

A COMPARATIVE STUDY OF THE VEGETATION IN HUBEI PROVINCE, CHINA, AND IN THE CAROLINAS OF THE UNITED STATES

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The study of the floristic relationship between Eastern Asia and North America involves many complex problems that concern both time and space. Timewise, a researcher can devote his time looking for paleobotanical information as well as studying current components of the vegetation of the areas concerned. Spacewise, the study can involve extensive research of widespread genera with disjunct distributions as well as intensive investigations of paired species occurring in limited areas. My report represents the result of field observations and herbarium and library investigations of two comparable areas: Hubei Province in Central China and the Carolinas in Eastern U.S.A. It covers the geographic background and general aspects of the floras of the two regions, and compares the similarities and differences of the vegetations they support.

GEOGRAPHICAL BACKGROUND AND GENERAL ASPECTS OF THE FLORAS

Hubei, a medium-sized province in central China, has an area of 187,000 square kilometers and is located in the middle portion of the Yangtze Valley, between 29°05' and 33°20' north latitude. It is surrounded on three sides by mountains, with the higher ones in the northwest reaching 3,000 m or more in elevation. Eastern Hubei is hilly and the central-southern portions of the province form the Jiangnan Plain.

The flora of Hubei is one of the richest in China, especially in the western Hubei mountainous region where remnants of virgin forests are preserved. According to preliminary investigation, the province has about 3,816 species and 242 varieties of vascular plants belonging to 1,165 genera and 207 families. This flora is composed of tropical, subtropical, and temperate elements.

Evergreen coniferous forests occur in some of the higher elevations of the mountains in western Hubei. Small deciduous forests occur at some

intermediate elevations, but usually the deciduous and evergreen coniferous species intermingle. At lower elevations, some areas are occupied by broadleaf evergreen forest. Limestone areas are sometimes occupied by *Cupressus funebris*, especially where the rock is near the surface, as in the Changjiang (Yangtze) Gorges.

The predominant species of deciduous trees in Hubei belong to the following genera: *Fagus* (*F. longipetiolata*, *F. lucida*, *F. engleriana*), *Castanea* (*C. seguinii*, *C. mollissima*), *Quercus* (*Q. acutissima*, *Q. acutidentata*, *Q. aliena*, *Q. variabilis*, *Q. fabri*, *Q. glandulifera* var. *glandulifera*, *Q. glandulifera* var. *brevipetiolata*), *Betula* (*B. luminifera*, *B. insignis*, *B. utilis*—all in western Hubei mountains), *Carpinus* (*C. fargesiana*, *C. fargesii*), *Juglans* (*J. regia*, *J. cathayensis*), *Pterocarya* (*P. stenoptera*, *P. hupehensis*), *Platycarya* (*P. strobilacea*), *Acer* (*A. davidii*, *A. mono*, *A. amplum*, *A. wilsonii*—most in western Hubei mountains), *Populus* (*P. adenopoda*, *P. davidiana*, *P. wilsonii*, *P. lasiocarpa*—most in the western part of the province), *Sorbus* (*S. alnifolia*, *S. wilsoniana*, *S. hupehensis*, *S. folgeri*—most in western Hubei mountains), and *Tilia* (*T. tuan*, *T. oliveri*—in western Hubei mountains). The major species of the broad-leaved evergreen trees belong to these genera: *Quercus* (*Q. glauca*, *Q. fargesii*, *Q. myrsinaefolia*, *Q. engleriana*—most in western Hubei mountains), *Castanopsis* (*C. tibetana*, *C. sclerophylla*), *Lithocarpus* (*L. glaber*, *L. henryi*), *Phoebe* (*P. neurantha*, *P. chinensis*), and *Cinnamomum* (*C. camphora*, *C. wilsonii*, *C. bodinieri*—most in western Hubei mountains). The major evergreen conifers are *Pinus massoniana* and *Cunninghamia lanceolata*, which usually occur in areas below 1,200 m in elevation. *Pinus armandii* occurs between 1,200 m and 2,500 m in northwestern Hubei, and *Abies fargesii* and *Abies chensiensis* occur at the higher elevations in the northwestern portion of the province.

We visited and collected specimens in the

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southern Appalachian mountains in April to late June and September, 1982. Although our visits were short (three months), the field observations and a study of the American botanical information obtained from literature have convinced us that Hubei Province and the Carolinas, even though separated by a great ocean and thousands of miles of land, are very similar, not only in their climates, but also in the vegetation.

North Carolina and South Carolina are bordered by the Southern Appalachians on the west and by the Atlantic Ocean on the east. This area has a total area of 217,000 square kilometers, and lies between 32° and 36°40' north latitude, a little further north than Hubei Province. The Carolinas are naturally divided into three physiographic regions: the Mountains in the west, the Piedmont, and the Coastal Plain in the east.

In general, the mountains of the Carolinas are similar to the western Hubei mountainous region. They vary in height from about 350 to 2,025 meters: Mt. Michell at ca. 2,025 m is the highest mountain in North America east of the Mississippi River. In western Hubei, the mountains are somewhat higher, with an average elevation of 1,000 meters. The highest peak, Non-name Peak, in the Shennongjia Forest District, reaches 3,105 meters.

On some of the high summits of Carolinian mountains occur fir forest of *Abies fraseri* and spruce forest of *Picea rubens*. The forests of most areas below the fir and spruce forests are composed of mixed deciduous species of *Quercus* (*Q. alba*, *Q. rubra*, *Q. coccinea*), *Betula* (*B. lutea*, *B. lenta*, *B. nigra*), *Fagus* (*F. grandiflora*), *Acer* (*A. rubrum*, *A. saccharum*, *A. spicatum*, *A. pensylvanicum*), and *Tilia* (*T. americana*).

There are two species of *Liriodendron*, one from China, and the other from the United States. In western Hubei, small areas of pure *Liriodendron* forest are rare; usually it is mixed with other species and is not abundant. The American species, *Liriodendron tulipifera*, is common in the Carolinas, where there are large areas of pure yellow poplar forests. *Aesculus*, distributed in temperate zone, consists of about 25 species. In Hubei Province there is only one species, *Aesculus wilsonii*, and its distribution is limited in western Hubei mountains. There are three species of *Aesculus* in the Carolinas, only one of which is a large tree, *Aesculus octandra*, occurring in the mountains. *Amelanchier* (Rosaceae) is also distributed in the north temperate zone. There are about five species occurring in the Carolinas.

Amelanchier arborea and its two varieties (var. *laevis* and var. *austromontana*) are widely distributed in the mountainous region. In April and May, their white to pinkish flowers are conspicuous along the mountainsides and in the valleys. In Hubei, there is a single species of *Amelanchier*, *A. sinica*, which is a shrub and is distributed at lower elevations.

The predominant conifers in the mountains of the Carolinas are *Pinus echinata*, *P. strobus*, *P. rigida*, and *P. virginiana*, *Picea rubens*, and *Abies fraseri*.

Generally, the Piedmont region of the Carolinas is comparable to the hilly areas of eastern Hubei, despite the fact that the elevation of the Piedmont is lower than its counterpart in China. In the Piedmont, altitudes vary between 100 and 350 meters, whereas the Dabieshan Mountains in eastern Hubei are about 1,700 meters. The vegetation of both regions is primarily mixed deciduous forest. Important elements of the Piedmont region are *Quercus* (*Q. alba*, *Q. coccinea*, *Q. stellata*, *Q. michauxii*), *Fagus* (*F. grandifolia*), *Carpinus* (*C. caroliniana*), and *Betula* (*B. nigra*). The major deciduous trees in eastern Hubei are: *Quercus* (*Q. variabilis*, *Q. acutidentata*, *Q. aliena*, *Q. dentata*), *Castanea* (*C. mollissima*, *C. seguinii*), and *Alnus* (*A. trabeculosa*). Of particular interest is the genus *Carya*, which has nine species in the Piedmont, and only one species, *Carya cathayensis*, in Hubei, occurring in eastern hilly region below 1,000 meters.

The Coastal Plain region of the Carolinas is comparable to the Jiangnan Plain region of Hubei Province. Both constitute the largest area and lowest elevation of the respective regions under discussion. The obvious difference is the water system: the Carolinian lowland is situated at the eastern border of the Carolinas with immediate connection to the ocean. The lowland in Hubei is located in the middle of the province and is the floodplain of the Changjiang River and its largest tributary, the Han River. The dominant deciduous ligneous plants of these two regions are various oaks; *Quercus chenii* and *Quercus acutissima* frequent in Jiangnan Plain region, *Quercus laevis* and *Quercus marilandica* common in the Coastal Plain region. Pines are important components in the lowlands of both areas. In the Jiangnan Plain of Hubei the masson pine (*Pinus massoniana*) is dominant, whereas in the Coastal Plain of the Carolinas large areas are covered by six species of pines. They are: the long-leaf pine (*Pinus palustris*), loblolly pine (*Pi-*

TABLE 1. A summary of the floras of Hubei and the Carolinas.

Categories	Spermatophytes									
	Pteridophytes		Gymnosperms		Angiosperms				Total	
					Monocots		Dicots			
	Hubei	Caro- linas	Hubei	Caro- linas	Hubei	Caro- linas	Hubei	Caro- linas	Hubei	Caro- linas
Families	35	16	7	3	23	31	142	130	207	180
Genera	67	30	23	8	169	226	906	687	1,165	951
Species	182	89	37	21	629	940	2,968	2,310	3,816	3,360
Infraspeci- fic taxa	0	0	5	0	0	42	237	132	242	174

nus taeda), pond pine (*Pinus serotina*), short-leaf pine (*Pinus echinata*), slash pine (*Pinus elliottii*), and spruce pine (*Pinus glabra*).

A COMPARISON OF THE FLORAS

The floristic relationship between Hubei and the Carolinas are very close, with comparable number of species, genera, and families. The number of vascular plants of both regions, taken from the Flora Hupehensis (Wuhan Institute of Botany, 1976, 1979) and Radford et al. (1968) are shown in Table 1.

Families that contain more than 20 species of ferns, 10 species of gymnosperms, 25 species of dicotyledons, and 50 species of monocotyledons are given in Table 2.

The floras of the two regions have numerous shared families and genera. Of 207 families of vascular plants in Hubei and 180 in the Carolinas, approximately 75% are represented in both regions. Many of the genera are common to both regions. For example, in *Urticaceae*, there are 15 genera in Hubei; 5 of these are represented in the Carolinas, i.e., *Urtica*, *Laportea*, *Boehmeria*, *Parietaria*, and *Pilea*. In the *Betulaceae*, *Betula*, *Alnus*, *Corylus*, *Carpinus*, and *Ostrya* are genera common to both floras. In *Saxifragaceae*, there are 18 genera in Hubei, and 14 in the Carolinas, 10 of which are shared.

Chinese and American botanists have shown that in many genera the species that occur in Eastern Asia and North America are closely related. For instance, in *Buckleya*, *Phryma*, *Cornus*, *Diphylleia*, and *Podophyllum* there are paired species in the floras of Hubei and the Carolinas.

There are, however, some obvious differences between the two floras. First, at the family level, there are 44 families in Hubei not represented

in the Carolinas, and 29 families in the Carolinas not occurring in Hubei.

Families in the Hubei flora not in the Carolinas are as follows: Ferns – *Angiopteridaceae*, *Plagiogyriaceae*, *Gleicheniaceae*, *Dicksoniaceae*, *Monachosoraceae*, *Lindsaeaceae*, *Sinopteridaceae*, *Gymnogrammaceae*, *Parkeriaceae*, *Loxogrammaceae*; Gymnosperms – *Ginkgoaceae*, *Taxaceae*, *Podocarpaceae*, *Cephalotaxaceae*; Dicots – *Piperaceae*, *Chloranthaceae*, *Proteaceae*, *Olacaceae*, *Balanophoraceae*, *Tetracentraceae*, *Eupteleaceae*, *Cercidiphyllaceae*, *Sargentodoxaceae*, *Illiciaceae*, *Pittosporaceae*, *Eucommiaceae*, *Daphniphyllaceae*, *Coriariaceae*, *Icacinaceae*, *Sabiaceae*, *Elaeocarpaceae*, *Actinidiaceae*, *Flacourtiaceae*, *Stachyuraceae*, *Begoniaceae*, *Alangiaceae*, *Myrtaceae*, *Trapaceae*, *Theligonaceae*, *Myrsinaceae*, *Pedaliaceae*, *Gesneriaceae*; Monocots – *Stemonaceae*, *Zingiberaceae*.

Families in the Carolina flora not in Hubei flora: Ferns – *Isoetaceae*, *Grammitidaceae*; Dicots – *Annonaceae*, *Bataceae*, *Empetraceae*, *Cactaceae*, *Diapensiaceae*, *Cyrtillaceae*, *Sapotaceae*, *Cabombaceae*, *Martyniaceae*, *Elatinaceae*, *Podostemaceae*, *Sarraceniaceae*, *Plumbaginaceae*, *Dionaeaceae*, *Turneraceae*; Monocots – *Bromeliaceae*, *Arecaceae*, *Zannichelliaceae*, *Zosteraceae*, *Ruppiaceae*, *Juncaginaceae*, *Xyridaceae*, *Mayacaceae*, *Cannaceae*, *Marantaceae*, *Haemodoraceae*, *Burmanniaceae*.

Secondly, in the flora of Hubei the woody elements are more diversified than those of the Carolinas. Based on an incomplete survey, there are about 650 species and varieties, belonging to 200 genera and 73 families, of woody plants native to Hubei. The number of species and varieties of woody plant in the Carolinas flora is 217, belonging to 82 genera and 46 families.

The gymnosperms are much better represent-

TABLE 2. Major families in Hubei and the Carolinas.

Categories	Families	Hubei		Carolinas	
		Genera	Species & vars.	Genera	Species & vars.
Ferns	Aspidiaceae	1	(1)	7	24
	Athyriaceae	6	20	(placed in Aspidiaceae)	
Gymnosperms	Pinaceae	8	18	4	14
Dicots	Salicaceae	2	31	2	(13)
	Fagaceae	5	47	3	43
	Polygonaceae	6	72	7	45
	Caryophyllaceae	15	36	17	53
	Ranunculaceae	21	94	16	67
	Berberidaceae	8	48	7	(8)
	Lauraceae	9	54	4	(5)
	Brassicaceae	22	45	26	73
	Saxifragaceae	18	60	14	34
	Rosaceae	31	215	23	117
	Fabaceae	55	131	50	184
	Euphorbiaceae	21	55	11	45
	Aceraceae	2	30	1	(10)
	Rhamnaceae	8	39	5	(5)
	Apiaceae	34	75	36	84
	Ericaceae	7	41	19	70
	Primulaceae	4	47	6	(18)
	Lamiaceae	42	105	34	90
	Scrophulariaceae	25	79	30	85
	Rubiaceae	23	47	11	37
	Caprifoliaceae	10	61	6	28
	Asteraceae	70	306	85	449
Monocots	Poaceae	70	150	93	337
	Cyperaceae	14	120	17	196
	Liliaceae	36	140	35	106
	Orchidaceae	44	104	21	61

ed in Hubei than in the Carolinas. *Metasequoia glyptostroboides* is one of the most outstanding and significant species in the Hubei flora. This relict species was found in western Hubei, where there are about 5,000 very large metasequoia trees growing in a small valley in Lichuan Xian.

Thirdly, each flora has its own endemic and unique genera and species. In Hubei they are: *Saruma* (endemic genus) (Aristolochiaceae), *Tetracentron* (Tetracentraceae), *Sinofranchetia* (Hamamelidaceae), *Bretschneidera* (Bretschneideraceae), *Fortunearia* (Hamamelidaceae), *Hosiea* (Icacinaceae), *Tapiscia* (Staphyleaceae), *Dipteronia* (Aceraceae), *Davidia* (Davidiaceae), and *Emmenopterys* (Rubiaceae). In the Carolinas: *Dionaea* (endemic genus) (Dionaeaceae), *Hexastylis* (Aristolochiaceae), *Houstonia* (Rubiaceae), *Kalmia*, *Leiophyllum*, *Menziesia* (Ericaceae), *Galax* (Diapensiaceae), *Gaylussacia*

(Ericaceae), *Sarracenia* (Sarraceniaceae), *Xanthorhiza* (Ranunculaceae), *Ceratiola* (Empetraceae), *Spigelia* (Loganiaceae), and *Conopholis* (Orobanchaceae).

The monotypic genus *Dionaea*, endemic to the Carolinas, is a rare and fascinating perennial known only from the Coastal Plain.

Fourthly, there are also some differences in vegetation types. In western Hubei, at places above 2,000 m, large areas of arrow bamboo (*Sinarundinaria nitida*) forests are common. In the lowland of the Jiangnan Plain of Hubei, there are large numbers of aquatic plants, with 100 or more species and varieties.

The unique vegetation of the Carolinas is found on stone outcrops and sandy areas. In some places of the Piedmont, there are areas with rock outcrops, such as 40-Acre Rock, in South Carolina, which support many lithophytes, such as *Sedum*



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