ZONATION OF EXTANT VEGETATION IN JAPAN

Paleoclimatologic inferences from Tertiary plants can be made from two distinct lines of reasoning, the floristic and the physiognomic. The floristic methodology involves deternination of taxonomic composition of a fossil assemblage and then inference of paleoenvironmental parameters from the presumed ecologic tolerances of most related extant taxa. This methodology depends on accuracy of taxonomic determination and unchanged climatic tolerances through Tertiary time.. Most of late Tertiary floras from Japan generally shows a close similarity to the modern vegetation of central Japan and to the central China: the fossil floras are composed mainly of temperate and/or some relict plants whose living allied species are distributed mainly in central Japan and central China. Indeed, among the 188 species described in this paper, all the fossil species are most allied to living species of Japan, except for Chinese 22 species, North American 3 species and a single Central Asian species. The distribution of the extant related taxa is, therefore, useful for paleoenvironmental inferences of fossile floras later discussed in detail. It may need that the forest zonation of Japanese Islands and its climatic relationships are outlined here.

The forest types of Japan and areas occupied, altitudinal and latitudinal, have been discussed by many botanists, based on the floristic, physiognomic and phytosociologic charcteristics and some temperature parameters. As shown in the comparison of the classification of Japanese forest zones that were proposed by principal authors (Table 1), the forests of northern region or high altitudes are not greatly different in definition, although no agreement has yet been for each zone name. The diverse opinions, however, are concentrated in the division beween the warm temperate to cool temperate zones. The discrepancy of the division of the temperate forests in Japan seems to be due to fact that each author gives more weight to physiognomic or phytosociologic characteristics and any weight to the application to the altitudinal zonation. The classification of the vegetation of East Asia including Japanese Islands was described by Wang (1961) and Wolfe (1979). It is inferred that Japanese vegetation between the cool temperate and warm temperate forest zones may lack some distinct forest types of Mainland China that were defined by Wolfe.

I temporally use seven zones for the forest distribution mainly in Japanese Islands, from 1 to 7, as shown in Table 1. Zone 1 corresponds to the subtropical forest zone by many workers. It ranges from 25°C to 20°C in mean annual temperature. Zone 2 and 3 are equivalent to the warm temperate forest zone by many workers (except Miyawaki, 1984), and correspond to a part of the evergreen broad-leaved forest zone ranging from 20°C to about 12° C in the mean annual temperature. Zone 2 is correlated with the region originally supported by *Castanopsis-Machilus* forest. The zone 3 is equivalent to the regions originally covered by evergreen oak forests and a part of the so-called meditemperate forest zone having evergreen broad-leaved trees. Zone 4 and 5 are equivalent to the Summer green forest zone (Miyawaki, 1984). The zone 4 ranges from the upper part of the so-called meditemperate forest zone to the lower part of beech forest; in the former the evergreen broad-leaved plants are mostly represented by small trees or shrubs, while the warm temperate taxa are sparse or absent in the latter. The zone 5 is equivalent to the upper region of the cool temperate forest zone. The mean annual temperature ranges from about 12°C to 10°C–8°C in the zone 4, and about from 10°C–8°C to 5°C in the zone 5. Zone 6 is equivalent to so-called subalpine forest zone ranging about 5°C to 0°C in mean annual temperature. Zone 7 corresponds to the alpine or tundra zones designated by many workers.

Table 1. Forests Zones of Japan and their altitudinal and Latitudinal Distribution (modified from Hotta, 1974)

Author	High Altitude or North ← Forest Zone → Low Altitude or South						
Tanaka, J. (1887)	*Pinus pumila*-zone	*Abies veitchii*-zone	*Fagus crenata*-zone	Intermediate-zone	*Pinus thunbergii*-zone	Mangrove-zone	
Honda, S. (1912)	Arctic forest		Temperate forest		Subtropical forest	Tropical forest	
Nakano, H. (1942)		Subarctic forest	Cool temperate forest		Warm temperate forest	Subtropical forest	
Kira, T. (1953, 1976)	Tundra	Evergreen needle-leaved forest	Deciduous broad-leaved forest	Warm temperate deciduous broad-leaved f. Lucidophyllous forest		Subtropical seasonal & rain forest	
Suzuki, T. (1961)	Alpine forest	Subarctic forest	Cool temperate forest	Meditemperate forest	Warm temperate forest	Subtropical forest	
Horikawa, Y. (1968)	Alpine desert	Mountain coniferous forest	Deciduous broad-leaved forest	Mediconiferous forest	Evergreen broad-leaved forest		
Yoshioka, K. (1973)	Alpine vegetation	Subalpine (Subarctic) coniferous forest	Northern Mixed coniferous & Deciduous broadleaved forest	*Abies firma*-*Tsuga sieboldii* forest	Evergreen broad-leaved forest		
Yamanaka, T. (1979)		Subarctic forest	Cool temperate forest	Meditemperate forest	Warm temperate forest	Subtropical forest	
Miyawaki, A. (1984)	Alpine Vegetation belt	Subalpine and subarctic conifer-forest (Vaccinio-Piceetea region)	Summergreen broad-leaved forest (Fagatea crenatae region)	Evergreen broad-leaved forest (Camellietae japonicae region)			
Wolfe, J. A. (1979, '85)		Mixed coniferous forest	Mixed northern hardwood forest	Mixed Mesophytic forest Mixed broad-leaved evergreen & coniferous f.	Notophyllous broad-leaved evergreen forest	Paratropical rain forest	
This paper	7	6	5	4	3	2	1
Mean annual temperature (°C)		0	(5)	8-10	12	13-14	20
Warmth Index		*15*	*45*	*85*		*100*	*180*

1 : Subtropical forest zone 2 : Lower warm temperate forest zone 3 : Upper warm temperate forest zone 4 : Lower cool temperate forest zone
5 : Upper cool temperate forest zone 6 : Subalpine forest zone 7 : Alpine forest zone