An Ecological Reconnaissance in the Native Home of Metasequoia glyptostroboides

Kwei-ling Chu and William S. Cooper

In August 1948, Professor Wan-chun Cheng of the National Central University, Nanjing, who with H. H. Hu named and described Metasequoia glyptostroboides, traveled to central China to see the trees for himself. He led an expedition that included Professor Chu, plant ecologist at the National Nanjing University, and C. T. Hwa, whom Cheng had sent to gather the seeds that he sent late in 1947 to Boston, St. Louis, Copenhagen, and Amsterdam, as well as to several institutions in China and elsewhere. The expedition was supported in the main by a grant from the American Philosophical Society under the joint sponsorship of E. D. Merrill and R. W. Chaney.

Chu's role in the enterprise was "to gather as much information as possible bearing upon the ecology of Metasequoia—its physical environment, its ecological life history, and its community relations." Cooper, professor of botany at the University of Minnesota, did not accompany the expedition, but provided literature not available in China and helped with the formulation of some of the conclusions as well as with the final preparation of the manuscript. The authors noted that within the short space of three years (1947–1949) fifty publications on Metasequoia had already appeared—almost all of them in China and the United States—about equally divided between scientific contributions and popular articles.

History of Shui-hsa Valley

Over the course of the expedition, the senior author was fortunate to glean something concerning the cultural history of Shui-hsa valley through conversations with Mr. Wu, more than sixty years old, who with his two brothers, prosperous and intelligent men, are the descendants of the earliest permanent settlers in the valley. The region was originally controlled by primitive nomadic tribes, some of whom still live in adjacent mountains. Mr. Wu's ancestors migrated from Szechuan to the Shui-hsa-pa region about two hundred years ago. From the Ching tribe in Chung-lu they bought an area of mountain land in the vicinity of Shui-hsa-pa more than eight kilometers [five miles] long. At that time, according to Mr. Wu, the mountain slopes bore a forest cover so dense that one could not see the blue sky through the canopy, and the level valley floor had never been disturbed by man. Fires were set to destroy the forest, and rice paddies were established. Rice culture since then has extended over practically the whole of the level valley floor, and the forests on the mountain slopes have been largely destroyed because of timber use and charcoal making. The era of agricultural economy, with the destruction of native vegetation that it has
entailed, thus goes back about two centuries. It is significant that Shui-hsa valley has suffered less than any other part of the region, and one reason for this is doubtless the fact that it is a closed basin with no easy river route into it.

The Natural Habitat of Metasequoia

The region within which trees of Metasequoia have been found is estimated to have an area of about 800 square kilometers [312 square miles], with altitudes ranging from 700 to 1350 meters [2,300 to 4,400 feet]. However, only in a much smaller area does the tree appear to be an actively reproducing constituent of a natural forest community. It is situated in Shui-hsa valley and forms a strip along the main river 25 kilometers [15.5 miles] long and less than 1.5 kilometers [one mile] wide. The altitude here ranges from 1000 to 1100 meters [3,280 to 3,600 feet]. Outward from this center in all directions Metasequoia decreases in frequency. For a considerable distance—5 kilometers [3 miles] south of Shui-hsa-pa and 35 kilometers [22 miles] north to Mo-tao-chi, with altitudinal range of 900 to 1250 meters [3,000 to 4,100 feet]—many good trees occur and some fine large ones, for example the type tree at Mo-tao-chi and a very large one at Wang-chia-ying. This area, which is marked by the occurrence of fairly good or large trees, may be regarded as the region of optimum growth. The trees themselves may be relics from a time when the natural community including Metasequoia was more widespread than now. The trees most remote from the center, at the lowest and highest altitudes, are in poor condition.

In Shui-hsa valley Metasequoia finds its natural habitat in side ravines descending to the valley floor. Following a ravine or side valley down the mountain slope from either side one is sure to find Metasequoia trees at the lower end. They thrive particularly along the banks of small streams, among rocks and boulders covered thickly by liverworts and mosses, occurring usually in small groups or short lines. With them grows a variety of other trees, and in many places there is a dense thicket-like growth of shrubs and woody lianas. These growths are often very difficult to penetrate; inside them it is much cooler, darker, and wetter than without. In such places Metasequoia reproduces naturally. The habitat as described above is strongly reminiscent of that of blue spruce (Picea pungens) in the Rocky Mountains of Colorado, U.S.A. Metasequoia grows also in seepage areas at the foot of the slopes where there is abundant shade and moisture. The tree is found upon the valley floor itself, but here it has obviously been planted.

Quadrat Studies

To obtain more accurate knowledge concerning Metasequoia in its home a quadrat study was undertaken. The main purpose was to discover
A sketch map of Shui-hsa valley and its immediate surroundings. Numbered black squares indicate the location of quadrats; the dotted line follows the approximate limits of Metasequoia. Large numbers give altitudes in meters. Shan means mountain range.

Ten 10 x 10-meter [33 x 33-foot] quadrats were laid out in areas in which Metasequoia was important. Selection of sites was determined by apparent approximation to natural conditions, and the area over which the quadrats were distributed coincided roughly with the region in which such conditions were found. The quadrats were placed along the foot of the mountain slopes on both sides of the river. A secondary quadrat (2 x 8 meters [6.6 x 26 feet]) was laid inside each major one for the counting of shrubs and seedling trees, and a still smaller one (0.25 x 4 meters [10 inches x 13 feet]) for herbs; but the density values of the shrubs and herbs were very variable and apparently of little significance and are therefore not given here.

For the tree species five size classes were distinguished: I, seedlings less than one foot tall; II, seedlings more than one foot tall; III, trees one to three inches in diameter; IV, trees four to nine inches in diameter; V, trees ten inches or more in diameter. Density (number of individuals in the 1000 square meters [a quarter of an acre] of the ten quadrats combined) has been computed for each species and each size class of a given species, and also presence (number of quadrats in total of ten in which a species occurs).

The following trees, not occurring in quadrats but close to them, are close associates of Metasequoia: Cephalotaxus Fortunei, Fagus longipetiolata, Quercus acutissima, Sas-satras tsumu, Tapiscia sinensis concolor, Ulmus multinervis.

The large number of tree species making up the assemblage of which Metasequoia is a constituent—27 species occurring in 1000 square meters [a quarter of an acre] and 6 others nearby—is a striking point. Of the 33 species, only 4 are gymnosperms. As to average spacing of individuals, one [with diameter greater than ten inches] occurs each 33 square meters [40 square yards]. Those of one to nine inches diam-
Density and Presence of Tree Species on Ten 10 x 10-Meter Quadrats

<table>
<thead>
<tr>
<th>Species</th>
<th>Density</th>
<th>All Classes</th>
<th>Presence</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
<tr>
<td>Metasequoia glyptostroboides</td>
<td>16</td>
<td>17</td>
<td>4</td>
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<tr>
<td>Cunninghamia lanceolata</td>
<td>18</td>
<td>7</td>
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<tr>
<td>Castanea Seguinii</td>
<td>5</td>
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<tr>
<td>Liquidambar formosana</td>
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<td>Rhus (3 spp.)</td>
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<td>1</td>
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<tr>
<td>Cornus controversa</td>
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<td>3</td>
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<tr>
<td>Lindera glauca</td>
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<tr>
<td>Meliosma Oldhami¹</td>
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</tr>
<tr>
<td>Acer Davidii</td>
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</tr>
<tr>
<td>Styrex japonica</td>
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<tr>
<td>Ilexa polycarpa</td>
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<td>Prunus sp.</td>
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<td>Kalopanax pictus²</td>
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<td>Clerodendron mandarinorum</td>
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<td>Taxus chinensis</td>
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<td>Pterocarya paliurus³</td>
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<tr>
<td>Morus sp.</td>
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<tr>
<td>Quercus variabilis</td>
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<tr>
<td>Torricelha angulata intermedia</td>
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<tr>
<td>Salix (2 spp.)</td>
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<td>Cercidiphyllum japonicum sinicum</td>
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<tr>
<td>Betula luminifera</td>
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<tr>
<td>Carpinus Fargesii⁴</td>
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<td>Ficus heteromorpha</td>
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<tr>
<td>Litsea elongata</td>
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Total                              | 61      | 101         | 11       | 40       | 30      | 243      |

Ratio of Metasequoia to Total     | .20     | .36         | .18      | .60      | .26     |

¹ = Meliosma pinnata
² = Kalopanax septemlobum
³ = Cyclocarya palurus
⁴ = Carpinus laxiflora var. macrostachya
Members of the ecological expedition, from left, C. T. Hwa, W. C. Cheng, the expedition's leader, and K. L. Chu, standing in front of the trunk of the largest Metasequoia glyptostroboides found in 1948, near Wang-chia-ying.

Meter are spaced one to each 20 square meters [24 square yards]. Seedlings occur one to each 6 square meters [7 square yards]. The picture is of a forest of moderate density as to mature trees and rather poor in reproduction. Five species are represented by individuals greater than ten inches in diameter—Metasequoia, Cunninghamia, Cornus, Populus, and Pterocarya. Fourteen are represented by individuals greater than four inches—in addition to the above, Castanea, Liquidambar, Rhus, Meliosma, Styrax, Idesia, Kalopanax, Clerodendron, and Cercidiphyllum. Eleven species are represented by seedlings only.

The species of outstanding importance, so far as the quadrats show, are obviously Metasequoia, Cunninghamia, Castanea, and Liquidambar—two gymnosperms and two angiosperms. They comprise 74 percent of the three upper size classes and 54 percent of the seedling classes. Moreover, they are for the most part well represented in all size classes, indicating that their present preeminence will be maintained. In presence they rank as high or higher than any in the list.

Turning to Metasequoia in particular, it is plain that this species is the most important one in the assemblage. Of the total trees greater than 10 inches in diameter it makes 60 percent, and most of these individuals are 24 to 36 inches in diameter. In the combined seedling classes it makes only 20 percent, but it surpasses every other single species. It is represented in every size class. All the evidence indicates that it will continue to maintain itself as an important member of the forest assemblage.

Notes on Ecological Life History

... Seedlings are found in crevices between rocks and boulders and in moist sandy places. In the thicket-like growth beneath the forest trees are seedlings and young saplings up to 3 meters [10 feet] tall. As they grow larger, they encounter serious interference from the lianas that are so thickly interlaced among the trees and shrubs. Other tree species are usually rigid enough to penetrate the mass without much difficulty. The stems and branches of Metasequoia, however, are flexible, and are bent over and deformed by the load of liana stems. The struggle to get through is a keen one. Such conditions are certainly not ideal for successful reproduction. Metasequoia, however, is evidently very shade-tolerant, and the dense thicket growth gives it a certain amount of protection from biotic dangers.

Having finally penetrated the shrub-liana layer, Metasequoia, which probably has a faster growth rate than its companion species, develops rapidly, finally standing out conspicuously above them and recognizable at a great distance by its bright green color.

Influence of Man

The present local distribution of Metasequoia has been much influenced by man, through destruction and also by planting. Its occurrence as an important forest constituent was once far more widespread than now, as is indicated by isolated big trees at considerable distances from Shui-hsa-pa. The type tree at Mo-tao-chi is 35 kilometers [22 miles] distant and the big tree near Wang-chia-ying more than 20 [12 miles].
The “big tree” noted by the authors, the largest found, photographed in 1948 by W. C. Cheng Chu measured it at 50 meters [165 feet] tall and 2.22 meters—over 7 feet—in diameter at breast height. It grew in isolation on an open slope near Wang-chia-ying, in 1951 it was struck by lightning, split in three parts, and killed.

Such trees, three centuries old at least, must antedate the initiation of agricultural activity in the valley. After the natural vegetation had been displaced or profoundly modified because of agricultural use, effective reproduction was no longer possible. The natives apparently venerated the biggest trees and therefore protected them. It seems quite natural that the first permanent settlers in the region should recognize in the tree something different, unusual, and worthy of special respect. A small temple stands beside the type tree at Mo-tao-chi. In neighboring valleys the natural communities of which Metasequoia was a constituent have been completely destroyed in the last two centuries. In Shui-hsa valley destruction has been only partial—but it still goes on. It seems certain that even before the period of destruction the stands of Metasequoia were discontinuous, occupying mainly ravines and stream banks as they do today.

In Shui-hsa valley there has been considerable planting of Metasequoia. Natives are constantly removing good-sized seedlings and saplings from their native sites. Small trees are growing along the banks of the main stream in straight rows. They are also seen on the margins of the rice paddies, along roadsides, and in home yards.

In view of the common practice of transplantation it is not surprising that stands of uncertain origin occur which may be hardly distinguishable from natural stands. Some of these consist of groups of ten to thirty mature trees that appear as if they had had a natural origin. The site, however, is not the normal one for Metasequoia. It is drier, the floor is clearer, and conditions are not favorable for reproduction. On the other hand, there are many natural stands so altered by man that they appear as planted.

It is not clear why the natives plant so extensively a tree that is of little economic importance to them. There is no systematic tree culture in Shui-hsa valley. A few trees of economic value are planted: Magnolia officinalis, the bark of which is used as a medicine, Juglans cathayana for the nuts, Rhus verniciflua for lacquer. Cunninghamia lanceolata is regarded as the best timber tree of the region, but it is not planted. Metasequoia is sometimes used for fuel and in construction, but its wood is not considered to be of good quality. Aside from these rather incidental uses,
Metasequoia glyptostroboides is most often found in the wild on unarable terrain. Professor Cheng photographed these trees in a ravine at the side of Shui-sha valley, August 1948. Members of the expedition found that Metasequoia trees in Shui-sha valley were generally 6–9 decimeters [2 to 3 feet] in diameter; medium-sized trees were uncommon.

The fate of Metasequoia rests with man. If destruction continues, all the native stands will be eliminated. The massive veterans will ultimately die, leaving only the planted trees surviving—the same fate that has already overtaken Ginkgo.

Conclusion

... [Metasequoia] is partial to slightly acid or circumneutral soils derived from sandstone; it avoids soils of limestone origin in areas that appear to be otherwise suitable. Moist soil and humid atmosphere seem to be essential for successful reproduction. These various conditions are fulfilled in narrow ravines and seepage grounds; the tree is essentially a member of a streambank community. The evidence for these conclusions comes from Shui-hsa valley, a very small part of the whole range of the species.

The scattered individuals of considerable or large size growing beyond the confines of the valley need to be accounted for. It seems necessary to conclude that conditions like those in Shui-hsa valley existed elsewhere nearby in the none too distant past; that in favorable spots reproduction of Metasequoia was possible recently enough to have given rise to the existing mature trees. Increase of human population, with consequent exploitation of the natural resources of the area, has resulted in general destruction of the conditions essential for reproduction of Metasequoia; a certain number of mature individuals survive.

Only in Shui-hsa valley does Metasequoia exist under an approximation to natural conditions. This may be due in part to certain environmental advantages. The valley lies at a somewhat higher elevation than others in the sandstone region, it is narrower, and certain features of its local climate seem to be in its favor. More important, probably, is the fact that this valley was the last to be occupied by permanent settlers, the period of occupation extending back only two centuries. Late settlement is doubtless due to its higher altitude, the comparatively small area favorable for rice culture, possibly poorer soil, and particularly its unique character as a basin completely enclosed by mountains, with no easy river route into it. Increase of population pressure outside finally became the incentive leading to its occupation. Shorter period of occupation and sparser population have permitted Metasequoia to remain here in an approximately natural state.

It is gratifying to know that a “Metasequoia Conservation Committee” has been formed in China. Its honorary chairman is Dr. Hu Shih, former ambassador to the United States; its chairman is Mr. Wong Wen Ho, former Premier of China and a noted geologist. It is to be hoped that the efforts of these Chinese scientists to preserve the natural stands of Metasequoia through the establishment of a national park or some other form of nature reservation will, in spite of formidable difficulties, be crowned with success before it is too late.