Aliso: A Journal of Systematic and Floristic Botany

Volume 30 | Issue 1 Article 4

2012

Naturalization of Sequoiadendron giganteum (Cupressaceae) in Montane Southern California

Rudolf Schmid
University of California, Berkeley

Mena Schmid

Aliso, 30(1), pp. 19–32

NATURALIZATION OF *SEQUOIADENDRON GIGANTEUM* (CUPRESSACEAE) IN MONTANE SOUTHERN CALIFORNIA

RUDOLF SCHMID[1,3] AND MENA SCHMID[2]

[1]*Department of Integrative Biology, University of California, Berkeley, California 94720-3140, USA (schmid@berkeley.edu);* [2]*Somerville, Massachusetts 02144, USA (aschmid@rcn.com)*
[3]*Corresponding author*

ABSTRACT

After the August 1974 fire in the upper Hall Canyon area on the southwestern flank of Black Mountain in the northwestern San Jacinto Mountains, Riverside Co., California, the United States Forest Service revegetated the burn in the mixed-conifer forest with the Sierra Nevada endemic *Sequoiadendron giganteum* (Cupressaceae). On 1 May 2009 a GPS census starting at the head of Hall Canyon revealed both in the canyon and upslope beyond it at least 157 individuals in the vicinity of the Black Mountain Trail, plus an outlier 450 m distant near the summit. This species alien to southern California is regenerating prolifically on Black Mountain, as revealed by multiple age classes, from juveniles (seedlings and saplings) about 20–60 cm tall to young adult trees over 6 m tall, up to about 40 years old, and reproductively mature. The naturalized population (<7 ha in 2009) also appears to be spreading from its initial "small area" of introduction (<2 ha in 1974). Analysis of published print and Internet literature suggests similar post-fire naturalizations of *S. giganteum* in the San Gabriel and San Bernardino Mountains of Los Angeles and San Bernardino Counties. State and regional floras and checklists for California should acknowledge the naturalization of this species in montane southern California in the San Jacintos and possibly elsewhere.

Key words: big tree, Cupressaceae, giant sequoia, naturalized species, Riverside Co., San Jacinto Mountains, *Sequoiadendron*, *Sequoiadendron giganteum*, southern California.

INTRODUCTION

On 3 May 2008 while hiking on the Black Mountain Trail in the San Jacinto Mountains, Riverside Co., California, we saw an interesting, reproductively mature conifer at 2144 m el. on the northwestern flank below the summit of Black Mountain (el. 2369 m), in mixed-conifer forest (Lower Montane Coniferous Forest), just above the head of Hall Canyon. The conifer turned out to be *Sequoiadendron giganteum* (Lindl.) J.Buchholz.

This monotypic California endemic (*Sequoiadendron* J.Buchholz) is native to the western slope of the Sierra Nevada, where it occurs in isolated groves (Fig. 1) in mixed-conifer forest between 825 and 2700 m el. (Stark 1968; Rundel 1972; Weatherspoon 1990; Willard 1995, 2000; Elliott-Fisk et al. 1997; Lanner 1999; Schellevis and Schouten 1999; Flint 2002; Fites-Kaufman et al. 2007; Krugman and Boe 2008; Eckenwalder 2009; Farjon 2010; Boyd and Griffin 2012; CCH 2012; Schmid 2012; Wikipedia 2012). The groves recognized vary in number from 65 to 80 or more, depending on how "grove" is defined; Willard's (2000) "67 groves" is now usually accepted. The groves are mostly of very restricted extent and/or threatened. They occur in a narrow strip measuring about 395 km long (northwest–southeast) and 19–21 km at the widest point (east–west). The groves extend over seven counties from southern Placer Co. southeasterly to southern Tulare Co. and vary in size from 6 to over 20,000 adult trees.

Our discovery of this Sierran species in the wilds of montane southern California posed these questions: (1) When and how did this Sierran endemic get to southern California, some 280 air km south of its closest native occurrence (Fig. 1)? (2) How extensively is this alien species distributed on Black Mountain? (3) Is the species regenerating itself or naturalizing there?

An Internet search for "Sequoiadendron 'Hall Canyon'" readily produced the answer to question #1. According to Keeler-Wolf (1990: 156, 2004: 128), in upper Hall Canyon "a small area of the [August] 1974 burn was revegetated with non-native giant sequoia (*Sequoiadendron giganteum*)." On 1 May 2009 we revisited Black Mountain to obtain the answers to questions #2 and #3, to take additional photos (Fig. 2–5 in 2009, Fig. 6 the original photo in 2008, items in Fig. 7–8 collected in 2009 and photographed in 2010), and to make voucher collections.

METHODS

Nomenclature and voucher information: Taxa follow *The Jepson manual*, 2nd edition (Baldwin et al. 2012). Voucher information is (all collections RSA, UC, UCR): 1 May 2009, Black Mountain (summit el. 2369 m/7772 ft), Riverside Co., California, at 2036 m/6680 ft to 2144 m/7034 ft: *Pinus lambertiana* (*R. Schmid and M. Schmid 2009-3*), *Sequoiadendron giganteum* (*Idem 2009-1*, *2009-2*, *2009-4*, *2009-5*, *2009-6*). For details of collection labels see Schmid and Schmid (2011). See also Observations.

Mapping aids: Mapping aids included: (1) Garmin MapSource version 6.15.11 with Topo US 2008 used to plot GPS data from a Garmin eTrex Legend HCx hiking GPS receiver (Fig. 9), (2) *San Jacinto Wilderness trail map* (Tom Harrison Maps 2006), (3–4) the Internet-based Google Earth (2012: version 6.1.0.5001) and United States Geological Survey Geographic Names Information System (GNIS) (2012), (5) atlases for California (Benchmark Maps 2007; DeLorme 2008), and (6) national-forest maps (print and downloadable PDF versions) of the United States Forest Service (2012).

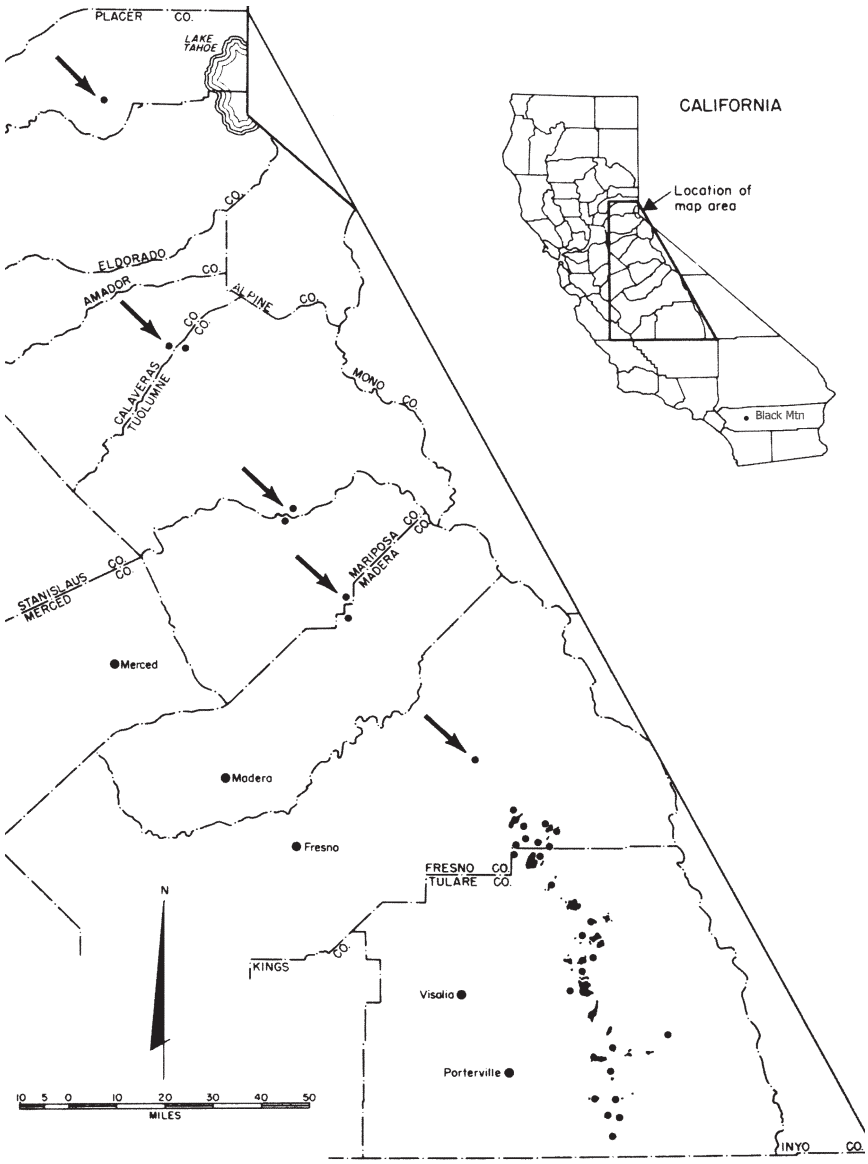

Fig. 1. Distribution of *Sequoiadendron giganteum* showing the 8 northern (arrows) and 67 southern (dots) native groves recognized by Weatherspoon [1990: 553, the map source; since Willard (2000), the current numbers are 8 northern and 59 southern groves] and, on the overview map, the naturalized population on Black Mountain, northwestern San Jacinto Mountains, Riverside Co.

On 1 May 2009 we used the Garmin GPS receiver to create waypoints for individuals of *Sequoiadendron giganteum* that we encountered in the vicinity of Black Mountain Trail. We made most of our field observations over a ca. 0.7 km linear distance between 2036 m and 2236 m el.

Except in quotations, we express GPS coordinates in DDD (decimal degrees) format to four decimal places (e.g., 37.9151°, −122.2866° = latitude, longitude; 173 m el.) because they seem simpler and less error-prone in transcribing than either the traditional DMS (degrees, minutes, and seconds) or usual GPS-device DMM (degrees, minutes with decimal seconds) formats (respectively, 37°54′54″N, 122°17′11″W and 37°54.906′N, 122°17.198′W for the previous example). Computer Support Group (2012) makes available on the Internet a GPS latitude/longitude coordinate converter and distance calculator.

Terminology: We define seedlings and saplings of trees as follows: *seedling*, shoot <30.5 cm/1 ft tall, main stem <1.3 cm/0.5 in. diameter, not reproductive; *sapling*, shoot 30.5–137 cm/1–4.5 ft tall, main stem ≥1.3 cm/0.5 in. diameter, usually not reproductive. These are essentially taxonomic-horticultural definitions, for example, by *Flora North America* (Lewis 1971: 18): ''sapling: a young tree, usually several feet high and less than 4 inches [10.2 cm] in diameter.'' The respective dimensions are appreciably greater when defined by foresters, for instance, by Northwest Illinois Forestry Association (2012): ''seedlings: trees that are less than 4.5 feet [1.4 m] tall'' and ''sapling[s]: trees taller than 4.5 feet [1.4 m] but less than 5.0 inches [12.7 cm] dbh'' (see also SORTIE-ND 2011). [We checked some 20 dictionaries of biology and botany for ''seedling'' and ''sapling'' and found only Lewis (1971) using actual dimensions to define these terms.]

Criteria for naturalization or regeneration of introduced plants.—The critical question regarding the introduction of

Fig. 2–8. *Sequoiadendron giganteum.*—2–6. Naturalized on Black Mountain (summit el. 2369 m), northwestern San Jacinto Mountains, Riverside Co., California.—2. Outlier sapling (#49) at 2361 m el.—3. Trees up to ca. 30 years old and ca. 5.5–6 m tall at the sloping plateau or saddle at 2144 m el.; tree (#28) left of center enlarged in Fig. 4, 6. Note the classic conical or pyramidal form of these uncrowded trees.—4, 6. Tree (#28) ca. 5.5 m tall, with Rudolf Schmid and male and female cones.—5. Male cones from tree (#c1) at 2066.5 m el.—Fig. 7–8. Items collected 1 May 2009 from the ground on Black Mountain at ca. 2070 m el.—7. Mature seed cones (70, 57 mm long).—8. Winged seeds (50) retrieved from 8 seed cones; mix of sandy granitic soil and sparse duff with needles (*Abies concolor*) and shoot segments (*Calocedrus decurrens*). Photos taken 1 May 2009 (Fig. 2–5), 3 May 2008 (Fig. 6), 31 Jan 2010 (Fig. 7), and 16 Apr 2010 (Fig. 8). Photos by M. Schmid (Fig. 2–4, 6) and R. Schmid (Fig. 5, 7, 8).

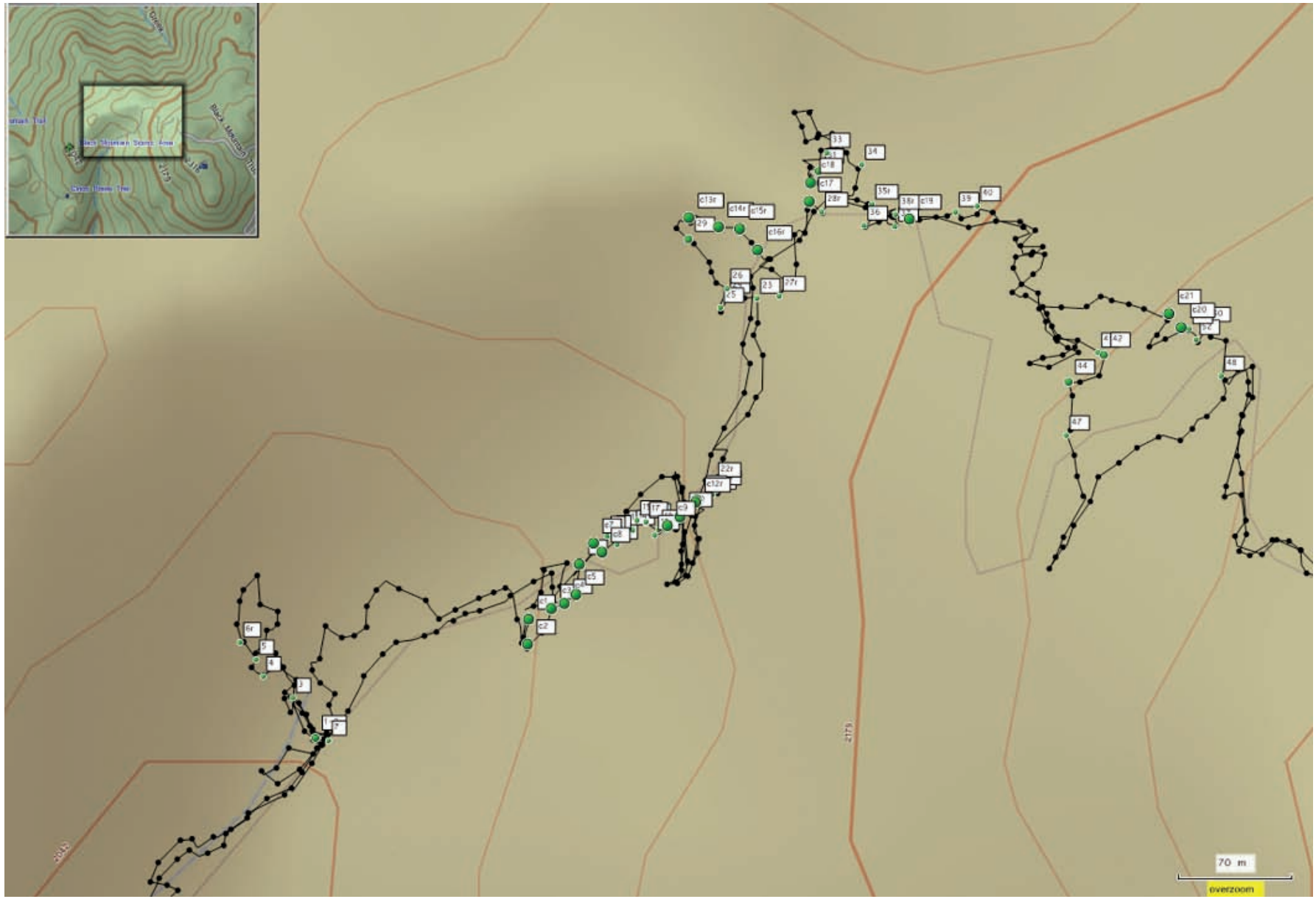

Fig. 9. Map showing GPS plots of specimens of *Sequoiadendron giganteum* encountered 1 May 2009 along and near Black Mountain Trail, Black Mountain (summit el. 2369 m).—At least 157 individuals were seen from 2036 to 2236 m el. (respectively, individuals #1, #48, a total of ca. 0.7 km linear distance, ca. 0.066 km^2 or 6.6 ha) downslope from Boulder Basin Campground. Note the four distinct groups of plots at progressively higher elevations, respectively, zones 1 to 4. Not shown to the lower right is an outlier (#49) 450 meters distant at 2361 m el. near the summit.—Abbreviations: *#1–#48*, *#50–#53*, plots of single trees, pairs, or triplets; *#c1–#c21*, plots of clusters, each with five or more trees; *r*, reproductive.—Green dots: *large*, tree cluster; *medium*, 2–3 single trees close together; *small*, single tree. Lines: *light gray dotted line*, Black Mountain Trail; *blue dashed line* (starting at plot #3), Indian Creek (intermittent stream) at head of Hall Canyon; *black dotted line*, GPS track ascending and descending; *contour intervals*, 46 m/150′; *thick contour lines*, 2042 m/6700′ (lower left), 2179 m/7150′ (middle right), 2316 m/7600′ (extreme lower right).—North is in standard vertical position. Inset map shows study area on northwest slope of Black Mountain below summit. Idyllwild is 9 linear km to the southeast.—Maps credit: Garmin MapSource 6.15.11 with Topo US 2008.

non-native species into an area is whether the individuals are regenerating themselves. The life-history stages of trees involve juveniles (seedlings and saplings) and adults of various age classes and, finally, snags or standing dead trees (SORTIE-ND 2011). There are several criteria to determine naturalization, or lack thereof, of introduced tree species:

1. Are the existing trees of a single stage and uniform age class, a situation indicative of one introduction but failure at reproduction (sexual or asexual)? Should multiple plantings have occurred in the same area, a discrete age class would be expected for each planting.
2. Are the existing trees of several stages and various age classes, a situation indicative of regeneration?

Two other factors might be relevant for planted introductions, as indicative of regeneration:

3. Has the species spread beyond the initial planted area?
4. Has the number of trees increased beyond the number initially planted, after accounting for juvenile and adult mortality?

STUDY SITE

(1) Location

On 3 May 2008 and especially on 1 May 2009 we made observations along and near Black Mountain Trail (Fig. 9), which begins off Highway 243 about 18 road-km northwest of Idyllwild, California. The trail extends 5.6 km from its trailhead at 1567 m el. to its junction with the Black Mountain Truck Trail at 2296 m el. It is an additional 1.2 km via dirt road to the summit of Black Mountain (2369 m el.), for a total distance of 6.8 km and an elevational gain of 802 m.

Black Mountain is in the northwestern San Jacinto Mountains, which are in the northernmost part of the Peninsular Ranges. Black Mountain is in Riverside Co. in the southern unit of the San Bernardino National Forest administered by the Forest Service, US Department of Agriculture (USDA). To the east of Black Mountain is the mountain massif of the San Jacintos (administratively covered by the San Jacinto Wilderness, the Mount San Jacinto State Park Wilderness, and Mount San Jacinto State Park), with Mount San Jacinto (3293 m el.) the highest point.

Black Mountain Trail begins at 1567 m el. in chaparral but then at higher elevations traverses mostly mixed-conifer forest (Lower Montane Coniferous Forest). The trail passes through the upper part of Hall Canyon, which occurs on the southwestern flank of Black Mountain. The trail then extends northeasterly out of the canyon and at about 2140 m el. levels into a sloping plateau or saddle on the northwestern flank of Black Mountain, near the westerly ridge and the final switchback ascent to the summit.

The James San Jacinto Mountains Reserve (2012) (33.8083, −116.7778, 1623–1692 m el.) is adjacent to Hall Canyon and a short distance upslope from Lake Fulmor (1622 m el.). Indian Creek is the small stream dropping through the drainage and into the lake. Administratively, Hall Canyon is a ''Research Natural Area'' (RNA; see Keeler-Wolf 1990, 2004) that was established in 1990 by the Forest Service, whereas the James Reserve, operational since 1966, is part of the Natural Reserve System of the University of California and is managed by its Riverside campus.

(2) Soils and Climate

Everett (2008: 1807) summarized edaphic and climatic information for the region: ''The relatively shallow soils are derived from granitic materials, and granitic boulders can occupy up to 20% of the area. … Climate is Mediterranean with cold wet winters and hot dry summers, with an annual precipitation at Black Mountain of 82.5 cm per year as winter rain or snow (…). Winter snowpacks at these elevations persist into March, and later on north-facing slopes. Summer thunderstorms account for less than 15% of annual precipitation (…). Mean monthly temperatures range from January lows of 0°C to July highs of 18°C.''

Everett's weather data are for the rather distant Big Bear Lake station (el. 2060 m) 48.6 km to the north of Black Mountain (summit el. 2369 m) in the San Bernardino Mountains. Closer weather stations (Western Regional Climate Center 2012) in the San Jacinto Mountains are the Idyllwild Fire Department (el. 1640 m) and the discontinued Mount San Jacinto WSP (el. 2568 m), respectively, 8.8 km southeast and 11.8 km east of the summit. The James Reserve (el. 1623–1692 m) on Black Mountain also has weather data (James San Jacinto Mountains Reserve 2012; see also Berg 1982). These stations are either much lower or much higher than our study site extending from 2036 to 2236 m el.

(3) Vegetation and Fire History

Keeler-Wolf (1990, 2004) described the vegetation in and near Hall Canyon. He recognized six ''association types'':

- White fir-sugar pine forest (dominated by *Abies concolor* and *Pinus lambertiana* and occurring at ''upper elevations,'' above 2042 m; see characterization in Discussion, Part 1c);
- Canyon live oak forest (*Quercus chrysolepis*; ''middle elevations,'' no specifics);
- Ponderosa pine forest (*P. ponderosa* var. *pacifica*; middle elevations, ''below'' 1829 m el.);
- California black oak forest (*Quercus kelloggii*; middle elevations, 1676–1874 m);
- Montane chaparral (two types, *Ceanothus* spp. and *Arctostaphylos* spp.; elevations unspecified);
- Incense-cedar canyon bottom forest (*Calocedrus decurrens*; middle elevations, ''up to about'' 2103 m, especially dominant along Indian Creek).

The quotations and sequencing of types are from Keeler-Wolf (1990, 2004), which summarize his 1986 and 1989 unpublished reports. These have detailed descriptions and different sequencings of the association types.

Everett (2008) used dendrochronology to study the fire history of the mixed-conifer forest on Black Mountain. He created a fire-scar chronology for the years 1349 to 2002. Keeler-Wolf (1990: 154, 2004: 125) wrote: ''Most of the [Hall Canyon] area of mid- and upper-slopes below about 6500 ft (1981 m) was burned in an extensive fire that occurred in approximately 1880. Most stems of conifers and re-sprouts of canyon live oak [*Quercus chrysolepis*]'' date from this old fire. ''The only survivors of the fire are in rocky areas or in the canyon bottom incense-cedar (*Libocedrus decurrens* [= *Calocedrus decurrens*]) forest. At upper elevations, fire intensity has been lower, with many survivor stems of sugar pine (*Pinus*

lambertiana) and white fir (*Abies concolor*).'' The most recent burn on Black Mountain was in 1974.

In August 1974 an extensive fire started near the town of Soboba, advanced toward Indian Mountain (summit el. 1765 m), crossed Highway 243, and extended upslope into Hall Canyon on the southwestern flank of Black Mountain (summit el. 2369 m), sparing, however, the adjacent James Reserve downslope. Moore et al. (1979: 156) give details: ''During August 27–31, 1974, approximately 70 square kilometers [68.01 km^2 fide Everett 2008: 1812] of chaparral and forest … burned in the devastating Soboba fire. … The fire was intense [at lower elevations], killing all the conifers and those portions of other trees and plants above ground. The surface was left with a cover of fine ash that averaged about 10 centimeters in depth….''

Keeler-Wolf's (1990: 154, 156, 2004: 126–128) account of the 1974 fire in the upper Hall Canyon area describes three vegetation types that we resequence here (see also Discussion, Part 1c):

> Montane chaparral: ''*Ceanothus* chaparral is most extensive where the 1974 fire occurred on the NW. side of [Hall Canyon]. Manzanita [*Arctostaphylos*] chaparral occurs in small isolated remnant patches that may have resulted from fires [from the 1800s]. The understory of both types is typically sparse.''
>
> Incense-cedar canyon bottom forest: ''Before the 1974 fire, incense-cedar [*Calocedrus decurrens*] dominated ["a narrow"] semi-riparian strip ["along the banks of Indian Creek"] from the lowest reaches of [Hall Canyon] up to about 6900 ft (2103 m). At present this [forest] type gives way to snags at about 6500 ft (1981 m).''
>
> White fir-sugar pine forest: ''The 1974 fire did not burn extensively into the upper elevation mixed conifer forest [of Hall Canyon], probably largely as a result of the open nature of this forest dictated by the numerous rock outcrops,'' as noted above, ''granitic boulders'' occupying ''up to 20% of the area.''

For the post-1974 revegetation of the upper Hall Canyon area with *Pinus jeffreyi* and *Sequoiadendron giganteum* see the Discussion (Parts 1b, 1c, 3, and 5) and Appendix.

OBSERVATIONS

Figure 9 shows 65 GPS plots for at least 157 individuals of *Sequoiadendron giganteum* that we encountered along and near Black Mountain Trail: Thus, #1–#48 as we ascended and #50–#53 as we descended are plots of 37 single trees, 6 pairs, and 1 triplet [= 52 trees]. In contrast, #c1–#c19 on our ascent and #c20–#c21 on our descent are plots of clusters, each with five or more trees [= 105+]. Our set of plots involved four distinct groups at progressively higher elevations:

1. at the head of Indian Creek in the drainage, 7 individuals, #1–#7 (Fig. 9), including #1 as voucher 2009-1;
2. on the slope coming out of the drainage, at least 75 individuals, #8–#22, #c1–#c12 (Fig. 9), including #c1 as voucher 2009-2 (Fig. 5) and mature seed cones, soil, and duff near #13 as voucher 2009-4 (Fig. 7–8);
3. on the sloping plateau or saddle, at least 53 individuals, #23–#40, #c13–#c19 (Fig. 9), including #27 and #28 as vouchers 2009-5 and 2009-6 (Fig. 3–4, 6);
4. on the northwest-facing slope closer to the summit, at least 22 individuals, #41–#48, #50–#53, #c20–#c21 (Fig. 9).

We refer to these four groups as, respectively, zone 1, zone 2, zone 3, and zone 4. The ''at least'' qualifier is needed because zones 2 to 4 each included multiple clusters.

The species was seen from 2036 m (#1) to 2236 m (#48) el. over a ca. 0.7 km linear distance (ca. 0.066 km^2 or 6.6 ha) and downslope from Boulder Basin Campground, plus an outlier sapling (#49), the 158th counted individual (Fig. 2), 450 m distant at 2361 m el. near the summit (2369 m).

We encountered individuals of *Sequoiadendron giganteum* of multiple age classes, from seedlings and saplings (juveniles) about 20–60 cm tall—many 30–45 cm (Fig. 2)—to young reproductively mature trees over 6 m tall and up to about 40 years old (Fig. 3–8), an age consistent with the introduction of the species to the area in the revegetation efforts after the August 1974 fire. [Revegetation presumably was in the fall with the onset of the rainy season and undoubtedly was by seedlings and *not* by seed (see Part 1 below). Assuming 4-year-old seedlings were used (see Discussion, Part 1b), it would be 4 years for the seedling age plus 35 years for the interval (1974 to our observation in 2009) for a total of 39 years or ''up to about 40 years old'' for the oldest trees.]

Uncrowded trees had the classic "'spiretop,' conical or pyramidal form'' (Fig. 3–4), which may persist for 75–100 years, or until crowding (Buchholz 1938; Weatherspoon 1990; Willard 1995: 8 for the quote; Lanner 1999; Schellevis and Schouten 1999; Eckenwalder 2009; Farjon 2010). Buchholz (1938) provided the first detailed report of shoot growth in *Sequoiadendron* (see synopsis in Schmid 2012). We also saw several two-stemmed trees and one three-stemmed tree.

Many trees were reproductive with abundant male and female cones (Fig. 5–7). Seed cones were 41–70 mm and averaged 50.6 mm length by 34.0 mm width (n = 16). Farjon's (2010) dimensions are 30–70(–95) mm by 25–50(–65) mm; other values for cone length in the literature are 40–90 mm (Eckenwalder 2009; Boyd and Griffin 2012), 50–75 mm (Schellevis and Schouten 1999), and 50–90 mm (Weatherspoon 1990; Krugman and Boe 2008).

In some areas lying on the ground were numerous intact old cones that had shed seeds. Most cones examined also contained some unshed seeds (Fig. 8). We tried unsuccessfully to germinate such seeds. Some individuals also appeared to be reproducing vegetatively by layering.

The surrounding vegetation is mixed-conifer forest with *Abies concolor*, *Pinus coulteri*, *P. ponderosa* var. *pacifica*, and *Quercus chrysolepis* dominant at lower elevations and *P. jeffreyi* and *P. lambertiana* dominant at higher elevations. *Calocedrus decurrens*, and *Ribes nevadense* occur throughout most of the aforenoted elevational range. Extensive *Alnus rhombifolia* and *Pteridium aquilinum* var. *pubescens* occur near Indian Creek. The soil in most of the area is sandy granitic and largely free of litter (Fig. 8).

DISCUSSION

(1) Ecological Considerations: Black Mountain, San Jacinto Mountains

(a) Prior ecological studies.—Moore et al. (1979), Keeler-Wolf (1986, 1989, 1990, 2004), Walter et al. (2005), and Everett (2008) are four ecological studies of the Black Mountain area:

Everett (2008) used dendrochronology to study the fire history of the mixed-conifer forest on Black Mountain. His

study area was at ca. 2259 m el. at 33.8328, −116.7422 (Everett, pers. comm., 25 Oct 2010, correcting the value on pp. 1806–1807 in his 2008 paper) on the northeastern flank of Black Mountain near the col with Fuller Ridge. Our study site about 1.8 km west-southwest on the northwestern flank of Black Mountain begins at 2036 m el. at 33.8257, −116.7663 and ends at 2236 m el. at 33.8276, −116.7602 (Fig. 9).

Walter et al. (2005) studied fire and non-fire succession of chaparral and forest vegetation in and near Hall Canyon, whereas Moore et al. (1979) studied post-fire colonization by *Drosophila* in the nearby Indian Mountain area to the southwest across Highway 243. Both investigations were at elevations (respectively, up to 1770 m and at about 1525 m) much lower than those of our study area beginning at 2036 m el. (Fig. 9).

Keeler-Wolf (1986, 1989 unpublished, but summarized in 1990, 2004—see Appendix) did the environmental analysis of Hall Canyon that resulted in its establishment in 1990 as a "Research Natural Area" (RNA) of the Forest Service. Keeler-Wolf's ecological interpretations of Hall Canyon are invaluable. Of the four ecological studies just cited, Keeler-Wolf (1986, 1990, 2004, but not 1989) is the only one to mention *Sequoiadendron* (see Appendix).

Moore et al. (1979) and Keeler-Wolf (1986, 1989, 1990, 2004) provide details for the ca. 1880 and 1974 files (see Study Site). We saw fire scars from the former and especially from the latter burns (see also Everett 2008).

(b) Life history of the introduced plants of Sequoiadendron.—After the August 1974 fire the United States Forest Service revegetated the upper Hall Canyon area with *Sequoiadendron giganteum* (Keeler-Wolf 1986, 1990, 2004). We saw at least 158 individuals of this species represented by multiple age classes, from seedlings and saplings (juveniles) about 20–60 cm tall (Fig. 2) to young reproductively mature trees over 6 m tall and up to about 40 years old (Fig. 3–8).

There is little doubt that seedlings rather than direct seeding of *Sequoiadendron* occurred on Black Mountain. Use of seedlings was the practice of the Forest Service (see Part 3) and has been the custom in horticulture. For example, the grove of *Sequoiadendron* in the Regional Parks Botanic Garden located in Tilden Regional Park, Contra Costa Co., consists of 19 large trees and one large stump. The trees stemmed from four-year-old seedlings planted in March 1946 and resulting from seed sown in January 1942 (Roof 1959). Furthermore, Keeler-Wolf (1986; see Appendix) indicated that seedlings of *Pinus jeffreyi* were "commonly planted" in the upper Hall Canyon area after the 1974 fire in addition to plantings of *S. giganteum* (see also Part 3).

Lanner (1999: 250), following Weatherspoon (1990; see also Buchholz 1938), states that in the Sierra Nevada the mature serotinous cones of *Sequoiadendron* may persist on trees for some 20 years (the cone stalks produce annual rings) unopened, green, and photosynthetic (Fig. 6), even becoming lichen encrusted, but finally open to disperse their seeds by "several ways … in the apparent order of importance":

1. heat from ground fires;
2. beetle larvae (*Phymatodes nitidus*) feeding in the cone obstructing the water supply from the branch;
3. Douglas squirrels (*Tamiasciurus douglasii*) feeding on green cone scales (technically bract-cone-scale complexes), which then lose moisture and open;
4. wind and ice storms dislodging from trees their cones or limbs with cones, "severing the vascular tissue supplying water to the cones."

These means result not only in "a year-round rain of seeds" beneath the canopy but also in "a reservoir of seeds" that the serotinous cones release after a fire (Lanner 1999: 250).

The "seeds are well adapted for wind dispersal. They are light (average 200,000/kg …), winged [Fig. 8], and fall in still air at a rate of 1.2 to 1.8 m per second. Winds common in late summer and winter storms in the Sierra Nevada can disperse seeds more than 0.4 km … from the tall crowns of mature trees" (Weatherspoon 1990: 555; see also Krugman and Boe 2008).

It is unclear what factor or factors are causing seed cones of the naturalized population of *Sequoiadendron* on Black Mountain to open to shed seeds. Lanner's first three methods do not apply: there has been no fire here since 1974, and the two animal taxa do not occur in the area (Anonymous, undated: checklists for 173 species of vertebrates, 478 species of invertebrates, and 242 species of plants), indeed not even in southern California. However, it is possible that a local squirrel or other rodent indigenous to the San Jacintos is eating the cone scales and performing a similar service. Lanner's fourth method seems relevant. Detached cones dry out quickly and shed seeds "within a few days" (Buchholz 1938: 303 for the quote; Krugman and Boe 2008). We picked up from the ground eight intact, mature seed cones with partly open seed scales from which we retrieved 50 winged seeds (Fig. 7–8).

A fifth method of seed release in *Sequoiadendron* seems relevant: cone scales of unshed mature seed cones shrink during the heat of late summer and release some seed (Buchholz 1938; Krugman and Boe 2008). This also occurs in some serotinous species of *Cupressus* and *Pinus*, the two other serotinous conifer genera in California (Barbour 2007).

It is well known that soil moisture is the critical feature characterizing *Sequoiadendron* (Stark 1968; Rundel 1972; Weatherspoon 1990; Lanner 1999; Fites-Kaufman et al. 2007; Farjon 2010): (1) Its groves occur in mesic sites and (2) its successful seed germination and subsequent seedling establishment require moist, well-drained, especially granitic soil that is bare or nearly bare and preferably optimized by fire. The sandy granitic soil in our study area is largely free of litter (Fig. 8) and thus meets these conditions. The 1974 fire would have produced the bare mineral soil essential for seed germination and seedling growth.

(c) Naturalization (regeneration) of the introduced plants of Sequoiadendron.—According to Weatherspoon (1990), trees as young as 10 years may produce seed, although abundant seed production usually occurs after 150 or 200 years. We assume four-year-old seedlings (see Part 1b) were planted in autumn 1974 after the fire. Therefore, the life history of *Sequoiadendron* on Black Mountain could have been completed in less than 40 years:

1. in the first generation, growth of seedlings introduced in 1974 (seed was not sown), then survival of seedlings and saplings (juveniles), and, finally, reproductive capacity of young adult trees;
2. in the second generation, germination of the locally produced viable seed, and survival of seedlings and

saplings to continue the life history (for details see Weatherspoon 1990: 554–560).

The population of *Sequoiadendron* in the Hall Canyon area is maintainable and should increase, both in numbers and potentially in extent, as long as edaphic and climatic parameters are within the adaptive tolerances of the species. In fact, the population could potentially even spread to nearby canyon drainages or amenable slopes.

In view of the multiple age classes of *Sequoiadendron* seen, we are confident that the planted population is naturalizing, that is, regenerating, on Black Mountain. However, we have only circumstantial evidence for its spread.

Keeler-Wolf's (1990, 2004) summary account of Hall Canyon indicates that the 1974 fire progressed upslope from the canyon into the adjacent conifer forest (see Study Site). His statement (1990: 156, 2004: 128) that "a small area of the 1974 burn was revegetated with non-native" *Sequoiadendron* leaves open where this occurred.

We sought more precise answers in Keeler-Wolf's (1986, 1989) unpublished reports based on observations he made in spring 1985. His color photos (and their captions) in both reports, and the detailed descriptions in especially the 1986 report confirm that the 1974 fire burned intensely into the Incense-cedar canyon bottom forest in the upper part of the canyon but then beyond it faded out in the White fir-sugar pine forest where there are many boulders (see Study Site). In contrast, Keeler-Wolf briefly mentions *Sequoiadendron* only in the 1986 report, stating that "the Forest Service replanted a small portion of the upper drainage" with seedlings of several species, "although only a small area (perhaps less than 2 ha) was planted" (see Appendix for detailed quote). "Upper drainage," however, still leaves open whether planting was restricted to the upper canyon, the adjacent upslope region, or occurred in both locations.

We documented at least 157 individuals of *Sequoiadendron* between 2036 m and 2236 m el. at the head of the canyon and just beyond it. The plantings occurred over a ca. 0.7 km linear distance and within a ca. 6.6-ha area (Fig. 9). This is the key to the interpretation that follows: Our naturalized population in 2009 encompassed an area over three times the initial "small area" of introduction in 1974; compare our <7 ha with Keeler-Wolf's <2 ha cited above. Thus *Sequoiadendron* appears to be spreading in the upper Hall Canyon area.

We found *Sequoiadendron* growing in four zones of progressively higher elevation (see Observations and Fig. 9): (1) 7 individuals at the head of Indian Creek in the drainage, (2) at least 75 individuals on the slope coming out of the drainage, (3) at least 53 individuals on the sloping plateau or saddle (Fig. 3–4), and (4) at least 22 individuals on the northwest-facing slope closer to the summit. Zones 1 and 2 are in Hall Canyon, zones 3 and 4 just beyond it. The zones vary in relative steepness from nearly level (zone 3), slightly steep (zone 1), fairly steep (zone 2), and markedly steep (zone 4). [Because zones 2 to 4 each included multiple clusters, the "at least" qualifier denotes the minimum census feasible.]

Was *Sequoiadendron* in 1974 planted solely in zones 1 and 2, which would have the mesic conditions amenable for optimal seedling survival, or perhaps in zones 1 and 2 plus some or all of zone 3, or simultaneously in all four zones? Most likely the initial planting was in zones 1 and 2, with the species later spreading onto the plateau (zone 3) and beyond it (zone 4) (Fig. 9). Keeler-Wolf's ambiguous "upper drainage" probably applies to both zones 1 and 2.

Our evidence is strongly circumstantial that *Sequoiadendron* spread into zone 4 and all or most of zone 3. We cite five points:

1. The steepness of zone 4 suggests it was unlikely to have been planted with sequoia trees, the ones now there having been seeded in from lower zones. After all, why would Forest Service personnel bother with the very steep zone 4 when the broad, nearly level zone 3 could be more easily and efficiently planted? Zone 4 was so steep that only the younger author of this paper wished to scramble down it.
2. Zones 3 and 4 are more exposed and windier than zones 1 and 2. Seed dispersal would be more effective into and within the former two zones.
3. Zones 3 and 4 are on the northwestern flank of Black Mountain in White fir-sugar pine forest. According to Keeler-Wolf (1986: 51–56): "This forest is typically open. … Snow accumulates to a deeper level and remains longer into the spring than in any other part of the study area." … The forest thus has a "mesic nature … and deep soils. … Shrubs and herbs are even sparser [here] than in the lower elevation[s]. … Dense crown cover and thick duff have not developed. … The large areas of uncolonizable substrate [perpetuate] an open, sunny forest." These conditions are highly conducive to the establishment of seedlings of *Sequoiadendron.*
4. We saw and documented via GPS and camera only sterile and fertile young adults in zone 1, juveniles (seedlings and saplings) and sterile and fertile young adults in zones 2 and 3 (Fig. 2–6), and only sterile plants in zone 4. However, our observations in zone 4 may be incomplete due to the steepness here.
5. Finally, the distribution of individuals in our census is also suggestive (Fig. 9). It is expected in a spreading population that the highest concentration of individuals would be closest to the initial introduction. This is exactly what we see. The 157 individuals are distributed across zones 1 to 4 as, respectively, 7, 75, 53, and 22 individuals. Zones 2 and 3 have the highest populations, which is consistent with spread from zones 1 and 2 into zones 3 and 4. Significantly, Zone 2 on the slope coming out of the drainage is a rather open site favorable for seedling survival. It is the area where we collected mature seed cones, soil, and duff (Fig. 7–8) as a voucher (*R. Schmid and M. Schmid 2009-4*).

In summary, *Sequoiadendron* appears to have spread upslope from the initial "small area" in the canyon (zones 1 and 2) to the sloping plateau or saddle (zone 3; Fig. 3, 4) and to the region just beyond it (zone 4) below the final steep ascent to the summit of Black Mountain.

All this is supposition. We can make only tenuous suggestions because we do not know the precise areas (zones) of original planting. We encourage researchers to visit the site, monitor it, and perhaps, using sophisticated analytical techniques, including dendrochronology, analyze it for evidence of *Sequoiadendron giganteum* spreading further within and without the site. This non-native species is thriving in the

upper Hall Canyon area of Black Mountain and definitely has become naturalized there since its introduction as seedlings planted in "a small area" after the August 1974 fire.

(2) Floristic Considerations: Black Mountain, San Jacinto Mountains

Berg (1982) issued for Hall Canyon on the southwestern flank of Black Mountain an "annotated floristic list" for 229 species. The "Hall Canyon plant species list" (Anonymous, undated) treats 242 species and is available on the website of the James Reserve. Both checklists, as well as Keeler-Wolf's (1986, 1989, 1990, 2004) descriptions of the area, include six of the seven species of gymnosperms mentioned above under Observations: *Abies concolor*, *Calocedrus decurrens*, *Pinus coulteri*, *P. jeffreyi*, *P. lambertiana*, and *P. ponderosa* var. *pacifica.* Only Keeler-Wolf (1986, 1990, 2004, but not 1989) mentions *Sequoiadendron giganteum* (see Appendix). We saw this species mainly between 2036 and 2236 m el. and collected it with *P. lambertiana* at the same site at 2066.5 m el.

The two checklists seem more complete for lower than for upper Hall Canyon and obviously exclude species above the canyon. Our study area involved two of Keeler-Wolf's six "association types" (see Study Site): (1) Incense-cedar canyon bottom forest (*Calocedrus decurrens*) occurring along Indian Creek up to about 2103 m el. in Hall Canyon, and (2) White fir-sugar pine forest (*Abies concolor*, *Pinus lambertiana*) occurring above 2042 m el. and hence mostly above the canyon.

Analysis of labels of herbarium collections for Riverside Co. that are in the database of the Consortium of California Herbaria (CCH 2012) showed (8 Feb 2012) for Black Mountain (summit el. 2369 m): no collections of *Sequoiadendron*; only three collections of *Pinus lambertiana* from ca. 2133 m el. Other native conifer species occur elsewhere in the San Jacinto Mountains: *Juniperus californica*, *Pinus contorta* subsp. *murrayana*, *P. flexilis*, *P. monophylla*, *P. quadrifolia*, and *Pseudotsuga macrocarpa* (CCH 2012; Chester 2012).

Previous collections of vascular plants in Hall Canyon on Black Mountain were from 1494 to 1829 m el. (CCH 2012), well below the highest point of the canyon at about 2140 m el. On 1 May 2009 our herbarium collections in and above the canyon were from 2036 to 2144 m el. and our GPS plots in and above the canyon were from 2036 to 2236 m el. (Fig. 9), excluding the outlier sapling (Fig. 2) 450 m distant at 2361 m el. Thus, our samples exceed the elevational range of prior collections.

Incidentally, we saw *Sequoiadendron* only on Black Mountain and not elsewhere in the San Jacinto Mountains, where we hiked several days each year from 2006 to 2009. We have shown that this species is thriving in the Hall Canyon area and has become naturalized there since its introduction as seedlings planted after the August 1974 fire. *Sequoiadendron* thus deserves inclusion in local and regional floras and checklists.

(3) Plantings of the Forest Service, Especially in Montane Southern California

Southern California has numerous mountains that occur in several mountain ranges of varying extent and height; the regional Transverse Ranges and Peninsular Ranges define cismontane southern California (Schoenherr 1992). The two largest and tallest ranges in the Transverse Ranges are (1) the San Gabriel Mountains, which occur mostly in northern Los Angeles Co. and slightly in adjacent southwestern San Bernardino Co., and, lying east of the San Andreas Fault, (2) the San Bernardino Mountains, which occur mostly in southwestern San Bernardino Co. and slightly in adjacent northwestern Riverside Co. The San Jacinto Mountains are the northernmost range in the Peninsular Ranges, which extend into Baja California.

For nearly a century the United States Forest Service, established in 1905 with Gifford Pinchot (1865–1946) as its first Chief, actively planted areas with species that were alien to the area. Burns and Sauer's (1992: 49) history of the Forest Service and other agencies introducing non-native conifer species to the San Gabriel Mountains is illustrative: The Forest Service planted in the Angeles National Forest (established 1892) about 100,000 seedlings of conifer species yearly in 1907 and the next few years in an ineffective attempt to reforest the San Gabriels. "Direct seeding was tried but quickly abandoned as futile." Burns and Sauer tabulated 44 conifer species and three hybrids alien to the area, for a total of about 647,000 seedlings planted: *Pinus attenuata* with 377,000 plantings and *P. halepensis* Mill. with 64,300 head the list; *Sequoiadendron giganteum* with 22,900 plantings ranks eighth. However, none of the 47 taxa listed "are invading adjacent natural habitats" of chaparral and montane forest. After fires, only *P. canariensis* C.Sm. resprouted, and only *P. attenuata* established seedlings, but these were "too few … to restore the stands."

A similar situation probably applies to the San Bernardino Mountains and other montane regions, but there are no detailed historical accounts akin to Burns and Sauer (1992). However, Rogers (1986: 33) wrote the following about *Sequoiadendron* and the San Bernardino National Forest (established 1907), which administratively consists of two units, the northern with the San Bernardino Mountains of the Transverse Ranges, and the southern with the San Jacinto and Santa Rosa Mountains of the Peninsular Ranges: "On all National Forests in the Sierra Nevada giant sequoias have been planted from time to time, as they have on several other forests in California. In fact, if interest in the species were measured by the amount of seed stored in the Forest Service seed bank at Placerville, then the San Bernardino National Forest runs a close second to the Sequoia [National Forest]. On the San Bernardino [National Forest] about 5000 to 10,000 seedlings are planted each year, and at least one instance of natural regeneration from some of the early plantings has been observed."

Unfortunately, Rogers (1986) did not elaborate where this "one instance" occurs. However, it may well be the introduction of *Sequoiadendron* to Hall Canyon after the August 1974 fire (Keeler-Wolf 1986, 1990, 2004) and its subsequent naturalization on Black Mountain in the San Jacintos.

Large plantings of *Sequoiadendron* occurred well into the 1990s, judging by a statement in Elliott-Fisk et al. (1997: 328): "The Forest Service commonly plants giant sequoia as a fast-growing species in various timber cuts outside the species['] natural range and between the existing groves. This practice should be curtailed until there is a more complete understanding of the species['] genetic architecture …."

Elliott-Fisk et al. (1997) were concerned with threats to the genetic integrity of native groves from outside plantings of individuals native to other groves. One hopes such threat is not a concern with the Black Mountain population some 280 air-km south of its closest native occurrence (Fig. 1). However, Keeler-Wolf (1986; see Appendix) called the use of the alien *Sequoiadendron giganteum* and the native *Pinus jeffreyi* (but grown from ''alien seed'') to revegetate Hall Canyon after the 1974 fire such an ''ill-conceived'' act that ''the area must relinquish the title of 'natural area.'''

Over the years increased disillusionment developed about certain practices of the Forest Service, notably regarding fire suppression and the introduction of non-native, often invasive plant and animal taxa to revegetate, restore, or rehabilitate areas. It thus is worth noting that the Forest Service's policy of using non-native species changed (US Forest Service 2010): on 13 Feb 2008 the Forest Service ''issued a new directive [Federal Register 73(30): 8265–8269 (PDF available)] for the use of native plant materials in the revegetation, restoration, and rehabilitation of National Forest System lands. This first-ever national direction on native plant materials will help the Forest Service to develop and implement a native plant materials program throughout the Agency. The policy helps achieve the Agency's goals of providing for the diversity of plant and animal communities, and restoring native species and habitat conditions in ecosystems that have been invaded by non-native species. [12-page Forest Service Manual Chapter 2070—Vegetation Ecology (PDF available)]. Key elements of the policy include: ….'' [A definition of ''native plants'' and five detailed guidelines follow.]

Finally, with regard to the Hall Canyon case mentioned above: There is a second irony besides the aforenoted one of introducing the alien *Sequoiadendron giganteum* and the native (but genetically alien) *Pinus jeffreyi* into a future ''natural area'': Within a decade of the 1974 fire the native tree species were ''growing rapidly on the burn'' and probably would have reforested the area without outside interference (Keeler-Wolf 1986; see Appendix for detailed quote).

(4) Floristic Considerations: Elsewhere in Montane Southern California

(a) Preamble.—*Sequoiadendron giganteum* has been extensively planted in California as an ornamental, as part of afforestation attempts, and as reforestation efforts, especially post-fire revegetation ones (see Part 3). We found this species thriving as a naturalized alien on Black Mountain in the San Jacinto Mountains of Riverside Co. (Parts 2–3). These facts suggest similar occurrences elsewhere in montane southern California, particularly in the San Gabriels and San Bernardinos, and possibly even elsewhere in the San Jacintos.

The recent checklist by Roberts et al. (2004, 2007 update) for western Riverside Co. does not include the San Jacintos and, incidentally, does *not* list *Sequoiadendron.* We have not seen this species mentioned in any published (print) flora or florula for southern California. However, our analysis of labels of herbarium collections in the database of CCH (2012) and of the results of Internet searches for ''Sequoiadendron Gabriel,'' ''Sequoia Gabriel,'' ''Sequoiadendron Bernardino,'' ''Sequoia Bernardino,'' etc., produced some intriguing possibilities:

On 3 May 2012 CCH contained 15 records representing nine herbarium collections of *Sequoiadendron giganteum* from mountain ranges in these counties:

San Gabriel Mountains:
  Los Angeles Co. (northern)
    Swinney 9461 (RSA, UCR)
    Swinney 10,938 (UCR)
    White 10,719 (RSA, UCR)
  San Bernardino Co. (southwestern)
    Swinney 1965 (UCR)
San Bernardino Mountains:
  San Bernardino Co. (southwestern)
    Feldman 36 (UCR)
    Fraga et al. 3064 (RSA, UCR)
    Mistretta 3768 (RSA)
    Pitzer 4202 (CAS, RSA 708965, RSA 745485, UCR)
    Wood 2261 (RSA)
  Riverside Co. (northwestern)
    no records
San Jacinto Mountains:
  Riverside Co.
    no records (*Schmid & Schmid* vouchers await deposition to RSA, UC, UCR)

[On 3 May 2012 the CCH database contained only one non-montane collection of the species: *Kingman s.n.* (Jan 1911) (GH) of a cultivated tree in Pasadena, Los Angeles Co.]

We thus conclude below about possible naturalization; see the methods section for ''Criteria for naturalization or regeneration of introduced plants.''

(b) San Gabriel Mountains.—Swinney and Sanders (2008) in an Internet checklist for the eastern San Gabriel Mountains list *Sequoiadendron giganteum* as having ''several trees persisting in San Savine [Sevaine] Flats, SB County; several trees, small to mature at Buckhorn Spring'' [Los Angeles Co.]. These localities have, respectively, voucher specimens in the database of CCH (2012):

1. *Swinney 1965* (17 Oct 1992): ''Elevation: 1692 m … Coordinates: 34.211, −117.510 … several planted among [native] trees at meadow. Cones from ground under trees.''
2. *Swinney 9461* (13 Sep 2008): ''Elevation: 2070 m … Coordinates: 34.341, −117.907 … At least 12 trees, 30–90 ft tall.''

Hawke and Hawke (2004) in an Internet checklist for the *entire* San Gabriel Mountains above 1825 m el. also list *S. giganteum*, but without comment. Finally, Tom Chester's (2012) extensive and searchable website for Internet floras for all of southern California yielded only these two online floras mentioning this taxon.

Although the aforenoted plantings of *Sequoiadendron* in the San Gabriels are ''persisting,'' it is not clear if they are naturalizing (regenerating). However, the following collection from the northeastern San Gabriel Mountains (Los Angeles Co.) more strongly suggests naturalization of this alien species:

White 10,719 (11 Aug 2004): ''Elevation: 2073–2195 m … Habitat: Open yellow pine forest; some dense brushy areas

without forest canopy, probably burned ca. 10 years ago. Coordinates: 34.383, −117.75 … Small trees, uneven sizes gen. ca. 2–4 m tall; locally common; emergent above brush in (evidently) recently burned-over areas; possibly planted here or possible post-fire seeding from an unknown seed source.''

(c) San Bernardino Mountains.—Herbarium labels of collections of *Sequoiadendron giganteum* in the San Bernardino Mountains of San Bernardino Co. (CCH 2012) also suggest naturalized introductions:

1. *Fraga et al. 3064* (6 Jul 2009): ''Elevation: 2104–2134 m. Coordinates: 34.160, −116.871 … Planted and persisting'':
2. *Pitzer 4202* (14 Aug 2000): ''Elevation: 1463 m. Coordinates: 34.040, −116.942 … Uncommon large trees on knoll …, and scattered in canyons.''

These plantings of *Sequoiadendron* are ''persisting.'' However, as with the San Gabriels, it is not clear if they are naturalizing (regenerating).

(d) Plantings probably not naturalized.—Some collections of *Sequoiadendron* from montane southern California clearly represent ornamental or horticultural plantings. Apparently these have not naturalized, for instance: from Los Angeles Co. collection #1, and from San Bernardino Co. collections #2–4:

1. *Swinney 10,938* (28 May 2009): ''Elevation: 1585 m. Coordinates: 34.367, −117.987. Two trees near water tank [presumably planted]; no cones present.''
2. *Feldman 36* (28 May 1988): ''Elevation: 1524 m. Coordinates: 34.216, −117.25. Uncommon large evergreen tree to c. 10 m. Probably planted.''
3. *Mistretta 3768* (2 Jun 2009): ''Elevation: 2136 m. Coordinates: 34.210, −116.911. Part of planted area around Converse Fire Station.''
4. *Wood 2261* (29 Jul 2010): ''Elevation: 2054 m. Coordinates: 34.165, −116.883. Tree. Scarce. Height ± 4 m.''

(e) Other mountain ranges.—Previous discussion focused on the San Jacintos (Parts 1–2) and the San Gabriels and San Bernardinos (Parts 4b–d) because we had various types of evidence—herbarium collections (CCH 2012), Internet or print-published floras and florulas, and personal observations—that report the occurrence of *Sequoiadendron* in these mountain ranges. These are also the tallest and most extensive in southern California. We ignore other mountain ranges here because we have no evidence that this species is growing elsewhere in montane southern California. In fact, compared to the San Jacintos, San Gabriels, and San Bernardinos, the relative lowness and probably greater aridity of other mountain ranges in southern California make them unlikely candidates for successful long-term or even short-term growth of *Sequoiadendron* due to its ecological requirements (see end of Part 1).

(5) Summary Conclusion

The site of this study was in the upper Hall Canyon area of Black Mountain in the San Jacinto Mountains, Riverside Co. (Fig. 1). After the August 1974 fire on the mountain the United States Forest Service revegetated ''a small area'' (Keeler-Wolf 1990: 156, 2004: 128) of this canyon with seedlings of the Sierran endemic *Sequoiadendron giganteum* (Fig. 1). Our GPS census on 1 May 2009 started at the head of the canyon and ended a short distance beyond it, extending from 2036 to 2236 m el. over a ca. 0.7 km linear distance and involving ca. 0.066 km^2 or 6.6 ha. We found both in the canyon and above it at least 157 individuals of *Sequoiadendron* in the vicinity of Black Mountain Trail, plus an outlier 450 m distant near the 2369-m summit. We also saw multiple age classes, from seedlings and saplings (juveniles) about 20–60 cm tall to young adult trees over 6 m tall, up to about 40 years old, and reproductively mature. This alien species thus is regenerating prolifically on Black Mountain, with juveniles beginning the second generation.

The initial planting of *Sequoiadendron* in 1974 in ''the upper drainage'' of Hall Canyon was made in ''only a small area (perhaps less than 2 ha)'' (Keeler-Wolf 1986; see Appendix). We documented at least 157 individuals within a ca. 6.6-ha area at the head of the canyon and just beyond it. They were growing in four zones of progressively higher elevation (see Fig. 9): (1) 7 individuals at the head of Indian Creek in the drainage, (2) at least 75 individuals on the slope coming out of the drainage, (3) at least 53 individuals on the sloping plateau or saddle (Fig. 3–4), and (4) at least 22 individuals on the northwest-facing slope closer to the summit. Zones 1 and 2 are in Hall Canyon, zones 3 and 4 just beyond it. Because each of zones 2 to 4 included multiple clusters, the ''at least'' qualifier denotes the minimum census feasible. Most likely the initial planting in 1974 was in zones 1 and 2 (Keeler-Wolf's ''upper drainage''), with the species later spreading onto the plateau (zone 3) and beyond it (zone 4) (Fig. 9).

We conclude that *Sequoiadendron giganteum* not only is thriving and definitely naturalized on Black Mountain, but also appears to be spreading from its initial ''small area'' of introduction.

We also made an extensive analysis (1) of labels of herbarium collections (CCH 2012) as well as (2) of the print and Internet literature for the floristics and ecology of southern California. On the basis of this analysis we suggest that this species is possibly also naturalized in the San Gabriel and San Bernardino Mountains of Los Angeles and San Bernardino Cos.

State and regional floras for California should acknowledge in their keys and descriptions such naturalizations of *Sequoiadendron giganteum* in montane southern California. *Sequoiadendron* also deserves inclusion in local and regional checklists.

ACKNOWLEDGMENTS

This study was conducted while Rudolf Schmid was a Research Associate at Rancho Santa Ana Botanic Garden (RSA). We thank Prof. Richard Everett, UCB, for information about his Black Mountain study and Teresa Baranowski, USDA Forest Service, Pacific Southwest Research Station, Albany, California, for copies of T. Keeler-Wolf's (1986, 1989) unpublished reports on Hall Canyon. We greatly appreciate the many helpful comments of Vanessa Ashworth, editor of *Aliso*, and two anonymous reviewers.

LITERATURE CITED

Anonymous. Undated. [I.] Hall Canyon plant species list. [II.] Hall Canyon vertebrate species list. [III.] Hall Canyon plant invertebrate list. *http://www.jamesreserve.edu/data_arch.html* (3 May 2012). 6 p., 4 p., 10 p., respectively. [Respectively, for 242, 173, 478 species.]

Baldwin, B. G., D. H. Goldman, D. J. Keil, R. Patterson, T. J. Rosatti, and D. H. Wilken (editors). 2012. The Jepson manual: vascular plants of California, 2nd ed. University of California Press, Berkeley, USA. xxii, 1568, [2] p. [Jepson eFlora available at *http://ucjeps.berkeley.edu/IJM.html* (3 May 2012). Ed. 1 1993 by J. C. Hickman (ed.).]

Barbour, M. G. 2007. Closed-cone pine and cypress forests, pp. 296–312. *In* M. G. Barbour, T. Keeler-Wolf, and A. A. Schoenherr [eds.], Terrestrial vegetation of California, 3rd ed. University of California Press, Berkeley, USA. xvii, 712 p. [Eds. 1–2, 1977, 1988.]

Benchmark Maps. 2007. California road & recreation atlas, 5th ed. Benchmark Maps, Medford, OR, USA. 143 p. [Ed. 1 1997/98.]

Berg, K. S. 1982. Hall Canyon annotated floristic list [at head of title: James San Jacinto Mountains Reserve]. University of California, Natural Land and Water Reserves System, [Riverside?] [ii], ii, 33 p.

Boyd, S. and J. R. Griffin. 2012. *Sequoiadendron.* Giant sequoia, p. 139. *In* B. G. Baldwin, et al. [eds.], The Jepson manual: vascular plants of California, 2nd ed. University of California Press, Berkeley, USA. xxii, 1568, [2] p. [Jepson eFlora available at *http://ucjeps.berkeley.edu/IJM.html* (3 May 2012).]

Buchholz, J. T. 1938. Cone formation in *Sequoia gigantea.* I. The relation of stem size and tissue development to cone formation. II. The history of the seed cone. *Amer. J. Bot.* **25**: 296–305.

Burns, C. and J. Sauer. 1992. Resistance by natural vegetation in the San Gabriel Mountains of California to invasion by introduced conifers. *Global Ecol. Biogeogr. Letters* **2**: 46–51.

CCH: See Consortium of California Herbaria.

Chester, T. J. 2012. Native and introduced plants of southern California. *http://tchester.org/plants* (3 May 2012).

Computer Support Group. 2012. GPS latitude and longitude converter. *http://www.csgnetwork.com/gpscoordconv.html* (3 May 2012).

Consortium of California Herbaria [CCH] 2012. *http://ucjeps.berkeley.edu/consortium* or via *http://ucjeps.berkeley.edu/interchange* (3 May 2012).

DeLorme. 2008. California atlas & gazetteer, [1st ed.] DeLorme. Yarmouth, ME, USA. 160 p. [Previous eds. separate as: Northern California atlas & gazetteer, eds. 1–6, 1986–2003; Southern & central California atlas & gazetteer, eds. 1–7, 1986–2005.]

Eckenwalder, J. E. 2009. Conifers of the world: the complete reference. Timber Press, Portland, OR, USA. 720 p., [24] p. pls. [For a comparative review of Eckenwalder (2009) and Farjon (2010) see Schmid (2010).]

Elliott-Fisk, D. L., S. L. Stephens, J. E. Aubert, D. Murphy, and J. Schaber. 1997. Mediated Settlement Agreement for Sequoia National Forest, Section B. Giant Sequoia Groves: an evaluation, pp. 277–328. *In* SNEP Science Team and special consultants, Sierra Nevada Ecosystem Project: final report to Congress: status of the Sierra Nevada. Addendum. Centers for Water and Wildland Resources, University of California, Davis (series: *Wildland Resources Center report*, no. 40). iii, [i], 328 p. [*http://ceres.ca.gov/snep* (3 May 2012) for PDF.]

Everett, R. G. 2008. Dendrochronology-based fire history of mixed-conifer forests in the San Jacinto Mountains, California. *Forest Ecol. Managem.* **256**: 1805–1814.

Farjon, A. 2010. A handbook of the world's conifers, vols.1–2. [Untitled.] Brill, Leiden, The Netherlands. 1111 p. [For a comparative review of Eckenwalder (2009) and Farjon (2010) see Schmid (2010).]

Fites-Kaufman, J. A., P. Rundel, N. Stephenson, and D. A. Weixelman. 2007. Montane and subalpine vegetation of the Sierra Nevada and Cascade ranges, pp. 456–501. *In* M. G. Barbour, T. Keeler-Wolf, and A. A. Schoenherr [eds.], Terrestrial vegetation of California, 3rd ed. University of California Press, Berkeley, USA. xvii, 712 p. [Eds. 1–2, 1977, 1988.]

Flint, W. D. 2002. To find the biggest tree, [rev. ed.]. Sequoia Natural History Association, Three Rivers, CA, USA. x, [ii], 126 p. [On *Sequoia sempervirens* and especially *Sequoiadendron giganteum.* Text expanded and format much enlarged from 1987 ed.]

Google Earth. 2012. *http://earth.google.com* (3 May 2012).

Hawke, R. T. and S. Hawke. 2004. Flora of the pine belt of the San Gabriel Mountains. *http://tchester.org/sgm/plants/floras/pine_belt_hawke.html* (3 May 2012). 23 p. (print version 12 p.).

James San Jacinto Mountains Reserve 2012. *http://www.jamesreserve.edu* or *http://nrs.ucop.edu/reserves/james/james_san_jacinto.htm* (3 May 2012).

Keeler-Wolf, T. 1986. Ecological survey of the proposed Hall Canyon Research Natural Area, San Bernardino National Forest, Riverside County, California. Unpublished report on file at USDA Forest Service, Pacific Southwest Research Station, Albany, California. 94 p. [Dated "May 1986"; pagination as pp. 1–94; with B&W maps, B&W drawings, 14 color photos (as "figures" 1–14). Summarized as Keeler-Wolf 1990, 2004; see Appendix.]

———. 1989. Establishment record for Hall Canyon Research Natural Area within San Bernardino National Forest, Riverside County, California. Unpublished report on file at USDA Forest Service, Pacific Southwest Research Station, Albany, California. 78 p. [Signed "12/1/89"; pagination irregular; with B&W maps, B&W drawings, 10 color photos (as "photos" 1–10). Summarized as Keeler-Wolf 1990, 2004; see Appendix.]

———. 1990. 66. Hall Canyon (Keeler-Wolf 1986e, 1988e), pp. 154–156, 161 (1986, 1989 references), 174, 177 (plant lists). *In* T. Keeler-Wolf, Ecological surveys of Forest Service Research Natural Areas in California. *USDA For. Serv., Pac. Sw. Res. Sta., Gen. Techn. Rep.* **PSW[-GTR]-125**: [cover 2], i–iii, 1–177. [*http://www.fs.fed.us/psw/publications* (3 May 2012) for PDF. See next citation for update.]

———. 2004. 36. Hall Canyon (Keeler-Wolf 1986e, 1989k), pp. 125–128, 319–320 (1986, 1989 references), 331, 333, 335–336 (plant lists) *In* S. Cheng [ed.], USDA Forest Service Research Natural Areas in California. *USDA For. Serv., Pac. Sw. Res. Sta., Gen. Techn. Rep.* **PSW-GTR-188**: [cover 2], 1–338. [*http://www.fs.fed.us/psw/publications* (3 May 2012) for PDF. Cheng (2004) updates Keeler-Wolf (1990).]

Krugman, S. L. and K. N. Boe. 2008. *Sequoiadendron giganteum* (Lindl.) Buchholz. Giant sequoia. Taxodiaceae—redwood family, pp. 1037–1038 *In* F. T. Bonner and R. P. Karrfalt [eds.], The woody plant seed manual. *USDA For. Serv. Agr. Handbk.* **727**: i–x, 1–1223 [*http://www.nsl.fs.fed.us/nsl_wpsm.html* for PDF. Supersedes: U. S. Forest Service, 1948, Woody-plant seed manual, *USDA For. Serv. Misc. Pub.* **654**: i–vi, 1–416; C. S. Schopmeyer (techn. coordinator), 1974, Seeds of woody plants in the United States, *USDA For. Serv. Agr. Handbk.* **450**: i–viii, 1–883, [16] pp. pls.; J. A. Young and C. G. Young, 1992, Seeds of woody plants in North America, revised and enlarged ed., Dioscorides Press, Portland, OR, USA (series: *Biosystematics, floristic & phylogeny series*, vol. 4), vii, 407 p.]

Lanner, R. M. 1999. Conifers of California. Cachuma Press, Los Olivos, CA, USA. x, 274 p.

Lewis, W. H. 1971. An ecological vocabulary for the Flora North America program. FNA Secretariat, Smithsonian Institution, Washington, D.C. (series: *FNA Rep.*, no. 57). [i], 23 leaves. [Revision of W. H. Lewis, 1970, Ecological vocabulary: a preliminary checklist for FNA (*FNA Rep.* 34), 12 leaves.]

Moore, J. A., C. E. Taylor, and B. C. Moore. 1979. The *Drosophila* of southern California. I. Colonization after a fire. *Evolution* **33**: 156–171.

Northwest Illinois Forestry Association. 2012. Glossary of forestry terms. *http://www.nifatrees.org/Glossary.html* (3 May 2012).

Roberts, F. M., Jr., S. D. White, A. C. Sanders, D. E. Bramlet, and S. Boyd. 2004. The vascular plants of western Riverside County, California: an annotated checklist. F. M. Roberts Publications, San Luis Rey, CA, USA. 192 p.

———, ———, ———, ———, and ———. 2007. Additions to the flora of western Riverside County, California. *Crossosoma* **33**: 55–69.

Rogers, R. R. 1986. Management of giant sequoia in the national forests of the Sierra Nevada, California, pp. 32–36. *In* C. P. Weatherspoon, Y. R. Iwamoto, and D. D. Piirto [techn. coordinators], Proceedings of the workshop on management of giant sequoia, May 24–25, 1985, Reedley, California. *USDA For. Serv.*, *Pac. Sw. For. Range Exp. Sta.*, *Gen. Techn. Rep.* **PSW[-GTR]-95**: i–iii, 1–47. [*http://www.fs.fed.us/psw/publications* (3 May 2012) for PDF.]

Roof, J. B. [comp]. 1959. Guide to the plant species of the Regional Parks Botanic Garden, Charles Lee Tilden Regional Park of the East Bay Regional Park District. East Bay Regional Park District, Oakland, CA (series: *Botanic publication*, no. 2). 145 p. [unpaginated], [1] p. pls.

Rundel, P. W. 1972. Habitat restriction in giant sequoia: the environmental control of grove boundaries. *Amer. Midl. Nat.* **87**: 81–99.

Schellevis, N. and J. Schouten. 1999. Giant sequoia (*Sequoiadendron giganteum* (Lindl.) Buchholz), pp. 92–94. *In* A. Farjon and C. N. Page [comp.], with IUCN/SSC Conifer Specialist Group, Conifers: Status Survey and Conservation Action Plan. IUCN: The World Conservation Union, Gland, Switzerland. ix, 121 p. [*http://www.iucn.org* (3 May 2012) for PDF.]

Schmid, R. 2010. Coniferous clash of the titans. *Taxon* **59**: 1951–1955 [Comparative review of Eckenwalder 2009 and Farjon 2010.]

———. 2012. John Theodore Buchholz (1888–1951) studying conifers in California, especially *Sequoiadendron* and *Sequoia* (Cupressaceae) in 1936. *Aliso* **30**: 5–17.

——— and M. Schmid. 2011. Noteworthy collection: California: *Sequoiadendron giganteum* (Lindl.) J. Buchholz (Cupressaceae) (giant sequoia, big tree, or Sierra redwood). *Madroño* **58**: 202–203 [Issued 2012. Preliminary report for present account of naturalization on Black Mountain.]

Schoenherr, A. A. 1992. A natural history of California. University of California Press, Berkeley, USA (series: *California natural history guides*, 56) (imprint: A centennial book). xi, 772 p., 16 p. pls.

SORTIE-ND: software for spatially-explicit simulation of forest dynamics. 2011. Trees [tree life history stages; tree life history stage transitioning—growth and death; tree organization; tree population initial conditions—densities and maps; tree parameters]. *http://www.sortie-nd.org/help/manuals/help/data/trees.html* (3 May 2012).

Stark, N. 1968. The environmental tolerance of the seedling stage of *Sequoiadendron giganteum. Amer. Midl. Nat.* **80**: 84–95.

Swinney, D. and A. C. Sanders. 2008. Plants of the eastern San Gabriel Mountains: an initial checklist. *http://www.glendoranaturalhistory.com/East_San_Gabriel_Plants.html* (3 May 2012). 32 p.

Tom Harrison Maps. 2006. San Jacinto Wilderness trail map. Tom Harrison Maps, San Rafael, CA, USA.

United States Forest Service Pacific Southwest Region. 2012. Forest visitor maps. *http://www.fs.fed.us/r5/forestvisitormaps* (3 May 2012). [For downloadable PDFs of print versions.]

United States Geological Survey (USGS) Geographic Names Information System (GNIS). 2012. *http://geonames.usgs.gov/pls/gnispublic* (3 May 2012).

US Forest Service. 2010. Native plant materials policy and authorities. *http://www.fs.fed.us/wildflowers/nativeplantmaterials/policy.shtml* (3 May 2012).

Walter, H. S., T. Brennan, C. and C. Albrecht. 2005. Fire management in some California ecosystems: a cautionary note, pp. 257–260 *In* B. E. Kus and J. L. Beyers [techn. coordinators], Planning for biodiversity: bringing research and management together: proceedings of a symposium for the south coast ecoregion, February 29–March 2, 2000, Pomona, California. *USDA For. Serv.*, *Pac. Sw. Res. Sta.*, *Gen. Techn. Rep.* **PSW-GTR-195**: [cover 2], [i–ii], i–v, 1–274. [*http://www.fs.fed.us/psw/publications* (3 May 2012) for PDF.]

Weatherspoon, C. P. 1990. *Sequoiadendron giganteum* (Lindl.) Buchholz. Giant sequoia. Taxodiaceae. Redwood family, pp. 552–562. *In* R. M. Burns, and B. H. Honkala [techn. coordinators], Silvics of North America, vol. 1, Conifers. *USDA For. Serv. Agr. Handb.* **654**: i–vi, 1–675. [Vol. 2. Hardwoods, by Burns and Honkala, also *Agr. Handb.* **654**: i–viii, 1–877. Both supersede H. A. Fowells (comp.), Silvics of forest trees of the United States, *Agr. Handb.* **271**: i–vi, 1–762 (1965, 1975 reprint). *http://www.demoforests.net/publications.html* (3 May 2012) for PDFs.]

Western Regional Climate Center. 2012. *http://www.wrcc.dri.edu* (3 May 2012).

Wikipedia. 2012. List of giant sequoia groves. *http://en.wikipedia.org/wiki/List_of_giant_sequoia_groves* (3 May 2012). [With a table for the groves, giving for each: name, location, GPS coordinates (in DMS format and linked to Google Earth, and other online mappers), elevation, and comments.]

Willard, D. 1995. Giant sequoia groves of the Sierra Nevada: a reference guide, 2nd ed. The Author, Berkeley, CA, USA. xix, [ii], 361 p. [Ed. 1 1994.]

———. 2000. A guide to the sequoia groves of California. Yosemite Association, Yosemite National Park, 124 p. [On *Sequoiadendron giganteum*, not *Sequoia sempervirens.*]

appendix

(Keeler-Wolf's 1986, 1989 Unpublished Reports on Hall Canyon)

In May 1985 Todd Keeler-Wolf did an environmental analysis of Hall Canyon that resulted in two unpublished reports for the US Forest Service (respectively, Keeler-Wolf 1986, 1989): (1) in May 1986 a 94-page ''Ecological survey of the proposed Hall Canyon Research Natural Area, San Bernardino National Forest, Riverside County, California'' and (2) in December 1989 a 78-page ''Establishment record for Hall Canyon Research Natural Area within San Bernardino National Forest, Riverside County, California.'' These reports were required documentation for the establishment in 1990 of Hall Canyon as a ''Research Natural Area'' (RNA) of the Forest Service. The reports, especially Keeler-Wolf (1986), were summarized and published in 1990 and 2004, the text of the latter being reformatted but minimally updated (Keeler-Wolf 1990, 2004). Both later publications cite the two earlier unpublished reports.

The relevant text, a mere sentence, that tantalized us is: ''Conflicting Impacts: … A small area of the 1974 burn was revegetated with non-native giant sequoia (*Sequoiadendron giganteum*)'' (Keeler-Wolf 1990: 156, 2004: 128). The revegetation presumably was done by the United States Forest Service but was the unspecified ''small area'' located in upper Hall Canyon and/or just above it?

We thus sought answers in the unpublished reports (Keeler-Wolf 1986, 1989). The 1986 report states (p. 59): ''After the fire of 1977 [1974, not ''1977''], the Forest Service replanted a small portion of the upper drainage. Although only a small area (perhaps less than 2 ha) was planted I was surprised to see *Sequoiadendron giganteum* among the most frequently planted species (the most commonly planted species is probably *Pinus jeffreyi*). Big tree was apparently chosen for its smog tolerance and rapid growth. However, there is little or no evidence of widespread damage to any of the native species at this elevation from smog. Little need be said on the subject of plantings of non-natives such as giant sequoia in a

potential scientific reserve. In addition, even though the other planted species are native to the drainage there is little doubt that the planted seedlings are of a different genetic stock than the native individuals. With ill-conceived established plantings of any kind the area must relinquish the title of 'natural area.' Natural post-fire regeneration of *Pinus jeffreyi*, *P. lambertiana*, *Calocedrus decurrens*, and resprouts of *Quercus chrysolepis* are growing rapidly on the burn and should be sufficient to revegetate the area in natural forest.''

The 1986 ecological report does not mention *Sequoiadendron* elsewhere. The 1989 establishment report does not refer to this taxon at all.