

BROMUS HALLII (POACEAE), A NEW COMBINATION FOR
CALIFORNIA, U.S.A., AND TAXONOMIC NOTES
ON BROMUS ORCUTTIANUS AND BROMUS GRANDIS

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ABSTRACT

Herbarium study of *Bromus grandis*, *B. orcuttianus*, and *B. orcuttianus* var. *hallii* from western North America has indicated that these taxa are morphologically and geographically distinct, and best treated as species. A new combination ***Bromus hallii*** (Hitc.) Saarela & P.M. Peterson is made. *Bromus hallii* differs from *B. orcuttianus* by having densely pubescent blades (verses glabrous in *B. orcuttianus*), lower sheaths with dense short stiff hairs 1 mm long or less (vs. long soft hairs 2–4 mm long), and 1–2(–3) culm nodes (vs. 2–4). *Bromus hallii* differs from *B. grandis* by having blades that are 7.5–16.5 cm long [vs. (13–)18–38 cm long in *B. grandis*], 1–2(–3) culm nodes (vs. 3–7), and lower glumes that are 1(–3)-nerved [vs. 3(1)-nerved]. We provide the first report of differences in the type of pubescence on the lower sheaths between *B. orcuttianus* and *B. hallii*. We confirm the diploid chromosome number of $2n = 14$ for *B. grandis*. We include descriptions, synonymies, and representative specimens examined for *B. grandis*, *B. hallii*, and *B. orcuttianus*, a key to all sections of *Bromus* in California, and a key to *Bromus* sect. *Bromopsis* in California.

RESUMEN

El estudio de *Bromus grandis*, *B. orcuttianus* y *B. orcuttianus* var. *hallii* de Norteamérica occidental ha indicado que estos taxa son morfológica y geográficamente diferentes, y están tratados mejor como especies distintas. Se hace una nueva combinación ***Bromus hallii*** (Hitc.) Saarela y P.M. Peterson. *Bromus hallii* se diferencia de *B. orcuttianus* por tener láminas densamente pubescentes (contra glabras en *B. orcuttianus*), vainas inferiores con los pelos rígidos cortos de 1 mm largo o menos (contra los pelos suaves largos de 2–4 mm), y 1 ó 2(–3) nudos en el culmen (contra 2–4). *Bromus hallii* se diferencia de *Bromus grandis* por tener las láminas de 7.5–16.5 cm de largo (contra 18–38 cm en *B. grandis*), 1 ó 2 nudos en el culmen (contra 3–6), y glumas inferiores 1(–3)-nervadas [contra 3(1)-nervadas]. Proporcionamos el primer informe de diferencias en el tipo de pubescencia en las vainas inferiores entre *B. orcuttianus* y *B. hallii*. Confirmamos el número diploide de cromosomas de $2n = 14$ para *B. grandis*. Incluimos descripciones, sinonimias, y especímenes representativos examinados de

TABLE 1. Diagnostic characters separating *Bromus grandis*, *B. hallii*, and *B. orcuttianus*.

Characters	<i>B. grandis</i>	<i>B. hallii</i>	<i>B. orcuttianus</i>
Leaf blades	pubescent	pubescent	glabrous, occasionally pilose near base
Lower leaf sheaths	densely pubescent, hairs up to 1(-3) mm long	densely pubescent, hairs up to 1 mm long	sparsely to moderately pilose, hairs 2-4 mm long, occasionally glabrous
Culm nodes	3-7	1-2(-3)	2-4
Leaf blade length	(13)18-38 cm	7.5-16.5 cm	7-24 cm
Glume surface	pubescent	pubescent	glabrous, scabrous, or pubescent
Lemma surface	pubescent	pubescent	glabrous or pubescent
Lower glumes, number of veins	3(1)	1(3)	1(3)
Awn length	3-6 mm	3.5-7 mm	(4-)5.5-8 mm
Inflorescence branches	flexuous, usually spreading > 90° from culm axis	stiff, erect, ascending and appressed, to spreading not > 90° from culm axis	stiff, erect, ascending and appressed, to spreading not > 90° from culm axis

Stebbins and Love (1941) reported a diploid chromosome count of $2n = 14$ for *B. orcuttianus*, and this was confirmed by counts by Wagnon (1952). Stebbins and Love (1941) synonymized *B. orcuttianus* var. *hallii* with *B. orcuttianus*, thus it is unclear if they obtained counts for material that we are treating here as *B. hallii*. Wagnon (1952) was unable to obtain living material of *B. hallii*, and attempts to germinate seeds of *B. hallii* for chromosome counts in this study were unsuccessful. The chromosome number of *B. hallii* remains unknown.

Bromus hallii and *B. orcuttianus* differ in their geographic distributions and mean (μ) elevations. *Bromus hallii* is a narrowly distributed species that occurs in southern California in the mountains of Kern, Fresno, Los Angeles, Monterey, Santa Barbara, San Bernardino, and Tulare counties, at high elevations ($\mu = 6658$ ft; $n = 29$). *Bromus orcuttianus* has a much wider range, occurring in the mountains throughout California, Oregon, southern Washington, eastern Nevada, and southeastern Arizona (Piper 1906; Wagnon 1952; Kearney et al. 1960; Pavlick 1995), generally at lower elevations ($\mu = 5306$ ft; $n = 40$).

Bromus hallii and *B. grandis* are distinguished morphologically by a combination of vegetative and reproductive characteristics (Table 1). The distribution and type of pubescence on the blades, sheaths, and spikelets is similar in *B. hallii* and *B. grandis*, although two specimens of *B. grandis* seen (Wolf 6888 and

B. grandis, *B. hallii* y *B. orcuttianus*, una clave de todas las secciones de *Bromus* en California, y una clave de *Bromus* sect. *Bromopsis* en California.

Bromus L. is a large genus of approximately 160 species that are distributed worldwide in temperate regions. The genus is distinguished from other grass genera by the combination of leaf sheaths that are connate for most of their length, awns that are inserted subapically, and hairy appendages on the apices of the ovary (Clayton & Renvoize 1986). In the New World, 79 native and introduced species are currently recognized (Pavlick et al. 2003), although new species are being described (e.g., Saarela et al. in review) and the taxonomic boundaries of several difficult species complexes have been reevaluated (e.g., Peterson et al. 2002; Oja et al. 2003; Massa et al. 2004). Molecular phylogenetic investigations have clarified several aspects of the evolutionary history of *Bromus*, and have identified major lineages in the genus, some of which correspond to commonly recognized intrageneric taxa (Pillay & Hilu 1990, 1995; Ainouche & Bayer 1997; Saarela et al. in press). A new classification of the genus has not yet been proposed, pending further study of morphological and molecular variation.

Bromus sect. *Bromopsis* Dumort., the largest of the traditionally recognized sections in the genus, is a non-monophyletic taxon comprised of several lineages that occur in North America, Mexico, South America, and Eurasia (Saarela et al. in press). The section is characterized morphologically by 1(3)- and 3(5)-nerved first and second glumes, lemmas that are dorsally flattened, and a perennial habit (Smith 1970), although some of these characteristics may be symplesiomorphies. In North America north of Mexico, there are 16 native species in section *Bromopsis* that have diversified in a variety of habitats (Pavlick 1995; Pavlick & Anderton, in press). Some species are wide-ranging (e.g., *B. ciliatus* L.), whereas others are highly restricted in distribution [e.g., *B. texensis* (Shear) Hitchc.]. Several taxa (*B. laevipes* Shear, *B. orcuttianus* Shear, *B. orcuttianus* var. *hallii* Hitchc., *B. pseudolaevipes* Wagnon, and *B. suksdorfii* Vasey) are restricted to mountainous regions in the southwestern part of the continent, largely in California (Pavlick 1995). Others [e.g., *B. porteri* (J.M. Coult.) Nash, *B. richardsonii* Link, *B. vulgaris* (Hook.) Shear] have broader distributions in western North America. While studying *Bromus* specimens from California to support preparation of the taxonomic treatment of *Bromus* for the Second Edition of the Jepson Manual (Saarela & Peterson, in prep.), it became clear that *B. orcuttianus* var. *hallii*, despite its varietal rank, is a readily identifiable taxon that can be consistently and reliably distinguished from both *B. orcuttianus* var. *orcuttianus* and *B. grandis*. These preliminary observations stimulated a more detailed investigation of its morphological variation and taxonomic status.

Vasey (1885) named and described *B. orcuttianus* based on collections by C.R. Orcutt from the mountains near San Diego, and collections by W.N. Suksdorf from Mt. Adams in Washington. In his revision of the North American

species of *Bromus*, Shear (1900) recognized *B. orcuttianus*, and described larger plants from La Maite, San Diego, with pubescent sheaths, leaves, culms, and spikelets as a new variety, *B. orcuttianus* var. *grandis* Shear. Hitchcock (in Jepson 1912) described plants from the mountains of southern California with densely pubescent blades and cataphylls, and pubescent glumes and lemmas as a new variety, *B. orcuttianus* var. *hallii* Hitchc. Hitchcock (in Jepson 1912) also elevated *B. orcuttianus* var. *grandis* to a species, *B. grandis* (Shear) Hitchc., indicating that it is similar to *B. orcuttianus* var. *hallii*, but differs in its drooping panicle and distinctly 3-nerved lower glumes. Subsequent authors have recognized *B. grandis*, *B. orcuttianus*, and *B. orcuttianus* var. *hallii* in their treatments (e.g., Hitchcock & Chase 1951; Wagnon 1952; Munz & Keck 1959; Hitchcock et al. 1969; Munz 1974; Wilken & Painter 1993; Pavlick 1995; Pavlick & Anderton, in press) although Clayton and Williamson (2002 onwards) synonymized *B. orcuttianus* var. *hallii* with *B. orcuttianus*. In his revision of *Bromus* sect. *Bromopsis* in North America, Wagnon (1952) hypothesized that *B. orcuttianus* var. *hallii* is equally related to *B. grandis* and *B. orcuttianus*, and indicated that it requires further study. Among species of *Bromus* sect. *Bromopsis* in North America, *B. orcuttianus* var. *hallii* is the only taxon recognized currently at the varietal level, even though the characteristics separating it from *B. orcuttianus* var. *orcuttianus* and *B. grandis* are similar in degree to those separating other morphologically similar species of *Bromus*. Here we discuss the morphological, cytological, geographical, and ecological characteristics of these three taxa, and propose a new combination, *B. hallii* (Hitchc.) Saarela & P.M. Peterson. We include synonymies, species descriptions, distributions, and specimens examined for *B. grandis*, *B. hallii*, and *B. orcuttianus*, and keys to the sections of *Bromus* in California, and *Bromus* section *Bromopsis* in California.

MATERIAL AND METHODS

This study is based on examination of over 425 herbarium specimens from CAS, DAO, K, OSU, UBC, UC/JEPS, US, W, and WTU, including most type specimens. Specimens were measured to generate morphological descriptions. Data on geographic distribution, elevation, and habitat were obtained from herbarium specimen labels. Cytological observations of *B. grandis* were carried out by the third author on living material germinated from seeds collected in 1994 (*Cayouette & Darbyshire C7947*). Detailed procedures for the chromosome count are provided in Peterson et al. (2002). The taxonomic key was generated through study of the literature and representative herbarium specimens at US.

RESULTS AND DISCUSSION

Bromus orcuttianus, *B. orcuttianus* var. *hallii*, and *B. grandis* are morphologically similar taxa that have been recognized as distinct for almost a century. Examination of morphological variability among individuals from across the

range of these three taxa indicates that they are each easily distinguished by a combination of quantitative and qualitative characteristics, and each has a distinctive geographic distribution. The degree of difference among the three taxa is approximately the same, although one taxon is recognized currently at the varietal level while two are recognized as species. It would be equally logical (although not valid nomenclaturally) to classify individuals currently included in *B. orcuttianus* var. *hallii* as an intraspecific taxon of *B. grandis*, if emphasis were placed on vegetative rather than reproductive characteristics when making taxonomic decisions. To minimize such ambiguity, either one wide-ranging polymorphic species could be recognized, or each morphologically and geographically distinct taxon could be treated as a species. We prefer the latter approach, and propose a new combination, *B. hallii* (Hitchc.) Saarela & P.M. Peterson to accommodate this. This morphological-geographical approach to circumscribing species follows existing treatments of *Bromus* sect. *Bromopsis* in North America, in which taxa with consistent morphological characteristics throughout their ranges are treated as species (e.g., Pavlick 1995; Pavlick & Anderton, in press; Saarela & Peterson, in prep).

Bromus hallii and *B. orcuttianus* are distinguished morphologically by several qualitative characteristics, including the presence or absence of pubescence on the blades, the type of pubescence, and the number of culm nodes (Table 1). *Bromus hallii* is characterized by blades that are densely pubescent abaxially and adaxially, lower sheaths that are densely pubescent with short, stiff hairs up to 1 mm long, and culms with 1-2(-3) nodes. In contrast, *B. orcuttianus* has blades that are glabrous abaxially and adaxially (sometimes with pilose margins towards the base), lower sheaths that are sparsely to densely pilose (occasionally glabrous) with long, soft hairs up to 4 mm long that are easily visible with the naked eye, and culms with 2-4 nodes. Previous authors (e.g., Hitchcock 1951; Pavlick 1995) noted that these two taxa differ in the distribution of the pubescence on the leaves, but they were apparently not aware of the differences noted here in the type of pubescence on the lower sheaths. Additional morphological characteristics distinguish *B. hallii* and *B. orcuttianus*, but there is some overlap in these character states. *Bromus hallii* consistently has pubescent glumes, lemmas, and blades that range in length from 7.5-16.5 cm long, whereas *B. orcuttianus* has glumes that are usually glabrous but sometimes scabrous or pubescent, lemmas that range from glabrous to pubescent, and leaf blades that range in length from 7-24 cm long. The morphology of the inflorescence is the same in both taxa, with stiff branches that are erect and appressed to spreading not more than 90° from the rachises. Good illustrations of the general habit and inflorescence morphology of *B. orcuttianus* and *B. hallii* are found in Pavlick (1995), but these do not adequately emphasize the diagnostic differences of the type of pubescence found on the lower leaf sheaths or the differences in culm node number.

Silveus 2829) have longer hairs up to 3 mm long on the blades and sheaths. The taxa differ in their blade lengths, number of culm nodes, number of nerves on the lower glume, and inflorescence morphology. *Bromus hallii* has blades that are 7.5–16.5 cm long [vs. (13–)18–38 cm long in *B. grandis*], 1–2(–3) culm nodes (vs. 3–7), and lower glumes that are 1(3)-nerved [vs. 3(1)-nerved]. *Bromus hallii* has panicles with stiff branches that are erect or spreading not more than 90° from the culm axis, whereas *B. grandis* has panicles with flexuous branches that are spreading often more than 90° from the culm axis. In immature specimens of *B. grandis* (those collected in late May and early June), the panicles appear similar in morphology to those found in *B. orcuttianus* and *B. hallii*, thus this characteristic should only be used on fully mature specimens. A good illustration of the inflorescence morphology of *B. grandis* is found in Hitchcock (1951). Wagnon (1952) indicated in his taxonomic keys that *B. hallii* differs from *B. grandis* in having cucullate (boat-shaped) blade tips, but thorough examination of this character indicates that several individuals of *B. grandis* share this character state, making this an unreliable character. Stebbins and Love (1941) reported a diploid chromosome number of $2n = 14$ for *B. grandis*. Wagnon (1952) did not have fresh material of *B. grandis* for chromosome counts. Our cytological observations of *B. grandis* confirm the diploid number $2n = 14$. Like *B. hallii*, *B. grandis* is a narrowly distributed species endemic to southern California, known from the mountains in the southern counties and in the coastal ranges from Santa Cruz to San Diego counties. *Bromus grandis* generally occurs at much lower elevations ($\mu = 3267$ ft; $n = 25$) than *B. hallii* ($\mu = 6658$ ft; $n = 29$).

Recognition of *B. hallii* as a distinct species increases the number of species in *Bromus* section *Bromopsis* in California to 11, 10 of which are native, and one that is introduced (*B. inermis* Leyss.). Keys distinguishing the sections of *Bromus* and the species of sect. *Bromopsis* in California are presented below. A revised key distinguishing all 34 native and introduced species of *Bromus* in California will be published in the Second Edition of the Jepson Manual (Saarela and Peterson, in prep).

TAXONOMIC TREATMENT

Bromus grandis (Shear) Hitchc., Fl. Calif. 1:175. 1912. *Bromus orcuttianus* var. *grandis* Shear, Bull. Div. Agrostol., U.S.D.A. 23:43. 1900. *Bromopsis grandis* (Shear) Holub, Folia Geobot Phytotax. 8(2):167. 1973. TYPE: U.S.A. CALIFORNIA. San Diego Co.: La Maite, 25 Jun 1883, C.R. Orcutt 472 (HOLOTYPE: US-81613).

Bromus porteri var. *assimilis* Burt Davy, Univ. Calif. Publ. Bot. 1:55. 1902. TYPE: U.S.A. CALIFORNIA: south side, San Jacinto Mts, 1901, H.M. Hall 2228 (HOLOTYPE: UC-37692; ISOTYPE: US-86543 fragm. ex UC).

Loosely caespitose perennial. Culms 70–180 cm tall, erect, glabrous to pubescent; nodes 3–7, dark brown, retrorsely pilose below, often covered by sheaths. Leaf sheaths 3.5–12 cm long, closed for most of their length; sheaths densely

pubescent, hairs up to 1 mm long; margins smooth, occasionally hyaline at apex; collars densely pilose, with hairs up to 2 mm long, auricles sometimes present; cataphylls and basal sheaths pubescent, sometimes shredding; ligules 1–3 mm long, membranous, densely pubescent to pilose adaxially, glabrous abaxially, apex obtuse, erose; blades (13–)18–38 cm long, 3–12 mm wide, flat, membranous, apically cucullate, sparsely to densely pubescent adaxially and abaxially, hairs up to 1(–3) mm long; margins glabrous, sparsely papillate or scabrous. Panicles 15–26 cm long, 6–17.5 cm wide, open; lower branches 5–26 cm long with 1–6 spikelets, flexuous, nodding and usually spreading more than 90° from the rachises, pubescent; lower inflorescence nodes with 1–4 branches. Spikelets 2.5–3.5(–4.5) cm long, 4–9-flowered, terete to conspicuously distichous at maturity with rachis visible; glumes subequal, shorter than lemmas, pubescent, margins sometimes hyaline; lower glumes 5–8.5 mm long, 3(1)-nerved, apex acute; upper glumes 7–10(–12) mm long, 3(5)-nerved, apex acute; lemmas 11–14 mm long, margins pubescent, backs glabrous to densely pubescent, marginal hairs sometimes longer; backs flattened dorsally; apex entire or minutely bifid, the teeth not greater than 0.2 mm long; awned just below apex, awns 3–6 mm long, straight; paleas 8–11 mm long, shorter than lemma, backs glabrous or slightly pubescent, margins usually pubescent; apex acute; anthers 3–5 mm long, yellowish-orange. Caryopses about 9 mm long, linear, dark brown. Chromosome number $2n = 14$.

Distribution.—Endemic to southern California; San Gabriel Mts., Santa Lucia Mts., San Bernardino Mts., San Antonio Mts., San Jacinto Mts., San Rafael Mts., and Topatopa Mts.

Habitat.—Dry areas in open pine woods, hillsides, and rocky slopes; elevation 1200–8000 ft.

Specimens examined. **U.S.A. California:** **Fresno Co.:** junction N of South Fork of Kings River, 1 May 1923, *Duncan s.n.* (CAS); Kings Canyon road 4.3 mi W of Horseshoe Bend, 3600 ft, 6 Jun 1960, *Howell* 35330 (CAS); Kaiser, 27 Jun 1935, *Bullard* 95 (UC/JEPS). **Los Angeles Co.:** San Dimas Canyon, San Gabriel Mts, 1750 ft, 4 Jul 1933, *Wheeler* 1894 (CAS, US); San Gabriel Mts, 3500 ft, 4 Jul 1933, *Ewan* 7857 (US); San Gabriel Mts, East Fork, Big Santa Anita Canyon, 2250 ft, 30 May 1931, *Ewan* 4249 (US); Little Santa Anita Canyon, 2 July 1902, *Abrams* 2632 (CAS, US); San Gabriel Mts, Bell Canyon, 2300 ft, 8 Jun 1936, *Wheeler* 4134 (CAS); San Gabriel Mts, Indian Canyon Camp, 2 mi off Soledad Canyon, 3000 ft, 27 May 1936, *Wolf* 7845 (CAS, W); San Gabriel Peak, 9 Jul 1900, *Dudley s.n.* (CAS); San Gabriel Mts., 990 m, 1 Sep 1994, *Cayouette & Darbyshire* C7947 (DAO); Summit of Mt. Wilson, 29 Jun 1902, *Abrams* 2600 (CAS, US); San Gabriel Mts, Big Tujunga Creek between Coldwater and Wickiup Canyons, 10 Jul 1992, *Ross* 6671 (UC/JEPS); Horse Flats, San Gabriel Mts, 16 Aug 1991, *Ross* 5873 (UC/JEPS); Roundtop Mtn, San Gabriel Mts, Chilao Flat, 14 Aug 1991, *Ross* 5780 (UC/JEPS). **Madera Co.:** 0.5 mi S of Southfork, 17 Jun 1933, *Hormay* 26 (UC/JEPS). **Monterey Co.:** Pico Blanco, 11 May 1901, *Davy* 7339 (US); Santa Lucia Mts, Jun 1901, *Davy* 7691 (US); Tassajara Hot Springs, Jun 1901, *Elmer* 3398 (CAS, US); Little Sur, 14 May 1901, *Davy* 7385 (US); coast range W of King City, 8 Jun 1927, *Swallen* 596 (US); Gavilan Peak, 3000 ft, 1 Jul 1861, *Brewer* 740 (US); Alder Creek, Santa Lucia Mts, 3000 ft, 23 Jul 1958, *Hardham* 3789 (CAS); Arroyo Seco River Canyon near Hanging Valley, 2 Jun 1957, *Howell* 32566 (CAS); Arroyo Seco River, Santa Lucia Mts, 5 Jun 1959, *Hardham* 4796 (CAS); Cruikshank Trail, Santa Lucia

Mts, 26 May 1963, *Howitt 1589* (CAS); Frances Simes Hastings Natural History Reservation, Santa Lucia Mts, 22 Jul 1944, *Linsdale s.n.* (CAS); Frances Simes Hastings Natural History Reservation, upper Carmel Valley, about 2 mi NE of Jamesburg, 22 Aug 1942, *Durham s.n.* (CAS); Nacimiento Summit, Santa Lucia Mts, 2800 ft, 18 Jun 1955, *Munz 20886* (CAS); near Carmel River, 26 Jun 1905, *Dudley s.n.* (CAS); near Nacimiento Summit Camp, Santa Lucia Mts, 26 Jun 1957, *Raven 10987* (CAS); Santa Lucia Mts, bank by road from Arroyo Seco Camp to Escondido Camp, 24 Jun 1956, *Howitt 980* (CAS); Santa Lucia Mts, between Middle and South Forks of Devil's Creek near Canogas Falls, 2000 ft, 23 May 1983, *Carpenter 218* (CAS); Santa Lucia Mts, Landels-Hill Big Creek Reserve, Gamboa Point Section, 27 May 1982, *Genetti & Engles 393* (CAS); Santa Lucia Mts, San Miguel Creek, below confluence with Anthony Creek, ca. 5 air km WNW of San Miguelito Ranch Ruins, 390 m, 5 Jun 1999, *Wilken 15707* (CAS); Santa Lucia Mts, South Fork Devil's Canyon, along Gamboa Trail near saddle of Twin Peak and Peak 3850, 4 Jun 1983, *Carpenter 257* (CAS); Santa Lucia Mts, Jun 1901, *Davy 7653, 7718, 7720* (UC/JEPS). **Orange Co.:** Santiago peak, 20 Jun 1927, *Swallen 640* (US); Silverado Canyon, 640 m, 3 Sep 1994, *Cayouette & Darbyshire C7953* (DAO); Santa Lucia Mts, Mill Creek, 25 May 1941, *Hoover 5260* (K). **Placer Co.:** N branch of Middle Fork of American River, at road crossing E of Forest Hill, 20 Jul 1952, *Stebbins et al. 5132* (CAS). **Riverside Co.:** San Jacinto Mts, Idyllwild Area, N of Strawberry Valley, between Bear Trap Cyn and Lily Creek, 5200–5300 ft, 1 Aug 1996, *White 4442* (CAS); Colorado Desert, 1889, *Palmer s.n.* (US); Fuller Creek, 29 Jun 1936, *Yates 6383* (UC/JEPS). **San Benito Co.:** Pinnacles National Monument, 3 Jun 1939, *Stebbins 2773* (UC/JEPS). **San Bernardino Co.:** San Bernardino Mts, 29 May & 28 Jun 1888, *Parish 2053* (US); San Bernardino Mts, 3300 ft, 13 Jun, *Reed 1011* (US); San Bernardino Mts, 29 May 1890, *Parish s.n.* (US); San Bernardino Mts, road below Highland and Running Springs, 26 Jun 1942, *Beetle 3645* (UBC); San Antonio Mts, 8000 ft, 28 Jul 1917, *Johnston 1407* (UC/JEPS, US); N of Snow Canon, 5500 ft, 20 Jun 1901, *Parish 5038* (CAS); San Bernardino Mts, 2500 ft, 5 Jun 1917, *Parish 11304* (CAS, UC/JEPS); San Bernardino Mts, road between Highland and Running Springs, 26 Jun 1942, *Beetle 3645* (CAS); San Bernardino Mts, 29 May 1888, *Parish s.n.* (CAS); San Bernardino Mts, 3000 ft, 29 Jun 1888, *Parish 2053* (CAS); San Bernardino Mts, Dobbs trail, Mill Creek, 2 Jul, *Crawford s.n.* (CAS); San Bernardino Nil Forest, road 38, near Angelus, 1654 m, 2 Sep 1994, *Cayouette & Darbyshire C7949* (DAO); 0.5 mi S of Santa Ana River, 26 Jun 1937, *Yates 6688* (UC/JEPS). **San Diego Co.:** Cleveland National Forest, 30 Jun 1915, *Hitchcock 13160* (US). **San Luis Obispo Co.:** between Rocky Butte and Pine Mt., Santa Lucia Mts, 21 Jun 1950, *Hoover 7998* (CAS, UC/JEPS); near Rocky Butte Fire Lookout, 12 June 1964, *Hoover 9076* (CAS). **Santa Barbara Co.:** San Rafael Mts, Potrero on SE side of Cachuma Peak, 4000 ft, 12 Jun 1961, *Blakley 4491* (CAS, US); N side of La Cumbre Peak, Santa Ynez Mts, 3600 ft, 5 Dec 1958, *Pollard s.n.* (CAS); Romero Canyon, Santa Ynez Mts, 7 Jul 1951, *Pollard s.n.* (CAS); W fork of Cold Spring Canyon, Santa Barbara, 16 Jun 1965, *Pollard s.n.* (CAS); Santa Ynez Mountains, 5 mi E of Santa Barbara, 12 Sep 1994, *Cayouette & Darbyshire C7971* (DAO); bank of Camino Cielo, E of and near San Marcos Pass, 2000 ft, 10 Jun 1958, *Pollard s.n.* (W); Zaca Lake Forest Reserve, 19–30 Jun 1906, *Eastwood 719* (UC/JEPS). **Santa Cruz Co.:** near Eagle Rock, 2500 ft, *Hesse 2731* (CAS); Santa Cruz, 27 Jun 1938, *Silveus 2829* (CAS). **Tuolumne Co.:** Tuolumne River at Early Intake dam, 10 mi W of Mather, 1 Jul 1951, *Stebbins 5000* (UC/JEPS). **Ventura Co.:** Red Reef Canyon, Topatopa Mts, 2800–3500 ft, 8 Jun 1908, *Abrams & McGregor 161* (US); above Murieta-Santa Ynez divide, Santa Ynez Mts, Ojai District, 4300 ft, 27 Jun 1963, *Pollard s.n.* (CAS); Matilija Canyon, 3 Jun 1945, *Pollard s.n.* (CAS); Murrieta Canyon, 15 Jun 1946, *Pollard s.n.* (CAS); Red Reef Canyon, Topatopa Mts, 2800–3500 ft, 8 Jun 1908, *Abrams & McGregor 161* (CAS); Santa Ynez Mts, Camino Cielo, 3500 ft, 29 Jul 1967, *Pollard s.n.* (CAS); Upper North Fork, Matilija Canyon, Ojai District, 27 Jun 1962, *Pollard s.n.* (CAS); Ventura River Basin, Camino Cielo, 4000 ft, 25 May 1946, *Pollard s.n.* (CAS); Santa Ynez Mts, Ojai to Cuyama Valley Road, N Fork of Ventura River, 2.2 mi below Wheelers Hot Springs, 1200 ft, 21 May 1935, *Wolf 6888* (CAS); 0.5 mi N of Whiteacre Pk, 18 Jun 1935, *Simontacchi 120* (UC/JEPS).

Bromus hallii (Hitc.) Saarela & P.M. Peterson, comb. nov. *Bromus orcuttianus* var. *hallii* Hitc., Fl. Calif 1:175. 1912. TYPE: U.S.A. CALIFORNIA: west side, San Jacinto Mts, 27 Jun 1901, *H.M. Hall 2301* (HOLOTYPE: US-4128941).

Loosely caespitose perennial. Culms 90–150 cm tall, erect, puberulent or occasionally glabrous; nodes 1–2(–3), dark brown, retrorsely pilose to densely pubescent below. Leaf sheaths 6–12.5 cm long, 1/4–3/4 as long as internodes, closed for most of their length, densely pubescent, hairs 0.3–1 mm long; margins smooth, occasionally hyaline at apex; collars densely pilose, with hairs up to 2 mm long, auricles absent; cataphylls and basal sheaths densely pilose, sometimes shredding; ligules 0.5–2.5 mm long, membranous, sparsely to densely pubescent adaxially, glabrous abaxially, apex obtuse, erose; blades 7.5–16.5 cm long, 3–12 mm wide, flat, membranous, apically cucullate, densely pubescent abaxially and adaxially, hairs 0.2–0.5 mm long, occasionally longer hairs up to 1.2 mm on margins near base; margins scabrous or smooth. Panicles 5–16 cm long, 2–11 cm wide, open to densely branched; branches erect, ascending and appressed to spreading not more than 90° from the rachises, pubescent; lower inflorescence nodes with 1–2 branches, lower branches 3.5–11 cm long with 1–2(–3) spikelets, upper spikelets occasionally sessile and spike-like. Spikelets 2.5–3.5(–4.5) cm long, 3–7-flowered, terete to conspicuously distichous at maturity with rachis visible, lowest rhachilla 2.5–4 mm long; glumes subequal, shorter than lemmas; sparsely to densely pubescent, margins sometimes hyaline; lower glumes 5–8(–9) mm long, 1(3)-nerved, apex acute; upper glumes (7–)8–9 mm long, 3-nerved, apex acute, acuminate, or mucronate, the mucro less than 1 mm long; lemmas 10–14 mm long, 5- to 7-nerved, sparsely to densely pubescent across back, marginal hairs sometimes longer, up to 0.5 mm long, backs flattened dorsally to slightly keeled; apex entire or minutely bifid, the teeth not greater than 0.2 mm; awned just below the apex, awns 3.5–7 mm long, straight; paleas 9–13 mm long, shorter than the lemmas, backs glabrous or slightly pubescent, margins usually pubescent; apex acute; anthers 3–6 mm long, yellowish-orange. Caryopses 9–11 mm long, linear, amber to dark brown. Chromosome number unknown.

Distribution.—Endemic to southern California; known only from Fresno, Kern, Los Angeles, Monterey, Santa Barbara, San Bernardino, and Tulare counties.

Habitat.—Dry, open or shady areas on hillsides, rocky slopes, and pine woods in the mountains; elevation 5200–8800 ft.

Specimens examined. **U.S.A. California: Fresno Co.:** between Vidette Meadow and Bullfrog Lake, 9 Aug 1940, *Howell 16079* (CAS); Bubbs Creek Canyon in vicinity of Vidette Meadows, 9,500–10,000 ft, 23 Jul 1948, *Howell 24942* (CAS); Simpson Meadow, Middle Fork of the Kings River, 6000 ft, 25 Jul 1958, *Howell 33926* (CAS); Wood's Creek, 19 Jul 1910, *Clemens s.n.* (CAS). **Kern Co.:** 1.5 mi W of Greenhorn Summit, 5200 ft, 22 Jun 1970, *Howell & True 46599* (CAS); Breckenridge Mountain Road, 0.4 mi E of Barrel Spring, 6500 ft, 19 Aug 1958, *Twisselmann 4725* (CAS); Greenhorn Mountains, 1.5 mi SE of Summit, 5000 ft, 8 Jul 1962, *Howell 38312* (CAS); Greenhorn Pass Road, about 0.5 mi E of Sprout Spring, Greenhorn Range, 5750 ft, 13 Aug 1958, *Twisselmann 4666* (CAS); Greenhorn Range, NW of Calf Creek, 17 Sep 1963, *Twisselmann 9010* (CAS); Greenhorn Range, Greenhorn Pass Road just S of Tiger Flat, 6600 ft, 13 Aug 1958, *Twisselmann 4653* (CAS); Kern Plateau, road to Bartolas Country E of Little Cannell Meadow, 7200 ft, 12 Jul 1966, *Howell & True 41851* (CAS); Kern Plateau, trail to Little Cannell

Meadow above Pine Flat, 7450 ft, 24 Jul 1964, *Twisselmann 9880* (CAS); Old Kernville Road, 4.4 mi E of Greenhorn Summit, Greenhorn Range, 5200 ft, 21 Jun 1957, *Twisselmann 3716* (CAS). **Los Angeles Co.:** Buckhorn, San Gabriel Mts, 6500 ft, 20 Jul 1933, *Duran 3521* (CAS, OSU, US); San Antonio Mts, S Fork of Lytle Creek, 6000 ft, 15 Jul 1917, *Johnston 1454* (CAS, US); San Antonio Canyon, 27 Jun 1927, *Swallen 679* (US); San Bernardino Mts, 2 mi N of Big Pine Camp, 25 Jun 1942, *Bcette 3640* (CAS); San Gabriel Mts, Blue Ridge, 8000–8500 ft, 18 Jul 1947, *Howell 23389* (CAS); San Antonio Mountains, Prairie Fork of San Gabriel River, 6500 ft, 6 Jul 1918, *Johnston 2070* (CAS); San Gabriel Mts., 1826 m, 1 Sep 1994, *Cayouette & Darbyshire C7948* (DAO). **Monterey Co.:** Tassajara Hot Springs, Jun 1901, *Elmer 3314* (CAS, K, OSU, US); Santa Lucia Mts, Jun 1901, *Davy 7709* (US), *7710* (OSU); NW of Tassajara Road summit, Chews Ridge, Los Padres National Forest, 15 Jun 1973, *Griffin 3625* (UC/JEPS). **San Bernardino Co.:** San Bernardino Mts, Little Bear Valley, Aug 1907, *Wilbur 1071* (US); San Bernardino Mts, 22 Jul 1902, *Abrams 2799* (CAS, K); San Bernardino Mts, Bear Valley, 6600 ft, 19 Jul 1900, *Jones s.n.* (CAS); San Jacinto Mts, W fork of Snow Creek, 5000 ft, Jul 1901, *Hall 2538* (CAS, K); San Geronio Mts., S of Barton Flats, 2251 m, 2 Sep 1994, *Cayouette & Darbyshire C7950* (DAO); San Bernardino Mts, Deep Creek, 6500 ft, 19 Jul 1899, *Hall 1348* (K); above Arrowhead Lake, San Bernardino Mts, 1 Jul 1927, *Swallen 700* (OSU, US); 2 mi W of Barton Flat, 26 Jun 1937, *Yates 6694* (UC/JEPS). **Santa Barbara Co.:** Mission Pine, San Rafael Mts, 6200 ft, 25 Apr 1930, *Hoffman 90* (US); San Bernardino Mts., Santa Ana Canyon above Clark's Ranch, 7400 ft, Jul 1926, *Quibell 59* (US). **Tulare Co.:** trail from Bakeoven to Templeton Meadows, 8800 ft, 17 Jul 1950, *Howell 27005* (US, CAS); Kaweah River Valley, 29 Jul 1891, *Coville & Funston 1346* (US); Kings Canyon National Park, below Mist Falls, S. Fork Kings River, 13 Jul 1927, *Swallen 770* (US); Copper Creek trail to Granite Basin, 11 Jul 1927, *Swallen 753* (US); Aug 1897, *Dudley s.n.* (CAS); Kern Plateau, about 2 mi NW of Beach Meadow, 8200 ft, 7 Aug 1967, *Howell & True 43419* (CAS); Kern Plateau, N of Cain Meadow, ca. 7200 ft, 24 Jun 1966, *Twisselmann 12421* (CAS); Kern Plateau, North Manter Creek, Big Meadow, 7700–8000 ft, 24 Jun 1970, *Howell & True 46696* (CAS); Monarch Lakes Trail, ca. 8000 ft, 19 Jul 1951, *Howell 27943* (CAS); Portugese Pass, 7400 ft, 5 Aug 1957, *Twisselmann 3946* (CAS); Quaking Aspen Road, 1.3 mi N of Ice Creek, 6600 ft, 8 Jul 1959, *Twisselmann 5497* (CAS); Sequoia National Forest, Lloyd Meadows Basin, 1.25 mi W of the Pyles Boys Camp in the Freeman Redwood Grove, 5800 ft, 19 Jun 1973, *Shevock 2770* (CAS); Sequoia National Forest, Lloyd Meadows Basin, along USFS road 22582, E base of the Needles, about 3 mi from the Pyles Boys Camp, 5800 ft, 4 Jun 1974, *Shevock 3580* (CAS); Sequoia National Forest, Lloyd Meadows Basin, approximately 2 mi NW of the Pyles Boys Camp, 5700 ft, 10 Jul 1974, *Shevock 3716* (CAS); Sequoia National Forest, near Belknap Creek, 26–28 Jul 1941, *Bacigalupi, Wiggins, & Ferris 2655* (CAS); Sequoia Ntl Forest, N limit of Sequoia Ntl Park road, 2010 m, 5 Sep 1994, *Cayouette & Darbyshire C7955* (DAO); Long Meadow, 8000–9000 ft, 14 Jun 1888, *Palmer 233* (K, US); Mt. Silliman, Clover Creek, 29 Jul 1896, *Dudley 1481* (CAS).

Bromus orcuttianus Vasey, Bot. Gaz. 10:223. 1885. *Bromopsis orcuttiana* (Vasey) Holub. Folia Geobot. Phytotax 8(2):168. 1973. TYPE: U.S.A. CALIFORNIA: in the mountains near San Diego, 1884, *C.R. Orcutt s.n.* (HOLOTYPE: US!).

Bromus brachyphyllus Merr., Rhodora 4:146. 1902. TYPE: U.S.A. OREGON: Crook Co.: Black Butte, open dry pine forests, 19 Jul 1901, *Cusick 2677* (HOLOTYPE: unknown; ISOTYPE: US!).

Loosely caespitose perennial. Culms 90–150 cm tall, erect, glabrous to pubescent; nodes 2–4, dark brown, retrorsely pilose to densely pubescent below. Leaf sheaths 3.5–11 cm long, usually 1/3–2/3 as long as internodes, closed for most of their length; lower sheaths sparingly to densely pilose, hairs 2–4 mm long, occasionally glabrous; upper sheaths pubescent, hairs up to 1 mm long; margins smooth, occasionally hyaline at apex; collars pilose with hairs up to 4 mm long or glabrous, auricles absent; cataphylls and basal sheaths glabrous, some-

times shredding; ligules 1–3 mm long, membranous, glabrous, occasionally pilose adaxially, apex obtuse, erose; blades 7–24 cm long, 3–12 mm wide, flat, membranous, apically cucullate, glabrous, edges sometimes pilose with hairs up to 2 mm or pubescent on lower 15–25%; margins scabrous or smooth. Panicles 7–13.5 cm long, 2–10 cm wide, open to densely branched; branches erect, ascending and appressed to spreading not more than 90° from the rachises, pubescent; lower inflorescence nodes with 1–2(–3), lower branches 3–7.5 cm long with 1–5 spikelets, upper spikelets occasionally sessile and spike-like. Spikelets 2–3.7 cm long, 3–9-flowered, terete to conspicuously distichous at maturity with rachis visible; glumes subequal, shorter than lemmas, glabrous, occasionally scabrous on veins or pubescent, margins sometimes hyaline; lower glumes 5–9 mm long, 1(3)-nerved, apex acute; upper glumes 7–11 mm long, 3-nerved, apex acute or mucronate, the mucro up to 1 mm long; lemmas 9–15 mm long, glabrous, scabrous, or sparsely to densely pubescent, marginal hairs sometimes longer, the hairs up to 0.5 mm long; backs flattened dorsally to slightly keeled; apex entire or minutely bifid, the teeth not greater than 0.2 mm, awned just below the apex, awns (4–)5.5–8 mm long, straight; paleas 8–11 mm long, shorter than lemmas, backs glabrous or slightly pubescent, margins usually pubescent; apex acute; anthers 3–5 mm long, yellowish-orange. Caryopses 6–9 mm long, linear, brown to purple-black. Chromosome number $2n = 14$.

Distribution.—Known from California, Nevada, Oregon, Washington, Arizona, and Utah.

Habitat.—Dry areas in open pine woods, on hillsides and rocky slopes, and in meadows in the mountains; elevation 1850–11500 ft.

Specimens examined. **U.S.A. ARIZONA:** Cochise Co.: Huachuca Mts, Sept 1883, *Lemmon s.n.* (US). **CALIFORNIA:** Alpine Co.: N side of Pigeon Flat, 22 Jul 1940, *Hoover 4423* (K). **Amador Co.:** Pioneer, 3500 ft, 13 Jul 1896, *Hansen 1835* (K, US); Jackson, 7 Sep 1937, *Johannsen 1247* (UC/JEPS). **Butte Co.:** Butte Meadows, 4600 ft, 26 Jul 1917, *Heller 12819* (CAS, OSU, US); Butte Creek, 5000 ft, 21 Jul 1930, *Copeland 1348* (CAS); Jackson Ranch Ridge, along Road 21N25Y ca 0.6 mi E of the W end of the ridge, 3750 ft, 27 Jul 1995, *Janeway 4877* (CAS); W side of Hwy. 32 ca. 1/4 mi N of Forest Ranch, 2357 ft, 18 Jul 1978, *Taylor 1674* (CAS); along Big Bar Mountain Road, about 3 mi SW of Coyote Gap, SE of Pulga, 8 Jul 1987, *Ahart 5796* (CAS). **Calaveras Co.:** near Dorrington, 26 Jun 1978, *Howell, Menzies, & Shockey 53063* (CAS); Dorrington, 1976, *Menzies s.n.* (CAS). **Colusa Co.:** Trout Creek, SE Snow Mt, 30 Jul 1981, *Heckard & Hickman 5763* (UC/JEPS). **El Dorado Co.:** along US hwy 50, 3 mi E of Camino, 3400 ft, 15 Jul 1945, *Robbins 2062* (US); Chute Champ Road, 3000 ft, 15 Jun 1937, *White 1078* (US); Fallen Leaf Lake, 27 Jul 1928, *Abrams 12630* (CAS); Fallen Leaf Lake, 9 Jul 1928, *Abrams 12627* (CAS); Glen Alpine region, Camp Agassiz, 21 Jul–15 Aug 1906, *Eastwood 998* (CAS); Echo Summit, 1 Sep 1946, *Howell 22986* (CAS); 0.5 mi W of Omo Ranch Post Office, 22 Jun 1956, *Crampton 3596* (CAS). **Fresno Co.:** Pine Ridge, 5300 ft, 15–25 Jun 1900, *Hall & Chandler 316* (UC/JEPS, US); Huntington Lake, 22 Jul 1927, *Swallen 810* (US); Bearskin Meadow, 2 Jul 1899, *Eastwood s.n.* (US); Granite Basin, 10 July 1927, *Swallen 743* (US); above Deer Creek, N shore of Huntington Lake, 7100 ft, 8 Aug 1951, *Quibell 486* (CAS); Dinkey Creek, Jul 1901, *Dudley s.n.* (CAS); Huntington Lake and vicinity, near ranger station, 7000 ft, 3 Aug 1951, *Pollard s.n.* (CAS); John Muir Trail N of Bear Creek, 9400 ft, 5 Aug 1954, *Raven 7789* (CAS); Mono Creek, 8200 ft, 9 Aug 1953, *Raven 6142* (CAS); Tehipite Valley, Middle Fork of the Kings River, 4650 ft, 26 Jul 1958, *Howell 33958* (CAS); drainage of Deer Creek, above Lakeshore Post

Office, Huntington Lake, 23 Aug 1958, *Bacigalupi & Quibell 6717* (UC/JEPS); E slope of Converse Mt, drainage of Indian Creek, along Kings Canyon Road, 23 Jul 1958, *Bacigalupi & Alawa 6498* (UC/JEPS); Huckleberry Creek, Huntington Lake, 28 Jul 1928, *Jepson 13330* (UC/JEPS). **Glenn Co.:** Plaskett Meadows, 6000 ft, 4 Aug 1943, *Howell 19020* (CAS, US); road 168, a few miles E of Shaver Lake, 2100 m, 6 Sep 1994, *Cayouette & Darbyshire C7958* (DAO); Mendocino National Forest, 5500 ft, 21 Jul 1956, *Burham 368* (K); near Fish Pond Plaskett Meadows, 5 Aug 1943, *Baker 10583* (CAS). **Humboldt Co.:** Orleans Mt., 2 Sep 1946, *Pollard s.n.* (CAS); Trinity Summit, on ridge 2 mi E of Grove's Prairie, 15 Aug 1948, *Tracy 18125* (UC/JEPS); Grouse Mt, 27 Jun 1934, *Clarks & Tracy 11079* (UC/JEPS). **Lake Co.:** N of Hoberg's, 14 Jul 1944, *Hoffman 1967* (UC/JEPS, US); foothills S of Mt. Sanhedrin, midway between Potter Valley and Hullville, 25 Jul 1902, *Heller 5987* (US); S base of Mt. Sanhedrin, 25 Jul 1902, *Heller & Brown 5987* (US); Bartlett Mtn, 23 Jun 1948, *Wagnon 1509* (K); 15 mi N of Lakeview, 6 Jul 1927, *Peck 15517* (CAS); summit of Bartlett Mt, 11 Jul 1939, *Stebbins 2971* (UC/JEPS); NW of Timber Lake, Snow Mt, 16 Jun 1979, *Heckard & Hickman 5086a* (UC/JEPS). **Lassen Co.:** 5 mi S of Susanville, 27 Jul 1927, *Swallen 872* (US); Black's Mt, 10 Jul 1934, *Howell 12554* (CAS); Elysian Valley, W of Janesville, 28 Jun 1973, *Howell, True & Williams 49472* (CAS); Gold Run Creek road S of Susanville, Diamond Range, 1 Aug 1973, *Howell & True 50180* (CAS); Gold Run Creek SW of Susanville, 19 Jul 1976, *Howell 51973* (CAS); on road from Janesville to Thompson Peak, Diamond Range, 31 Jul 1973, *Howell & True 50029* (CAS). **Madera Co.:** 9 mi above Bass Lake on Beasore Meadow Road, 18 Jul 1933, *Springer 505* (OSU); Bass Lake Fish Hatchery, 1 Sep 1951, *Holt s.n.* (CAS). **Mariposa Co.:** 11 Aug 1895, *Ngdon s.n.* (US); Signal Peak, Chowchilla Mt., 25–31 Jul 1938, *Quick 2003* (CAS); road 41, Sierra Ntl Forest, 5 miles of Yosemite Ntl Park, 1914 m, 8 Sep 1994, *Cayouette & Darbyshire C7964* (DAO); Yosemite to Wawona, 28 Jun 1911, *Jepson 4295* (UC/JEPS). **Mendocino Co.:** along roadside enroute to summit of Mt. Sanhedrin from Towhead Flat, 7 Jul 1981, *Knight & Knight 4295* (CAS). **Modoc Co.:** Forestdale, 4500 ft, 25 Aug 1894, *Baker & Nutting s.n.* (US); 13 July, *Baker & Nutting s.n.* (US). **Nevada Co.:** Truckee, 14–16 Jul 1913, *Hitchcock 10516* (K, US, W); Banner Mt, 4 mi E of Nevada City, 15 Sep 1961, *True 261* (CAS); Hwy 20, ca. 2.5 mi E of Washington Jct., 5000 ft, 10 Jul 1968, *True 4341* (CAS); Omega Rd, between Omega Diggings and Diamond Creek 14 mi NE of Skillman Flat on Hwy 20, 15 Jul 1965, *True & Howell 2359* (CAS); Mayflower Mine, 5 Jun 1966, *Mott s.n.* (CAS); Banner Mt, ca. 4 mi E of Nevada City, 15 Jul 1965, *True & Howell 2319A* (CAS); on road to Pierce Meadows, short distance from the S Fork of the Yuba River, Tahoe National Forest, 30 Jun 1931, *Smith 2575* (UC/JEPS). **Placer Co.:** Tahoe, 5 Aug 1908, 6225–7000 ft, *Hitchcock 3091* (US); railroad crossing at Blue Canyon, 17 Jul 1956, *Crampton 3723* (CAS); about 2 mi SW of French Meadows on the road to Big Meadow, 2 Aug 1981, *Best s.n.* (CAS); 1 mi from Blue Canyon on road to Emigrant Gap, 4 Aug 1956, *Raven 9999* (CAS); Truckee, 8 Aug 1936, *Yates 5981* (UC/JEPS); Eldorado Canyon, above Bullion Mine, Tahoe National Forest, 4 Jun 1926, *Smith 1883* (CAS, UC/JEPS); Antone Meadow, 7 Sep 1967, *Hoover 10858* (UC/JEPS). **Plumas Co.:** between Blairsden and Gold Lake, 5500 ft, 5 Jul 1938, *Wood 7* (US); Truckee River, July 1888, *Sonne 21* (US, CAS); Butterfly Botanical Area, confluence of Spanish Creek and Butterfly Creek, 2900 ft, 11 Jun 1968, *Howell, Knight, Knight, & True 2352* (CAS); Fern Glen, 26 Jul 1966, *Knight, Knight & Howell 1576* (CAS); Drakesbad, 5500–6000 ft, 17 Jul 1960, *Howell 35494* (CAS); Drakesbad, 5500–6000 ft, 20 Aug 1960, *Howell 36274* (CAS); Gold Lake Road above Blairsden, 5500 ft, 25 Jun 1934, *Ewan 8227* (CAS); Johnsville, 5200 ft, 28 Jun 1951, *Howell 27656* (CAS); Lassen Volcanic National Park, trail to Little Willow Lake, 21 Jul 1960, *Howell 35860* (CAS); near Prattville, Lake Almanor, 14–26 Aug 1944, *Kearney 7* (CAS); near the summit of Soapstone ridge 12 mi W of Bucks, 5500 ft, 7 Jul 1915, *Heller 12053* (CAS, OSU); Quincy, 31 Jul 1942, *Quick 42–46* (CAS); Willow Lake Meadow near the east inlet, 5450 ft, 17 Jul 1957, *Gillett 805* (CAS, UC/JEPS); 3 mi W of Keddir, Butterfly Valley, 3600 ft, 10 Jul 1967, *Rose 67152* (W); near Prattville, 20 Jul 1926, *Howell 2088* (CAS); Round Valley, 9 Jul 1973, *Howell 49722* (CAS); 2 mi NW of Spring Garden, 22 Jul 1975, *Howell 51363* (CAS); Butterfly Valley, 3 mi. W of Keddie, 27 Jul 1966, *Rose 66060* (CAS); about 0.5 mi N of Humboldt Summit, 23 Jul 2001, *Ahart & Oswald 8998* (UC/JEPS). **San Diego Co.:** Cleveland National Forest, E of San Diego, near Cuyamaca Lake, 1700 m, 29, 30 Jul 1915, *Hitchcock 13168* (K, UC/JEPS, US, W); Cuyamaca Mts, 30 Jun 1903, *Abrams 3945* (OSU). **Shasta Co.:** Goose

Valley, 29 Jun–11 Jul 1912, *Eastwood* 930, 985 (CAS, US); 4 Jul 1914, *Smith* 735 (CAS); 0.25 mi above Manzanita Creek on Chaos Crags trail, 11 Jul 1957, *Gillett* 705 (UC/JEPS, CAS); Goose Valley, 29 Jun, 11 Jul 1912, *Eastwood* 930 (CAS); Redding, 5 Jun 1934, *Krachel* 25 (UC/JEPS); Logan Mt, 13 mi N of Lassen Peak, Lassen National Forest, 12 Jul 1934, *Whitncy* 2163 (UC/JEPS); Little Hatchet Creek, 4 Jul 1940, *Jepson* 20131 (UC/JEPS). **Sierra Co.:** near summit of Yuba Pass, 6350 ft, 17 Aug 1944, *Beetle* 3041 (US); Tahoe Forest, 10 Sep 1925, *Smith* 1727 (CAS); Tahoe Forest, 10 Jun 1926, *Smith* 1906 (CAS); Tahoe forest, 19 Jul 1926, *Smith* 1994 (CAS); Tahoe Forest, 4 Jul 1926, *Smith* 1883 (CAS); Independence Lake watershed, W of Independence Lake, 7200 ft, 26 Jul 1977, *True* 8380 (CAS); 2 mi E of Bassett station, North Fork of Yuba River, 4 Aug 1934, *Jepson* 16850 (UC/JEPS). **Siskiyou Co.:** base of Mt. Eddy, 18 Jul 1915, *Heller* 12124 (CAS, OSU, US); S Fork of Shasta River, Mount Eddy, Shasta Forest, 1850–2000 m, 11, 12 Aug 1915, *Eggleston* 11635 (US); Sisson, 30 Jul 1894, *Howe* 122 (US); near Shasta Springs, 13 Jun 1905, *Heller* 8026 (CAS, US); between upper reaches of China and Blind Horse Creeks, S side of South Fork of Salmon River, 24 Jul 1955, *Wiggins* 13497 (CAS, UC/JEPS); toward Black Fox, 15 Aug 1899, *Dudley* s.n. (CAS); Trinity Mts, about 6 mi SE of Cecilville, W side of Rush Creek, 21 Jul 1954, *Thomas & Thomas* 4432 (CAS); on Everitt Memorial Hwy, 4.7 mi N of McCloud River railroad crossing, 13 Jul 1963, *Frenkel* 229 (CAS); English Lake, Salmon Mts, 16 Aug 1969, *Oettinger* 1392 (UC/JEPS); below Pine Lake Basin, Salmon Mts, 6 Aug 1969, *Oettinger & Thorne* 1246 (UC/JEPS); Humbug Creek, 20 Jul 1908, *Butler* 469 (UC/JEPS). **Tehama Co.:** Deer Creek Canon, 17 Jul 1911, *Eggleston* 7284 (US); 5.1 mi from Whitlock Camp, 12 Jul 1953, *Baker & Wagnon* 12861 (UC/JEPS); E side of Willow Creek, about 1.25 mi N of Jonesville, 24 Jul 1994, *Ahart* 7513 (UC/JEPS). **Trinity Co.:** Grasshopper Public Camp, 2.5 mi NW of Stuart Gap, North Yolla Bolly Mts, 17 Jul 1951, *Munz* 16575 (CAS); North Fork of Trinity River, Hobo Gulch Camp vicinity, 18 mi NW of Weaverville, along backbone Creek Trail near Keystone, 15 Jun 1972, *Carter* 435 (CAS). **Tulare Co.:** S Fork of Kaweah River, 20 Jul 1904, *Culbertson* 4512 (US); above Mineral King, 30 Jul 1927, *Swallen* 883 (US); Sequoia National Park, 18 Jul 1927, *Swallen* 882 (US); Grant Park, 4000–8000 ft, 11 Aug 1895, *Dudley* 1205 (CAS); Hollow Log Camp, Jul 1900, *Dudley* s.n. (CAS); middle Kaweah River, 2 Aug 1900, *Dudley* 3031 (CAS); Mineral King road, 6000 ft, 15 Jul 1951, *Howell* 27780 (CAS); Sequoia National Park, 12 Aug 1896, *Dudley* 1625; Sequoia Forest, Freeman Creek, 2 Aug 1916, 7500 ft, *Cunningham* 3 (CAS); Sequoia National Forest, 11500 ft, 23 Jul 1912, *Hopping* 22 (CAS); Kaweah River, 20 Jul 1904, *without collector* (US); Sequoia National Park, road to Crystal Cave, near start of Black Oak trail, 21 Jul 1948, *Bailey & Bailey* 2446 (UC/JEPS); Lloyd Meadow, near trail to Quaking Aspen on the Springville Road, 24 Jul 1964, *Smith* 1316 (UC/JEPS). **Tuolumne Co.:** Yosemite National Park, Echo Creek Canyon, 17–25 Aug 1908, *Hitchcock* 3352, 3355 (US); Yosemite National Park, Tenaya Trail, 6500 ft, 21–22 Jul 1915, *Hitchcock* 13136 (US); Yosemite to Wawona, 28 Jun 1911, *Jepson* 4295 (US); Yosemite Valley, 4060 ft, 5 Jul 1909, *Jepson* 3125 (US); Yosemite National Park, 1 Jul 1938, *Silveus* 2873 (CAS); Yosemite National Park, Glacier Point, 11 Aug 1915, *Abrams* 5428 (CAS); Yosemite Valley, Sierra Nevada Mts, 5000–8000 ft, 4–12 Jul 1901, *Parish* 4360 (CAS); Yosemite, Jul 1902, *Bacon* s.n. (CAS); along Hwy 108, between Twain Harte and Confidence, 10 Jul 1972, 4000 ft, *Wiggins* 21785 (CAS); along South Fork road, 2.6 mi E of Twain Harte, 4000 ft, 11 Jul 1971, *Wiggins* 21679 (CAS); Dodge Ridge SE of Pinecrest, 21 Jul 1953, *Quick* 53–42 (CAS); Herring Creek, 4 mi from Strawberry, 17 Jul 1936, *Wiggins* 8543 (CAS); Mather, in the Sierra Nevada in the lower borders of the Transition Zone, 1400 m, 6 Jun 1931, *Keck* 1252 (CAS); near Cow Creek Research Station, 5750 ft, 11 Jul 1941, *Quick* 41–69 (CAS); Twain Harte, 3700 ft, 6 Jun 1954, *Howell* 29944 (CAS); Long Barn, 16 Jul 1941, *Hoover* 5470 (K). **Yuba Co.:** about 2 mi NE of Dobbins on Oregon Hill road, 22 Jun 1981, *Howell*, *Fuller & Barbe* 54081 (CAS); about 200 yards S of the 4-H Camp, on W side of Oregon Hill Road, about 0.5 mi N of Marysville Road, about 2 mi NE of Dobbins, 2 Jul 2003, *Ahart* 10340 (UC/JEPS). **NEVADA: Washoe Co.:** Incline, 1 Aug 1928, *Smith* s.n. (CAS). **OREGON:** Gayhart Buttes, 1850 m, 8 Aug 1896, *Leiberg* 2887 (OSU); East Eagle Creek, 5500 ft, 10 Aug 1909, *Cusick* 3369, 3370 (OSU). **Crook Co.:** base of Black Butte, 19 Jul 1901, *Cusick* 2677 (UC/JEPS, US). **Douglas Co.:** along Golden Stairs Trail, E fork of Abbott Creek, ca. 20 mi W of Crater Lake, near Abbott Butte, 19 Jul 1972, *Mitchell* 241 (OSU). **Grant Co.:** Strawberry Lake, Strawberry Mts, 17 Jul 1910, *Cusick* 3525 (OSU, US).

Jackson Co.: Klamath Forest, 4800 ft, 19 Jul 1934, *Wheeler 2931* (CAS, UC/JEPS, US); Ashland Butte, Siskiyou Mountains, 20 Jul 1887, *Howell 253, 369* (OSU, UC/JEPS, US, W, WTU); summit of Cascades, 10 Jul 1931, *Peck 16747* (OSU); Carberry Creek, 3 mi from mouth of Applegate River, 25 Jun 1931, *Peck 16386* (OSU). **Jefferson Co.:** Suttle Lake, 18 Jul 1925, *Peck 14421* (CAS, K, OSU); Abbot Butte Spring Road, 15 September 1959, *Swedberg 100* (OSU); NW of Sisters, 23 July 1960, *Johnson 543* (OSU); NW of Sisters, 27 Aug 1960, *Johnson 611* (CAS, OSU); near Hwy. 20, W of Black Butte, 20 Jul 1962, *West s.n.* (OSU); Siskiyou, 21 Jul 1908, *Hitchcock 2879, 2909, 2916* (US). **Klamath Co.:** Klamath Valley at Keno, 27 Jun 1902, *Cusick 2838* (CAS, OSU, UC/JEPS, US, W); Pelican Bay, W side of Upper Klamath, 16 Jul 1920, *Peck 9516* (CAS, WTU); Fort Klamath, 29 Jul 1908, *Hitchcock 3012* (US). **Lake Co.:** 15 mi N of Lakeview, 6 Jul 1927, *Peck 15517* (OSU). **Wallowa Co.:** Imnaha River, Wallowa Mountains, 10 Aug 1909, *Cusick 3310* (OSU, WTU). **Washington Co.:** Dixie Mountain, 15 Jul 1910, *Cusick 3518* (US). **UTAH:** 1876, *McLean s.n.* (US). **WASHINGTON: Yackima Co.:** Klickitat River, near Mt. Paddo, 12 Jun 1885, *Suksdorf s.n.* (CAS, K, US); Mt. Paddo, 21 Aug 1905, *Suksdorf 5265* (US); Mt. Paddo, 27 Aug 1884, *Suksdorf 120* (US). **Klickitat Co.:** Falcon Valley, 13 Jul 1924, *Suksdorf 11754* (CAS, K, OSU, UBC, UC/JEPS, US, WTU); 6 Jun 1891, *Suksdorf 826* (UC/JEPS).

KEY TO THE SECTIONS OF *BROMUS* IN CALIFORNIA

1. Spikelets laterally compressed; lemmas compressed and keeled _____ sect. **Ceratochloa** (P.Beauv.) Griseb.
1. Spikelets not laterally compressed; lemmas not keeled.
 2. Lemma apex bidentate, teeth 3–7 mm, awn-like to acuminate.
 3. Awn of the lemma geniculate and/or twisted _____ sect. **Neobromus** (Shear) Hitchc.
 3. Awn of the lemma straight, not twisted _____ sect. **Genea** Dumort.
 2. Lemma apex entire or bidentate, teeth 0–3 mm, not awn-like or acuminate.
 4. Plants perennial, with or without rhizomes, the bases fibrous; lower glume 1- or 3-nerved; upper glume 3- or 5-nerved _____ sect. **Bromopsis**
 4. Plants annual; lower glume 3- or 5-nerved; upper glume 5- or 7-nerved _____ sect. **Bromus** L.

KEY TO *BROMUS* SECTION *BROMOPSIS* IN CALIFORNIA

1. Plants with rhizomes; awns absent or up to 3 mm long _____ **B. inermis**
1. Plants without rhizomes; awns present, 1.5–11 mm long.
 2. Most lower glumes on a plant 3-veined.
 3. Upper glumes 5-veined.
 4. Ligule 0.4–1 mm long; glumes scabrous or pubescent; upper glume 6–9 mm long; blades and sheaths pubescent or glabrous _____ **B. pseudolaevipes**
 4. Ligule (1.5–)2–4 mm long; glumes glabrous; upper glumes 7–11 mm long; blades and sheaths glabrous _____ **B. laevipes**
 3. Upper glumes 3-veined.
 5. Lemma awns 1.5–3(–4) mm long; blades 2–5 mm wide; anthers 1.5–3.5 (–4) long _____ **B. porteri**
 5. Lemma awns 3–9 mm long; blades 3–12 mm wide; anthers 3.5–5 mm long.
 6. Blades glabrous; lower sheaths pilose, hairs 2–4 mm long; nodes 2–4; inflorescence branches mostly ascending to spreading $\leq 90^\circ$ from the rachises _____ **B. orcuttianus**
 6. Blades pubescent; lower sheaths pubescent, hairs up to 1(–3) mm long; nodes 3–7; inflorescence branches mostly spreading $>90^\circ$ from the rachises _____ **B. grandis**
 2. Most lower glumes on a plant 1-veined.
 7. Glumes pubescent.

8. Panicles narrow at anthesis, ≤ 2 cm wide; branches erect or tightly ascending; blades and sheaths glabrous _____ **B. suksdorfii**
8. Panicles broad at anthesis, > 2 cm wide; branches erect, ascending, or nodding, usually spreading or divaricate; blades and sheaths pubescent or glabrous.
9. Ligules (2-)3-6(-7) mm long; lemma awns (4-)6-11 mm long; branches of inflorescence glabrous or scabrous _____ **B. vulgaris**
9. Ligules 0.5-3 mm long; lemma awns 3-7(-9) mm long; branches of inflorescence pubescent.
10. Lower sheaths pilose with hairs 2-4 mm long, or glabrous; blades glabrous _____ **B. orcuttianus**
10. Lower sheaths densely pubescent with hairs up to 1 mm long; blades densely pubescent.
11. Longest blades 7.5-16.5 cm long; 1-2(-3) nodes per culm _____ **B. hallii**
11. Longest blades (13-)18-38 cm long; 3-6(-7) nodes per culm _____ **B. grandis**
7. Glumes glabrous.
12. Panicles narrow at anthesis, ≤ 2 cm wide; branches erect or tightly ascending _____ **B. suksdorfii**
12. Panicles broader at anthesis, > 2 cm wide; branches erect, ascending, or nodding, usually spreading or divaricate.
13. Ligules (2-)3-6(-7) mm long; awns (4-)6-11 mm long _____ **B. vulgaris**
13. Ligules 0.5-3 mm long; awns 4-7(-9) mm long.
14. Lemmas not densely pubescent along margins; lemma awns (4-)5-7(-9) mm long; inflorescence branches mostly ascending to spreading $\leq 90^\circ$ from the rachises _____ **B. orcuttianus**
14. Lemmas densely pubescent along margins; lemma awns (2-)3-5(-6) mm long; inflorescence branches spreading to drooping $> 90^\circ$ from the rachises.
15. Lemmas glabrous on lower back between pubescent margins; anthers (0.9-)1-1.4(-1.6) mm; second glumes (6.2-)7.1-8.5(-9.5) mm long; basal sheaths glabrous or with long hairs; top culm blades with hairs on upper surface; top culm nodes usually hairy; caryopses (5.4-)6.2-7.2(-7.5) mm; top culm sheath usually pubescent _____ **B. ciliatus**
15. Lemmas with scattered hairs on lower back between pubescent margins; anthers (1.2-)1.6-2.7(-3.4) mm long; second glumes (7.8-)8.9-11.3(-13.2) mm long; basal sheaths with dense, short, or medium hairs; top culm blades glabrous on the upper surface; top culm nodes usually glabrous; caryopses (6.9-)7.7-9.7(-10.5) mm long; top culm sheath glabrous _____ **B. richardsonii**

ACKNOWLEDGMENTS

We thank Dieter Wilken, an anonymous reviewer, and Barney Lipscomb for constructive comments on the manuscript; the curators of the cited herbaria for the loan of specimens or assistance during visits; Cindy Sayre (UBC) for assistance in the herbarium; and Nicole Fillion (Ottawa) for assistance with the

chromosome count. J.M.S. was supported by a Canada Graduate Scholarship from the Natural Sciences and Engineering Research Council of Canada, the University of British Columbia, and a travel grant from the Lawrence R. Heckard Fund of the Jepson Herbarium to visit the U.S. National Herbarium.

REFERENCES

- AINOUCHE, M.L. and R.J. BAYER. 1997. On the origins of the tetraploid *Bromus* species (section *Bromus*, Poaceae): insights from the internal transcribed spacer sequences of nuclear ribosomal DNA. *Genome* 40:730–743.
- CLAYTON, W.D. and S.A. RENOIZE. 1986. Genera graminum. Grasses of the world. *Kew Bull. Add. Ser.* 13:1–389.
- CLAYTON, W.D. and H. WILLIAMSON. 2002 onwards. World grass flora: Nomenclature. Royal Botanic Gardens, Kew.
- HITCHCOCK, A.S. 1951. Manual of grasses of the United States (ed. 2, revised by A. Chase). U.S. Department of Agriculture, Washington, D.C.
- HITCHCOCK, C.L., A. CRONQUIST, M. OWNBEY, and J.W. THOMPSON. 1969. Vascular cryptogams, gymnosperms, and monocotyledons. Vascular plants of the Pacific Northwest. University of Washington Press, Seattle. 1:1–194.
- JEPSON, W.L. 1912. A flora of California. Volume 1. University of California, Berkeley.
- KEARNEY, T.H., R.H. PEEBLES, and COLLABORATORS. 1960. Arizona flora. University of California Press, Berkeley.
- MASSA, A.N., K. B. JENSEN, S. R. LARSON, and D.J. HOLE. 2004. Morphological variation in *Bromus* sect. *Ceratochloa* germplasm of Patagonia. *Canad. J. Bot.* 82:136–144.
- MUNZ, P.A. 1974. A flora of southern California. University of California Press, Berkeley.
- MUNZ, P.A. and D.D. KECK. 1959. A California flora. University of California Press, Berkeley. 1–1681.
- OJA, T., V. JAASKA, and V. VISLAP. 2003. Breeding system, evolution and taxonomy of *Bromus arvensis*, *B. japonicus* and *B. squarrosus* (Poaceae). *Pl. Syst. Evol.* 242:101–117.
- PAVLICK, L.E. 1995. *Bromus* L. of North America. Royal British Columbia Museum, Victoria.
- PAVLICK, L.E. and L.K. ANDERTON. In Press. *Bromus*. In: Barkworth, M.E., K.M. Capels, S. Long, and M.B. Piep, eds. Magnoliophyta: Commelinidae (in part): Poaceae, part 1. Flora of North America North of Mexico, volume 24. Oxford University Press, New York.
- PAVLICK, L.E., A.M. PLANCHUELO, P.M. PETERSON, and R.J. SORENG. 2003. *Bromus*. Pp. 154–191. In: Soreng, R.J., P.M. Peterson, G. Davidse, E.J. Judziewicz, F.O. Zuloaga, T.S. Filgueiras, and O. Morrone, Catalogue of New World grasses (Poaceae): IV. Subfamily Pooideae. *Contr. U.S. Natl. Herb.* 48:1–730.
- PETERSON, P.M., J. CAYOUILLE, Y.S.N. FERDINANDEZ, B. COULMAN, and R.E. CHAPMAN. (2001) 2002. Recognition of *Bromus richardsonii* and *B. ciliatus*: evidence from morphology, cytology, and DNA fingerprinting (Poaceae: Bromeae). *Aliso* 20:21–36.
- PILLAY, M. and K.W. HILLU. 1990. Chloroplast DNA variation in diploid and polyploid species of *Bromus* (Poaceae) subgenera *Festucaria* and *Ceratochloa*. *Theor. Appl. Genet.* 80: 326–332.

- PILLAY, M. and K.W. HILL. 1995. Chloroplast-DNA restriction site analysis in the genus *Bromus* (Poaceae). *Amer. J. Bot.* 82:239–249.
- PIPER, C.V. 1906. Flora of the State of Washington. *Contr. U.S. Natl. Herb* 11:1–635.
- SAARELA, J.M., P.M. PETERSON, R.M. KEANE, J. CAYOUILLE, and S.W. GRAHAM. 2005. Molecular systematics of *Bromus* (Poaceae: Pooideae) based on chloroplast and nuclear DNA sequence data. Pp. xxx–xxx. In: Columbus, J.T., E.A. Friar, J.M. Porter, L.M. Prince and M.G. Simpson, eds. *Monocots: comparative biology and evolution*, 2 vols. Rancho Santa Ana Botanic Garden, Claremont, CA. In Press.
- SAARELA, J.M., P.M. PETERSON, and N.F. REFULIO-RODRIGUEZ. In review. *Bromus ayacuchensis* (Poaceae: Pooideae: Bromeae), a new species from Peru. *Syst. Bot.*
- SHEAR, C.L. 1900. A revision of the North American species of *Bromus* occurring north of Mexico. *Bull. U.S.D.A. (1895–1901)* 23: 1–66.
- SMITH, P. 1970. Taxonomy and nomenclature of the brome-grasses (*Bromus* L. s. l.). *Notes Roy. Bot. Gard. Edinburgh* 30:361–375.
- STEBBINS, G.L., JR., and R.M. LOVE. 1941. A cytological study of California forage grasses. *Amer. J. Bot.* 28:371–382.
- VASEY, G. 1885. Some new grasses. *Bot. Gaz.* 10:223–224.
- WAGNON, H.K. 1952. A revision of the genus *Bromus*, section *Bromopsis*, of North America. *Brittonia* 7:415–480.
- WILKEN, D.H. and E.L. PAINTER. 1993. *Bromus*. In: J.C. Hickman, ed., *The Jepson manual: higher plants of California*. University of California Press, Berkeley. Pp. 1239–1243.