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Some similarities in the climates and vegetation of Central Honshu and Central Eastern North America

Einige Ähnlichkeiten der Klimate und Vegetationen von Mittel-Honshu und dem mittleren Osten Nordamerikas

by

Elgene O. Box

1. INTRODUCTION

Due to the early and continuing influence of European botanists and geographers, the climates and vegetation of Japan have often been compared with those of Europe (e.g. MIYAWAKI 1960, HAEMET-AHTI et al. 1974). Because of the regularities of global atmospheric circulation, however, there is probably greater climatic similarity between East Asia and eastern North America (see MIYAWAKI 1967, WALTER 1968, SCHMITHUESEN

1976, KIRA et al. 1976). In the boreal (subarctic) and maritime cool-temperate zones to the north, vegetation similarities are strong between all three regions, despite the higher latitudes in Europe. To the south, the East Asian evergreen broad-leaved forests have been called "laurel forest" by Europeans and compared with the Mediterranean forests of Europe. In the south, however, East Asia and eastern North America have corresponding sequences of humid warm-temperate and then subtropical climates and vegetation at similar latitude, while Europe (plus North Africa) diverges into mediterranean climate with increasing summer dryness and more xeromorphic vegetation, eventually becoming subtropical desert.

Of course, similarities in climate and vegetation between East Asia and eastern North America have been described before (see GRAY 1846; LI 1952; GRAHAM 1972a, b; WOLFE 1979; BOUFFORD and SPONGBERG 1983). Such comparisons have often focused more on the larger East Asian mainland (e.g. Missouri Botanical Garden 1983), but there has also been a continuing, long interest in comparison with Japanese vegetation (e.g. GRAY 1859, 1860; SARGENT 1894; HARA 1952, 1956, 1972; IWATSUKI 1972, KUROKAWA 1972, KATO and IWATSUKI 1983). Nevertheless, though often quite good, comparisons between East Asia and North America have largely concentrated on taxon evolution and biogeography, with only more general, somewhat unsynthesized observations of similarity in climate or vegetation structure. Also, North America has not done the phytosociological or other detailed, descriptive vegetation analysis which has been done in Japan and which is necessary for more detailed vegetation comparison with East Asia.

No single paper can fill these gaps. This paper seeks only to provide a short but integrated comparison of similar climate and vegetation types between that part of Japan visited during the 18th IPE, namely central Honshu, and the corresponding part of eastern North America, as a basis for further work. Although Japan and eastern North America show strong natural similarities throughout, the natural similarity is perhaps greatest in precisely the region visited by the 18th IPE. In treating the vegetation, the emphasis is on zonal and azonal vegetation types, structure, and environmental relationships. Since a consistent basis for comparing the two regions is needed, some important but perhaps more local or specialized literature must be overlooked in favor of more general treatments.

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2. ENVIRONMENTAL SIMILARITIES

The relative locations of Honshu and the corresponding part of eastern North America (west to about 85°W) are shown in Figure 1. One can immediately note the following similarities:

- Both Honshu and the eastern USA are oriented from NNE to SSW with an east coast facing the open ocean and a long mountain chain.
- The mountains in both regions run from NNE to SSW, parallel to the (east) coast; some peaks also are high enough for alpine belts, but only in the north.
- The oceanic coastlines of both regions run N to S in the north, but change at about 36°N to a NE-SW orientation, facing the hurricanes/typhoons of late summer.

Of course, North America is a much larger land mass, extending 4000 km westward. The western slopes of the Appalachians, however, are influenced by wetter air from the Great Lakes in the north and the Gulf of Mexico in the south, somewhat like the influence of the Sea of Japan on the west side of Honshu.

Some climatic similarities are also obvious, but one should perhaps note the following in particular:

- Both regions have essentially humid forest climates throughout, with four distinct seasons and ample summer rainfall.
- Both regions show the normal north-south sequence of east-coast climates; the parts treated herein involve mainly typical temperate climates in the north and warm-temperate climates along the coastal areas to the south.

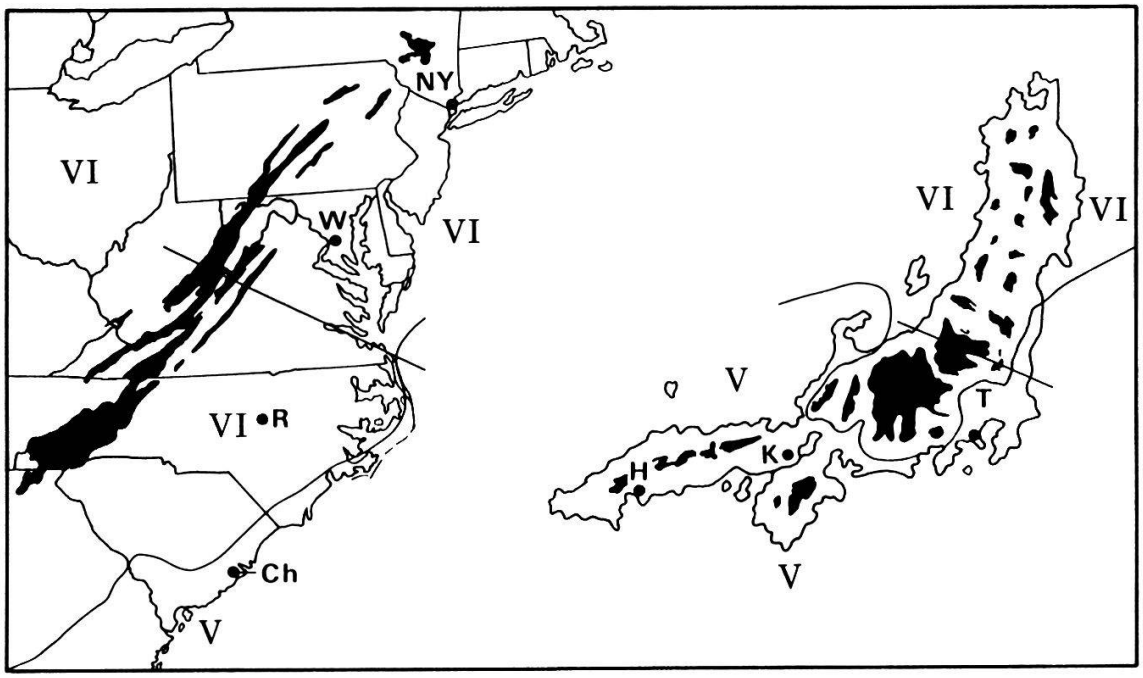

Fig. 1. Relative locations of Honshu and central eastern North America.

Honshu and central eastern North America are projected side by side, at corresponding latitudes, in order to suggest their environmental similarities. Both regions have mountains (solid black) and eastern coastlines with similar latitudinal range and NNE-to-SSW orientation. Honshu and central eastern North America involve primarily two climate types (sensu WALTER and LIETH 1960-1967), shown by Roman numerals and the boundary lines:

1. a typical temperate region (VI), covering northern and interior central Honshu and the eastern USA; and
2. a warm temperate region (V), covering southern Honshu and a relatively narrow coastal strip in the southeastern USA.

The main climatic differences involve Japan's extremely maritime climates (with a west coastline). Nevertheless, one can note particular similarities between Kanto and coastal North Carolina, between western Honshu and Georgia - South Carolina, between Tohoku (northern Honshu) and Pennsylvania - New York, and between the Japanese mountain chain and the Appalachians.

The straight lines across central Honshu and Virginia - West Virginia represent the locations of the vegetation profiles shown in Fig. 2.

Locations shown:

Ch = Charleston (South Carolina)
R = Raleigh (North Carolina)
NY = New York
W = Washington
H = Hiroshima
K = Kyoto
T = Tokyo-Yokohama

Abb. 1. Honshu und das mittelöstliche Nordamerika sind auf den entsprechenden Breitegraden einander gegenübergestellt, um die klimatischen Aehnlichkeiten aufzuzeigen.

Beide Regionen weisen Gebirgsketten auf (schwarz) und östliche Küstenstreifen (NNE-SSW orientiert). Honshu und der mittlere Osten Nordameri-

kas haben zwei Haupt-Klimatypen (mit römischen Zahlen bezeichnet, im Sinne von WALTER und LIETH 1960-1967):

1. Eine nemorale Zone (VI) in Nord- und Zentral-Honshu bzw. im mittleren Osten Nordamerikas; und
2. Eine warmtemperierte Zone (V) in Süd-Honshu bzw. im schmalen Küstenstreifen im Südosten Nordamerikas.

Die Klimate Japans unterscheiden sich von denjenigen Nordamerikas hauptsächlich durch den starken Einfluss des Pazifischen Ozeans bzw. des Japan-Meeres. Besondere Aehnlichkeiten sind erkennbar zwischen Kanto und dem Osten Nordkarolinas, zwischen West-Honshu und Georgia-Südkarolina, zwischen Tohoku (Nord-Honshu) und Pennsylvania - New York, und zwischen der japanischen Bergkette und den Appalachen.

Die geraden Linien durch Zentral-Honshu und Virginia-West Virginia beziehen sich auf die Vegetationsprofile in Abb. 2.

The largest climatic difference follows from the much larger size of North America, with no maritime influence to the west. Thus, Japan has very maritime climates throughout, while eastern North America has rather continental climates all the way to the east coast (see CURREY 1974). In general, Japan has about 50% more precipitation per year than do comparable areas of eastern North America. As a result, the Japanese climates have less severe winters than in North America, except on Hokkaido in the north. The more maritime typical-temperate climate in Japan has often been called cool-temperate (e.g. KIRA 1949, NUMATA et al. 1972, SHIDEI 1974), but summers can be quite warm, even in southern Hokkaido. An attempt to summarize similarities and differences between the parallel climatic zones in Japan and eastern North America is given in Table 1.

In addition, both regions receive westerly winds (wetter western slopes, especially in winter), a winter monsoon effect with heavy snowfall (Japan Sea coast vs. southern shoreline of Great Lakes), and receive typhoons (Japan) or hurricanes (SE USA) in late summer. Japan, however, has few if any tornadoes, and eastern North American has no true summer monsoon effect. Climatic and bioclimatic classifications in Japan have been offered by FUKUI (1933), KIRA (1945), SEKIGUCHI (1959), NUMATA and MITSUDERA (1969), YOSHINO (1980), and others. A good national climatic atlas is also available (Japan Meteorological Agency 1984).

In addition to climate, one can also note a somewhat similar sequence of soils in the two regions, from boreal podzols in the north through brown forest soils to red-yellow podzolic clays in the south. Perhaps the most widely used Japanese soil classifications are based on KANNO (1953).

Soil maps have been presented by KAMOSHITA (1958), the Environment Agency (1982), and others. The correspondence of soils between Japan and eastern North America is confounded, however, by two important differences:

- Eastern North America has a much wider coastal plain, at least in the south, with large areas of geologically young coastal sand as well as more localized but important areas of histosols.
- Eastern North America has no recent volcanoes and little if any volcanic soil, whereas volcanic soil is very important and extensive in Japan.

Due to its larger size, eastern North America also has a much greater extent of relatively zonal soils on the level terrain.

Two bioclimatic differences are perhaps of greatest importance. The extra precipitation in Japan, distributed more evenly by the more maritime Japanese situation, greatly reduces the frequency and duration of

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Table 1 (p. 147). Overview of climate types in Central Japan and eastern North America.
The genetic climate types of H. WALTER (e.g. WALTER and LIETH 1960-1967; WALTER 1968) are used as a framework, with occurrences in Central Japan and eastern North America described in parallel columns. In general, the climates of Japan represent perhumid, maritime variations while the climates of eastern North America are more typical, i.e. continental toward the interior, with only a narrow maritime strip along the coast. Especially in the south (warm-temperate region), the climate of eastern North America is subcontinental right up to the east coast, with perhaps higher winter mean temperatures but often much lower nighttime extremes than at comparable latitudes in Japan. As a result, deciduous trees remain important components of the potential matural vegetation much further south in the USA than in Japan. Note that the warm-temperate montane/alpine situation does not occur in eastern North America (though perhaps in northeastern Mexico).

Tab. 1 (S. 147). Vergleichende Uebersicht der Klimatypen in Mittel-Honshu und im östlichen Nordamerika.
Die genetischen Klimatypen von H. WALTER (z.B. WALTER und LIETH 1960-1967, WALTER 1968) bilden den Rahmen, innerhalb welchem die eigentlichen Vorkommen in Mittel-Honshu und im östlichen Nordamerika parallel dargestellt werden. Im allgemeinen sind die japanischen Klimate perhumide, maritime Varianten, während die amerikanischen Klimate dem Typ eher entsprechen, d.h. kontinental im Innern, mit einem schmalen, maritimen Küstenstreifen. Im östlichen Noramerika ist das Klima vor allem im Süden (warmtemperierte Zone) subkontinental bis zur Ostküste (mit höheren Mitteltemperaturen im Winter aber viel tieferen Temperaturen in der Nacht als in den gleichen Breitengraden in Japan. Infolgedessen sind laubwerfende Bäume in den USA wichtige Bestandteile der potentiellen natürlichen Vegetation bis weiter südlich als in Japan. Bemerkenswert ist, dass die warmtemperierten montanen und alpinen Stufen im östlichen Nordamerika nicht vorhanden sind (ausser vielleicht im nordöstlichen Mexiko).

Table 1.

Climate type (WALTER)	Regional climatic characteristics: Central Japan	Regional climatic characteristics: Eastern North America	Zonation vegetation type
warm-temperate (V)	perhumid: - typical maritime type (Pacific side) - winter-monsoon type (Japan Sea side)	subcontinental (coastal SE USA)	evergreen broad-leaved and mixed forests
montane	mountains similarly perhumid	-	mainly evergreen mixed forest with special conifers
typical temperate (VI)	perhumid: - typical maritime type (Pacific side) - winter-monsoon type, with heavy snowfall (Japan Sea side)	typical: subcontinental to continental (most of interior eastern USA)	deciduous broad-leaved forests
temperate montane (VIII/X)	wet montane (Japan Alps, etc.)	typical temperate-montane (N and S Appalachians)	evergreen conifer forests (deciduous woodlands in maritime areas)
alpine	wet alpine (Japan Alps, etc.)	typical temperate alpine (N Appalachians)	alpine heaths and "tundra", treeline krummholz

droughts in Japan, in comparison to more continental eastern North America. In addition, the maritime Japanese climate greatly reduces the degree and duration of extreme winter cold. January monthly mean temperatures (at similar latitudes and elevations) are similar throughout the two regions, perhaps even higher in eastern North America. Nighttime low temperatures, however, are generally much lower in eastern North America. Even if the lowest temperatures (e.g. -15° to -20°C in interior Georgia in 1985) occur for only a few days and not every year, they are sufficient to exclude subtropical and most warm-temperate evergreen species, except in narrow, moderated coastal strips.

Thus, the warm-temperate (evergreen) region in eastern North America appears to end further south (36°N) and at a higher January mean temperature of about 5-6°C in North America, as compared with about 3°C in eastern China (near Shanghai) and about 0.5°C in Japan (near Sendai, at 38°N). In Japan, the lowest temperatures recorded since 1931 are, for example, only -8.1°C at Kyoto, -6.8°C at Yokohama, and still only -11.7 °C at Sendai (Japan Meteorological Agency 1984). Mean January nighttime minima for lowest individual years (since 1931) at these sites are only -3.4° at Kyoto, -3.1° at Yokohama, and -7.1° at Sendai. At Charleston (33°N), on the South Carolina coast, by comparison, the lowest temperature recorded (before 1985) was -13.9°, with a mean January nighttime minimum (averaged over 75 years) of +6.1° (MUELLER 1982). At inland Atlanta (33.6°N, 308 m elevation), the corresponding values are -22.2° and +1.7°C.

Some attempts to relate Japanese and adjacent vegetation zones to climate have been made, notably by KIRA (1945, 1949, 1977), HAEMET-AHTI et al. (1974), YIM and KIRA (1975-1976), YIM (1977), YOSHINO (1978), NUMATA (1979, pp. 35-42), WOLFE (1979), and others. Similar attempts have been made in eastern North America by MERRIAM (1898), LIVINGSTON and SHREVE (1921), SAWYER and LINDSEY (1964), MATHER and YOSHIOKA (1966), LINDSEY and SAWYER (1971), and others. Successful comparison of vegetation zones and environmental relationships in Japan and eastern North America requires applying the same climatic system to both regions. This has been done for the higher latitudes by TUHKANEN (1984). The attempt by BOX (1981) to relate plant types to mean climatic conditions worldwide did not work well in Japan, due to Japan's extremely maritime climates.

3. FLORISTIC SIMILARITIES

Floristic similarities, including the evolutionary development and historical biogeography of the East Asian and North American floras, represent a major focus of botanical work comparing East Asia and eastern North America. Table 2 provides an overview of important common and non-common genera in the two regions. The genera are grouped by plant growth forms in order to provide a more graphic image of potential vegetation structure in the two regions. More detailed comparison of similar vegetation types, including ecological as well as phytosociological structure, will require stratified comparison by plant types as well as by taxonomic units. More complete treatments of floristic biogeography, evolutionary history, common and non-common taxa have been presented by HARA (1952-1956, 1972), LI (1952-1972), GRAHAM (1972a), GOOD (1974), WU (1983), and the Missouri Botanical Garden (1983).

Table 2 (p. 150). Some important common and unique native genera in Central Japan and eastern North America.
Important common and non-common genera are listed by plant growth form, usually with seasonal habit (evergreen vs. deciduous). No attempt is made to include all genera. Unique genera naturalized successfully in the other region are denoted by asterisks. The number of important genera common to the two regions is quite large, especially as compared to the number of non-common genera. In general, Japan shows more regionally endemic genera than does eastern North America, especially among the deciduous Angiosperm trees, evergreen shrubs, evergreen conifers, and bamboos. In some cases it was not yet possible to classify non-common examples, due to insufficient information on seasonality. Main sources include: BROCKMAN (1968), ELIAS (1980), GOOD (1974), GRAHAM (1972), HARA (1959), HORIKAWA (1972-1976), LI (1952), OHWI (1965), RADFORD et al. (1968).

Tab. 2 (S. 150). Wichtige gemeinsame bzw. nicht gemeinsame Gattungen in Mitteljapan und im mittelöstlichen Nordamerika.
Wichtige gemeinsame bzw. nicht gemeinsame Gattungen sind nach Wuchsform (nach Möglichkeit mit jahreszeitlichem Habitus, d.h. immergrün bzw. laubwerfend) geordnet. Es war unmöglich alle Gattungen zu erfassen. Gattungen, die im anderen Gebiet naturalisiert sind, sind mit einem Stern (*) bezeichnet. In Japan gibt es mehr regional endemische Gattungen als im östlichen Nordamerika (besonders bei den laubwerfenden Bäumen, immergrünen Sträuchern, immergrünen Koniferen und Bambus-Gräsern). Wichtigste Quellen sind: BROCKMAN (1968), ELIAS (1980), GOOD (1974), GRAHAM (1972), HARA (1959), HORIKAWA (1972-1976), LI (1952), OHWI (1965), RADFORD et al. (1968).

Table 2.

Plant type	Common to both regions	Japan only	Eastern N America only
Trees			
broad-leaved evergreen	Persea (= Machilus), Quercus, Ilex, Osmanthus	Castanopsis, Cyclobalanopsis, Cinnamomum, Eurya	Gordonia
broad-leaved deciduous	Quercus, Fagus, Acer, Tilia, Alnus, Betula, Sorbus, Salix Malus, Prunus, Fraxinus	Zelkova, Kalopanax, Chosenia, Toisusu, Disanthus, Cercidiphyllum, Euptelea	Liriodendron, Carya, Robinia, Planera
conifers (evergreen)	Abies, Picea, Pinus, Chamaecyparis, Tsuga, Thuja, Juniperus	Cryptomeria, Thujopsis, Sciadopitys, Podocarpus	-
conifers (deciduous)	Larix	-	Taxodium
tuft-trees	-	Livistonia	Sabal
Shrubs and other scrub			
broad-leaved evergreen	Rhododendron, Vaccinium, Myrica, Symplocos, Ilex, Euonymus	Camellia, Aucuba, Skimania, Fatsia, Pittosporum, Ligustrum*	Ceratiola, Cyrilla, Hudsonia, Leiophyllum
broad-leaved deciduous	Vaccinium, Rhododendron, Viburnum, Rosa, Rhus, Rubus	Oplopanax, Tripetaleia, Corylopsis, Rhodotypos	Amorpha, Baccharis, Fothergilla
conifer krummholz	Abies, Juniperus, Picea	Larix, Taxus, Pinus	-
rosette-scrub	-	Cycas	Serenoa, Yucca

Plant type	Common to both regions	Japan only	Eastern N America only
Graminoids			
tall bamboo	-	Phyllostachys, Pleioblastus	-
short bamboo	Arundinaria	Sasa, Sasamorpha	-
grasses	Phragmites, Muhlenbergia, Cynodon, Festuca, Poa	Miscanthus*	Uniola
sedges, rushes, etc.	Carex, Cyperus, Scirpus, Rhynchospora, Typha	Machaerina	Dichromena
Forbs			
evergreen	Pyrola, Chimaphila	Alpinia, Liriope, Schizocodon	Sarracenia, Dionaea
geophytes	Narcissus, Iris, Lilium	Brachycyrtis, Hosta	Pleea
seasonal forbs	Oxalis, Viola, Urtica, Ranunculus	Anemonopsis, Caryopteris, Adenophora	Baptisia, Macbridea
Compositae	Artemisia, Bidens, Senecio, Erigeron	Ainsliaea, Pertya	most Solidago spp., Palafoxia, Silphium
Succulents			
stem-succulents	-	-	Opuntia
Vines and lianas			
evergreen vines	Smilax, Hedera, Ficus	Kadsura	Gelsemium
deciduous vines	Wisteria, Vitis, Rhus	Akebia, Lonicera*, Pueraria*	Campsis
Ferns			
ground ferns	Dryopteris, Asplenium, Osmunda	Angiopteris, Microlepia	?

* successfully naturalized in other region

4. VEGETATION STUDIES IN JAPAN

The vegetation of Japan can be described generally in terms of three main zones: evergreen conifer forests in the subarctic and higher mountains, deciduous broad-leaved forests in the typical and cool-temperate zone, and evergreen broad-leaved forests in the warm-temperate and subtropical south (e.g. NUMATA et al. 1972, MIYAWAKI 1967, 1979). These three main divisions, plus an alpine region, have been formalized phytosociologically as evergreen Camellietea japonicae, summergreen Fagetea crenatae, and largely coniferous Vaccinio-Piceetea japonicae regions (MIYAWAKI 1979, 1984). The composition of the evergreen broad-leaved forests suggests a distinction between warm-temperate forests (Kyushu, Shikoku, southern Honshu) and subtropical forests in the Ryukyu Islands (e.g. FUJIWARA 1981-1983, 1985). Counting the alpine region (but excluding the subtropical), this makes four distinct vegetation regions on Honshu.

Not only general regions but also successional and areal patterns and finer vegetation units have been studied in great detail. Such studies include the very detailed, ten-volume Vegetation of Japan series (MIYAWAKI 1980-1987) and detailed studies of individual types (e.g. NAKANO 1942-1943, OSHIMA 1961-1962, OHBA 1969, MIYAWAKI and FUJIWARA 1970, MAKITA et al. 1979, OKUDA 1979, FUJIWARA 1981-1983, OHNO 1983; see also MIYAWAKI and OKUDA 1979). Many of the more detailed vegetation studies are phytosociological in nature, reflecting the strong European influence on Japanese botany. Other work shows a more environmental or "functional" approach comparable to that of E.P. Odum, H. Walter or present-day ecosystem ecology (e.g. NUMATA 1965, 1976; OGAWA et al. 1965-1969; SHIDEI and KIRA 1977, HAYASHI 1984). Phenological work is currently very well developed (e.g. HAYASHI 1971, WATANABE 1979, NAKAGOSHI 1985). A recent geographic study of spring foliation phenology in eastern North America (WICKHAM 1984) would make a good basis for comparative phenology between Japan and eastern North America. Of course, the modern manuals and maps of the Japanese flora, in English (e.g. HARA 1959, OHWI 1965, HORIKAWA 1972-1976) and in Japanese, are excellent and indispensable.

On the one hand, the "ecological" studies perhaps provide more immediate information on vegetation structure, function, and environmental relationships. Phytosociological description, on the other hand, provides a consistent basis for geographic comparison, both locally and with other

regions. These two approaches could be integrated, in all parts of the world.

5. VEGETATION TYPES IN HONSHU AND EASTERN NORTH AMERICA

For an initial comparison of vegetation types and structure in Japan versus eastern North America, an ecological basis perhaps provides the best framework, especially if it includes more general aspects of vegetation structure. For Japan this is provided nicely by the Flora and Vegetation of Japan, expertly edited by NUMATA (1974) so that the individual contributions form a unified whole, with minimal overlap or variation in definition of vegetation units. Less complete descriptions for eastern North America have been provided by BRAUN (1950), SHELFORD (1963), KNAPP (1965), KUECHLER (1964), BAILEY (1978), DAUBENMIRE (1978), and VANKAT (1979). Individual regions have been treated by WELLS (1928, 1942), ROWE (1972), WHARTON (1978) and others.

The four main vegetation regions of Honshu also occur in eastern North America, with the same north-south sequence. The main difference in vegetation zonation seems to be that North America, with its larger land area, has two wide bands of transitional mixed forest which are not as well developed in Japan. These occur between the boreal and temperate zones in the north and between the temperate and warm-temperate evergreen zones in the south, as described below.

An attempt to organize and juxtapose comparable vegetation compositions in central Honshu and central eastern North America, based on the framework of NUMATA (1974), is shown in Table 3. This initial comparison involves all four main vegetation zones: warm-temperate evergreen, temperate deciduous, montane conifer belts, and alpine vegetation. An initial comparison of mountain vegetation types, including the East Asian mainland, has been attempted elsewhere (BOX 1986 and in press). In addition, representative vegetation profiles across central Honshu and eastern North America, at about 37°N latitude, are shown in Figure 2.

In the typical temperate zone, deciduous forests cover the largest area in eastern North America and are widespread also in central Japan, especially since deciduous forests commonly arise as substitute communities following the destruction of evergreen broad-leaved forests. The zonation of deciduous forest types in Japan is dictated by the mountains,

which divide Honshu into a more typical-temperate Pacific side and a winter-monsoon Japan Sea side, with heavy snowfall and a wetter climate overall (see, for example, SHIDEI 1974; MIYAWAKI 1979, 1984). In eastern North America the zonation is influenced by the Appalachians but perhaps more by the less perhumid conditions overall and by increasing continentality westward. The wettest areas, in the Allegheny and Cumberland plateau region on the windward west side of the Appalachians (Ohio, West Virginia, Pennsylvania, eastern Kentucky), show "mixed mesophytic forests" (BROWN 1950) which are very similar to the Fagus-dominated forests of Honshu, especially on the Pacific side. A somewhat less species-rich "beech-maple" (Fagus-Acer) region is found somewhat to the west but

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Table 3 (p. 155). Preliminary summary of corresponding natural vegetation types in central Japan and central eastern North America.
The regeneration classification is quite general, based on the system presented for Japan by NUMATA (1974) with only minor modifications and some additions for North America. Similar compositions, at the genus level, can be found in the two regions for most of the vegetation types listed. Dissimilar types involve mainly the more continental North American interior and the wide American coastal plain (with extensive coastal wetlands). Further comparison will require more systematic vegetation analysis, mainly in North America. Main vegetation references for Japan include FUJIWARA (1981-1983), HARA (1959), HORIKAWA (1972-1976), MIYAWAKI (1967, 1979, 1980-1987, 1984), MIYAWAKI and OKUDA (1979, 1984), NUMATA et al. (1972), NUMATA (1974). Materials for North America include mainly BRAUN (1950), BROCKMAN (1968), DAUBENMIRE (1978), ELIAS (1980), KUECHLER (1964), LIETH et al. (1979-1981), MONK (1968), PENFOUND (1952), QUARTERMAN and KEEVER (1962), RADFORD et al. (1968), ROWE (1972), WELLS (1928, 1942), WHARTON (1978), WHITTAKER (1956).

Tab. 3 (S. 155). Vorläufige Zusammenfassung gemeinsamer natürlicher Vegetationstypen in Mitteljapan und im mittelöstlichen Nordamerika.
Die Vegetationsgliederung ist sehr allgemein und basiert auf dem System von NUMATA (1974), mit kleinen Aenderungen und einigen zusätzlichen Einheiten für Nordamerika. Für die meisten aufgelisteten Vegetationstypen treten in den beiden Regionen ähnliche Zusammensetzungen auf. Nicht ähnliche Typen kommen vor allem im kontinentaleren Innern Nordamerikas und in den ausgedehnten Sumpfgebieten der amerikanischen Küstenebene vor. Vor allem in Nordamerika aind für genauere Vergleiche weitere pflanzensystematische Untersuchungen notwendig. Wichtige Quellen für Japan sind FUJIWARA (1981-1983), HARA (1959), HORIKAWA (1972-1976), MIYAWAKI (1967, 1979, 1980-1987, 1984), MIYAWAKI and OKUDA (1979, 1984), NUMATA et al. (1972), NUMATA (1974). Angaben über Nordamerika machen BRAUN (1950), BROCKMAN (1968), DAUBENMIRE (1978), ELIAS (1980), KUECHLER (1964), LIETH et al. (1979-1981), MONK (1968), PENFOUND (1952), QUARTERMAN and KEEVER (1962), RADFORD et al. (1968), ROWE (1972), WELLS (1928, 1942), WHARTON (1978), WHITTAKER (1956).

Table 3

Forest zones and subtypes	Composition in Central Japan	Composition in eastern N America
Montane belt (typical temperate zone)	Picea jezoensis v. hondoensis, Tsuga diversifolia, Abies veitchii, A. mariesii, with Larix leptolepis and other Picea spp., Ericaceae	N and S Appalachians: Picea rubens, Abies fraseri, with Betula spp., Sorbus americana, Rhododendron, Tsuga canadensis, Vaccinium, etc.
Montane-temperate (transition) mixed forest	N central Honshu: Quercus crispula, Q. dentata, Ulmus davidiana, U. laciniata, Acer mono, Tilia japonica, Abies sachalinensis, Picea	Appalachians ("mixed hardwoods"): Acer saccharum, Betula lutea, B. papyrifera, Tsuga canadensis, Pinus strobus, Picea rubens, Abies fraseri, Rhododendron
Typical temperate zone deciduous forest	N Honshu: Fagus crenata, with Acer, Quercus, Fraxinus, etc. Pacific side: with Sasamorpha, Abies, deciduous shrubs Japan Sea side: with Sasa, creeping "trees", some evergreen shrubs	Allegheny-Cumberland ("mixed mesophytic forest"): Fagus grandifolia, Liriodendron tulipifera, Acer saccharum, Tilia spp., Aesculus octandra, Quercus sp., Tsuga canadensis Ohio Valley - S Michigan ("beech-maple association"): Fagus grandifolia, Acer saccharum, with Tilia, Liriodendron, Tsuga, Quercus, Carya, etc.
Ultra-cool temperate deciduous forest	Upland N Honshu: Quercus crispula, Q. dentata, Ulmus davidiana, U. laciniata, Acer mono, Tilia japonica (without conifers)	NE USA ("northern hardwoods"): Acer saccharum, Betula lutea, B. papyrifera, Tsuga canadensis, Pinus strobus, Fagus grandifolia, Ulmus, Quercus rubra, Tilia

Table 3 (continued)

Forest zones and subtypes	Composition in Central Japan	Composition in eastern N America
Sub-continental deciduous forests (warmer summers but winters still cold)	Interior Honshu: Zelkova serrata, Quercus acutissima, Castanea crenata, Aphanathe aspera, Celtis sinensis, Styrax japonica, Fagus japonica	E and S piedmont: Quercus alba, Q. rubra, Q. vellutina, Carya spp., Pinus spp., with Cornus florida, Cercis canadensis, Ulmus, Fagus, Acer, Celtis, etc.
Continental deciduous forest	(no equivalent: climates too maritime)	Northern Midwest: Quercus macrocarpa, other Quercus spp., Carya spp., Pinus spp.
Cool riverine/wetland forests	N Honshu: Alnus japonica, Salix gracilistyla, S. sachalinensis	NE USA: Alnus rugosa, A. serrulata, Salix nigra, other Salix spp., Populus balsamifera
Edaphic and coastal pine forests	Most areas: mainly Pinus densiflora, sometimes P. thunbergii (especially coastal)	Great Lakes: Pinus banksiana, P. resinosa, P. strobus NE USA: Pinus resinosa, P. strobus E and S piedmont: Pinus taeda, P. virginiana, P. echinata
Temperate-warm temperate (transition) Mixed semi-evergreen forest	Central Honshu (lowland): Quercus, Zelkova, with Fagus, Abies firma, etc.	Southern coastal plain ("southern mixed hardwoods"): Fagus grandifolia, Quercus alba, Q. virginiana (evergreen), Liquidambar styraciflua, Magnolia grandiflora (evergreen), Pinus spp., etc.

Table 3 (continued)

Forest zones and subtypes	Composition in Central Japan	Composition in eastern N America
Warm-temperate zone evergreen broad-leaved/mixed forest	Coastal: Persea thunbergii, Castanopsis cuspidata, with Camellia japonica, Litsea, Eurya, etc. Inland: Quercus gilva, Q. salicina, Q. acuta, Q. glauca, Q. myrsinaefolia, Q. sessilifolia, Castanopsis cuspidata var. sieboldii, Skimmia japonica, with Cinnamomum camphora, Symplocos, Pieris, Cephalotaxus	Coastal: Quercus virginiana, Q. laurifolia, Q. myrtifolia, Persea borbonia, Ilex opaca, I. vomitoria, Gordonia lasianthus, Pinus spp., Magnolia grandiflora, Tillandsia usneoides, Fagus grandifolia (no inland occurrence)
Floodplain forest (coastal plains)	(not wel developed on narrow Japanese coastal plains)	Southern "swamp forests": Taxodium distichum, Persea borbonia, Cyrilla racemiflora, Magnolia, Ilex, Gordonia, etc.
Edaphic pine forests and woodlands	SW Honshu (mainly on granite): Pinus densiflora	SE USA: (mainly on sandy coastal plain): Pinus taeda, P. echinata, P. palustris, P. elliottii
Coastal sclerophyll forests	SW Honshu (especially Setonaikai): Quercus phillyraeoides, with Rapanae, Pittosporum tobira, other broad-leaved evergreen shrubs	SE coast: Quercus virginiana, Q. myrtifolia, Ilex vomitoria, I. glabra, Juniperus virginiana, Serenoa repens
Coastal pine forest	SW Honshu: Pinus thunbergii, with evergreen shrubs	SE USA: Pinus palustris, P. elliottii
Special conifer stands	Abies firma, Tsuga, Cryptomeria, Podocarpus, Sciadopitys, Chamaecyparis	(some remnants of Torreya, Tsuga)

still resembles the Japanese Fagus crenata forests. The heaviest snowfall in eastern North America is along the south shores of Lake Ontario and Lake Erie, where one finds mainly Fagus-Acer and mixed "northern hardwood" forests (Acer, Betula, with Quercus). Of course the conspicuous dwarf bamboo (Sasa, Sasamorpha, etc.) of Japanese deciduous forests is totally lacking in North America.

In interior Honshu and in the subcontinental eastern and southern piedmonts and inner coastal plains of the USA one finds comparable deciduous forests dominated by Quercus spp. The oaks are joined in Japan mainly by Zelkova serrata, Castanea crenata, and other deciduous species, and in the somewhat drier eastern USA mainly by Carya spp. but also Pinus spp. In the American Midwest there are extensive Quercus and Quercus-Carya forests, but these continental forests are more xeric and have no true

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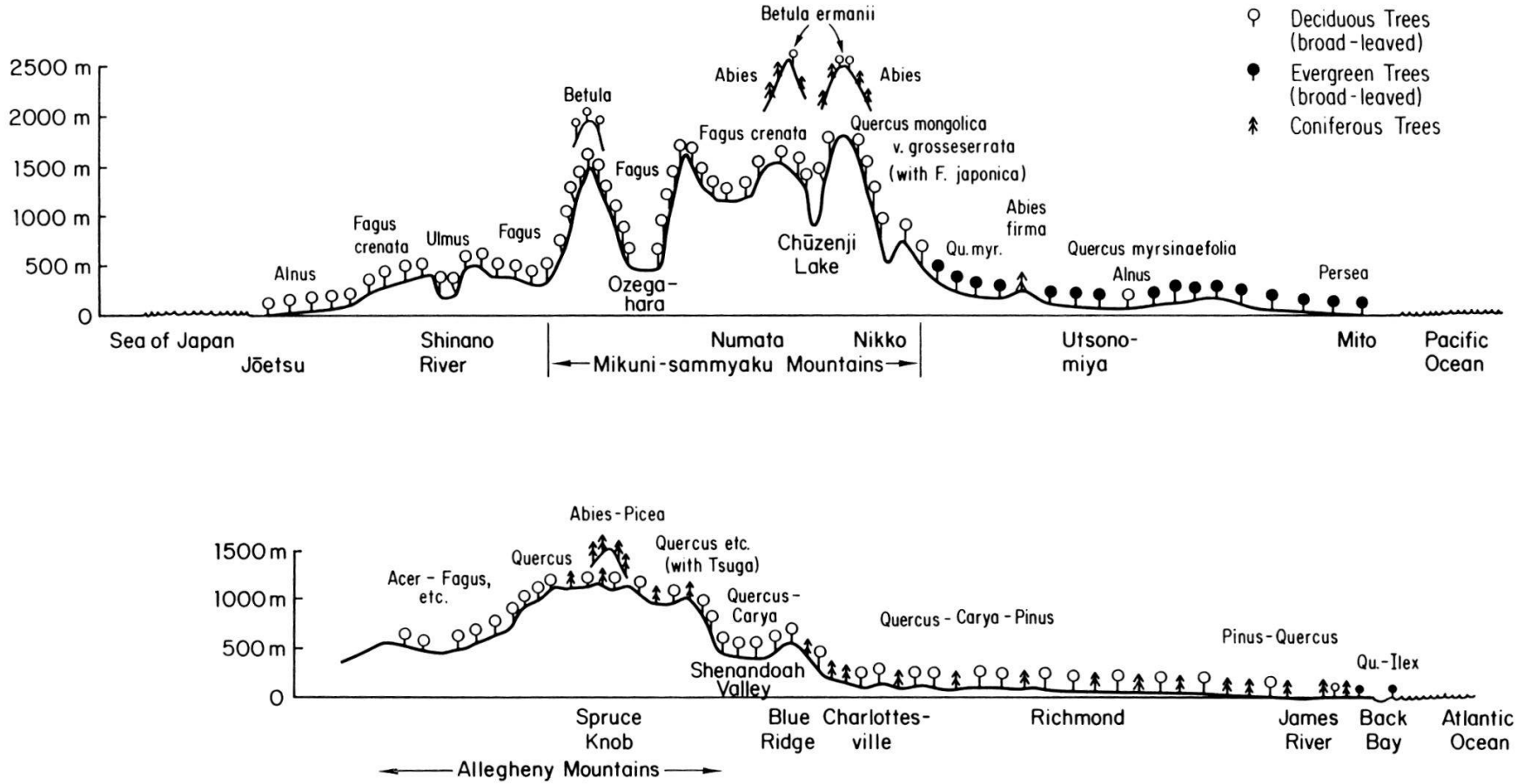
Fig. 2 (p. 159). Representative vegetation profiles across central Honshu and central eastern North America

Both profiles run WNW to ESE, at about 37°N latitude, roughly perpendicular to the main mountain chains (see Fig. 1). Despite the much greater westward extension of North America, comparison of the two profiles can reasonably begin with the Fagus crenata area just west of the Shinano river (Niigate Prefecture) and the Acer-Fagus "mixed mesophytic forest" region on the western side of the Allegheny Mountains (West Virginia). Both regions show rich deciduous forests (Fagus, Acer, etc.) on their windward western slopes, mixed and purely coniferous (Abies, Picea) forests in the higher mountains, somewhat less mesic deciduous (especially Quercus) forests on their leeward eastern slopes, and a region of potential evergreen broad-leaved forest (Quercus, with Persea, etc.) near the east coast. This evergreen region is much less developed in the drier, more continental climate of eastern North America and is replaced over most of the wide American coastal plain (and piedmont) by deciduous Quercus-Carya and more xeric Pinus forests.

Abb. 2 (S. 159). Repräsentative Vegetationsprofile in Mittel-Honshu und im mittleren Osten Nordamerikas.

Beide Profile gehen in WNW-ESE-Richtung, ca. 37°N, senkrecht zu den Bergketten (s. Abb. 1). Trotz der westlicheren Lage Nordamerikas kann der Vergleich der zwei Profile mit dem Fagus crenata-Gebiet westlich des Shinano Flusses (Präfektur Niigate) und dem Acer-Fagus-Gebiet am westlichen Abhang des Allegheny Gebirges (West Virginia) beginnen. Beide Gebiete weisen an den westlichen Luvhängen sommergrüne Laubwälder (Fagus, Acer, etc.) auf, in den höheren Gebirgen Misch- und reine Nadelwälder (Abies, Picea), an den östlichen Leehängen etwas trockenere sommergrüne Laubwälder (vor allem Quercus), und an der Ostküste potentiellen Lorbeer-Wald (Quercus mit Persea, etc.). Dieser immergrüne Lorbeerwald ist weniger üppig im trockeneren kontinentalen Klima im Osten Nordamerikas und wird über weite Flächen der amerikanischen Küstenebene (und dem Piedmont) durch sommergrüne Quercus-Carya- und Pinus-Wälder ersetzt.


Deciduous Trees (broad-leaved)
Evergreen Trees (broad-leaved)
Coniferous Trees
2500 m
2000 m
1500 m
1000 m
500 m
0
Betula ermanii
Abies
Abies
Betula
Fagus crenata
Quercus mongolica v. grosseserrata (with F. japonica)
Fagus
Abies firma
Fagus crenata
Ulmus
Fagus
Alnus
Chūzenji Lake
Qu. myr.
Quercus myrsinaefolia
Alnus
Persea
Ozega-hara
Sea of Japan
Jōetsu
Shinano River
Numata
Nikko
Mikuni-sammyaku Mountains
Utsono-miya
Mito
Pacific Ocean
1500 m
1000 m
500 m
0
Abies-Picea
Quercus etc. (with Tsuga)
Quercus
Acer - Fagus, etc.
Quercus-Carya
Quercus - Carya - Pinus
Pinus-Quercus
Qu.-Ilex
Shenandoah Valley
Spruce Knob
Blue Ridge
Charlottes-ville
Richmond
James River
Back Bay
Atlantic Ocean
Allegheny Mountains

counterpart in Japan. To the north, the Japanese deciduous forests (Quercus, Acer, Ulmus, etc.) and the "northern hardwoods" forests of the northeastern USA are similar in their relative lack of Fagus and inclusion of some conifers, such as Tsuga. Especially wet areas are generally dominated in both regions by Salix, Alnus, and similar scrub. Both temperate regions also have extensive areas of edaphic and/or successional Pinus forests, with North America having more species.

The transition from cool-temperate deciduous to warm-temperate evergreen forests in Japan is marked mainly by the more continental but still deciduous Quercus-Zelkova forests of the interior (without Fagus crenata). KIRA (1949) explains these forests as belonging to the warm-temperate zone in terms of summer warmth but being too cold in winter for evergreen broad-leaved species. This explanation would also fit the large deciduous forest areas of interior southeastern USA, where the concept "warm-temperate" focuses more on winter cold than on summer warmth and should be restricted to the more moderate evergreen areas along the coast. The transition from typical-temperate deciduous to warm-temperate forests in the southeastern USA is marked by a rather broad band of "southern mixed hardwoods" (BRAUN 1950, QUARTERMAN and KEEVER 1962) in which Magnolia grandiflora, Quercus virginiana, Pinus spp., and a few other evergreens join the mainly deciduous forest of Quercus, Carya, Liquidambar styraciflua, and Fagus grandifolia. This transitional area, especially along the southern piedmont-coastal plain boundary, also includes extensive areas of edaphic pinewoods (Pinus), similar to those of southwestern Honshu, except for the flat terrain.

The extensive warm-temperate, evergreen broad-leaved forest zone of Japan has its North American counterpart in relatively narrow, coastal strips along the Gulf of Mexico and the Atlantic Ocean (from Virginia southward), including much of Florida. The closest American equivalents to the more maritime Persea-Castanopsis forests of coastal southern Honshu are found only in the wettest coastal areas, including "bay forests" (Persea, Gordonia, etc.) growing in wet depressions. A better parallel is found between the low sclerophyll forests (Quercus with Ilex and Myrica) of the southeastern US coastal plain and Japan's inland evergreen Quercus forests, including also the sclerophyll Quercus phyllyraeoides scrub (with Rapanaea and Pittosporum) in dry regions along the Inland Sea. The southeastern USA does, however, also have extensive floodplain forests, dominated by evergreen Persea, Magnolia, Ilex and Gordonia,

plus deciduous Nyssa aquatica and Taxodium distichum.

The most extensive warm-temperate forests of the southeastern USA occur on flat, sandy, at least somewhat nutrient-poor, xeric substrates. These forests can perhaps best be described as mixed and often represent edaphic climaxes. Most typically these may have an overstorey involving Pinus and deciduous trees (e.g. Celtis laevigata, Liquidambar styraciflua, Quercus spp.) and an understorey of evergreen Quercus spp., Myrica cerifera, some deciduous trees (e.g. Cornus florida), plus dwarf palms to the south.

As in the transition region, the US coastal warm-temperate region also has extensive areas of edaphic pinewoods on young, coastal-plain sands, as well as pine plantations (mainly Pinus palustris and P. elliottii). Eastern North America does not, however, have special warm-temperate conifer stands comparable to Japan's Cryptomeria or Chamaecyparis, with the exception of Taxodium distichum, a potentially tall, deciduous conifer (cf. Metasequoia) growing on wet substrates, including swamps. Shorter Chamaecyparis thyoides grows in certain coastal swamps (north to New England), while Torreya taxifolia survives as a relict species in a small area of northwestern Florida. The eastern USA has no mountains in its warm-temperate zone.

Natural boreal-like conifer forests occur throughout the higher elevations of northern and central Honshu as well as the higher northern and southern Appalachians. In both areas these forests involve mainly species of Abies and Picea, with successional Betula and Sorbus. Perhaps more interesting is the boreal-temperate transition zone. In North America this involves a band of mixed forests (summergreen broad-leaved "northern hardwoods" plus subboreal and boreal conifers) running inland from maritime SE Canada across northern New England and southern Ontario to the Great Lakes area, where it is replaced on certain substrates by special Pinus forests (see KUECHLER 1964). In Japan, a less mixed forest involving mainly Quercus, Tilia, Ulmus, and Acer species (but not Fagus crenata), plus Abies and Picea, occurred over lowland Hokkaido and perhaps some areas of northern Tohoku. These are perhaps more similar to cool-maritime Quercus forests of northwestern Europe, areas with maritime temperature regimes but with wind and reduced total precipitation.

6. CONCLUSION

There is considerable similarity between the vegetation zonation, physiognomy, composition, and environmental relationships in Japan and in eastern North America. In addition to similarities, there are also important differences.

It is easy to identify interesting questions for further comparative research. For example:

- Can better concepts of bioclimates be developed which would permit better intercontinental comparisons?
- If classified phytosociologically, how would the vegetation units of eastern North America compare with those of Japan? (or China or Europe?)
- Why do isotherms for the northern limits of evergreen broad-leaved trees vary so much between Japan, China, and North America, often for species in same genera? How would these limits correspond to absolute minimum temperatures?
- Why have mostly deciduous East Asian malacophylls (e.g. Lonicera japonica, Ligustrum ovalifolium) been so successful as soft-leaved evergreens in the southeastern USA?
- How do successional patterns and potentially stable substitute vegetation communities compare in the two regions?
- Can Japanese revegetation techniques, with native evergreen broad-leaved species, work as well in eastern North America with its colder winters and mainly deciduous flora?

A next step would appear to involve the application of common climatic indices and systems to both regions. One problem is that most existing systems do not really capture the differences between maritime and continental climates which may be most important to the vegetation.

SUMMARY

Central Honshu and central eastern North America (from the Appalachians eastward), occupy roughly the same latitudes (about 34°-40°N) on the east sides of the Northern Hemisphere's two large land masses. Because of this and the regularities of global atmospheric circulation, the two regions have similar climates ranging from warm-temperate in the south, through typical temperate, to temperate/montane and temperate alpine at high elevations. Vegetation similarities parallel the climatic similar-

ities, but with a relatively much larger deciduous forest region in North America. Montane conifer forests, temperate and cool-maritime deciduous forests, edaphic and coastal pine forests, and some warm-temperate evergreen forests all show similar physiognomic and taxonomic structure in the two regions. Eastern North America also has extensive boreal-temperate and temperate-subtropical transitional mixed forests, as well as extensive warm-temperate coastal wetlands, but lacks the warm-temperate elevational sequence found in southern Japanese mountains.

ZUSAMMENFASSUNG

Mittel-Honshu und das mittelöstliche Nordamerika (das Appalachen-Gebiet und die östliche Küstenebene) befinden sich in fast gleicher geographischer Breitenlage (34-40°N) auf den Ostseiten der zwei grossen Erdteile der Nordhemisphäre. Deswegen und wegen der Gesetzmässigkeiten globaler atmosphärischer Zirkulation besitzen die zwei Regionen ähnliche, entsprechende Klimazonen, eingeschlossen die warmtemperierte Zone im Süden, die nemorale temperierte Zone und die montane Stufe, sowie eine alpine Stufe in den höheren Lagen. Entsprechende Vegetationszonen widerspiegeln diese klimatischen Aehnlichkeiten, doch nimmt das sommergrüne Laubwaldgebiet einen viel grösseren Raum in Nordamerika ein. Montane Nadelwälder, temperierte und kühltemperierte sommergrüne Laubwälder, edaphische und küstennahe Kiefernwälder, und einige warmtemperierte immergrüne Wälder zeigen ähnliche Physiognomik sowie ähnliche taxonomische Struktur in beiden Regionen. Der Osten Nordamerikas hat auch ausgedehnte boreal-temperierte und temperiert-subtropische Uebergangs-Mischwälder sowie grössere Moor- und Sumpfflächen in der warmtemperierten Küstenzone. Auf der anderen Seite fehlt in Nordamerika die vertikale Stufenfolge der japanischen warmtemperierten Berge.

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