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Front cover: *El Arbol del Tule*, a venerable giant of the species *Taxodium mucronatum*, the Mexican bald cypress. Photograph by Rác & Debreczy.

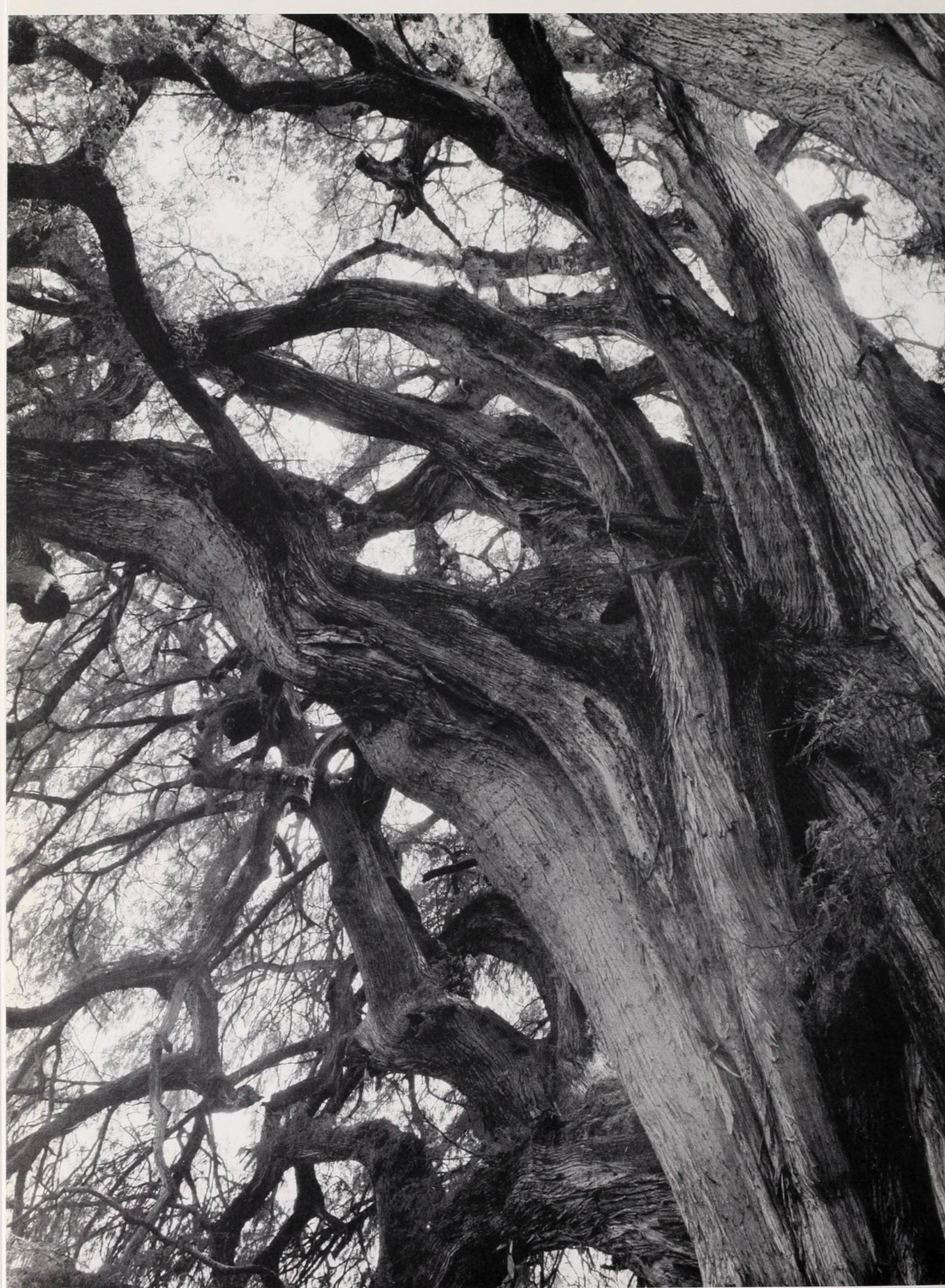
Inside front cover: *Magnolia tripetala*, an Asian umbrella magnolia, in flower in Pomona, New York. Photograph by Richard B. Figlar.

Inside back cover: *Magnolia macrophylla*, the large-leaved cucumber tree, photographed at the Arnold Arboretum by Peter Del Tredici.

Back cover: A mature stand of *Taxodium mucronatum*, just north of Sola de Vega, Oaxaca, Mexico. Photograph by Rác & Debreczy.



El Arbol del Tule



El Arbol del Tule: The Ancient Giant of Oaxaca

Zsolt Debreczy and István Rácz

The famous tree that has puzzled travelers and botanists for hundreds of years with its legends now raises new questions about its future.

Outside the city of Oaxaca, on the ancient lands of the Mixtecs and Zapotecs in southern Mexico, stands a tree, perhaps the most famous and most frequently measured among the giants: a unique specimen of the fast-growing southern bald cypress, *Taxodium mucronatum*, known by the Aztecs as an *ahuehuete*, the "graybeard of the swamp." What "General Grant" is to the giant sequoias, El Arbol del Tule is to the bald cypresses.

The Mexican bald cypress is a member of the Taxodiaceae, the family of giant sequoias, California redwoods, and bald cypresses, which, excluding tropical species, has the greatest potential of all tree families for achieving both great age and enormous size. Amazingly, this family of giants, like other conifers, is described as primitive because of its elementary conducting system of single-celled tracheids. In fact, this simple system can carry water and minerals to heights over 110 meters (366 feet), even under extreme conditions such as those found on the slopes of the Sierra Nevadas of western North America, which remain dry for many months at a time, and those in the waterlogged, oxygen-deficient swamps, the habitat of *Glyptostrobus* of southeast China and *Taxodium* of the southeastern United States and Mexico. *Taxodium mucronatum* represents the southernmost species of the genus, which was once found all over the Northern Hemisphere but is now restricted to North America.

The giant tree grows in the town of El Tule, little more than fifteen kilometers from the city of Oaxaca, the capital of the southern Mexican state of the same name. The highlands where it is located, at an elevation of about 1,550 meters

(5,100 feet), form a wide valley up in the Sierras. The area has only two distinct seasons: a humid, often cloudy, hot, rainy season typical of the "summer-rain tropics" south of the Tropic of Cancer, and a warm, dry "winter" season with bright sunny days, cool nights, and frequent frosts in the mountains. Near the city, frost has been reported only once a decade or so.

At one time, the tree ruled over wide fields of the brown-headed cattail—*Typha domingensis*, a close ally of *T. latifolia* of the north temperate regions of the world—called the *tule* in the native Zapotec tongue. Today, instead of an extensive swamp supplied by such rivers as the Atoyac and its tributary, the (local) Rio Grande, flowing down from the nearby Sierra de Juárez, the tree is surrounded by a neatly maintained lawn, colorful flowerbeds, and a wrought iron fence. The growing village of Tule has swallowed the swamp, its buildings and yards gradually encircling it, forming a lethal noose around it.

Our First Encounter

Having seen giant sequoias and redwoods in both the higher Sierras and the Coast Ranges of California, we were accustomed to the drama of large specimens. However, when engulfed by the spreading arms of Arbol del Tule, we experienced a totally different degree of awe, not comparable to anything we had previously encountered. While the big trees of California are majestic, like the skyscrapers of downtown New York they are out of reach. Arbol del Tule is an accessible "seated giant," welcoming us with broad, sweeping branches that extend almost the length of two tennis courts.



Although the tree is not particularly tall, it takes seventeen people with outstretched arms to encircle its gigantic trunk.

Fascinated at first by its enormous dimensions, we soon turned to the details of the tree. Each limb, towering upward, could itself be an independent tree of huge size. Like a gothic cathedral, arches rise above arches as the limbs disappear into the jungle of the crown 40 meters (130 feet) above, simultaneously reaching outward an incredible distance. Dramatically fluted in outline, the trunk has an air of mystery: sunlit ribs alternate with deeply shadowed recesses that are partly curtained by a veil of fine, light-green foliage.

The Inevitable Question

A correlation between the age and size of trees, at least within a species, would seem logical: the bigger the tree, typically the older it is. Seeing the almost 60-meter (200-foot) circumference of our giant, one assumes that this tree must be thousands of years old. Poets, politicians, scientists, and the technically ingenious have tried to answer the inevitable question: how old is it? Estimates have varied; some have gone as high as three thousand years, as suggested by A. Villaseñor in 1892, or even six thousand, as put forward

The giant tree dwarfs schoolboys and the chapel of Santa María alike in these postcards. The sign tells us that in 1987 El Arbol del Tule was 41.85 meters (137 feet) high, 57.9 meters (190 feet) in circumference, and 14.5 meters (48 feet) in diameter, with an estimated volume of 816,829 cubic meters and a weight of 636,107 tons. In 1992, our clinometer measurement showed that the tree was only 39.40 meters (130 feet) high, which, assuming the data are correct, indicates an almost two-meter (seven-foot) decrease in height in five years.



Taxodium mucronatum differs little from its northern relative, *T. distichum*. C. S. Sargent in his *Silva* of North America (1896) wrote that "it may prove to be a mere geographical form of our tree." Others, like Harper in 1902, consider it a "Sonorized" form of the northern species. Except for its "knees," which are absent or short and roundish, the differences lie mostly in phenological characters: the growth of the southern tree is more compact; its cones are smaller and leaves shorter, often pruinose gray ("bloomy") and semipersistent. These two old trees grow in the highlands near Oaxaca.

by E. W. Berry in 1923. An old legend among the local Zapotecs and Mixtecs tells us that the tree, along with several others nearby, was planted for the benefit of the people by Pecocho, a representative of the Aztec god of wind and storms, Ehecatl. This story puts the age of the tree at around fourteen hundred years.

Estimates, to be correct, should consider the tree's rate of growth, but in the case of the Tule

tree, another question has been raised through the past two centuries: is it a single tree or a group of trees that have coalesced to form a single individual? Although the tree is thought to have been visited by Alexander Humboldt on his visit to Mexico in 1803, evidence suggests that he never reached Oaxaca and therefore never visited the tree. However, he wrote in his *Political Essay on the Kingdom of New Spain*:

In the village of Santa María del Tule, three leagues from the capital, there is an enormous sabino (*Cupressus disticha* [now *Taxodium mucronatum*]), the trunk of which is 36 meters [120 feet] in circumference. This old tree is even more corpulent than the cypress of Atlixco of which we have spoken above, than the Dragon tree of the Canary Isles and than any of the baobabs (*Adansonia*) of Africa. But examined closely, señor Anza has observed that, that sabino which is such a surprise to travelers is not a single individual but a group of three trunks united (II: 45–47).

In 1892, Alejandra Villaseñor summed up nearly a century of controversy:

The trunk of the tree of Santa María del Tule, far from being compact and almost cylindrical, is, on the contrary, rough-barked, unequal, and fissured, covered with senile excrescences [burls], some of large size, with bold projections which made a certain Sr. Anza suppose that it was not a single tree but three united; but later observations by Dr. J. Bolaños in 1840 and by other people have shown the error of the supposition.

Botanist Juan Bolaños climbed the tree to the point where the common trunk ends and the primary branches begin



Some characteristics of *Taxodium mucronatum* are strongly influenced by climate. The compound leaves are semipersistent: the foliage of the previous year detaches only when the new leaves unfold. The southern species is less cold-hardy than its northern cousin, especially in sudden frosts. When cultivated in areas where the winter temperatures fall below freezing, most of the green foliage becomes yellowish brown and falls, even on the trees of Tule.

In the United States, the Montezuma bald cypress grows well throughout the West and mostly below 30 degrees North latitude in the East while it is easy to cultivate in the Mediterranean basin up to 40 to 44 degrees North, and in western Europe, it survives far above the latitude of 50 degrees North.



Ahuehuate gallery forest near Sola de Vega, Oaxaca. Note the root system weaving a protective lattice on the riverbank. Instead of adaptation to anaerobic swamps, *Taxodium mucronatum* is adapted to periodically high riverbeds and riversides. The fantastic root systems grasp the riversides, fencing the riverbed with such efficiency they seem to be created for that purpose. At Sola de Vega, the most beautiful riverbed habitat of the species is still untouched, providing dramatic views of trees 12 to 15 meters (40 to 50 feet) tall.

and found a large enclosed place “which could serve as a habitation in case of need.” This observation convinced him that the trunk belonged to one individual and that the divisions at the base of the trunk, considered to stem from separate trees, are only parts of a sole specimen.

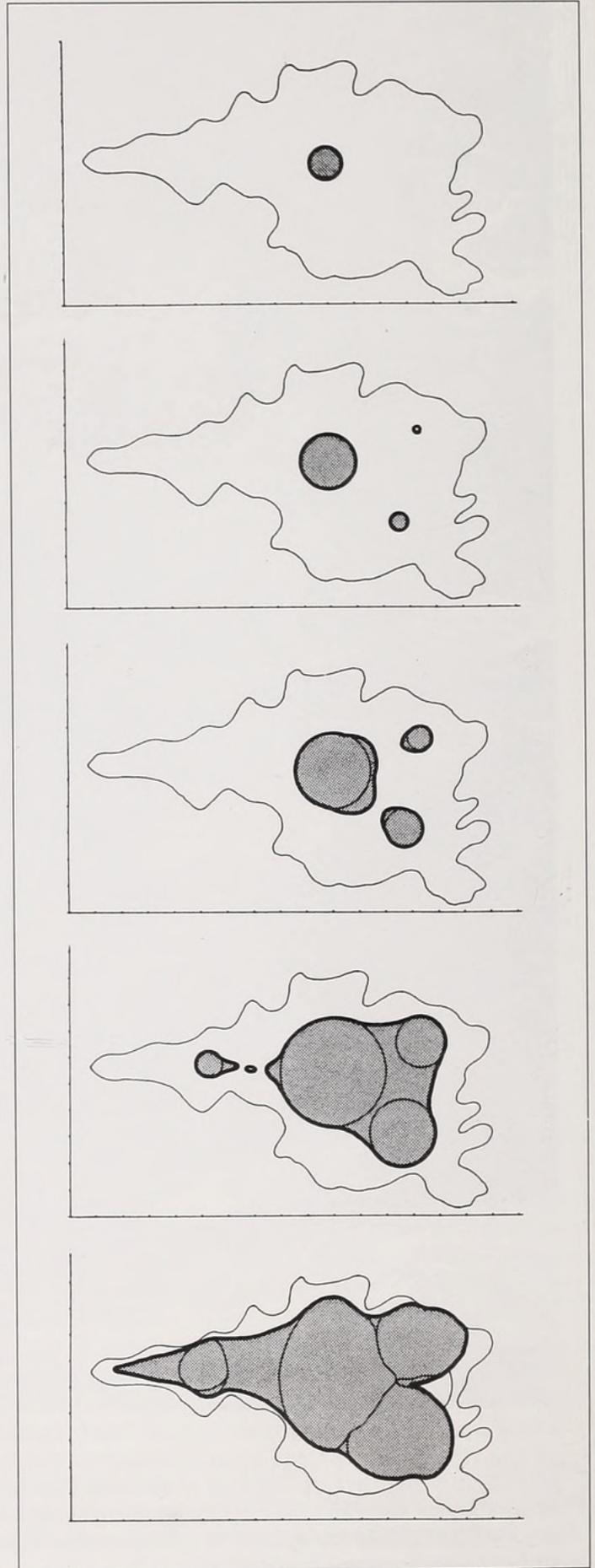
Another botanist, Casiano Conzatti, after a year spent studying the tree, published his findings in a 1921 article entitled in its English translation, “Monograph on the Tree of Santa María del Tule.” Conzatti drew on records from previous writers—Desiré Charnay (1863), Manuel Ortega Reyes (1884), and Manuel F. Alvarez (1900) as well as Bolaños (1841) and Villaseñor (1892)—to make comparisons. To get an idea of the growth rate of the species locally (without damaging the venerable one), he correlated size and age of bald cypresses in the area by measuring trunk sizes and counting annual rings of cut branches. He found that the species has a surprisingly fast growth rate, and that, as a rule of thumb, the diameter of the trunk in centimeters is about half the age of the tree in years. Using this number in conjunction with an average diameter of 8 meters (more than 26 feet) for the irregularly shaped trunk of the giant, his calculations suggested that the tree was between 1,433 and 1,600 years old (numbers which, interestingly, approach the planting time given in the legend of Pechoca).

Three or More, Yet One

Three trees, three genetically different organisms—as we stood before Arbol del Tule in 1990, the fusion of several trunks appeared plausible.

Biologist Angel Salas Cuevas proposed a scenario for the life history of El Arbol del Tule: The young tree is small and single. Its trunk is joined by a second trunk—a root sprout—about 2.5 meters (8 feet) away.

When the third trunk appears, the original tree and its two suckers form an almost equilateral triangle. After their fusion, the newly enlarged trunk, with its deep ribs along the fusion lines, takes on a cloverleaf shape in cross section. These trunks become a single trunk scored with deep furrows and gaps, and a fourth trunk appears 3.5 meters (12 feet) away on the east side. The greatest change, however, is yet to come: the fourth trunk gradually joins the triad. The tree is now almost 5 meters (16 feet) in diameter, and the main section quickly expands to over 7.5 meters (25 feet) at its widest.



However, the crown, the foliage, and the cones were so strikingly uniform that we were doubtful of its multiple nature. Boone Hallberg of the Instituto Tecnológico de Oaxaca confirmed our doubts, noting that in the thirty years he has been observing the tree, the timing of budding, the development and color of the leaves and strobili, the shedding of pollen, as well as the leaf color after frost—all were the same. In contrast, he had watched another tree growing along a nearby stream, a fusion of two different seedlings. The two trees were easily distinguished by subtle differences in both morphology and phenology.

To be three trees and one at the same time implies the union of sprouts of the same tree. The Taxodiaceae, including the genus *Taxodium*, possesses the ability to sprout from stumps following logging, as is often seen in the northern bald cypress, *T. distichum*, a very close ally of *T. mucronatum*. It is quite possible that the independent trunks that gradually “built” Arbol del Tule originated as sprouts from the trunk of a single damaged tree, or as layered branches from a tree whose single central trunk died out, after which the layers grew and fused together. The process by which the tree could have formed from several separate trunks has been illustrated by biologist Angel Salas Cuevas, using old descriptions, drawings, and photographs as a basis. His proposed scenario for the life history of the Tule tree from the appearance of the first tree, to its fusion with two of its suckers, and finally its coalescence with a later, third sucker can be seen on the preceding page.

In 1990 (Hall et al.), the results of enzyme analysis of samples taken from eight major segments of the tree provided undeniable evidence to support the theory of a single specimen, and as such, one of the world’s largest trees in circumference. These results were further supported in 1996 (Dorado et al.) by evidence of genetic uniformity from DNA analysis. The competing theories of multiple trees vs. a single tree were thus apparently resolved.

Epilogue

Before being leveled by the Europeans, the 300,000-person Aztec capital, Tenochtitlan, was a large, well-organized city, a place of spectacu-

lar art, its market loaded with food brought from Xochimilco’s floating gardens through a dense network of canals. Reaching almost 5,500 meters, the snow-covered peaks and rims of the sacred mountains, the Popocatepetl and his partner, Iztaccihuatl, hung like floating crystals above the city. The graybearded *ahuehuetes* were revered and planted everywhere along the canals, including areas that were later incorporated into the beautifully nurtured parks of Texcoco and Chapultepec. Some of their biggest trees were still with us only two or three decades ago, and it sends a shiver up the spine to think that the Aztecs once walked in their shade.

Smog and especially the drop in water table—pressures of a dramatically changing world—finished Mexico City’s El Sargento in the 1970s, as well as the famous Ahuehete of Popotla, the Arbol de la Noche Triste, and the big tree near the temple of the Aztec king Netzahualcoyotl in Texcoco. With a leaf surface of 9,300 square meters, the Tule tree has a tremendous evapotranspiration rate. It is enough to look at the tree to see that something is wrong. Gone is the beauty of the light-green foliage drooping ten meters downward with no branches visible beneath it, as it was seen just a human generation ago. The entire circumference of the tree, but particularly its southern side, is now full of twisted, skeletal branches. The tree has begun to decline, losing crown size in response to the changing environment. Anyone who has ever dealt with conifers knows exactly where this will end if the process is not halted and reversed as soon as possible.

Just decades ago, in the 1950s, Oaxaca was still a peaceful town of 40,000 people: somewhat provincial, with friendly merchants, silent streets of colonial elegance, and mainly Zapotec and Mixtec vendors in the market. The city has expanded rapidly and is now ten times as large, and it is about to celebrate a half million inhabitants. Water is used freely and El Tule’s water table has dropped to its lowest level ever. Once a citizen of the swamp with a root system developed for a high water table and a crown adapted to higher humidity, Arbol del Tule and its neighboring, smaller giants, the Son and Grandson, are now clearly suffering. The soil is compacted



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