METASEQUOIA GLYPTOSTROBOIDES—ITS PRESENT STATUS IN CENTRAL CHINA

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DURING THE LATE SUMMER and early fall of 1980, we participated in the 1980 Sino-American Botanical Expedition to western Hubei Province in the People's Republic of China.[1] Most of our fieldwork was conducted in the Shennongjia Forest District, but a brief visit (5–10 October) was also made to the metasequoia region (lat. 30°10′N, long. 108°45′E) of Lichuan Xian (Hsien)[2] after most of the field activities were completed.

To reach the metasequoia area we traveled west by boat up the Changjiang (Yangtze) River from Yichang in Hubei Province to Wanxian in Sichuan Province (MAP 1). From Wanxian we proceeded southward by jeep back into Hubei Province to the town of Modaoqi (Mo-tao-chi), where *Metasequoia* was first discovered as a living plant. After a brief stop at the type tree of *Metasequoia glyptostroboides* Hu & Cheng (see FIGURE 1), we continued on to the town of Lichuan (the county seat of Lichuan Xian), our base of operations for the next four days. We visited the metasequoia valley (about three hours away) in Xiaohe Commune on each of three consecutive days (6–8 October). Although this region has been visited by Chinese botanists and foresters over the past four decades, we had the very great privilege to be the first foreigners to visit the area since 1948 (see below). Part of our time in the valley was spent walking or traveling to noteworthy trees of *M. glyptostroboides* and meeting with commune and local forestry officials to learn of their inventories, care, and preservation of the naturally occurring trees and their program of seed collection and propagation. We also had an interesting and informative interview with

[1]The American participants were: Bruce Bartholomew, California Academy of Sciences (then at University of California Botanical Garden, Berkeley); David E. Boufford, Harvard University Herbaria (then at Carnegie Museum of Natural History); Theodore R. Dudley, U. S. National Arboretum; James L. Luteyn, New York Botanical Garden; and Stephen A. Spongberg, The Arnold Arboretum of Harvard University. The principal Chinese participants included: A. L. Chang, Kunming Institute of Botany; Z. Cheng, Wuhan Institute of Botany; S. A. He, Jiangsu Institute of Botany; Y. X. Jin, Wuhan Institute of Botany; Q. Y. Li, Wuhan University; S. C. Sun (expedition leader), Wuhan University and Wuhan Institute of Botany; Y. C. Tang, Institute of Botany, Beijing; J. X. Wan, Wuhan Institute of Botany; and T. S. Ying, Institute of Botany, Beijing. The expedition was conducted under the auspices of Academia Sinica and the Botanical Society of America, with funding by Academia Sinica and additional support from the National Geographic Society (Grant #2133-80) and members of the American Association of Botanical Gardens and Arboreta.

[2]The Pinyin system of romanization is used throughout except for names of older collectors, authors, and places for which changes in spelling might cause confusion. In these instances the Wade-Giles spelling is given in parentheses.

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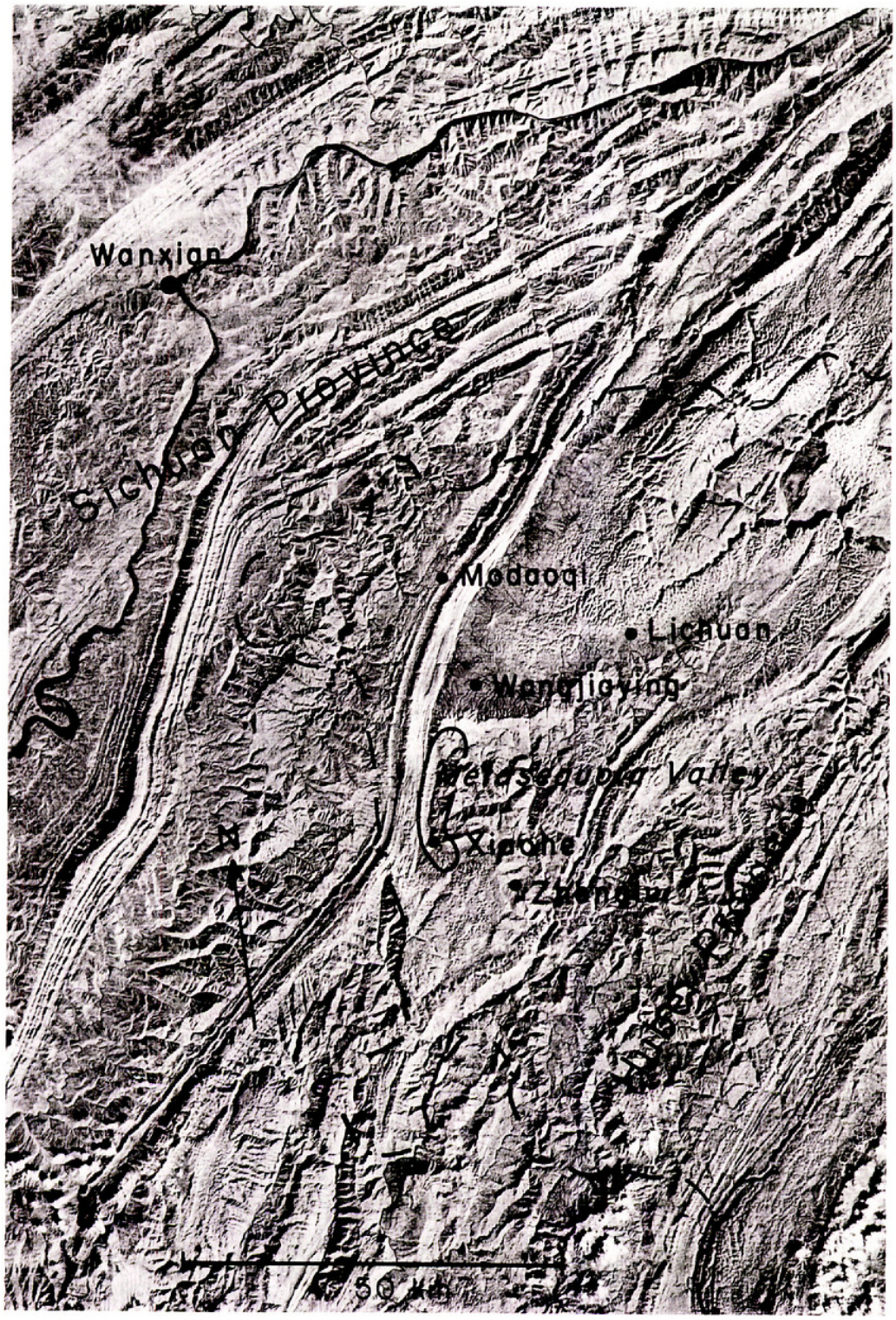

MAP 1. Metasequoia valley, Lichuan County, western Hubei Province, People's Republic of China (lat. 30°10′N, long. 108°45′E), and surrounding territory. Place names, metasequoia valley, and boundary between Hubei and Sichuan provinces superimposed on portion of NASA LANDSAT and Satellite Image (No. 8230502370500, taken 23 November 1975 and reproduced by U. S. Geological Survey EROS Data Center) to show topography of region. Wanxian located on banks of Changjiang (Yangtze) River.

two elderly members of the commune, who remembered the 1948 visit of Americans to the region. The remainder of the time was spent collecting specimens and determining the extent and nature of the vegetation associated with *Metasequoia.* No quantitative ecological data were gathered, but 161 collections of herbarium specimens were made. The identities of the vascular plants are included in the 1980 Sino-American Botanical Expedition report (Bartholomew *et al.,* 1983) and are represented by numbers *1925–2085.* Those not previously recorded for the metasequoia area are listed below.

Although we spent only a portion of three days in the valley, the limited number of firsthand reports in English concerning the natural occurrence of *Metasequoia* (Chaney, 1948; Chu & Cooper, 1950; Gressitt, 1953) makes our visit of interest. In addition, over 32 years have elapsed since the observations that served as the basis for these previous reports were made. Our impressions of current conditions in the valley are noted below.

THE DISCOVERY OF METASEQUOIA GLYPTOSTROBOIDES

The discovery of *Metasequoia glyptostroboides* as a "living fossil" has received a great deal of coverage in both the scientific and the popular literature (Fulling, 1976, 1977). However, to provide background information, we present a brief summary based on information given by Fulling (1976, 1977), Hu (1980), Böcher (1964), and Belder and Wijnands (1979) of the sequence of events surrounding the discovery and introduction of *Metasequoia* into cultivation outside of China.

Metasequoia was discovered in 1941 at Modaoqi in Sichuan Province near the border with Hubei Province[3] by T. Kan (Gan Duo), of the Department of Forestry of National Central University. Kan, however, did not collect or make specimens, and it was not until 1943 that C. Wang (Wang Zhang) of the Central Bureau of Forestry made the first collections of herbarium material. The tree was initially thought to be a form of *Glyptostrobus lineatus* (Poiret) Drude (syn.: *G. pensilis* (Staunton) Koch), but W. C. Cheng (Cheng Wanjun), of National Central University in Nanjing, realized that it represented a new genus. As a result, Cheng sent one of his assistants, C. J. Hsueh (Xue Jiru), to collect more herbarium material in February and May of 1946. In the fall of 1946, H. H. Hu (Hu Xiansu), then director of the Fan Memorial Institute of Biology, Beijing, received material from W. C. Cheng. Hu recognized that the newly discovered tree belonged to the genus *Metasequoia,* described in 1941 from Pliocene fossils by the Japanese botanist Shigeru Miki (Miki, 1941). Miki determined that certain fossils, which for nearly 100 years had been variously assigned to either *Sequoia* or *Taxodium,* actually represented a new genus, which he named *Metasequoia.* At the time, he did not realize that a living species of *Metasequoia* was still extant in south-central China.

In 1946 Cheng also sent herbarium specimens to E. D. Merrill, then director of the Arnold Arboretum of Harvard University. Merrill, realizing the significance of the new discovery, immediately arranged through Hu to obtain seeds.

[3]After the founding of the People's Republic of China, the boundary between Sichuan and Hubei provinces in this region was changed so that Modaoqi is now in Hubei.

FIGURE 1. American participants, 1980 Sino-American Botanical Expedition to western Hubei Province, People's Republic of China, at foot of type tree of *Metasequoia glyptostroboides* just outside hamlet of Modaoqi: (from left) David E. Boufford, James L. Luteyn, Bruce Bartholomew, Stephen A. Spongberg, and Theodore R. Dudley. Chinese characters on tree trunk indicate "Lichuan County Tree Number One" and illustrate record of this tree in *Metasequoia* count.

Merrill provided $250 for Cheng to organize a collecting trip in the late summer and fall of 1947, when seeds would be mature, and Cheng assigned C. T. Hwa (Hua Jingan) to undertake the expedition. During the three-month collecting period, Hwa found trees of *Metasequoia* scattered over an area of about 800 km^2, with the largest concentration (what he thought to be about 1000 trees) in the Shuishaba (Shui-sa-pa) valley of western Hubei.[4] About 1 kg of mature seeds was collected on this expedition, and Cheng sent the initial batch to the Arnold Arboretum in December, 1947. It has generally been thought that this was the first introduction of living *Metasequoia* into the West. However, based on evidence provided by Böcher (1964, in legend to *fig. 1*) and Belder and Wijnands (1979), Cheng apparently also sent seeds to Copenhagen and Amsterdam at the same time that he sent them to Merrill at the Arnold Arboretum; thus, the introduction of *Metasequoia* into the West was essentially simultaneous in Europe and North America. (This information differs from that given by Fulling (1976)). Merrill immediately distributed seeds to institutions and interested individuals around the world, and one recipient was Ralph W. Chaney, a paleontologist at the University of California, Berkeley.

Early in 1948 Chaney traveled to see *Metasequoia* in the wild. He was accompanied by Milton Silverman, who was then science writer for the *San Francisco Chronicle.* Chaney and Silverman were in the metasequoia area for five days in March, 1948, and returned with seeds and several seedlings of *Metasequoia.*

Fulling (1976) believed that Chaney did not collect seeds of *Metasequoia,* but according to Silverman (pers. comm.), he and Chaney collected seeds from cones on the ground. Chaney and Silverman divided these seeds in China (Silverman returned to the United States first), and they each carried some back. The fact that Chaney brought seeds back is corroborated by Jean Spitzer, a stewardess on the Pan American flight that Chaney took from Wake Island to Honolulu. According to Mrs. Spitzer (pers. comm.), Chaney told her of the seeds, which he had in an inside pocket of his coat, and stated that he was not going to declare them at Honolulu—he feared that the seedlings of *Metasequoia* he had with him might be confiscated and did not want to lose the seeds as well.

Later in 1948 two additional expeditions, one led by Cheng and the other by J. L. Gressitt, of Lingnan University, stayed for extended periods in the metasequoia area. Gressitt was mainly interested in collecting insects associated with *Metasequoia,* but he also made plant collections that, in addition to seeds and herbarium specimens from the Cheng expedition, were sent to the Arnold Arboretum. The herbarium material from these two expeditions served in large part as the basis for Hu's floristic analysis (1980). Gressitt also collected seeds and seedlings of *Metasequoia,* and these were sent to Lingnan University and to the California Academy of Sciences in San Francisco (Gressitt, pers. comm.).

[4]The valley containing the main *Metasequoia* population is usually referred to in the literature as Shuishaba (Shui-sa-pa); however, according to Xi Xingwen, head of the Xiaohe Commune, the name Shuishaba only refers to the region immediately around the hamlet of Shuishaba rather than to the entire valley.

THE TYPE TREE OF METASEQUOIA GLYPTOSTROBOIDES

The original tree from which the type specimens of *Metasequoia glyptostroboides* were taken is still growing just outside of Modaoqi, about 35 km north of Xiaohe, where the main *Metasequoia* population occurs. Gressitt (1953) reported that two smaller trees of *Metasequoia* occurred in a row with the type tree, but in 1980 only the one large tree remained at this location. Inquiries in Modaoqi about the other two drew a complete blank. There are now many *Metasequoia* trees along the road that passes through Modaoqi, but these have been planted during the past 30 years, along with *Cryptomeria japonica* (L. f.) D. Don, as the principal roadside trees in the area.

In 1948 there was a small shrine on one side of the type tree and a shed on the other. Both of these structures have been removed. The tree looks essentially the same now as it does in photographs taken in 1948 (see FIGURES 2, 3). It appears to be in excellent health and was bearing seed-filled cones in October, 1980. However, it has grown only very slightly over the past 30 years. We measured the buttress reported as 230 cm in diameter in the late 1940's (Hu & Cheng, 1948): it was 241 cm across, and the diameter of the trunk above the buttress was 167 cm. Based on partial cores, Chaney estimated this tree to be 300 years old (Chu & Cooper, 1950). Extrapolations from partial cores made in 1977 yielded an estimated age of 450 years.

PRESENT STATUS OF NATURALLY OCCURRING METASEQUOIA

Almost all of the naturally occurring trees of *Metasequoia* grow in the central valley of Xiaohe Commune. Since 1974 the Bureau of Forestry of Lichuan Xian has maintained a staff of five people in the Commune, with one of their objectives being to measure each tree every four years. The Forest Bureau has counted and numbered 5420 trees with a d.b.h. of at least 20 cm. We were told that approximately 1700 to 1800 of these are mature, seed-producing trees. The tallest recorded trees in the valley are on the east side in the vicinity of Hongshaxi: several reach a height of about 50 m, but they have smaller trunk diameters than the one that grew at Wangjiaying (see below). The oldest tree in Xiaohe Commune (approximately 420 years, estimated from a partial coring made in 1977) is near the town of Xiaohe (FIGURE 4); in 1980 it had a d.b.h. of 160 cm.

There are several outlying populations and individuals (Ling, 1976; Liu *et al.*, 1978; Zhang Fengyun, pers. comm.) in addition to the major *Metasequoia* population at Xiaohe. Near the town of Zhonglu (ca. 15 km southeast of Xiaohe), there are about ten trees, with a d.b.h. of 40–50 cm; in Shizhu Xian (about 40 km west of Xiaohe in Sichuan Province) there are two; in Longshan (in northwestern Hunan Province about 110 km southeast of Xiaohe), three (two growing together and one some distance away). Another outlying tree is the type tree at Modaoqi.

There was previously an isolated tree at Wangjiaying, discovered by Hwa in 1947 (Hu & Cheng, 1948); with a diameter of 2.2 m and a height of about 50 m, it was the largest recorded *Metasequoia* (Chu & Cooper, 1950). This tree

FIGURES 2, 3. Type tree of *Metasequoia glyptostroboides*. 2, photograph taken in 1948 by J. L. Gressitt. Note shrine at base of tree. 3, photograph taken on 5 October 1980. Shrine removed, and tree now surrounded by rice paddies and small, ditched stream. Buildings in background constructed since 1948.

was also seen by Gressitt in 1948 (Gressitt, 1953). Unfortunately, lightning struck it in 1951, splitting it into three parts and killing it. Another large tree, with a diameter of 2 m, was found between the main population in Xiaohe Commune and the three trees in Hunan Province, but it was cut down during the Cultural Revolution.

In its natural habitat *Metasequoia* is now protected by the government, and not even small trees may be cut. The trees that we saw (including the two ancient ones at Modaoqi and Xiaohe) all appeared to be in good health. However, we did not see any small seedlings. This differs from the situation in 1948, when Chu and Cooper (1950) found seedlings in thickets surrounding older *Metasequoia* trees. In 1980 vegetation was either absent around the trees of *Metasequoia,* or very closely cropped (see FIGURE 5), presumably by the local people and not by animals. The lack of governmental protection of the habitat (and thus the lack of associated vegetation) probably accounts for the lack of seedling establishment.

THE "METASEQUOIA FLORA"

The occurrence of *Metasequoia* trees in the main valley is essentially the same as that reported by Chu and Cooper (1950) and Gressitt (1953): *Metase-*

FIGURE 4. Oldest *Metasequoia* tree in Xiaohe Commune (approximately 420 years old, based on partial corings made in 1977, and with d.b.h. of 160 cm in 1980).

quoia grows primarily along the sides of the valley, and most of the flat land in the valley is planted in rice.

There have been a number of reports of plants associated with *Metasequoia*

(Chaney, 1948; Chu & Cooper, 1950; Hu, 1980). It is of interest to compare these reports with the present situation of *Metasequoia* in Xiaohe Commune. Chaney (1948) enumerated a few species and genera that he recognized, but his report was fragmentary and not based on the collection of specimens. In contrast, the paper by Hu (1980) was based on all of the material in the Arnold Arboretum herbarium that was collected in the metasequoia area in the late 1940's. It enumerates 550 species of vascular plants belonging to 301 genera and 127 families. Based on our firsthand observations, it is our impression that Hu's paper gives a very deceptive picture of the plants associated with *Metasequoia,* and that it is not accurate to refer to these 550 species as the "*Metasequoia* Flora." Although most of the specimens seen by Hu were collected in the vicinity of the metasequoia valley, it is quite likely that many were collected at higher elevations than where *Metasequoia* grows, and some were, no doubt, from cultivated trees. Hu admits the cultivated status of *Ginkgo biloba* L., and it is probably also true for such others as *Pinus armandii* Franchet (Gressitt, 1953, p. 49, reported one large tree in Shuishaba (*Gressitt 2536*) but many more near Modaoqi), *Juniperus formosana* Hayata (Gressitt, 1953, p. 51, reported two trees at "Suen-wu" and another on the approach to "Suen-wu"), and *Keteleeria davidiana* (Bertrand) Beissner (we saw two very large trees of this near a school a short distance from Xiaohe). It is also clear from the accounts of Gressitt's treks in search of other populations of *Metasequoia* that many of the plants he collected were found at some distance from the known *Metasequoia* stands, and many were from high elevations or from habitats unsuitable for *Metasequoia* (Gressitt, 1953). Also, of the 18 species of gymnosperms listed by Hu (1980) for the "*Metasequoia* Flora," we saw only one, *Cunninghamia lanceolata* Hooker, outside of cultivation and in close proximity to *Metasequoia.* However, *Cunninghamia* is restricted to drier habitats on well-drained slopes above *Metasequoia.* Chu (Chu & Cooper, 1950) also found *Taxus chinensis* Rehder in his quadrats and reported *Cephalotaxus fortunei* Hooker as being nearby. Chu and Cooper (1950, p. 272) noted that of the 33 tree species growing either in the *Metasequoia* quadrats or nearby, "only four are gymnosperms." Similar examples of cultivated angiosperms growing with *Metasequoia* can likely be found. Hu herself (1980, p. 49) considers that at least 13 listed angiosperms do not grow in the metasequoia community.

Chu and Cooper's study (1950), derived from Chu's quadrat analysis, is the only report on plants associated with *Metasequoia* based on systematic studies. Chu's quadrats were placed in areas that included *Metasequoia* and were made during the 1948 expedition to the metasequoia area led by W. C. Cheng. Specimens from this expedition labeled as collected by *W. C. Cheng–H. T. Hwa* were part of the material used by Hu (1980). However, although Chu and Cooper (1950, p. 273) stated that "nearly one hundred species of herbs, including the lower forms, have been collected from the area in which *Metasequoia* grows," they did not indicate that vouchers for the quadrat studies had been made. There are plants reported by Chu (see below) that were not represented among the specimens available to Hu. If there were vouchers made for Chu's quadrat studies, they were not among the material sent to the Arnold Arboretum. It is also unfortunate that not all of Chu and Cooper's determinations are

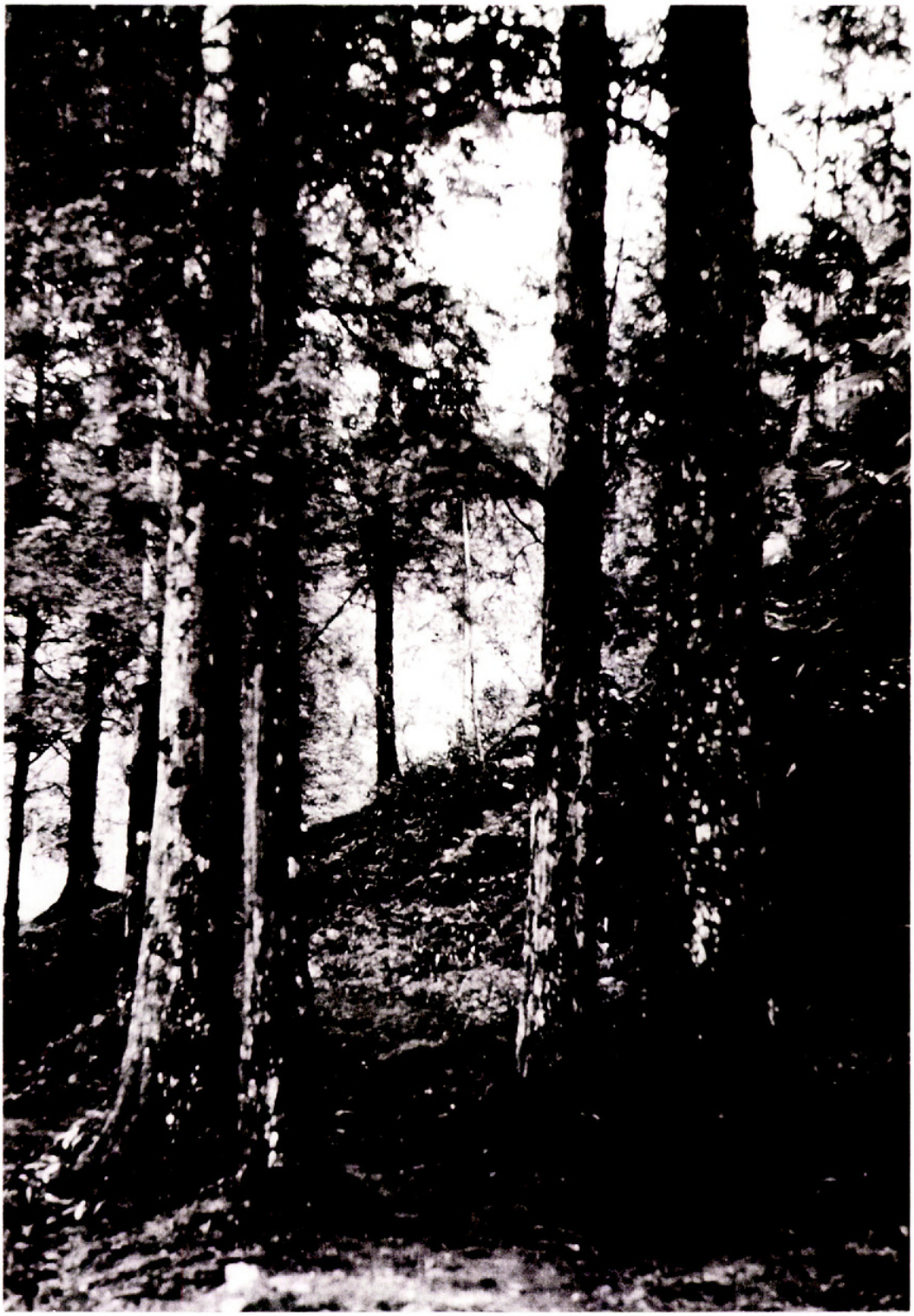

FIGURE 5. Grove of *Metasequoia glyptostroboides* growing at bottom of small ravine above main valley floor near village of Xiaohe. Note absence of associated plants.

complete. In light of the deterioration of the vegetation in the metasequoia valley, and especially that growing in close association with *Metasequoia,* if vouchers for this study are extant in some herbarium in China, a reworking

of the determinations of the material would give the best picture of the plants originally associated with *Metasequoia* that will ever be possible.

The habitat of *Metasequoia* is reminiscent of that of *Taxodium distichum* (L.) Rich. in the southeastern United States, a parallel previously drawn by Chaney (1948). *Metasequoia* is a riparian species, and before habitation the valley floor may well have been a *Metasequoia* forest (see below). *Metasequoia* trees that occur away from the valley floor are restricted to the moist bottoms of ravines and draws that drain into the main valley (see FIGURE 5). *Taxodium* commonly occurs in flat, poorly drained depressions behind natural levees along slow-moving rivers. Based on this similarity of habitats, on reports of the species associated with *Metasequoia* (Chaney, 1948; Chu & Cooper, 1950; Gressitt, 1953), on Hu's (1980) enumeration of the "*Metasequoia* Flora," and on our own observations both in the southeastern United States and in the metasequoia valley in 1980, it is possible to hypothesize a past *Metasequoia* forest analogous to present-day *Taxodium distichum* forests. Among the dominant tree species usually found with *Taxodium distichum* are *Nyssa aquatica* L., *N. sylvatica* var. *biflora* (Walter) Sarg., *Populus heterophylla* L., *Quercus* spp., *Liquidambar styraciflua* L., *Carpinus caroliniana* Walter, *Betula nigra* L., *Acer rubrum* L., *Ulmus americana* L., *Carya* spp., *Fraxinus* spp., and *Salix* spp. The associated shrubs include *Ilex* spp., *Viburnum* spp., *Itea virginica* L., *Cornus* spp., and *Lindera benzoin* (L.) Blume. The vines include *Berchemia scandens* (Hill) K. Koch, *Bignonia capreolata* L., *Rhus radicans* L., *Decumaria barbara* L., *Parthenocissus quinquefolia* (L.) Planchon, *Vitis* spp., *Ampelopsis* spp., and *Smilax* spp. While each of the species of this group has specific microhabitat requirements, all are usually found growing in close proximity to *Taxodium*.

In their list of plants growing with *Metasequoia*, Chu and Cooper (1950) included species of many of the same genera. We noted several large trees of *Liquidambar acalycina* (*L. formosana* Hance *in* Chu & Cooper, 1950; and *in* Hu, 1980) and species of *Salix, Acer, Pterocarya,* and *Quercus* in habitats similar to those occupied by *Metasequoia,* but not on the adjacent slopes. Moreover, it seems likely that at one time the floor of the metasequoia valley was occupied by trees that were tolerant of periodic flooding, could grow in poorly drained soils, and occupied more or less specific microhabitats. Among the species listed as being associated with *Metasequoia glyptostroboides* by Chu and Cooper (1950), Gressitt (1953), and Hu (1980), the following grow in habitats similar to those of their American counterparts associated with *Taxodium*: *Houttuynia cordata* Thunb. (in place of *Saururus cernuus* L. in the southeastern United States); *Populus adenopoda* Maxim.; *Salix* spp.; *Pterocarya hupehensis* Skan, *P. paliurus* Batalin, and *P. stenoptera* C. DC. (all in place of *Carya* spp.); *Betula luminifera* Winkler; *Carpinus fargesii* Franchet; *Quercus* spp.; *Morus* sp.; *Cocculus orbiculatus* (L.) A. P. DC.; *Ulmus multinervis* Cheng; *Lindera glauca*; *Liquidambar acalycina* Chang; *Ilex* spp.; *Berchemia* spp.; *Nyssa sinensis* Oliver; *Cornus controversa* Hemsley and *C. macrophylla* Wallich; *Clethra fargesii* Franchet; *Styrax bodinieri* Lévl. and *S. suberifolius* Hooker f. & Arnott (*S. japonica* Sieb. & Zucc. was reported by Chu and Cooper

(1950) as being in the quadrats but is not included in Hu's (1980) enumeration); *Viburnum* spp.; and *Smilax* spp.

These similarities, however, should not be taken as evidence that the associations we see now have existed over long periods of time. Hu (1980, p. 64) states that "the vegetation of the metasequoia area is a living sample of a comparatively well-preserved ancient flora." It is highly doubtful that this is true. It would perhaps be better to say that the flora in the metasequoia region contains a number of genera that have fossil records dating back to the Tertiary and ecological adaptations enabling them to grow together at present. Davis (1976) has compiled data showing that the forests of eastern North America and Europe, which are often thought of as stable communities, are actually the result of differential migrations in the past of the individual components that have come together only fairly recently. She has shown that the current associations may be a feature of the present, and that the species growing together now often occurred in different associations and abundance even within the past few thousand years. The fact that we see members of genera with long geologic histories growing together today in the metasequoia region of China only indicates that their ecological tolerances overlap; it gives no indication that their migrational or evolutionary histories have coincided.

Davis (1976) suggests that the glacial periods (perhaps as many as 16 in North America and Europe), each of which lasted 50,000–100,000 years, are the normal and most stable phases of the Pleistocene, while the interglacials, which lasted only 10,000–20,000 years each, were catastrophic periods. There is little reason to believe that the climate of eastern Asia remained unchanged during this time when the climates in North America and Europe were undergoing such wide fluctuations. It seems almost certain that there would have been widespread migrations in the Asian flora like there were in North America and Europe, and that what we see now are the assemblages of species (communities) resulting from the sorting out of the flora in response to the rather drastic changes in climate during the glacial and interglacial periods of the Pleistocene and Holocene.

Chu and Cooper (1950) stated that *Metasequoia* appears to grow naturally only in sandy soil derived from Jurassic sandstone, and that only cultivated trees grow over limestone. They also mentioned that the valley floor is derived mainly from sandstone, providing rather strong suggestive evidence that the floor could have been occupied—and perhaps dominated—by much more extensive stands of *Metasequoia*. Additional evidence of a once more-widespread *Metasequoia* forest on the valley floor is provided by several large trunks of *Metasequoia* that we saw that had recently been unearthed in the center of paddy fields far from the nearest slopes and ravines where the trees now grow. Altogether, more than 200 of these trunks, many over two meters in diameter, have been found in the paddies along the level floodplain of the main river and side streams (T. S. Ying, pers. comm.). Also (according to Liu *et al.*, 1978), some of the houses in the valley were constructed of boards cut from *Metasequoia*. These houses are believed to be 200–300 years old and date roughly from the time of the original settlers.

FIGURES 6, 7. General views of metasequoia valley. 6, photograph taken in 1948 by J. L. Gressitt. Note forest-covered slopes in background, and fields only on level valley floor. 7, photograph taken in 1980. Note extensive cultivation of rice on valley floor and on terraced fields on lower slopes. Columnar trees along edges of paddies an admixture of *Metasequoia glyptostroboides* and *Cunninghamia lanceolata*, with columnar habit due to pruning of lateral branches for firewood.

CLIMATE

There are no climatic data available for Xiaohe Commune. The nearest weather station is in Lichuan, 40 km northeast of Xiaohe, but data from this station[5] give a much more accurate picture of the climate where *Metasequoia* grows than do those reported by Chaney (1948), which were based on information obtained from Zhongjing (Chungking), or those used by Chu and Cooper (1950) based on records from Guiyang (Kweiyang). Lichuan is at an elevation of about 1070 m (essentially the same as the floor of the metasequoia valley) and is within the range of *Metasequoia,* if one includes the outlying populations and individuals.

TABLE 1 presents temperature records from Lichuan for the years 1959–1978. The lowest monthly mean minimum temperature is −6.1°C for January, and the absolute lowest temperature is −15.4°C recorded in February, 1972. These temperatures are nowhere near the physiological lower limit of *Metasequoia* since trees survive the winters in Jamaica Plain, Massachusetts, where temperatures as low as −23°C have been recorded. The highest monthly mean maximum in Lichuan is 32.2°C for August, and the absolute highest temperature is 35.4°C recorded in August, 1959. This is also not the physiological upper limit for *Metasequoia.* In St. Louis, Missouri, where *Metasequoia* is used as an ornamental and street tree, temperatures higher than 38°C are not uncommon.

Precipitation data for Lichuan are given in TABLE 2. Rainfall is very seasonal: two thirds of the total amount occurs in the five-month period from May through September, and less than one sixth from November through March. There were no months lacking rain between 1959 and 1978, although only a trace (1.1 mm) was recorded in January, 1963. During this 20-year period the wettest year was 1975, with 1529 mm of rain; the driest was 1966, with 863.1 mm.

Without data from Xiaohe Commune, it is impossible to compare the climate there with that of Lichuan, but the fact that the valley is completely enclosed would probably provide for some insulation and moderation of the climate. Of particular note is the ridge about 1500 m in elevation that bounds the valley to the north. One might expect that the absolute minimum temperature in the metasequoia valley would be somewhat higher than in Lichuan.

THE HUMAN POPULATION IN THE METASEQUOIA VALLEY

The Lu family, the first to settle in the metasequoia valley, moved into the area about 310 years ago.[6] They settled in the area now occupied by the hamlet of Jiantianba, about 7 km west of the present town of Xiaohe. Xiaohe itself

[5]Weather records from the Lichuan Weather Station were supplied by Zhang Fengyun, director of the Lichuan Forest Research Institute.

[6]Information on Xiaohe Commune was supplied by Xi Xingwen, head of Xiaohe Commune.

TABLE 1. **Temperature records (°C) for Lichuan, Hubei Province, People's Republic of China, 1959-1978.**

RECORD	MONTH											
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Monthly mean	1.7	3.0	7.8	12.9	16.9	20.3	23.3	22.8	18.6	13.6	8.1	3.6
Monthly mean maximum	12.5	15.6	21.5	26.5	27.8	30.7	32.2	32.3	29.3	24.5	18.6	14.5
Monthly mean minimum	−6.1	−5.8	−1.6	2.7	8.7	11.9	15.8	14.7	9.3	3.9	−1.2	−3.7
Absolute maximum	16.9	20.0	27.1	30.2	30.6	32.9	34.8	35.4	32.0	27.5	22.1	17.7
Absolute minimum	−13.8	−15.4	−3.5	−1.5	5.9	8.6	13.7	12.2	7.1	−0.6	−3.5	−8.2

TABLE 2. **Precipitation records (mm) for Lichuan, Hubei Province, People's Republic of China, 1959-1978.**

RECORD	MONTH												ANNUAL TOTAL
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Mean monthly precipitation	18.7	30.0	67.9	109.5	187.5	183.8	171.9	144.1	170.8	109.2	61.2	28.3	1282.9
Percentage of annual total	1.5	2.4	5.3	8.5	14.6	14.3	13.4	11.2	13.3	8.5	4.8	2.2	100
Lowest monthly precipitation	1.1	6.0	26.6	60.2	74.9	55.7	15.9	24.6	47.0	19.3	26.6	8.7	
Highest monthly precipitation	40.7	71.1	117.3	179.7	321.1	383.2	293.9	307.6	378.9	204.0	121.9	55.6	

was first settled by the Wu family about 200 years ago. Chu and Cooper (1953), however, reported that the Wu family was the first family to settle in the valley. The family names Lu and Wu are still common in the area.

It seems probable that the flat valley floor with its *Metasequoia* stands was the first site to be cleared for agriculture when the original inhabitants settled the valley (FIGURES 6, 7). The settlers most likely cleared vegetation from the richest and easiest areas for cultivation but left the trees in marginal areas such as immediately along the river or in the narrow ravines leading into the main valley. Perhaps some trees were also spared due to their large size or because of possible religious significance.

The valley containing the main *Metasequoia* population is in Xiaohe Commune. This commune occupies a total area of 10,640 ha and has a population of 21,000 people, of whom 12,000 live in the valley itself, mostly in scattered hamlets of several houses situated along the edges of the valley. Within the valley there are 670 ha of rice paddies and 1400 ha of other fields; outside there are an additional 1270 ha of nonpaddy fields planted in corn and other crops. In addition to the fields, the commune contains 7300 ha of mountainous land.

The high population density in Xiaohe Commune (if the figures we were given are correct, there are 6.287 persons per ha or only 0.159 ha per person!) has resulted in considerable damage to the local vegetation. Both Chu and Cooper (1950) and Gressitt (1953) reported that the forests had largely been destroyed by the time of their visits, and even the *Metasequoia* communities showed signs of alteration due to man's activities. We found that conditions had deteriorated even more since these reports. Our observations indicate that there has been so much human and domestic animal disturbance that there are very few plants now associated with *Metasequoia* (FIGURE 5). However, there are areas in Xiaohe Commune, particularly in side ravines and on slopes on the east side of the main valley, where secondary forests are developing. Although these areas are close to the *Metasequoia* groves, they are separated from the riparian areas occupied by *Metasequoia* by cut-over slopes and cultivated fields. Comparison of the present condition of the forests with pictures taken in 1948 shows considerable destruction during the past 32 years (see FIGURES 6–9). We were told that many large trees, particularly *Castanea henryi* Rehder & Wilson and *C. mollissima* Blume, were cut in the mid to late 1950's during the Great Leap Forward to make charcoal for smelting iron. However, no significant amount of iron was ever produced.

The protected status currently given by the government to the remaining naturally occurring trees of *Metasequoia* will probably insure their survival for the immediate future, but the lack of protection for the surrounding habitat will likely result in little, if any, natural reproduction. The thickets that Chu and Cooper (1950) mentioned as being around many of the trees are no longer there, and it was in those habitats that they reported finding seedlings and small trees of *Metasequoia*. The efforts to monitor the natural populations of *Metasequoia* may have resulted in disturbance and clearing of other vegetation, thereby contributing to the destruction of suitable germination sites.

FIGURE 8. Small side valley connecting with eastern portion of metasequoia valley (photograph taken by J. L. Gressitt in 1948). Note relatively undisturbed forest surrounding terraced field.

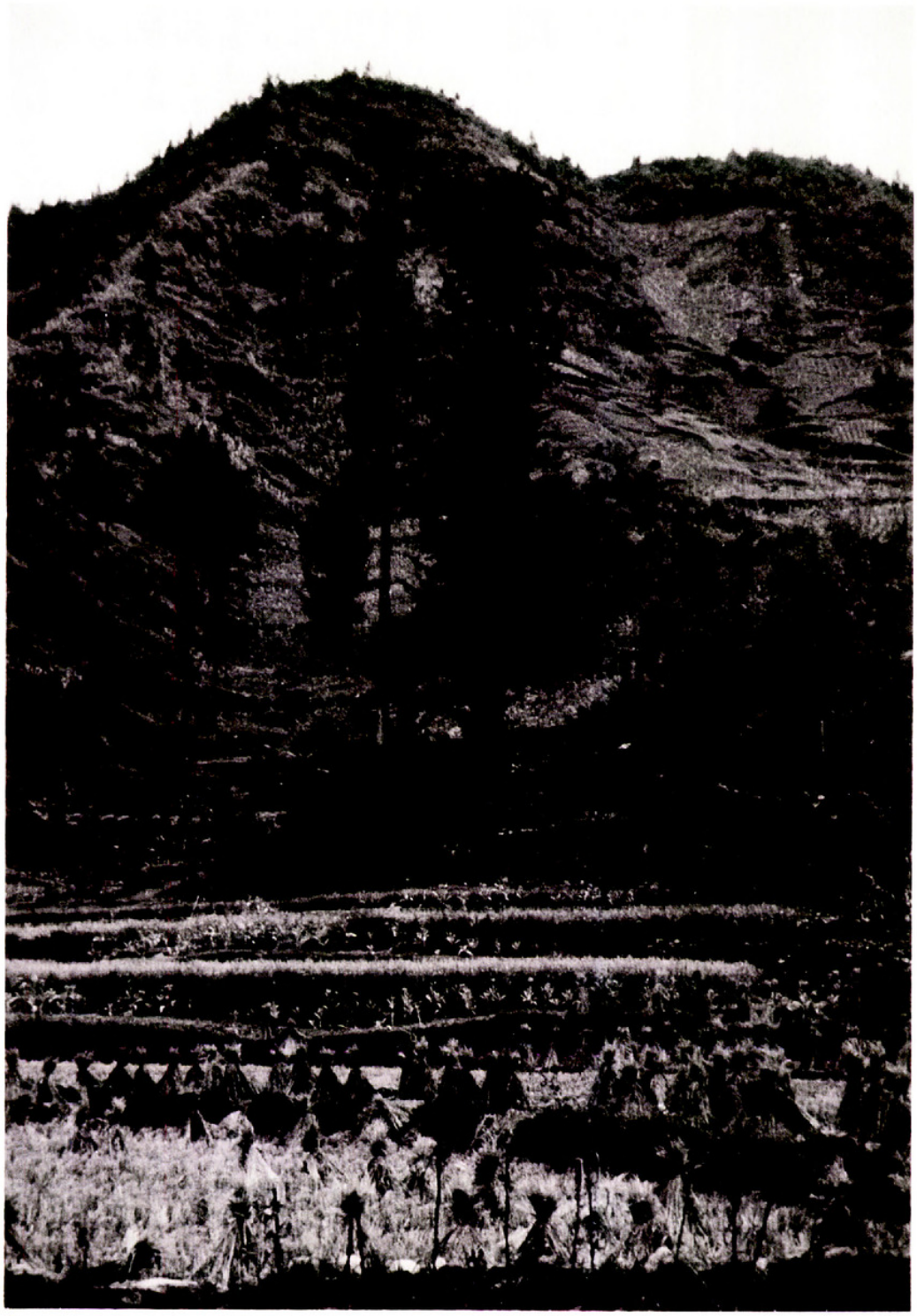

FIGURE 9. Highly disturbed slopes of side valley showing results of human habitation (photograph taken in 1980). Upper slopes largely denuded of native vegetation and lower slopes given over to rice paddies and corn fields. Tree behind building is *Ginkgo biloba*.

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ADDITIONS TO THE FLORA OF THE METASEQUOIA REGION

Of the 160 numbers collected in the metasequoia valley on the 1980 Sino-American Botanical Expedition, 122 of them represent taxa of vascular plants. Of these, 71 have not been previously reported from the valley. The following enumeration presents these additions to the flora of the region. Collection numbers of the Sino-American Botanical Expedition are in parentheses. The 20 taxa reported as associated with *Metasequoia* by Chu and Cooper (1950) that are not in Hu's (1980) enumeration are also included here; these names are followed by an asterisk. The arrangement of taxa follows the same scheme used in the report of the 1980 Sino-American Botanical Expedition to western Hubei (Bartholomew *et al.*, 1983), and reference to that paper is suggested for annotations and discussions of taxonomic problems and for descriptions of new taxa.

PTERIDOPHYTA

LYCOPODIACEAE

Lycopodium crispatum Ching (*1974*)

HYMENOPHYLLACEAE

Hymenophyllum barbatum Bosch (*2023*)

DENNSTAEDTIACEAE

Microlepia marginata (Houtt.) C. Chr. (*2052*)

HYPOLEPIDACEAE

Hypolepis punctata (Thunb.) Mett. (*1943, 1944*)

PTERIDACEAE

Pteris wallichiana Agardh (*2026*)

HEMIONITIDACEAE

Coniogramme robusta Christ var. *repandula* Ching (*2049*)

WOODSIACEAE

Peranema cyathioides D. Don (*2085*)

BLECHNACEAE

Woodwardia unigemmata (Makino) Nakai (*2057*)

ATHYRIACEAE

Athyrium epirachis (Christ) Ching (*2011*)
Athyrium vidallii (Franchet & Sav.) Nakai (*2053*)
Lunathyrium vermiforme Ching, Boufford, & Shing (*2025*)
Lunathyrium wilsonii (Christ) Ching (*2048*)
Pseudocyclosorus tsoi Ching (*1946*)

DRYOPTERIDACEAE

Dryopteris labordei (Christ) C. Chr. (*2054*)
Dryopteris supraimpressa Ching, Boufford, & Shing (*2020*)
Polystichum lobatopinnulum Ching, Boufford, & Shing (*2059*)

ASPLENIACEAE

Asplenium tripteropus Nakai (*2046*)

POLYPODIACEAE

Arthromeris cuneata Ching (*1971, 2029*)
Drymotaenium miyoshianum (Makino) Makino (*2058*)
Lepidogrammitis drymoglossoides (Baker) Ching (*2027*)
Lepidomicrosorium subhastatum (Baker) Ching (*2083*)

AZOLLACEAE

Azolla imbricata (Roxb.) Nakai (*2056*)

ANGIOSPERMAE

DICOTYLEDONES

FAGACEAE

Castanea seguinii Dode*
Quercus glandulifera Blume (*1931*)

MORACEAE

Ficus foveolata Wallich*
Morus alba L.*

URTICACEAE

Gonostegia hirta (Blume) Miq. (*1937*)

POLYGONACEAE

Polygonum caespitosum Blume (*1956*)
Polygonum hydropiper L. (*1954*)
Polygonum muricatum Meisner (syn.: *P. strigosum* R. Br. var. *muricatum* (Meisner) A. N. Steward) (*1955*)
Polygonum persicaria L. (*2015*)
Polygonum thunbergii Sieb. & Zucc. (*1953*)

RANUNCULACEAE

Clematis urophylla Franchet (*1940*)

LARDIZABALACEAE

Akebia trifoliata (Thunb.) Koidz.*
Holboellia sp.*

BERBERIDACEAE

Berberis sargentiana Schneider (*1938*)
Berberis virgetorum Schneider (*2079*)

SCHISANDRACEAE

Schisandra pubescens Hemsley & Wilson*

LAURACEAE

Phoebe neurantha (Hemsley) Gamble (*2045*)

HAMAMELIDACEAE

Corylopsis veitchiana Bean (*2033*)
Liquidambar acalycina Chang (*1950*)

ROSACEAE

Cotoneaster aff. *dielsiana* Pritzel (*1935*)
Pyracantha crenulata (D. Don) Roemer (*1961*)
Pyracantha fortuneana (Maxim.) H. L. Li*
Rosa henryi Boulenger*
Rubus amphidasys Focke ex Diels (*2076*)
Rubus lambertianus Sér. (*1936*)
Rubus setchuenensis Bur. & Franchet (*1952*)

LEGUMINOSAE

Dalbergia stenophylla Prain*

SIMAROUBACEAE

Picrasma quassioides Benn.*

RUTACEAE

Euodia rutacarpa (Juss.) Bentham var. *bodinieri* (Dode) Huang (*1947*)

EUPHORBIACEAE

Acalypha australis L. (*1973*)
Mallotus tenuifolius Pax* (author as Muell.-Arg. *in* Chu & Cooper, 1950)

BUXACEAE

Sarcococca humilis Stapf (syn.: *S. hookeriana* Baillon var. *humilis* Rehder & Wilson) (*1967*)

RHAMNACEAE

Rhamnus davuricus Pallas (*2024*)

CELASTRACEAE

Euonymus kiatschovicus Loes. (*2075*)
Microtropis triflora Merr. & Freeman (*2018*)

VITACEAE

Parthenocissus tricuspidata (Sieb. & Zucc.) Planchon*
Tetrastigma hemsleyanum Diels & Gilg (*2010*)

SABIACEAE

Meliosma dilleniifolia (Wallich ex Wight & Arnott) subsp. *flexuosa* (Pampan.) Beus. (*1949*)
Meliosma oldhamii Miq.* (syn.: *M. pinnata* (Roxb.) Maxim. subsp. *barbulata* Cufod. var. *oldhamii* (Maxim.) Beus.)

BALSAMINACEAE

Impatiens cf. *exiguiflora* Hooker f. (*1960*)

THEACEAE

Eurya loquaiana Dunn (*2028*)
Eurya obtusifolia Chang (*2004*)

LYTHRACEAE

Rotala indica (Willd.) Koehne (*2084*)

ARALIACEAE

Nothopanax davidii (Franchet) Harms ex Diels*

CORNACEAE

Cornus kousa Hance var. *angustata* Chun (*2032*)

ERICACEAE

Rhododendron fortunei Lindley subsp. *discolor* (Franchet) Chamberlain (*2040*)

MYRSINACEAE

Ardisia crispa (Thunb.) DC.*
Ardisia japonica (Thunb.) Blume (*1926*)

OLEACEAE

Jasminum urophyllum Hemsley (*2078*)

GENTIANACEAE

Tripterospermum affine (Wallich) H. Sm. (*1927*)

LABIATAE

Clinopodium polycephalum (Vaniot) C. Y. Wu & Hsuan (*1968*)
Elsholtzia ciliata (Thunb.) Hylander (*1962*)
Elsholtzia flava Bentham (*1945*)
Mosla scabra (Thunb.) C. Y. Wu & H. W. Li (*1965*)

SCROPHULARIACEAE

Veronicastrum caulopterum (Hance) Yamazaki (*2008*)

RUBIACEAE

Anotis hirsuta (L. f.) Boerl. (*2006*)

CAPRIFOLIACEAE

Lonicera japonica Thunb.*
Lonicera pileata Oliver*
Lonicera similis Hemsley*
Viburnum cylindricum Buch.-Ham. ex D. Don (*1930*)
Viburnum foetidum Wallich (*2002*)

COMPOSITAE

Ainsliaea gracilis Franchet (*1970, 2041*)
Lactuca graciliflora (Wallich) DC. (*2017*)
Solidago decurrens Lour. (*2016*)

MONOCOTYLEDONES

GRAMINEAE

Isachne nipponensis Ohwi (*1959*)
Microstegium nudum (Trin.) A. Camus (*1966*)
Pennisetum alopecuroides (L.) Sprengel (*1948*)

CYPERACEAE

Bulbostylis densa (Wallich) Hand.-Mazz. (*1969*)

ZINGIBERACEAE

Zingiber mioga (Thunb.) Roscoe (*2022*)

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