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JOHN THEODORE BUCHHOLZ (1888–1951) STUDYING CONIFERS IN CALIFORNIA,  
ESPECIALLY *SEQUIADENDRON* AND *SEQUOIA* (CUPRESSACEAE) IN 1936

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ABSTRACT

Biographical details are given for John Theodore Buchholz (1888–1951), including his interest in conifers of California and New Caledonia. Buchholz made detailed studies of the vegetative morphology, reproductive morphology, and embryology of *Sequoiadendron giganteum* and *Sequoia sempervirens* prior to his 1939 segregation of *Sequoiadendron* from *Sequoia*. Buchholz, a professor at the University of Illinois (1929–1951), spent spring and summer of his 1936 sabbatical in California. Description of Buchholz's technique for morphological collections provides valuable information about his itineraries and his herbarium collections of *S. giganteum* in 1936. Buchholz also spent the summers of 1940, 1942, and 1944 in California collecting *Sequoiadendron* (1940) and cultivated material of *Podocarpus* (1942), as well as investigating *Pinus* (1942, 1944). Information sources included: obituaries and other biographical accounts of Buchholz and his students, labels of his herbarium collections, 55 letters archived at the California Academy of Sciences and the University of Illinois, and Buchholz's extensive bibliography on gymnosperms (57 titles, including those of his student Neta Elizabeth Gray, 1913–1970). Publications with available PDFs allowed systematic searching of relevant dates and text strings.

Key words: Buchholz, Cupressaceae, giant sequoia, New Caledonia, *Pinus*, *Podocarpus*, redwood, *Sequoia*, *Sequoiadendron*.

INTRODUCTION

John Theodore Buchholz (1888–1951; Fig. 1) is remembered today chiefly for proposing in 1939 “The generic segregation of the Sequoias” (the title of his July 1939c paper published on 1 Aug 1939) into the classic genus *Sequoia* Endl. and the new genus *Sequoiadendron* J.Buchholz. These genera were traditionally placed in Taxodiaceae, which is now merged with Cupressaceae (Eckenwalder 2009; Farjon 2010). Each genus is monotypic, containing a single extant species: *Sequoia sempervirens* (D.Don) Endl. (redwood or coast redwood) is native to coastal central and northern California and adjacent southwestern Oregon, whereas *Sequoiadendron giganteum* (Lindl.) J.Buchholz (giant sequoia, big tree, or Sierra redwood) is endemic to the western slope of the Sierra Nevada of California (Fig. 2; Weatherspoon 1990; Willard 1995, 2000; Farjon and Page 1999; Lanner 1999; Schellevis and Schouten 1999; Schmid 1999; Flint 2002; Eckenwalder 2009; Farjon 2010; CCH 2012; Schmid and Schmid 2012; Wikipedia 2012b). Both genera are endemic to the California Floristic Province (Schmid 1999).

Buchholz's (1939c: 535–538) tabular “summary of outstanding generic and specific differences” between *Sequoia* and *Sequoiadendron* emphasized “external taxonomic characters” and “internal” embryological characters. The magnitude of these “differences” thus “thoroughly convinced” Buchholz of his “generic segregation.” In a paper on *Sequoia* published earlier on 15 May 1939, Buchholz (1939b: 256) had noted that “at least 55 important differences between the Sequoias are known,” including 36 “well marked external contrasts ... The results ... all point to one conclusion, that the two Sequoias belong to different genera.”

Initially, however, this proposed segregation was highly controversial and unpopular. Dayton (1943) summarized in

*Leaflets of Western Botany* (30 Apr 1943 issue) the mostly negative opinions of 29 botanists, including Alice Eastwood and John Thomas Howell (both at CAS), who favored *Sequoia gigantea* Lindl. Two respondents would even have preferred *Sequoia wellingtonia* Seem. for *Sequoiadendron* as the lesser of “the two evils” (Jens Clausen, CI, for the quote; Rimo Bacigalupi, JEPS). Jones (1943) publicized Dayton's survey in *Science* (5 Nov 1943 issue). [See Methods for abbreviations of institutions.]

California is a “hot spot” or center of diversity for conifers (Farjon and Page 1999; Lanner 1999; Schmid 1999; Eckenwalder 2009; Farjon 2010; CCH 2012; Conifers of the world 2012). Statistics from *The Jepson manual*, 2nd ed. (Baldwin et al. 2012: 1521) are telling: 3 families of conifers with 15 genera (1 endemic) and 55 species (all native, 10 endemic) [it is 61, not “59,” native species of gymnosperms minus 6 native species of Ephedraceae]. These numbers await comparison and perhaps reconciliation with worldwide treatments of conifers (Farjon and Page 1999; Eckenwalder 2009; Farjon 2010; Conifers of the world 2012).

In addition, coastal California has a moderate Mediterranean climate that allows cultivation of alien conifer taxa native to temperate and subtropical regions elsewhere in the world. The cooler coastal climate of Santa Barbara Co. and northward not only is more amenable to most cultivated conifers but also is more supportive of native forests, especially in central and northern California.

Buchholz, a world authority on conifers, recognized that California was a potentially rich source of both native and alien conifer taxa that might be available for morphological, anatomical, and embryological study. He thus sought the assistance of renowned California taxonomist Alice Eastwood (1859–1953), Curator of Botany and Director of the Herbarium at the California Academy of Sciences (1893–1948)—see

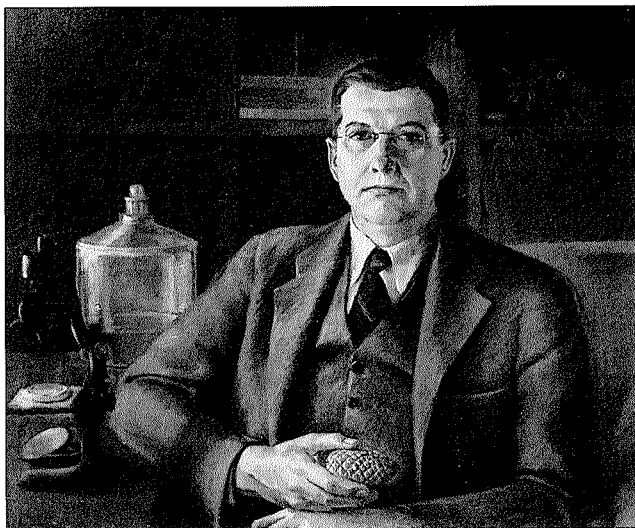


Fig. 1. John Theodore Buchholz (14 Jul 1888–1 Jul 1951) holding a persistent, unopened, green female cone of *Sequoiadendron giganteum* (giant sequoia, big tree, or Sierra redwood); portrait painted by his daughter and noted artist, Olive Miriam Buchholz Parmelee (1913–1970) (photo enhanced by Steve Ruzin from original photo by Thomas Jacobs, from <http://www.life.illinois.edu/plantbio/history.htm>, by permission).

Daniel (2008). The archive Alice Eastwood Papers (2012) has two early letters that Buchholz wrote to Eastwood:

- (1) A two-page, four-paragraph hand-written letter dated 25 Jun 1933 begins: “Could you arrange to have some

cones of various conifers collected and sent to us? I understand that you have some rare species in cultivation at the Golden Gate Park, or at least species which are not available in the central states. Of course we want the green cones, which are about in fertilization stages or just past—we want them for a study of the early embryo.” Buchholz provided further details on how to collect and ship the cones. “We have pines here [in Illinois], so would not need *Pinus*, *Picea* or *Larix*. Any of the following would be interesting if available:” *Sequoia* (“either species”), *Libocedrus*, *Thujopsis*, *Torreya californica*, *Pseudotsuga*, and the alien genera *Araucaria* and *Cedrus*. “I have a class of graduate students working on gymnosperms and several of them may wish to undertake a special problem in embryology, and, of course, I would be interested in any species not worked on before, especially *Sequoia* and *Thujopsis*.” Finally: “Even if you can obtain only one [genus] from the list of genera suggested, it would be very greatly appreciated by us.”

- (2) A one-page, two-paragraph typed letter dated 10 Jan 1936 states: “At the end of this month I am starting on a 7-month sabbatical leave of absence for California for the purpose of studying the embryology of conifers. My primary purpose is to study certain native species such as the Sequoias, the Monterey Cypress, Plumb Yews, Incense cedar, *Pseudotsuga macrocarpa*; any or all that I find time to investigate. I

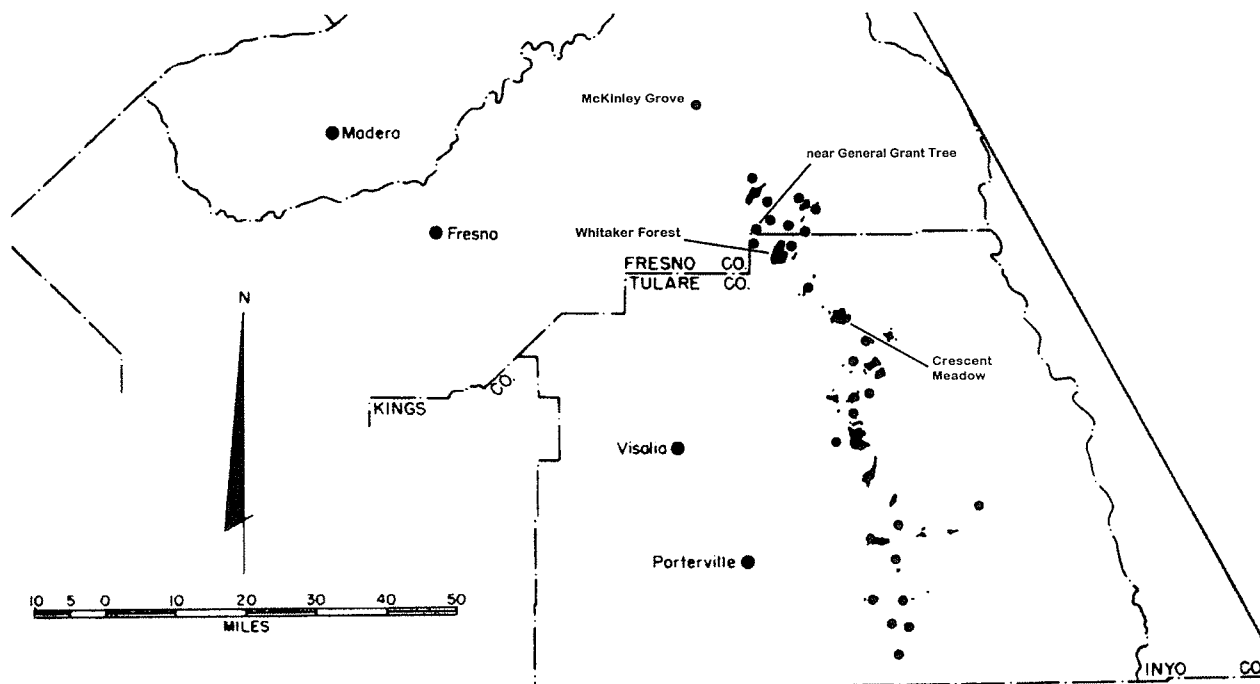


Fig. 2. Distribution of *Sequoiadendron giganteum* showing McKinley Grove, the southernmost of the 8 northern groves, and the 67 southern groves recognized by Weatherspoon (1990: 553, the map source; since Willard (2000) the current numbers are 8 northern and 59 southern groves).—The long labeled lines denote Buchholz’s sites (listed north to south): near General Grant Tree, northwestern part General Grant National Park (an obsolete name—see text, Part 4b; since 1940 known as General Grant Grove or Grant Grove, Kings Canyon National Park). Fresno Co. (1936 morphological and herbarium collections); Whitaker Forest, northwestern part Redwood Mountain Grove, Sequoia National Forest, Tulare Co. (1936 morphological collections); Crescent Meadow, southeastern part Giant Forest, Sequoia National Park, Tulare Co. (1940 herbarium collection).—Linear distances: 6.2 km from General Grant Tree to Whitaker Forest; 22.9 km from latter to Crescent Meadow.

would also like to obtain material of any exotic species, if there are species of *Podocarpus*, *Callitris*, *Widderingtonia* [*Widdringtonia*], *Dacrydium*, *Phyllocladus*, or any other conifers in cultivation on estates, parks, or experimental plantings. I have been told that you have considerable information concerning the localities in California at which exotic material may be found in cultivation. [new paragraph:] Possibly you know the locations of nurseries which have gone in for unusual exotic material. It would oblige me greatly if you would give me any general information which I should have, as soon as convenient, and if you will keep my needs in mind so that I may have the more detailed information when I arrive, which may be in about two months."

Buchholz (1888–1951), a professor at the University of Illinois (1929–1951), spent considerable time in California: spring and summer of 1936 during his sabbatical, and summers of 1940, 1942, and 1944. I sketch Buchholz's life and outline his contributions to the morphology and taxonomy of conifers as a prelude to discussing his 1936 work on the vegetative morphology, reproductive morphology, and embryology of *Sequoiadendron giganteum* and *Sequoia sempervirens*. Description of Buchholz's technique for morphological collections should provide valuable information about his itineraries and his herbarium collections of *S. giganteum* in 1936. Finally, I briefly discuss Buchholz's activities in California in the 1940s involving *Pinus* and *Podocarpus*.

#### METHODS

*Nomenclature.*—Taxa in the California flora follow *The Jepson manual*, 2nd ed. (Baldwin et al. 2012). Cultivated conifer taxa alien to California follow *A handbook of the world's conifers* (Farjon 2010).

*Mapping aids.*—These included: (1–2) the Internet-based Google Earth (2012: version 6.1.0.5001) and United States Geological Survey Geographic Names Information System (GNIS) (2012), (3) atlases for California (see Schmid and Schmid 2012), and (4) national-park maps (print and downloadable PDF versions) of the National Park Service (2012).

*Archives.*—On 21 Dec 2011 I examined correspondence in the Alice Eastwood Papers, Special Collections, California Academy of Sciences Library, San Francisco (2012). This archive has six letters that Buchholz wrote to Alice Eastwood: 25 Jul 1933, 10 Jan 1936, 6, 16 Jun 1941, and 7, 27 Oct 1944. The University of Illinois Archives (2012) supplied copies of 50 letters of Buchholz correspondence: 10 letters from 1936, 4 from 1937, 29 from 1938 to 1944, and 7 from 1948 to 1950, including only one Buchholz-Eastwood letter (27 Oct 1944), which is duplicated in the Alice Eastwood Papers. I have not seen any letters of Eastwood responding to Buchholz. Other archives were also accessed via the Internet.

*Herbarium-specimen databases.*—These included Conifers of the world (2012) and Consortium of California Herbaria [CCH] (2012). Other databases were also accessed via the Internet.

*Buchholz and Gray's publications on conifers.*—I have a nearly complete set of reprints, some 57 titles total [see Jones and Tippo (1952), Dilcher (1973), Stafleu and Mennega (1995)]: 48 by Buchholz, including 8 works coauthored with his M.A. student, Netta Elizabeth Gray (1913–1970), plus 9 titles soloed by Gray. Moreover, I obtained PDFs of available publications to allow systematic searching of relevant dates and text strings.

*Abbreviations of herbaria* (fide Index Herbariorum 2012).—A, Arnold Arboretum, Harvard University; CAS, California Academy of Sciences; CI, Carnegie Institute, Stanford; DS, Dudley Herbarium, Stanford University (on permanent loan to CAS); ILL, University of Illinois; JEPS, Jepson Herbarium, University of California, Berkeley; MO, Missouri Botanical Garden; NY, New York Botanical Garden; UC, University of California, Berkeley.

#### DISCUSSION

##### (1) *Buchholz's Life and His Work on the Morphology and Taxonomy of Conifers*

Buchholz was born on 14 Jul 1888 in Polk Co., Nebraska, and died on 1 Jul 1951 in Urbana, Illinois. He married Olive Peterson on 15 Aug 1912. They had three daughters: Miriam, Christine, and Ruth. Miriam (21 Jun 1913–5 Mar 1970) painted the portrait of Buchholz in Fig. 1. Olive Buchholz was killed on 23 Apr 1951 in an auto-train accident. After a brief illness Buchholz died on 1 Jul 1951, just shy of his 63<sup>rd</sup> birthday.

Buchholz was a product of the famous labs of John Merle Coulter (1851–1928) and Charles Joseph Chamberlain (1863–1943) at the University of Chicago. Morphological research of these labs focused on the embryology of angiosperms and especially gymnosperms; Buchholz's doctoral research (Ph.D. 1917) on pine embryology was done under Chamberlain's direction. Buchholz held professorships in botany at the Universities of Arkansas (1919–1926), Texas (1926–1929), and Illinois (1929–1951).

Buchholz's research centered on the angiosperm *Datura* L., especially its genetics, and on the gymnosperms, particularly their embryology *sensu lato*. Buchholz's mentor for the research on *Datura* was Albert Francis Blakeslee (1874–1954) of the Carnegie Institution's Cold Spring Harbor Laboratory, New York (1915–1941); they coauthored 17 papers (1922–1937; see Jones and Tippo 1952). "During summers, 1921 to 1941" [except 1940—see Part 6b], Buchholz was visiting investigator in Carnegie's Department of Genetics (Jones and Tippo 1952: 182). Buchholz confided to Blakeslee minute details of his *Sequoia-Sequoiadendron* work, as revealed in four long letters dated 26 Sep 1936 to 27 Jan 1940 and held by the University of Illinois Archives (2012).

Buchholz's publications on gymnosperms (1918–1951) fall into three phases: (1) work through 1936 on mostly Pinaceae, (2) work from 1937 through 1940 on mostly Cupressaceae (i.e., traditional Taxodiaceae), especially *Sequoia* and *Sequoiadendron* (Buchholz 1937, 1938, 1939a,b,c; Buchholz and Kaesler 1940; Fig. 1, 2), and (3) work after 1940 on Podocarpaceae and Pinaceae *redux*. [For biographies and bibliographies see Jones and Tippo (1952), Dilcher (1973), Stafleu and Mennega (1995), and Department of Plant Biology, University of Illinois (2012).]

Buchholz published three early papers on *Podocarpus*, two on its embryology (Buchholz 1936, 1941a), and one on its horticulture in California (Buchholz 1941b). The embryological work involved non-California material. Buchholz (1941a: 1–2) remarked: “While I have observed many species of the Podocarpaceae on estates and in parks and public gardens in California [in 1936 and 1940], very few of the species grown in this country, aside from *P. macrophyllus* [(Thunb.) Sweet], were found to produce seeds. Some in California produce pollen cones and ovules, but unfortunately many of the plantings of rare species are so scattered as isolated specimens that the dioecious species lack the facilities for pollination.”

On 13 May 1942 Buchholz wrote F. E. Butters, University of Minnesota, Minneapolis, requested leaf and ovule-seed material of *Podocarpus*, and explained: “I have a graduate student at work on the anatomy of leaves in Podocarpaceae, especially *Podocarpus*. This work gives promise of resulting in a key to the leaves on the basis of internal leaf anatomy. It may be possible, eventually I hope, to make it unnecessary to have the reproductive structures at hand in making a reliable diagnosis, and you may be aware of this difficulty when we are concerned with dioecious species that are collected so frequently in the sterile condition, and often from isolated cultivated specimens.”

The student was Mrs. Netta Elizabeth Gray (1913–1970), M.A. 1941, University of Illinois (no Ph.D.), who taught at Emory University, Atlanta, and, from 1953 to 1970, at Agnes Scott College, Decatur, Georgia (Dilcher 1973). Until his death in July 1951 Buchholz worked closely with Gray on the systematics and leaf anatomy of *Podocarpus* l'Hér. ex Pers. They published a series of 13 papers (1948–1962), the last seven by Gray solo (Buchholz and Gray 1948a,b; Gray and Buchholz 1948; Buchholz and Gray 1948c; Gray and Buchholz 1951a,b; Gray 1953a,b, 1955, 1956, 1958, 1960, 1962a). Seven works (Buchholz 1936, 1941a,b, 1948; Buchholz and Gray 1957; Gray 1962b, 1969) supplement the 13-part series on *Podocarpus*. Some of these papers cite Buchholz's collections of various species of *Podocarpus* cultivated in California (see Part 6d).

Buchholz and his wife spent his sabbatical leave for the academic year of 1947–1948 on the small Pacific island of New Caledonia, a French Overseas Territory since 1946, and “the most diverse and remarkable conifer centre of all, ... an area the size of Wales,” with 4 conifer families with 43 species, all endemic, and 14 genera, 3 of which are both monotypic and endemic (Farjon 2010, p. 13 for the quote; see also Farjon and Page 1999, Jaffré et al. 2010, and Schmid 2010). *Podocarpus* s.l. is well represented on New Caledonia. The Buchholzes collected extensively on the island and discovered nine new species of gymnosperms that he named, including three of *Podocarpus* s.l. (Buchholz 1949), and six new species of angiosperms that others named, including the euphorb *Baloghia buchholzii* Guillaumin (Jones and Tippe 1952) (see also Part 8).

In 1950 Buchholz attended the meetings of the International Botanical Congress, Stockholm. On 31 May 1950 he wrote to E. J. Salisbury, director of Kew: “My wife and I are sailing from New York on June 7 for Le Havre, France. We expect to visit the Paris Museum for ten days or more, then to visit London. I hope to make use of your collections at Kew during the period before the International Botanical Congress in

Stockholm [12–20 Jul 1950], if not it will be after the Congress, prior to our return to USA on August 11.”

Although Buchholz and his 1939c paper are familiar because of the nomenclatural transfer of *Sequoia gigantea* to *Sequoiadendron giganteum*, it is worth stressing that his 1938 and 1939a papers contributed significant information to our knowledge of the vegetative morphology and anatomy as well as the reproductive morphology and embryology of *Sequoiadendron*. Buchholz's two-part 1938 paper is especially worth reading for its morphological insights; regrettably, this paper is often *not* cited (e.g., Weatherspoon 1990; Willard 1995; Lanner 1999; Schellevis and Schouten 1999; Eckenwalder 2009; Farjon 2010), although its novel findings are discussed. Three examples from Buchholz (1938) will suffice:

- (1) It is well known that young trees of *Sequoiadendron* have a perfect conical shape (e.g., Weatherspoon 1990; Willard 1995; Lanner 1999; Schellevis and Schouten 1999; Eckenwalder 2009; Farjon 2010; Schmid and Schmid 2012: Fig. 3, 4) for 75 to 100 years, or until crowding, whereas mature trees have dense, irregular crowns. As Buchholz (1938: 296) explained: “The leader and its side branches in a young [*Sequoiadendron*] give the tree a graceful conical form, while the old trees, which have long ago attained their height, have lost the central leader and have irregular tops. Young trees, therefore, appear to have a different growth form and do not resemble the parent patriarchs of the forest which have stood for more than a thousand years. However, in both, the form of branching at the stem tip is monopodial.” [This corresponds to Massart's model of shoot architecture (Hallé and Oldeman 1975).]
- (2) Female cones may remain attached to branches for many years (in some cases more than 20), still retain many seeds (e.g., a 19-year-old cone had 137 seeds), are green and apparently photosynthetic, and may become heavily lichen encrusted.
- (3) The age of female cones “may be determined by several methods, including the [annual] growth rings found in the [stalks] of the cones themselves” (Buchholz 1938: 305).

(2) *Buchholz's Morphological Collections of Cones of Sequoiadendron giganteum*

Buchholz (1939a: 93) wrote: “During the spring and summer of 1936 the writer went to California for the purpose of making a study of the Sequoias.” Buchholz was based at the Carnegie Institution affiliated with Stanford University. “In connection with my *Sequoia* [sensu lato] investigations I wish to acknowledge the courtesies of the United States Forest Service, the Carnegie Institution of Washington, Stanford University, and the University of California” (Buchholz 1939b: 248). Buchholz had strong ties to the Carnegie Institution, because of his work at its Cold Spring Harbor Laboratory with Blakeslee on *Datura* (see Part 1).

Buchholz (1939a: 93) discussed the “difficulties encountered” in collecting reproductive material of *Sequoiadendron* for developmental studies. The sheer size of native trees is a major obstacle. Moreover, “ovules and seeds of the cones that

may occasionally be found” on young cultivated trees are “usually abortive.”

The following paragraphs quote extensively from Buchholz’s April 1938 and February 1939a papers on *Sequoiadendron giganteum*:

The only practical plan worked out at that time which would not entail expensive equipment was to use the occasional [seed] cones produced on the small second-growth trees. Trees less than 75 years old are abundant in Whitaker Forest [Fig. 2], a preserve [officially a “research station”—Center for Forestry (2012)], owned by the University of California near Redwood Canyon. They are also abundant in the cut-over region near General Grant National Park (Buchholz 1939a: 93). [See Part 4b for specifics on these localities.] [As a sidenote, fide A. Farjon (pers. comm., 5 Aug 2011, “probably the largest such area of young trees is the Converse Basin in Sequoia National Forest, traversed on the trail to the Boole Tree. Thousands of spires of young trees there!”]

During late June and early July while the new cones are still only partially grown, they may be recognized with field glasses by their smaller size and lighter color. It was found (Buchholz [1938]) that while only one tree in several hundred in this second-growth stand [Whitaker Forest] may bear one or two cones (always near its top), they may be marked and mapped for collections during the summer when the cones are in the desired stage. About eight such trees were found, and the cones collected from them furnished me with the material for a study of the embryogeny (Buchholz 1939a: 93). [This explains the array of specific dates noted below.]

Buchholz (1938: 297) also indicated “occasional” seed-cone production, but on p. 302 stated: “Seed cones are very rare and difficult to find on young trees.” However, if “only one tree in several hundred ... may bear one or two cones,” the expression “very rare” would be more accurate than “occasional,” using Schmid’s (1982) percentage criteria for descriptors.

The stage of fertilization was not included. The cone collected nearest that date [“the second week in August”—see below] happened to be a teratologically misshapen specimen containing very few normal ovules. Some of the other collections were spaced a little too far apart in time, but the cones obtained were excellent and yielded an abundance of embryological material in their respective stages both before and *after* [emphasis added] fertilization (Buchholz 1939a: 93).

In his earlier paper Buchholz (1938) had explained:

A severe storm following the formation of a burden of snow and ice in the region of General Grant Park brought down many large branches of the big trees. Though this happened in March 1936, these branches were preserved in the snow at the base of the trees and could still be obtained fresh and green as the snow disappeared in April. On these branches the very small seed and pollen cones (which had formed during the previous season) could be collected for study. Also, there were many mature seed cones from previous years from which the history of their development could be determined [i.e., Buchholz 1938: Part II]. Each annual section of shoots in the vegetative branching system could be identified, so that dates for the years of their growth, going back six or eight years, could be determined. Successive shoot-growths for the years 1932–1935 are included in Fig. 2 [in Buchholz 1938]. It was largely the cone-bearing tips of branches from the old trees in General Grant Park that contributed the material of the twigs and leaders for this investigation (Buchholz 1938: 296).

Pollination [by wind] occurs in the latter half of April or early in May. There may possibly be differences in the time of pollination in different seasons; the only observation made by the writer was for 1936 in the region of General Grant Park. Late in June the female cones have enlarged very little, but by the middle of July they are nearly half grown and appear to be full grown by the end of the first week in August. During their period of rapid enlargement, the cones remain succulent, but during August, after they have become full grown, they rapidly become woody (Buchholz 1938: 303).

Fertilization takes place during the second week in August (1936), and the embryos of one or two cells are found developing on the ends of very long suspensor cells during September and well into October (Buchholz 1938: 303).

Specific dates for developmental stages appear in the text and figure captions of Buchholz’s 1939a paper: 14, 17, 26 Jul, 18 Aug, 8 Sep, 5, 11, 15 Oct 1936. The 22 Nov 1934 date refers to a softened ovule dissected from an herbarium specimen at UC (*Frost s.n.*).

Information in Buchholz’s archived correspondence allows amplification of some of his published statements:

[On 26 Sep 1936 Buchholz lamented to A. F. Blakeslee] Last April I worked out the history of the cone of *Sequoia gigantea*. The cones are evergreen and persist for many years after the seeds are mature. The cones may usually be dated accurately so that one may identify the year of their pollination by the growth rings in the peduncle of the cone, also by the position on the twigs, and by the growth rings in the stem to which the cone is attached. I’m sure this fact is entirely new [for details see the end of Part I], and it is a very interesting feature, but I wonder whether it would be considered worthy of a paper before the N. A. S. [National Academy of Sciences]. Of course, I can give the approximate calendar of events in their life history, even if I fail to get the balance of the material which was to be collected after I left California, but feel handicapped if I should fail to get the collections which were to be made.

[Writing again to Blakeslee on 16 Oct 1936 Buchholz rejoiced] For the N.A.S. program at Chicago I am considering the subject of cone production in the big tree, under which title I can present all for which there will be time. I’ve finally received my sequoia [*Sequoiadendron*] collection [from Whitaker Forest—see Part 4b] and the only gap which may remain now in my series is between 12 August and 6 September, a set of collections which can be made in some other summer if they are necessary. I would need a closer series of collections if I wished to observe fertilization.

Buchholz (1937) is the abstract of the paper presented on Tuesday, 17 Nov 1936 at the Chicago meeting held on 16 to 18 Nov 1936. Buchholz corrected his reprints to read: “Fertilization takes place during the second [“last” crossed out] week in August.”

Finally, on 19 Apr 1938 R. B. Thomson, University of Toronto, after seeing Buchholz’s 1938 paper on *Sequoiadendron* published on 13 Apr requested “some young cones left over” in order to study development of the cone scale. Buchholz obliged on 23 Apr 1938, commenting: “I am sending you several of the cones ... in the stage shown in Figure 2 of my recent paper [Buchholz 1938]. ... I fear that they may be more advanced in stage than what you wish. ... If one were to obtain [cones] during their [cone-scale] development it would be necessary to have the samples from the tips of the branches of the Big Trees during July and August in a year in which

these cones happened to be forming. They do not form every year, and unless a storm occurs or a fallen tree happens to be available, there seems to be little hope of reaching them by ordinary means.”

(3) *Buchholz's Morphological Collections of Cones of Sequoia sempervirens, with Embryological Comparisons to Sequoiadendron giganteum*

In 1936 Buchholz (1939b: 248) also collected embryological stages of *Sequoia sempervirens*. These came from a 12-meter-tall cultivated tree on the grounds of Stanford University and from native trees in “Palo Colorado Canyon [via Palo Colorado Canyon Rd., 24 km] south of Carmel ... in the cooler fog belt.” Presumably, Buchholz and Kaeiser (1940: 282) used collections from 1936 for their statistical study published in May–June 1940: “One cone of *Sequoia sempervirens* obtained from cultivation in the Santa Clara Valley [now known as “Silicon Valley” (Hart 1987)] yielded a total of 16 embryos, all with 2 cotyledons. This particular yield is much above that obtained from any other locality.”

The following dates for developmental stages appear in the figure captions of Buchholz’s 1939b paper on *Sequoia sempervirens*: 20, 24, 26–29 May, 1, 7, 8, 11, 18, 20 Jun 1936 (“June 1, 1938” on p. 252 undoubtedly should be “June 1, 1936”). Contrast this with a similar sequence noted in Part 2 for Buchholz’s 1939a paper on *Sequoiadendron giganteum*: 14, 17, 26 Jul, 18 Aug, 8 Sep, 5, 11, 15 Oct 1936.

There is no overlap between the previous two ranges of dates! This is to be expected because these taxa are temporally separated for the vital life-history events of pollination and fertilization, namely:

in *Sequoia* pollination in January to February, fertilization in May,  
in *Sequoiadendron* pollination in April to May, fertilization in August.

Writing to Blakeslee on 19 Jan 1937, Buchholz proclaimed: “Right now I’m working very hard on the morphology of the redwood, *Sequoia sempervirens*. ... [four sentences deleted] I am beginning to find all states of the embryos, both early stages visible only in paraffin sections and the late stages which I removed by dissection *last summer* [emphasis added]. My story of the big tree will not be as complete, because there I believe I missed fertilization and the earliest stages of the embryo, but now that I know when to look for these stages I’ll surely get them the next time I go after material, and I may be able to have some collected and sent to me next summer by persons living out there [by Whitaker Forest].” On 12 Jun 1937 Buchholz wrote to Charles Crose in Badger by Whitaker Forest requesting more cones of *Sequoiadendron* from “trees that [Buchholz] had marked last summer.”

The incompleteness of his embryological series for *Sequoiadendron* bedeviled Buchholz. He frequently lamented that he “may have to return to California some time for a few weeks collection in August for a closer series of stages” (19 Oct 1936 letter to E. Fritz, Berkeley). In fact, as late as 1940 Buchholz was still considering obtaining additional embryological material of the species, as evidenced by his 27 Jan 1940 letter to Blakeslee quoted in Part 6b.

(4) *Buchholz's 1936 Collection Dates and Sites in California*

(a) *1936 collection dates in California.*—Buchholz’s letter of 10 Jan 1936 to Alice Eastwood quoted in the Introduction clearly indicates his intention to be in California “in about two months.” This would presumably be around mid-March and is consistent with Buchholz’s published statement (1939a: 93) that “during the spring and summer of 1936” he was in California; vernal equinox was Friday, 20 Mar 1936.

[By sheer happenstance I found that Buchholz was in the Mexican state of Nuevo León on 23 Feb 1936, when he collected three species of angiosperms from near Monterrey (University of Arizona Herbarium 2012). I do not know why Buchholz was in northeastern Mexico, but this apparently was before his lengthy visit to California.]

A synthesis of information from Buchholz’s papers (1938, 1939a,b,c) discussed in Parts 2 and 3 reveals that his visit to California in “spring and summer of 1936” (Buchholz 1939a: 93) consisted of at least five components for collecting research material:

- (1) in late March and most of April at his base at the Carnegie Institution, Stanford;
- (2) in the Sierra in late April and early May (specifically 28, 30 Apr, and 5 May—see Appendix) dealing with *Sequoiadendron*;
- (3) on the coast from at least 20 May through at least 20 June (the “20, 24, 26–29 May, 1, 7, 8, 11, 18, 20 Jun 1936” in Part 3) dealing with *Sequoia*;
- (4) back in the Sierra from “late June and early July” (Buchholz 1939a: 93) into early August (specifically 14, 17, 26 Jul, but *not* 18 Aug, 8 Sep, 5, 11, 15 Oct 1936—see Part 2 and below) dealing again with *Sequoiadendron*;
- (5) finally, in the first half of August at his base at the Carnegie Institution, prior to returning home.

By mid-September 1936 Buchholz had to be back at the University of Illinois for the start of the fall semester, which officially began on Friday, 18 September, for student registration and on Wednesday, 23 September, for the start of classes (IDEALS 2012).

Early in his California stay Buchholz visited various parks, nurseries, and estates for embryological material of cultivated conifer species. On 19 Oct 1936 Buchholz wrote the famed nurseryman, English-born Edward Owen Orpet (1863–1956), Santa Barbara, a follow-up letter about his findings: “When I visited your nursery last April inquiring about rare conifers in cultivation, you expressed the wish to be informed if I found anything especially interesting.” Buchholz (1941b) mentions his observations in 1936 of *Podocarpus gracilior* Pilg. cultivated in California.

While in the San Francisco Bay area Buchholz interacted with various botanists, including, undoubtedly, plant anatomist-morphologist Adriance S. Foster (1901–1973) at the University of California, Berkeley. Buchholz sought the assistance of forester and redwood expert Emanuel Fritz (1886–1988), also at Berkeley, but was unable to meet him. On 19 Oct 1936 Buchholz wrote Fritz: “I tried to call on you at one time while I was in Berkeley during the summer, but you happened to be away. ... My interest in the Sequoias goes beyond the embryological field.” Then Buchholz requested

bibliographic and ecological information for *Sequoia* and *Sequoiadendron* and photos of the latter.

Consultation of archived Buchholz correspondence explains the 18 Aug, 8 Sep, 5, 11, 15 Oct 1936 dates noted for *Sequoiadendron* in Parts 2 and 3. On 15 Sep 1936 Buchholz wrote to Charles Crose in Badger by Whitaker Forest inquiring if “the cones of *Sequoia* [*gigantea*] ... that you have collected since I left California and put into killing solutions, might be sent by express” or “Air Mail.” On 26 Sep 1936 Buchholz informed Blakeslee: “I left the details of collection in charge of a couple of men living out at Whitaker Forest, who were able to ship the material collected since I left them, *about 15 August* [emphasis added]. This material has not arrived [yet], and when depending upon others, one is never sure of obtaining it, even though the arrangements seemed practically perfect.” Despite the intricacy of obtaining a developmental series for embryology, Buchholz had no choice but to “farm out” the task.

To further summarize, Buchholz studied material of *Sequoiadendron* not only from “small second-growth trees” in Whitaker Forest (Buchholz 1939a: 93) and near “General Grant National Park” (an obsolete name—see Part 4b), but also from old-growth trees actually in the park (Buchholz 1938, 1939a,c).

(b) 1936 collection sites in California.—Whitaker Forest or Whitaker’s Forest, a research station of the College of Natural Resources, University of California, Berkeley (Center for Forestry 2012), is located northeast of the town of Badger in far northern Tulare Co. (Fig. 2). Whitaker Forest is in the northwestern part of Redwood Mountain Grove, Sequoia National Forest, adjacent to Kings Canyon National Park.

In contrast, “General Grant National Park” is located in extreme southeastern Fresno Co. just across the county boundary (Fig. 2), 6.2 km linear distance to the northwest (fide the United States Geological Survey 2012, Whitaker Forest 36.7027, -118.9323, 1646 el. versus General Grant Grove 36.7466, -118.9759, 1902 m el.). The General Grant Tree, the second most voluminous giant sequoia after the General Sherman Tree, was named in August 1867 in honor of Ulysses S. Grant (1822–1885), 18<sup>th</sup> president of the United States (1869–1877). General Grant National Park was established in 1890 and is now known as General Grant Grove (Fig. 2) following its incorporation into the isolated northern part of Kings Canyon National Park in 1940 (Hart 1987; Willard 1995, 2000; Gudde 1998; Flint 2002; Wikipedia 2012a). In turn, Kings Canyon National Park is north of and contiguous with Sequoia National Park, which was established in 1890 along with Yosemite National Park. [Giant Sequoia National Monument was established in 2000 and includes 38 of the 39 groves of *Sequoiadendron* located in the Sequoia National Forest (Wikipedia 2012a).]

In other words, before 1940, for instance, in 1936 when Buchholz visited California, *Sequoiadendron* could be observed in three National Parks—Yosemite, General Grant, and Sequoia—ranging from north to south, and all established in 1890. Yosemite National Park straddles Tuolumne, Mariposa, and Madera Cos. General Grant and Sequoia National Parks were/are, respectively, in Fresno and Tulare Cos. (Fig. 2).

Curiously, Buchholz’s papers (1938, 1939a,b,c) do not mention Sequoia and Yosemite National Parks. These papers

also do not mention Mariposa Grove in Yosemite National Park at its southern portal. However, on 3 Oct 1936 Buchholz wrote to W. R. Mattoon, USDA, Washington, D.C.: “During the past summer I spent much time in the Big Tree region of California, Sequoia Park and General Grant Park and Mariposa Grove in Yosemite.” A similar statement appears in Buchholz’s 27 Jan 1940 letter to Blakeslee quoted in Part 6b. Moreover, Buchholz (1940: 733) clearly stated that embryological material of *Torreya californica* Torrey was “obtained in 1936 from specimens ... from Yosemite National Park near [the] El Portal entrance.”

#### (5) Buchholz’s Herbarium Collections of *Sequoiadendron giganteum*

Buchholz (1939c: 536–537) stated that “the external taxonomic characters are fully exemplified by specimens [of *Sequoiadendron*] ... collected by the writer during April 1936, at General Grant National Park. These have been deposited in the Herbarium of the University of Illinois [ILL], also similar specimens at Stanford University [DS, on permanent loan to CAS], the University of California [UC], and elsewhere [A, MO, NY].”

An Appendix lists chronologically Buchholz’s herbarium collections of *Sequoiadendron giganteum*. Part 4b gives specifics on localities mentioned below.

The database of the Consortium of California Herbaria (CCH 2012) showed (3 May 2012) seven records for collections of *Sequoiadendron* that Buchholz made in California (Appendix, records 1–2, 4–8). David S. Seigler (pers. comm., 29 Apr 2011) informed me that ILL has some of these collections (Appendix, records 1, 8) as well as additional Buchholz or likely-Buchholz collections of *Sequoiadendron* (Appendix, records 3, 9–10).

Records 1–2 and 4–6 in the Appendix are all from the same area in Fresno Co.: near General Grant Tree, General Grant National Park (Fig. 2; since 1940 as General Grant Grove, Kings Canyon National Park); records 1–2, and 4 thus need their county assignments corrected to “Fresno Co.” Records 1–2 versus 4–6 are undoubtedly the same and involve two collection dates, respectively, 28 Apr and 5 May 1936.

Record 3 (ILL) is a significant addition to the list because it represents a “new” 1936 collection date and site, 30 Apr in Sequoia National Park in Tulare Co. Records 9 and 10 are possibly the same. In summary, records 1–6 and possibly 9–10 in the Appendix represent three collections (28, 30 Apr and 5 May) of *Sequoiadendron* that Buchholz had made in Fresno and Tulare Cos. in 1936.

Record 7, being a photograph, in a sense is a “pseudo-collection.” Record 8 will be discussed in Part 6b.

In conclusion, in 1936 Buchholz made all of his herbarium voucher collections of *Sequoiadendron* from mature trees in two national parks (Fig. 2):

- (1) from mature trees in General Grant National Park (since 1940 known as General Grant Grove in Kings Canyon National Park) in Fresno Co., as evidenced not only by statements in his papers (1938, 1939a,b,c) but also by information on labels on his herbarium vouchers (respectively, Part 2 versus this part, the Appendix, records 1–2, 4–6) and



- (2) from mature trees in Sequoia National Park in Tulare Co., as evidenced by information on labels on his herbarium vouchers (Appendix, record 3).

There is no evidence that Buchholz made vouchers of cultivated or young second-growth trees of *Sequoiadendron* in Whitaker Forest or elsewhere.

(6) *Buchholz in California After 1936*

(a) *Preamble.*—Buchholz visited California and *Sequoiadendron* in years other than 1936. Record 10 in the Appendix is of interest as a possible Buchholz collection made before 1936, perhaps in 1931. However, in the early 1930s Buchholz was heavily involved with his *Datura* research (see Part 1). Moreover, Buchholz's 1937 abstract is the first to cite California material.

Buchholz was in California in the summers of 1940, 1942, 1944, and 1948, but definitely not in 1941 (see below) and probably not in other years of the 1940s and 1950s. In fact, I found no evidence indicating Buchholz was in California in years other than 1936, 1940, 1942, 1944, and 1948.

(b) *1940.*—In a long letter written to Blakeslee on 27 Jan 1940, Buchholz stated:

I am glad that you are thinking about attending the Seattle meeting [106<sup>th</sup> meeting of AAAS, 17–22 June 1940, Seattle (AAAS 2012)]. Mrs. Buchholz and I hope that Mrs. Blakeslee will accompany you. We are expecting to drive out in the car in order to have transportation after we get out west. I will probably leave as early in June as it is possible to get away. I want to examine the Big Trees in Mariposa Grove, General Grant Park and Sequoia Park to see if cones are forming this year. If this is not a good cone year, I may change my plans somewhat for the rest of the summer. If I find that new cones are forming, I must mark some trees from which it is possible to collect them later and I intend to do all of this, if possible, before going to Seattle [for the meetings].

In view of the 20-year relationship between Buchholz and Blakeslee (see Part 1), one is surprised at the formality of Buchholz's letters: "My dear Dr. Blakeslee;" "Mrs. Blakeslee," and "Mrs. Buchholz." Apparently Buchholz wished to continue embryological work on *Sequoiadendron giganteum*, but if he did such work nothing appeared in print. On 2 Jul 1940 he collected *Sequoiadendron*, probably for the last time: record 8 in the Appendix. Buchholz made this collection in Crescent Meadow, Giant Forest, Sequoia National Park, Tulare Co. (Fig. 2) after his final paper on the sequoias had been published in May–June 1940 (Buchholz and Kaiser 1940). I have been unable to obtain other information about Buchholz's visit to California in 1940.

(c) *1941.*—In a one-page hand-written note sent to Alice Eastwood on 6 Jun 1941 Buchholz stated: "I'll not be out this summer but you may look for me next year." It is important to clarify, however, that Buchholz's California collections of *Podocarpus gracilior* dated January and February 1941 and cited by Gray (1953a: 73) were actually vouchers made in Illinois from material that he had received from collectors (J. J. Mulvihill, A. D. Robertson) in southern California (Buchholz 1941b).

(d) *1942.*—"For several months during the summers of 1942 and 1944" Buchholz was "a visiting investigator at the

Placerville Laboratory of the Institute of Forest Genetics" (Buchholz 1945: 135; Buchholz and Stiemert 1946: 27).

In 1942 Buchholz and Stiemert (1946: 28–29) studied the embryology, especially seed size, of *Pinus ponderosa* Lawson & C. Lawson [now as var. *pacifica* J.R. Haller & Vivrette]. "A large number of cones [was] harvested" from 15 trees "and measured during the early part of August 1942. ... The trees used were marked seed trees, most of them situated near the site of Sportsman's Hall, eleven miles [17.7 km] east of Placerville along US Highway 50 at an elevation of 3700 feet [1130 m]. The seeds from several other trees were included, one from the grounds of the Institute of Forest Genetics at an elevation of 2740 feet [835 m], also a few trees from another site 32 miles [51.5 km] east of Placerville at an elevation of 4100 feet [1250 m]. Some of these seed trees were so tall that cones could be reached only by climbing with rope." Buchholz (1946) made a detailed study of one of the trees for various parameters: seed size, cotyledon number, embryo and "endosperm" (i.e., female gametophyte) volume, and embryo growth rate. Specific dates mentioned by Buchholz (1946) and Buchholz and Stiemert (1946) combined are 11 Jul, 1, 2, 5, 8, 12–15 Aug 1942 (see also below for 29 Jun 1942).

In summer 1942 Buchholz also collected at least five species of *Podocarpus* cultivated in Golden Gate Park, San Francisco: *P. alpinus* R.Br. ex Hook.f., *P. andinus* Poepp. ex Endl., *P. gnidioides* Carrière, *P. salignus* D. Don, and *P. totara* G. Benn. ex D. Don (Buchholz and Gray 1948b: 66, 1948c: 144; Gray 1956: 165, 169, 170).

The CCH (2012) database lists an additional Buchholz collection, a real curiosity. On 29 Jun 1942 Buchholz collected (*Buchholz s.n.*, UC998824) *Aesculus californica* (Spach) Nutt. on the "hills near Placerville," El Dorado Co. (no elevation stated). I cannot even surmise why Buchholz made an herbarium collection of this widespread California endemic that he surely had encountered before. Incidentally, *Sequoiadendron* does not even occur in Eldorado Co. (Weatherspoon 1990; Willard 1995, 2000; Lanner 1999; Flint 2002; CCH 2012; Wikipedia 2012b). Conceivably Buchholz could have visited the nearby sequoias in Placer County Grove to the north or in North and South Calaveras Groves to the south.

(e) *1944.*—Buchholz would return to Placerville in 1944. Buchholz (1945) reports on his 1944 work there, whereas Buchholz (1946) and Buchholz and Stiemert (1946) report on his 1942 research at Placerville; Mary Stiemert did measurements from Urbana. In 1944 Buchholz's graduate student accompanied him to California: "Mr. F. H. Wang ... served as [my] assistant during the summer of 1944" (Buchholz 1945: 136).

On 10 Jun 1944 Buchholz wrote to Léon Croizat, then at the Arnold Arboretum, Harvard University: "For the present I'm laying aside my study on the seed cone etc. of conifers for other activities. I assure you that I appreciate your notes and comments. Of course I'm concerned chiefly with the history of gymnospermy as it actually applies to Gymnosperms, but should know more than this and did not realize that naked ovules and seeds were discussed at such length in relation to so many of our Angiosperms. [new paragraph:] In a week or so I expect to go to California where I have some research going on sterility in Pines when cross-pollinated, work which will keep me occupied until August."

In 1944 Buchholz (1945) studied the embryology of hybrid vigor in *Pinus*. He used the artificial hybrid *P. contorta* Loudon subsp. *murrayana* (Grev. & Balf.) Critchf. (♀) × *P. banksiana* Lamb. (♂); Buchholz's nomenclature is "*P. Murryana* [Balf.] × *P. Banksiana*" (p. 136). Buchholz also studied the wind-pollinated parents of the hybrid, the paternal parent "growing in the Eddy Arboretum at Placerville [at an] elevation of 2,740 feet [835 m]" (p. 139), the maternal parent "growing on the west slope of the Sierras [sic] near Strawberry, along highway 50 at 5,700 feet [1737 m] elevation" (p. 140). Specific dates mentioned by Buchholz (1945) are 10, 12 Jul, 8, 15, 22, 25 Aug 1944. Staff at the Institute of Forest Genetics, not Buchholz, repeated the cross pollination "in the spring of 1943 so that a series of cones bearing the F<sub>1</sub> embryos during their development could be made available for [Buchholz's] study during July and August 1944" (p. 136). Incidentally, "the cones of 1942 were much better than in the year 1944, when many of them were heavily infested with seed chalcids" (Buchholz and Stiemert 1946: 29).

On 7 Oct 1944 Buchholz reported to Alice Eastwood: "I spent several hours at Golden Gate Park this summer in company with a colleague and a graduate student [F. H. Wang]. We meant to call at the herbarium, but spent so much time with Mr. Eric Walther [1892–1969, first director of Strybing Arboretum (1940–1957), now called San Francisco Botanical Garden] in the Park that there was no time left before closing time of the Museum [to see Eastwood]. [new paragraph:] I spent the summer at Placerville at the Institute of Forest Genetics, and had a very good summer in my research on sterility in the cross-pollination between species of pines. Had there been no [wartime] transportation difficulties, I'm sure I would have spent several days at Golden Gate Park."

(f) 1947 and 1948.—Buchholz and his wife spent his sabbatical leave for 1947 and 1948 in New Caledonia (see Parts 1 and 8). Los Angeles was (and still is) the usual point in the United States to embark for and return from New Caledonia. Another visit to California would be feasible for Buchholz before or after New Caledonia. Buchholz's letter of 17 Sep 1948 to L. G. M. Baas, Buitenzorg, Java, confirms the latter option: "Professor W. W. Went of [the] California Institute of Technology at Pasadena gave me your name and address. ... While in his office a few months ago, I saw a copy of [a Javanese publication]. ... For the past thirty years I have been working on the embryology of conifers. I spent the past year in New Caledonia collecting embryological material as well as making taxonomic collections of the conifers on that island. ... In New Caledonia I found it possible to collect conifers only in mountain stations since none of the native species, aside from *Araucaria Cookii* [R.Br. = *A. columnaris* (J.R.Forst.) Hook.] have been cultivated."

Buchholz's 1948 paper on "Generic and subgeneric distribution of the Coniferales" was part of a symposium on "Evolution and classification of gymnosperms" held in Chicago on 30 Dec 1947. Buchholz, of course, was in New Caledonia on this date; a proxy might have presented the symposium paper.

I have no other information about Buchholz visiting California in 1948 or possibly in 1947.

### (7) Summary Discussion

Before his involvement with Netta Gray monographing *Podocarpus* (Part 1), Buchholz was primarily a morphologist rather than a taxonomist. In Buchholz's time, and even nowadays, the usual practice in morphological, developmental, and embryological investigations of live material was *not* to make voucher herbarium collections of the material studied, especially if the project lacked taxonomic relevance. Comparative anatomists, of course, were usually more mindful of the importance of herbarium vouchers, and, indeed, herbarium material might comprise the bulk of a comparative anatomical study.

One thus must distinguish between Buchholz's (1) abundant collections made for morphological study and his (2) limited collections made for herbarium vouchers. For example, by 1940 Buchholz had "seeds of more than 100 species of conifers" worldwide (Butts and Buchholz 1940: 58).

Buchholz spent appreciable time in California: spring and summer of 1936 while on sabbatical, and summers of 1940, 1942, and 1944. He thus had ample opportunity to make collections not only of native species of conifers growing in the wild or under cultivation but also of alien species of conifers cultivated in the amenable coastal climate of California. Buchholz could readily collect reproductive stages from cultivated conifer "species ... encountered in [his] visits to many parks and estates in California" in 1936 (13 Oct 1936 letter to T. R. Bard, Santa Barbara).

In 1936 Buchholz made morphological collections of *Sequoiadendron giganteum* (Part 2) and *Sequoia sempervirens* (Part 3). While in California in 1936 he also collected embryological stages from the following species: *Abies bracteata* (D. Don) Poit. [as *A. venusta* (Dougl.) K. Koch] and *Picea smithiana* (Wall.) Boiss. from cultivated trees at Stanford University (Buchholz 1942: 156, 159); *A. pinsapo* Boiss. from cultivated trees on two estates in the San Francisco Bay Area (Buchholz 1942: 162); *Torreya californica* from cultivated trees at Golden Gate Park, San Francisco, as well as "later stages" from native trees at "Yosemite National Park near [the] El Portal entrance" (Buchholz 1940: 733). Buchholz (1942: 159) usually shunned native trees as "too inaccessible and too far removed from a laboratory. Those [cultivated] on the grounds of Stanford University could be studied within an hour after collection. Their advantages were the early fertilization and the fact that the schedule of development fitted more conveniently into a research program which included other conifers."

The archived Buchholz correspondence contains this little gem about the closed-cone pine *Pinus attenuata* Lemmon. On 19 Oct 1936 Buchholz wrote O. E. Orpet, Santa Barbara, that he had "collected [this species] in its native region in the mountains east of Point Sur during the summer while I stayed at Carmel." On 29 Mar 1937 Buchholz wrote to E. I. Kotok, USDA Forest-Service station, Berkeley: "My series on the knob cone pine may be supplemented if this is desirable, by additional samples. I have many sections of the trunk of the tree which was cut down bearing the unopened cones as far back as about 1908 [fide the countable growth rings enveloping the pairs or whorls of cones buried in the tree trunk]. The seeds I am sending were from cones pulled off either above or below the sections that were sawed out and I have felt that these samples are probably large enough, in view of the fact that the

oldest seeds, those of 1895 and 1898, only contained small numbers of good seeds from the few cones that were obtainable." Earlier in the letter to Kotok, Buchholz had remarked about his study of seed viability of *P. attenuata* and *Sequoiadendron giganteum*: "From my studies of conifer embryology it is obvious that many of the seeds of conifers become imperfect ["aborted, infected with insects, or otherwise imperfect and not viable"] during the maturity of the seed crop. In such cases the seed coats may be full sized but empty."

In addition, while in California in 1942 and 1944 Buchholz collected morphological material of several species and hybrids of *Pinus* (Parts 6d–e).

Buchholz made herbarium vouchers only for *Sequoiadendron giganteum* that he collected in 1936 and 1940 from mature trees in two national parks (Fig. 2; Part 5, Appendix). He apparently did not make voucher collections for any of the other conifer species mentioned in the previous three paragraphs, including, surprisingly, *Sequoia sempervirens*. There are no records of Buchholz collections of these taxa in various herbarium-specimen databases consulted, including Conifers of the world (2012) and the Consortium of California Herbaria (CCH 2012). However, in the summers of 1941 and 1942 Buchholz did make voucher collections of species of *Podocarpus* cultivated in California (Parts 6c–d) in connection with his and Gray's 13-part monograph of the genus (see Part 1).

In conclusion, Buchholz's last known sojourn to the big trees was on 2 Jul 1940, the date of his last herbarium collection of *Sequoiadendron giganteum* in Crescent Meadow, Giant Forest, Tulare Co. (Fig. 2). Possibly he visited them in summer 1942 or summer 1944 when he was in Placerville doing research on *Pinus*. Whatever the date of Buchholz's last visit to the sequoias, I hypothesize that at that time he must have stood in awe of these majestic trees, proud of his research achievements on them, but also a tad rueful that they had ended.

#### (8) Coda: The Value of Internet Resources for Biography

This paper is basic literature review. However, it is worth noting that modern technology allows great accuracy in establishing chronologies and itineraries. Thus one could download PDFs of Buchholz's papers (1937, 1938, 1939a,b,c) on *Sequoiadendron* and *Sequoia* and systematically search the PDFs for dates and text strings to show when and where he was in California. Obviously nowadays one can also use various search engines to probe for information on the Internet.

According to D. S. Seigler (pers. comm., 28 Jul 2011), the University of Illinois Archives (2012) "do not seem to have any Buchholz field notes or notebooks." Internet resources are particularly useful in such cases. An excellent starting point for Buchholz would be Aljos Farjon's Brahm's database, Conifers of the world (2012). On 3 May 2012 the database had 150 records for 88 collections that Buchholz made in New Caledonia in 1947 and 1948 during his sabbatical from the University of Illinois (see also Part 1). These collections span 27 Sep to 28 Dec 1947 (*Buchholz 1082 to 1575*, 57 collections, 90 records) and 6 Jan to 5 Apr 1948 (*Buchholz 1584 to 1786*, 31 collections, 60 records) and involve 12 genera and 28 species (sensu Farjon 2010), including 8 types. In addition, Buchholz

made one collection in Australia: *Buchholz 1599*, on 16 Jan 1948, of *Araucaria heterophylla* (Salisb.) Franco on Norfolk Island, where it is endemic.

A list of these collections (and their label information) extracted not only from Farjon's database (Conifers of the world 2012) but also from Buchholz and Gray's publications on New Caledonian taxa (Buchholz 1949; Gray and Buchholz 1951a; Gray 1955, 1956, 1960, 1962a) would thus be especially valuable in reconstructing fragments of Buchholz's collection notebook(s). In the summer of 1950 Buchholz was in Europe visiting herbaria in Paris and England (see Part 1). "As it was mainly in New Caledonia that Buchholz collected, could it be that [his field notebook] was left in Paris" (A. Farjon, pers. comm., 6 Sep 2011)?

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Cold Spring Harbor, NY, 26 Sep, 16 Oct 1936, 19 Jan 1937, 27 Jan 1940; F. E. Butters, Minneapolis, 13 May 1942; L. Croizat, Jamaica Plain, MA, 10 Jun 1944; C. Crose, Badger, CA, 15 Sep 1936, 12 Jun 1937; E. Fritz, Berkeley, 19 Oct 1936; E. I. Kotok, Berkeley, 29 Mar 1937; W. R. Mattoon, Washington, D.C., 3 Oct 1936; O. E. Orpet, Santa Barbara, 19 Oct 1936; E. J. Salisbury, Kew, 31 May 1950; R. B. Thomson, Toronto, 23 Apr 1938; also: R. B. Thomson to J. T. Buchholz, 19 Apr 1938.

## APPENDIX

Buchholz's herbarium collections of *Sequoiadendron giganteum* arranged chronologically<sup>a,b</sup>.

Record	Buchholz collection
(1) <i>Buchholz s.n.</i> (28 Apr 1936) (NY64527; also at ILL, <sup>c</sup> MO <sup>d</sup> ): County unknown: National Park (corrected at right in summary 1). Notes/comments: From branches buried in snow, broken off by ice and storm in March (?) 1936, from trees near General Grant tree in National Park (California tree, Lafayette tree or one nearby). Tips of branches show female cones before pollination, male cones and seed cones of years prior to 1935.	Summary 1: Records 1 and 2 = Buchholz collection 1: 28 Apr 1936, Fresno Co.: near General Grant Tree (Fig. 2), General Grant National Park (an obsolete name—see Part 4b; since 1940 known as General Grant Grove or Grant Grove, Kings Canyon National Park) (see text, Part 5).
(2) <i>Buchholz s.n.</i> (28 Apr 1936) (A357787 <sup>e</sup> ): Tulare Co.: Sequoia National Park (corrected at right in summary 1). Notes/comments: From branches buried (“burned”) in snow, broken off by ice and storm in Mar.(?) 1936, from trees near Gen'l Grant tree in Nat'l Park (Calif. tree, Lafayette tree or one near by).	
(3) <i>Buchholz s.n.</i> (30 Apr 1936) (ILL): Tulare Co. (unspecified, but inferred from location): “Sequoia National Park.” Notes/comments: none. Fide D. S. Seigler, <sup>f</sup> “with male cones.”	Summary 2: Record 3 = Buchholz collection 2: 30 Apr 1936, Tulare Co.: specific area not noted, Sequoia National Park.
(4) <i>Buchholz s.n.</i> (5 May 1936) (UC552372 <sup>g</sup> ): Tulare Co.: near General Grant Tree—General Grant National Park (corrected at right in summary 3). Notes/comments: Specimen from branch of giant tree broken off by snow, ice, and wind.	Summary 3: Records 4 to 6 = Buchholz collection 3: 5 May 1936, Fresno Co.: as for summary 1, collection 1 (see text, Part 5).
(5) <i>Buchholz s.n.</i> (5 May 1936) (DS679689 <sup>g</sup> ): Fresno Co.: General Grant National Park (elaborated at right in summary 3). Notes/comments: Male cones and female flower cones from tip of branch blown down by weight of ice and snow. From one of the giant trees.	
(6) <i>Buchholz s.n.</i> (5 May 1936) (DS245138 <sup>g</sup> ): Fresno Co.: General Grant National Park (elaborated at right in summary 3). Notes/comments: none.	
(7) <i>Buchholz s.n.</i> (1939) (DS558353 <sup>g</sup> ): Calaveras Co.: Calaveras Grove. Notes/comments: Photograph of type.	Summary 4: Record 7 not an herbarium collection: 1939 photograph, Calaveras Co.
(8) <i>Buchholz s.n.</i> (2 Jul 1940) (A357784; also 4 sheets, ILL—see below): Tulare Co.: Crescent Meadow, Sequoia National Park. Notes/comments: none. Supplementary information from sheets at ILL <sup>f</sup> : Tulare Co. (unspecified, but inferred from location): “Crescent Meadows, Sequoia National Park” (Fig. 2). Buchholz's annotation: “Immature cones from a tree at Crescent Meadows.” [Note: Fide the United States Geological Survey (2012), it is properly “Crescent Meadow,” at 36.5588, -118.7484, 2048 m el.]	Summary 5: Record 8 = Buchholz collection 4: 2 Jul 1940, Tulare Co.: Crescent Meadow, Giant Forest, Sequoia National Park (Fig. 2).
(9) <i>Buchholz? s.n.</i> (undated, but probably 1936, possibly 30 Apr) (2 sheets, ILL): Tulare Co. (unspecified, but inferred from location): “Sequoia National Park.” Notes/comments: none. Fide D. S. Seigler, <sup>f</sup> “there is [a] sheet with nothing other than ‘16B’ written on the tag and another one with ‘8B’ on the tag. They appear to be Buchholz materials as well, but without other information it might be hard to establish that.” However, “I believe these are Buchholz material. The tagging on par with collection [record] 1 above suggests 1936 whereas the location as on collection [record] 3 above suggests 30 Apr. [1936].”	Summary 6: Records 9 and 10 = possible Buchholz collections, same as Buchholz collection 2: date? (1936?, 1931?), Tulare Co.: as for summary 2, collection 2.
(10) <i>Buchholz? s.n.</i> (annotated “1927–1935, ca? 1931”) (ILL): Tulare Co. (unspecified, but inferred from location): “Sequoia National Park.” Notes/comments: none. Fide D. S. Seigler, <sup>f</sup> the annotation “1927–1935, ca? 1931” is “on a paper tag on one of the branches ... there's nothing written on the sheet itself.” However, “in appearance it is like the other specimens (paper, age etc.) of Buchholz.”	

## NOTES:

<sup>a</sup> Records 2, 4–7 are from the CCH (2012) database (accessed 3 May 2012); records 3, 9–10 are from ILL (David S. Seigler, pers. comm., 29 Apr 2011); records 1, 8 are from both CCH and ILL. For simplicity, information copied from CCH (2012) is given without quotation marks; the CCH transcriptions copied may have modified text on the original labels. Information for ILL is given with quotation marks; quotes are from specimen annotations or D. S. Seigler (pers. comm., 29 Apr 2011). Some of these records also appear in Conifers of the world (2012).

<sup>b</sup> Buchholz apparently did not make herbarium vouchers of *Sequoia sempervirens* or other native species of California conifers (Part 7).

<sup>c</sup> Fide D. S. Seigler (pers. comm., 29 Apr 2011), ILL has two sheets of record 1; “a tag on ... the specimen ... says ‘3B.’”

<sup>d</sup> Fide Aljos Farjon (pers. comm., 5 Aug 2011).

<sup>e</sup> This record entered the CCH database on 15 Mar 2012 and postdates the correspondence with Farjon and Seigler.

<sup>f</sup> Fide D. S. Seigler (pers. comm., 29 Apr 2011).

<sup>g</sup> Fide D. S. Seigler (pers. comm., 29 Apr 2011), ILL does not have material of records 4–7.