

A Botanist's View of the Big Tree¹

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Abstract: Although assigned to *Sequoia* for most of its taxonomic life, there is general consensus that the Big Tree merits its own genus (*Sequoiadendron*). Recent taxonomists have suggested that its traditional family (Taxodiaceae) should be merged with the Cypress Family (Cupressaceae), to comprise the expanded Cupressaceae. Like its redwood relatives, the Big Tree has an extensive fossil record and once had a wider range than at present. Its current range appears to have been rather recently occupied, and to have been shaped by Pleistocene glaciations and an extensive Xerothermic period a few thousand years ago. The maximum height and maximum mass of the Big Trees have been a matter of dispute, but both are exceeded by other organisms. Botanists, foresters, and the public continue to be impressed by the majesty of the Big Trees.

The invitation to present a paper about the Big Tree came as a surprise to me, since my own botanical work has been devoted mostly to annual herbs whose life span is counted in weeks or months. I can claim to be a true innocent, then, and what I know about the Big Tree has been learned from others. My view encompasses a number of features, including the interesting ecological relationships of the Big Tree and its attenuated genetic structure. But since these will be described by experts, I will say little about them and confine myself to topics which have not been covered by other contributors.

Naming the Big Tree

In 1852, San Francisco botanist Dr. Albert Kellogg was the first botanist to possess specimens of the Big Tree. Kellogg had intended to name this new species as the sole member of a new genus *Washingtonia* but delayed doing so. In 1853 he showed his specimens to English plant collector William Lobb, who had been sent to California by the prominent English nursery, Veitch and Sons, to locate promising California plants for British horticulture. After seeing Kellogg's specimens of the Sierran giants, Lobb traveled to the Calaveras County populations, collected seeds, herbarium specimens, and living seedlings, and departed with them for England. Lobb's material was shown to English botanist John Lindley, who named and described *Wellingtonia gigantea* on Christmas Eve, 1853. He named the tree after the Duke of Wellington, who had died a year earlier. Lindley wrote "Wellington stands as high above his contemporaries as the Californian tree above all the surrounding foresters" (1853a,1853b). That an Englishman snatched from Californians the opportunity to name this tree after an American hero led botanical historian Joseph Ewan (1973) to remark that Lindley's choice of a generic name

"unleashed American cross fire that was to consume hundreds of pages for decades to come." Even today, British horticulturists refer to our Giant Sequoia or Big Tree as "Wellingtonia."

Although the impression was given that American botanists believed that Lindley had pulled a fast one by his expeditious scientific naming of the Big Tree, I am not convinced that his rush into print reflected anything other than excitement over what he had learned of the tree. He wrote "What a tree is this! -of what portentous aspect and almost fabulous antiquity!" (Lindley 1853a). To Lindley (1853b), as a horticultural subject the Big Tree promised to be an "extraordinary tree... of almost imperial aspect." We will never know whether Lobb told Lindley of his meeting with Albert Kellogg; if this tale has a villain, it might well be William Lobb. According to Ewan (1973) southern California botanist C.C. Parry, "who was evidently with Lobb at Monterey just before (he) set out for the Calaveras Grove, and therefore should have firsthand information, places almost criminal shades on Lobb's actions." At the time of this chauvinistic furor, American, British, and European botanists apparently were unaware that the name *Wellingtonia* was invalidly applied to the Big Tree, since 13 years earlier Swiss botanist Carl Meisner had applied it to a genus of tropical hardwoods. In 1855, French botanist Decaisne transferred the Big Tree to the genus *Sequoia*, a genus that had been established to accommodate our Coast Redwood.

For many decades after its discovery our Coast Redwood had passed as a member of the bald cypress genus *Taxodium*, but in 1847 Viennese botanist Stephan Endlicher recognized its distinctiveness and assigned the tree to a new genus that he called *Sequoia*. While the name *Sequoia* is believed to commemorate a prominent member of the Cherokee nation, it was published without any explanation of its derivation. The mystery of a Viennese botanist who had never visited the United States naming a genus after Sequoyah (otherwise known as George Guess) has been explained by Cook (1955): Endlicher was not only a botanist but a linguistic student as well, and was probably aware that in 1821 the man Sequoyah had invented an 86-character alphabet to accommodate the Cherokee language. Cook wrote that this invention and its impact on the Cherokee nation are "considered one of the cultural masterpieces of modern times." Thus, Endlicher the botanist commemorated an American who was not a botanist, but who came to his attention because of his interest in linguistics.

Most botanists writing about the Big Tree from the time of its scientific naming until well into this century have referred to it as *Sequoia gigantea*. In 1939, John Buchholz, a professor of botany at the University of Illinois, studied various botanical features of our coastal and Sierran redwoods and concluded that the several differences

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between the two species were sufficiently strong to merit placement of the Sierran species in a distinct, new genus which he called *Sequoiadendron* (Buchholz 1939). It was not until a few years later that the difference in chromosome number between the two redwoods was discovered and added to the intergeneric distinctions. Botanists in California, however, found it irksome that a midwesterner should meddle with the nomenclature of one of our most cherished endemics. In an amusing article (not intended to amuse, apparently, but nevertheless humorous today), forester W.A. Dayton published a poll of California botanists in 1943, asking their opinions on the correct generic placement of the Big Tree and what they considered to be its correct species name (Dayton 1943). Before describing the results of this poll, I should mention that in 1943, as today, there was in force an internationally accepted code of botanical nomenclature, which, among other things, provides the legalistic basis for determining the correct specific name for a species. Acceptance of *Sequoiadendron* or continuing to recognize the Big Tree as a species of *Sequoia* is a matter of botanical opinion, but the code leaves little room for opinion as to which species name must be used in either genus. In 1943, the terms of the code apparently specified that as *Sequoia*, the Big Tree must be called *S. wellingtonia*; at least that was the interpretation of Roxana Ferris of Stanford and Lincoln Constance of Berkeley. Constance, however, preferred the name *S. gigantea*, though he said "we are all quite aware that this is a specific violation of the International Rules." (Dayton 1943). Kelsey and Dayton (1942) stated that the name *S. wellingtonia* was "unpalatable to the American people... There is every reason for believing that, Rules or no Rules, *Sequoia gigantea* will continue to be the name in general use." Bay Area botanists David Keck and John Thomas Howell both rejected the new genus *Sequoiadendron*; Jens Clausen suggested both redwoods should be returned to *Taxodium*! Southern Californian botanists Lyman Benson and Carl Epling, on the other hand, accepted the new genus *Sequoiadendron*, with Benson writing that "there is ample support for the segregation of *Sequoiadendron*." (Dayton 1943). Emmanuel Fritz, another northerner, wrote dramatically "I beg of you, on bended knee, don't accept Buchholz's new genus." (Dayton 1943). Current opinion favors the Big Tree as a member of its own genus, fully called *Sequoiadendron giganteum*. This status apparently is accepted by the diverse sponsors of this symposium. A more extensive account of the nomenclatural history of the Big Tree is given by St. John and Krauss (1954).

Family Position of the Big Tree and Its Relatives

The family status of the bald cypress family (Taxodiaceae), to which redwoods are traditionally assigned, has been challenged from time to time. In 1976, a graduate student of mine, Jim Eckenwalder, although not working on redwoods or conifers for his dissertation, published a carefully reasoned

and fully documented analysis that proposed merging the Taxodiaceae with the cypress family (Cupressaceae), which single collective family would have to be called the Cupressaceae (Eckenwalder 1976). Eckenwalder argued that cypresses (*Cupressus*) and the southern hemisphere genus *Callitris* of the cypress family are as closely allied to the redwoods as the redwoods are to other members of the Taxodiaceae, and thus assigning these genera to two families is unsound. So far as I can tell, Eckenwalder's proposal was not accepted by subsequent taxonomists. A decade later, Harvard botanist Jeffrey Hart published a cladistic analysis of conifers and concluded that "if one chooses to recognize the Cupressaceae... at the family rank, then the Taxodiaceae cannot be recognized" (Hart 1987). Hart thus supported Eckenwalder's proposal. More recently, another graduate student of mine, Bob Price (whose doctoral dissertation dealt with wallflowers and not conifers), working with Jerold Lowenstein at the UC Medical Center in San Francisco and using immunological techniques, supported a merger of the two families. These workers pointed out that in a single family, members of the Cupressaceae and Taxodiaceae would be scattered, and that collectively the group represents a single evolutionary lineage (Price and Lowenstein 1989). All these researchers have suggested a very close relationship between *Sequoia* and *Sequoiadendron*, a pair of genera closely related to the Asian genus *Metasequoia*. Two years ago, Hart and Price (1990) merged the two families, saying that "the two families are held together by an impressive number of morphological characters" and that the Cupressaceae, taken in the broad sense to include the Taxodiaceae, are "a natural group quite distinct from other families of conifers." Since these views were published in an influential arboretum journal I suspect they will be taken seriously. You might be interested, however, to learn that in the newly revised Jepson's manual of California plants, the two families are kept apart (Hickman 1993). There is still much to be learned about our redwoods, and new ways for botanists to think about them.

Evolutionary History of the Big Tree

Redwoods are well represented in the fossil record, although the discovery of *Metasequoia*, named in 1941, and its earlier confusion with *Sequoia* in the fossil record necessitated a revision of ideas concerning the past history of the latter genus. At one time, the redwoods and their allies were conspicuous members of the forest vegetation of much of the northern hemisphere. In time, the distribution of most of these trees contracted considerably, leaving remnants in North America, represented by our two redwoods and the bald cypress (*Taxodium*) and in eastern Asia, represented by the Dawn Redwood (*Metasequoia glyptostroboides*) and a few other genera. Fossils attributed to *Sequoiadendron* are known from several localities in what are now the western and eastern United States, Greenland, Spitsbergen, Europe, the British Isles (Florin 1963) and eastern Asia (*vide* Axelrod 1986). The tree, or an ancestral species, persisted in the Old

World at least until the late Oligocene, about 30 million years ago (Florin 1963). In North America, Big Tree antecedents had a wider range than did those of the Coast Redwood, which appears always to have been restricted to the western portion of the continent.

Thanks to the extensive work of paleobotanist Daniel Axelrod (1956,1959,1976,1986) much has been written about the history of the Big Tree in western North America. Axelrod has studied fossil remains of *Sequoiadendron* and has found that prior to migrating to California, this genus grew in Nevada where an oak woodland/chaparral/conifer forest mosaic existed in a mild climate with year round precipitation between 25 and 35 inches. These Nevada populations occurred in ecological and floristic settings that can be more or less duplicated in parts of the lower margin of the current range of the species in the southern Sierra Nevada. The rainfall at the modern sites is much lower, however, than that postulated for the Nevada localities and the winters are much more severe. The higher rainfall in its former habitat may explain the current preference of the Big Tree for moister sites, where enhanced soil moisture conditions compensate for lower rainfall. Axelrod (1986) has suggested that with the increasing continentality of the climate of interior western North America and the gradual rise of the Sierra Nevada and the development of its spectrum of climates on the western slopes, the Big Tree disappeared from its former interior range and its increasingly inhospitable climate, and migrated westward to the young Sierra Nevada, where it had arrived by 7 million years ago. By 6 million years ago, the Big Tree community was termed "near modern" (Axelrod 1986). At that time there were a few plant associates growing with the Big Tree which have subsequently disappeared from the area, such as cypresses and an elm.

Although over a century ago John Muir (1876) suggested that the modern distribution of the Big Tree was shaped by the Pleistocene glaciations, Axelrod (1986) believes that the present discontinuities that characterize the range of the species were also strongly affected by a dry, warm climatic regime (a Xerothermic period) that occurred between 8,000 and 4,000 years ago. Gloomy about the future of the Big Tree, Axelrod wrote in 1986 that "the scattered stands of the Sierra redwood are certainly on the road to extinction. This is the result of continued fire suppression by the U.S. Forest Service and National Park Service... Unless the forest groves are opened by clearing, or controlled burning, these forest giants-some of which are over 3,000 years old, and whose ancestry reaches back fully 70 million years-will all be gone within a few hundred years, or possibly less."

Features of the Big Tree

Certainly the most impressive features of the Big Tree to both botanists and the public are the enormous mass and great age of the trees. Harvard botanist Asa Gray visited the Mariposa and Calaveras groves in 1872 and referred to the

Big Trees as the "wonder of the world" and commented on "their singular majesty" (Gray 1872). Gray's contemporary, botanist Sereno Watson, wrote in 1880 that both our redwoods are "remarkable and noted" (Watson 1880). And, early in this century, California botanist Willis Linn Jepson (1923) wrote of "standing in rhapsodical admiration" before a Big Tree. Even foresters such as Gifford Pinchot (1900) have expressed admiration for the Big Trees as "the grandest, the largest, the oldest, [and] the most majestically graceful of trees...". He pointed out that, at the time, "the majority of the Big Trees..., certainly the best of them, are owned by people who have every right, and in many cases every intention, to cut them into lumber." Based on second-hand information, Pinchot reported that a specimen called Starr King in the Calaveras Groves was 360 feet tall (Pinchot 1900). Jepson (1923) gave 331 feet as the maximum height, which he said is "a figure in excess of any measurements hitherto given which have been made by presumably accurate methods." Munz (1959) gave 100 meters (328 feet) as the maximum height. In any event, the tallest trees are or were taller than the Statue of Liberty or Berkeley's campanile.

The maximum volume of the largest trees is said to be about twice that of the largest individuals of the Coast Redwood. The total mass of a very large Big Tree has been estimated variously; the maximum figure I have found is somewhat over 6,000 tons (Engbeck 1973). The greatest age is about 3,300 years. When we speak of age, however, we must remember that no living cell in a Big Tree is over a few decades old, and that the living tissues of the tree form a shell over a dead, wooden interior of greater mass and age. There are plants in California that are older, depending on how age is described. An extreme example is a clone of Creosote Bush (*Larrea divaricata*), the so-called "King Clone," estimated to be about 12,000 years old (Vasek 1980). The individuals of this "specimen" are physically separated from each other, but are believed to represent the clonal descendants of a seedling that established itself in the desert about 12,000 years ago, the time at which the first Creosote Bushes may have invaded the North American continent from South America.

The Big Tree's mass also may be much exceeded by other organisms. Recently, in northern Michigan, a fungus was discovered whose "body" occupies an area of about 30 acres, and which weighs over 20,000 pounds (Smith and others 1992). Critics have pointed out, however, that Big Trees and Blue Whales have "relatively determinate growth within a defined boundary," whereas this gargantuan fungus does not (Brasier 1992), and thus "its status as a champion organism depends upon one's interpretation of the rules."

The history of the scientific discovery and naming of the Big Tree is a fascinating one. The present consensus of plant taxonomists is that *Sequoiadendron* merits generic distinction from Sequoia, although the proposed well-argued merger of the bald cypress family (Taxodiaceae) into an expanded cypress family (Cupressaceae) will doubtless meet continued resistance by botanists and foresters.

The Big Tree is a member of ancient evolutionary lineage and currently persists in a series of scattered groves along the western slopes of the Sierra Nevada. Its continued well-being will require intelligent vegetation management practices on the part of the Federal and state agencies that are custodians of this remarkable botanical relic. The size and age of the Big Trees, each exceeded by other species, continue to impress scientists and the public alike. I join W.L. Jepson in his "rhapsodical admiration" of these formidable giants.

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