ANNALS
OF THE
MISSOURI BOTANICAL GARDEN

VOLUME 70 1983 NUMBER 4

ON THE SIGNIFICANCE OF PACIFIC INTERCONTINENTAL DISCONTINUITY

WU ZHENGYI[1]

The abundant disjunctions in the ranges of plant families and genera in Eastern Asia and temperate North America is one of the most familiar and important patterns of discontinuity in all of biology. From the time Asa Gray (1859) drew special attention to these discontinuities in range over a century ago, they have been studied and discussed by many authors (e.g., Li, 1952; Good, 1974; Graham, 1972; Wood, 1972). Formerly, it was believed that there were only about 80 genera of plants with such ranges, but now it is known that there may actually be more than 120, of which 117 are recorded from China (see Appendix 1). These genera comprise about 4% of the total number of genera of higher plants (2,980) in the entire Chinese flora. They belong to 60 families, mostly temperate in distribution; some of these families are primarily tropical and subtropical in distribution, however. Woody families that include trees or shrubs are listed in Table 1.

In all, there are 45 genera distributed among 28 families of which four (Illiciaceae, Calycanthaceae, Nyssaceae—sensu stricto, and Styracaceae) exhibit the same sorts of disjunctions in range as the genera they include. The same pattern—with familial and generic disjunctions approximately parallel—is exhibited by families composed of herbaceous plants (Nelumbonaceae, Saururaceae, Phrymaceae, Croomiaceae). To these families perhaps should be added Schisandraceae, which exhibits a similar pattern of distribution. All of them are disjunct between eastern Asia and eastern North America, although Nelumbonaceae extends through the tropics to northern Australia, and Illiciaceae, Schisandraceae, and Nyssaceae extend to the West Indies and to southeast Asia. Styracaceae have a range similar to that of Hydrangeaceae sensu stricto, and might be derived from the latter through genera such as *Deutzia*. A single species of *Styrax* extends from eastern Asia to the Mediterranean region. For Hydrangeaceae, *Hydrangea* and *Deutzia* range through the mountains of Mexico and the Andes to Chile.

In agreement with Good (1974), I believe that many of these genera could be survivors of an ancient flora that failed to persist in Europe and western Asia. I do not agree with Good, however, that these plants can appropriately be regarded as "circumboreal" in distribution. Rather, I believe that they might be relicts of a warm temperate to subtropical montane flora derived from a Tertiary Paleotropical flora that was present on the mountains in warm-temperate to subtropical climates in the Old World in early Tertiary or perhaps late Cretaceous time. The persistence of such ancient patterns of distributions is suggested, among other lines of evidence, by the extension of some of these genera far southward into the tropics or even to the lands of the Southern Hemisphere; even in these cases, however, the centers of distribution are definitely in North America and temperate Eastern Asia.

[1] Kunming Institute of Botany, Academia Sinica, Kunming, Yunnan, People's Republic of China.

ANN. MISSOURI BOT. GARD. 70: 577–590. 1983.

TABLE 1. Families with trees or shrubs.

	Number of Genera
Taxaceae (*Torreya*)	1
Pinaceae (*Pseudotsuga, Tsuga*)	2
Cupressaceae (*Calocedrus, Chamaecyparis, Thuja*)	3
Magnoliaceae (*Liriodendron, Magnolia*)	2
Illiciaceae (*Illicium*)	1
Lauraceae (*Sassafras*)	1
Berberidaceae (*Mahonia*)	1
Calycanthaceae (*Calycanthus*)	1
Theaceae (*Gordonia, Stewartia*)	2
Iteaceae (*Itea*)	1
Hydrangeaceae (*Decumaria, Hydrangea*)	2
Rosaceae (*Photinia, Physocarpus, Sorbaria,* and 2 herbaceous genera)	3(–5)
Caesalpiniaceae (*Gleditsia, Gymnocladus*)	2
Papilionaceae (*Lespedeza* and 4 herbaceous genera)	1(–5)
Buxaceae (*Pachysandra*)	1
Hamamelidaceae (*Hamamelis, Liquidambar*)	2
Santalaceae (*Buckleya, Pyrularia*)	2
Rhamnaceae (*Berchemia*)	1
Anacardiaceae (*Toxicodendron*)	1
Juglandaceae (*Carya*)	1
Cornaceae (*Bothrocaryum* = *Cornus* sect. *Thelycrania*)	1
Nyssaceae (*Nyssa*)	1
Araliaceae (*Aralia, Oplopanax,* and herbaceous *Panax*)	2(–3)
Ericaceae (*Leucothoe, Lyonia, Pieris, Therorhodion,* and *Hugeria*)	5
Styracaceae (*Halesia*)	1
Oleaceae (*Chionanthus* s.s., *Osmanthus*)	2
Rubiaceae (*Cephalanthus* and 2 herbaceous genera)	1(–3)
Caprifoliaceae (*Symphoricarpos* and 1 herbaceous genus)	1(–2)
TOTAL 28 families	45 genera

Among the genera listed in Appendix 1, some of the monotypic ones (including *Glehnia* of Umbelliferae, *Phryma* of Phrymataceae, *Symplocarpus* of Araceae, *Diarrhena* and *Schizachne* of Graminae) belong to two distinct categories of distribution. *Phryma*, for example, appears to be one of the relictual representatives of the Tertiary flora previously mentioned. It has a typical pattern of disjunction between eastern Asia and eastern North America. In contrast, *Glehnia, Symplocarpus, Diarrhena,* and *Schizachne* (for a discussion of *Schizachne* and *Diarrhena* see Koyama & Kawano, 1963) might actually have a Beringian distribution and might therefore be direct decendents of the flora that was common to northeastern Asia and Pacific North America when migration through Beringia was still quite possible in the middle Tertiary. This latter group of genera might be considered "circumboreal" in distribution and, in some cases (*Schizachne*) might have been distributed throughout Arctic Europe by way of northeastern Siberia and Japan, temperate North America, and even the mountainous regions of the western United States. Genera of this group appear to be "younger" in their distribution than *Phryma*, and their pathway of distribution can be regarded as very obvious.

Other oligotypic genera mentioned in Appendix 1 can be analyzed as follows. First, three families and six genera of conifers are common in eastern Asia and North America. Among them, *Pseudotsuga, Tsuga,* and *Chamaecyparis*, although not oligotypic, might still dominate in forests in these regions like the oligotypic genera *Torreya, Thuja,* and *Calocedrus*. *Calocedrus* has a range that extends through northern Burma and northeastern Thailand, and southwestern China to Hainan and Taiwan (two species) and then reappears in the Pacific region in North America as a single species. Such a distribution, taken together with the fact that its close relatives are found in the Southern Hemisphere [i.e., *Libocedrus* with three species in New Caledonia and two species in New Zealand; *Papuacedrus* from New Guinea to the Moluccas (Li, 1953)], suggests that the range disjunction of *Calocedrus* might have originated as a result of a Gondwanan distribution that extended through the Southern Hemisphere.

The remaining genera number no fewer than 35 that have either two or three species. Paired species occur in many oligotypic genera and have been fully discussed by Li (1952). Among the better known of these are *Liriodendron* (Magnoliaceae), *Nelumbo* (Nelumbonaceae), *Achlys* and *Caulophyllum* (both Podophyllaceae), *Menispermum* (Menispermaceae), *Saururus* (Saururaceae), *Stylophorum* (Papaveraceae), *Adlumia* (Fumariaceae), *Decumaria* (Hydrangeaceae), *Chionanthus* (Oleaceae), and *Campsis* (Bignoniaceae). Genera with three species are not as richly

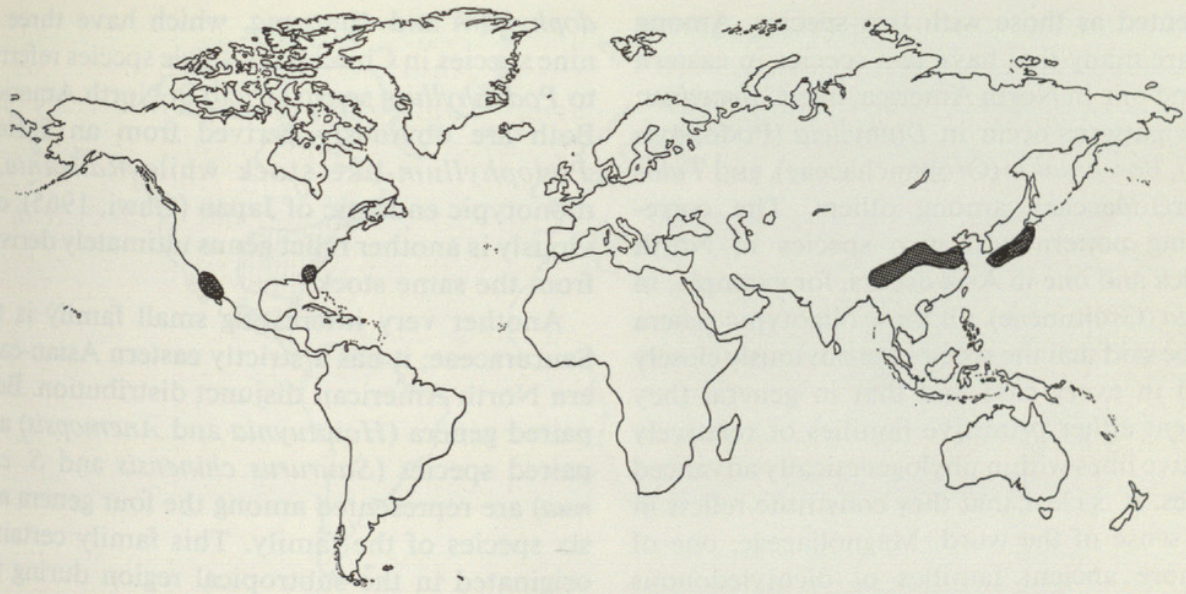

FIGURE 1. The distribution of *Torreya*.

FIGURE 2. The distribution of *Pachysandra*.

FIGURE 3. The distribution of *Carya*.

represented as those with two species. Among them are many that have two species in eastern Asia and one in North America, like *Calocedrus*; similar patterns occur in *Diphylleia* (Podophyllaceae), *Boschniakia* (Orobanchaceae), and *Tulotis* (Orchidaceae), among others. The corresponding pattern with two species in North America and one in Asia occurs, for example, in *Zizania* (Gramineae). Of these oligotypic genera it can be said that the species are obviously closely related in every case and that in general they represent either primitive families or relatively primitive lines within phylogenetically advanced families. It is clear that they constitute relicts in every sense of the word. Magnoliaceae, one of the more ancient families of dicotyledonous plants, has in general a distribution pattern that can be represented by that of the genus *Magnolia*. In general, the family is disjunct between eastern Asia and North America but extends south in the mountains into tropical southeast Asia and to South America. *Liriodendron*, on the other hand, is strictly an eastern Asian-eastern North American genus confined to temperate and subtropical zones. The western limit of *Liriodendron* in China extends to southeastern and northeastern Yunnan, where many other relict genera such as *Rhoiptelea*, *Diplopanax*, *Annamocarya*, and *Davidia* are also known. *Liriodendron* also extends to the northern part of Viet Nam where the most primitive species of *Platanus* (*P. kerrii*, with unlobed leaves and pinnate venation) exists, as well as to adjacent mountains of southeastern Yunnan. In view of these distribution patterns it can be hypothesized that both Magnoliaceae and Platanaceae originated in the subtropical mountains of southeastern Asia.

Although the theories that formerly placed Nelumbonaceae as an ancestor of the monocots have now largely been discarded, this family certainly represents a very ancient lineage that has been in existence for a very long time both in Asia and in America; it might represent a survivor of the floras that existed in both areas in the early Tertiary and Late Cretaceous times. The same appears to be true of many of the other genera discussed here. Among the families Ranunculaceae, Paeoniaceae, Berberidaceae, and Podophyllaceae, there are at least four bispecific or trispecific genera that are disjunct between eastern Asia and eastern North America. Among them, *Jeffersonia* is now occasionally divided into two genera, with the Asian species placed in the genus *Plagiorhegma*. *Podophyllum* is represented by two closely allied, segregate genera, *Sinopodophyllum* and *Dysosma*, which have three to nine species in China but a single species referred to *Podophyllum* sensu stricto in North America. Both are obviously derived from an ancient *Podophyllum*-like stock while *Ranzania*, a monotypic endemic of Japan (Ohwi, 1965), obviously is another relict genus ultimately derived from the same stock.

Another very interesting small family is the Saururaceae; it has a strictly eastern Asian-eastern North American disjunct distribution. Both paired genera (*Houttuynia* and *Anemopsis*) and paired species (*Saururus chinensis* and *S. cernua*) are represented among the four genera and six species of the family. This family certainly originated in the subtropical region during the Late Cretaceous and early Tertiary. Among the members of this family, *Houttuynia* occurs from the Himalayas to Japan; *Anemopsis* in Mexico and the southwestern United States; *Saururus* from the Philippines and Indochina through the Yangtze Valley; and *Gymnotheca* with two closely allied species of scattered distribution in southeastern Yunnan, Guangxi, Guizhou, and Sichuan. *Saururus* is morphologically and geographically quite similar to *Zippelia* ("*Circaeocarpus*") of the Piperaceae, a large pantropical family that appears to be ultimately of Gondwanan distribution. The possible relationship between the *Saururus* and *Zippelia* should be investigated further.

Menispermum, which has many perianth segments that are irregularly spirally arranged and more than four whorls of stamens, is one of the most primitive members of the mainly tropical and subtropical Menispermaceae. It is the only member of this family that has a disjunction in range between eastern Asia and temperate North America, which suggests that *Menispermum* could be an ancient relict derived from subtropical mountains in Laurasia. It might be close to the ancestral form of this now primarily tropical family.

The genus *Penthorum* (Penthoraceae) can be regarded as intermediate between the Crassulaceae and Saxifragaceae. Its disjunct distribution pattern coincides with its primitive morphology and critical phylogenetic position. Similar statements could be made for *Tiarella* (Saxifragaceae) and *Decumaria* (Hydrangeaceae).

Other primitive families such as Hamamelidaceae, Altingiaceae, Cornaceae, Araliaceae, and the more primitive tribes in some large families, such as Sophoreae of the Papilionaceae (*Cladrastis*), also are represented in the disjunct eastern

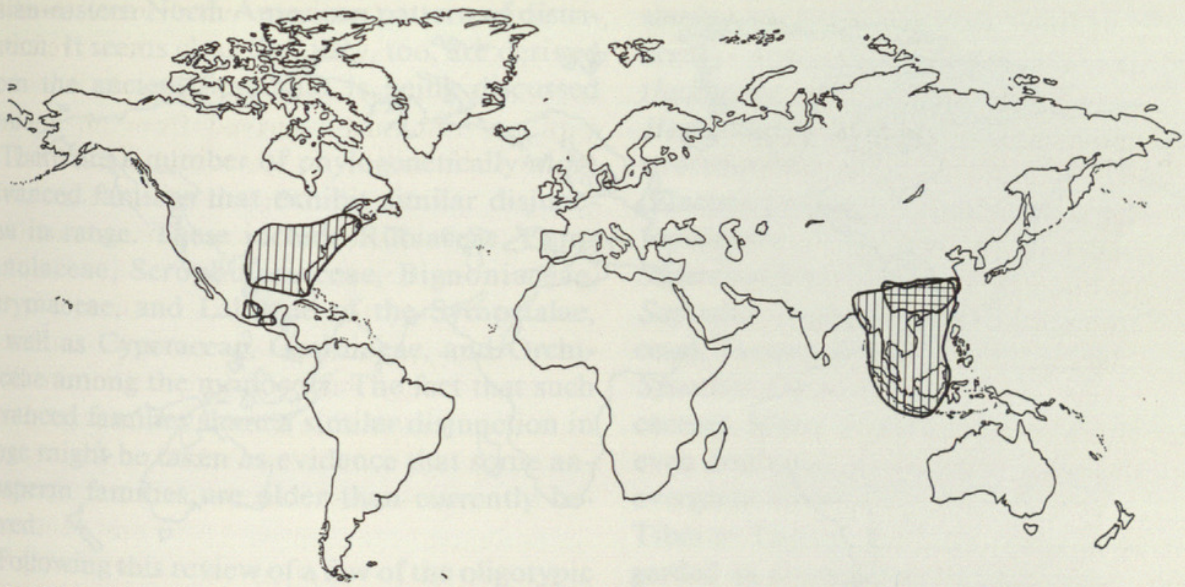

FIGURE 4. The distributions of *Camptotheca* (horizontal lines) and *Nyssa* (vertical lines).

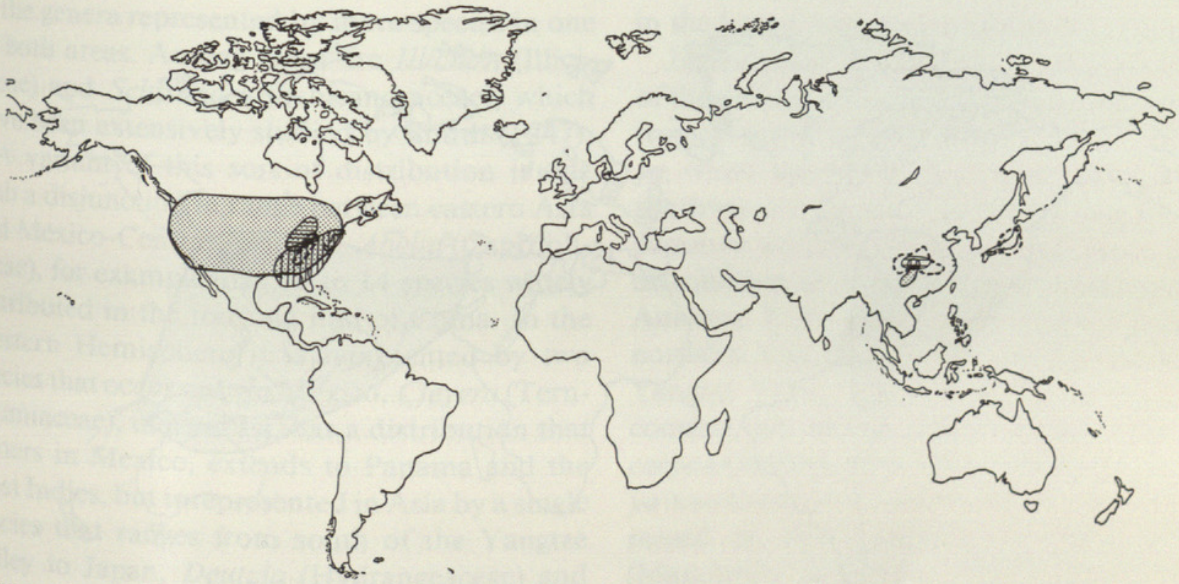

FIGURE 5. The distributions of *Buckleya* (dashed outline), *Decumaria* (vertical lines), *Stylophorum* (horizontal lines), and *Symphoricarpos* (shaded).

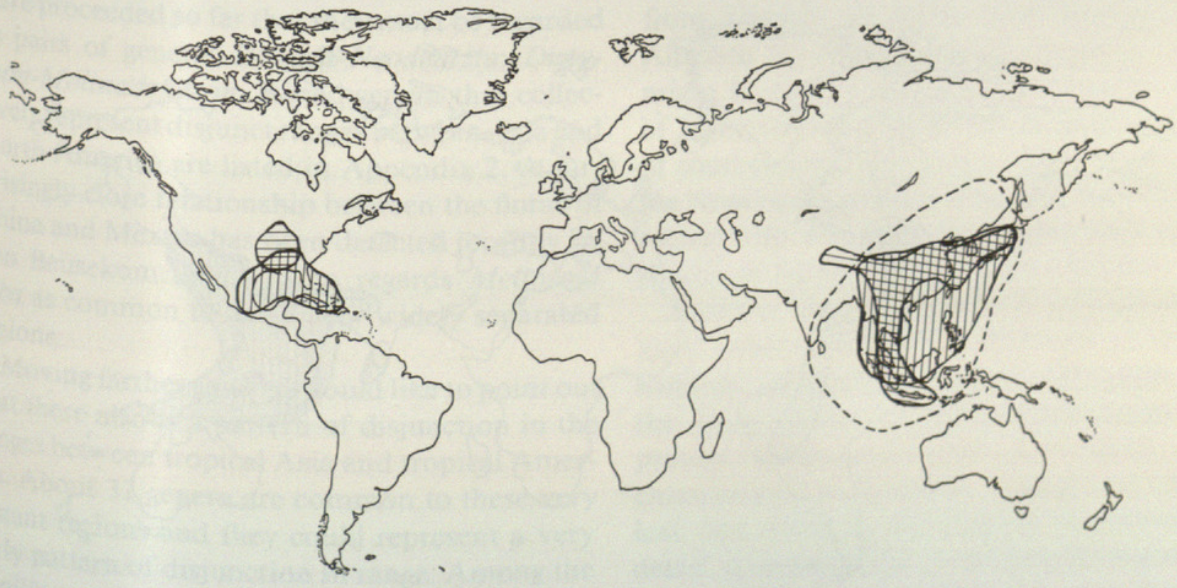

FIGURE 6. The distributions of Illiciaceae: *Illicium* (vertical lines); and Schisandraceae: *Kadsura* (dashed outline) and *Schisandra* (horizontal lines).

FIGURE 7. The distributions of Calycanthaceae: *Calycanthus* (vertical lines) and *Chimonanthus* (shaded).

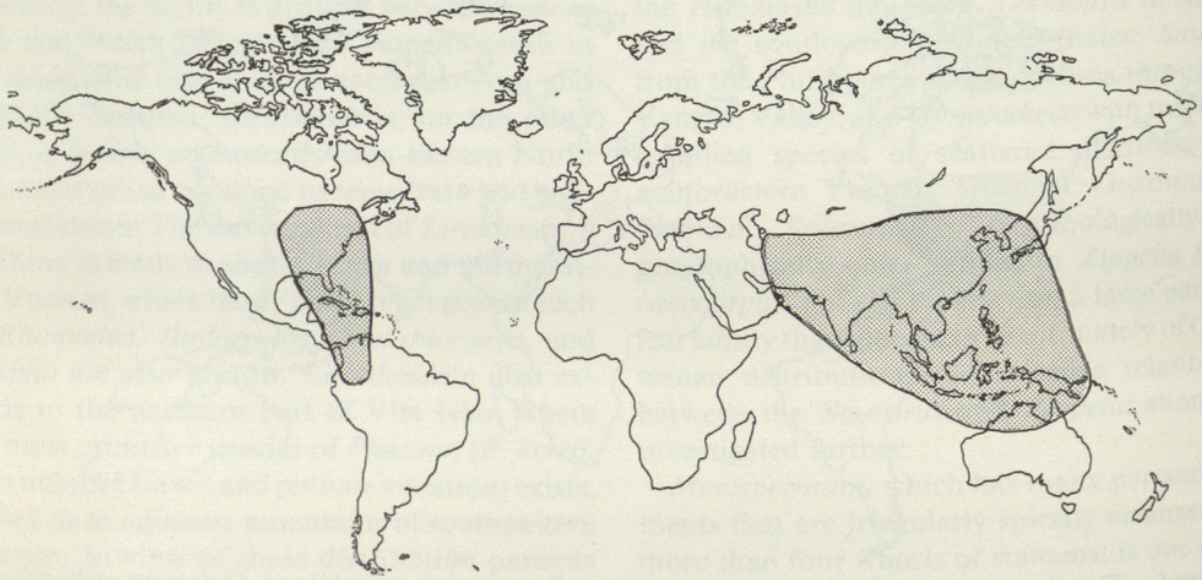

FIGURE 8. The distribution of *Nelumbo*.

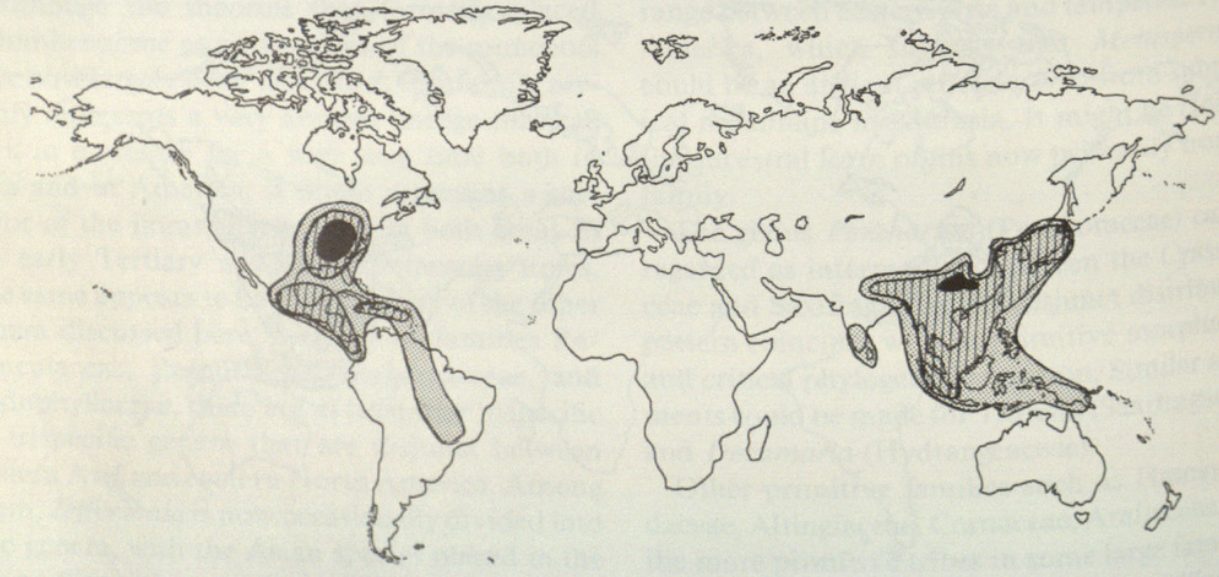

FIGURE 9. The distributions of Magnoliaceae (shaded): *Liriodendron* (solid) and *Magnolia* (vertical lines).

Asian-eastern North American pattern of distribution. It seems clear that they, too, are derived from the ancient flora that is being discussed here.

There are a number of phylogenetically more advanced families that exhibit similar disjunction in range. These include Rubiaceae, Campanulaceae, Scrophulariaceae, Bignoniaceae, Phrymaceae, and Labiatae of the Sympetalae, as well as Cyperaceae, Gramineae, and Orchidaceae among the monocots. The fact that such advanced families share a similar disjunction in range might be taken as evidence that some angiosperm families are older than currently believed.

Following this review of a few of the oligotypic genera that are represented both in Asia and in North America, we now pass on to consider some of the genera represented by more species in one or both areas. Among them are *Illicium* (Illiciaceae) and *Schisandra* (Schisandraceae), which have been extensively studied by Smith (1947).

A variant of this sort of distribution is one with a disjunction in range between eastern Asia and Mexico-Central America. *Abelia* (Caprifoliaceae), for example, has 10 to 14 species widely distributed in the forested half of China. In the Western Hemisphere it is represented by two species that occur only in Mexico. *Cleyera* (Ternstromiaceae), in contrast, has a distribution that centers in Mexico, extends to Panama and the West Indies, but is represented in Asia by a single species that ranges from south of the Yangtze Valley to Japan. *Deutzia* (Hydrangeaceae) and *Distylium* (Hamamelidaceae) are similar in their distribution, but in these cases differentiation of the Eastern and Western Hemisphere elements have proceeded so far that they must be regarded as pairs of genera: *Deutzia-Neodeutzia*; *Distylium-Molinadendron*. Paired genera that collectively represent disjunct ranges between Asia and North America are listed in Appendix 2. A surprisingly close relationship between the floras of China and Mexico has been detected recently by van Beusekom (1971), who regards *Meliosma alba* as common to these very widely separated regions.

Moving farther south, I would like to point out that there also is a pattern of disjunction in the ranges between tropical Asia and tropical America. About 37 genera are common to these very distant regions and they could represent a very early pattern of disjunction in range. Among the families represented primarily by trees and shrubs are genera such as *Talauma* (Magnoliaceae), *Anaxagorea* (Annonaceae), *Litsea, Nothaphoebe, Persea,* and *Phoebe* (Lauraceae), *Hedyosmum* (Chloranthaceae), *Eurya* (Ternstroemiaceae), *Saurauia* (Saurauiaceae), *Sloanea* (Elaeocarpaceae), *Microtropis* (Celastraceae), *Pristimera* (= *Reissantia*) (Hippocrateaceae), *Sageretia* (Rhamnaceae), *Picrasma* (Burseraceae), *Sapindus* (Sapindaceae), *Meliosma* (Meliosmaceae), *Turpinia* (Staphyleaceae), *Allospondias* and *Spondias* (Anacardiaceae), and *Gaultheria* (Ericaceae). Many of these genera are common or even dominant in the tropical and subtropical evergreen forests that extend from southeastern Tibet to Taiwan in China. They can also be regarded as descendents of the sort of vegetation that seems to have predominated in the subtropical mountains of the Northern Hemisphere in the Late Cretaceous and the early Tertiary.

Juglandaceae presents an interesting example of the differentiation of these warm temperate to tropical northern floras (Lu, 1980). *Annamocarya,* which extends from tropical Indochina into southwestern China, is very likely to be near the common ancestor of *Carya,* which is disjunct in distribution in eastern Asia and eastern North America. It is distributed in eastern Asia from northern Viet Nam to the southern part of the Yangtze Valley. *Pterocarya* and *Platycarya,* in contrast, are mainly eastern Asian, with *Platycarya* extending west of the Caucasus; *Cyclocarya* is endemic to China, but known from the fossil record in the Paleogene of North America (Manchester & Dilcher, 1982); *Juglans,* which also appears to be a relict from the Late Cretaceous, is widely distributed, ranging in Asia south to Indochina and in the Western Hemisphere from Canada to Cuba and through Central America to Andean South America. *Juglans* might be closely related to an ancestral species of Juglandaceae. *Engelhardtia,* which is a genus of southeastern Asia that extends northward to the Nanling Mountains of south China, is a genus paired with *Oreomunnea,* represented by three species in Mexico and Central America.

Another family that can be hypothesized to have originated in the mountains of the subtropical regions of the Northern Hemisphere, like the Juglandaceae, is the Chloranthaceae. The present distribution of this small family can be characterized as primarily tropical and subtropical, but when its distribution is examined in detail, it appears that it can best be regarded as being of Gondwanic origin (see also Raven &

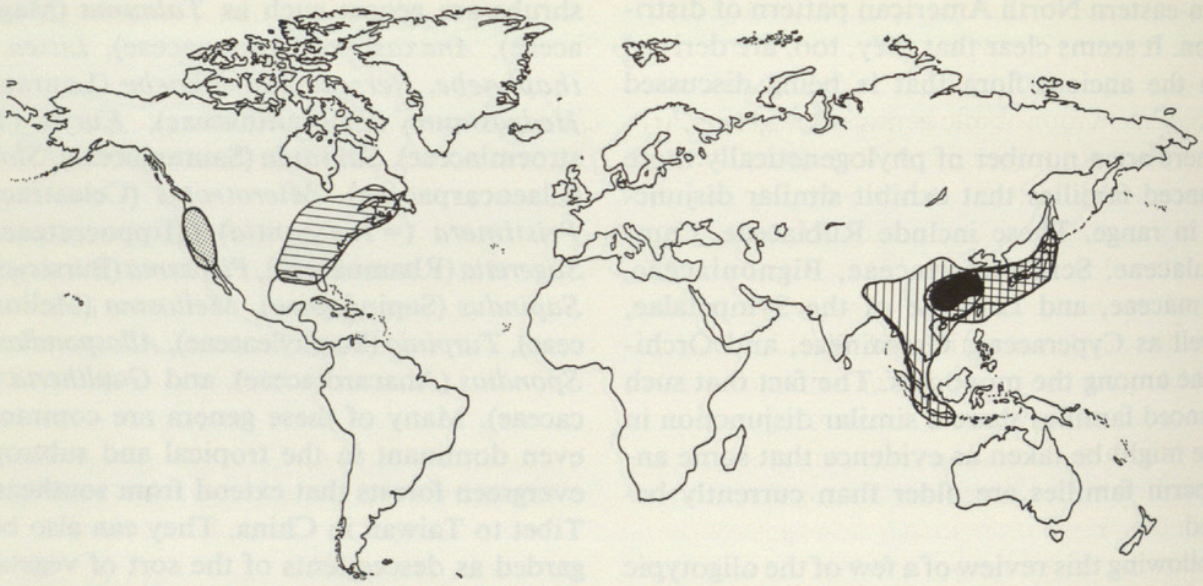

FIGURE 10. The distributions of Saururaceae: *Anemiopsis* (shaded), *Gymnotheca* (solid), *Houttuynia* (vertical lines), and *Saururus* (horizontal lines).

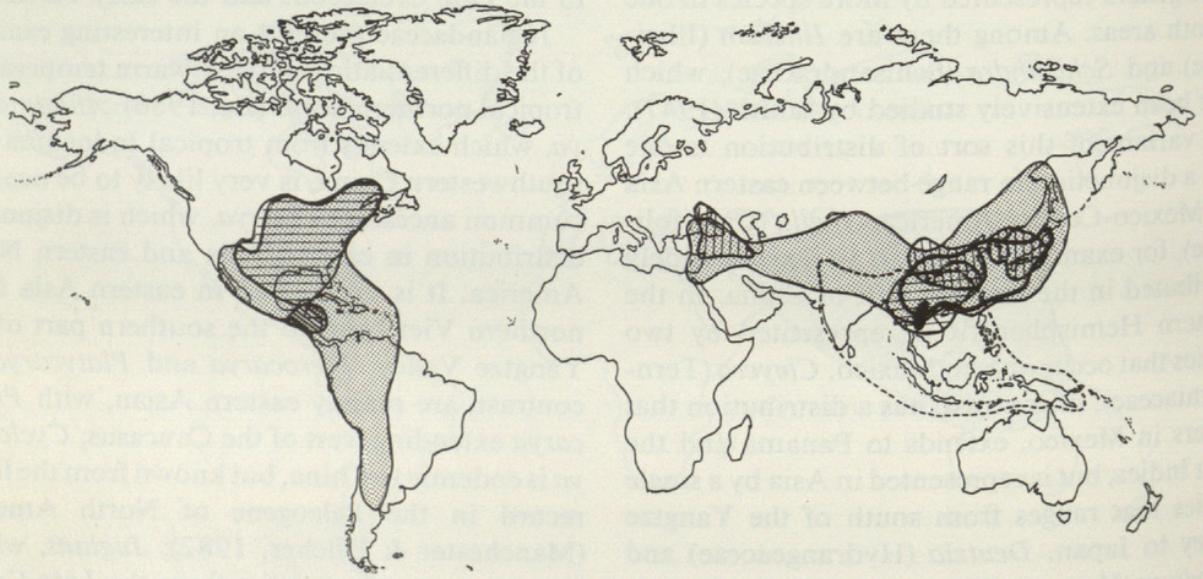

FIGURE 11. The distributions of Juglandaceae: *Annamocarya* (solid), *Carya* (horizontal lines), *Engelhardtia* (dashed outline), *Juglans* (shaded), *Oreomunnea* (diagonal lines), *Platycarya* (heavy outline), and *Pterocarya* (vertical lines).

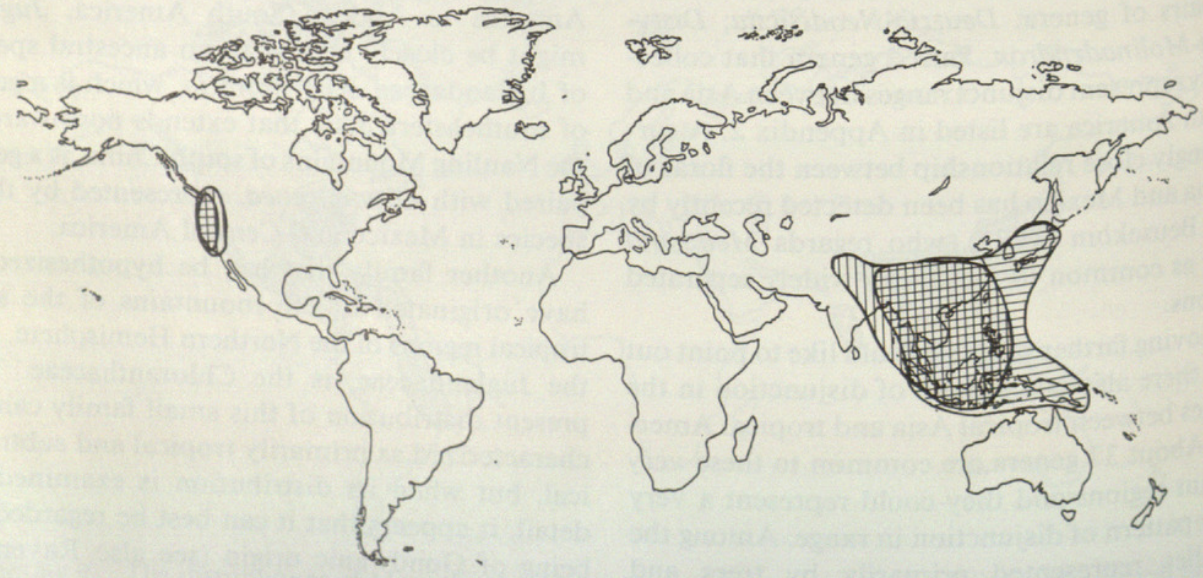

FIGURE 12. The distributions of *Castanopsis* (vertical lines) and *Lithocarpus* (horizontal lines).

Axelrod, 1974). The relatively close relationship between *Ascarina* (with eight species from Malaysia and Polynesia, including New Zealand) and *Ascarinopsis* (a monotypic genus of Madagascar) suggests that these genera differentiated when migration between Australasia and Africa was much easier than it is at present. *Hedyosmum,* on the other hand, is very well developed with about 40 species in tropical America and the West Indies, and one in the Old World, where it occurs from Sumatra and Borneo northward to Hainan in southern China. The most primitive member of Chloranthaceae surviving at the present time, however, is certainly *Sarcandra,* which is one of the very few angiospermous genera that lacks vessels. Overall, *Sarcandra* is relatively closely related to *Chloranthus* and occurs with that genus from tropical southeastern Asia northward through eastern Asia. *Chloranthus* extends further north to the mixed forest in northeastern China and is clearly of Late Cretaceous origin.

Similar floristic connections between tropical Asia and tropical America are found among more advanced families such as Compositae. Thus, *Gochnatia* (= *Leucomeris*) is a woody genus of this family that has about 64 species extending from the southern United States through Mexico and the West Indies to South America; but it is also represented by two species that have a discontinuous distribution in the Himalayas and southeastern Asia. One of these Asian species occurs in Nepal and the other ranges from Pegu-Burma to southwestern Yunnan and the upper Yangtze Valley between Yunnan and Sichuan. *Gochnatia,* together with the monotypic and endemic genus *Nouelia* that occurs in the same part of Asia, is a small tree belonging to the tribe Mutisieae, perhaps the most primitive of the family Compositae. In the tribe Mutisieae, there are many woody genera that appear to be primitive in their characteristics and occur in Central and South America and in Africa, where they are well represented both in the tropical regions and in the southern, more temperate portions. Mutisieae certainly appear to be of Gondwanic origin.

The two members of Mitrastemonaceae recently discovered in Yunnan and Fujian on the mainland of China are extremely interesting. *Mitrastemon* is represented by one species in Japan (Ohwi, 1965), and one or two species in Taiwan (Liu & Lai, 1976) (one of which extends to Fujian), one species from Indochina and southeastern Yunnan, one species in Borneo, and one species in Sumatra, with an additional two species completely isolated from their Asian relatives in Mexico (Matuda, 1947) and Central America. In southeastern and temperate eastern Asia, every species of this genus is, without exception, a root parasite of *Castanopsis. Castanopsis* is a dominant genus that forms extensive forests in the subtropical to tropical mountains from which so many of the genera discussed in this paper are derived. If *Castanopsis* ever occurred in the New World, it is now extinct, but it has been replaced during the course of evolution by the related genus *Chrysolepis,* which consists of two species in California and Oregon. Despite the absence of *Castanopsis* and related genera in Mexico and Central America, Mitrastemonaceae, which are parasites of this genus in Asia, have persisted in a more depleted vegetation than has survived in Asia.

I would now like to summarize with a few general conclusions derived from the preceding discussion:

(1) The discontinuity in plant range that spans the Pacific Ocean is a very important one for the study of floristic evolution.

(2) The eastern Asian-eastern temperate North American, and the tropical Asian-tropical American disjunctions both appear to have been derived from similar ancestral floras and are closely related to the tropical southeastern (Indo-Malayan) and temperate eastern (including Sino-Japanese and Sino-Himalayan) Asian elements.

(3) All of these disjunctions in range seem to have been derived from the same upper Cretaceous and lower Tertiary paleotropical flora that occurred on the mountains within the tropical to subtropical zones (Axelrod, 1952, 1960).

(4) The pattern of these disjunctions is consistent with an origin of some of the constituent groups of angiosperms in the Late Cretaceous or even earlier (Axelrod, 1961).

Literature Cited

Axelrod, D. I. 1952. A theory of angiosperm evolution. Evolution 4: 29–60.

———. 1960. The evolution of flowering plants. Pp. 227–307 *in* S. Tax (editor), Evolution after Darwin. Vol. 1, The Evolution of Life. Univ. Chicago Press, Chicago.

———. 1961. How old are the angiosperms? Amer. J. Sci. 259: 447–459.

Beusekom, C. F. van. 1971. Revision of *Meliosma* (Sabiaceae) section *Lorenzanea* excepted, living and fossil, geography and phylogeny. Blumea 19: 355–529.

Good, R. 1974. The Geography of Flowering Plants, 4th ed. Longman, London.

GRAHAM, A. (editor). 1972. Floristics and Paleofloristics of Eastern Asia and North America. Elsevier Publishing Company, Amsterdam.

GRAY, A. 1859. Observations upon the relationship of the Japanese flora to that of North America and of other parts of the northern hemisphere. Mem. Amer. Acad. Arts 6: 377–453.

KOYAMA, T. & S. KAWANO. 1963. Critical taxa of grasses with North American and eastern Asiatic distribution. Canad. J. Bot. 42: 859–884.

LI, H. L. 1952. Floristic relationships between eastern Asia and eastern North America. Trans. Amer. Philos. Soc. 42: 371–429. Reprinted 1971, with a forward, pp. i + ii, and without pagination as Morris Arboretum Monograph.

———. 1953. Present distribution and habitats of the conifers and taxads. Evolution 7: 245–261.

LIU, T. S. & M. J. LAI. 1976. Rafflesiaceae. *In* H. L. Li, T. S. Liu, T. C. Huang, T. Koyama & C. E. DeVol (editors), Flora of Taiwan 2: 582–584.

LU, A. M. 1980. On the geographical distribution of the Juglandaceae. Acta Phytotax. Sin. 20: 257–274. (In Chinese, English summary.)

MANCHESTER, S. R. & D. L. DILCHER. 1982. Pterocaryoid fruits (Juglandaceae) in the Paleogene of North America and their evolutionary and biogeographic significance. Amer. J. Bot. 69: 275–286.

MATUDA, E. 1947. On the genus *Mitrastemon*. Bull. Torrey Bot. Club 74: 133–141.

OHWI, J. 1965. Flora of Japan. (English edition.) Smithsonian Institution, Washington.

RAVEN, P. H. & D. I. AXELROD. 1974. Angiosperm biogeography and past continental movements. Ann. Missouri Bot. Gard. 61: 539–673.

SMITH, A. C. 1947. The families Illiciaceae and Schisandraceae. Sargentia 7: 1–224.

WOOD, C. E. 1972. Morphology and phytogeography: the classical approach to the study of disjunctions. Ann. Missouri Bot. Gard. 59: 107–124.

APPENDIX 1. Eastern Asia and eastern North America intercontinental discontinuities.

Family	Genus	Number of Species in E. Asia/ N. Am.	Distribution in	
			E. Asia	N. Am.
Cupressaceae	*Calocedrus* (*Heyderia*)	2/1	S to N Burma, NE Siam	Pacific N. Am.
Cupressaceae	*Chamaecyparis*	3/3	S to Taiwan	
Cupressaceae	*Thuja*	3/2		
Pinaceae	*Pseudotsuga*	5/2		W N. Am.
Pinaceae	*Tsuga*	5–10/2		
Taxaceae	*Torreya*	5/2		Florida and California
Anacardiaceae	*Toxicodendron*	18+/8		S to S. Am.
Apocynaceae	*Amsonia*	1/17		N. Am.
Apocynaceae	*Trachelospermum*	10/1		SE United States
Araliaceae	*Aralia*	30+/4+	S to Indo-Malaya	
Araliaceae	*Oplopanax*	1/1		
Araliaceae	*Panax*	7/2		
Berberidaceae	*Mahonia*	40+/30−	S to Sumatra	S. Am.
Bignoniaceae	*Campsis*	1/1		S to W. Indies
Bignoniaceae	*Catalpa*	7/4		S to W. Indies
Buxaceae	*Pachysandra*	3/1		E United States
Caesalpiniaceae	*Gleditsia*	10/2	Tropical Africa	S to S. Am.
Caesalpiniaceae	*Gymnocladus*	3/1	S to Assam, Burma	
Calycanthaceae	*Calycanthus*	1/1		SW and E United States
Campanulaceae	*Heterocodon*	1/1		W N. Am.
Caprifoliaceae	*Symphoricarpos*	1/15		
Caprifoliaceae	*Triosteum*	3–6/4–5		
Compositae	*Brachyactis*	4/1	N Asia	N. Am.
Compositae	*Cacalia*	±60/4		N. Am. + and S to S. Am.
Compositae	*Crossostephium*	1+3/1		California
Cornaceae	*Bothrocaryum* (*Cornus* sect. *Thelycrania*)	1/1		NE Am.
Penthoraceae	*Penthorum*	1/1	S to Indochina	Atlantic N. Am.
Diapensiaceae	*Shortia*	4–8/1		SE United States
Ericaceae	*Leucothoe*	4/3(–40)		S to S. Am.
Ericaceae	*Lyonia*	9/21	S to Himalayas	W. Indies
Ericaceae	*Pieris*	6/2		
Ericaceae	*Therorhodion*	1/2	NE Asia	NW Am.
Ericaceae	*Hugeria*	2/1		
Iteaceae	*Itea*	12/1	S to W. Malaysia	Atlantic N. Am.
Fagaceae	*Castanopsis* (incl. *Chrysolepis*)	60–100/2	S to tropical Asia	W United States
Fumariaceae	*Adlumia*	1/1	NE Asia	E N. Am.
Fumariaceae	*Dicentra*	2+1/10–11		
Hamamelidaceae	*Hamamelis*	1+/2		E N. Am.
Hamamelidaceae	*Liquidambar*	2+1/3	SW Asia Minor	Atlantic N. Am.
Hydrangeaceae	*Decumaria*	1/1	S to Indochina	
Hydrangeaceae	*Hydrangea*	45/35+	S to Philippines, Java	Atlantic N. Am., Chile
Illiciaceae	*Illicium*	21+/	S to W. Malaysia	Mexico, W. Indies
Juglandaceae	*Carya*	2/23	S to Indochina	E N. Am.
Labiatae	*Agastache*	1/20		S to Mexico
Labiatae	*Meehania*	5/1	sp. complex	E United States
Loganiaceae	*Gelsemium*	1/2	S to N Borneo, Sumatra	N Mexico

APPENDIX 1. (Continued).

Family	Genus	Number of Species in E. Asia/ N. Am.	Distribution in	
			E. Asia	N. Am.
Magnoliaceae	*Liriodendron*	1/1	S to N Indochina	
Magnoliaceae	*Magnolia*	30+/5+	S to Java	Venezuela
Menispermaceae	*Menispermum*	1/2		Atlantic N. Am., S to Mexico
Monotropaceae	*Hypopitys*	1/1	S to Himalaya	Colombia
Nelumbonaceae	*Nelumbo*	1/1	NE Australia	S to Colombia
Nyssaceae	*Nyssa*	6/4	S to W Malaysia	E N. Am.
Oleaceae	*Chionanthus* s.s.	1/2		E N. Am.
Oleaceae	*Osmanthus*	15/3	S to SE Asia	
Orobanchaceae	*Boschniakia*	2/1		NW N. Am.
Papaveraceae	*Stylophorum*	2/1		Atlantic N. Am.
Papilionaceae	*Amphicarpaea*	2–3+1/1	S. Africa	?S to tropical Am.
Papilionaceae	*Apios*	6/4		
Papilionaceae	*Cladrastis*	4/1		E N. Am.
Papilionaceae	*Lespedeza*	65+/15–30	S to Australia	
Papilionaceae	*Thermopsis*	7/23		E United States
Papilionaceae	*Wisteria*	7/3		E N. Am.
Phrymaceae	*Phryma*	1/1		
Podophyllaceae	*Achlys*	1/1		Pacific N. Am.
Podophyllaceae	*Caulophyllum*	1/1		
Podophyllaceae	*Diphilleia*	2/1		Atlantic N. Am.
Podophyllaceae	*Jeffersonia*	1/1		
Podophyllaceae	*Podophyllum*	1/1		E N. Am.
Polygonaceae	*Antenoron*	2–3/1	S to Philippines	
Ranunculaceae	*Enemion* (*Isopyrum*)	1/1–3		
Rhamnaceae	*Berchemia*	13+/1–2	S to tropical Africa	Atlantic N. Am.
Rosaceae	*Acomastylis*	1/12		
Rosaceae	*Photinia*	40/20	S to Sumatra	
Rosaceae	*Physocarpus*	1/9–10	NE Asia	
Rosaceae	*Sieversia*	1/1	NE Asia	Aleutian Isl.
Rosaceae	*Sorbaria*	5+/1	?W to central Asia	
Rubiaceae	*Cephalanthus*	1+1/5	Africa	to warm Am.
Rubiaceae	*Kelloggia*	1/1	Yunnan-Tibet	SW United States
Rubiaceae	*Mitchella*	1/1	NE Asia	Atlantic N. Am.
Santalaceae	*Buckleya*	2/1		S United States
Santalaceae	*Pyrularia*	2/2	S to Himalaya	SE United States
Saururaceae	*Saururus*	1/1	S to Philippines	E United States
Saxifragaceae	*Astilbe*	15/2		
Saxifragaceae	*Mitella*	2/12		
Saxifragaceae	*Tiarella*	1/6		Pacific and Atlantic N. Am.
Schisandraceae	*Schisandra*	17/1	S to tropical Asia	
Scrophulariaceae	*Castilleja*	1/30–200		N. Am. to S. Am.
Scrophulariaceae	*Orthocarpus*	1/25–30		W Am.
Scrophulariaceae	*Veronicastrum* s.s.	1/1	NE Asia	temperate NE N. Am.
Solanaceae	*Leucophysalis* (= *Physaliastrum*)	4/1		
Styracaceae	*Halesia*	1/3		SE United States
Theaceae	*Gordonia*	8–32/1	S to Indo-Malaya	SE United States
Theaceae	*Stewartia*	7–10/2	incl. *Hartia*, S to Indochina	E United States
Umbelliferae	*Glehnia*	1/1	NE Asia	Pacific N. Am.

APPENDIX 1. (Continued).

Family	Genus	Number of Species in E. Asia/ N. Am.	Distribution in	
			E. Asia	N. Am.
Umbelliferae	*Osmorrhiza*	1+/10–14	W to Caucasus	S to Andes
Vitaceae	*Ampelopsis*	15/2		
Vitaceae	*Parthenocissus*	9/2		
Alliaceae	*Nothoscordum*	1/2	NE Asia, 4 African	N. Am., 28 S. Am.
Araceae	*Symplocarpus*	2/1	NE Asia	Atlantic N. Am.
Croomiaceae	*Croomia*	2/1		E United States
Cyperaceae	*Trichophorum*	1/3		
Gramineae	*Diarrhena*	1/1		
Gramineae	*Hystrix*	2/3	S to New Zealand	
Gramineae	*Muehlenbergia*	6/94–110		S to Andes
Gramineae	*Schizachne*	1/1		S to Mt. SW United States
Gramineae	*Zizania*	1/1–2	S to Burma	
Liliaceae	*Aletris*	13/5	S to Himalaya	
Liliaceae	*Clintonia*	2/4		
Liliaceae	*Disporum*	8/12	S to Indochina	
Liliaceae	*Smilacina*	14/11	S to Himalaya	Central Am.
Liliaceae	*Zigadenus*	1/20		S to Central Am.
Orchidaceae	*Erythrodes*	3+/97−	S to Indo-Malaya, Polynesia	Argentina
Orchidaceae	*Pogonia*	2/1+		(40 to tropical S. Am.?), S to W. Indies, and tropical S. Am.
Orchidaceae	*Tipularia*	2/1	N to E Asia	
Trilliaceae	*Trillium*	3+/ca. 40	Kamchatka to W Himalaya	
Zosteraceae	*Phyllospadix*	2/3		Pacific coast of N. Am.