Hawaiian Moss Names

Bartram (1933) did not include Hawaiian names in his manual of Hawaiian mosses. The Hawaiian dictionary by Pukui & Elbert (1986) lists two general terms for mosses, limu and huluhulu, and names for specific types of mosses and liverworts. Unfortunately, only one of these specific names has a scientific name attached to it, *Thuidium hawaiiense* (now *T. cymbifolium*). The rest are orphan names that cannot be attached to known species unless other records can be found. A dictionary of modern Hawaiian by Komike Hua`olelo (2003) lists another general term, mākōpi`i, and one specific term hulu pō`ē`ē for *Sphagnum* moss.

Table 10. *Known Hawaiian words for mosses, liverworts, and a lichen.*

Hawaiian	English definition
`ekaha	a moss growing on rotted trees, also limu `ekaha
hini hini `ula	an upland moss
huluhulu a Ka`au hele moa	a moss said to grow only in Palolo Valley, Honolulu, named for Ka`au-hele-moa a legendary cock defeated in battle by a hen. She pulled his feathers which became this moss. It is used in leis.
hulu pō`ē`ē	Sphagnum
huluhulu	kinds of seaweeds and mosses
huluhulu a `īlio	a green, velvety carpet-like mountain moss. The spore cases rise above the plants. Lit. fur like a dog.
iliohe	a name reported for a green freshwater moss
kala maka pi`i	same as mākole mākō pi`i and kale maka pi`i
kalau ipo	a moss found in water
kale maka pi`i	variant of kala maka pi`i, a moss
lī pepei ao	1. a seaweed 2. a freshwater moss, usually qualified by wai
lī poa kua hiwi	a non-edible mountain moss as opposed to the edible lī poa
limu	general name for plants including mosses, liverworts, lichens, etc..
limu `ahu`ula	an upland moss
limu ahi	a tree moss or liverwort
limu haea	a lichen (Stereocaulon sp.) with erect, branching stalks
limu holo `a wai	a freshwater moss
limu kaha	a kind of liverwort
limu kala maka pi`i	same as kala maka pi`i
limu kale maka pi`i	same as kale maka pi`i
limu kau lā`au	all tiny ferns (filmy ferns), lichens, liverworts, mosses growing on trees
limu kele	moss growing on trees in rainforest
limu mā kole maka `ō pi`i	same as mākole mākō pi`i
limu pepei ao	same as lī pepei ao
maka `ō pi`i	same as mākole mākō pi`i
mākō pi`i	moss general term
mākō pi`i `elenahu	peatmoss
mākole mākō pi`i	a native moss (*Thuidium hawaiiense*), the branches on one plane looking like small ferns. See mākō pi`i, maka `ō pi`i
`oau	a moss
`onohī awa	a black moss found in freshwater. Lit. eyeball of the fish awa.
`opulepule	a spotted land moss
`owau	same as `oau

Management Concerns

Alien species

The very dense growth exhibited by two alien species in the park, *Pseudoscleropodium purum* and *Hypnum plumaeforme*, strongly suggests they displace native bryophytes along roads and trails. Both species are already widespread along park roads and trails so park-wide removal is unlikely. Neither species produces spores or other wind dispersed propagules and instead are spread by human or animal activity. Efforts should be made to reduce their accidental spread by staff and visitors. For example, mowing equipment should be thoroughly cleaned before transport to job sites not yet invaded by alien moss otherwise small fragments of both moss species clinging to the equipment can easily fall off during equipment operation and grow vegetatively on any damp substrate.

High traffic centers such as the Resources Management field station should be cleared of alien mosses to reduce accidental transport by park vehicles. Special effort should be made to prevent the introduction of *P. purum* into the Kahuku unit and to prevent the introduction of *H. plumaeforme* into the western side of the Kahuku unit. *P. purum* is also growing successfully in the Kipuka Puaulu forest well beyond the trailsides. *P. purum* should be controlled at Kipuka Puaulu where it is growing under the forest beyond the trailsides to prevent potential problems with seedling recruitment and prevent total replacement of the original native terrestrial bryophyte layer which may have unknown consequences for tree fern and seedling recruitment. Both *P. purum* and *H. plumaeforme* should be controlled at Thurston Lava Tube and Kilauea Iki Trail to maintain an easily accessible example of a diverse Hawaiian bryophyte community for public enjoyment and education. Mosses grow slowly compared to vascular plants such that even one or two days of work by a group of volunteers a year might be enough to stop the increase in alien moss cover at Kipuka Puaulu, Thurston Lava Tube, and Kilauea Iki. Because *Breutelia arundinifolia* is not found in natural habitats in the park it should be treated as an alien species and controlled in high traffic sites such as the Kilauea Visitor Center and the Resource Management field station areas to prevent accidental spread further along the park's roads and trails. *Sphagnum palustre* should be monitored to see if it starts increasing in abundance anywhere in or near the park. *S. subpinnatum* spreads by spores and is consequently now too widespread to possibly control. Roadsides and lawns in Volcano Village should be monitored every few years to watch for the appearance of new alien species that may come in with horticultural plantings. The State of Hawaii should be encouraged to ban the importation of live bryophyte material to prevent the introduction of potentially invasive mosses.

Rare species

In general, too little is known about the population sizes of uncommon moss to accurately assess their risk of extinction. This is true both locally and internationally. The online database of worldwide IUCN Red List of Threatened Species includes 39 moss species currently threatened with extinction (http://www.redlist.org accessed November 3, 2005). None of the listed species are found in HAVO. However, as discussed by the IUCN Bryophyte Specialist Group, the list is admittedly incomplete because so little is known about the actual distribution and population numbers of the world's moss species

(http://www.dbs.nus.edu.sg/lab/crypto-lab/WorldBryo.htm accessed November 3, 2005). It could be argued that at least one species in the park, *Scopelophila infericola,* should be considered a critically endangered species because of its extremely narrow distribution limited to only sulfurous steam vents at Sulphur Banks. On the other hand, a taxonomic review of this species could very well find that it should be considered an isolated population of the more widespread *S. ligulata*.

Species that have not been collected for many years such as *Breutelia affinis* are probably very rare. However, in some cases they may be simply difficult to find because they are so small or difficult to distinguish from other, more common species.

Education

High rainfall and diverse microhabitats, such as Thurston Lava Tube Trail, support a high diversity of mosses in a relatively small area. The accessibility and high use of this area makes it an ideal place to introduce park visitors to a wide range of relatively large and easily identifiable mosses and their role in the ecological community.

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APPENDIX I: CHECKLIST OF THE MOSSES OF HAWAII VOLCANOES NATIONAL PARK

Currently accepted names are listed in ***bold italic*** type followed by recently used synonyms, primarily since Bartram (1933), in *smaller italic* type. Determination of status (endemic, indigenous, or alien) and distribution in Hawaii follows Staples, et al. (2004) except where noted. Endemic refers to a species whose natural range is limited to the Hawaiian Islands, indigenous refers to a species whose natural range includes both the Hawaiian Islands and elsewhere, and alien refers to a species whose natural range does not include the Hawaiian Islands and which arrived in Hawaii via human transport. Status data may be different in NPSpecies than in the checklist below, because NPSpecies uses slightly different definitions. Known distribution within the Hawaiian Islands is listed with the abbreviations K=Kauai, O=Oahu, Mo=Molokai, L=Lanai, Ma=Maui, and H=Hawaii Island. Abundance of each species within HAVO, using the abundance terms defined in NPSpecies (see table below), was estimated based on the author's experience in the field. Specimens from the HAVO Herbarium (HAVO) or the Bishop Museum Herbarium (BISH) examined to verify identification are listed last. Only representative specimens are listed for species having an unwieldy abundance of herbarium specimens.

NPSpecies abundance terms

Abundant	Large number of individuals; wide ecological amplitude or occurring in habitats covering a large portion of the park.
Common	Large numbers of individuals predictably occurring in commonly encountered habitats but not those covering a large portion of the park.
Uncommon	Few to moderate numbers of individuals; occurring either sporadically in commonly encountered habitats or in uncommon habitats.
Rare	Few individuals, usually restricted to small areas of rare habitat.

Acroporium fuscoflavum (C. Müller) Brotherus, 1925

Endemic. K, O, Mo, L, Ma, H.

Abundant. In wet forests on trees and logs.

Representative specimens examined: Cuddihy 1742 ; Higashino & Katahira 9990, 9973 (HAVO).

Aerobryopsis subdivergens ssp. ***scariosa*** (E.B. Bartram) Nog.

Aerobryopsis scariosa Bartr. 1939

Indigenous. K, O, Mo, Ma.

Uncommon. In wet forests on humus and logs.

Specimens examined: Hoe 662.0, 1501.0 (BISH); Skottsberg 2010, 2028 (BISH); Waite 040622-03, 040710-z-01 (HAVO).

Amphidium tortuosum (Hornschuch) Cufodontis, 1951
Amphidium cyathicarpum (Montagne) Brotherus, 1902
Grimmia haleakalae Reichardt, 1877

Indigenous. Ma, H.

Uncommon. Frequent on wet rock in high elevation lava tube entrances of Mauna Loa.

Representative specimens examined: L.W. Cuddihy s.n. (HAVO); Waite 040617-06e, 040619-04-04, 040703-07-03, 040714-05a-7, 040715-03-03 (HAVO)

Andreaea acutifolia J. D. Hooker & Wilson, 1844

Indigenous. Ma, H.

Unknown abundance. On rock at high altitude.

Notes: Vitt & Hoe (1980) first report this species in Hawaii based on specimens from Haleakala and Mauna Kea.

Specimens examined: Waite 040714-06-08 (HAVO).

Anoectangium aestivum (Hedwig) Mitten, 1869
Anoectangium euchloron

Indigenous. K, O, Mo, L, Ma, H.

Common. Locally abundant on shaded, wet rock in lava tube tubes and lava cracks.

Representative specimens examined: Weber & Bujakiewicz B-81931; Waite 040608-17a-1, 040702-04b, 040703-07-04, 040703-09-04, 040715-03-01, 040715-06-11 (HAVO)

Anoectangium haleakalae (C. Müller) Paris, 1900

Endemic. K, O, Mo, Ma, H.

Uncommon. Usually intermixed with *A. aestivum* in wetter cave entrances and rocky cliffs.

Notes: Zander, et al. (1979) sunk *A. haleakalae* into *A. aestivum*. However, *A. haleakalae* is in the current list of world-wide accepted moss species (Magil et al. 2000 online at www.mobot.org).

Specimens examined: Waite 040605-09, 040605-12a, 040617-3f, 040710-z-02, 040714-05a5 (HAVO).

Baldwiniella kealeensis (Reichardt) E. B. Bartram, 1933
Baldwinella kealeensis (Reichardt) E. B. Bartram, 1933

Endemic. K, O, Mo, L, Ma, H.

Common. In very wet, shaded microhabitats such as on the forest floor in Olaa Tract and lava tube entrances in wet forest.

Specimens examined: Weber & Bujakiewicz B-81933, B-81965 (BISH & HAVO); Cuddihy s.n.; Waite s.n. (HAVO).

Barbellopsis trichophora (Montagne) W. R. Buck, 1998
Barbella trichophora (Montange) Fleischer 1906

Endemic. K, O, Mo, Ma, H.

Uncommon. On trees in mesic to wet forest

Specimens examined: Selling, O. 4694 (BISH); Waite s.n. (HAVO).

Brachymenium exile (Dozy & Molkenboer) Bosch & Sande Lacoste, 1860

Indigenous. K, O, Mo, Ma, H.

Common. Locally abundant on exposed ash soil.

Specimens examined: Waite 040607-24, 040607-36a, 040608-02h-1, 040703-01 (HAVO).

Brachythecium hawaiicum E. B. Bartram, 1939

Endemic. Ma, H.

Unknown abundance.

Specimens examined: None.

Brachythecium lamprocarpum (C. Müller) Jaeger, 1878

Indigenous. K, Ma, H.

Uncommon. On shaded rock or humus. Sometimes abundant in cave entrances.

Specimens examined: Winona Char s.n.; Waite 040608-17b-3.1, 040617-07-05, 040619-04-01, 040715-06-01 (HAVO);

Brachythecium plumosum (Hedwig) W. P. Schimper in B.S.G., 1853

Brachythecium oxyrrhynchium (Dozy & Molkenboer) Jaeger, 1876-1877

Indigenous. K, O, Mo, Ma, H.

Unknown abundance. On shaded damp soil.

Specimens examined: Waite 040702-02-09(HAVO).

Breutelia affinis (W. J. Hooker) Mitten, 1856

Breutelia kilaueae (C. Müller) Brotherus, 1904

Indigenous. H.

Rare or extinct. Not collected in the Hawaiian Islands since the first specimen was collected From Kilauea, Island of Hawaii (Virtanen, 1997).

Specimens examined: None.

Breutelia arundinifolia (Duby in Moritzi) Fleischer, 1904

Indigenous or possibly misidentified alien. K, O, Ma, H.

Uncommon. Locally abundant along roadsides near Kilauea Visitor Center and the Resources Management field station and likely to spread further along roadsides in the wetter parts of the park.

Specimens examined: Hoe 1623.0 from Volcano Village (BISH): Waite 040622-01 (HAVO).

Bryum argenteum Hedwig var. ***lanatum*** (Palisot de Beauvois) 1839

Indigenous. K, O, Ma, H.

Common. Locally abundant on ash soil or rock. Only rarely with sporophytes.

Specimens examined: Cuddihy s.n.; Waite 040607-35, 040619-05-03, 040712-03-01, 040715-06-07 (HAVO).

Bryum atrovirens Bridel, 1803

Bryum erythrocarpum Schwaegrichen, 1816

Indigenous. O, Ma, H.

Uncommon. Possibly more common but easily overlooked because of its small size. On shaded rock in dry habitats.

Specimens examined: Cuddihy 1606, Cuddihy 1585; Waite 040703-09-07, 040722-B-03 (HAVO).

Bryum caespiticium Hedwig, 1801

Indigenous. Ma, H.

Unknown abundance. Easily overlooked because of its small size. On exposed soil or rock.

Specimens examined: Waite 040722-A-02 (HAVO).

Bryum hawaiicum Hoe, 1974

Bryum crassicostatum Brotherus, 1927

Indigenous (Redfearn et al. (1996) extend the range of this species to China). Ma, H.

Common. Easily overlooked because of its small size. On exposed humus or soil.

Specimens examined Hoe s.n.; Cuddihy 1618; Waite 040608-02h-4, 040608-03a, 040617-05-02 (HAVO).

Buckiella draytonii (Sullivant) Ireland

Catagonium draytonii
Hypnum draytonii Sullivant, 1854
Hypnum eudorae Sullivant, 1854
Plagiothecium draytonii (Sullivant) E. B. Bartram, 1933

Endemic. K, O, Mo, Ma, H.

Uncommon. In shaded wet forest habitats.

Specimens examined: L.W. Pratt s.n.; Higashino 9900; Weber & Bujakiewicz B-81952 (HAVO).

Calymperes tenerum C. Müller, 1872

Indigenous. K, O, Mo, Ma, H.

Unknown abundance. Collected by Hoe from area along the Kalapana Highway just outside the park now covered by lava. Probably still extant in forested low elevation kipukas. On shaded rocks and branches.

Specimens examined: None.

Campylopodium medium (Duby in Moritzi) Giese & Frahm, 1985

Campylopodium euphorocladium (C. Müller) Bescherelle, 1873

Indigenous. K, O, Mo, Ma, H.

Unknown abundance. Easily confused with *Campylopus* species on humus and tree trunks in wet forests.

Specimens examined: Weber & Bujakiewicz B-81910; Winona Char s.n. (HAVO).

Campylopus exasperatus (Nees & Blume) Bridel, 1826

Endemic. K, O, L, Ma, H

Abundant. On exposed rock or soil especially in dry areas but frequent along roadsides in wet areas.

Representative specimens examined: Hoe 1252; Higashino & Muller 9870; Cuddihy 1617; Waite 040608-18a, 040617-08, 040624-01-04, 040720-09-02, 040721-01-02 (HAVO).

Campylopus fragilis ssp. zollingerianus

Campylopus boswellii

Indigenous. K, O, Mo, Ma

Unknown abundance.

Specimens examined: Weber & Bujakiewicz B-81921; Waite 040620-07-02, 040624-01-01(HAVO).

Campylopus hawaiicus var. densifolius (Ångström) Frahm, 1978
Campylopus densifolius var. densifolius Ångström, 1872

Endemic. K, O, Mo, Ma, H.

Abundant. On tree trunks, humus, and shaded rocks in mesic to wet forests.

Representative specimens examined: Weber & Bujakiewicz B-81907; Waite 040607-04a, 040607-25, 040607-30a (HAVO).

Campylopus hawaiicus var. hawaiico-flexuosus (C. Müller) Frahm, 1978
Campylopus densifolius var. hawaiico-flexuosus
Campylopus hawaiico-flexuosus (C. Müller) Paris, 1900

Endemic. K, O, Mo, L, Ma, H.

Abundant. On tree trunks and humus in mesic to wet forests.

Specimens examined: Weber & Bujakiewicz B-81938, B-81967; Higashino & Muller 9852; Waite 040607-11a, 040616-02, 040710-x-01 (HAVO).

Campylopus hawaiicus* (**C. Müller) Jaeger, 1872 var. ***hawaiicus
Campylopus densifolius var. purpureo-flavescens
Campylopus purpureo-flavescens Hampe, in herbaria

Indigenous. K, O, Mo, L, Ma, H.

Abundant. On tree trunks and humus in mesic to wet forests.

Specimens examined: Waite 040609-02b, 040710-y-05, 040719-03, 040720-08 (HAVO).

Campylopus latitextus Sande Lacoste, 1872
Campylopus fumarioli C. Mull., 1900

Indigenous. K, O, Mo, L, Ma, H.

Unknown abundance.

Specimens examined: None.

Campylopus praemorsus (C. Müller) Jaeger, 1872

Endemic. K, O, L, Ma, H.

Unknown abundance. Very similar in appearance to *C. exasperatus*.

Specimens examined: None.

Campylopus schmidii ssp. schimidii (C. Müller) Jaeger, 1872
Campylopus aureus Bosch & Sande Lac, 1858
Campylopus introflexus misapplied
Campylopus polytrichoides misapplied

Indigenous. K, O, Ma, H.

Abundant. Abundant on exposed soil between 1500-2100 m (5000-7000 ft.) elevation.

Representative specimens examined: Weber & Bujakiewicz B-81895; W.J. Hoe 1261; Winona Char s.n.; T. Belfield s.n.; Waite 040624-08-02, 040702-02-05, 040702-07a (HAVO).

Campylopus umbellatus (Schwägrichen & Gaudichaud ex Arnott) Paris, 1894

Indigenous. K, O, L, Ma, H.

Abundant. On exposed rock or soil in dry to wet locations.

Representative specimens examined: Waite 040608-06b, 040620-06-05, 040710-03 (HAVO).

Campylopus wheeleri (C. Müller) Hampe ex Paris, 1900
Dicranoloma wheeleri (C. Mull.) Par. 1904

Endemic. K, Ma, H.

Unknown abundance. This is recorded from the park based on a single specimen at BISH.

Specimens examined: None.

Ceratodon purpureus (Hedwig) Bridel, 1826

Indigenous. Distribution: K, O, Ma, H.

Abundant. Usually on exposed ash soil and rock but also in cave entrances at higher elevations.

Representative specimens examined: Hoe s.n.; MacDonald s.n.; Smathers s.n.; Waite 040605-03, 040702-07c, 040714-06-09, 040715-06-04, 040718-03-04, 040722-B-01 (HAVO).

Ctenidium elegantulum Brotherus, 1927

Endemic. O, Ma, H.

Unknown abundance.

Specimens examined: None.

Dicranella hawaiica (C. Müller) Brotherus, 1901

Endemic. K, O, Mo, Ma.

Unknown abundance.

Specimens examined: Cuddihy s.n.; Waite 040718-07c-02, 040725-11-02 (HAVO).

Dicranella integrifolia E. B. Bartram, 1933

Endemic. O, Mo, Ma, H.

Abundant. On exposed ash soil.

Representative specimens examined: Hoe s.n., Weber & Bujakiewicz B-81919; Waite 040624-08-06, 040702-02-06, 040718-03-03, 040718-07a, 040718-08 (HAVO).

Dicranodontium porodictyon Cardot & Thériot, 1911
Dicranodontium falcatum Brotherus, 1927

Indigenous. K, O, Mo, Ma, H.

Uncommon. On humus and tree trunks in wet forest.

Specimens examined: Higashino & Allen 10179; Waite 040710-z-04 (HAVO).

Dicranum speirophyllum Montagne, 1843

Endemic. K, O, Mo, Ma, H.

Common. On humus and logs in mesic to wet vegetation.

Representative specimens examined: Higashino & Allen 10187; Hoe 1256; Weber & Bujakiewicz B-81923; Waite 040607-40, 040608-02a, 040702-04f (HAVO).

Didymodon insulanus (De Not.) M.O. Hill
Barbula vinealis var. flaccida B.S.G., 1842
Barbula vinealis Bridel *ssp. cylindrica* (Taylor) Boulay, 1884
Didymodon vinealis var. *flaccidus* (Brach. & Schimp.) RH Zander

Indigenous. O, Ma.

Unknown abundance. On soil and rock.

Specimens examined: Weber & Bujakiewicz B-81899, B-81900; Waite 040608-16a, 040715-03-02 (HAVO).

Didymodon vinealis (Bridel) Zander, 1978
Barbula vinealis

Indigenous. H (this report)

Unknown abundance. On soil.

Notes: *D. vinealis*, in its current circumscription, is a new record for the Hawaiian Islands. Old concepts of *D. vinealis* included a taxon already recorded from the Hawaiian Islands as a variety but now classified as the separate species *D. insulanus*.

Specimens examined: Waite 040702-02-07, 040703-09-03 (HAVO).

Distichophyllum freycinetii (Schwägrichen) Mitten in Seemann, 1873

Endemic. K, O, Mo, L, Ma, H.

Common. On wet soil or humus in understory of wet forests.

Representative specimens examined: Weber & Bujakiewicz B-81989; Higashino 9894, 9899; Waite s.n. (HAVO).

Distichophyllum paradoxum (Montagne in Gaudichaud) Mitten in Seemann, 1873

Endemic. K, O, Mo, L, Ma, H.

Common. On wet soil or humus in understory of wet forests.

Specimens examined: Cuddihy 1741; Higashino & Katahira 9987; Weber & Bujakiewicz B-81947; Waite s.n., 040725-08a-03 (HAVO).

Ectropothecium arcuatum Mitten in Seemann, 1873

Endemic. K, O, Ma, H.

Unknown abundance.

Specimens examined: None.

Ectropothecium decurrens (Sullivant) Nishimura, 1985
Ctenidium decurrens (Sullivant) Brotherus, 1927

Endemic. K, O, Mo, Ma, H.

Common. On humus in partially shaded mesic to wet habitats

Specimens examined: Anonymous 1913; Waite s.n., 040607-01, 040607-12, 040609-02f, 040702-02-01(HAVO).

Ectropothecium sandwichense (W. J. Hooker & Arnott) Mitten in Seemann, 1873

Indigenous. K, O, Mo, L, Ma, H.

Unknown abundance.

Specimens examined: None.

Entosthodon subintegrus (Brotherus) H. A. Miller, H. O. Whittier & B. Whittier, 1978
Funaria subintegra Brotherus, 1927

Endemic. K, O, Mo, L, Ma, H.

Common. On partially shaded, damp soil.

Specimens examined: Cuddihy 1695; Waite 040702-02-12, 040720-02 (HAVO).

Fabronia degeneri E. B. Bartram, 1933

Endemic. O, Mo, H.

Unknown abundance. Common on *Sapindus* trees in Kipuka Puaulu.

Specimens examined: Waite 040718-02-04 (HAVO).

Fissidens bryoides Hedwig, 1801
Fissidens hawaiicus E.B. Bartram, 1933
Fissidens insularis E.B. Bartram 1933
Fissidens oahuensis E.B. Bartram 1939

Indigenous. K, O, Mo, L, Ma, H.

Abundant. On damp soil in deep shade such as under logs and in cave entrances.

Representative specimens examined: Weber & Bujakiewicz B-81949; Waite 040608-17b-2, 040617-01a, 040619-04-05, 040715-04-05 (HAVO).

Fissidens elegans Bridel, 1806
Fissidens bishopii Hoe
Fissidens baldwinii Brotherus, 1927

Indigenous. K, O, Mo, L, Ma, H.

Common. On damp soil or rock in deep shade such as in lava tube entrances.

Specimens examined: Waite 040721-01-01, 040722-01 (HAVO).

Fissidens kilaueae Hoe & H. Crum, 1971 [1972]

Endemic. K, O, L, Ma, H.

Unknown abundance. Its minute size makes it difficult to locate. Hoe & Crum (1971) described this as new species from hapu`u (*Cibotium*) stipes at Thurston Lava Tube, Hawaii Volcanoes National Park.

Specimens examined: Hoe 1072.0 (HAVO).

Fissidens lancifolius E. B. Bartram, 1939

Endemic. K, O, Mo, L, Ma, H.

Unknown abundance. This genus typically inhabits deeply shaded wet environments.

Specimens examined: None.

Funaria hygrometrica Hedwig, 1801

Indigenous. O, H.

Unknown abundance. Usually present as a weed on potting media in the green houses at near the Resource Management Field Station. An ephemeral species that usually appears in great numbers on exposed soil in the second year after fires in the park such as at Hilina Pali (CW Smith pers. comm.).

Specimens examined: Waite 040610-01 (HAVO).

Grimmia longirostris W. J. Hooker, 1818
Grimmia haleakalae Reichardt, 1877 misapplied

Indigenous. Ma.

Abundant. On exposed rock and soil at higher elevations such as at the top of the Mauna Loa Strip Road.

Representative specimens examined: Anonymous s.n.; Waite 040608-13, 040619-02-02, 040714-06-05 (HAVO).

Grimmia trichophylla Greville, 1824

Indigenous. Ma, H.

Unknown abundance.

Specimens examined: Waite 040619-05-02, 040715-06-03(HAVO).

Holomitrium seticalycinum C. Müller, 1896

Common. On tree branches in wet forests.

Endemic. K, O, Mo, L, Ma, H.

Common. On tree branches in wet forests.

Specimens examined: Cuddihy 1509; Hoe 1584; Waite 040612-04-04 (HAVO).

Homaliodendron flabellatum (Smith) Fleischer, 1906

Indigenous. K, O, Mo, L, Ma, H.

Common. On tree trunks in wet forests.

Representative Specimens examined: Cuddihy 1562; Higashino & Muller 9866; Weber & Bujakiewicz B-81948; T. Belfield s.n. (HAVO).

Hookeria acutifolia W. J. Hooker & Greville, 1825

Indigenous. O, L, Ma, H.

Common. On deeply shaded soil in wet forests.

Specimens examined: Weber & Bujakiewicz B-81996; Cuddihy s.n.; Waite s.n. (HAVO).

Hyophila involuta (W. J. Hooker) Jaeger, 1873
Hyophila dozy-molkenboeri Fleischer, 1900-1902

Indigenous. K, O, Mo, Ma, H.

Uncommon. Rock walls and trails.

Specimens examined: Waite 040720-04-03, 040722-B-04 (HAVO).

Hypnum plumaeforme Wilson, 1848

Alien. O (recent coll. Waite), Mo(recent coll. Stone), Ma, H.

Abundant. Invasive along roads, trails, and lawns in wet to mesic areas. Potentially invasive in other open canopy vegetation.

Representative specimens examined: Cuddihy s.n.; Weber & Bujakiewicz B-81912; Waite 040702-01a, 040702-02-02, 040717-03, 040718-03-02 (HAVO).

Isopterygium albescens (W. J. Hooker in Schwägrichen) Jaeger, 1878

Indigenous. K, O, Mo, L, Ma, H.

Abundant. In wet microhabitats.

Representative specimens examined: Cuddihy 1612; Higashino 9897; Smathers s.n.; Waite 040715-03-05, 040717-02, 040718-07c-05 (HAVO).

Isopterygium vineale E. B. Bartram, 1933

Endemic. K, O, Mo, Ma, H.

Unknown abundance. Only one record from the park.

Specimens examined: Waite 040620-06-01 (HAVO).

Leptobryum pyriforme (Hedwig) Wilson, 1855

Indigenous. Ma, H.

Unknown abundance. This species is probably present in the park based on its presence just outside the park. Skottsberg also collected it once from the vicinity of Kilauea (Bartram 1933).

Specimens examined: Waite 040606-01 from residence in Volcano near park (HAVO).

Leptodontium flexifolium (Dickson) Hampe in Lindberg, 1864

Leptodontium brevicaule E. B. Bartram, 1933

Indigenous. M, H.

Abundant. On exposed ash soil at higher elevations.

Representative specimens examined: Winona Char s.n.; Cuddihy s.n.; Waite 040617-05-01, 040619-01-03, 040619-05-06, 040702-07d (HAVO).

Leucobryum gracile Sullivant, 1874

Endemic. K, O, Mo, L, Ma, H.

Abundant. On humus and tree trunks in mesic to wet forests

Representative specimens examined: Cuddihy 1633; Weber & Bujakiewicz B-81904; Higashino 9908; Waite 040608-02b-1, 040620-06-02, 040718-07c-04 (HAVO).

Leucobryum seemannii Mitten in Seemann, 1873

Leucobryum hawaiiense (Reichardt) E.B. Bartram, 1933

Endemic. K, O, Mo, L, Ma, H.

Common. On humus and tree trunks in mesic to wet forests.

Representative specimens examined: Cooper s.n.; Cuddihy 1461; Hoe 1265; Higashino, Cuddihy, Weber, & Bujakiewicz 9875 (HAVO).

Macrocoma tenue ssp. ***sullivantii*** (Mull. Hal.) Vitt

Macromitrium intricatum C. Müller, 1896

Indigenous. K, O, Mo, Ma, H.

Unknown abundance. Epiphytic on small trees at the end of Mauna Loa Strip Road.

Specimens examined: Cuddihy s.n.; Waite 040619-a-01 (HAVO).

Macromitrium brevisetum Mitten in Seemann, 1873

Endemic. K, O, Mo, L, Ma, H.

Unknown abundance. Collected from Kipuka Puaulu and Kipuka Ki in 1966 by Hoe.

Specimens examined: None.

Macromitrium emersulum C. Müller, 1896

Endemic. K, O, Mo, L, Ma, H.

Probably present. This species was collected in 1983 from Kalapana outside the park (HAVO) growing epiphytically on a mango tree trunk.

Specimens examined: Weber & A. Bujakiewicz B-82000 (HAVO).

Macromitrium microstomum (W. J. Hooker & Greville) Schwägrichen, 1827
Macromitrium reinwardtii
Macromitrium owahiense C. Müller, 1864

Indigenous. K, O, Mo, L, Ma, H.

Abundant. On trees in wet forests.

Specimens examined: L.W. Cuddihy 1601; Hoe 1245; Smathers s.n.; Waite 040612-04-02 (HAVO).

Macromitrium piliferum Schwägrichen, 1826

Endemic. K, O, Mo, L, Ma, H.

Abundant. On trees in wet forests.

Representative specimens examined: Cuddihy 1570, 1431; Hoe 1258; Waite 040608-02d (HAVO).

Orthotrichum diaphanum Schrader ex Bridel, 1801

Indigenous. M, H.

Unknown abundance. Epiphytic on trees and shrubs.

Specimens examined: Hoe 981.0 (BISH).

Orthotrichum hawaiicum C. Müller, 1896

Endemic. Ma, H.

Unknown abundance. Epiphytic on trees and shrubs.

Specimens examined: Hoe 828.1, 836.0 (BISH); Vitt 14955, 14956 (BISH).

Orthotrichum rupestre Schleicher x Schwägrichen, 1816
Orthotrichum hillebrandi C. Müller, 1896

Indigenous. O, Ma, H.

Unknown abundance. Epiphytic on trees and shrubs.

Specimens examined: Hoe 828.0 (BISH).

Palamocladium wilkesianum (Sullivant) C. Müller, 1896
Pleuropus wilkesianum (Sullivant) Brotherus, 1908

Endemic. K, O, Mo, L, Ma, H.

Common. In damp, shaded places on humus, tree trunks, and rock. Variable in size and in degree of pitting in the leaf cells. Smaller sized plants with little or no pitting of the leaf cells were once recognized as the distinct variety *P. w. sciuroides*. This form is especially common at Kipuka Puaulu on *Sapindus* trunks.

Representative specimens examined: Char s.n.; Cuddihy 1728; Weber & Bujakiewicz B-81960; Waite 040607-16, 040607-33, 040619-04-02, 040718-02-02 (HAVO).

Pelekium versicolor (Hornsch. Ex Mull.Hal.) Touw, 2001
Thuidium crenulatum Mitten, 1873
Thuidium nanophyllum

Indigenous. O, Ma, H.

Unknown abundance. Very similar in appearance to the abundant *Thuidium cymbifolium*.

Specimens examined: Char s.n.; Weber & Bujakiewicz B-81961(HAVO).

Philonotis falcata (W. J. Hooker) Mitten, 1859

Indigenous. K, O, Mo, Ma.

Unknown abundance.

Specimens examined: Cuddihy 1701; Waite s.n. (HAVO).

Philonotis hawaica (C. Müller) Brotherus, 1904

Endemic. K, O, Mo, L, Ma, H.

Unknown abundance.

Specimens examined: Waite (HAVO).

Philonotis turneriana var. sullivantii (C. Müller) Bartram, 1933

Bartramia sullivantii C. Muller, 1896

Endemic. O, Ma, H.

Unknown abundance.

Specimens examined: Cuddihy 1608 (HAVO).

Philonotis turneriana var. turneriana (Schwägrichen) Mitten, 1859

Indigenous. K, O, Mo, L, Ma, H.

Common. On damp soil and humus.

Specimens examined: Waite 040718-03-01(HAVO).

Phyllodon lingulatus (Cardot) W.R. Buck, 1987

Glossadelphus baldwinii Brotherus, 1927

Glossadelphus laevifolius (Mitt.) Bartr.

Taxiphyllum laevifolium (Mitten) W. R. Buck, 1987 misapplied

Indigenous. K, O, Mo, Ma, H.

Unknown abundance. On wet soil or rock in shaded places.

Specimens examined: Higashino & Katahira 9952 (HAVO).

Plagiomnium rhynchophorum (W. J. Hooker) T. Koponen, 1971

Plagiomnium rostratum (Schrader) T. Koponen, 1968 misapplied

Mnium rostratum Schwägrichen, 1816 misapplied

Indigenous. K, O, Mo, Ma, H.

Common. On deeply shaded wet soil, humus, or rock.

Specimens examined: Cuddihy 1552; Weber & Bujakiewicz B-81995; Higashino, Cuddihy, Weber, & Bujakiewicz 9877 (HAVO).

Pogonatum tahitense W. P. Schimper in Bescherelle, 1894

Pogonatum baldwinii (C. Müller) Paris, 1898

Indigenous. K, O, Mo, L, Ma, H.

Common. On wet soil banks.

Specimens examined: Higashino & Katahira 9979; Higashino & Muller 9869;
Higashino, Cuddihy, Weber, & Bujakiewicz 9874; Cuddihy s.n.; Waite 040702-02-08 (HAVO).

Pohlia flexuosa W.J. Hooker 1836
Pohlia leucostoma (Bosch & Sande Lacoste) Fleischer, 1904
Webera leucostomoides Brotherus, 1927
Webera gracilescens E.B. Bartram, 1933

Indigenous. K, O, Mo, Ma, H.

Unknown abundance.

Specimens examined: Weber &. Bujakiewicz B-81905; Waite 040617-03g (HAVO).

Polytrichum commune Hedwig, 1801

Alien. H.

Common. On exposed soil along roadsides and in the shrub lands between Kilauea Military Camp and the Hawaiian Volcano Observatory. Extremely abundant outside the park along Highway 11 in Glenwood.

Specimens examined: Waite 040605-12b, 040624-08-04 (HAVO).

Polytrichum piliferum Hedwig, 1801

Indigenous. Ma, H.

Unknown abundance. On exposed soil.

Specimens examined: Waite 040702-07e (HAVO).

Pseudoscleropodium purum (Hedwig) Fleischer in Brotherus, 1925
S*cleropodium purum* (Hedwig)

Alien. H.

Common. Locally abundant along roadsides and lawns and in the Kipuka Puaulu forest.

Representative specimens examined: Weber & Bujakiewicz B-81962, B-81924 (HAVO); Vitt 15087 (BISH); Waite 040605-05, 040605-11, 040620-01-01 (HAVO).

Pseudosymblepharis angustata (Mitten) Hilpert, 1933
Pseudosymblepharis mauiensis (C. Müller) Brotherus, 1927

Indigenous. K, O, Mo, Ma, H.

Uncommon. Locally common to abundant on the wet cliff walls of Olaa Trench.

Specimens examined: Jacobi s.n.; Waite 040710-y-02 (HAVO).

Pyrrhobryum pungens (Sullivant) Mitten, 1868
Rhizogonium pungens Sullivant, 1854

Endemic. K, O, Mo, L, Ma, H.

Unknown abundance. This is an uncertain species for the park because specimens identified as this species in the past are not typical *P. pungens* and instead intermediate in form between *P. spiniforme* and *P. pungens*. The leaf blades of typical *P. pungens* end more or less abruptly near the base of the leaf while the blades of typical *P. spiniforme* are relatively broad from the base all the way to the tip of the leaf. *P. pungens* is also usually larger than *P. spiniforme*. The *P. pungens* identified from the park are large but have leaf blades that, although very narrow, extend all the way to the tip of the leaf.

Specimens examined: Fagerlund, G.O. & A.L. Mitchell 189, 255 (BISH); Higashino, Cuddihy, Weber, & Bujakiewicz 9876; P.K. Higashino 9890, 9909 (HAVO).

Pyrrhobryum spiniforme (Hedwig) Mitten, 1868
Rhizogonium spiniforme (Hedwig) Bruch, 1846

Indigenous. K, O, Mo, L, Ma, H.

Abundant. Widespread on humus and tree trunks in wet forests.

Representative specimens examined: Weber & Bujakiewicz B-81935; Higashino & Muller 9847; Waite 040607-06 (HAVO).

Racomitrium crispulum (J. D. Hooker & Wilson) J. D. Hooker & Wilson, 1854

Indigenous. K, Ma, H.

Unknown abundance. Reported from the vicinity of Kilauea, Hawaii Island, based on one specimen collected by Lieutenant Hinds (Bartram, 1933).

Specimens examined: None.

Racomitrium lanuginosum var. ***lanuginosum*** (Hedwig) Bridel, 1819 [1818]
Racomitrium lanuginosum var. pruinosum misapplied

Indigenous. K, O, Mo, Ma, H.

Abundant. Abundant on lava rock especially at higher elevations above 1500 m (5000 ft.)

Note: Vitt & Marsh (1988) revised *Ramomitrium lanuginosum* and *R. pruinosum* and determined that all *R. lanuginosum* and *R. pruinosum* in Hawaii were *R. lanuginosum var. lanuginosum*, that specimens previously identified as *R. pruinosum* were in fact misidentified variable *R. lanuginosum*.

Representative specimens examined: Cuddihy 1602, Higashino & Katahira 9976; Fagerlund & Mitchell 70; Waite 040607-14, 040624-08-01, 040702-04a, 040713-05-01(HAVO).

Racopilum cuspidigerum (Schwägrichen in Gaudichaud in Freycinet) Ångström, 1872
Rhacopilum cuspidigerum (Schwägrichen in Gaudichaud in Freycinet) Ångström, 1872

Indigenous. K, O, Mo, L, Ma, H.

Abundant. On soil, rock, or bark in mesic to wet forest.

Representative specimens examined: Cuddihy 1609: Higashino & Katahira 9973; Belfield/LG 32; Waite 040607-32b, 040718-02-03 (HAVO).

Radulina hamata (Dozy & Molkenboer) W. R. Buck & B. C. Tan, 1989 [1990]
Trichosteleum hamatum (Dozy & Molkenboer) Jaeger, 1876-1877

Indigenous. K, O, Mo, L, Ma, H.

Common. On humus and tree trunks in wet forests.

Specimens examined: Cuddihy 1565; Higashino & Katahira 9948; Waite 040616-01 (HAVO).

Rhynchostegium celebicum (Sande Lacoste) Jaeger, 1878
Eurhynchium celebicum (Lacoste) E.B. Bartram, 1933

Indigenous. K, O, Mo, Ma, H (this study).

Unknown abundance. In wet forest.

Specimens examined: Weber & Bujakiewicz B-81908 (HAVO).

Rhynchostegium selaginellifolium C. Müller, 1896
Eurhynchium sellaginellifolium (C. Müller) E.B. Bartram, 1933

Endemic. K, O, Mo, Ma, H.

Unknown abundance. In wet forest.

Specimens examined: Cuddihy s.n. (HAVO).

Rosulabryum billarderi (Schwägrichen) Spence, 1996
Bryum billardieri Schwägrichen, 1816
Bryum decaisnei Dozy &Molkenboery, 1845

Indigenous. O, Ma, H.

Unknown abundance. Collected twice in 1966 by Bill Hoe from the Mauna Loa Trail.

Specimens examined: None.

Rosulabryum capillare (Hedwig) Spence, 1996
Bryum capillare Hedwig, 1801
Bryum vino-viride E. B. Bartram, 1933

Indigenous. K, O, Ma, H.

Uncommon. On soil and rock at higher elevations especially in lava tube entrances.

Representative specimens examined: Waite 040607-38, 040619-04-03, 040703-05-02, 040715-02-01 (HAVO).

Schizymenium pulvinatum (C. Müller) A. J. Shaw, 1985
Mielichhoferia pulvinata C. Mull. 1896

Endemic. Ma, H.

Uncommon. On soil at higher elevations including in lava tube entrances.

Representative specimens examined: MacDonald s.n.; Waite 040702-04h, 040703-05-05, 040703-07-02, 040714-05b-09(HAVO).

Scopelophila infericola Hoe, 1973

Endemic. H.

Rare. Sulphur Banks on rock and ash substrate is the only locality known to date.

Specimens examined: Siegel s.n. (BISH); Hoe 4852.0 (BISH); Waite 040620-09-01, 040624-10-01, 040624-12-03, 040624-13-07 (HAVO).

Sematophyllum hawaiiense (Brotherus) Brotherus, 1925

Indigenous. K, O, L, Ma, H.

Common. Widespread from low to high elevations on shaded soil, rock or bark in mesic to wet vegetation.

Representative specimens examined: Waite 040612-04-01, 040619-03-03, 040717-01, 040722-A-01(HAVO).

Sematophyllum subpinnatum (Brid.) E. Britton
Acroporium caespitosum (Hedwig) W. R. Buck, 1983 misapplied
Sematophyllum caespitosum (Hedwig.) Mitt. 1869 misapplied

Alien. O, H.

Probably present. On trees and rocks in wet forests

Not collected in the park but abundant in lower elevation wet forests and probably present in the lower elevation forest kipukas in the Kalapana section of the park.

Specimens examined: Waite 040612-07 from Waiakea Forest Reserve, Road B off Stainback Hwy (HAVO).

Sphagnum palustre Linnaeus, 1753
Sphagnum henryense misapplied

Indigenous. O, H.

Unknown abundance. Recently found in the park's Kahuku Unit by Thomas Belfield. Also known from two locations near the park in Volcano Village. On humus in wet forest.

Specimens examined: Will Haines s.n.from Hawaiian Orchid Island Estates; Waite 040722-E-01 from near the Volcano Village Post Office (HAVO).

Syrrhopodon armatus Mitten, 1864
Syrrhopodon oahuense Brotherus, 1927

Indigenous. O, Ma, H.

Unknown abundance. On *Pritchardia beccariana* trunks in Olaa Tract.

Specimens examined: Waite s.n. (HAVO).

Syrrhopodon hawaiicus C. Müller, 1896

Endemic. K, O, Mo, Ma, H.

Unknown abundance. On tree trunks in wet forest.

Specimens examined: Weber & Bujakiewicz B-81940, B-81941; Waite s.n. (HAVO).

Syrrhopodon prolifer Schwägrichen, 1827
Syrrhopodon kilaueae C. Müller, 1900

Indigenous. O, Mo, Ma, H.

Unknown abundance. Specimens from Kilauea, Island of Hawaii were originally described as an endemic species in 1900.

Specimens examined: None.

Taxithelium mundulum (Sullivant) E. B. Bartram, 1933

Indigenous. K, O, Mo, L, Ma, H.

Common. On rock and bark in wet to mesic forests.

Specimens examined: Cuddihy 1727, Cuddihy 1702; Waite 040612-04-03, 040718-01-03 (HAVO).

Thuidium cymbifolium (Dozy & Molkenboer) Dozy & Molkenboer, 1865
Thuidium hawaiense Reichardt, 1877
Thuidium plicatum Mitten in Seemann, 1873

Indigenous. K, O, Mo, L, Ma, H.

Abundant. On humus, rock, and tree trunks in shaded, wet microhabitats from forest to lava tube entrances.

Representative specimens examined: Cuddihy 1481; Higashino & Katahira 9972; Hoe 1255; Waite 040607-18b, 040702-02-03, 040702-04d (HAVO).

Tortella humilis (Hedwig) Jennings, 1913
Tortella caespitosa (Schwaegrichen) Limpricht, 1888

Indigenous. K, O, L, Ma, H.

Unknown abundance. On exposed soil or rock.

Specimens examined: Cuddihy s.n.; Waite 040617-05-05(HAVO).

Trematodon latinervis C. Müller, 1896

Indigenous. K, O, Mo, Ma, H.

Common on damp, partially shaded soil.

Specimens examined: Higashio & Muller 9870 (HAVO).

Trichostomum crispulum Bruch

Trichostomum bartramii Mill. 1967

Trichostomum mauiense Brotherus, 1927

Indigenous. K, O, Mo, L, Ma, H.

Abundant. On soil, humus, and rock in dry to mesic areas especially on the west side of Kahuku unit.

Representative specimens examined: Weber & Bujakiewicz B-81915; Hoe s.n., Hoe 1578; Waite 040607-12a, 040607-15, 040607-29b, 040608-05, 040609-01a (HAVO).

Vesicularia perviridis (Ångström) C. Müller, 1896

Vesicularia graminicolor (Ångström) Brotherus, 1927

Hookeria sandvicensis Reichardt, 1877

Endemic. K, O, Mo, L, Ma, H.

Common. On soil and humus in shaded wet microhabitats

Specimens examined: Higashino & Cuddihy 9873; Waite 040722-D-02, 040725-08a-01, 040725-09-01, 040725-11-01 (HAVO).

Weissia controversa Hedwig, 1801

Weissia viridula Hedwig, 1801

Indigenous. Ni, K, O, H.

Unknown abundance. On soil. Difficult to distinguish from the following *Weissia* species.

Specimens examined: None identified to species.

Weissia ovalis (Williams) E.B. Bartram, 1933

Endemic. K, O, Mo, L, Ma, H.

Unknown abundance. On soil. Difficult to distinguish from ***W. controversa.***

Specimens examined: Waite 040608-06a (HAVO).

Zygodon tetragonostomus A. Braun ex B.S.G., 1838

Indigenous. K, O, Ma, H.

Common. On trees and shrubs an occasionally on shaded rock or soil in mesic to dry vegetation above 1200 m (4000ft).

Representative specimens examined: Char s.n.; Weber & Bujakiewicz B-81898; Waite 040608-19, 040619-03-01, 040619-05-01, 040718-02-01 (HAVO).

APPENDIX II: PHOTOGRAPHS OF MOSSES AT HAWAII VOLCANOES NATIONAL PARK

Figure A1. *Acroporium fuscoflavum* from Olaa Trench. Leaf microphotograph from Oahu specimen.

Figure A2. *Aerobryopsis subdivergens ssp. scariosa* from Olaa Trench. Leaf microphotograph from Oahu specimen.

Figure A3. *Baldwiniella kealeensis* from Olaa Trench

Figure A4. *Brachymenium exile* with immature sporophytes from West Kahuku and with mature sporophytes from Crater Rim Trail.

Figure A5. *Bryum argenteum* var. *lanatum* from West Kahuku.

Figure A6. *Campylopus umbellatus* from Olaa Trench.

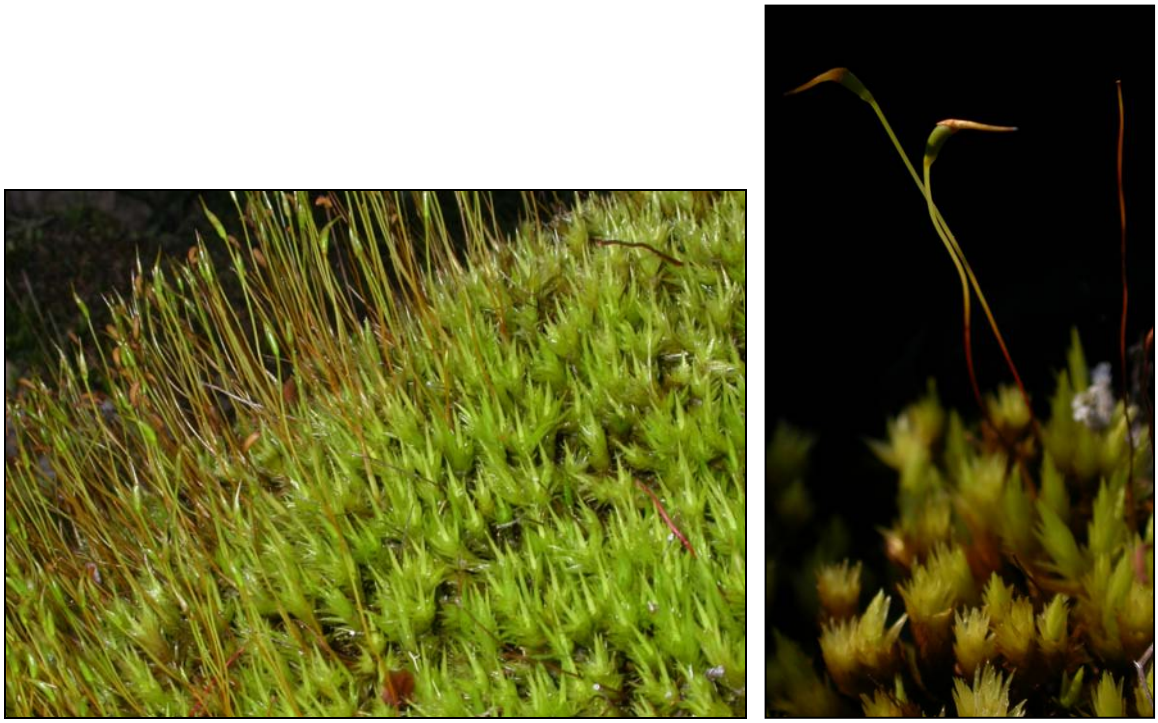

Figure A7. *Dicranum speirophyllum* from West Kahuku.

Figure A8. *Distichophyllum freycinetii* from Thurston Lava Tube area.

Figure A9. *Distichophyllum paradoxum* from Thurston Lava Tube area.

Figure A10. *Leucobryum seemannii* from Thurston Lava Tube area.

Figure A11. *Palamocladium wilkesianum* from West Kahuku.

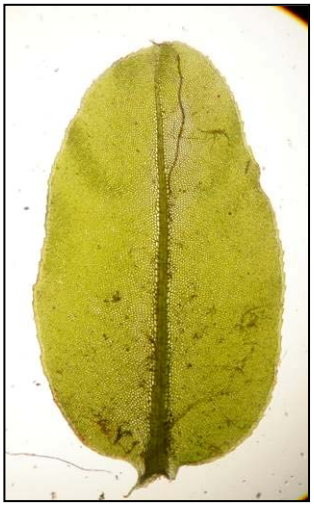

Figure A12. *Plagiomnium rhynchophorum* from a Mauna Loa lava tube. Leaf microphotograph from Oahu specimen.

Figure A13. *Pogonatum tahitense* from Crater Rim Trail.

Figure A14. *Pseudosymblepharis angustata* from Olaa Trench.

Figure A15. *Pyrrhobryum spiniforme* from Olaa Trench. Leaf microphotograph from Oahu specimen.

Figure A16. *Racomitrium lanuginosum* with sporophytes, West Kahuku.

Figure A17. *Thuidium cymbifolium*. This photograph from plant collected on Oahu