

# A standard taxonomic effort (STE) for bryophytes collected from dry streambeds in California and Arizona



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SOUTHERN CALIFORNIA COASTAL WATER RESEARCH PROJECT

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# INTRODUCTION

The University of Nevada at Las Vegas, the Watershed Environments and Ecology (WEE) Lab at California State University, Monterey Bay, and the Southern California Coastal Water Research Project (SCCWRP) developed standardized levels for the taxonomic identification for bryophytes (i.e., mosses and liverworts) associated with non-perennial river and streams in support of bioassessment of these systems. This document defines the standard levels of taxonomic effort (STE) for analyzing bryophyte samples collected as part of assessing ecological assessments of dry phase non-perennial rivers and streams using methods described in Robinson et al. (2018) and will provide sufficient taxonomic resolution for use with current bioassessment indices (i.e., Robinson 2019; Caudillo 2021).

This STE is based on our current understanding of dry-stream bryophyte taxonomy, and this document was prepared following sections in Rogers and Richards (2006) STE Rules, as well as Rogers and Richards (2011) Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT) List of Freshwater Macroinvertebrate Taxa from California and Adjacent States including Standard Taxonomic Effort Levels. This list includes taxa found during the dry phase of non-perennial rivers and streams in southern and eastern California and throughout Arizona. This document is a compilation and distillation of data gleaned from the peer-reviewed literature, the input of various WEE Lab staff, and the Integrated Taxonomic Information System (ITIS) Report database. Specialized references are suggested for some taxa; however, this document is not a procedural guideline, but rather a list of defined, reproducible endpoints.

This STE list should not be interpreted as a comprehensive list of dry-stream bryophyte flora of these regions, and many species (both described and undescribed) are likely to be found with additional sampling. This STE list includes the bryophyte taxa encountered in bioassessment samples as of the date of this document, together with literature records from published taxonomic literature. This STE List will be adjusted as new taxonomic information is found.

Any suggestions for modifications of this list should comply with the STE Rules, and be sent to the attention of Dr. Raphael Mazor, Southern California Water Research Project ([raphaelm@sccwrp.org](mailto:raphaelm@sccwrp.org)).

# **DEVELOPMENT OF THE STANDARD TAXONOMIC EFFORT (STE)**

The goal of this document is to standardize levels of taxonomic effort used by the WEE Lab for assessment of ecological health of dry phase non-perennial rivers and streams or similar protocols. For bryophyte datasets to be compatible, taxa need to be identified to a common, reproducible level, thus we defined levels of taxonomic resolution (i.e., the standard taxonomic effort or STE) for all labs assessing ecological health of dry phase non-perennial rivers and streams following the protocol by Robinson et al. (2018) or later/similar protocols.

A total of 88 species in 43 genera and 17 families were identified in voucher collections collected by WEE-CSUMB. Within those 17 families, a total of 437 species in 102 genera are known to occur in California (Norris and Shevok 2004a; Malcolm et al. 2009). This STE is developed for those 437 taxa.

## **Rules for Developing a Standard Taxonomic Effort**

This document was drafted following sections 2.5.1-2.5.3 and 3.1-3.4.5 of the STE Rules (Rogers and Richards 2006) for the validity of taxonomic names and provisional taxa, their use and reporting in bioassessment datasets. The STE Rules document also outlines the procedures and criteria for subsequent revisions of the STE list.

References for taxonomic identification listed in the STE were obtained from the ITIS database.

## **The WEE Lab Standard Taxonomic List**

We aim to identify taxa to the lowest taxonomic level while balancing cost-effectiveness relative to effort. We recognize this will vary dependent on individual taxonomic skill, up to date keys, and peer reviewed literature needed to identify taxa. For most bryophytes, the STE requires species-level identifications.

Names conform to those presented in the Bryophyte Flora of North America (BFNA) ([http://floranorthamerica.org/Main Page](http://floranorthamerica.org/Main_Page)).

## **Morphospecies**

We define morphospecies as a group of organisms that differ from all other groups in some aspect of their morphology, but are so similar among themselves that they are lumped together for the purposes of analysis. Morphospecies are identified by their family and a unique numeric

code. As genus or species of each morphospecies is determined, we expect that later versions of the STE will replace morphospecies with proper taxonomy.

Morphospecies are not currently used for the bryophyte STE.

## **METHODS AND MATERIALS**

The taxa listed were encountered in field collections while performing the protocol for assessing ecological health of dry phase non-perennial rivers and streams (Robinson et al. 2018). This document was created following Rogers and Richards (2006) STE Rules, and Rogers and Richards (2011) SAFIT List of Freshwater Macroinvertebrate Taxa from California and Adjacent States including Standard Taxonomic Effort Levels.

### **Life Stage Terminology**

Life stages are not currently recorded for bryophyte taxa.

## **THE STANDARD TAXONOMIC EFFORT**

Taxa indicated with **bold text** were found in voucher data sets<sup>1</sup>. Several taxa not found in voucher data sets but listed as occurring in California by Malcolm et al. (2009) and Norris and Shevock (2004b) are also included in the STE. Some of these taxa may be found in dry riverbeds, while others may be restricted to other habitats.

These families are identified in Malcom et al. (2009) as occurring in California, but were not found in voucher collections:

- Sphagnaceae (1 genus)
- Andreaeaceae (1 genus)
- Polytrichaceae (6 genera)
- Tetrarhizaceae (1 genus)
- Buxbaumiaceae (1 genus)
- Timmiaceae (1 genus)
- Encalyptaceae (1 genus)
- Diseliaceae (1 genus)
- Scouleriaceae (1 genus)

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<sup>1</sup> Bold and colored text is used for visual purposes. The STE tables also include a column that identifies voucher specimens.



- Ptychomitriaceae (2 genera)
- Seligeriaceae (1 genus)
- Archidiaceae (1 genus)
- Bruchiaceae (1 genus)
- Rhabdoweisiaceae (7 genera)
- Dicranaceae (3 genera)
- Leucobryaceae (2 genera)
- Piaceae (1 genus)
- Hookeriaceae (1 genus)
- Climaciaceae (1 genus)
- Calliergonaceae (2 genera)
- Helodiaceae (1 genus)
- Hypnaceae (11 genera)
- Pterigynandraceae (3 genera)
- Hylomiaceae (4 genera)
- Plagiotheciaceae (1 genus)
- Sematophyllaceae (1 genus)
- Cryphaeaceae (1 genus)
- Leucodontaceae (2 genera)
- Eckeraceae (5 genera)
- Leptodontaceae (1 genus)
- Lembophyllaceae (2 genera)

# PLEUROCARPS

## Amblystegiaceae

Standard effort level: Genus

Two species in two genera were found in voucher collections

Genus	Species	Author	Voucher	Comments
Amblystegium	juratzkanum	-	-	-
Amblystegium	radicale	-	-	-
Amblystegium	serpens	(Hedwig) Schimper	Yes	Microscopic cell structure confirms ID readily combined with small leaf size.  Widespread throughout California, near springs and streams.
Amblystegium	varium	-	-	-
Campylium	chrysophyllum	-	-	-
Campylium	hispidulum	-	-	-
Campylium	stellatum	(Hedwig) C.E.O. Jensen	-	-
Conardia	compacta	(C. Müller Hal.) H. Robinson	-	Monospecific genus. Near calcareous streams, common in transmontane California.

Genus	Species	Author	Voucher	Comments
Cratoneuron	filicinum	(Hedwig) Spruce	-	Only species of the genus in California. Calcareous stream channels
Drepanocladus	aduncus	(Hedwig) Warnstorf	-	Bogs, fens and meadows. Lawn weed in coastal areas.
Drepanocladus	capillifolius	-	-	-
Drepanocladus	polycarpus	-	-	-
Drepanocladus	polygamus	(Schimper) Hedenäs	-	Fens, wet meadows and shallow ponds, mostly in coniferous forests.
Hygroamblystegium	tenax	(Hedwig) Jennings	-	Only species of the genus in California. Seeps and springs from Sierra Nevada northwards.
Hygrohypnum	alpinum	-	-	-
Hygrohypnum	bestii	-	-	-
Hygrohypnum	cochlearifolium	-	-	-
Hygrohypnum	duriusculum	-	-	-
Hygrohypnum	luridum	-	-	-
Hygrohypnum	molle	-	-	-
Hygrohypnum	ochraceum	Loeske	-	Seasonally submerged splash zones
Hygrohypnum	smithii	-	-	-
Hygrohypnum	styriacum	(Limpricht) Brotherus	-	Near streams. Uncommon, mostly in subalpine forests.
Leptodictyum	humile	-	-	-

Genus	Species	Author	Voucher	Comments
Leptodictyum	riparium	Hedwig	Yes	Stems appear flattened & leaves attached at an upward angle.  Near streams, ponds, or lakes, often submerged. Cismontane.
Limprichtia	revolvens	(Swartz) Loeske	-	Fens and springs
Palustriella	commutata	(Bridel) Ochyra	-	Only genus in California. Northern California fens.
Pseudo-calliergon	angustifolium	Hedenäs	-	Wet fens and meadows in transmontane California.
Sanionia	uncinata	(Hedwig) Loeske	-	Only species in the genus in California. Fens, meadows, streambanks.

Malcolm, W., Malcolm, N., Shevock, J., and Norris, D. 2009. California Mosses. 430 pages. Micro-Optics Press. Nelson, New Zealand.

Norris, D.H, Shevock, J.R. 2004a. Contributions towards a bryoflora of California I. a specimen-based catalogue. Madroño 51: 1-131.

Norris, D.H, Shevock, J.R. 2004b. Contributions towards a bryoflora of California II. A key to the mosses. Madroño 51: 133-269.

## Brachytheciaceae

Standard effort level: Genus

7 species in four genera were found in voucher collections

Genus	Species	Author	Voucher	Comments
Brachythecium	albicans	(Hedwig) Schimper	-	Cismontane California
Brachythecium	asperrimum	-	-	-
Brachythecium	bolanderi	-	-	-
Brachythecium	calcareum	-	-	-
Brachythecium	collinum	(Schleicher) Ignatov & Huttunen	-	Common in montane California
Brachythecium	erythrorrhizon	-	-	-
Brachythecium	fendleri	-	-	-
Brachythecium	frigidum	(Müller Hal.) Bescherelle	Yes	Target stem leaves, not branch leaves. Near streams, springs, and seasonally submerged sites.
Brachythecium	holzingeri	-	-	-
Brachythecium	leibergii	-	-	-
Brachythecium	nelsonii	-	-	-
Brachythecium	rivulare	-	-	-
Brachythecium	rutabulum	-	-	-
Brachythecium	salebrosum	(Weber & D. Mohr) Bruch & Schimper	-	-
Brachythecium	velutinum	(Hedwig) Ignatov & Huttunen	-	Cismontane California

Genus	Species	Author	Voucher	Comments
Brachythecium	venustum	-	-	-
Eurhynchiastrum	pulchellum	(Hedwig) Ignatove & Huttunen	-	Cismontane northern California
Homalothecium	aureum	(Spruce) H. Robinson	Yes	Synonym of <i>H. pinnatifidum</i> . Braided rope stems; plicate leaves, long costa & quadrate alar cells
Homalothecium	californicum	-	-	-
Homalothecium	fulgescens	(Mitten ex Müller Hal.) A. Jaeger	Yes	Synonym of <i>H. lutescens</i> subsp. <i>Fulgescens</i> . Messy stems with curved branch tips, plicate, strong costa, small alar cells of various sizes; Stems ± remotely pinnate, very unequal so branching appears not pinnate; branch leaves erect and somewhat spreading when dry.
Homalothecium	nevadense	(Lesquereaux) Renauld & Cardot	-	Widespread in inland California and the Great Basin
Homalothecium	nuttallii	(Wilson) A. Jaeger	-	Endemic to western North America. Cismontane California.
Homalothecium	pinnatifidum	-	-	-
Kindbergia	oregana	(Sullivant) Ochyra	-	Endemic to western North America. Central Coast Ranges Northward.

Genus	Species	Author	Voucher	Comments
Kindbergia	praelonga	(Hedwig) Ochyra	-	Near streams and springs.
Platyhypnidium	pringlei	-	-	-
Platyhypnidium	riparioides	(Hedwig) Dixon	-	Only species of the genus in California. Splash zone of streams and rivers. Cismontane California.
Pseudoscleropodium	purum	(Hedwig) Fleischer	-	Monotypic genus. Introduced into California.
Rhynchostegium	aquaticum	A. Jaeger	Yes	Synonym of <i>Platyhypnidium riparioides</i> , <i>Torrentaria riparioides</i> , <i>Eurhynchium riparioides</i> .  Thick stems; wide-spreading & spaced leaves wet; dry leaves look shiny, large, smooth with no crinkling; cells are so narrow you can barely see them at 40x.
Rhynchostegium	serrulatum	(Hedwig) A. Jaeger	-	Cismontane California.
Scleropodium	californicum	(Lesquereaux) Kindberg	-	Endemic to cismontane California and northern Baja California, Mexico. Primarily near coast.
Scleropodium	cespitans	L. Koch	-	Cismontane California.
Scleropodium	julaceum	-	-	-

Genus	Species	Author	Voucher	Comments
Scleropodium	obtusifolium	(Mitten) Kindberg	Yes	Leaves julaceous and obtuse apices; elongate basal cells next to costa. Rheophytic species, common throughout cismontane California. Seasonally submerged. Found in intermittent streams.
Scleropodium	touretii	(Bridel) L. F. Koch	Yes	Leaves julaceous and some pointed (apiculus); small alar region not or little inflated; elongate basal cells by costa. Found roadbanks and trails, from coast to interior mountains, but typically away from seasonally inundated streams.
Tomentypnum	nitens	(Hewig) Loeske	-	Only species in the genus in California. Fens.
Tachybryum	megaptilum	-	-	

Malcolm, W., Malcolm, N., Shevock, J., and Norris, D. 2009. California Mosses. 430 pages. Micro-Optics Press. Nelson, New Zealand.

Norris, D.H, Shevock, J.R. 2004a. Contributions towards a bryoflora of California I. a specimen-based catalogue. Madroño 51: 1-131.

Norris, D.H, Shevock, J.R. 2004b. Contributions towards a bryoflora of California II. A key to the mosses. Madroño 51: 133-269.



## Fabroniaceae

Standard effort level: Genus

One species in one genus was found in voucher collections

Genus	Species	Author	Voucher	Comments
<i><u>Fabronia</u></i>	<i><u>pusilla</u></i>	Raddi	Yes	Long cilia margin and small leaves (lvs 0.4 - 0.8 mm) with long acuminate apices.

Malcolm, W., Malcolm, N., Shevock, J., and Norris, D. 2009. California Mosses. 430 pages. Micro-Optics Press. Nelson, New Zealand.

Norris, D.H, Shevock, J.R. 2004a. Contributions towards a bryoflora of California I. a specimen-based catalogue. Madroño 51: 1-131.

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## Fontinalaceae

Standard effort level: Genus

One species in one genus was found in voucher collections

Genus	Species	Author	Voucher	Comments
<i>Dichelyma</i>	<i>uncinatum</i>	Mittens		Only species in the genus in California. Grows along seasonally inundated streambanks. Rare in coast ranges of northwest California.
<b><u>Fontinalis</u></b>	<b><u>antipyretica</u></b>	Hedwig	Yes	Large spread-out folded leaves, long stems, aquatic, so folded it's almost impossible to unfold them Submerged in streams or lakes, but can be exposed during periods of low-flow. Cismontane California. Rarely grows with other <i>Fontinalis</i> species.
<i>Fontinalis</i>	<i>chrysophylla</i>			
<i>Fontinalis</i>	<i>gigantea</i>			
<i>Fontinalis</i>	<i>howellii</i>			
<i>Fontinalis</i>	<i>mollis</i>			
<i>Fontinalis</i>	<i>neomexicana</i>	Sullivant & Lesquereaux		Endemic to western North America. Grows submerged in rapidly flowing streams.

Malcolm, W., Malcolm, N., Shevock, J., and Norris, D. 2009. California Mosses. 430 pages. Micro-Optics Press. Nelson, New Zealand.

Norris, D.H, Shevock, J.R. 2004a. Contributions towards a bryoflora of California I. a specimen-based catalogue. Madroño 51: 1-131.

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## Leskeaceae

Standard effort level: Genus

Two species in two genera were found in voucher collections

Genus	Species	Author	Voucher	Comments
Claopodium	<i>bolanderi</i>	Best		Endemic to western North America. Cismontane California from Sierra Nevada and Coast Ranges northwards
Claopodium	<i>crispifolium</i>	(Hooker) Renault & Cardot		Endemic to Pacific Coast
<b><u>Claopodium</u></b>	<b><u>whippleanum</u></b>	(Sullivant) Renault & Cardot	Yes	Small stems & leaves, papillae, strong costa. Endemic to Pacific Coast and Iberian Peninsula. Common along trails and road banks
Leskea	<i>polycarpa</i>	Erhart ex Hedwig		Only species of the genus in California.
Pseudoleskea	<i>incurvata</i>	(Hedwig) Loeske		
Pseudoleskea	<i>patens</i>	(Lindberg) Kindberg		Sierra Nevada northwards
Pseudoleskea	<i>radicosa</i>			
Pseudoleskea	<i>radicosa</i> var. <i>pallida</i>			
Pseudoleskea	<i>saviana</i>			
Pseudoleskea	<i>stenophylla</i>	Renault & Cardot		Montane coniferous forests of northwest California
Pseudoleskea	<i>tribulosa</i>			

Genus	Species	Author	Voucher	Comments
Pseudoleskeella	<i>serpentinensis</i>	P.Wilson & Norris		Serpentine soils, usually along streams and rivulets
<b><u>Pseudoleskeella</u></b>	<b><u>tectorum</u></b>	(Funck ex Bridel) Kindberg ex Brotherus	Yes	Tiniest stems and leaves in CA feather mosses. Round-oval cells, no costa, smooth edges. Primarily in desert mountain ranges.

Malcolm, W., Malcolm, N., Shevock, J., and Norris, D. 2009. California Mosses. 430 pages. Micro-Optics Press. Nelson, New Zealand.

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Norris, D.H, Shevock, J.R. 2004b. Contributions towards a bryoflora of California II. A key to the mosses. Madroño 51: 133-269.

# ACROCARPS

## Aulacomniaceae

Standard effort level: Genus

One species in one genus was found in voucher collections.

Genus	Species	Author	Voucher	Comments
<u><i>Aulacomnium</i></u>	<u><i>androgynum</i></u>	(Sullivant) Renauld & Cardot	Yes	Chain-like (catenulate), very toothed leaves. Dark green, sprawling stems in a low-lying mat. Tight small leaves. Hand-cupped shape. Cells appear almost conical with projecting bump (papilla).  Malcolm et al. (2009) note that this species is widespread in deserts, whereas <i>A. palustre</i> is found in bogs and lake margins and is therefore unlikely to be collected from dry streambeds.
<i>Aulacomnium</i>	<i>palustre</i>			

Malcolm, W., Malcolm, N., Shevock, J., and Norris, D. 2009. California Mosses. 430 pages. Micro-Optics Press. Nelson, New Zealand.

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Norris, D.H, Shevock, J.R. 2004b. Contributions towards a bryoflora of California II. A key to the mosses. Madroño 51: 133-269.

## Bartramiaceae

Standard effort level: Genus

Three species in three genera were found in voucher collections.

Genus	Species	Author	Voucher	Comments
<i>Anacolia</i>	<i>baueri</i>			Formerly <i>A. menziesii</i> var. <i>braueri</i> .
<i>Anacolia</i>	<i>laevisphaera</i>			
<b><u>Anacolia</u></b>	<b><u>menziesii</u></b>	(Turner) Paris	Yes	<p>Long awn-like leaves erect when dry. Upper cells smooth (few bearing low prorulae on back side); inner basal cells quadrate or short-rectangular; distal lamina 1 (or 2)-stratose.</p> <p>Malcolm et al. (2009) note that <i>A. baueri</i> is also found in California, and the two species are difficult to separate.</p>
<i>Bartramia</i>	<i>ithyphylla</i>			
<i>Bartramia</i>	<i>pomiformis</i>			
<b><u>Bartramia</u></b>	<b><u>stricta</u></b>	Bridel	Yes	<p>Long subulate leaves, large teeth, recurved margins, smooth rectangular cells, thick costa, no plications at base, flat triangular leaves.</p> <p>Malcolm et al. (2009) note that this species mostly found in grasslands and oak woodlands of cismontane northern California. Other species they note include <i>B. pomiformis</i> from northwestern California) and <i>B. ilythiphylla</i> (from high elevation alpine areas).</p>
<i>Philonotis</i>	<i>americana</i>			
<i>Philonotis</i>	<i>caespitosa</i>			

Genus	Species	Author	Voucher	Comments
<i>Philonotis</i>	<i>calcareo</i>			
<i>Philonotis</i>	<i>capillaris</i>			
<b><u>Philonotis</u></b>	<b><u>fontanus</u></b>	(Hedwig) Bridel	Yes	Slender shoots densely packed with light green leaves and red stems showing between leaves neatly arranged on fuzzy stems. One-stratose, ovate-lanceolate leaves with prorulose cells.  Two other species are noted by Malcolm et al. (2009) as occurring in California: <i>P. americana</i> (found throughout mountainous regions) and <i>P. yezoana</i> (montane to subalpine coniferous forest)
<i>Philonotis</i>	<i>marchica</i>			
<i>Philonotis</i>	<i>muhlenbergii</i>			
<i>Philonotis</i>	<i>tomentella</i>			
<i>Philonotis</i>	<i>yezoana</i>			
<i>Conostomum</i>	<i>tetragonum</i>			Malcolm et al. (2009) note that this genus has one species in California, and is found in soil moistened by melting snow, and is therefore unlikely to be collected from dry riverbeds.

Malcolm, W., Malcolm, N., Shevock, J., and Norris, D. 2009. California Mosses. 430 pages. Micro-Optics Press. Nelson, New Zealand.

Norris, D.H, Shevock, J.R. 2004a. Contributions towards a bryoflora of California I. a specimen-based catalogue. Madroño 51: 1-131.

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## Bryaceae

Standard effort level: Genus

Eighteen species in five genera were found in voucher collections.

Genus	Species	Author	Voucher	Comments
<i>Anomobryum</i>	<i>concinatum</i>			
<i>Anomobryum</i>	<i>julaceum</i>	(Schrader ex. P.G. Gärtner, B. Meyer, & Scherbius) W.P. Schimper		Formerly <i>Bryum julaceum</i> . Malcolm et al. (2009).
<b><u>Bryum</u></b>	<b><u>argenteum</u></b>	Hedwig	Yes	Clear cells above mid-leaf; acuminate lvs; costa ends at mid-leaf; diamond or rhomboidal cells above, square or short-rectangle below; red stems with innovations.  Malcolm et al. (2009) note that this species is common in many habitats throughout California.
<i>Bryum</i>	<i>blindii</i>			
<i>Bryum</i>	<i>calobryoides</i>	J.R. Spence		Malcolm et al. (2009) note that this species is rare and only found in alpine to sub-alpine areas of the Sierra Nevada.
<i>Bryum</i>	<i>chryseum</i>			

Genus	Species	Author	Voucher	Comments
<u><b>Bryum</b></u>	<u><b>lanatum</b></u>	(P. Beauvois) Bridel	Yes	Synonym of <i>B. argenteum</i> var. <i>lanatum</i> .  Tiny bryums. Bright white leaves (not yellow-white indicating dead tissue), appressed but with flaring leaf tips, costa to 3/4
<u><b>Gemmabryum</b></u>	<u><b>barnesii</b></u>	(J. B. Wood ex Schimper) J. R. Spence	Yes	Hexagonal cells above, quadrate below. Dioicous, many bulbils in many leaf axils, strong excurrent awn, short bud-like males, taller female shoots.
<i>Gemmabryum</i>	<i>caespiticium</i>	(Hedwig) J.R. Spence		Malcolm et al. (2009) note that this is widespread in cismontane California, especially in ruderal areas.
<i>Gemmabryum</i>	<i>californicum</i>			
<i>Gemmabryum</i>	<i>dichotomum</i>			
<i>Gemmabryum</i>	<i>gemmiferum</i>			
<i>Gemmabryum</i>	<i>gemmilucens</i>			
<u><b>Gemmabryum</b></u>	<u><b>klinggraeffii</b></u>	(Schimper) J. R. Spence & H. P. Ramsay	Yes	Relatively small, spheric, red to crimson tubers with distinctly protuberant cells and pale rhizoids. This species is probably introduced in the flora area.
<u><b>Gemmabryum</b></u>	<u><b>kunzei</b></u>	(Hornschuch ) J. R. Spence	Yes	Small plants < 0.5mm tall, lvs < 1 mm, strong excurrent awn, square basals, clear upper cells, compact leaves overlapping, no tubers or bulbils.

Genus	Species	Author	Voucher	Comments
<u><b>Gemmabryum</b></u>	<u><b>radiculosum</b></u>		Yes	Synonym of <i>Bryum radiculosum</i> . Warmer climates, characterized by large red rhizoidal tubers, long awns, quadrate proximal laminal cells, and a preference for calcareous substrates.
<u><b>Gemmabryum</b></u>	<u><b>subapiculatum</b></u>		Yes	Synonym of <i>Bryum subapoculatum</i> . Huge bright red tubers on orange rhizoids; vertical tufted shoots well-spaced, short, lvs < 1.5mm, rectangular basal cells.
<u><b>Gemmabryum</b></u>	<u><b>tenuisetum</b></u>	(Limpricht) J. R. Spence & H. P. Ramsay	Yes	Synonym of <i>Bryum tenuisetum</i> . Large ovate lanceolate leaves, red stems, strong gold costa short excurrent, rectangular basals, big yellow tubers on yellowish rhizoids.
<u><b>Gemmabryum</b></u>	<u><b>valparaisense</b></u>		Yes	Synonym of <i>Bryum valparaisense</i> . Tubers pear-shaped, brownish, basal cells quadrate mostly, <i>Gemmabryum</i> traits.
<i>Gemmabryum</i>	<i>violaceum</i>			Synonym of <i>Bryum violaceum</i>
<i>Haplodontium</i>	<i>tehamense</i>	(Showers) J.R. Spence		Formerly <i>Mielichhoferia tehamensis</i> . Only one species in the genus, endemic to Lassen Volcanic National Park.
<u><b>Imbribryum</b></u>	<u><b>alpinum</b></u>			Synonym of <i>Bryum alpinum</i>
<i>Imbribryum</i>	<i>gemmiparum</i>		Yes	Synonym of <i>Bryum gemmiparum</i>
<i>Imbribryum</i>	<i>microchaeton</i>			Synonym of <i>Bryum microchaeton</i>
<i>Imbribryum</i>	<i>mildeanum</i>			Synonym of <i>Bryum mildeanum</i>
<i>Imbribryum</i>	<i>miniatum</i>			Synonym of <i>Bryum miniatum</i>
<i>Imbribryum</i>	<i>muhlenbeckii</i>			Synonym of <i>Bryum muhlenbeckii</i>

Genus	Species	Author	Voucher	Comments
<u><i>Imbribryum</i></u>	<u><i>sp. nov.</i></u>		Yes	Long wavy upper cells near apex; thickened red cell walls; long shoots, little branching; semi-aquatic (diatoms); strong costa percurrent to slightly excurrent pointed, basal cells quadrate & rectangular (not thin & wavy).
<i>Plagiobryoides</i>	<i>vinosula</i>	(Cardot) J.R. Spence		Formerly <i>Brachymenium vinosulum</i> . Only one species in genus in California, from a single population in the Mojave Desert.
<i>Ptychostomum</i>	<i>arcticum</i>			Synonym of <i>Bryum arcticum</i>
<i>Ptychostomum</i>	<i>badium</i>			Synonym of <i>Bryum badium</i>
<i>Ptychostomum</i>	<i>bimum</i>			Synonym of <i>Bryum bimum</i>
<i>Ptychostomum</i>	<i>cernuum</i>			Synonym of <i>Bryum cernuum</i> , <i>B. uliginosum</i>
<i>Ptychostomum</i>	<i>creberrimum</i>			Synonym of <i>Bryum creberrimum</i> , <i>B. lissae</i>
<i>Ptychostomum</i>	<i>cyclophyllum</i>			Synonym of <i>Bryum cyclophyllum</i>
<i>Ptychostomum</i>	<i>inclinatum</i>			Synonym of <i>Bryum amblyodon</i>
<i>Ptychostomum</i>	<i>lonchocaulon</i>			Synonym of <i>Bryum lonchocaulon</i>
<i>Ptychostomum</i>	<i>neodamense</i>			Synonym of <i>Bryum neodamense</i>
<i>Ptychostomum</i>	<i>pallens</i>			Synonym of <i>Bryum pallens</i>
<i>Ptychostomum</i>	<i>pallescens</i>			Synonym of <i>Bryum pallescens</i>

Genus	Species	Author	Voucher	Comments
<u><b>Ptychostomum</b></u>	<u><b>pseudotriquetrum</b></u>		Yes	Synonym of <i>Bryum pseudotriquetrum</i> , <i>P. bimum</i> , <i>P. neodamense</i> . Short awns, long ovate-lanceolate lvs with decurrent costa, big hexagonal or 5-sided cells, rectangular basal cells, strong costa, red & fuzzy lower stems, no tubers or leaf gemmae (rare).
<i>Ptychostomum</i>	<i>schleicheri</i>			Synonym of <i>Bryum schleicheri</i>
<i>Ptychostomum</i>	<i>turbinatum</i>			Synonym of <i>Bryum turbinatum</i>
<i>Ptychostomum</i>	<i>weigeli</i>	(Hedwig) J.R. Spence and H.P. Ramsay		Malcolm et al. (2009) note that this co-occurs with corn lilies in coniferous forests and is unlikely to be found in dry river samples. Synonym of <i>Bryum weigeli</i>
<i>Roellia</i>	<i>roellia</i>	(Brotherus ex Röhl) Andrews ex H. Crum		A monotypic genus found in western North America. Mostly found in coniferous forests.
<i>Rosulabryum</i>	<i>canariense</i>			Synonym of <i>Bryum canariense</i>
<u><b>Rosulabryum</b></u>	<u><b>capillare</b></u>		Yes	Obovate leaves with large hexagonal cells, Tubers large red.
<i>Rosulabryum</i>	<i>elegans</i>			Synonym of <i>Bryum elegans</i>

Genus	Species	Author	Voucher	Comments
<i>Rosulabryum</i>	<i>flaccidum</i>			As noted in BFNA ( <a href="http://floranorthamerica.org/Rosulabryum_flaccidum">http://floranorthamerica.org/Rosulabryum_flaccidum</a> ): In North America there has been significant confusion over the identity of the small species that produce filiform gemmae in the leaf axils. H. Syed (1973) named the common widespread species with short, rosulate innovations <i>Rosulabryum flaccidum</i> , and described a new species, <i>R. laevifilum</i> , for specimens with smooth gemmae. However, these two species completely intergrade, and the name <i>R. flaccidum</i> was incorrectly applied. The correct name is thus <i>R. laevifilum</i> for what has passed as <i>R. flaccidum</i> in North America. True <i>R. flaccidum</i> is a very different species related to <i>R. pseudocapillare</i> with a type from Hispaniola.
<i>Rosulabryum</i>	<i>gemmaescens</i>			Synonym of <i>Bryum gemmaescens</i>
<b><u><i>Rosulabryum</i></u></b>	<b><u><i>laevifilum</i></u></b>		Yes	Synonym of <i>Bryum laevifilum</i> or <i>Bryum flaccidum</i> (latter incorrectly applied to many N. American specimens). Obovate leaves with a highly variable costa, and rosulate innovations.
<b><u><i>Rosulabryum</i></u></b>	<b><u><i>rubens</i></u></b>		Yes	Synonym of <i>Bryum rubens</i> . Broadly ovate leaves, a weak limbidium, serrate distal leaf margins, and large red tubers with strongly protuberant cells.

Genus	Species	Author	Voucher	Comments
<u><i>Rosulabryum</i></u>	<u><i>torquescens</i></u>	(Bruch ex D Notaris) J.R. Spence	Yes	Must look at multiple gametangia at stem apices, cut in half and put on slide to observe antheridia/archegonia. Must also look for tubers. Lots of work!!

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## Ditrichaceae

Standard effort level: Genus

Two species in two genera were found in voucher collections. Five genera are noted in Malcolm et al. (2009).

Genus	Species	Author	Voucher	Comments
<u><i>Ceratodon</i></u>	<u><i>purpureus</i></u>	Hedwig	Yes	Smooth cells, triangular leaves, unistratose, recurved margins
<i>Ceratodon</i>	<i>stenocarpus</i>			
<i>Distichium</i>	<i>capillaceum</i>	(Hedwig) Bruch & W.P. Schimper		Malcolm et al. (2009) note it as a montane species.
<i>Distichium</i>	<i>inclinatum</i>			
<u><i>Ditrichum</i></u>	<u><i>ambiguum</i></u>		Yes	Long subulate leaves slightly curved to one side; Wide costa at base, long rectangular cells throughout, margins recurved slightly throughout
<i>Ditrichum</i>	<i>heteromallum</i>			
<i>Ditrichum</i>	<i>montanum</i>			
<i>Ditrichum</i>	<i>pusillum</i>			
<i>Ditrichum</i>	<i>schimperi</i>	(Lesquereaux) Kuntz		Endemic to the Pacific coast, from Central California northward.
<i>Pleuridium</i>	<i>acuminatum</i>			
<i>Pleuridium</i>	<i>mexicanum</i>			
<i>Pleuridium</i>	<i>subulatum</i>	(Hedwig) Rabenhorst		Cismontane California
<i>Trichodon</i>	<i>cylindricus</i>	(Hedwig) W.P. Schimper		Cismontane California. Small, easily overlooked.

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## Fissidentaceae

Standard effort level: Genus

Family contains one genus. Two species in one genus were found in voucher collections.

Genus	Species	Author	Voucher	Comments
<i>Fissidens</i>	<i>aphelotaxifolius</i>	Pursell		Endemic to Pacific Northwest. Rare.
<b><u>Fissidens</u></b>	<b><u>bryoides</u></b>		Yes	May be the same as <i>F. crispus</i> .
<b><u>Fissidens</u></b>	<b><u>crispus</u></b>	Montague	Yes	Synonym of <i>F. limbatus</i> . Throughout cismontane California.
<i>Fissidens</i>	<i>curvatus</i>			Synonym of <i>Fissidens milobakeri</i>
<i>Fissidens</i>	<i>dubius</i>			
<i>Fissidens</i>	<i>fontanus</i>	(Bachelot de Pylaie)		Rare and grows in disjunct populations.
<i>Fissidens</i>	<i>grandifrons</i>	Bridel		Grows in calcareous springs, streams, and seeps
<i>Fissidens</i>	<i>obtusifolius</i>			
<i>Fissidens</i>	<i>pauperculus</i>	M.A. Howe		Endemic to Pacific Coast, primarily in redwood forests
<i>Fissidens</i>	<i>taxifolius</i>			
<i>Fissidens</i>	<i>taylorii</i>			
<i>Fissidens</i>	<i>ventricosus</i>	Lesquereaux		Primarily on the coast

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## Funariaceae

Standard effort level: Genus

Four species in three genera were found in voucher collections.

Genus	Species	Author	Voucher	Comments
<i>Entosthodon</i>	<i>californicus</i>	(Sullivant & Lesquereaux) H. Crum & L.E. Anderson		Endemic to the Pacific Coast. Cismontane northern California, mostly in grasslands and woodlands. Easily overlooked.
<i>Entosthodon</i>	<i>drummondii</i>	Sullivant		Spring ephemeral in cismontane California. Capsules essential for identification.
<b><u>Entosthodon</u></b>	<b><u>fascicularis</u></b>		Yes	Capsules have teeth and are exerted & symmetric, straight seta, with long-pear-shaped capsule capped by long-beaked calyptra, peristome absent; costa long excurrent in a subula
<i>Entosthodon</i>	<i>kochii</i>			
<i>Entosthodon</i>	<i>rubrisetus</i>			
<i>Entosthodon</i>	<i>tusconi</i>			
<i>Funaria</i>	<i>convexa</i>			Newly documented species in California, as per Malcolm et al. (2009)
<b>Funaria</b>	<b>hygrometrica</b>	Hedwig	Yes	Asymmetric capsule opening, red, grooved capsules on tall setae, to species is tricky. Widespread and abundant in California.

Genus	Species	Author	Voucher	Comments
<i>Funaria</i>	<i>microstoma</i>			
<b><u>Funaria</u></b>	<b><u>muhlenbergii</u></b>	Turner	Yes	Square or short rectangular basal cells with very delicate thin walls, almost looking like cells are inflated; light delicate costa; apex into a delicate apiculus; branching red stems.  Frequent in deserts.
<i>Physcomitrella</i>	<i>patens</i>			
<i>Physcomitrella</i>	<i>readeri</i>	(C. Müller Hal) Stone & G.A.M. Scott		Found in seasonally inundated wetland and reservoir margins in cismontane California.
<i>Physcomitrium</i>	<i>californicum</i>			
<i>Physcomitrium</i>	<i>collenchymatum</i>			
<i>Physcomitrium</i>	<i>hookeri</i>			
<b><u>Physcomitrium</u></b>	<b><u>pyriforme</u></b>		Yes	No peristome, symmetrically placed on capsule, big smooth cells, sub-rectangular, obovate.  Cismontane California

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## Grimmiaceae

Standard effort level: Genus

Six species in two genera were found in voucher collections. Several species noted in Malcolm et al. (2009) but absent from voucher collections occur in intermittent streams (e.g., *Cadrophorus*).

Genus	Species	Author	Voucher	Comments
<i>Bucklandiella</i>	<i>affinis</i>			
<i>Bucklandiella</i>	<i>heteroscticha</i>	(Hedwig) Bednarek -Ochyra & Ochyra		Cismontane northern California.
<i>Bucklandiella</i>	<i>lawtoniae</i>			
<i>Bucklandiella</i>	<i>macounii</i>			
<i>Bucklandiella</i>	<i>microcarpa</i>			
<i>Bucklandiella</i>	<i>obesa</i>			
<i>Bucklandiella</i>	<i>occidentalis</i>			
<i>Bucklandiella</i>	<i>pacifica</i>	(Ireland & J. Spence) Bednarek- Ochyra & Ochyra		Endemic to Pacific coast, primarily Central Coast mountains. Riverine.
<i>Bucklandiella</i>	<i>sudetica</i>			
<i>Codriophorus</i>	<i>depressus</i>	(Lesquereaux) Bednarek-Ochyra & Ochyra		Restricted to western North America, mostly in California. Found in intermittent streams.
<i>Codriophorus</i>	<i>norrissii</i>	(Bednarek-Ochyra & Ochyra) Bednarek-Ochyra & Ochyra		Seasonally inundated boulders in streams

Genus	Species	Author	Voucher	Comments
<u>Coscinodon</u>	<u>calyptratus</u>	(Drummond) C.E.O. Jensen	Yes	Big calyptra covering entire capsule; Straight seta, many sporophytes, long awns, keeled lvs, 1 or 2-stratose margins, otherwise 1-stratose x-sections, rectangular basal cells, upper cells quadrate to round.  Primarily transmontane.
<u>Coscinodon</u>	<u>sp. nov.</u>		Yes	Autoicous with males at different locations along the stem, females terminal; keeled x-section w/ hydroids & bistratose margins in 1-2 rows
<u>Grimmia</u>	<u>alpestris</u>		Yes	Bistratose distally, margins incurved, cells bulging in x-section, basal cells quadrate to long rectangular, but most are square to short-rectangular; dioicous
<i>Grimmia</i>	<i>anodon</i>	Bruch & W.P. Schimper		Common throughout California, especially deserts.
<i>Grimmia</i>	<i>anomola</i>	Hampe		Northern California mountains, found in seeps and areas seasonally inundated by snowmelt.
<i>Grimmia</i>	<i>arizonae</i>			
<i>Grimmia</i>	<i>caespiticia</i>			
<i>Grimmia</i>	<i>hamulosa</i>	Lesquereaux		Northern California mountains, found in seeps and areas seasonally inundated by snowmelt.
<i>Grimmia</i>	<i>incurva</i>			
<u>Grimmia</u>	<u>laevigata</u>	(Bridel) Bridel	Yes	Widespread in California.

Genus	Species	Author	Voucher	Comments
<i>Grimmia</i>	<i>leibergii</i>	Paris		Synonym of <i>Dryptodon leibergii</i> . Conifer and oak woodlands.
<i>Grimmia</i>	<i>lesherae</i>			
<b><u>Grimmia</u></b>	<b><u>lisae</u></b>		Yes	Muticous, deeply keeled, ovate-lanceolate lvs; 2-to-3-stratose margins in 2-4 rows plus 2-stratose patches; recurved 1 or both margins in lower half; round upper cells bulging slightly; rectangular inner basals; square outer basals
<i>Grimmia</i>	<i>longirostris</i>			
<i>Grimmia</i>	<i>mariniana</i>			
<i>Grimmia</i>	<i>montana</i>	Bruch & W.P. Schimper		
<i>Grimmia</i>	<i>moxleyi</i>			
<i>Grimmia</i>	<i>nevadensis</i>			
<i>Grimmia</i>	<i>orbicularis</i>			
<i>Grimmia</i>	<i>ovalis</i>			
<i>Grimmia</i>	<i>plagiopodia</i>			
<i>Grimmia</i>	<i>poecilostoma</i>			
<b><u>Grimmia</u></b>	<b><u>pulvinata</u></b>	(Hedwig) J.E. Smith	Yes	Widespread in urban areas.
<b><u>Grimmia</u></b>	<b><u>raymondii</u></b>	(Lamarck & A.P. de Candolle) Margadant	Yes	Mostly in northern California coniferous forests
<i>Grimmia</i>	<i>serrana</i>	J. Muñoz, Shevock & Toren		Endemic to California
<i>Grimmia</i>	<i>sessitana</i>			

Genus	Species	Author	Voucher	Comments
<i>Grimmia</i>	<i>shastae</i>			
<i>Grimmia</i>	<i>torenia</i>	Hastings		Endemic to coastal mountains of central California
<i>Grimmia</i>	<i>torquata</i>	Drummond		Sierra Nevada and northward
<i>Grimmia</i>	<i>trichophylla</i>	Greville		Widespread in California
<i>Grimmia</i>	<i>unicolor</i>			
<i>Hydrogrimmia</i>	<i>mollis</i>	(Burch & W.P. Schimper) Loeske		Monotypic genus. Mostly in Sierra Nevada crest.
<i>Niphotrichum</i>	<i>elongatum</i>	Bednarek-Ochyra & Ochyra		Genus recently split from <i>Racomitrium</i> . Coastal central California and northward.
<i>Niphotrichum</i>	<i>ericoides</i>			
<i>Racomitrium</i>	<i>lanuginosum</i>	(Hedwig) Bridel		Extreme northwestern California
<i>Schistidium</i>	<i>agassizii</i>			
<i>Schistidium</i>	<i>atrichum</i>			
<i>Schistidium</i>	<i>cinclidodonteum</i>	B. Bremer		Along streams and rivulets. Largest species in genus in California.
<i>Schistidium</i>	<i>confertum</i>			
<i>Schistidium</i>	<i>dupretii</i>			
<i>Schistidium</i>	<i>flaccidum</i>			
<i>Schistidium</i>	<i>maritimum</i>	Burch & Schimper		Spray zone along coast, Mendocino and northwards.
<i>Schistidium</i>	<i>occidentale</i>			
<i>Schistidium</i>	<i>platyphyllum</i>			
<i>Schistidium</i>	<i>rivulare</i>	(Bridel) Podpěra		In seasonally submerged edges of streams or splash zone. Synonym of <i>Grimmia rivulare</i> .



Genus	Species	Author	Voucher	Comments
<i>Schistidium</i>	<i>tenerum</i>			

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## Hedwigiaceae

Standard effort level: Genus

One species in one genus was found in voucher collections.

Genus	Species	Author	Voucher	Comments
<i>Hedwigia</i>	<i>ciliata</i>			
<b><u>Hedwigia</u></b>	<b><u>detonsa</u></b>	(Howe) W.R. Bucke & Norris	Yes	Large wispy branching acrocarps with large flat white awns  Endemic to cismontane California
<i>Hedwigia</i>	<i>stellata</i>			
<i>Pseudobraunia</i>	<i>californica</i>	(Hedwig) Schwägrichen		Monotypic genus endemic to Pacific Coast. Found in low elevation cismontane California.

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## Meesiaceae

Standard effort level: Genus

One species in one genus was found in voucher collections.

Genus	Species	Author	Voucher	Comments
<u><i>Leptobryum</i></u>	<u><i>pyriforme</i></u>	(Hedwig) Wilson	Yes	Only species in genus in California. Seeps and streambanks. Widely distributed.
<i>Meesia</i>	<i>longiseta</i>	Hedwig		Streams and meadows in Sierra Nevada and northward
<i>Meesia</i>	<i>triquetra</i>	(H. Richter) Ångström		Fens and meadows
<i>Meesia</i>	<i>uliginosa</i>	Hedwig		Fens and meadows, mostly in lodgepole pine forests

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Norris, D.H, Shevock, J.R. 2004b. Contributions towards a bryoflora of California II. A key to the mosses. Madroño 51: 133-269.

## Mielichhoferiaceae

Standard effort level: Genus

One species of *Pohlia* was found in voucher collections.

Genus	Species	Author	Voucher	Comments
<i>Epipterygium</i>	<i>tozeri</i>	(Greville) Lindberg		Only species in the genus. Abundant in coastal California.
<i>Mielichhoferia</i>	<i>elongata</i>	Nees & Hornschuch		Cismontane California
<i>Mielichhoferia</i>	<i>mielichhoferiana</i>	(Funke) Loeske		Disjunct populations in coniferous forests.
<i>Mielichhoferia</i>	<i>shevockii</i>	(A.J. Shaw) A.J. Shaw		Endemic to California. Synonym of <i>Schizymerium shevockii</i> .
<i>Pohlia</i>	<i>andaluscia</i>			
<i>Pohlia</i>	<i>annotina</i>			
<i>Pohlia</i>	<i>bolanderi</i>	(Lesquereaux) Brotherus		Endemic to western North America. Sierra Nevada northwards.
<i>Pohlia</i>	<i>camptotrachela</i>	(Renauld & Carodt) Brotherus		Cismontane California, along streambanks.
<i>Pohlia</i>	<i>cardotii</i>			
<i>Pohlia</i>	<i>cruda</i>	(Hedwig) Lindberg		Widespread in California.
<i>Pohlia</i>	<i>dummondii</i>			
<i>Pohlia</i>	<i>elongata</i>			
<i>Pohlia</i>	<i>filum</i>			
<i>Pohlia</i>	<i>flexuosa</i>			
<i>Pohlia</i>	<i>lescuriana</i>			
<i>Pohlia</i>	<i>longibracteata</i>	Brotherus		Endemic to Pacific Coast. Near streams.

Genus	Species	Author	Voucher	Comments
<i>Pohlia</i>	<i>ludwigii</i>			
<i>Pohlia</i>	<i>nutans</i>			
<i>Pohlia</i>	<i>obtusifolia</i>			
<i>Pohlia</i>	<i>pacifica</i>			
<i>Pohlia</i>	<i>proligera</i>			
<i>Pohlia</i>	<i>robertsonii</i>	Shevock & A.J. Shaw		Endemic to Central Coast Ranges of California.
<i>Pohlia</i>	<i>tundrae</i>			
<b><u>Pohlia</u></b>	<b><u>wahlenbergii</u></b>	(Weber & D. Mohr) Andres	Yes	Common throughout California.

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## Mniaceae

Standard effort level: Genus

One species of *Pohila* was found in voucher collections, but this taxon has been moved to the family Mielichhoferiaceae.

Genus	Species	Author	Voucher	Comments
<i>Leucolepis</i>	<i>acanthoneura</i>	(Schwägrichen) Lindberg		Monotypic genus endemic to the Pacific Coast. Found near streams.
<i>Mnium</i>	<i>arizonicum</i>	Amann		Endemic to western North America. Alpine to subalpine Sierra Nevada, eastward
<i>Mnium</i>	<i>blyttii</i>			
<i>Mnium</i>	<i>marginatum</i>	Palisot de Beauvois		Near streams. Widespread but infrequent.
<i>Mnium</i>	<i>spinulosum</i>			
<i>Mnium</i>	<i>thomsonii</i>			
<i>Plagiomnium</i>	<i>cuspidatum</i>			
<i>Plagiomnium</i>	<i>ellipticum</i>			
<i>Plagiomnium</i>	<i>insigne</i>	(Mitten) T. Koponen		Endemic to western North America. Near streams. Cismontane California.
<i>Plagiomnium</i>	<i>medium</i>	(Burch & W.P. Schimper) T. Koponen		Inland areas of cismontane California. Humus-rich soils near streams and in meadows.
<i>Plagiomnium</i>	<i>rostratum</i>			
<i>Plagiomnium</i>	<i>venustum</i>	(Mitten) T. Koponen.		Endemic to Western North America. Cismontane central California and northwards.

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## Orthotrichaceae

Standard effort level: Genus

Three species in one genus were found in voucher collections.

Genus	Species	Author	Voucher	Comments
<i>Orthotrichum</i>	<i>affine</i>			
<i>Orthotrichum</i>	<i>alpestre</i>			
<i>Orthotrichum</i>	<i>anodon</i>			
<i>Orthotrichum</i>	<i>bolanderi</i>			
<i>Orthotrichum</i>	<i>consimile</i>			
<i>Orthotrichum</i>	<i>coulteri</i>			
<i>Orthotrichum</i>	<i>cupulatum</i>			
<i>Orthotrichum</i>	<i>diaphanum</i>			
<i>Orthotrichum</i>	<i>euryphyllum</i>			
<i>Orthotrichum</i>	<i>flowersii</i>			
<i>Orthotrichum</i>	<i>hallii</i>			
<i>Orthotrichum</i>	<i>holzingeri</i>			
<i>Orthotrichum</i>	<i>kellmanii</i>			
<i>Orthotrichum</i>	<i>laevigatum</i>			
<b><u>Orthotrichum</u></b>	<b><u>lyellii</u></b>		Yes	Hairy golden, mitrate calyptra, 8-ribbed capsules; No hair points (not Grimmiaceae), triangular leaves, big smooth cells, abundant filamentous, red gemmae on leaves
<i>Orthotrichum</i>	<i>macounii</i>			



Genus	Species	Author	Voucher	Comments
<u><b>Orthotrichum</b></u>	<u><b>norissii</b></u>		Yes	Synonym of <i>O. tenellum</i> complex.  Leaves erect (dry); autoicous; no gemmae on lvs; strongly recurved margins; capsules emergent with sunken stomata & 8 ribs; peristome with striations, no endostome (only big teeth); costa straight; apex acute s/t mucro; erect teeth (dry)
<i>Orthotrichum</i>	<i>pallens</i>			
<i>Orthotrichum</i>	<i>papillosum</i>			
<i>Orthotrichum</i>	<i>pellucidum</i>			
<i>Orthotrichum</i>	<i>praemorsum</i>			
<i>Orthotrichum</i>	<i>pulchellum</i>			
<i>Orthotrichum</i>	<i>pumilum</i>			
<i>Orthotrichum</i>	<i>pylaisii</i>			
<i>Orthotrichum</i>	<i>rivulare</i>			
<u><b>Orthotrichum</b></u>	<u><b>rupestre</b></u>		Yes	Hairy golden, mitrate calyptra, 8-ribbed capsules (superficial stomata) w/ 16 paired teeth, erect; No hair points (not Grimmiaceae), long lanceolate leaves (erect when dry); recurved margins; ; large, papillose cells; no gemmae; monoecious; low papillae; 1-stratose lvs;
<i>Orthotrichum</i>	<i>schimperi</i>			
<i>Orthotrichum</i>	<i>shawii</i>			
<i>Orthotrichum</i>	<i>shevockii</i>			
<i>Orthotrichum</i>	<i>speciosum</i>			
<i>Orthotrichum</i>	<i>striatum</i>			
<i>Orthotrichum</i>	<i>texanum</i>			
<i>Orthotrichum</i>	<i>unerwoodii</i>			

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## Pottiaceae

Standard effort level: Genus

Thirty-two species in twelve genera were found in voucher collections.

Genus	Species	Author	Voucher	Comments
<i>Acaulon</i>	<i>rufescens</i>	A. Jaeger		Ruderal
<i>Acaulon</i>	<i>triquetrum</i>			
<i>Aloina</i>	<i>ambigua</i>	Limpricht		Foothill woodlands to desert. Synonym of <i>Aloina aloides</i> var. <i>ambigua</i> .
<b><u>Aloina</u></b>	<b><u>bifrons</u></b>		Yes	Synonym of <i>A. pilifera</i> . Thick, succulent-like leaves, dark, shiny, tongue-shaped leaves with some wavy awns, leaves curled into a tight ball (cupped hands) dry, spreading rosette wet
<b><u>Aloina</u></b>	<b><u>rigida</u></b>		Yes	
<i>Anoectangium</i>	<i>handelii</i>	Schiffner		Only species in the genus in California. Deserts.
<i>Barbula</i>	<i>bolleana</i>			Synonym of <i>Barbula ehrenbergii</i>

Genus	Species	Author	Voucher	Comments
<b><u>Barbula</u></b>	<b><u>convoluta</u></b>	Hedwig	Yes	Firm leaves (wet); long ligulate or oblong-lanceolate (<2 mm); margins plane but sometimes weakly recurved below; percurrent costa; obtuse apex (or apiculate but I didn't see that); crowded papillae obscure cell wall visibility on distal half; dense rhizoids (tomentose); perichaetial leaves sheathing & convolute; male buds very short at base of female; tall sporophytes (< 2mm seta)  Mainly ruderal
<i>Barbula</i>	<i>eustegia</i>			
<i>Barbula</i>	<i>unguiculata</i>	Hedwig		Ruderal, cismontane California.
<i>Bryoerythrophyllum</i>	<i>columbianum</i>			Synonym of <i>Didymodon columbianus</i>
<i>Bryoerythrophyllum</i>	<i>ferruginascens</i>			
<i>Bryoerythrophyllum</i>	<i>recurvirostrum</i>	(Hedwig) P.C. Chen		
<b><u>Crossidium</u></b>	<b><u>aberrans</u></b>	Holzinger & E.B. Bartram	Yes	tiny (<3mm), unbranching shoots tipped with smooth awns; awn less than length of leaf; recurved margins; smooth cells (usually); narrow costal pad of filaments; oblong leaves; exerted capsules  Common throughout deserts.
<i>Crossidium</i>	<i>crassinerve</i>			
<b><u>Crossidium</u></b>	<b><u>seriatum</u></b>		Yes	

Genus	Species	Author	Voucher	Comments
<i>Crossidium</i>	<i>squamiferum</i>	(Viviani) Juratzka		Desert mountain ranges.
<b><u>Crumia</u></b>	<b><u>latifolia</u></b>	W.B. Schofield.	Yes	<p>Synonym of <i>Scoplophila latifolia</i>. Large (&gt;3 mm usu), spatulate-obovate leaves, reddish stems, big cells with 4+ bumpy papillae; <i>Syntrichia/Tortula</i>-like but thick-walled border of cells that are inflated in x-section</p> <p>Must cross section upper half of leaves and stems.</p> <p>Monospecific genus endemic to northwestern North America. Found in riparian areas in coastal and desert mountain ranges.</p>
<b><u>Didymodon</u></b>	<b><u>australasiae</u></b>	Zander	Yes	<p>Also known as <i>Tirchostomopsis australasiae</i>, <i>T. brevifolia</i>, and <i>T. diaphanobasis</i>.</p> <p>Common in deserts and arid areas.</p>
<b><u>Didymodon</u></b>	<b><u>bistratosus</u></b>	Hébrard & R.B. Pierrot.	Yes	<p>Bistratose distally (almost completely); short lvs (&lt;1 mm); deeply channeled-keeled at tip; square adaxial costal cells; tiered growth obvious.</p> <p>Primarily coastal in chaparral and woodlands.</p>

Genus	Species	Author	Voucher	Comments
<u><i>Didymodon</i></u>	<u><i>brachyphyllus</i></u>	Zander	Yes	Synonym of <i>D. vinealis</i> var. <i>brachyphyllus</i> ; <i>Barbula olivacea</i> .  Tiny, keeled leaves (< 1.5 mm); strongly recurved to near apex; ovate to ovate-triangular (never lanceolate); slightly cucullate; usually apiculate; unistratose or margins s/t bistratose; low papillae.  Arid to semi-arid regions of California.
<i>Didymodon</i>	<i>eckeliae</i>			
<i>Didymodon</i>	<i>fallax</i>			
<i>Didymodon</i>	<i>ferrugineus</i>			
<i>Didymodon</i>	<i>insulanus</i>			
<u><i>Didymodon</i></u>	<u><i>nicholsonii</i></u>		Yes	widely bistratose margins and patches of 2-st throughout upper half;
<i>Didymodon</i>	<i>norrisii</i>	Zander		Endemic to Pacific Coast, primarily in California.
<i>Didymodon</i>	<i>occidentalis</i>			Synonym of <i>Didymodon vinealis</i> var. <i>rubiginosus</i>
<i>Didymodon</i>	<i>revolutus</i>			
<u><i>Didymodon</i></u>	<u><i>rigidulus</i></u>		Yes	Gemmae, long-lanceolate leaves, square adaxial costa cells, widely channeled above & below;

Genus	Species	Author	Voucher	Comments
<u><i>Didymodon</i></u>	<u><i>tectorum</i></u>		Yes	Recurved margins usually most of leaf; pointed apical cell on many leaves; sub-round cells; papillae strong on many leaves; apical groove w/ window on some leaves
<u><i>Didymodon</i></u>	<u><i>tophaceus</i></u>	(Bridel) Lisa	Yes	Calcareous seeps, springs, riparian areas. Found throughout California.
<i>Didymodon</i>	<i>umbrosus</i>			
<u><i>Didymodon</i></u>	<u><i>vinealis</i></u>	(Bridel) Zander	Yes	Long lanceolate leaves, low lumpy papillae; recurved margins (entire length or mid up); clear conical apical cell on many lg leaves; "costa window" seen from back of leaf tip; sub-quadrate upper & lower cells. Widespread throughout California.
<i>Ephemerum</i>	<i>serratum</i>	(Hedwig) Hampe		Only species in the genus in California. Compact, caly soils in grasslands and oak savannas.
<u><i>Eucladium</i></u>	<u><i>verticillatum</i></u>	Bruch & W.P. Shcimper	Yes	Monotypic genus. Found in calcareous springs and streambanks.
<u><i>Gymnostomum</i></u>	<u><i>aeruginosum</i></u>		Yes	Bigger, messier (irregular shapes) apical lamina cells than <i>D. tophaceus</i> , but similar. Way bigger plants too.
<i>Gymnostomum</i>	<i>calcareum</i>	Nees & Hornschuch		Calcareous sites. Common in deserts and arid areas, but found throughout California.

Genus	Species	Author	Voucher	Comments
<u><b>Gymnostomum</b></u>	<u><b>viridulum</b></u>		Yes	Tiny tongue-shaped leaves (< 1 mm); mostly plane margins (can be recurved slightly at mid leaf); papillae project around margin as bumps (crenulate); costa percurrent; sub-circular cells above, rectangular below; apex variable (rounded to pointed or apiculate); axillary hairs based with brown cell
<i>Hennediella</i>	<i>heimii</i>			
<i>Hennediella</i>	<i>stanfordensis</i>	(W.C. Steere) Blockeel		Primarily on coast in ruderal areas.
<i>Hymenostylium</i>	<i>recurvirostrum</i>	(Hedwig) Dixon		
<i>Leptophascum</i>	<i>leptophyllum</i>	J. Guerra & M.J. Cano		Only species in the genus in California. Synonym of <i>Chenia leptophylla</i> .
<i>Microbryum</i>	<i>davallianum</i>			
<i>Microbryum</i>	<i>starckeanum</i>	(Hedwig) Zander		
<i>Microbryum</i>	<i>vlassovii</i>			Synonym of <i>Phascum vlassovii</i>
<i>Micromitrium</i>	<i>tenerum</i>	(Bruch & W.P. Schimper) Crosby		Only species in the genus in California
<i>Oxystegus</i>	<i>tenuirostris</i>	A.H.E. Smith		Only species in the genus in California. Primarily along creeks and streams.
<u><b>Pseudocrossidium</b></u>	<u><b>crinitum</b></u>	(Schultz) Zander	Yes	



Genus	Species	Author	Voucher	Comments
<i>Pseudocrossidium</i>	<i>obtusulum</i>			Synonym of <i>Pseudocrossidium revolutum</i> var. <i>obtusulum</i>
<i>Pterygoneurum</i>	<i>californicum</i>			
<i>Pterygoneurum</i>	<i>lamellatum</i>			
<i>Pterygoneurum</i>	<i>ovatum</i>	(Hedwig) Dixon		Mostly transmontane California
<i>Pterygoneurum</i>	<i>subsessile</i>	(Bridel) Juratzka		Mostly transmontane California, especially deserts.
<i>Scopelophila</i>	<i>cataractae</i>	(Mitten) Brotherus		Rare in California, mostly in the Sierra Nevada foothills near Copperopolis, CA.
<i>Scopelophila</i>	<i>ligulata</i>	(Spruce) Spruce		Rare in California.
<i>Stegonia</i>	<i>hyalinotricha</i>	(Cardot & Thériot) Zander		Near <i>Atriplex</i> , especially in the San Joaquin valley
<i>Stegonia</i>	<i>latifolia</i>			
<i>Stegonia</i>	<i>pilifera</i>	H. Crum & L.E. Anderson		Mostly along crest of the Sierra Nevada
<i>Syntrichia</i>	<i>bartramii</i>			
<i>Syntrichia</i>	<i>caninervis</i>	Mitten		Common in desserts and the Great Basin, infrequent in chaparral and woodlands
<i>Syntrichia</i>	<i>laevipiloa</i>			
<i>Syntrichia</i>	<i>latifolia</i>			
<i>Syntrichia</i>	<i>montana</i>			

Genus	Species	Author	Voucher	Comments
<u><b>Syntrichia</b></u>	<u><b>norvegica</b></u>		Yes	Synonym of <i>Tortula norvegica</i> . Spatulate leaves w/ long awn (but weak, so breaks in older shoots), tall c-shaped & forked papillae; 1-stratose; strongly recurved margins (to upper 1/4); Costa without hydroids; stem without central strand; median juxtacostal cells mostly about 12 µm; plant dioecious;
<u><b>Syntrichia</b></u>	<u><b>obtusifolia</b></u>		Yes	Synonym of <i>Desmatodon obtusifolius</i> . Awn, circular papillae, tiny plants, hydrate rapidly
<i>Syntrichia</i>	<i>pagorum</i>	(Milde) Amann		Mostly in urbanized areas, orchards, and landscaped parks.
<i>Syntrichia</i>	<i>papillosa</i>	(Wilson) Juratzka		Mostly in urbanized areas, orchards, and landscaped parks, especially along coast.
<i>Syntrichia</i>	<i>papillosissima</i>			
<u><b>Syntrichia</b></u>	<u><b>princeps</b></u>	(De Notaris) Mitten	Yes	Synonym of <i>Tortula princeps</i> . Leaves twisted around stem dry, >2mm, spatulate, recurved in middle; awns spinulose to serrate, ~1mm, hyaline except reddish base; central strand & hydroids; 4-6 low, forked papillae per cell; distal cells large (12-20 µm wide); dioicy observed.  Widespread in California.

Genus	Species	Author	Voucher	Comments
<i>Syntrichia</i>	<i>ruralis</i>	(Hedwig) F. Weber & D. Mohr		Throughout California. Synonym of <i>Tortula ruralis</i> .
<i>Syntrichia</i>	<i>sucrosa</i>			
<i>Syntrichia</i>	<i>viriscens</i>			
<i>Timmiella</i>	<i>anomala</i>	(Bruch & W.P. Schimper) Limpricht		Cismontane California
<b><u>Timmiella</u></b>	<b><u>crassinervis</u></b>		Yes	Synonym of <i>Phascum acaulon</i> .
<i>Tortella</i>	<i>tortuosa</i>	(Hedwig) Limpricht		Sierra Nevada northward.
<b><u>Tortula</u></b>	<b><u>acaulon</u></b>		Yes	
<i>Tortula</i>	<i>amplexa</i>			
<b><u>Tortula</u></b>	<b><u>atrovirens</u></b>		Yes	Synonym of <i>Desmatodon convolutus</i> , <i>D. californicus</i> . Small, rosulate plants with brownish leaves strongly twisted around the stem when dry; the massive costal pad is easily visible when wet
<i>Tortula</i>	<i>bolanderi</i>			Synonym of <i>Syntrichia bolanderi</i>
<b><u>Tortula</u></b>	<b><u>brevipes</u></b>		Yes	Synonym of <i>Barbula macrotichia</i> . Oblong leaves; Exserted capsules; No leaf border; Awned; densely papillose; strongly recurved whole leaf;

Genus	Species	Author	Voucher	Comments
<u><i>Tortula</i></u>	<u><i>californica</i></u>	E.B. Bartram.	Yes	Obovate leaves, plane or slight recurve proximally, smooth cells; longish, excurrent awn, large (>17 um) round-hexagonal cells.  Endemic from Central California to northern Baja California, Mexico.
<u><i>Tortula</i></u>	<u><i>quepinii</i></u>	(Bruch & W.P. Schimper) Brotherus	Yes	Leaves <2mm; smooth awns; papillae few & low c-shaped; distal cells huge (>15 um); central strand & hydroids; recurved middle 4/5 of leaf; no border; twisted messy dry.  Throughout California, in chaparral and woodlands.
<i>Tortula</i>	<i>hoppeana</i>	(Schultz) Ochyra		Montane northern California, especially the Sierra Nevada and Klamath mountains.
<u><i>Tortula</i></u>	<u><i>inermis</i></u>	Bridel	Yes	Tall basal membrane; Strong papillae & revolute margins; big cells; rounded apex only apiculate at most; exerted capsule, long capsule 2-4 mm; orange KOH.  Common in dry areas of California, especially deserts.
<i>Tortula</i>	<i>leucostoma</i>			

Genus	Species	Author	Voucher	Comments
<u><b>Tortula</b></u>	<u><b>mucronifolia</b></u>		Yes	Large (>2mm usu), oblong leaves with acute apices, mucronate, large, round, smooth distal cells, border weak or absent, narrowly recurved below not above; autoicous; long seta & straight capsule
<u><b>Tortula</b></u>	<u><b>muralis</b></u>	Hedwig	Yes	Oblong leaves; Exserted capsules; weak leaf border; long-awned; densely papillose; strongly recurved 4/5 leaf; twisted peristome, basal membrane low (<50 um); smooth round spores (8-14um); distal cells small (<12 um); central strand & hydroids.  Common in urban areas growing on concrete.
<u><b>Tortula</b></u>	<u><b>obtusifolia</b></u>		Yes	Synonym of <i>Desmatodon obtusifolius</i> .
<i>Tortula</i>	<i>plinthobia</i>			
<i>Tortula</i>	<i>protobryoides</i>			
<u><b>Tortula</b></u>	<u><b>subulata</b></u>	Hedwig	Yes	Tortula features but more narrow tip, mucro only, thick-walled border of 3-4 cells at mid-leaf; plane margins curving inward slightly; multiple c-shaped papillae throughout (not low basals).  Montane coniferous forests from Sierra Nevada northwards.

Genus	Species	Author	Voucher	Comments
<i>Tortula</i>	<i>systylia</i>			
<i>Trichostemmum</i>	<i>brachydontium</i>			
<i>Trichostemmum</i>	<i>crispulum</i>			
<i>Trichostemmum</i>	<i>sweetii</i>	(E.B. Bartram) Stark		Sometimes called <i>T. plannifolium</i> . Deserts.
<i>Triquetrella</i>	<i>californica</i>	(Lesquereaux) Grout		Only species of the genus in California. Species endemic to coastal California, northward to southern Oregon.
<i>Weissia</i>	<i>condensa</i>			
<b>Weissia</b>	<b>controversa</b>	Hedwig	Yes	Inrolled margins, short mucro, long- elliptic leaves (base similar width to upper leaf), apex broad, rounded- acute, distal cells often large (10–13 µm wide); capsule lacks teeth or just rudimentary tips; costa consuming < 1/3 of base width.  Throughout California, especially grasslands and oak woodlands.
<i>Weissia</i>	<i>inoperculata</i>			
<i>Weissia</i>	<i>ligulaefolia</i>			

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# APPENDIX: TECHNICAL NEEDS FOR A STANDARDIZED TAXONOMIC EFFORT FOR BRYOPHYTES IN CALIFORNIA AND ARIZONA DRY STREAMS AND RIVERS

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## Available keys and identification guides

Malcolm et al. (2009) and Norris and Shevock (2004b) provide identification keys that will allow practitioners to identify all families and most genera found in California, as well as a few species. The University of California herbarium maintains an online key to the genera ([https://ucjeps.berkeley.edu/CA\\_moss\\_eflora/general.html](https://ucjeps.berkeley.edu/CA_moss_eflora/general.html)). An identification guide ([https://data.sccwrp.org/owncloud/apps/files\\_sharing/get.php?token=ea4de71fb19fd7389c5a597067de8923c33b5ed5&path=/2022-02-18-09:53:30](https://data.sccwrp.org/owncloud/apps/files_sharing/get.php?token=ea4de71fb19fd7389c5a597067de8923c33b5ed5&path=/2022-02-18-09:53:30)) developed as part of a SWAMP-funded effort will help practitioners identify species found in the WEE-CSUMB voucher collection.

However, updated keys are needed. These resources are insufficient to identify all possible taxa that may be encountered in non-perennial streams in California, especially newly described species (e.g., *Imbibryum* sp. nov), or species recently discovered to occur in California.

Keys should be updated to incorporate these new additions to the California flora (vs. Malcolm et al. 2009 and Norris and Shevock 2004a):

- *Amblystegium radicale*
- *Anoetangium handeli*
- *Bryoerythrophyllum ferruginascens*
- *Bryum blindii*, *B. chryseum*
- *Coscinodon* sp. nov.
- *Didymodon bistratosus*, *D. tectorum*
- *Entosthodon fascicularis*
- *Fissidens obtusifolius*
- *Funaria convexa*
- *Gemmabryum californicum*, *G. klinggraeffii*
- *Grimma arizonae*, *G. incurva*, *G. sessitana*, *G. torenii*, *G. unicolor*



- *Gymnostomum aeruginosum*, *G. viridulum*
- *Hedwigia ciliate*
- *Homalothecium californicum*
- *Imbibryum sp. nov*
- *Limprichtia revolens*
- *Microbryum vlassovii*
- *Mielichhoferia ielichhoferiana*
- *Orthotrichum anodon*, *O. coulteri*, *O. kellmanii*, *O. schimperi*, *O. shawii*
- *Plagiobryoides vinosula*
- *Platyhypnidium pringlei*
- *Pleuridium mexicanum*
- *Pohlia flexuosa*, *P. robertsonii*
- *Pseudoleskea tribulosa*
- *Rhynchostegium aquaticum*
- *Scopelophila ligulate*
- *Syntrichia montana*, *S. obtusifolia*, *S. sucrosa*, *S. virescens*
- *Tomentypnum nitens*
- *Tortella tortuosa*
- *Weissia ligulaefolia*

Family	Number of genera in California
Andreaeaceae	1
Archidiaceae	1
Bruchiaceae	1
Buxbaumiaceae	1
Calliergonaceae	2
Climaciaceae	1
Cryphaeaceae	1
Dicranaceae	3
Disceliaceae	1
Eckeraceae	5
Encalyptaceae	1
Helodiaceae	1
Hookeriaceae	1
Hylomiaceae	4
Hypnaceae	11
Lembophyllaceae	2

Family	Number of genera in California
Leptodontaceae	1
Leucobryaceae	2
Leucodontaceae	2
Piaceae	1
Plagiotheciaceae	1
Polytrichaceae	6
Pterigynandraceae	3
Ptychomitriaceae	2
Rhabdoweisiaceae	7
Scouleriaceae	1
Seligeriaceae	1
Sematophyllaceae	1
Sphagnaceae	1
Tetraphidaceae	1
Timmiaceae	1

## Additional sampling

The STE focuses on species found in the 18 families with specimens in the voucher collection. Additional sampling will likely discover species in other families in dry riverbeds of California. 31 additional families are identified in Malcom et al. (2009) as occurring in California, but were not found in voucher collections. Many of these families are typically found in terrestrial habitats, and are unlikely to be found in ephemeral or intermittent channels (e.g., Timiaceae), but others could occur in these habitats.

## Development of molecular taxonomy tools

Molecular methods, such as DNA barcoding, can produce taxonomic data comparable to traditional, morphological methods, as long as reference sequences are available in genetic databases. In addition, the use of molecular methods could reduce sampling impacts to bryophytes by reducing collection quantities needed for identifications. We evaluated every family (n=18), genus (n=99), and species (n=431) name in the STE to determine if molecular sequences were available in GenBank database or the Barcode of Life Database (BOLD). Within BOLD, we looked for sequences generated primers that target loci in the mitochondrion (i.e., COI), nuclear ribosomal genes (i.e., rbcL and ITS), or chloroplast (trnL). Because BOLD also had geographic metadata, we were able to tally sequences from specimens collected in the US or within the Southwest (i.e., California, Arizona, Nevada, Utah, New Mexico, Colorado, and

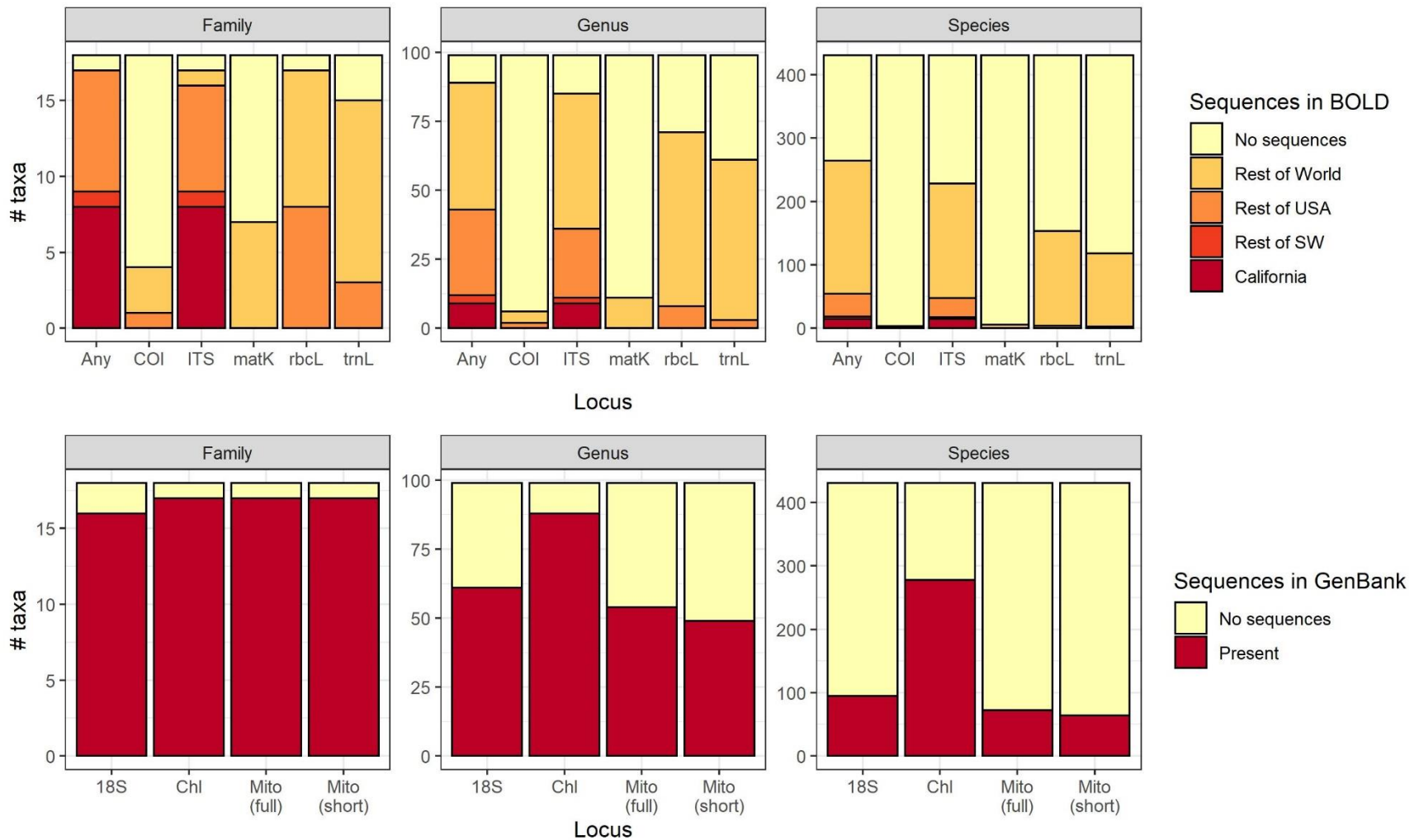
Texas). Within GenBank, we queried the number of mitochondrial, chloroplast, and nuclear ribosomal (18S) sequences. Queries were restricted to short sequences (i.e., 200 to 3400 base-pairs); separately, we conducted an additional query of “full length” mitochondrial sequences over 200 base-pairs.

Within BOLD, more taxa were represented with the ribosomal nuclear marker ITS, followed by *rbcl* and *trnL*. In contrast, the mitochondrial COI marker was very poorly represented. Overall, 61% of all species, and 90% of all genera had sequences in BOLD. Although queries failed to find any sequences for one family (i.e., Mielichhoferiaceae), genera (e.g., *Pohlia*) within this family were represented, indicating the database likely contains errors and/or gaps in taxonomic metadata. Most sequences in BOLD were from specimens collected outside the USA (Figure 1, Table 1).

Within GenBank, 74% of species and 93% of genera were represented. Again, although queries failed to find any sequences for one family (i.e., Mielichhoferiaceae), genera and taxa within this family were represented. Chloroplast markers (*rbcl*, *trnL*) were better represented than mitochondrial (COI) or nuclear ribosomal markers (18S). For example, 65% of taxa had chloroplast sequences, compared with 17% having mitochondrial and 22% having nuclear ribosomal (18S) sequences.

Based on this review of GenBank and BOLD, molecular identification of California bryophyte flora is promising, at least at the genus level. Specifically, we recommend:

- Focusing on chloroplast and nuclear ribosomal markers, rather than mitochondrial markers
- Generating reference sequences for the 4 genera not represented in either database:
  - Amblystegiaceae: *Limprichtia*
  - Bryaceae: *Plagiobryoides*
  - Grimmiaceae: *Hydrogrimmia*
  - Pottiaceae: *Leptohascum*
- Generating reference sequences for the 85 species not represented in either database, prioritizing the 11 taxa that have occurred in voucher data sets:
  - Bryaceae: *Brym lanatum*, *Gemmabrym kunzei*, *G. tenuisetum*, *G. valparaisense*, *Rosulabryum laevifilum*
  - Funariaceae: *Funaria muhlebergii*
  - Pottiaceae: *Aloina bifrons*, *Crossidium seriatum*, *Pseudocrossidium crinitum*, *Tortula guepinii*, *T. obtusifolia*
- Improving representation of California specimens in sequence databases for taxa represented by specimens collected elsewhere.



**Figure 1. Number of bryophyte taxa with sequences in BOLD (top row) or GenBank reference databases (bottom row). Mitochondrial markers are indicated by COI, Mito (full) and Mito (short). Chloroplast markers are indicated by matK, rbcL, trnL, and Chl. Nuclear ribosomal markers are indicated by 18S and ITS.**

**Table 1. Number of taxa with sequences represented in BOLD or GenBank databases.**

Level	Number of taxa evaluated	BOLD	GenBank 18S	GenBank mitochondrial genes	GenBank full-length mitochondrion sequence	GenBank chloroplast sequence
Order	11	10	10	10	10	10
Family	18	17	17	17	17	17
Genus	98	90	77	84	86	90
Species	439	286	170	126	130	304

## **Develop a coarser STE level to facilitate cost-effective identifications of bryophytes**

The current STE requires species-level identifications. Some species can be identified fairly rapidly, but a few require a lot of time at the microscope, based on the typical condition of specimens collected with our protocols. A coarser level of effort (e.g., genus) may be sufficient to assess biological conditions with less time for taxonomic analysis or by using molecular identification methods. This coarser level of effort should be developed in consultation with professional taxonomists in the region.