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NEW ADDITIONS TO THE FLORA OF SAN NICOLAS ISLAND, VENTURA COUNTY, CALIFORNIA

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ABSTRACT

Ongoing collecting efforts on San Nicolas Island have substantially increased the number of plant species documented from the island. Here we report thirty-one plants previously unrecorded from the island. The list includes six eudicots, one monocot, four liverworts and twenty mosses. Five of these species are understood to be introduced on San Nicolas and the remainder are believed to be native. The native vascular plants are *Logfia filaginoides*, *Cistanthe maritima* and *Muhlenbergia microsperma*. Of the twenty-four new bryophytes, one—*Asterella bolanderi*—is the first record from the Channel Islands. Specific ecological and locality information are provided for the new vascular plant finds and general patterns of bryophyte richness and ecological preferences are discussed.

Key words: bryophytes, California, Channel Islands, floristics, land plants.

INTRODUCTION

San Nicolas Island is one of the eight California Channel Islands, an archipelago located off the coast of southern California. At 58 km^2, San Nicolas ranks 5th in size among the eight islands of the archipelago, and it is also the most remote, with a distance of 98 km to the closest point on the mainland. Perhaps owing to its relatively small size, distance from the mainland, and only modest elevational relief (maximum elevation 277 m), the island has relatively low vascular plant taxonomic richness. In the most recent floristic inventory of the island, Junak (2008) listed a total of 278 minimum rank taxa (species, subspecies, and varieties), 137 of which are naturally occurring and 141 are presumed to be introduced. The non-vascular plant flora (mosses, liverworts and hornworts), while not well studied, has a similarly low taxonomic richness, with 11 species previously observed (Carter 2015, 2017). Given the historical lack of attention to the non-vascular flora, it has not been clear if low taxonomic richness reported for non-vascular plants reflects low natural richness, the historically meager attempt to document these plants, or both.

Since 2008 there have been few purely collection-oriented trips to San Nicolas Island, but there has been consistent effort to collect data for long-term vegetation transects and rare plant monitoring locations. Collecting efforts aimed solely at improving our understanding of species distributions have been challenging to fund, however collections supporting restoration efforts, genetic sampling and monitoring of rare vascular plants, and mapping of vegetation have presented opportunities for collections to be made opportunistically. Beginning in 2016, this effort has been extended to the non-vascular flora. Together, the improvements to our knowledge of both vascular and non-vascular floras on San Nicolas represent a substantial increase in the number of taxa known and present a strong case for further exploration.

The purpose of this report is to aggregate the results of recent vascular plant and bryophyte collecting efforts on San Nicolas Island. A vouchered list is provided (Appendix 1), including all unpublished new discoveries for the island since the most recent vascular plant (Junak 2008) and bryophyte (Carter 2015) floristic treatments.

MATERIALS AND METHODS

Vascular plant observations were made during rare plant inventories, general reconnaissance surveys, bryophyte inventories, and vegetation surveys by the authors during 2016 and 2017. Collecting trips and participants were as follows (authors of this paper listed by first and last initial): collections of new vascular plant species were made on 9 April 2010 (SJ), 16 April 2013 (SJ & Valerie Vartanian), 17 April 2016 (WH & BC), 9 June 2016 (SJ), 18 March 2017 (JD and Ed Kentner), 11–12 May 2017 (CMG & WH), 29 June 2017 (WH). Voucher specimens are deposited at the Clifton Smith Herbarium at the Santa Barbara Botanic Garden (SBBG).

Bryophyte inventories were performed by BC 5–7 February 2016 (with WH & CMG) and 15–17 April 2016 (with WH). Approximately 100 collections were made from localities throughout the island. Voucher specimens are deposited at the Carl W. Sharsmith Herbarium at San José State University (SJSU).

RESULTS

Seven new island records of vascular plant species were made during surveys between 2010 and 2017 (Fig. 1–5; Appendix 1). Three of these species are native to California and are thought

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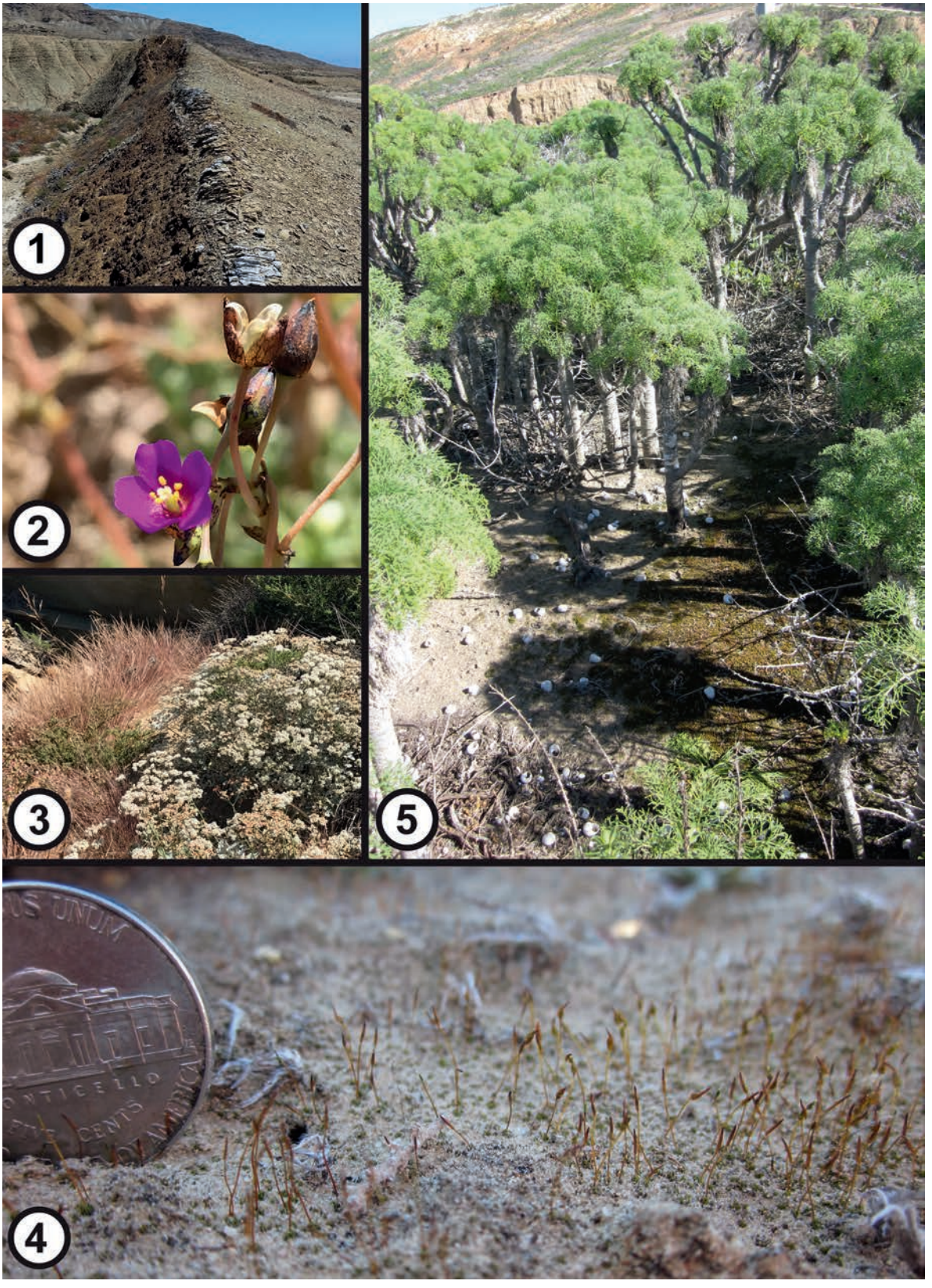

Fig. 1–5. Habitat and flora of San Nicolas Island.—1. Band of soil derived from porphyritic andesite harboring *Cistanthe maritima* and associated locally uncommon vascular plants.—2. Flowers and fruits of *Cistanthe maritima*.—3. Several *Muhlenbergia microsperma* individuals growing with island endemic *Eriogonum grande* var. *timorum*.—4. *Crossidium crassinervium*, one of the most abundant mosses on San Nicolas.—5. Mat of *Didymodon vinealis* (Brid.) R.H. Zander beneath canopy of *Leptosyne*. All photos by the authors.

to be naturally occurring on the island: *Logfia filaginoides* (Asteraceae), *Cistanthe maritima* (Montiaceae), and *Muhlenbergia microsperma* (Poaceae). Four species are not native to California and represent new introductions to the island: *Capsella bursa-pastoris* (Brassicaceae), *Polycarpon tetraphyllum* var. *tetraphyllum* (Caryophyllaceae), *Euphorbia terracina* (Euphorbiaceae), and *Malva nicaeensis* (Malvaceae).

The bryophyte surveys resulted in new vouchered reports for nine of the ten historically known moss species reported by Carter (2015). The only species that was not recollected was *Ceratodon purpureus* (Hedw.) Brid., a common and often weedy species that is most likely still present despite going undetected. The new surveys uncovered an additional four liverwort species and 22 moss species that were not previously reported for the island. Of the new records, *Tortella humilis* (Hedw.) Jenn. was new for California, as reported by Carter (2017), and *Asterella bolanderi* (Austin) Underw. was recorded for the first time from the Channel Islands. Both are presumed to be naturally occurring (i.e., not anthropogenically introduced). All the other species have been previously reported from one or more of the other Channel Islands (Carter 2015) and most have been documented from the adjacent mainland in the Santa Monica Mountains (Sagar 2009). Two specimens could be identified to genus but not to species due to the lack of necessary reproductive material. These were in the genera *Fossombronia*, which has two species known from the Channel Islands, *F. longiseta* (Austin) Austin and *F. pusilla* (L.) Nees, and *Microbryum*, which also has two species known from the islands, *M. davallianum* (Sm.) R.H. Zander and *M. starckeanum* (Hedw.) R.H. Zander. These four species all occur in similar habitats throughout the Channel Islands, primarily on exposed soil within grasslands and shrub-dominated communities. *Fossombronia longiseta* is the more widespread of the two *Fossombronia* species and has been documented from Santa Catalina, San Clemente, Santa Cruz and Santa Rosa Islands; *F. pusilla* has been documented from Santa Catalina and San Clemente (Carter 2015). Of the two *Microbryum* species, *M. davallianum* has been documented from Santa Catalina, San Clemente and San Miguel Islands, and *M. starckeanum* has been documented from Santa Catalina and San Clemente (Carter 2015).

DISCUSSION

The Vascular Plant Flora

The vascular plant flora of San Nicolas Island, while small relative to the other Channel Islands, is consistent with expected taxonomic richness on the basis of island size and distance to the mainland (Moody 2000; B.E. Carter and C.M. Guilliams, unpubl. data). With only 137 native and 141 introduced minimum-rank vascular plant taxa, a restricted geographic coverage, and a long history of botanical exploration (Junak 2008), the addition of seven new vascular plant taxa is significant. These recent findings increase the size of the vascular flora to 140 native and 145 introduced taxa, an overall increase of 2.5%, and an increase in the native component of 2.2%.

We infer that three of the new vascular plant records—species considered native on the mainland—are naturally occurring on San Nicolas Island based on the evidence available to us. First, populations of these new species are in relatively undisturbed areas in native vegetation. Second, they occur in remote areas away from centers of human activity. Finally, populations are well-established but could easily be overlooked due to one or more of the following: 1) remoteness; 2) relatively small spatial extent of populations; 3) possible lack of yearly germination and development; and 4) small stature. These species, along with four new records of introduced species, are discussed in the following paragraphs.

Capsella bursa-pastoris was first collected on San Nicolas Island by SJ on 9 April 2010 from the disturbed flats in Nicktown (*Junak SN-1745*, SBBG). Along with the airfield area, Nicktown is one of the primary centers of human activity on the island and the main location for housing on the island. As a result, Nicktown is a common location for new records of non-native species. This species is now known from all of the Channel Islands except Anacapa. It is a common weed throughout North America and is native to Eurasia.

Cistanthe maritima was first collected on San Nicolas Island on 12 May 2017 by CMG and WH (*Guilliams 3498*, SBBG) on the coastal terrace between Cliff Canyon and Desert Fan Canyon, west of Daytona Beach, in the southeastern part of the island (Fig. 2). Plants were growing on an igneous dike (Fig. 1) composed of porphyritic andesite (Vedder and Norris 1963), where they co-occurred with other uncommon native taxa such as *Eschscholzia ramosa* (Greene) Greene and *Mentzelia affinis* Greene. Later field surveys focusing on this soil type resulted in the discovery of another population of *C. maritima* (*Hoyer 022*, SBBG), suggesting an affinity for this substrate type among these rare island taxa. With the new records from San Nicolas, this species is now documented from all of the Channel Islands except for San Miguel. On the mainland, it is narrowly distributed in coastal locations from Santa Barbara County to northwestern Baja California.

Euphorbia terracina was first observed on San Nicolas Island in the winter of 2012–2013 at two locations: Humphrey's Sump and on the South West Mesa. Both populations numbered in the thousands of individuals, with the Humphrey's Sump population covering ca. 0.49 ha and the Mesa population covering 5.87 ha in the 2012–2013 season. This native of Europe is considered an invasive weed in California, and annual treatment began on San Nicolas the year it was discovered and continues through the present. The origin of these populations on San Nicolas Island may be anthropogenic, but also could be the result of bird dispersal. The two localities have very low human traffic, which also may explain the large size of the populations at initial detection in 2012–2013. This is the first published report for this species on the California Channel Islands, although it has been recorded from Santa Cruz Island (S. Junak, unpubl. data). A native of Europe, it occurs throughout the southern coastal areas of California.

Logfia filaginoides was first collected on San Nicolas Island on 17 April 2016 by WH and BC on the mesa north of the airfield (*Hoyer 20*, SBBG), then again south of the airfield in 2017 (*Meszaros s.n.*, 27 March 2017, SBBG). The species has likely gone undetected previously because it is a small and relatively inconspicuous annual, and the localities near the airfield are not frequented by botanists. With the San Nicolas populations, this species is now known from all eight of the Channel Islands. The native range spans California and extends in scattered localites east to Texas and south to northern Mexico.

Malva nicaeensis All. was first collected on San Nicolas Island on 16 April 2013 by SJ in two widely spaced locations

on the island: ruderal, sandy, flat areas in Nicktown (*Junak SN-1747*, SBBG), and at the edge of the parking area at Barge Landing, Daytona Beach (*Junak SN-1749*, SBBG). This introduced mallow species is also known from Santa Cruz Island. Native to western Europe and the Mediterranean region, its North American distribution includes low elevation regions throughout California.

Muhlenbergia microsperma (Fig. 3) was first collected on San Nicolas Island on 18 March 2017 by JD (*Dunn 17041801*, SBBG) from a south-facing canyon slope approximately halfway between Dutch Harbor and Daytona Beach in the southeastern part of the island. The scant soils present consist of weathering-indurated sandstones (mapped as Rock Outcrops in Estrada 1985). Associated species include *Eriogonum grande* Greene var. *timorum* Reveal, *Cylindropuntia prolifera* (Engelm.) F.M. Knuth and *Opuntia littoralis* (Engelm.) Cockerell. *Muhlenbergia microsperma* is an annual to short-lived perennial that is now documented from all the Channel Islands except San Miguel. The native range extends from the southwestern United States to Central and South America.

Polycarpon tetraphyllum var. *tetraphyllum* was first collected on San Nicolas Island on 9 June 2016 by SJ (*Junak SNi-1750*, SBBG) from an area supporting ruderal vegetation in Nicktown. With this collection, the species has now been documented from all Channel Islands. Native to southwestern Europe, it is common throughout western North America.

The Bryophyte Flora

With 35 species currently known, the bryophyte flora of San Nicolas Island is quite small relative to the other Channel Islands, which range in richness from five species (Santa Barbara Island) to 118 (Santa Catalina Island). An important explanatory factor is likely the lack of appropriate substrate. On other islands in the archipelago, large rock outcrops, large woody plants (especially *Quercus tomentella* Engelm., *Q. pacifica* Nixon & C.H. Mull. and *Pinus muricata* D. Don), seasonal streams and dense clay soils each provide important substrates for bryophyte species that are conspicuously missing from San Nicolas Island. Conversely, some of the substrates that provide important habitats for vascular plant species, for example sand dunes and caliche soils, are inhospitable to bryophytes.

Bryophyte distributions across San Nicolas Island can be separated into three general habitat classes: seeps, north facing slopes and arid scrublands. Seeps harbor a small number of specialist species, especially *Eucladium verticillatum* (With.) Bruch & Schimp. and *Didymodon tophaceus* (Brid.) Lisa, which are both historically recorded from San Nicolas. The steep north-facing slopes along the north and east edge of the island are the richest habitats for bryophytes and harbor a number of species that are very common on the northern islands (San Miguel, Santa Rosa, Santa Cruz and Anacapa Islands) but mostly excluded from the extensive drier parts of San Nicolas Island. All of the liverworts, the pleurocarpous mosses (*Scleropodium* and *Homalothecium*) and the moss genera *Fissidens* and *Rosulabryum* exhibit this distribution. The majority of the island is very dry and most of the bryophyte species occurring throughout the island are very small species that contribute to the lichen-dominated soil crusts (e.g., *Didymodon* spp., *Gemmabryum* spp., *Tortula* spp. and *Crossidium crassinervium* (De Not.) Jur.; Fig. 4–5). In general, bryophyte richness on San Nicolas Island corresponds to soil stability, with the oldest and most stable soils harboring the highest number of species. The caliche soils, which harbor several interesting vascular plant species, support only a few of the most tolerant generalist bryophyte species.

Introduced species constitute a large proportion of the vascular flora of San Nicolas Island, but the same is not true of the bryophytes. Currently only one of the 35 species, *Fissidens curvatus* Hornsch., is thought to be introduced to the island. Similarly, endemism is lower in bryophyte island floras than in corresponding vascular plant floras, and San Nicolas currently has no known endemic bryophytes. Across all the Channel Islands, there are no known endemic bryophytes, although two undescribed species might be endemic, pending future collecting efforts in mainland southern California (Carter 2015).

The Importance of Continuing Efforts to Document the Flora

Recent work on the flora of the Channel Islands is beginning to provide a clearer understanding of the evolution and assembly of the Channel Island floras. For example, molecular studies in *Acmispon* (Fabaceae) have demonstrated the importance of large-scale molecular analyses with dense infraspecific sampling to disentangle the complicated evolutionary history of island *Acmispon* species (McGlaughlin et al. 2014; Wallace et al. 2017). Looking at the whole vascular flora of the archipelago, Moody (2000) and Riley and McGlaughlin (2016) have likewise begun to develop the Channel Islands as an important system for understanding the role of prevailing wind patterns in establishing floras of near-shore islands.

These insights are critical in the pivot from the basic documentation of floras to delving into the mechanisms that underlie floristic patterns. However, a steady increase in the number of species documented from San Nicolas and the other Channel Islands highlights two critical aspects of floristic botany. The first is that, especially in a changing world, a flora is never complete. The Channel Islands are an extreme example of this. With the drastic environmental changes brought on by the removal of introduced herbivores, including more than 30,000 sheep on San Nicolas Island (Schoenherr et al. 1999), the recovery of plant populations results in a measurable change in the flora and vegetation over the timespan of decades. Only dedicated field observation can document these changes across time. The second is that the flora extends beyond vascular plant species and that a checklist of the vascular flora is the beginning, rather than the end, of a botanical inventory. Biogeographic patterns of bryophytes across the Channel Islands differ in important ways from the vascular plants, for example in reduced endemism and in different contributions of species from the adjacent mainland versus mainland areas to the north and south (Carter 2015; B.E. Carter and C.M. Guilliams, unpubl. data). Recent collecting efforts have also uncovered more than 150 lichen species on San Nicolas Island (K. Knudsen, pers. comm. 2016), and the eventual biogeographic comparisons of the lichen, bryophyte and vascular plant floras will undoubtedly yield a much richer and more nuanced understanding of the basic biology of San Nicolas Island, and thereby increase our capacity for making prudent management decisions with the goal of maintaining the island flora in perpetuity.

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APPENDIX 1.

List of new discoveries with detailed collection information. Vascular plant vouchers are deposited at SBBG and bryophyte vouchers are deposited at SJSU. Introduced species are indicated with an asterisk (*). General locality on the island is provided along with specific localities for one or more voucher specimens representing each species.

EUDICOTS

*Capsella bursa-pastoris (L.) Medik. Central mesa; disturbed flats in Nicktown, 9 Apr 2010, *Junak SN-1745.*

Cistanthe maritima (Nutt.) Carolin ex Hershk. Southeast quarter of the island; between Cliff Canyon and Desert Fan Canyon along igneous dike (33.21788, -119.46409), 12 May 2017, *Guilliams & Hoyer 3498*; east of Desert Fan Canyon and west of western edge of Daytona Beach on an igneous dike (33.21951, -119.46084), 31 May 2017, *Hoyer 022*.

*Euphorbia terracina L. North shore; bottom of Tule Creek Canyon below Humphrey Sump, 16 Apr 2013, *Junak & Vartanian SN-1746*; southwest side of island, caliche flats just southwest of Building #323, 16 Apr 2013, *Junak & Vartanian SN-1749*; southwest eroded mesa (33.25140, -119.53864), 5 July 2017, *Hoyer 23*.

Logfia filaginoides (Hook. & Arn.) Morefield. Central mesa; between Beach Road and airfield, 17 Apr 2016, (33.24627, -119.45861), *Hoyer & Carter 020.*

*Malva nicaeensis All. Central mesa; disturbed sandy flats in Nicktown, 16 Apr 2013, *Junak SN-1747*; edge of parking area at Barge Landing, Daytona Beach, 16 Apr 2013, *Junak SN-1748*.

*Polycarpon tetraphyllum (L.) L. var. tetraphyllum. Central mesa; disturbed flats in Nicktown, 9 Jun 2016, *Junak SN-1750*.

MONOCOTS

Muhlenbergia microsperma (DC.) Kunth. Southeast quarter; approximately halfway between Dutch Harbor and Daytona Beach, 18 Mar 2017, *Dunn 17041801*; top of small bowl at toe of small sandstone escarpment, 12 May 2017, *Guilliams & Hoyer 3494*.

LIVERWORTS

Asterella bolanderi (Austin) Underw. Northeast slopes; (33.255, -119.474), 16 Apr 2016, *Carter 9372.*

Asterella californica (Hampe ex Austin) Underw. Northeast slopes; road from north end of airstrip down to lower coastal mesa, 5 Feb 2016, *Carter 9084.*

Fossombronia sp. Northeast slopes; road from north end of airstrip down to lower coastal mesa, 5 Feb 2016, *Carter 9085.*

Targionia hypophylla L. Northeast slopes; road from north end of airstrip down to lower coastal mesa, 5 Feb 2016, *Carter 9086*.

MOSSES

Aloina aloides (Koch ex Schultz) Kindb. var. ambigua (Bruch & Schimp.) E.J. Craig. Central mesa (33.262, -119.535), 6 Feb 2016, *Carter 9142.*

Aloina bifrons (De Not.) Delgad. Widespread; road from north end of airstrip down to lower coastal mesa, 5 Feb 2016, *Carter 9082.*

Bryum argenteum Hedw. Widespread; mesa below southern tip of airstrip, 5 Feb 2016, *Carter 9096.*

Fissidens crispus Mont. Northeast slopes; road from north end of airstrip down to lower coastal mesa, 5 Feb 2016, *Carter 9080.*

*Fissidens curvatus Hornsch. Northeast slopes; coastal mesa below Nicktown, 5 Feb 2016, *Carter 9066.*

Fissidens sublimbatus Grout. Northeast slopes; northeast edge of island (33.246, -119.457), 15 Apr 2016, *Carter 9358.*

Gemmabryum dichotomum (Hedw.) J.R. Spence & H.P. Ramsay. Northeast slopes; northeast edge of island (33.246, -119.457), 15 Apr 2016, *Carter 9361.*

Gemmabryum gemmilucens (R. Wilczek & Demaret) J.R. Spence. Northeast slopes, southeast quarter; coastal terrace, northeast side of island (33.247, -119.460), 15 Apr 2016, *Carter 9350.*

Gemmabryum radiculosum (Brid.) J.R. Spence & H.P. Ramsay. Widespread; central mesa (33.262, -119.535), 6 Feb 2016, *Carter 9149.*

Hennediella stanfordensis (Steere) Blockeel. North shore; Humphrey Sump, 6 Feb 2016, *Carter 9131.*

Homalothecium arenarium (Lesq.) E. Lawton. Northeast slopes; coastal mesa below Nicktown, 5 Feb 2016, *Carter 9071.*

Microbryum sp. Northeast slopes; northeast side of island (33.247, -119.460), 15 Apr 2016, *Carter 9351.*

Ptychostomum creberrimum (Taylor) J.R. Spence & H.P. Ramsay. Northeast slopes, south shore; large canyon along west edge of Nicktown, 7 Feb 2016, *Carter 9160*.

Rosulabryum canariense (Brid.) Ochyra. Northeast slopes; coastal mesa below Nicktown, 5 Feb 2016, *Carter 9074*.

Rosulabryum capillare (Hedw.) J.R. Spence. North shore of island (33.261, -119.493), 16 Apr 2016, *Carter 9379*.

Timmiella crassinervis (Hampe) L.F. Koch. Northeast slopes; coastal mesa below Nicktown, 5 Feb 2016, *Carter 9078*.

Tortula acaulon (With.) R.H. Zander. South shore; south-central coastal part of the island (33.222, -119.516), 7 Feb 2016, *Carter 9173*.

Tortula atrovirens (Sm.) Lindberg. Widespread; southern edge of island (33.229, -119.454), 5 Feb 2016 *Carter 9092*.

Tortula guepinii (Bruch & Schimp.) Broth. North shore; north side of island (33.269, -119.537), 17 Apr 2016, *Carter 9404*.

Weissia controversa Hedw. Northeast slopes; road from north end of airstrip down to lower coastal mesa, 5 Feb 2016, *Carter 9091*.