the south-west monsoon winds, and therefore its precipitation is extremely high, generally reaching 2000 mm. annually, and the majority of it falls in the summer season. Temperature variation is small, only has 18.2 degree variation, because in the summer there are more rainy and cloudy days, and on the north it is protected by the high plateau which keeps the cold current from flowing in.

Koeppen's⁽⁷⁾ classification of the vegetation of the regions of the world, stresses the moisture as well as temperature as being a controlling factor; thus, according to his classification, the vegetation map of China should have the following 11 regions.

1. Tundra mountainous region: Portion of eastern Siberia.
2. Temperate Coniferous forest region: Northern parts of Hai-Lung-kiang.
3. Temperate mixed coniferous and deciduous forest region: The rest of Nine Eastern provinces.
4. The prairie steppe semidesert region: Mongolia and Sinkiang.
5. Desert vegetation region: Hopei, Shansi Honan, Shensi, Kansu.
6. The Lower Yangtze River basin region: Including Shantung, Kiangsu, Anhwei, Hupei, Hunan, Kiangsi.
7. Subtropical and tropical mixed evergreen and coniferous forest region: Including the provinces south of the Yangtze River.
8. Tropical and subtropical rainforest region: Including Southern Kiangsi, Chekiang, Taiwan, Fukien and Kwangtung.
9. High plateau vegetation region: Including west Hupei and the Szechuan basin.
10. Tropical deciduous forest region: Including Kwangsi, Yunnan and the west.
11. Tropical shrub-woodland region: Including Tibet and Tsinghai.

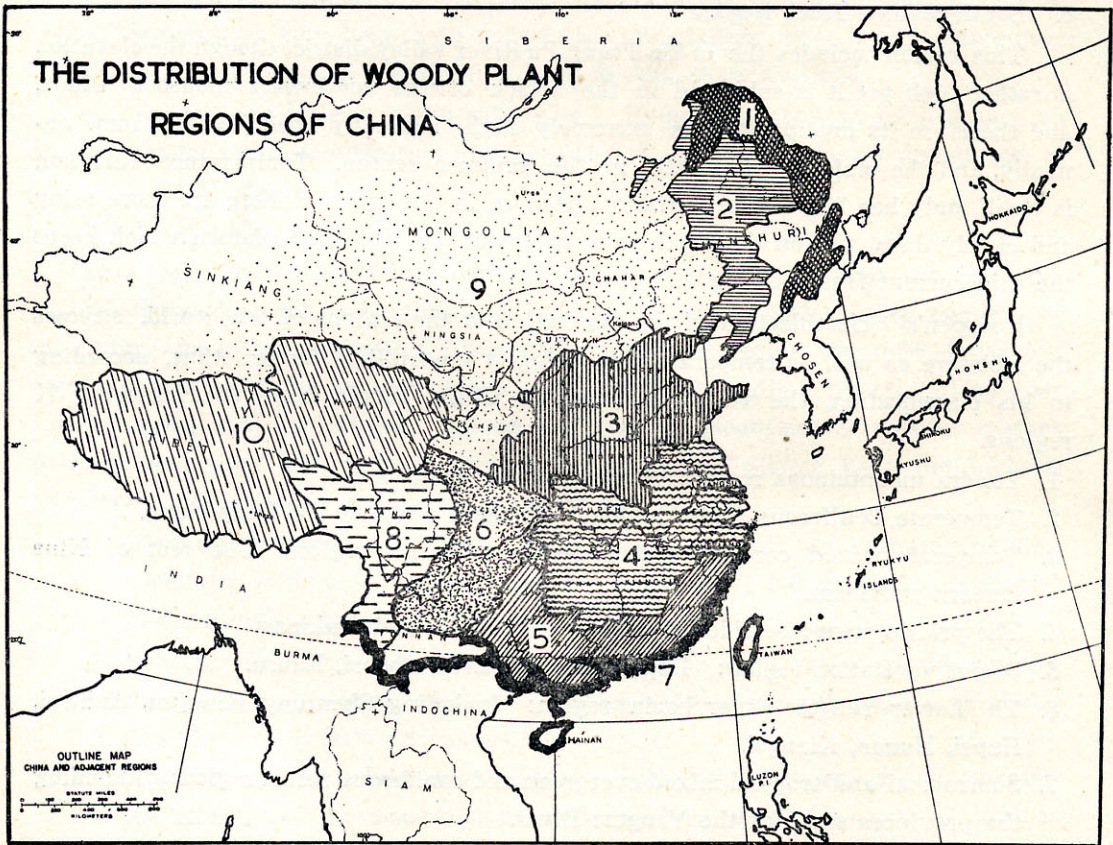
Borchert's modification of Koepp's work divides China into three main climatic regions.

1. South China: Warm rainy climate, with long hot summers and mild winters, which equals Koeppen's Type. C.

- 2. North China: Cold and rainy, Koppen's Type D, with short summers and severe winters.
- 3. Central Mongolia and the Sinkiang desert Type B.

SUMMARY

Based upon the prevalent number of species and varieties of trees and important shrubs occurring in different regions and the characteristic growth habit of woody plants in various habitats and correlating them to the climatic, edaphic, especially soil condition, and biotic factors of the country, the woody plants of China may be divided into the following eight regions (and two grassland regions):



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| 1. THE NORTH-EAST MONTANE CONIFEROUS FOREST REGION | 6. THE UPPER YANG-TZE RIVER EVERGREEN FOREST REGION |
| 2. THE NORTH CHINA BOREAL CONIFEROUS AND DECIDUOUS MIXED FOREST REGION | 7. THE OCEANIC SUB-TROPICAL EVERGREEN AND TROPICAL RAIN-FOREST REGION |
| 3. THE NORTH CHINA DECIDUOUS FOREST REGION | 8. THE SIKONG-YUNNAN EVERGREEN BROAD-LEAVED FOREST REGION |
| 4. THE CENTRAL CHINA LAUREL-FAGACEAE FOREST REGION | 9. THE MONGOLIAN DESERT AND GRASSLAND REGION |
| 5. THE SOUTH CHINA SUB-TROPICAL EVERGREEN AND DECIDUOUS MIXED FOREST REGION | 10. THE TSIN-TSANG GRASSLAND REGION |

1. The North-east Montane Forest Region.
2. The North China Boreal Coniferous and Deciduous Mixed Forest Region.
3. The North China Deciduous Forest Region.
4. The Central China Laurel-Fagaceae Forest Region.
5. The South China Sub-tropical Evergreen and Deciduous Mixed Forest Region.
6. The Upper Yangtze River Evergreen Forest Region.
7. The Oceanic Sub-tropical Evergreen and Tropical Rain Forest Region.
8. The Sikong-Yunnan Evergreen Broad-leaved Forest Region.
9. The Mongolian Desert and Grassland Region.
10. The Tsin-Tsang Grassland Region.

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