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Woody Vegetation Exchange Zones: Eastern North America and Eastern Asia

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Abstract. *Comparison of meteorological data for eastern Asia and eastern North America suggests that similar humid, macrothermal, temperate climates may facilitate successful establishment of plants transferred by man between the two regions. Latitude for latitude, reasonably good matches exist for mean January and July temperatures and precipitation: Caribou, ME vs. Vladivostok, Siberia; Atlantic City, NJ vs. Kangnung, Korea or Matsumoto, Japan; Atlanta, GA vs. Fukuoka, Japan; and 11 other pairs. Matches between U.S. east coast and Chinese stations are not as close as those above, because China's ΔT's between summer and winter mean temperatures are greater than those in eastern North America; however, resemblances are still good enough for many species to be transferred successfully. A list of 137 species of eastern Asian trees growing in New Jersey is cited, and 105 species from eastern North America growing as exotics in eastern Asia are listed.*

Key words: plant introduction, temperature, precipitation, eastern North America, eastern Asia.

Much has been written about floristic similarities between eastern North America and eastern Asia, but it has all concerned relationships of genera and species sharing common descent from the Arcto-Tertiary flora. An excellent bibliography on this subject was prepared by Haynie (1989), who summarized views expressed by Linnaeus, Kalm, Gray, and Li. To our knowledge, only one study (He,1990) has examined climatic similarities and their role in facilitating plant transfers, specifically adaptive ranges of American species in China. An earlier paper by Sheng (1979) noted the superior adaptability of eastern North American trees in China compared to that of trees from the Mediterranean region and central Asia, but he did not compare climates *per se*. However, Sheng pointed out the desirability of ecological similarities between donor and recipient regions.

As the world's human population continues to grow, man's cultivation of plants to provide food, fiber, and amenities has resulted in transfer of many species to regions outside their native ranges. Familiar examples are corn, *Zea mays* L.; wheat, *Triticum aestivum* L., and potatoes, *Solanum tuberosum* L. Originally native respectively to Mexico, the Mediterranean region, and the Andes of South America, these crops are now grown on nearly every continent. Less well known but equally widespread is the use of woody species to provide fiber or amenities wherever suitable conditions exist for their transfer and successful growth. Examples of this include *Pinus radiata* Don., a California native which is now the principal timber producer in New Zealand and Chile (Zobel *et al.* 1987) and *Platanus X acerifolia* (Ait.) Willd., used in urban forestry in temperate climates worldwide (Arnold, 1993).

As people's demands for food, fiber, and amenities continue to grow, plant transfers may become increasingly important with the use of more exotic species and better adapted provenances of those already being used. What are the criteria for successful transfer? The most important of the "ecological similarities" mentioned by Sheng (1979) is climate. World areas with roughly similar climates are potential species transfer zones, used by foresters in selecting exotic trees for timber production (Wright, 1976), plant explorers seeking new woody ornamentals or hardier forms of already-used species (Meyer, 1992), and agriculturalists seeking to introduce or improve crops such as soybeans (USDA, 1941). Some major exchange zones are: 1) western North America, western Europe, New Zealand, and southern Chile; 2) eastern North America and eastern Asia; and 3) areas with Mediterranean climates worldwide: the Mediterranean basin and Iberian peninsula, South Africa, southwestern Australia, southern California, and central Chile.

A list of 258 species of exotic trees growing in New Jersey (Kuser, 1992) shows 41 species originating elsewhere in eastern North America, 137 species from eastern Asia, 59 from Europe and the Mediterranean region, 21 from western North America, and nóne from temperate areas (35°S - 45°S) of the Southern Hemisphere (one from Chile has since been reported). Because the number of species furnished by the four donor regions outside eastern North America seemed out of proportion to their forested land areas, we investigated possible reasons. We first sought to compare the number of successfully introduced species from each donor area to the number available in that area, but being unable to determine the number in eastern Asia because we could not distinguish temperate from subtropical species listed in Sylva Sinica, or reliably distinguish tree and shrub species of some genera in the same text, we retreated to a next-best strategy of relating numbers of successfully introduced species to the forested land areas of donor regions.

In this paper, we define the forested land areas of the four regions and compare numbers of woody species successfully transferred from them. Finding that the numbers of species are strikingly out of proportion to areas of donor regions, we advance the hypothesis that similarities or dissimilarities of climate are a principal reason for the overperformance of eastern Asia as a donor region and the underperformance of two of the three other temperate-zone regions. We compare climates of eastern Asia and eastern North America, identify the nearest matches, and list species which have been successfully transferred in both directions.

METHODOLOGY

Defining Land Areas

Using NASA space flight data on natural (preagricultural) vegetation based on the UNESCO classification system (Matthews, 1983), we defined land areas of donor regions as 1) eastern Asia from latitude 30°N - 55°N, and longitude 105°E - 150°E; 2) Europe, 30°N - 60°N and 15°W

- 60°E, 3) western North America, 30°N - 55°N and 105°W - 135°W, and 4) the South Temperate region: South America, 30°S - 60°S, 45°W - 90°W; Australasia, 30°S - 60°S, 105°E - 180°E; and South Africa, 30°S - 40°S, 15°E - 40°E. (Table I).

We included eastern North America, 30°N - 55°N and 45°W - 90°W, for comparison. Within these five areas, we included 8 vegetation types possessing arborescent woody vegetation: 1) tropical/subtropical evergreen broadleaf, 2) temperate/subpolar evergreen forest, 3) temperate evergreen broadleaf forest with summer rain, 4) temperate/subpolar evergreen needleleaf forest, 5) cold deciduous forest with evergreen, 6) cold deciduous forest without evergreen, 7) evergreen needleleaf woodland, and 8) cold deciduous woodland. We excluded other vegetation types ranging from sclerophyll forest to xeromorphic shrubland, grassland, and desert.

Areas of the four donor regions (eastern Asia, Europe, western North America, and South Temperate) possessing arborescent woody vegetation were totaled, converted to logarithms (Pielou, 1976), and χ^2 comparison was made to determine whether the numbers of species furnished by each donor region were proportional to *log* area (Table I). After it was apparent that this method gave a very high χ^2, we tried adding *log* of each separate forest type in each donor region, reasoning that eastern Asia's greater site diversity results in more different forest types, thus more species diversity. This "method B" treats each forest type in each donor region as a separate "island"; in contrast to "method A" which lumps forest types in each donor region.

Climate Pair Selection

Comparisons were made between pairs of weather stations at the latitude of New Jersey and far enough north, south, and inland (in both eastern Asia and eastern North America) to cover areas with substantially similar vegetation. Starting at the north with taiga forest, vegetation changes to mixed conifers and hardwoods, then to vegetation with more evergreen broadleaved species to the south. Climatic records for 51 stations in the middle latitudes of eastern Asia and 45 in eastern North America were examined to identify intercontinental pairs with analogous climatic conditions (NCDC 1988, World Weather Records). Comparison of January and July temperatures and precipitation resulted in the selection of 15 pairs (Figure 1). We chose January and July mean temperatures and precipitation for comparison because these exert much more influence on vegetation type than do annual means (Spurr and Barnes 1980).

Species Exchange

A list of Asian species growing in New Jersey (a representative mid-latitude region, 39°N - 41°N) was abstracted from Kuser's 1992 list of all exotic trees growing here. Native ranges were verified, using appropriate texts (Bailey, 1933; Rehder, 1987; Dirr, 1990). In some cases the exact area of Asian origin is known (ex: *Metasequoia*), but in many other cases (ex: *Ailanthus*, *Paulownia*) there are no seed-source data on the Asian populations ancestral to our introduced populations.

A list of eastern North American species growing in eastern Asia (Table II) was compiled from references available in the U.S.D.A. Forest Service's research library at Washington, DC, at Morris Arboretum in Philadelphia, PA, and lists obtained by correspondence with botanists in Japan, Korea, and China. These included He, Miller, Takahashi, and Tanaka, who are referenced in Table II and whose addresses are listed in our literature citation section. We were not able to determine degrees of naturalization without on-site experience.

RESULTS

The χ^2 comparison of expected *vs* observed numbers of woody species from four donor regions (eastern Asia, Europe, western North America, and combined South Temperate) showed only Europe furnishing the expected number of exotics. Eastern Asia's overperformance made the largest contribution to total χ^2, followed by the South Temperate's striking underperformance and western North America'a underperformance in that order. The total χ^2's by method A ($\chi^2 = 183$) or Method B ($\chi^2 = 109$) are attributable mainly to eastern Asia's overperformance and the South Temperate's underperformance; the values are so high that obviously factors other than land areas of donor regions are responsible for the geographic imbalance in the distribution of origins of successfully introduced woody species (Table I).

Locations of the paired weather stations in eastern North America and eastern Asia are shown in Figure 1, and temperature and pre-

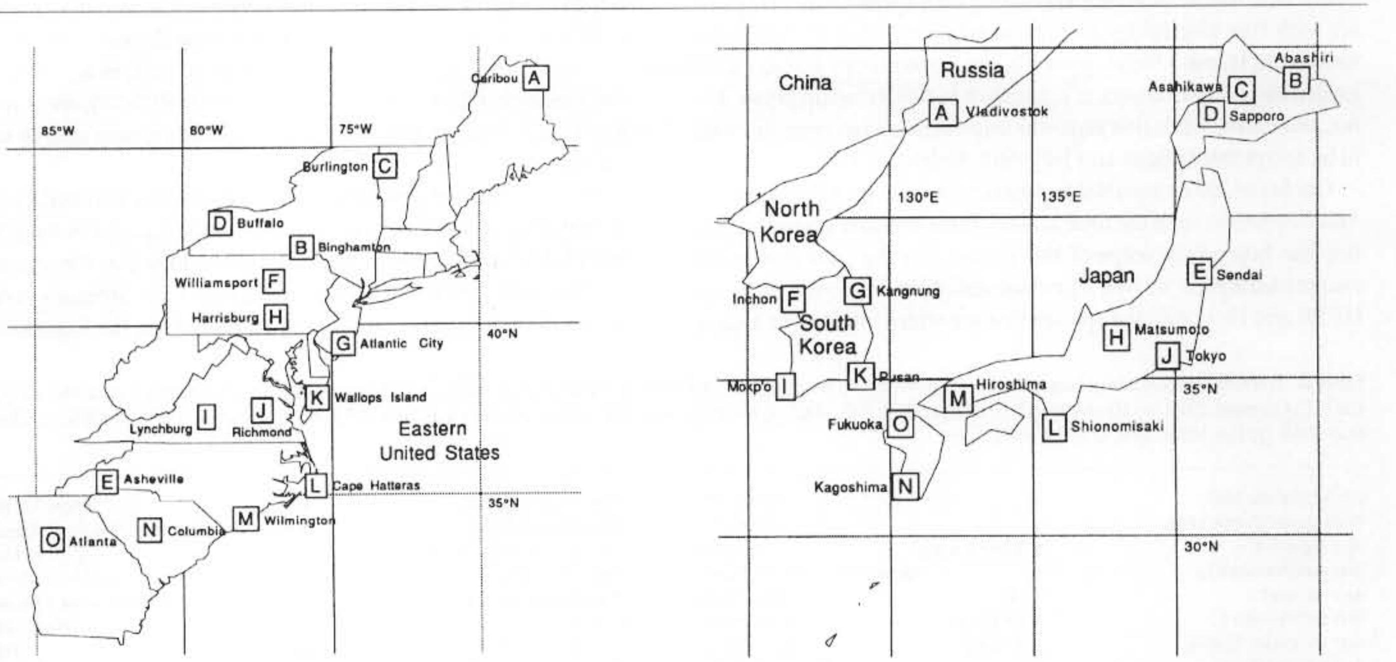
Table I. World areas of temperate forest, KM²

Forest Type	30°-55°N E.N. AM. 45° - 90°W	30°-55°N E. ASIA 105°-105°E	30°-60°N EUROPE 15°W-60°E	30°-55°N W.N. AM. 105°-135°W	30°-60°S S. AM. 45°-90°W	30°-60°S AUS-NZ 105°-180°E	30°-40°S S. AFR. 15°-40°E
Tropical/Subtropical Evergreen Broadleaf		20,270					41,169
Temperate/Subpolar Evergreen					285,301	144,878	
Temperate Evergreen Broadleaf with Summer Rain		279,696				78,773	
Temperate/Subpolar Evergreen Needleleaf	1,076,584	720,384	1,158,442	1,053,128			
Cold Deciduous with Evergreen	1,512,455	1,764,474	2,728,639	75,239	72,201		
Cold Deciduous without Evergreen	830,114	1,159,809	1,302,015				
Evergreen Needleleaf Woodland	460,651	125,500	83,297	351,943			
Cold Deciduous Woodland		124,512		60,611			
Total	3,879,804	4,194,645	5,272,393	1,540,921	357,502	223,651	41,169
					Total S. Temp.	622,322	
Log of km2		6.623	6.722	6.188		5.794	
No. of species (Total 218)							
Exp'd.		57	58	53		50	
Obs'd.		137	59	21		1	
χ^2 contribution		112	0	19		48	

Total 02 = 183; Method B 02 - 109

Total χ^2: Method A = 179; Method B = 106

Figure 1. Locations of eastern North American and eastern Asian climatic pairs. Letters refer to the stations listed in Figure 2.



cipitation data in Figure 2.

In only five cases is the mean July temperature of one member of a pair more than 1°C warmer than its counterpart. In January this holds true in three cases. July is more than 50 mm wetter at nine Asian stations, and U.S. stations have more January precipitation than their Asian counterparts for 12 pairs; however, for all pairs, totals fall within 50 mm of each other. In nine of the 15 pairs, the U.S. stations are between 1°30' and 4°00' of latitude north of their Asian counterparts, while in only two cases are the east Asian station more than 1°30' north of their US counterparts. Eastern Asia and eastern North America share similar humid, macrothermal temperate climates. These are characterized by ΔT's between January and July mean temperatures of 20°C to 30° C (Fig. 2), and sufficient summer rainfall (100 mm/mo., with accompanying high humidity) for good growth and survival of large woody plants. From pair "F" southward, July precipitation at Asian stations greatly exceeds that at American stations; January precipitation follows an opposite pattern, with that of American pairs greater in 11 out of 14 pairs.

DISCUSSION

Granted that exotic trees from Asia were popular for planting on estates for many decades, we believe this alone cannot account for their preponderance, because European and western North American species were (and still are) popular also. Our results suggest that climatic similarity is at least one reason for the preponderance of eastern Asian species among exotics in our studied region, and for the comparative vigor of eastern North American species in China reported by Sheng (1979) and He (1990). In contrast to the ΔT's of east coast climates, ΔT's are much less in western North America, western Europe, and the south temperate zone. For Auckland (New Zealand), Perth (Australia), and Capetown (South Africa), ΔT's range from 6°C to 8°C while east coast stations such as Atlantic City (New Jersey), Sendai (Japan) and others (Fig. 3) have ΔT's ranging from 20°C to 31°C. Trees adapted to the climates of these regions (except Europe) are unable to withstand the cold winters of eastern North America between latitudes 35°N and 45°N. This appears to be the explanation for the almost complete absence of trees from the south temperate zone cultivated or naturalized in these latitudes of eastern North America, and it also explains why Pacific coast races of many western North American trees cannot be grown in eastern states. For example, *Sequoia sempervirens* (D. Don.) Endl., cannot be successfully grown north of Williamsburg, Virginia (Kuser, 1976, 1996), and eastern Christmas tree growers must use inland, montane provenances of *Pseudotsuga menziesii* (Mirb.) Franco (Heit, 1968, DeHayes, and Wright, 1976). Europe's woody species are better pre-adapted to eastern North America's climate than western North American or South Temperate species, probably because Europe is occasionally subject to waves of intense cold when a Siberian high-pressure area expands westward during winter. It may also be possible that during the Pleistocene, European species acquired more tolerance to extremes than did those from other low-ΔT regions (Huntley, 1993), although sometimes still insufficient: the widely planted and naturalized Norway maple, *Acer platanoides* L., is subject to winter freezing damage in colder parts of the Northeast (USDA, 1971). Many European species are not as well adapted to eastern North America's hot, humid summers as are east Asian species. For example, Lombardy poplar, *Populus nigra* var. *italica* Muenchh., is subject to a canker disease of the trunk and upper branches (Dirr, 1990) and a bacterial infection of the woody cylinder associated with warm, humid summers (USDA, 1971); and Norway maple gets a leaf scorch disease associated with heat and drought (USDA, 1971). Hot, humid summers facilitate the spread of *Sphaeropsis* needle blight on European *Pinus nigra* Arnold (Sinclair *et al.* 1987) and of *Cercospora* and *Acanthostigma* needle blight on western North American *Sequoiadendron* (USDA, 1971), killing the former and disfiguring the latter; while eastern Asia's *Pinus densiflora* Sieb. & Zucc., *P. parviflora* Sieb & Zucc., and *Sciadopitys* survive both summers and winters in eastern North America with no damage (Dirr, 1990). Hot, humid summers alternating with cold winters may interact with tree physiology to explain why the wood of *Paulownia tomentosa* (Thunb.) Steud. grown in the eastern United States is regarded by Japanese buyers as equivalent to that grown in Japan, Korea, and China, while that grown in tropical Brazil has rings too wide to be acceptable (Hogan and Joy, 1983, Goldman, 1985).

Our list of 105 eastern North American species growing in eastern Asia may be less than the total actually there, because on-site inspection was beyond the scope of this project. For the same reason, we cannot identify species which have naturalized in Asia, but both Sheng (1979) and He (1990) list species that are widely planted or appear promising for forestry use, and Kurokawa (Director of Botanical Gardens, Toyama, Japan), writes that *Robinia pseudoacacia* L., is widely naturalized in northern Japan and that *Cornus florida* L., and *Kalmia latifolia* L., are commonly planted. Listings of eastern North American species in Ohwi (1965), Lee (1982), K'O (1972-76), and Chung-Kuo (1983) imply that species listed are widely grown and/or naturalized.

We speculate that possible reasons for the northward displacement of matching climates in North America (as compared to Asia) may be 1) Asia's larger size, with a stronger winter high over the continent pushing cold air farther south, and 2) the Gulf Stream's greater moderation of coastal winter temperatures than the Kuroshiwo's.

Table II. Trees native to eastern North America growing in China, Japan, or Korea, according to: a) Wu 1983, b) Hanzhou 1976, d) Krugman et al 983, e) Wang 1983, f) Guangxi 1982, g) He, h) Tanaka, i) Kobe Mun.Arb. 1991, j) Korean Assn. Bot. Gdns. 1991, k) Tsukuba 1993, m) Takahashi, n) Ohwi 1965, o) Chung-Kuo 1983, p) Lee 1982, q) K'O 1972-1976.

Abies balsamea Mill.	i,j	Balsam Fir
Abies fraseri (Pursh.) Poir.	j	Fraser Fir
Acer negundo L.	a,d,h,i,j,k,n,p,q	Boxelder
Acer pensylvanicum L.	i,j	Moosewood, Striped Maple
Acer rubrum L.	a,i,k	Red Maple
Acer saccharinum L.	a,d,e,f,i,j,p	Silver Maple
Acer saccharum Marsh.	a,d,h,i,k,p	Sugar Maple
Acer spicatum Lam.	j	Mountain Maple
Aesculus glabra Willd.	m	Ohio Buckeye
Aesculus octandra Marsh.	j	Yellow Buckeye
Alnus rugosa (Du Roi) Spreng.	k	Speckled Alder
Amelanchier arborea (Michx.f.)Fern.	j,k	Servicetree
Amorpha fruticosa L.	a,d,p,q	False Indigo
Aralia spinosa L.	j	Devil's Walking Stick
Aronia arbutifolia (L.) Elliott	j	Red Chokeberry
Aronia melanocarpa (Michx.)Elliott	j	Purple Chokeberry
Asimina triloba Dun.	i,k	Pawpaw
Betula alleghaniensis Britton	i,j	Yellow Birch
Betula lenta L.	i,j	Black Birch
Betula papyrifera Marsh.	b,i,j	Paper Birch
Carpinus caroliniana Walt.	j	American Hornbeam
Carya glabra var. *odorata* (Marsh.) Little	m	Red Hickory
Carya illinoensis Koch.	a,b,d,e,f,j,o	Pecan
Carya ovata (Mill.) K. Koch.	j	Shagbark Hickory
Castanea dentata Borkh.	j	American Chestnut
Catalpa bignonioides Walt.	a,h,i,j,p	Southern Catalpa
Catalpa speciosa Warder ex Engelm.	a,b,d,f,h,i,q	Northern Catalpa
Celtis occidentalis L.	a,i,k	Hackberry
Cercis canadensis L.	d,h,i,j	Redbud
Chamaecyparis thyoides Brit.	a,i,j,o	Atlantic Whitecedar
Chionanthus virginicus L.	j	Fringetree
Cladrastis kentukea (Dum.-Cours.)	j	Yellowwood
Cornus florida L.	h,i,j,k,n	Flowering Dogwood
Corylus americana Marsh.	j	Hazelnut
Corylus cornuta Marsh.	j	Beaked Hazelnut
Diospyros virginiana L.	a,d,h,i,j	Persimmon
Franklinia alatamaha Marsh.	j	Franklinia
Fraxinus americana L.	a,d,e,f,i,j,k,p,q	White Ash
Fraxinus pennsylvanica Marsh.	a,j,p	Green Ash
Gleditsia triacanthos L.	a,d,e,i,j,k,o	Honeylocust
Gymnocladus dioicus Koch	a,o	Kentucky Coffee
Halesia carolina L.(incl.monticola)	j	Silverbell
Hamamelis virginiana L.	j,n	Witch Hazel
Ilex opaca Ait.	j,k	American Holly
Juglans nigra L.	a,b,d,i,j	Black Walnut
Juniperus virginiana L.	a,e,h,i,j,k,o,p	Eastern Redcedar
Larix laricina Koch	i	Tamarack
Lindera benzoin Blume	g,j	Spicebush
Liquidambar styraciflua L.	a,b,d,f,h,i,j,k	Sweetgum
Liriodendron tulipifera L.	a,b,e,h,i,j,k,o,p,q	Tuliptree
Maclura pomifera (Raf.) Schneid.	b,h	Sage Orange
Magnolia acuminata L.	i,j	Cucumber Magnolia
Magnolia fraseri Walt.	j	Fraser Magnolia
Magnolia grandiflora L.	a,b,d,e,f,h,i,j,k,n,o,p,q	Southern Magnolia
Magnolia macrophylla Michx.	j	Bigleaf Magnolia
Magnolia tripetala L.	j	Umbrella Magnolia
Magnolia virginiana L.	h,i,j	Sweetbay, Swamp Magnolia
Nyssa aquatica L.	j	Water Tupelo
Nyssa sylvatica Marsh.	f,j	Tupelo
Ostrya virginiana K. Koch	i	Hophornbeam
Oxydendrum arboreum (L.)DC	j	Sourwood
Picea glauca (Moench) Voss.	a,h,i	White Spruce
Picea mariana (Mill.)B.S.P.	a,i,j	Black Spruce
Picea rubens Sarg.	i,j	Red Spruce
Pinus banksiana Lamb.	a,e,i,o,p	Jack Pine
Pinus echinata Mill.	a,d,f,i,j,o	Shortleaf Pine
Pinus elliottii Engelm	a,d,f,i,o	Slash Pine
Pinus glabra Walt.	a,d,f,j	Spruce Pine
Pinus palustris Mill.	a,d,h,i,j,k,o	Longleaf Pine
Pinus rigida Mill.	a,f,h,i,j,k,o,p	Pitch Pine
Pinus serotina Michx.	a,d,o	Pond Pine
Pinus strobus L.	a,d,h,i,j,k,o,p	E. White Pine
Pinus taeda L.	a,d,f,h,i,j,k,o,p	Loblolly Pine
Pinus virginiana Mill.	a,d,j,o	Virginia Pine
Platanus occidentalis L.	a,d,h,i,o,p	Sycamore
Populus deltoides Marsh.	a,d,o,p	E. Cottonwood
Prunus serotina Ehrh.	g,i,j	Black Cherry
Quercus alba L.	j	White Oak
Quercus coccinea Muenchh.	h,j	Scarlet Oak
Quercus falcata Michx.	j	S. Red Oak
Quercus ilicifolia Wangenh.	j	Scrub Oak
Quercus macrocarpa Michx.	i	Bur Oak
Quercus marilandica Muenchh.	j	Blackjack Oak
Quercus nigra L.	j	Water Oak
Quercus palustris Muenchh.	a,h,i,j,k,o	Pin Oak
Quercus phellos L	g,j	Willow Oak
Quercus prinus L.	j	Chestnut Oak
Quercus rubra L.	a,i,j,k	N. Red Oak
Quercus shumardii Buckl.	j	Shumard Oak
Quercus virginiana Mill.	g,j	Live Oak
Rhus glabra L.	g	Smooth Sumac
Rhus typhina L.	e	Staghorn Sumac
Robinia hispida L.	a,e,i,o,p	Clammy Locust
Robinia pseudoacacia L.	a,d,e,i,j,k,n,o,p,q	Black Locust
Sabal palmetto Lodd.	a,j	Cabbage Palm
Sambucus canadensis L.	j	Elderberry
Sassafras albidum (Nutt.) Nees	j	Sassafras
Sorbus americana Marsh.	j	Mountain Ash
Taxodium distichum nutans(Ait.)Sweet	a	Pond Cypress
Taxodium distichum (L.) Rich.	a,f,h,i,j,k,o,p	Baldcypress
Thuja occidentalis L.	a,b,h,i,j,o,p	N. Whitecedar
Tilia americana L.	h,i,j	Basswood, Am. Linden
Tsuga canadensis (L.) Carr.	i,j	Eastern Hemlock
Ulmus americana L.	a,d,i	American Elm
Ulmus rubra Muhl.	a	Slippery Elm

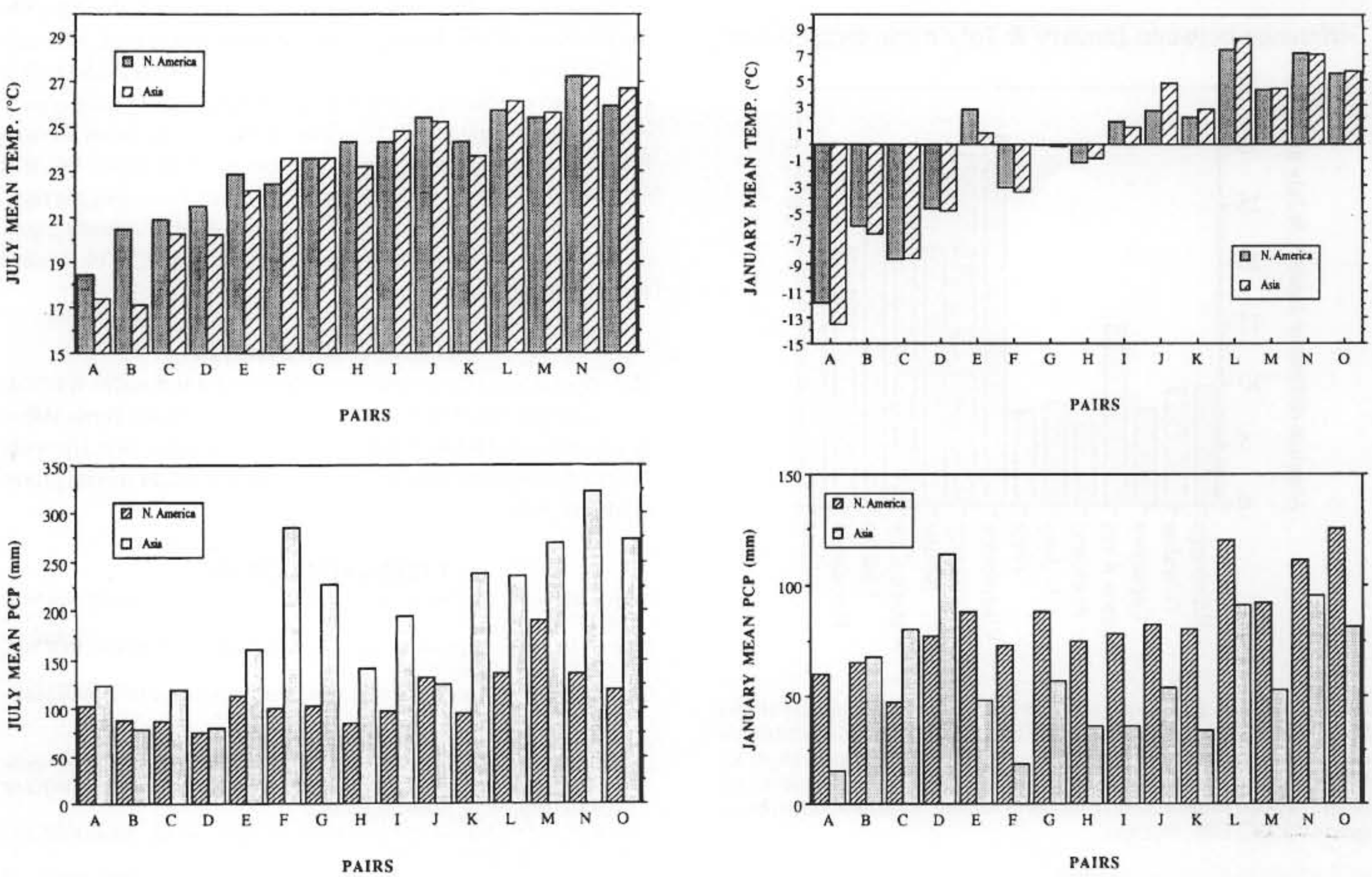


Figure 2.

a) July mean temperatures at the stations comprising the 15 study pairs:

- A: Caribou, Maine - Vladivostok, Siberia.
- B: Binghamton, New York - Abashiri, Japan.
- C: Burlington, Vermont - Asahikawa, Japan.
- D: Buffalo, New York - Sapporo, Japan.
- E: Asheville, North Carolina - Sendai, Japan.
- F: Williamsport, Pennsylvania - Inchon, Korea.
- G: Atlantic City, New Jersey - Kangnung, Korea.
- H: Harrisburg, Pennsylvania - Matsumoto, Japan.
- I: Lynchburg, Virginia - Mokp'o, Korea.
- J: Richmond, Virginia - Tokyo, Japan.
- K: Wallops Island, Virginia - Pusan, Korea.
- L: Cape Hatteras, North Carolina - Shionomisaki, Japan.
- M: Wilmington, North Carolina - Hiroshima, Japan.
- N: Columbia, South Carolina - Kagoshima, Japan.
- O: Atlanta, Georgia - Fukuoka, Japan.

b) July mean precipitation at the stations comprising the 15 study pairs.
c) Same as a, except for January.
d) Same as b, except for January.

Perhaps these two reasons are different ways of saying the same thing: Asia's summer and winter monsoons are well developed, with cold, dry offshore winds in winter and warm, moist onshore winds in summer. Similar conditions prevail in North America on the average, but less steadily.

It would be interesting to know the geographic sources of the Asian populations of species which are ancestral to derived populations in North America. Many of the Asian species, or species-complexes (ex: *Evodia, Maackia, Phellodendron, Cercidiphyllum*) occupy wide ranges in China, Korea, and/or Japan (Rehder, 1987, Bailey, 1935); consequently one might expect a more northern race of *Castanea mollissima* Blume, or *C. crenata* Sieb & Zucc., to grow more vigorously in a more northern location in America, and a more southern race to flourish farther south. To some extent, naturalized Asian species in North America may be making these adjustments themselves by developing land races adapted to local conditions. This seems to be happening with *Paulownia tomentosa*, which contains heritable variation in winter hardiness (Kuser and Fimbel, 1990). Going in the opposite direction, North American species in China seem to be doing very well in areas that are roughly climatically analogous on the two continents, in spite of China's hotter summers and colder winters (He, 1990). Apparently the increased continentality of China's climate, which resulted in our selecting many Japanese and Korean match stations rather than Chinese, is not too great for first-generation immigrant species to cope with; perhaps North America's occasional wider extremes than China's (He, 1990) drove them to pre-adaptation.

Ecological (climate and soil) similarities between the two regions may be part of the reason why *Liriodendron chinense* L., and *L. tulipifera* (Hemsl.) Sarg., have diverged so little morphologically after twelve and a half million years of separation (Cook, 1994). The climatic resemblance between the two east coasts facilitates other exchanges besides those of trees. Japanese honeysuckle, *Lonicera japonica* Thunb., Oriental bittersweet, *Celastrus orbiculatus* Thunb., multiflora rose, *Rosa multiflora* Thunb., Amur honeysuckle, L. *maackii* Maxim., Siebold's viburnum, *Viburnum sieboldii* Mig., Japanese barberry, *Berberis thunbergii* DC, a common annual woodsgrass, *Microstegium vimineum* (Trin.) A. Camus, and Japanese cane, *Polygonum cuspidatum* Sieb. & Zucc., are well established in the mid-Atlantic states. The

Difference between January & July mean temperatures

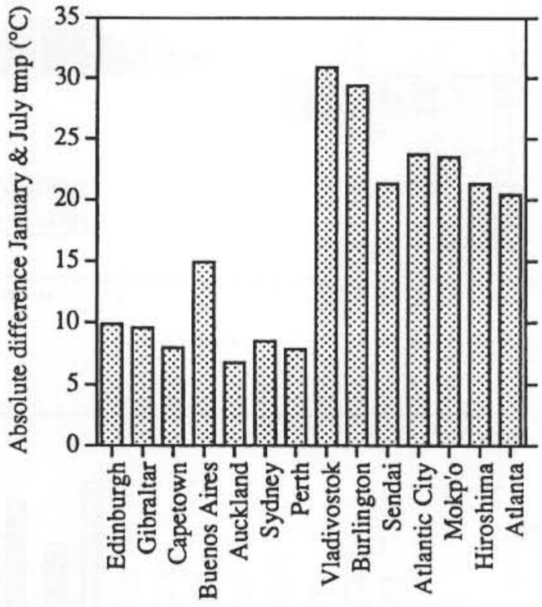


Figure 3. Difference between January and July mean temperatures at 14 sites located close to oceans across the middle latitudes of the northern and southern hemispheres. The seven sites on this figure with the greatest ranges are all found in eastern Asia or North America, while the remaining seven are located near the eastern shore of the north Atlantic or in the southern hemisphere (NCDC, 1988; NCDCa).

Japanese beetle, *Popillia japonica* Newm., was probably preadapted to the same area by climatic similarity. Chestnut blight, *Cryphonectria parasitica* (Murrill) Barr, white pine blister rust, *Cronartium ribicola* Fisch., and Dutch elm disease, *Ophiostoma ulmi* (Buisman) Nannf., all originated in eastern Asia. Going the other way, our relatively harmless pinewood nematode, *Bursaphelenchus xylophilus* (Steiner & Buhrer) Nickle, has become a destructive pest in Japan (Mamiya, 1987).

Some Differences

North America's lack of east-west mountain barriers and ocean protection makes it possible for locations east of the Rocky Mountains to experience extreme temperature variation in a short period of time (Zobel and Talbert, 1984). While mean winter temperatures are higher in eastern North America, extremes are lower because of this lack of barriers. This displaces the broadleaved evergreen forest (Miyawaki *et al* 1995) and "camellia belt" farther south than they would otherwise be, and often kills the flowers of spring-blooming Asian trees such as magnolias, which evolved in an area where spring frosts are rare. Another difference is that summer drought, such as the east coast of North America experienced in 1993 and 1995, is less common along the east coast of Asia (Miller, 1993).

Outlook

Provenance testing of interchangeable species can lead to the selection of local races of species better adapted to their new homes, by collecting from the nearest-match areas in the other major continent. This may be hardier Korean snowbells for America, faster-growing pitch pines for Korea, or better-adapted eastern white pines for Hokkaido.

Those who conduct such tests must be made aware, through public education, of the dangers as well as benefits involved. Although APHIS (Animal and Plant Health Inspection Service, U.S.D.A.) is currently strengthening regulations governing imports, enforcement is difficult according to Dr. J. L. Stewart, director of the Forest Service's Forest Insect and Disease Research center in Washington, DC. It is incumbent on all of us involved in such endeavors to obey the regulations, educate others, and do all we can to avoid repeating past disasters such as the introduction of chestnut blight, or of invasive woody species.

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