Bryoecology in the American southwest: Patterns of biodiversity and responses to global change

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BRYOECOLOGY IN THE AMERICAN SOUTHWEST:

PATTERNS OF BIODIVERSITY AND RESPONSES

TO GLOBAL CHANGE

by

John Carroll Brinda

Bachelor of Science
Western Washington University
2000

A dissertation submitted in partial fulfillment
of the requirements for the

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John Carroll Brinda

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ABSTRACT

Bryoeology in the American Southwest: Patterns of Biodiversity and Responses to Global Change

by

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This dissertation combines investigation of the large-scale responses of bryophyte species diversity and distribution with small-scale physiological adaptations to global change. These two areas of inquiry are linked because one way to predict plant species responses to global change is to examine their distribution across current ecological gradients produced by factors such as latitude and elevation. By examining these biogeographic patterns one can identify those species that have a narrow tolerance and therefore are most sensitive to change. Selected bryophytes might then be used as indicator species in long-term monitoring programs. Where historical data exist, these can be used to reconstruct the past and continuing range shifts of bryophytes in response to decades of global change.

In chapter 2 a checklist of the 310 bryophyte taxa (two hornworts, 46 liverworts and 262 mosses) reported to occur within the political boundaries of the state of Nevada is presented. 238 new county records are also listed. Notes are provided for species with complex synonymies, taxonomic difficulties or interesting histories. This checklist is intended to improve efforts towards a complete bryophyte flora of the state by identifying those species, habitats and geographic regions that have
been neglected or poorly sampled. Chapter 4 describes a baseline assessment of the bryophyte diversity on the Grand Canyon-Parashant National Monument. Collecting locations were selected in order to maximize the number of species collected and to cover the monument both geographically and ecologically. Forty-seven sites were visited and 679 voucher specimens were collected. A checklist, flora and photographic guide were prepared for the 110 species identified from among these collections.

Finally, chapter 3 describes an experiment where intact Mojave desert scrub and associated biological soil crust were exposed over multiple years to experimental treatments designed to simulate predicted global change. Field treatments included a FACE (Free Air Carbon dioxide Enrichment) site where plants were exposed to experimentally elevated atmospheric CO$_2$ (550 ppm). In order to determine the responses of the bryophyte component of the soil crust to elevated CO$_2$ concentrations, patches of the dominant Mojave Desert moss *Syntrichia caninervis* Mitt. were sampled from the FACE treatments. Shoots grown under elevated CO$_2$ expressed sex more frequently and tolerated repeated cycles of desiccation better than their ambient counterparts. In a follow-up experiment, plants were grown at both elevated and ambient CO$_2$ concentrations in the laboratory. All plants grown at elevated CO$_2$ under laboratory conditions exhibited greater regenerational vigor than plants grown at ambient CO$_2$; however there were interaction effects between the laboratory and field treatments that suggest photosynthetic down-regulation is occurring. It appears that while they are capable of harnessing additional CO$_2$ for growth, in the harsh conditions of their native environment these plants preferentially allocate those added resources to sexual reproduction and stress tolerance. Biological soil crusts perform several valuable
ecosystem functions in arid regions so it is important that we understand their responses under various scenarios of global change.
ACKNOWLEDGEMENTS

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I believe Fred Rhoades was the first person to show me the world of bryophytes (and other cryptogams) in an introductory botany course. Jan Henderson and Robin Lesher offered me the opportunity to pursue that interest further while working as a biological technician for the US Forest Service. Much of what I know about field ecology can be traced to the time spent with them and my co-worker Sonya Schaller in the old-growth forests of Washington State.

One of the best ways to learn a subject is through teaching. I have Beth Newingham and Cheryl Vanier to thank for the very interesting and challenging experience of teaching basic biology to wildland firefighters. The 401 program firefighters and my co-TA Adam Leland were a great group and I am lucky to have gotten that assignment.

I need to acknowledge Jim Shevock for encouraging me to begin collecting again which eventually led to the work at the Parashant National Monument. Jim was also a collaborator (along with John Spence) on my first manuscript. Catherine Fernando and Jessica Rampy helped with specimen and data collection for the FACE project and I’d also like to thank Doug Merkler and Mandy Williams for their infectious enthusiasm and
enlightening discussions on plant-soil interactions.

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CHAPTER 1
INTRODUCTION

by

John C. Brinda (sole author)

In arid environments, bryophytes are an important part of the complex community of organisms that form biological soil crusts. Development of biological soil crusts can influence susceptibility to erosion, hydrology, nutrient inputs, and the associated vascular plant community structure (Belnap & Lange 2003). Bryophytes in particular help accelerate soil formation by trapping windblown dust within their turfs (Danin & Ganor 1991, Carter & Arocena 2000). Mosses and other bryophytes are usually dominant on the areas most favorable to crust development and are somewhat analogous to a “climax” vegetation type on these sites (West 1990). Besides being ecologically important, bryophytes are especially useful in studies on plant responses to climate change. Bryophytes are unique among land plants because their photosynthetic responses are not complicated by stomatal control and are therefore more directly under the influence of climate. In addition, the widespread distributions of many bryophyte species often allow comparisons across continents without the confounding effects of differences among species.

This dissertation combines investigation of the large-scale responses of bryophyte species diversity and distribution (chapters 2 & 4) with small-scale physiological adaptations to climate change (chapter 3). These two areas of inquiry are linked because one way to predict plant species responses to climate change is to examine their distribution across current climatic gradients produced by factors such as latitude and
elevation. By examining these biogeographic patterns one can identify those species that have a narrow tolerance and therefore are most sensitive to changes in climate. Selected bryophytes might then be used as indicator species in long-term climate monitoring programs. Where historical data exist, these can be used to reconstruct the past and continuing range shifts of bryophytes in response to decades of climate change (NSF 2011). The usefulness of bryophytes as model organisms on both the large scale (Gignac 2001) and small scale (Wood et al. 2004) has only barely begun to be exploited.

Recent recognition of the contribution of understudied organisms to the biodiversity of public lands in the United States has spurred research aimed at documenting this diversity (All Taxa Biodiversity Inventory Alliance 2006). Besides the inherent benefits of a greater understanding of the bounty of diversity that exists on our public lands, this research helps managers anticipate and preemptively deal with questions regarding species rarity and persistence in the face of management action, disturbance and/or climate change. For example, many of the “old-growth associated species” (including hundreds of species of bryophytes, lichens, fungi, etc.) protected under the survey and manage guidelines for the Northwest Forest Plan (USDA & USDI 1994) achieved that status because little if anything was known about them that would justify their removal from that list. Subsequent systematic surveys have therefore reduced the number of species requiring protection substantially (Molina et al. 2006). All too often decisions of this nature depend on historical records that contain little information and collections that were made incidentally or inconsistently.

Therefore the sort of information presented here can be useful both for ecologists investigating sensitive indicators of climate change and land managers charged with
stewardship of the biodiversity present in their region. For example, the Nevada Natural Heritage Program website that contains information on the distribution of bryophytes in Nevada (Stark & Shevock 2001-2011) that is useful to both biogeographers and land managers. The Nevada bryophyte checklist (chapter 2) and bryophyte flora of Grand Canyon-Parashant National Monument (chapter 4) are likewise intended to help lower the barrier preventing the study of these organisms by non-specialists. Only when accurate and current information regarding the biodiversity and biogeography of bryophytes is made more accessible will their usefulness as both ecological indicators and experimental organisms be fully realized.

Literature Cited

All Taxa Biodiversity Inventory Alliance. 2006. ATBI Alliance Initiative Draft Proposal: A Plan to Develop the Organizational and Operational Structure for a National ATBI Alliance (Phase II), <http://www.atbialliance.org/initiative_draft.pdf>.


Molina, R., B. G. Marcot, and R. Lesher. 2006. Protecting Rare, Old-Growth, Forest-


USDA Forest Service and USDI Bureau of Land Management. 1994. Final Supplemental Environmental Impact Statement on Management of Habitat for Late-Successional and Old-Growth Related Species within the Range of the Northern Spotted Owl. Portland, OR.


CHAPTER 2

AN ANNOTATED CHECKLIST OF THE BRYOPHYTES OF NEVADA, WITH NOTES ON COLLECTING HISTORY IN THE STATE

by

John C. Brinda (first author),

Lloyd R. Stark, James R. Shevock, and John R. Spence

Abstract

A checklist of the 310 bryophyte taxa (two hornworts, 46 liverworts and 262 mosses) reported to occur within the political boundaries of the state of Nevada is presented. 238 new county records are also listed. Notes are provided for species with complex synonymies, taxonomic difficulties or interesting histories. This checklist is intended to improve efforts towards a complete bryophyte flora of the state by identifying those species, habitats and geographic regions that have been neglected or poorly sampled.

Introduction

The last comprehensive checklist of the bryophytes of the state of Nevada was by Elva Lawton in 1958. Much has changed in the nearly 50 years since Lawton’s work was published and it seems useful at this point to present a more current list. The absence of an accessible and up-to-date checklist prevents accurate assessments of bryophyte biodiversity from being made and contributes to the lack of interest shown

to bryophytes by land managers and general botanists. Assessments of biodiversity are impossible without baseline data on species distributions and these data are often sorely lacking for bryophytes (Mutke et al. 2005). The available information concerning the bryoflora of Nevada is either woefully outdated or fragmentary and therefore has led to the misperception that the bryoflora of the state is depauperate (e.g., Mutke & Barthlott 2005). In fact, nothing could be further from the truth and as our field collecting activities in the state continues we expect to add many more species to this checklist including several new to science. While a more complete assessment must await further collection and study of specimens from Nevada we present this list now so that botanists in the state can work with a current dataset. While the Nevada bryoflora will continue to grow with increased exploration, several taxa will also need to be excluded due to past misidentification of specimens. Therefore, we have added notes under the species where we feel that this is likely to be an issue.

The floras by Flowers (1961, 1973) and the checklists by Spence (1988b) and Stark and Whittemore (2000) are very useful in a regional context, however, they are not particularly suited to answering questions about which species occur strictly within the political boundaries of the state of Nevada. The foundation of this checklist is the pioneering work of Sereno Watson and Elva Lawton (Clark 1957; James 1871; Lawton 1958, 1971; Watson 1874, 1880). McVaugh and Fosberg (1941) was an essential reference for finding the locations referred to by older place names in these publications. We have included a map (Figure 1) showing the approximate locations of the routes traveled by these early collectors as well as county boundaries and the major vegetation features of Nevada. A rather exhaustive investigation of somewhat obscure literature
Figure 1. A map showing the political boundaries, vegetation zones, and early bryological exploration of Nevada. Collecting areas are mapped after Coville (1893), Lawton (1958) and Cronquist et al. (1972) with vegetation data from the National Gap Analysis Program (2005).
reports as well as recent collecting efforts by the authors have approximately doubled the number of bryophyte taxa known from the state. However, Nevada is still a virtual terra incognita with regard to bryology. Given its large size and diverse array of habitats as clearly shown in Figure 1, many more species may be expected to be discovered through further collecting and examination of specimens. In particular, those species found on either the Spence (1988b) or Stark and Whittemore (2000) checklists but not in this publication should be priority taxa to locate in Nevada. It is our hope that this list will serve to focus future collecting efforts towards species, habitats, and geographic regions that have been neglected or poorly sampled.

Table 1. The sizes of Nevada’s 16 counties and one independent city sorted by number of bryophyte species recorded per county. Population estimates were gathered from current information available online.

<table>
<thead>
<tr>
<th>County Name</th>
<th>Population</th>
<th>Area (km²)</th>
<th>Species Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elko</td>
<td>47,586</td>
<td>44,555</td>
<td>152</td>
</tr>
<tr>
<td>Clark</td>
<td>1,710,551</td>
<td>20,955</td>
<td>113</td>
</tr>
<tr>
<td>White Pine</td>
<td>9,181</td>
<td>23,042</td>
<td>102</td>
</tr>
<tr>
<td>Washoe</td>
<td>383,453</td>
<td>16,968</td>
<td>88</td>
</tr>
<tr>
<td>Nye</td>
<td>46,714</td>
<td>47,031</td>
<td>68</td>
</tr>
<tr>
<td>Douglas</td>
<td>50,108</td>
<td>1,910</td>
<td>60</td>
</tr>
<tr>
<td>Carson City</td>
<td>57,104</td>
<td>403.2</td>
<td>51</td>
</tr>
<tr>
<td>Humboldt</td>
<td>17,129</td>
<td>25,014</td>
<td>46</td>
</tr>
<tr>
<td>Lander</td>
<td>5,794</td>
<td>14,295</td>
<td>40</td>
</tr>
<tr>
<td>Pershing</td>
<td>6,736</td>
<td>15,715</td>
<td>36</td>
</tr>
<tr>
<td>Esmeralda</td>
<td>1,276</td>
<td>9,295</td>
<td>27</td>
</tr>
<tr>
<td>Lincoln</td>
<td>4,165</td>
<td>27,549</td>
<td>23</td>
</tr>
<tr>
<td>Eureka</td>
<td>1,651</td>
<td>10,826</td>
<td>19</td>
</tr>
<tr>
<td>Churchill</td>
<td>26,106</td>
<td>13,010</td>
<td>12</td>
</tr>
<tr>
<td>Mineral</td>
<td>5,071</td>
<td>9,876</td>
<td>12</td>
</tr>
<tr>
<td>Lyon</td>
<td>48,865</td>
<td>5,222</td>
<td>8</td>
</tr>
<tr>
<td>Storey</td>
<td>4,074</td>
<td>683</td>
<td>8</td>
</tr>
</tbody>
</table>
Table 1 lists the counties and one independent city of Nevada along with their populations, land areas and the number of species so far collected in each. A simple bivariate correlation of species count with land area and population (log transformed) shows that both land area and population are significantly correlated with species counts \((r = 0.599, p = 0.011\) for area; \(r = 0.595, p = 0.012\) for population). When used as predictors in a multiple regression these two variables alone explain much of the variation in species counts \((R^2 = 0.599, p = 0.002)\). Species distributions in Nevada are still heavily skewed by collecting efforts and much work remains to be done to elucidate the true levels of biodiversity that exist within its boundaries. A brief glance at Table 1 shows where efforts are most needed. Nevada holds over 300 tall, rugged mountain ranges within its borders (Charlet 1996). Access to many of these areas is difficult and much of the land above 2500 meters is designated wilderness and therefore permanently without road access. Because of this and the low population density in much of the state, it remains essentially unexplored by bryologists. The pronounced elevational gradients produced by these mountain ranges harbor a multitude of microhabitats for many different kinds of bryophytes. The adventuresome collector will find that many species more common in wetter climates also reside in Nevada’s mountains. We have refrained from adding ecological data for individual species to this checklist, in part due to space constraints but also because these data are very incomplete for species in Nevada. The reader is referred to the wider regional floras for this information and encouraged to help obtain this knowledge for species’ occurrences in Nevada.

We bring together here for the first time the many scattered references regarding the bryophytes of Nevada. By publishing this list in a practical format, we hope that
both professional and amateur bryologists alike will be better able to contribute to our
knowledge of the bryoflora of Nevada. All the following species have been reported
either in the literature, by reliable electronic sources or in the form of herbarium records
as occurring within the state. The following list does not represent an exhaustive
herbarium search; however, we have used those records readily available to us. If the
counties where the species occurs could also be determined, that information is listed
as well. These distributional data are meant to serve as a starting point since, except
perhaps for the Grimmiaceae (Lavin 1982), we know very little about the distribution or
abundance of bryophyte species statewide. We have limited our citations of electronic
sources and unexamined herbarium records to cases where this was necessary in order to
develop a better picture of species distributions within the state. However, we are limiting
this list to only those species that have already been published in hard copy format. New
species for the state will continue to be published as a separate series (Shevock et al.
2005, Spence et al. 2006) and we hope that given this list and forthcoming publications
by the authors, botanists will be able to keep current with the status of the Nevada
bryoflora.

We have tried to be conservative and use names familiar to those who are already
working with the current North American checklists (Anderson 1990; Anderson et al.
1990; Stotler & Crandall-Stotler 1977, 2005). However, we have departed from the above
lists when necessary to bring our nomenclature in line with more modern concepts and
the upcoming publications of the Bryophyte Flora of North America (BFNA) project. For
the genus *Grimmia* we use Muñoz and Pando’s (2000) synopsis as our starting point with
modifications by Hastings and Greven (2006), and for the related species of *Schistidium,*
Blom’s (1996, 1998) treatments have been very helpful. For the Pottiaceae we generally follow Zander (1993), and for the Bryaceae and we have integrated the treatments by Spence (1987, 1988a, 1996, 2004a, b, 2005; Spence & Ramsay 2005). Our treatments of the Brachytheciaceae, Orthodicranum and Hymenoloma closely follow Ignatov and Huttunen (2002), Ochyra et al. (2003) and Huttunen and Ignatov (2004). We recognize that these concepts are constantly being refined with additional evidence and our aim is to keep the resulting nomenclatural changes to a minimum. For cases where the name of a taxon has changed, we have provided the older name as it was used in the publication cited so that one may return to the original work as needed. The authors of species names are abbreviated according to Brummitt and Powell (1992) or the more current online International Plant Names Index <http://www.ipni.org/index.html>. In most cases the Missouri Botanical Garden’s W3MOST database <http://mobot.mobot.org/W3T/Search/most.html> was consulted for the proper authors.

Some of the generic treatments for the BFNA are already published online in draft form at <http://www.mobot.org/plantscience/BFNA/> and we have used the relevant information as it has become available. Another valuable resource is The New York Botanical Garden’s (NY) virtual bryophyte herbarium, accessible at <http://sciweb.nybg.org/science2/hcol/allbryo/index.asp>. It has allowed us to locate many old records and make note of whether cited herbarium collections have subsequently been annotated after being published for Nevada. The reader can find more detailed information on the herbarium records at NY cited herein by accessing this online database. The NY website should serve as a model for all herbaria to work towards as they move into the digital age and it is the direction we intend to take the bryophyte herbarium at UNLV. With just
a few clicks of a mouse button one can download a spreadsheet of the 596 bryophyte records currently at NY for the state of Nevada. The University of British Columbia herbarium (UBC) and the Swedish Museum of Natural History (S) are also online at <http://herbarium.botany.ubc.ca/index.html> and <http://www.nrm.se/> and we have incorporated the Nevada collections from these institutions as well. We encourage our readers to make use of these excellent resources in studies of the bryofloras of their own areas.

In order to avoid repetition, superscripted letters are used to connect particular counties (listed in brackets following the species name) to the citations or specimens which provide the report. For the same reason superscripted numbers are used to connect citations to the names used in those publications if different from the names used here. While it looks confusing at first it is a fairly straightforward notation system and becomes easier with use. For example under *Aneura pinguis*, Clark (1957\(^1\)) means that Clark (1957) reported *A. pinguis* for White Pine County using the older name *Riccardia pinguis*. The superscripts have been omitted when this information is clear from the context, as in *Anthoceros fusiformis* immediately below. We should point out that the previously published names listed here are not intended to imply taxonomic synonymy; they are simply presented as an historical reference.

Nevada Bryophyte Checklist

**Anthocerotophyta (2 Species)**

*Anthoceros fusiformis* Austin [Humboldt] Spence et al. (2006)

*Phaeoceros carolinianus* (Michx.) Prosk. [Clark] Spence et al. (2006)
Notes: Current species concepts within this genus require the examination of spore ornamentation in order to make a final determination and rule out a few segregates from this species complex. The cited specimen is monoicous but the sporophytes are in a very early embryonic stage. However, some characters of the gametophyte and recent collections of *P. carolinianus* in nearby Death Valley National Park, California (Laeger 2005) lend support to the belief that this collection is referable to *P. carolinianus*.

Marchantiophyta (46 Taxa; 45 Species and 1 Variety)

*Aneura pinguis* (L.) Dumort. [Elko*, Washoe*, White Pine†] Clark (19571c), Schuster (1992b) *Shevock 26054a* (CAS, UNLV), *Whittemore 162b* (NY)

Previously published name: *Riccardia pinguis*1

*Anthelia juratzkana* (Limpr.) Trevis. [Elko] Spence et al. (2006)

*Asterella californica* (Hampe) Underw. [Clark] Stark et al. (2002)

*Asterella gracilis* (F. Weber) Underw. [Elko] Clark (19571)

Previously published name: *Asterella ludwigii*1 (misapplied)

*Asterella saccata* (Wahlenb.) A. Evans [Elko] Clark (1957)

*Athalamia hyalina* (Sommerf.) S. Hatt. [Elko] Spence et al. (2006)

*Blepharostoma arachnoideum* M. Howe [Douglas] Frantz and Cordone (1967)

Notes: The record that forms the basis of this report and others collected at Cave Rock in Lake Tahoe at a depth of 329 feet is *Frantz 18* (NY).

*Blepharostoma trichophyllum* (L.) Dumort. [Elko] Spence et al. (2006)

*Cephalozia lunulifolia* (Dumort.) Dumort. [Washoe*] Clark (1957*), Conard and Redfearn
Vigno (1983)


*Cephaloziella divaricata* (Sm.) Schiffn. var. *divaricata* [Washoe\(^a\), White Pine\(^b\)] Clark

(1957\(^{1,b}\)), Hong (1986\(^c\))

Previously published name: *Cephaloziella byssacea*\(^1\) (rejected name)

*Cephaloziella divaricata* var. *asperifolia* (Taylor) Damsh. [Washoe\(^a\), White Pine\(^b\)] Clark

(1957\(^{1,b}\)), Hong (1986\(^{3,a}\)), Schuster (1980\(^{2,b}\))

Previously published names: *Cephaloziella alpina*\(^1\) (misapplied), *C. byssacea* var. *asperifolia*\(^2\) (rejected name), *C. divaricata* var. *scabra*\(^3\)

Notes: Schuster (1980) and Hong (1986) discussed Frye and Clark’s (1945)
confusion regarding this variety, thus excluding *C. alpina*. Compare with
Paton (1999) who explained that this variety intergrades completely with
the typical variety and does not warrant taxonomic recognition.

*Chiloscyphus minor* (Nees) J. J. Engel & R. M. Schust. [White Pine] Clark (1957\(^{1}\))

Previously published name: *Lophocolea minor*\(^1\)

*Chiloscyphus pallescens* (Hoffm.) Dumort. [Elko, Nye, Washoe, White Pine] Clark

(1957)

*Chiloscyphus polyanthos* (L.) Corda [Carson City\(^a\), Elko\(^b\), Humboldt\(^c\), Nye\(^d\), Washoe\(^e\)]

Heise (2000\(^g\)), Whittemore (1994\(^c\)), *Lavin M-129*, *M-598* (NY), *Shevock 27543*\(^c\)

(CAS, UNLV)

*Conocephalum salebrosum* Szweyk., Buczkowska & Odrzykoski [Elko\(^a\)] Clark (1957\(^e\)),
Frost (1871\(^{1,a}\))
Previously published names: *Fegatella conica*¹, *Conocephalum conicum*²

Notes: Szweykowski et al. (2005) showed that the two formerly “cryptic”
species of *Conocephalum* are actually morphologically distinguishable.

Apparently, *C. conicum* (L.) Dumort. is restricted to Europe and most
North American specimens of *Conocephalum* are referable to this newly
described species. The specimen this report is based on has not yet been
located and may turn out to be misidentified considering the lack of
modern records.

*Fossombronia* sp. [Elko] Spence et al. (2006)

*Frullania franciscana* M. Howe [White Pine] Clark (1957)

*Jungermannia confertissima* Nees [Washoe⁵] Váňa and Hong (1999⁵), Whittemore
(1994⁵)

*Jungermannia exsertifolia* Steph. subsp. *cordifolia* (Dumort.) Váňa var. *cordifolia* [Elko⁶,
Washoe⁶, White Pine⁶] Clark (1957¹,⁵), Váňa (1973), Váňa and Hong (1999), Lavin
s.n.⁶ (NY), Shevock 22508⁶ (CAS, UNLV)

Previously published name: *Jungermannia cordifolia*¹

*Jungermannia subulata* A. Evans var. *leiantha* (Grolle) Damsh. [White Pine] Váňa and
Hong (1999⁵)

Previously published name: *Jungermannia leiantha*¹

*Lophozia bantriensis* (Hook.) Steph. [White Pine⁶] Clark (1957¹,⁵), Hong (2002b¹,⁵),

Previously published name: *Leiocolea bantriensis*¹

*Lophozia bicrenata* (Schmidel) Dumort. [White Pine⁶] Clark (1957¹,⁵), Hong (2002a⁶)
Previously published name: *Isopaches bicrenatus*¹

*Lophozia collaris* (Nees) Dumort. [Elko, White Pine] Hong (2002b¹)

Previously published name: *Leiocolea collaris*¹


Previously published name: *Lophozia porphyroleuca*¹ (misapplied)

*Lophozia sudetica* (Huebener) Grolle [Elkoᵃ] Clark (1957ᵃ,ᵃ), Hong (2002ᵃ)

Previously published name: *Lophozia alpestris*¹ (rejected name)

*Lophozia ventricosa* (Dicks.) Dumort. [Elkoᵃ, White Pineᵇ] Clark (1957ᵃᵇ), Hong (2002ᵃᵇ)

*Mannia californica* (Gottsche) L. C. Wheeler [Clark, Lincoln] Spence et al. (2006)

Notes: *Lavin M603* (NY) currently listed as this species in the NY database is referable to *Mannia fragrans* (Balb.) Frye & L. Clark (Daniela Schill pers. comm.)

*Mannia fragrans* (Balb.) Frye & L. Clark [Elko] Shevock et al. (2005)

*Marchantia polymorpha* L. [Douglasᵃ, Elkoᵇ, Esmeraldaᶜ, Eurekaᵈ, Humboldtᵉ, Landerᶠ, Mineralᵍ, Nyeʰ, Pershing¹, Washoe¹, White Pineˢ] Clark (1957ᵇʰᵏ), Frost (1871ᵇⁱ), Heise (2000⁵ʰ), Remy and Brenchley (1860¹ᵇ, 1861¹ᵇ), *Archer 6958²* (NY), *Shevock 22021ᵃ, 21834ᵃ, 22374ᵈ, 22627, 27481ᵉ* (CAS, UNLV)

Previously published name: *Marchantia¹*

Notes: There are three genetically distinct subspecies of *M. polymorpha* (Bischler

*Nardia geoscyphus* (De Not.) Lindb. [Elko<sup>a</sup>] Clark (1957<sup>a</sup>), Hong and Vána (2000<sup>a</sup>)

*Plagiochasma wrightii* Sull. [Elko<sup>a</sup>] Bischler-Causse et al. (2005), Clark (1957<sup>a</sup>), Schuster (1992)

*Porella cordaeana* (Huebener) Moore [Douglas<sup>a</sup>, Elko<sup>b</sup>] Hong (1983<sup>+</sup>), Piippo and Norris (1996), Shevock et al. (2005<sup>b</sup>)

Notes: Shevock et al. (2005) raised concerns regarding Hong’s (1983) citation of *Lawton 3053* (TE.<sup>NN</sup>) which was distributed as *Porella roellii* Steph.

*Porella roellii* Steph. [Douglas<sup>a</sup>] Clark (1957<sup>a</sup>), Hong (1983<sup>a</sup>, 1987), Piippo and Norris (1996)

Notes: Clark (1957) erroneously cited *Lawton 3055*, the correct specimen is *Lawton 3053*. See Shevock et al. (2005) for discussion.

*Reboulia hemisphaerica* (L.) Raddi [Clark] Stark et al. (2002)

*Riccardia latifrons* (Lindb.) Lindb. [county not given] Ammons (1940)

*Riccardia palmata* (Hedw.) Carruth. [White Pine] Clark (1957)

*Riccia cavernosa* Hoffm. [Pershing<sup>a</sup>] Clark (1957<sup>1</sup>), Frost (1871<sup>1</sup>–<sup>a</sup>), Frye and Clark

17
(1937), Schuster (1992), Underwood (1884, 1894)

Previously published name: *Riccia crystallina* (misapplied)

Notes: In the past this species has not been well understood and nearly every report of *Riccia crystallina* L. has been in fact *R. cavernosa*. However, *R. crystallina* has recently been verified as occurring in North America (Stotler & Doyle 2004) and should be looked for in Nevada.

*Riccia frostii* Austin [Carson City] Austin (1875a), Bischler-Causse et al. (2005), Clark (1957a), Evans (1917), Frye and Clark (1937), Howe (1899, 1923), Jovet-Ast (1986, 1993), Schuster (1992), Underwood (1884, 1891)

Previously published name: *Riccia watsonii*

*Riccia sorocarpa* Bisch. [Elko] Clark (1957)

*Riccia stenophylla* Spruce [Clark] Frye & Clark (1937), Howe (1899), Schuster (1992), Underwood (1891)

Previously published name: *Riccia fluitans* (misapplied)

Notes: This population found “In the ditch flowing from the Vegas springs” is now almost certainly extirpated. See Schuster (1992) and Howe (1899) for further discussion of this plant.

*Riccia trichocarpa* M. Howe [Carson City] Clark (1957)


*Scapania irrigua* (Nees) Nees [Washoe] Clark (1957)

Notes: There are two species of *Targionia* in Nevada, one of which has yet to be described. Stark et al. (2002) reported the undescribed *Targionia* from Nye County incidentally and it appears to be widespread in the Mojave Desert region. See Whittemore (1982, 1996), Stark and Whittemore (2000) and Doyle and Stotler (2006) for more information. This may have been the first bryophyte collected in southern Nevada, “On the north face of a limestone cliff, 1 kilometer east of Cottonwood Springs” (Coville 1893). At the time this locality was in Lincoln County, but the county was divided in 1909 and it now lies within Clark County (see Figure 1). This plant is also a species of concern in Clark County and an evaluation species under the multiple species habitat conservation plan for the county.

*Bryophyta s. str. (262 Taxa; 260 Species and 2 Varieties)*

*Aloina bifrons* (De Not.) Delgad. [Clark*, Humboldt*] Stark and Delgadillo (2001*), Stark and Whittemore (2000*), Zander et al. (1995*), *Vitt 7129* (MO)


Previously published name: *Amblystegium serpens var. juratzkanum*¹

Notes: Stark and Whittemore (2000) reported this species from Clark County but the report was based on *Lawton 2992* which was actually collected in Nye County. Recently Hedenäs (2003) has synonymized this species with *Amblystegium serpens* (Hedw.) Schimp.

*Amblystegium serpens* (Hedw.) Schimp. [Carson City*, Clark*, Douglas*, Elko*]

Previously published name: Hypnum serpens


Notes: This is a species of concern in Clark County that is covered under the multiple species habitat conservation plan for the county. The very similar species Anacolia baueri Hampe is also possible for our area.

Antitrichia californica Sull. [Carson City, Douglas, Elko] Conard and Redfearn (1979), Lawton (1958, 1971), Shevock 21997, 22766 (CAS, UNLV)


Barbula convoluta Hedw. [Clark] Stark et al. (2002)


Blindia acuta (Hedw.) Bruch & Schimp. [Carson City, Elko, Washoe] Shevock et al. (2005), Shevock 22048 (CAS, UNLV)
Brachytheciastrum collinum (Schleich. ex Müll. Hal.) Ignatov & Huttunen [Churchill\textsuperscript{a}, Clark\textsuperscript{b}, Douglas\textsuperscript{c}, Elko\textsuperscript{d}, Eureka\textsuperscript{e}, Humboldt\textsuperscript{f}, Lander\textsuperscript{g}, Nye\textsuperscript{h}, White Pine\textsuperscript{i}] Flowers (1973\textsuperscript{1}), James (1871\textsuperscript{1,d}), Lavin (1982\textsuperscript{1,b}), Lawton (1958\textsuperscript{1,b,c,d,f,g,i}, 1971\textsuperscript{1}), Lesquereux and James (1884\textsuperscript{2}), Stark and Whittemore (2000\textsuperscript{1,b}), Watson (1880\textsuperscript{2,d}), Shevock 22416\textsuperscript{a}, 22385\textsuperscript{e}, 21678\textsuperscript{h} (CAS, UNLV)

Previously published names: Brachythecium collinum\textsuperscript{1}, Hypnum collinum\textsuperscript{2}

Brachytheciastrum fendleri (Sull.) Ochyra & Žarnowiec [Esmeralda\textsuperscript{a}, Nye\textsuperscript{b}, White Pine\textsuperscript{c}] Lawton (1958\textsuperscript{1,c}, 1965\textsuperscript{a\textsuperscript{2,c}, 1971\textsuperscript{2}}, McFarland (1988\textsuperscript{2}), Shevock 22303\textsuperscript{a}, 21584\textsuperscript{b} (CAS, UNLV)

Previously published names: Brachythecium utahense\textsuperscript{1}, B. fendleri\textsuperscript{2}

Brachytheciastrum velutinum (Hedw.) Ignatov & Huttunen [Carson City\textsuperscript{a}, Nye\textsuperscript{b}, White Pine\textsuperscript{c}] Lawton (1958\textsuperscript{1,a,c}, Shevock 23695\textsuperscript{b} (CAS, UNLV)

Previously published names: Brachythecium collinum var. idahense\textsuperscript{1}, Brachythecium velutinum\textsuperscript{2}

Notes: See Lawton (1965a) for a discussion of this taxon in western North America. See Ignatov and Huttunen (2002), Ochyra et al. (2003) and Vanderpoorten et al. (2005) for the use of the name Brachytheciastrum.

Brachythecium albicans (Hedw.) Schimp. [Clark\textsuperscript{a}, Douglas\textsuperscript{b}] Shevock et al. (2005\textsuperscript{b}), Shevock 23973\textsuperscript{a} (CAS, UNLV)

Brachythecium asperrimum (Mitt. ex Müll. Hal.) Sull. [Carson City\textsuperscript{a}, Elko\textsuperscript{b}, Eureka\textsuperscript{a}, Washoe\textsuperscript{d}] James (1871\textsuperscript{b}), Shevock et al. (2005\textsuperscript{a,c,d})

Brachythecium erythrorrhizon Schimp. [Elko\textsuperscript{a}] Ireland (1982), Lawton (1958\textsuperscript{1,a}, 1971)

Previously published name: Brachythecium leibergii\textsuperscript{1} (misapplied)
Notes: Lawton 2711 (NY) has been annotated as Brachythecium erythrorhizon thus excluding Brachythecium leibergii Grout from our flora at this time.

Brachythecium frigidum (Müll. Hal.) Besch. [Carson City\textsuperscript{a}, Clark\textsuperscript{b}, Elko\textsuperscript{c}, Esmeralda\textsuperscript{d},

Eureka\textsuperscript{e}, Nye\textsuperscript{f}, Washoe\textsuperscript{g}, White Pine\textsuperscript{h}] Conard and Redfearn (1979), Heise (2000\textsuperscript{g}),
Lawton (1958\textsuperscript{i, f, b}, 1971), Robinson (1963), Lavin s.n.\textsuperscript{b} (NY), Nachlinger 2470\textsuperscript{g}
(CAS, UNLV), Shevock 21814\textsuperscript{d}, 22369\textsuperscript{g} (CAS, UNLV), Train 32331\textsuperscript{a} (NY)

Previously published name: Brachythecium lamprochryseum\textsuperscript{i} (misapplied)

Brachythecium rivulare Schimp. [Douglas\textsuperscript{a}, Elko\textsuperscript{b}, Esmeralda\textsuperscript{c}, White Pine\textsuperscript{d}] Crum and Anderson (1981), Flowers (1973), Ireland and Bellolio-Trucco (1987), Ireland (1982), James (1871\textsuperscript{b}), Lawton (1958\textsuperscript{b, d}, 1971), Shevock 21988\textsuperscript{a}, 21812\textsuperscript{c} (CAS,
UNLV)

Brachythecium rutabulum (Hedw.) Schimp. [Clark\textsuperscript{a}, Douglas\textsuperscript{b}, Elko\textsuperscript{c}, Pershing\textsuperscript{d}, White Pine\textsuperscript{e}] Ireland (1982), James (1871\textsuperscript{d}), Lawton (1958\textsuperscript{a, b, c, d}), Lesquereux and James (1884\textsuperscript{i, d}), Stark and Whittemore (2000\textsuperscript{a}), Watson (1880\textsuperscript{i, d}), Shevock 17774\textsuperscript{e} (CAS,
UNLV)

Previously published name: Hypnum rutabulum\textsuperscript{i}

Brachythecium salebrosum (Hoffm. ex F. Weber & D. Mohr) Schimp. [Elko\textsuperscript{a}, Nye\textsuperscript{b}]

James (1871\textsuperscript{a}), Shevock et al. (2005\textsuperscript{a}), Watson (1880\textsuperscript{i, a})

Previously published name: Hypnum salebrosum\textsuperscript{i}

Bruchia bolanderi Lesq. [Washoe] Spence et al. (2006)

Bryoerythrophyllum recurvirostrum (Hedw.) P. C. Chen [Clark\textsuperscript{a}, Elko\textsuperscript{b}, Nye\textsuperscript{c}, White Pine\textsuperscript{d}]

Heise (2000\textsuperscript{g}), James (1871\textsuperscript{i, b}), Lawton (1958\textsuperscript{b, d}), Watson (1880\textsuperscript{i}), Brinda 148\textsuperscript{a}
(UNLV, CAS)
Previously published names: *Didymodon rubellus*¹ (misapplied), *D. recurvirostris*²

*Bryum argenteum* Hedw. [Carson City², Clarkᵇ, Douglasᶜ, Elkoᵈ, Landerᵉ, Lincolnᶠ,
Mineral,g, Nyeʰ, Washoe¹, White Pine¹] Bowker et al. (2000ᵇ), Heise (2000ᵉ), James (1871ᵃ), Lawton (1958ᵇ,ᵈ,ᵉ), Stark and Whittemore (2000ᵇ), Watson (1880ᵃ), Lavin 3016ᵃ (NY), *Nachlinger 2544* (CAS, UNLV), *Shevock 24035*c, 26482ᵗ, 21687ʰ (CAS, UNLV)

*Bryum bicolor* Dicks. [Clarkᵃ, Elkoᵇ, Nyeᶜ, Pershingᵈ, Storeyᵉ] James (1871¹ᵇ,ᵈ),
Lesquereux and James (1884¹), Vanderpoorten and Zartman (2002ᵉ), Watson (1880¹), *Allen 22034*a (MO), *Nachlinger 2484*c (CAS, UNLV)

Previously published name: *Bryum atropurpureum* Bruch & Schimp. non
(Wahlenb.) Wahlenb.¹

Notes: Lesquereux and James were referring to *Bryum atropurpureum* Bruch & Schimp. which is a synonym for *B. bicolor*, the combination in Bryologia Europaea being illegitimate. Crum and Anderson (1981) show that early exsiccati by Sullivant and Lesquereux contain *B. bicolor* misnamed as *B. atropurpureum*. This species is a *Gemmabryum* and will be transferred to that genus in a different publication.

*Bryum flaccidum* Brid. [Clarkᵃ, Douglasᵇ, Elkoᶜ, Nyeᵈ] Spence et al. (2006¹ᵃᵇᶜ), *Shevock 21681*d (CAS, UNLV)

Notes: This species is a *Rosulabryum* and will be transferred to that genus in a different publication.

*Bryum gemmiparum* De Not. [Clark] Spence et al. (2006)

Notes: This species is an *Imbribryum* and will be transferred to that genus in a
different publication.


Notes: This species is a *Ptychostomum* and will be transferred to that genus in a different publication.

*Bryum lanatum* (P. Beauv.) Brid. [Clark\(^a\), Nye\(^b\)] Spence (1988a), *Nachlinger 2431\(^b\)* (**CAS**, **UNLV**), *Stark NV-35\(^a\)* (**UNLV**)

*Bryum miniatum* Lesq. [Clark\(^a\)] Schofield (1992), *Ertter s.n.\(^a\)* (**NY**)

Notes: This species is an *Imbrhythrum* and will be transferred to that genus in a different publication.

*Bryum valparaisense* Thér. [Clark] Spence et al. (2006)

Notes: This taxon has also been known by the name *Bryum pyriferum* Crundw. & H. Whitehouse (Arts et al. 1995). This species is a *Gemmabryum* and will be transferred to that genus in a different publication.


*Ceratodon purpureus* (Hedw.) Brid. [Carson, City\(^a\), Churchill\(^b\), Clark\(^c\), Douglas\(^d\), Elko\(^e\), Humboldt\(^f\), Washoe\(^g\), White Pine\(^h\)] James (1871\(^b\)), Lawton (1958\(^b,c,d,h\)), Mozingo (1976\(^g\)), Stark and Whittemore (2000\(^h\)), Watson (1880\(^b\)), *Shevock 22047\(^a\), 22724\(^c\), 27491\(^f\)* (**CAS**, **UNLV**)

Notes: Burley and Pritchard (1990) discuss the status of the two *Ceratodon* taxa that are possible for our area, *C. purpureus* and *C. stenocarpus* Bruch & Schimp. ex Müll. Hal.

*Claopodium whippleanum* (Sull.) Renaud & Cardot [Clark] Stark et al. (2002)
Notes: This is a species of concern in Clark County that is covered under the multiple species habitat conservation plan for the county.

*Codriophorus acicularis* (Hedw.) P. Beauv. [Washoe] Spence et al. (2006)

*Codriophorus depressus* (Lesq.) Bednarek-Ochyra & Ochyra [Washoe] Frisvoll (1988a), Lavin (1982), Spence et al. (2006a)

Previously published names: *Racomitrium heterostichum*¹ (misapplied),

*Racomitrium depressum*²

Notes: *Lavin M-5720 (WTU)* was determined by Frisvoll (1988) to be *Racomitrium depressum* Lesq., excluding *R. heterostichum* (Hedw.) Brid. from our flora. See Ochyra et al. (2003) for the use of the name *Codriophorus*.

*Conardia compacta* (Müll. Hal.) H. Rob. [Clark, Douglas, Lander, Lyon, Pershing, White Pine] Cheney (1897a), Flowers (1973a), Heise (2000g), James (1871a,c), Lawton (19581,3,a,f, 1971a), Lesquereux and James (1884b), Stark and Whittemore (2000), Watson (18802,e), *Nachlinger 2453d (CAS, UNLV)*, *Shevock 22000b (CAS, UNLV)*

Previously published names: *Amblystegium compactum*¹, *Hypnum compactum*², *A. americanum*³, *Rhynchostegiella compacta*⁴

*Conostomum tetragonum* (Hedw.) Lindb. [Elko] Spence et al. (2006)

*Coscinodon calyptratus* (Drumm.) C. E. O. Jensen [Carson City, Churchill, Clark, Douglas, Elko, Esmeralda, Eureka, Humboldt, Lander, Lincoln, Lyon, Mineral, Nye, Pershing, Washoe, White Pine] Conard and Redfearn (1979), Hastings (1999), James (1871a), Lavin (19821,3,a,b,c,f,h,g,j,k,l,m,n,o,p), Lawton (19581,a,b,h,i,j,m,o,p, 1971a), Muñoz (1998b), Stark and Whittemore (2000j), Stark et
al. (2002i), Steere (1978), Watson (1880i,a), Shevock 22153d, 22366g (CAS, UNLV),

Stark 1547c (UNLV)

Previously published name: Grimmia calyptratai

Cratoneuron filicinum (Hedw.) Spruce [Carson Citya, Clarksb, Douglasc, Elkos, Esmeraldae, Eurekas, Nyes, Pershingb, Washoeb, White Pinec] Heise

(2000ab), Lawton (1958bdk, 1971), Stark and Whittemore (2000b), Edgington s.n.a

(NY), Lavin s.n.i (NY), Nachlinger 2438c, 2491i (CAS, UNLV), Shevock 21999c, 21828c

(CAS, UNLV)


(1977a), Stark (1997a, 2005a), Stark and Whittemore (2000ab), Thompson et al.

(2005a), Zander et al. (1995a)

Crossidium crassinerve (De Not.) Jur. [Clarks] Stark (1997a, 2001a, 2001b, 2005a), Stark

and Whittemore (2000a), Weber and Wittmann (2005), Zander et al. (1995a)

Crossidium seriatum H. A. Crum & Steere [Clarks] Delgadillo (1996a), Stark and

Whittemore (2000a), Stark et al. (2002a), Thompson et al. (2005a), Weber and

Wittmann (2005), Zander et al. (1995a)

Notes: This plant is on the Nevada Heritage Program’s sensitive list and the

Nevada Native Plant Society’s watch list. It is also a species of concern in

Clark County as an evaluation species under the multiple species habitat

conservation plan. See Cano (2006) for a discussion of Tortula brevissima

Schiffl., a very similar European species.

Crossidium squamiferum (Viv.) Jur. [Clarks, Minera] Delgadillo (19962a,b), Lawton

(19581a), Stark (1997a), Stark and Whittemore (20002a), Zander et al. (1995a)
Previously published names: *Crossidium griseum*¹, *C. squamiferum* var. *pottioideum*²

Notes: Without sporophytes it is not possible to determine this species to variety. See Cano et al. (1993) and Delgadillo (1996, 2000) for discussions concerning this species and its varieties.

*Crumia latifolia* (Kindb.) W. B. Schofield [Clarkᵃ, Douglasᵇ] Conard and Redfearn (1979⁵), Lawton (1958¹ᵃ, 1971²), Schofield (1966⁶), Stark and Whittemore (2000ᵃ), *Shevock 22003ᵇ (CAS, UNLV)*

Previously published names: *Merceya latifolia*¹, *Scopelophila latifolia*²

*Dichodontium pellucidum* (Hedw.) Schimp. [Elkoᵃ, White Pineᵇ] Shevock et al. (2005ᵃ), *Shevock 27610ᵇ (CAS, UNLV)*


*Didymodon brachyphyllus* (Sull.) R. H. Zander [Clarkᵃ, Landerᵇ, Lincolnᶜ, Mineralᵈ, Nyeᵉ] Shevock et al. (2005ᵈᵉ), *Brinda 511ᵃ (UNLV), Lavin M-207ᵇ (NY), Nachlinger 2697ᶜ (CAS, UNLV)*

Notes: See Zander (2002) and Zander and Ochyra (2001) for a discussion of the past confusion concerning this species, *Didymodon trifarius* (Hedw.) Röhl., and *D. luridus* Hornsch.

Notes: This plant is on the Nevada Heritage Program’s sensitive list and the Nevada Native Plant Society’s watch list as well as being a Bureau of Land Management special status species in Nevada. It is also a species of concern in Clark County and an evaluation species under the multiple species habitat conservation plan for the county. The type of *D. nevadensis* was collected in Clark County, Nevada and it is named in honor of the state.

*Didymodon nicholsonii* Culm. [Clark\textsuperscript{a}, Douglas\textsuperscript{c}] Shevock et al. (2005\textsuperscript{b}), *Lavin 1\textsuperscript{a} (NY)*

*Didymodon tophaceus* (Brid.) Lisa [Clark\textsuperscript{a}, Elko\textsuperscript{b}, Humboldt\textsuperscript{c}, White Pine\textsuperscript{d}] Lawton (1958\textsuperscript{a}, 1971), Stark and Whittemore (2000\textsuperscript{d}), *Howell 105\textsuperscript{b} (CAS, UNLV), 114\textsuperscript{d} (CAS, MO), Lavin 4412\textsuperscript{a} (NY)*

*Didymodon vinealis* (Brid.) R. H. Zander [Carson City\textsuperscript{a}, Clark\textsuperscript{b}, Douglas\textsuperscript{c}, Elko\textsuperscript{d}, Eureka\textsuperscript{d}, Humboldt\textsuperscript{f}, Washoe\textsuperscript{g}] Lawton (1958\textsuperscript{1,f}, 1971\textsuperscript{1}), Stark (1997\textsuperscript{b}), Stark and Delgadillo (2001), Stark and Whittemore (2000\textsuperscript{b}), Stark et al. (2002\textsuperscript{b}), *Edgington 78-174\textsuperscript{e} (NY), Howell 8\textsuperscript{d} (CAS, UNLV), Nachlinger 2437\textsuperscript{e} (CAS, UNLV), Shevock 21955\textsuperscript{c}, 21992\textsuperscript{c} (CAS, UNLV)*

Previously published name: *Barbula vinealis* var. *vinealis*\textsuperscript{1}

*Distichium capillaceum* (Hedw.) Bruch & Schimp. [Clark\textsuperscript{a}, Elko\textsuperscript{b}, Esmeralda\textsuperscript{c}, Humboldt\textsuperscript{d}, White Pine\textsuperscript{e}] Conard and Redfearn (1979), James (1871\textsuperscript{b}), Lawton (1958\textsuperscript{b,e}, 1971), Watson (1880\textsuperscript{b}), *Norris 24449\textsuperscript{d} (NY), Shevock 22093\textsuperscript{e} (CAS, UNLV), Stark s.n.\textsuperscript{a} (UNLV)*

*Distichium inclinatum* (Hedw.) Bruch & Schimp. [Clark\textsuperscript{a}] Conard and Redfearn (1979), Ireland (1982), Lawton (1958\textsuperscript{a}, 1971), Stark and Whittemore (2000), Steere
Notes: This plant is a species of concern in Clark County and an evaluation species under the multiple species habitat conservation plan for the county.

_Ditrichum flexicaule_ (Schwägr.) Hampe [Elko] Spence et al. (2006)


Previously published names: _Hypnum aduncum^1_, _Drepanocladius aduncus_ var. _typicus^2, D. a. var. _polycarpus^3, D. a. var. _kneiffii^4

_Drepanocladius longifolius_ (Mitt.) Broth. ex Paris [Elko] James (1871^1,a), Wynne (1944^2,a)

Previously published names: _Hypnum_ sp. nov.^1, _Drepanocladius aduncus_ var. _capillifolius^2

Notes: This report is based on Watson 1480 (NY), now annotated as

_Drepanocladius capillifolius_ (Warnst.) Warnst., a synonym of this species.

See Hedenäs (2000) for a discussion of this taxon in North America.


_Encalypta intermedia_ Jur. [Clark, Douglas, Elko, Lander, Lincoln, Nye, Pershing, Washoe, White Pine] Conard and Redfearn (1979), Holzinger (1893^3,c), Horton (1983^a,c,d,h,i), James (1871^1,2,c,g), Lavin (1982^a), Lawton (1958^4,a,b,d,f,g,h,i), Stark and Whittemore (2000^3,a), Steere (1978^3), _Brinda 141^e (UNLV)
Previously published names: *Encalypta vulgaris* (misapplied), *E. vulgaris* var. *obtusa* (misapplied), *Leersia trachymitria* (misapplied), *E. vulgaris* var. *mutica* (misapplied), *E. streptocarpa* (misapplied), *E. procera* (misapplied)

Notes: Lawton’s (1958) concept of *Encalypta vulgaris* Hedw. var. *mutica* Brid. probably corresponded to *E. intermedia* sensu Horton (1983). Lawton (1958) referred *Watson 1397* (NY) from Pershing County originally distributed as typical *E. vulgaris* to here as well. Stark and Whittemore (2000) reported *E. vulgaris* but this is based on Lawton’s reports of the variety. More recently, Lawton (1971) lumped the entire complex into *E. vulgaris*. While this species is perhaps one of the most common and distinctive mosses in Nevada it remains poorly understood. The treatment of the genus in Weber and Wittmann (2005) is very helpful for our species.

*Encalypta rhaptocarpa* Schwägr. [Elko, Lincoln, Pershing] Conard and Redfearn (1979), Flowers (1973), James (1871a), Lawton (1958a, 1971c), Lesquereux and James (1884), Steere (1978), Watson (1880b), *Brinda 43* (UNLV), *Vitt 7160* (s)

Previously published name: *Encalypta vulgaris* var. *rhabdocarpa*


Previously published names: *Encalypta commutata* (misapplied), *E. extinctoria*.
E. vulgaris var. apiculata


Notes: This plant is on the Nevada Native Plant Society’s watch list. It is a globally rare species known from only a few collections, including one in Nye County. It has also recently been found widely disjunct in Egypt (Shabbara 1999).

*Eucladium verticillatum* (With.) Bruch & Schimp. [Clark] Shevock et al. (2005)

*Eurhynchiastrum pulchellum* (Hedw.) Ignatov & Huttunen var. pulchellum [county not given] Flowers (19731), Lawton (19711), Steere (19781)

Previously published name: *Eurhynchium pulchellum*¹

Notes: See Ignatov and Huttunen (2002) and Ochyra et al. (2003) for the use of the name *Eurhynchiastrum*.

*Eurhynchiastrum pulchellum* var. *diversifolium* (Schimp.) Ochyra and Żarnowiec [Elko] Flowers (19732), Lawton (19581a)

Previously published names: *Eurhynchium diversifolium*¹, *E. pulchellum* var. *diversifolium*²

*Fabronia pusilla* Raddi [Clarka, Douglasb, Humboldtc] Lavin (1981c) Shevock 26513a, 24046a (CAS, UNLV)

*Fissidens crispus* Mont. [Clarka, Lincolnb, Washoec] Shevock et al. (2005c), *Brinda* 935a (UNLV), Shevock 26500a (CAS, UNLV)

**Fissidens sublimbatus** Grout [Clark³] Jiménez et al. (2002), Pursell (1997ᵃ), Ros et al. (2001), Stark et al. (2002ᵃ)


Previously published name: *Fontinalis antipyretica* var. *gigantea¹* (misapplied)

Notes: Lawton (1958, 1971) and Welch (1960) referred *Watson 1452* (US, NY) to the typical variety. Welch also cited *Brandegee, Aug. 1885* (fh) collected at Fish Creek, Eureka County. Smith (2004) stated that forms traditionally reduced to varieties of *Fontinalis antipyretica* are “probably more than mere habitat variants.” We follow Crosby et al. (1999) in giving them species status. However, compare with Shaw and Allen (2000) who illustrated that these taxonomic problems are not yet fully resolved.

**Fontinalis gigantea** Sull. [Elko] Spence et al. (2006)

**Fontinalis howellii** Renauld & Cardot [Washoeᵃ] Allen (1988¹ᵃ), Welch (1960¹ᵃ)

Previously published name: *Fontinalis antipyretica* var. *oreganensis¹* [sic]

**Fontinalis mollis** Müll. Hal. [Elko⁴] Remy and Brenchley (1860¹ᵃ, 186¹ᵃ), Tan (1990²ᵃ), Thériot (1927²ᵃ), Welch (1960³ᵃ)

Previously published names: *Fontinalis¹*, *F. utahensis²*, *F. antipyretica* var. *mollis³*

Notes: The specimen cited by Thériot (1927) and Welch (1960) is *Remy, Sept. 1855* (fh). This is the earliest record of a bryophyte collection for the state. It was collected in 1855 when Nevada was still a part of Utah Territory near the source of the Humboldt River. Remy and Brenchley’s (1861) record of their journey is a fascinating piece of natural history and also
places the location of the collection in modern day Elko County. The holotype of *Fontinalis utahensis* Cardot & Thér. presumably resides at PC, possibly along with other bryophyte collections made by Remy in what is now Nevada.


*Funaria calvescens* Schwägr. [Carson City] James (1871), Watson (1880)

Previously published name: *Funaria hygrometrica* var. *calvescens*

Notes: This species has been variously considered a variety of *Funaria hygrometrica* Hedw. or a specific rank by multiple authors. See Fife and Seppelt (2001) and Allen (2002) for further discussion.


Previously published names: *Funaria hygrometrica* var. *convoluta*, *F. h.* var. *utahensis*

Notes: Lawton (1958) referred *Watson 1420* (US) from Elko County to this species.

*Funaria muhlenbergii* Turner [Clark, Lincoln] Stark et al. (2002), *Shevock 26470* (CAS, UNLV)

(2006)


Previously published name: *Grimmia tenerrima* (misapplied)

Notes: Following Crum et al. (1973), Conard and Redfearn (1979) and Lavin (1982) considered *G. alpestris* to be a synonym of *G. tenerrima* Renauld & Cardot. Muñoz (1997) showed this to be incorrect and more recently, Hastings and Greven (2006) showed that both taxa are present in North America. Therefore the above records should be reexamined for segregate taxa.


Notes: This plant is on the Nevada Heritage Program’s sensitive list and the Nevada Native Plant Society’s watch list. It is also a species of concern in Clark County and an evaluation species under the multiple species
habitat conservation plan for the county. *Grimmia americana* is a globally rare species with only three known occurrences, one of which is in the Newberry Mountains of Clark County.

*Grimmia anodon* Bruch & Schimp. [Carson City\(^a\), Churchill\(^b\), Clark\(^c\), Douglas\(^d\), Elko\(^e\), Esmeralda\(^f\), Eureka\(^g\), Humboldt\(^h\), Lander\(^i\), Lincoln\(^j\), Lyon\(^k\), Mineral\(^l\), Nye\(^m\), Persing\(^n\), Storey\(^o\), Washoe\(^p\), White Pine\(^q\)] Cao and Vitt (1986), Conard and Redfearn (1979), Heise (2000\(^i\)), Ireland (1982), Ireland and Miller (1982), James (1871\(^e\)), Lavin (1982\(^a,b,c,d,e,f,g,h,i,j,k,l,m,n,o,p,q\)), Lawton (1958\(^b,c,i,j,k,m,q\), 1971), Lesquereux and James (1884), Steere (1978), Stark and Whittemore (2000\(^c,i,m\))


*Grimmia laevigata* (Brid.) Brid. [Clark\(^a\), Douglas\(^b\), Elko\(^c\), Lander\(^d\), Lincoln\(^e\), White Pine\(^f\)] James (1871\(^1,c\)), Fernandez et al. (2006\(^c\)), Lavin (1982\(^a,c,d,f\)), Lawton (1958\(^a,e\), 1971), Stark and Whittemore (2000\(^a\)), Watson (1880\(^1,c\)), *Shevock 22158*, 26477\(^e\)

(\text{CAS, UNLV})

Previously published name: *Grimmia leucophaea*\(^1\)

*Grimmia longirostris* Hook. [Churchill\(^a\), Clark\(^b\), Lyon\(^c\), Nye\(^d\), Persing\(^e\), Washoe\(^f\)] Ireland (1982\(^i\)), Lavin (1982\(^1,a,b,d\)), Lawton (1958\(^1,b,e,f\)), Stark and Whittemore (2000\(^1,b,d\)), *Mozingo 75-86b*\(^e\) (NY)

Previously published name: *Grimmia affinis*\(^1\) (misapplied)

*Grimmia montana* Bruch & Schimp. [Carson City\(^a\), Douglas\(^b\), Elko\(^c\), Humboldt\(^d\), Lander\(^e\), Lyon\(^f\), Persing\(^g\), Storey\(^h\), Washoe\(^i\), White Pine\(^j\)] Cao and Vitt (1986), Conard and Redfearn (1979), James (1871), Lavin (1982\(^b,c,d,f,i\)), Lawton (1958\(^e\), 1971), Lesquereux and James (1884), Muñoz (1998\(^a\)), Watson (1880), *Nachlinger 2488*\(^n\)
(CAS, UNLV), Shevock 22355c, 21945i (CAS, UNLV)

Notes: Lawton (1958) referred Watson 1416 (US) from Pershing County to this species.


**Grimmia ovalis** (Hedw.) Lindb. [Carson Citya, Churchilla, Clarkc, Douglassd, Elkoa, Humboldt1, Lincolna, Mineralb, Nyea, Pershingi, Washoeh, White Pinej] Cao and Vitt (1986), Conard and Redfearn (1979), James (1871ij,k), Lavin (1982cefg,ijk), Lawton (1958afg, 1971), Lesquereux and James (1884i), Stark and Whittemore (2000ae), Watson (1880j, Nachlinger 2469 (CAS, UNLV), Shevock 2241lb, 24031d, 2211lb (CAS, UNLV)

Previously published name: *Grimmia ovata*

**Grimmia plagiopodia** Hedw. [Humboldt1, Washoeb] Flowers (1973), Lavin (1981ab, 1982b)

**Grimmia poecilostoma** Cardot & Sebille [Clarka, Elkok] Lavin (1981b, 1982b), Stark NV-25B (UNLV, MO)

Grimmia pulvinata (Hedw.) Sm. [Churchill\textsuperscript{a}, Clark\textsuperscript{b}, Elko\textsuperscript{c}, Lincoln\textsuperscript{d}] Cao and Vitt (1986), James (1871\textsuperscript{a}), Lavin (1982\textsuperscript{b,d}), Lawton (1958\textsuperscript{a,d}, 1971), Lesquereux and James (1884), Stark and Whittemore (2000\textsuperscript{b,d}), Watson (1880\textsuperscript{c}), Shevock 26009\textsuperscript{c} (CAS, UNLV)

Grimmia torquata Drumm. [Carson City\textsuperscript{a}, Washoe\textsuperscript{b}] Conard and Redfearn (1979), Lavin (1982\textsuperscript{b}), Lawton (1958\textsuperscript{a}, 1971), Steere (1978)

Grimmia trichophylla Grev. [Carson City\textsuperscript{a}, Douglas\textsuperscript{b}, Washoe\textsuperscript{c}] Lavin (1982\textsuperscript{b,c}), Lawton (1958\textsuperscript{a,b}, 1971)

Grimmia ungeri Jur. [Carson City\textsuperscript{a}] James (1871\textsuperscript{1,a}), Austin (1875\textsuperscript{2,a}), Lesquereux and James (1884\textsuperscript{3}), Muñoz (1998\textsuperscript{a}), Muñoz and Pando (2000\textsuperscript{a}), Watson (1880\textsuperscript{2-a})

Previously published names: Grimmia orbicularis\textsuperscript{1} (misapplied), G. jamesii\textsuperscript{2}, G. montana var. truncata\textsuperscript{3}

Notes: According to Greven (2003) Grimmia ungeri is restricted to Europe with specimens from North America actually representing forms of either G. alpestris or G. montana. However, Muñoz (1998\textsuperscript{a}) referred Watson 1412 (FH), the basis of these records, to G. ungeri. Also see Norris and Shevock (2004\textsuperscript{a}) for further discussion.

Gymnostomum aeruginosum Sm. [Elko\textsuperscript{a}] Lawton (1958\textsuperscript{a}, 1971), Steere (1978)

Notes: These plants need to be reevaluated; they are much more likely to be Gymnostomum calcaratum Nees & Hornsch.

Helodium blandowii (F. Weber and D. Mohr) Warnst. [Elko\textsuperscript{a}, Washoe\textsuperscript{b}] Flowers (1973), Lawton (1958\textsuperscript{b}, 1971), Steere (1978), Shevock 22711\textsuperscript{a} (CAS, UNLV)

Hennediella heimii (Hedw.) R. H. Zander [Lander\textsuperscript{a}, Pershing\textsuperscript{b}, Washoe\textsuperscript{c}, White Pine\textsuperscript{d}]
Flowers (1973), Heise (2000a), James (1871,1,2), Lawton (1958,1,4, 1971),
Lesquereux and James (1884), Watson (1880,1,2), Lavin s.n. (NY)

Previously published name: *Pottia heimii*


Previously published names: *Camptothecium nevadense*, *Hypnum nevadense*


Previously published names: *Leptodictyum trichopodium*, *Amblystegium trichopodium*, *L. humile*


Previously published names: *Amblystegium orthocladon*, *Hygroamabilystegium orthocladon*, *A. tenax*

*Hygroamabilystegium varium* (Hedw.) Mönk. [Pershing] James (1871)

 Previously published name: *Amblystegium radicale* (misapplied)

Notes: Hedenäs (1997) explained the problems behind the name *Amblystegium radicale* in detail. Crum and Anderson (1981) showed that early exsiccati
from Sullivant and Lesquereux were *Hygroamblystegium varium*

misnamed as *Hypnum radicale*. Also, see the synonymy in Lesquereux
and James (1884) and Cheney (1897). Recently, Vanderpoorten (2004)
lumped *Hygroamblystegium fluviatile* (Hedw.) Loeske, *H. humile*, *H. tenax*, and *H. varium* together representing a single polymorphic species
based on numerous lines of molecular and morphological evidence

*Hygrohypnum duriusculum* (De Not.) D. W. Jamieson [Elko\(^a\), White Pine\(^b\)] Jamieson

(1976\(^b\)), Lawton (1958\(^1,b\), 1971\(^2\)), *Lavin 2B* (NY)

Previously published names: *Hygrohypnum molle*\(^1\), *H. dilatatum*\(^2\)

Notes: Jamieson (1976) referred *Lawton 2810* (NY) to this species. See Jamieson

(1980) for the use of this name.

*Hygrohypnum luridum* (Hedw.) Jenn. [Elko\(^a\)] Lawton (1971), *Mozingo 76-130b* (NY)

*Hygrohypnum molle* (Hedw.) Loeske [Elko\(^a\), Esmeralda\(^b\), Washoe\(^c\)] Flowers (1973),

Steere (1978), *Lavin s.n.* (NY), *Mozingo 72-32c* (NY), *Shevock 21821b* (CAS, UNLV)

*Hygrohypnum ochraceum* (Turner ex Wilson) Loeske [Elko\(^a\), Nye\(^b\), Storey\(^c\), Washoe\(^d\),

White Pine\(^e\)] Conard and Redfearn (1979), Jamieson (1976\(^a\)), Lawton (1958\(^a\),


*Nachlinger 2483c* (CAS, UNLV)

*Hygrohypnum smithii* (Sw.) Broth. [Elko\(^a\), Washoe\(^b\)] Lavin (1981\(^a\)), *Lavin s.n.* (NY)

*Hymenoloma conterminum* (Renauld & Cardot) Ochyra [Carson City\(^a\), Clark\(^b\), Douglas\(^c\),

Elko\(^d\), White Pine\(^e\)] Lavin (1982), Lawton (1958\(^{1,a,b,c,e}\), 1971\(^2\)), Stark and

Whittemore (2000\(^{1,b}\)), Steere (1978\(^2\))
Previously published names: *Dicranoweisia crispula* s. lat., *D. crispula* var. *contermina*

Notes: Lawton (1971) implied that she considers her Nevada collections to be *Dicranoweisia crispula* (Hedw.) Milde var. *contermina* (Renauld & Cardot) Grout (a synonym of this species) although they may not be annotated accordingly. Lavin (1982) reported the species incidentally without stating a variety; this is probably *Hymenoloma conterminum* as well. Following Lawton (1958), Stark and Whittemore (2000) reported *D. crispula* s. lat.; see Norris and Shevock (2004a), Ochyra et al. (2003), Lawton (1971), Flowers (1956), Grout (1937), and Williams (1913) for discussions on this taxon. A careful examination of Nevada specimens will be required to determine which taxa actually occur in the state. This plant is also a species of concern in Clark County that is covered under the multiple species habitat conservation plan for the county.

*Hymenoloma crispulum* (Hedw.) Ochyra [Douglas] Norris and Shevock (2004a)

Previously published name: *Dicranoweisia crispula* s. str.

Notes: The only report of *Hymenoloma crispulum* s. str. from Nevada is by Norris and Shevock (2004a) however, this specimen needs to be reexamined. See notes above for *H. conterminum*.

*Hymenostylium recurvirostre* (Hedw.) Dixon [Clark\(^a\), Elko\(^b\), White Pine\(^c\)] Lawton (1958\(^1,b\), 1971\(^1\)), Steere (1978), Nachlinger 2473\(^c\) (CAS, UNLV), Shevock 23625\(^a\) (CAS, UNLV)

Previously published name: *Gymnostomum recurvirostre*\(^1\)

*Hypnum revolutum* (Mitt.) Lindb. var. revolutum [Carson City\(^a\), Clark\(^b\), Elko\(^c\), Humboldt\(^d\),

Previously published name: Hypnum revolutum var. molendoanum


Schultz 2359 (NY)


Previously published name: Bryum muehlenbeckii


Previously published name: Grimmia wrightii


Previously published names: Eurhynchium stokesii, E. praelongum var. stokesii, Stokesiella praelonga var. stokesii, S. praelonga

Leptobryum pyriforme (Hedw.) Wilson [Carson City, Clark, Douglas, Elko]
Esmeralda, Humboldt, Lander, Nye, Pershing, Washoe, White Pine] Heise (2000\(^{a,b}\)), James (1871\(^{d,i}\)), Lawton (1958\(^{a,d,h,j,k}\)), Mozingo (1976\(^{a}\)), \textit{Brinda} 251\(^{b}\) (\text{UNLV}), Shevock 22451\(^{e}\), 22300\(^{f}\), 27477\(^{i}\) (\text{CAS, UNLV})

\textit{Leptodictyum riparium} (Hedw.) Warnst. [Douglas, Elko, Lander] Frantz and Cordone (1967\(^{a}\)), James (1871\(^{1,b}\)), Lawton (1958\(^{1,b}\), 1971\(^{1}\)), Watson (1880\(^{2,b}\), Shevock 22340\(^{f}\) (\text{CAS, UNLV})

Previously published names: \textit{Amblystegium riparium}\(^{1}\), \textit{Hypnum riparium}\(^{2}\)

\textit{Lescuraea saxicola} (Schimp.) Molendo [White Pine] Spence et al. (2006)


Notes: This plant is on the Nevada Native Plant Society’s watch list and is also a United States Forest Service sensitive species for the Lake Tahoe Basin Management Unit.

\textit{Melesia uliginosa} Hedw. [Elko, Washoe] Conard and Redfearn (1979), Grout (1935\(^{1,a}\)), James (1871\(^{a}\)), Lawton (1958\(^{a,b}\), 1971), Steere (1978), Watson (1880\(^{a}\))

Previously published name: \textit{Melesia uliginosa} var. minor\(^{1}\)

\textit{Meiotrichum lyallii} (Mitt.) G. L. Merr. [Carson City, Elko] James (1871\(^{1,b}\)), Lawton (1958\(^{1,b}\), 1971\(^{1}\)), Watson (1880\(^{2,b}\)), Baker 1492\(^{a}\) (NY)

Previously published names: \textit{Polytrichadelphus lyallii}\(^{1}\), \textit{Oligotrichum lyallii}\(^{2}\)

\textit{Metaneckera menziesii} (Drumm.) Steere [Carson City, Washoe] Conard and Redfearn (1979), Lawton (1958\(^{1,a}\), 1971\(^{1}\)), Shevock 24055\(^{b}\) (\text{CAS, UNLV})

Previously published name: \textit{Neckera menziesii}\(^{i}\)

Stark et al. (2002a), Thompson et al. (2005a)


*Mnium blyttii* Bruch & Schimp. [Elkoa, Nyeb] Heise (2000b), Shevock 22535a (UNLV)

*Mnium marginatum* (Dicks. ex With.) P. Beauv. [Douglasa, Elkoa, Esmeraldae, Nyea, Washoe, White Pine] Flowers (1973), Lawton (19581,a,b,d,f), Mozingo (19761,c), Shevock 22296a (UNLV)

Previously published name: *Mnium serratum*

*Molendoa sendtneriana* (Bruch & Schimp.) Limpr. [Clark] Shevock et al. (2005)

*Oncophorus virens* (Hedw.) Brid. [Elkoa, Humboldt, White Pine] Frahm et al. (1998), Lawton (1958a, 1971), *Lavin 6D* *b* (NY), Shevock 27629c (UNLV)

*Orthodicranum tauricum* (Sapjegin) Smirnova [Douglas, Washoe] Shevock et al. (2005)

*Orthotrichum affine* Schrad. ex Brid. [Douglasa, Elko, Washoe] Shevock et al. (2005a), Shevock 22546b, 21980c (CAS, UNLV)

*Orthotrichum alpestre* Hornsch. ex Bruch & Schimp. [Carson Citya, Churchilla, Douglas, Eureka, Humboldt, Lander, Pershinge, Washoe, White Pine] Britton (18932,g, 1894a2,e), Flowers (1973), Grout (19353, 19463), James (18711,2,h), Lawton (19583,a,b,c,d,e,f,g,l, 19713), Lesquereux and James (18842,g), Lewinsky (1977a8), Rau and Hervey (18802), Sullivant (18742,g), Vitt (1973b9), Watson (18802,g), Shevock 22060c, 22389d (CAS, UNLV)

Previously published names: *Orthotrichum occidentale* var. nov.1, *O. watsonii2, O. alpestre* var. *watsonii3, O. a. var. *occidentale4, O. a. var. majus5*

*Orthotrichum anomalum* Hedw. [county not given] Flowers (1973)
Orthotrichum cupulatum Hoffm. ex Brid. [Clark\textsuperscript{a}, Douglas\textsuperscript{b}, Elko\textsuperscript{c}, Humboldt\textsuperscript{d}, Lander\textsuperscript{e}]

Heise (2000\textsuperscript{a}), Lavin (1982), Lawton (1958\textsuperscript{e}, 1971), Stark and Whittemore (2000\textsuperscript{a}), Vitt (1973b\textsuperscript{c}), Lavin s.n.\textsuperscript{d} (NY), Shevock 22018\textsuperscript{b}, 22819\textsuperscript{c} (CAS, UNLV)

Orthotrichum flowersii Vitt [Humboldt\textsuperscript{e}, Nye\textsuperscript{b}] Lewinsky-Haapasaari and Hedenäs (1998\textsuperscript{a}), Shevock et al. (2005\textsuperscript{b})

Orthotrichum hallii Sull. & Lesq. [Churchill\textsuperscript{a}, Clark\textsuperscript{b}, Lander\textsuperscript{c}, Nye\textsuperscript{d}, White Pine\textsuperscript{e}]

Conard and Redfearn (1979), Flowers (1973), Lawton (1958\textsuperscript{b,c,e}, 1971), Lewinsky (1977b), Stark and Whittemore (2000\textsuperscript{a}), Vitt (1973b\textsuperscript{c}), Shevock 22328\textsuperscript{d} (CAS, UNLV)

Orthotrichum laevigatum J. E. Zetterst. [Carson City\textsuperscript{a}, Douglas\textsuperscript{b}, Elko\textsuperscript{c}, Lander\textsuperscript{d}, Nye\textsuperscript{e}, Persing\textsuperscript{f}, Washoe\textsuperscript{g}] Britton (1894a), Conard and Redfearn (1979), Grout (1935, 1946), Heise (2000\textsuperscript{d,e}), James (1871\textsuperscript{i}), Lawton (1958\textsuperscript{a,b,c}, 1971), Lesquereux and James (1884\textsuperscript{f}), McIntosh (1986), Rau and Hervey (1880\textsuperscript{j}), Stark and Whittemore (2000\textsuperscript{c}), Vitt (1973b\textsuperscript{c}), Vitt et al. (1971), Watson (1880\textsuperscript{1,j}), Shevock 21978\textsuperscript{g} (CAS, UNLV)

Previously published name: Orthotrichum kingianum\textsuperscript{1}

Orthotrichum lyellii Hook. and Taylor [Clark\textsuperscript{a}, Douglas\textsuperscript{b}, Esmeralda\textsuperscript{c}, Nye\textsuperscript{e}] Britton (1893\textsuperscript{1,c}), Shevock et al. (2005\textsuperscript{a,b,d})

Previously published name: Orthotrichum pringlei\textsuperscript{1}

Orthotrichum macounii Austin [Douglas\textsuperscript{a}, Humboldt\textsuperscript{b}, Persing\textsuperscript{c}, Washoe\textsuperscript{d}, White Pine\textsuperscript{e}] Lavin (1982\textsuperscript{2}), Lawton (1958\textsuperscript{1,a,b,c,e}, 1971\textsuperscript{2}), Steere (1978\textsuperscript{2}), Vitt (1973b\textsuperscript{2,e}), Mozingo s.n.\textsuperscript{d} (NY)

Previously published names: Orthotrichum macounii var. lonchothecium\textsuperscript{1}, O. laevigatum fo. macounii\textsuperscript{2}
Notes: Vitt (1973b, 2003) considered this species to be a form of *O. laevigatum*.

*Orthotrichum papillosum* Hampe [Douglas] Shevock et al. (2005)

Notes: Vitt (1973b, 2003) considered this species to be a synonym of *O. lyellii*.

*Orthotrichum pellucidum* Lindb. [Clark\textsuperscript{a}, Elko\textsuperscript{b}, Lander\textsuperscript{c}, Nye\textsuperscript{d}, White Pine\textsuperscript{e}] Britton (1894\textsuperscript{a, b}), Flowers (1973\textsuperscript{i}), Grout (1935\textsuperscript{1, b}, 1946\textsuperscript{1, b}), James (1871\textsuperscript{1, b}), Lavin (1982\textsuperscript{i}), Lawton (1958\textsuperscript{1, a, b, e}, 1971\textsuperscript{2}), Lesquereux and James (1884\textsuperscript{1, b}), Lewinsky (1977\textsuperscript{a, b, e}, 1977\textsuperscript{b, i}), Rau and Hervey (1880\textsuperscript{i}), Sullivant (1874\textsuperscript{1, b}), Stark and Whittemore (2000\textsuperscript{a}), Steere (1978\textsuperscript{i}), Vitt (1973\textsuperscript{b, c}), Watson (1880\textsuperscript{1, b}), *Lavin* 8\textsuperscript{c} (NY), *Shevock* 21586\textsuperscript{d} (CAS, UNLV)

Previously published names: *Orthotrichum jamesianum\textsuperscript{1}, O. cupulatum var. jamesianum\textsuperscript{2}*

*Orthotrichum praemorsum* Venturi [Carson City\textsuperscript{a}] Lavin (1982), Lawton (1958\textsuperscript{a}, 1971), Vitt (1973\textsuperscript{b, a})

*Orthotrichum pumilum* Sw. [Elko] Shevock et al. (2005)

*Orthotrichum pylaisii* Brid. [Douglas\textsuperscript{a}, Storey\textsuperscript{b}] Lavin (1982), Lawton (1958\textsuperscript{a}), Steere (1978), *Nachlinger* 2489\textsuperscript{b} (CAS, UNLV)

*Orthotrichum rivulare* Turner [Humboldt\textsuperscript{a}] Lavin (1981\textsuperscript{a}, 1982)

*Orthotrichum rupestre* Schleich. ex Schwägr. [Clark\textsuperscript{a}, Douglas\textsuperscript{b}, Elko\textsuperscript{c}] Britton (1894\textsuperscript{a}), James (1871\textsuperscript{c}), Lawton (1958\textsuperscript{b}, 1971), Lesquereux and James (1884), Vitt (1973\textsuperscript{b, a}), Watson (1880\textsuperscript{a}) *Mozingo* 76-14\textsuperscript{a} (NY)


Notes: This plant is on the Nevada Native Plant Society’s marginal list as rare
in Nevada while more common elsewhere. It is also a Bureau of Land
Management special status species in California.

*Orthotrichum speciosum* Nees [Washoe\textsuperscript{a}] Shevock et al. (2005\textsuperscript{a}), Vitt and Darigo (1997\textsuperscript{a})


*Orthotrichum texanum* Sull. & Lesq. [Carson City\textsuperscript{a}, Douglas\textsuperscript{b}, Pershing\textsuperscript{c}, Washoe\textsuperscript{d}]

Britton (1894\textsuperscript{a}), James (1871\textsuperscript{1,2,a,c}), Lawton (1958\textsuperscript{a,b,c}), Lesquereux and James (1884\textsuperscript{1,2,a}), Mozingo (1976\textsuperscript{d}), Watson (1880\textsuperscript{1,2,a,c})

Previously published names: *Orthotrichum anomalum\textsuperscript{1*} (misapplied), *O. sturmii\textsuperscript{2*}

Notes: Lawton (1958) referred *Watson 1400, 1403 (US)* to this species. Vitt (1973b, 2003) considered this species to be a synonym of *Orthotrichum rupestre*.

*Palustriella falcata* (Brid.) Hedenäs [Elko\textsuperscript{a}, Esmeralda\textsuperscript{b}, Nye\textsuperscript{e}, White Pine\textsuperscript{d}] Conard and Redfearn (1979\textsuperscript{1}), Heise (2000\textsuperscript{e}), Ireland (1982\textsuperscript{3}), Lawton (1958\textsuperscript{1,2,a}, 1971\textsuperscript{3}), Spence (1986\textsuperscript{1,a}), *Nachlinger 2459\textsuperscript{d*} (CAS, UNLV), *Shevock 21832\textsuperscript{b*} (CAS, UNLV)

Previously published names: *Cratoneuron commutatum\textsuperscript{1*}, C. *falcatum\textsuperscript{2*}, C. *commutatum var. falcatum\textsuperscript{3*}

*Phascum cuspidatum* Hedw. [Clark\textsuperscript{c}, Lincoln\textsuperscript{b}, Washoe\textsuperscript{c}] Lavin (1981\textsuperscript{c}), *Brinda 952\textsuperscript{a}, 35\textsuperscript{b*} (UNLV)

Notes: Zander (1993) included this species in the genus *Tortula* as *T. acaulon* (With.) R. H. Zander.

*Philonotis americana* Dism. [Elko\textsuperscript{a}, Esmeralda\textsuperscript{b}, Washoe\textsuperscript{c}] Crum and Anderson (1981\textsuperscript{2}), Flowers (1935, 1973\textsuperscript{2}), Ireland (1982\textsuperscript{3}), James (1871\textsuperscript{1,a}), Mozingo (1976\textsuperscript{c}), Zales (1973\textsuperscript{2,c}), *Shevock 21824\textsuperscript{b*} (CAS, UNLV)
Previously published names: *Philonotis calcarea* var. contorta\(^1\), *P. fontana* var. americana\(^2\)

Notes: Flowers (1935) referred the basis of James’ report, *Watson 1447*, to this species.

*Philonotis fontana* (Hedw.) Brid. [Carson City\(^a\), Clark\(^b\), Douglas\(^c\), Elko\(^d\), Lyon\(^e\), Mineral\(^f\), Nye\(^g\), Washoe\(^h\), White Pine\(^i\)] Heise (2000\(^g\)), James (1871\(^1,d\)), Lawton (1958\(^c,d,g,h,i\)), Lesquereux and James (1884\(^i\)), Mozingo (1976\(^b\)), Watson (1880\(^2,d\)), Zales (1973\(^a,d,h,i\)), *Allen 21968* (MO), *Lavin SW14* (NY), *Nachlinger 2450* (CAS, UNLV)

Previously published names: *Philonotis calcarea*\(^1\), *Bartramia calcarea*\(^2\)

Notes: The basis of James’ report, *Watson 1446* (NY), has been annotated to this species. Lawton (1958) referred *Watson 1446* (US) here as well.

*Philonotis tomentella* Molendo [Elko\(^a\)] Flowers (1935\(^1\)), *Howell 12* (CAS, UNLV)

Previously published name: *Philonotis fontana* var. pumila fo. longifolia\(^1\)

*Physcomitrium californicum* E. Britton [Carson City\(^a\)] Flowers (1973), Lawton (1958\(^a\), 1971\(^1\))

Previously published name: *P. megalocarpum* var. californicum\(^1\)

Notes: Crum and Anderson (1955) considered *Physcomitrium californicum* distinct while others have synonymized it with *P. pyriforme* (Hedw.) Hampe (e.g. Anderson et al. 1990). Upon further study this species may need to be excluded from the bryoflora of Nevada.

*Physcomitrium pygmaeum* James [Carson City\(^a\)] Crum and Anderson (1955), Flowers (1937, 1973), Grout (1935), Lawton (1958\(^a\), 1971)

*Physcomitrium pyriforme* (Hedw.) Hampe [county not given] Britton (1894b\(^1\)), Grout
Previously published names: *Physcomitrium megalocarpum*¹, *P. acuminatum*² (misapplied)

Notes: Lawton (1958) referred the basis of Grout’s report, *Palmer s.n.* (US), to *P. megalocarpum*, a synonym of this species.


Previously published name: *Plagiommium rugicum*¹

*Plagiommium medium* (Bruch & Schimp.) T. J. Kop. [Elko, Esmeralda, White Pine]

Conard and Redfearn (1979²), James (1871¹,a), Koponen (1971²,a,c), Lawton (1958¹,²,a,c, 1971), Watson (1880¹,a), *Shevock 21813* (CAS, UNLV)

Previously published names: *Mnium affine*¹ (misapplied), *Mnium medium*²

Notes: Koponen (1971) referred Watson 1440 (US) to this species. Watson’s specimen is also the source of Lawton’s (1958) misapplication of the name *Mnium affine*.


*Pohlia bolanderi* (Lesq.) Broth. var. bolanderi [Humboldt, Washoe, White Pine]

Lawton (1958 in part¹,c), Shaw (1982²), *Shevock 27505*, *22647* (CAS, UNLV)

Previously published name: *Pohlia cruda*¹ (misapplied in part)

Notes: Shaw (1982) determined *Lawton 2833* (WTU) originally determined as
*Pohlia cruda* (Hedw.) Lindb. to be this species.

*Pohlia camptotrachela* (Renauld & Cardot) Broth. [Washoe]\(^a\) Shaw (1981b, c\(^a\), 1982)

*Pohlia cruda* (Hedw.) Lindb. [Douglas]\(^a\), Elko\(^b\), Esmeralda\(^c\), Humboldt\(^d\), White Pine\(^e\)]

James (1871\(^{1,b}\), Lawton (1958 in part\(^b-c\)), Shaw (1982\(^b-c\)), Watson (1880\(^2b\)),

*Shevock 21991\(^a\)*, 22318\(^c\), 27493\(^d\) (CAS, UNLV)

Previously published names: *Webera cruda\(^1\)*, *Bryum crudum\(^2\)*

*Pohlia drummondii* (Müll. Hal.) A. L. Andrews [Elko\(^a\), Washoe\(^b\)] Cardot and Thériot

(1904\(^{1,b}\), Lawton (1958\(^b\), 1971), Steere (1978), *Shevock 25980\(^a\)* (CAS, UNLV)

Previously published name: *Webera chlorocarpa\(^1\)*

*Pohlia nutans* (Hedw.) Lindb. [Elko\(^a\), Eureka\(^b\), Washoe\(^c\), White Pine\(^d\)] Lawton (1958\(^{c,d}\),

1971), Mozingo (1976\(^c\)), *Mozingo 76172b* (NY), *Shevock 25998\(^a\)* (CAS, UNLV)


*Pohlia tundrae* A. J. Shaw [Washoe\(^a\)] Conard and Redfearn (1979\(^2\)), Flowers (1973\(^1,3\)),

Lawton (1958\(^{1,a}\), 1971\(^2\)), Shaw (1981a), Vitt (1973\(^a\))

Previously published names: *P. annotina* var. *decipiens\(^1\)* (misapplied), *P. proliger\(^a\)* (misapplied), *P. annotina* var. *loeski\(^b\)* (misapplied)

Notes: Shaw (1981a) determined the basis of most of these reports, *Lawton 3071* (WTU), to be part of the new species *Pohlia tundrae* and stated that virtually all of the specimens that Flowers (1973) named *P. annotina* (Hedw.) Lindb. belong here as well.

*Pohlia wahlenbergii* (F. Weber & D. Mohr) A. L. Andrews [Carson City\(^a\), Douglas\(^b\),

Elko\(^c\), Esmeralda\(^a\), Humboldt\(^e\), Lander\(^f\), Nye\(^g\), Storey\(^h\), White Pine\(^i\)] Heise

(2000\(^{c,g}\)), James (1871\(^{1,e}\), Lawton (1958\(^c\)), Shaw (1982\(^c\)), Watson (1880\(^2c\)),

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Nachlinger 2576\textsuperscript{b}, 2481\textsuperscript{b} (CAS, UNLV), Shevock 22050\textsuperscript{a}, 21815\textsuperscript{i}, 27661\textsuperscript{i} (CAS, UNLV),

Train T211\textsuperscript{a} (NY)

Previously published names: \textit{Webera albicans}\textsuperscript{i} (misapplied), \textit{Bryum albicans}\textsuperscript{2} (misapplied)

\textit{Polytrichastrum longisetum} (Sw. ex Brid.) G. L. Sm. [Elko] Lavin (1981\textsuperscript{i})

Previously published name: \textit{Polytrichum longisetum}\textsuperscript{i}

\textit{Polytrichum juniperinum} Hedw. [Elko\textsuperscript{a}, Washoe\textsuperscript{b}, White Pine\textsuperscript{c}] Lawton (1958\textsuperscript{a}), Mozingo (1976\textsuperscript{b}), Lavin 6\textsuperscript{c} (UBC)

\textit{Polytrichum piliferum} Hedw. [Elko\textsuperscript{a}, Mineral\textsuperscript{b}, White Pine\textsuperscript{c}] Bodenberg (1954), Frye (1937), Steere (1978), Shevock et al. (2005\textsuperscript{a,b}), \textit{Shevock 24196}\textsuperscript{c} (CAS, UNLV)

\textit{Porotrichum bigelovii} (Sull.) Kindb. [Clark\textsuperscript{a}, Douglas\textsuperscript{b}] Frantz and Cordone (1967\textsuperscript{1,b}), Shevock et al. (2005\textsuperscript{a})

Previously published name: \textit{Porothamnium bigelovii}\textsuperscript{i}

\textit{Pseudocrossidium crinitum} (Schultz) R. H. Zander [Clark\textsuperscript{c}] Lawton (1958\textsuperscript{1,a}), Stark and Whittemore (2000\textsuperscript{a}), Stark et al. (2002\textsuperscript{a})

Previously published name: \textit{Tortula aurea}\textsuperscript{i}

Notes: This plant is a species of concern in Clark County and an evaluation species under the multiple species habitat conservation plan for the county.

\textit{Pseudoleskea incurvata} (Hedw.) Loeske [Elko\textsuperscript{a}] Conard and Redfearn (1979), Flowers (1973\textsuperscript{1}), Krieger (2002\textsuperscript{1,a}), Lavin (1982\textsuperscript{1}), Lawton (1957\textsuperscript{1,a}, 1958\textsuperscript{1,a}, 1971\textsuperscript{1})

Previously published name: \textit{Lescuraea incurvata}\textsuperscript{i}

\textit{Pseudoleskea patens} (Lindb.) Kindb. [Carson City\textsuperscript{a}, Douglas\textsuperscript{b}] Lawton (1957\textsuperscript{1,a}, 1958\textsuperscript{1,a}, 1971\textsuperscript{1}), Conard and Redfearn (1979), Krieger (2002\textsuperscript{1,a}), \textit{Shevock 25959}\textsuperscript{b} (CAS,
Previously published name: *Lescuraea patens*¹


Previously published name: *Lescuraea radicosa*¹

*Pseudoleskea saviana* (De Not.) Latzel [Elko] Spence et al. (2006)

*Pseudoleskeella rupestris* (Berggr.) Hedenäs & L. Söderstr. [White Pineᵃ] Lawton (1958¹ᵃ), Steere (1978²)

Previously published names: *Pseudoleskeella catenulata* var. *filescens*¹ (misapplied), *P. catenulata*² (misapplied)

Notes: See Lawton (1965ᵃ), Wilson and Norris (1989), and Hedenäs and Söderström (1991) for discussions of this taxon. Lawton (1971) did not list Nevada as a locality for this species; however, it has been found in the Rocky Mountains as far south as New Mexico.


Previously published names: *Pseudoleskeella tectorum* var. *flagellifera*¹, *Leskeella tectorum*²

*Pterigynandrum filiforme* Hedw. [Carson City] Shevock et al. (2005)

*Pter ygoneurum lamellatum* (Lindb.) Jur. [Clarkᵃ, Lyonᵇ] Lavin (1981ᵇ), *Stark s.n.*ᵃ (UNLV)

*Pter ygoneurum ovatum* (Hedw.) Dixon [Carson Cityᵃ, Clarkᵇ, Elkoᶜ, Eurekaᵈ, Nyeᵉ]

Bowker et al. (2000ᵇ), James (1871¹ᵃ), Lavin (1982), Lawton (1958ᵃ⁻ᵈ, 1971),
Lesquereux and James (18841,a), Thompson et al. (2005b), Watson (18801,a),

*Brinda 1033* (UNLV), *Lavin M-443* (UBC)

Previously published name: *Pottia cavifolia*


Previously published name: *Pottia subsessilis*

*Ptychostomum angustifolium* (Brid.) J. R. Spence & H. P. Ramsay [Elkoa, Landerb, Nyec, Pershingd, White Pinee] Heise (20001,b), James (18711,d), Lawton (19581,b,c), Watson (18801,d), *Nachlinger 2532* (CAS, UNLV), *Shevock 21583* (CAS, UNLV)

Previously published name: *Bryum caespiticium*

Notes: Spence (2004b) distinguished three distinct species in the *Bryum caespiticium* Hedw. complex and most of the older records that are simply determined as *B. caespiticium* will need to be reevaluated (including the literature citations above). All three species of the complex occur in Nevada.

*Ptychostomum arcticum* (R. Br.) J. R. Spence [county not given] Lawton (19711), Spence (1988a1)

Previously published name: *Bryum arcticum*


*Ptychostomum bimum* (Schreb.) J. R. Spence [Elkoa, Landerb, Nyec] James (18711,a), Lesquereux and James (18841), Spence et al. (2006b,c), Watson (18801,a)
Previously published name: *Bryum bimum*¹

*Ptychostomum cernuum* Hornsch. [county not given] Flowers (1973¹)

Previously published name: *Bryum uliginosum*¹

Notes: If the specimen this report is based on cannot be located, this species will need to be excluded.


Previously published names: *Bryum intermedium¹, B. cuspidatum², B. creberrimum³, B. lisae⁴*

*Ptychostomum inclinatum* (Sw. ex Brid.) J. R. Spence [Elko⁹] Eckel (1996³,⁹), James (1871¹,⁹), Lawton (1958²,⁴,⁹), Steere (1978²), Watson (1880¹,⁹),

Previously published names: *Bryum inclinatum¹, B. stenotrichum², B. amblyodon³*

*Ptychostomum lonchocaulon* (Müll. Hal.) J. R. Spence [Clark⁹, Douglas⁸, Elko⁶, White Pine⁹] Cardot and Thériot (1904¹,⁴), Lawton (1958²,⁴,⁹), Spence et al. (2006³,⁴,⁹)

Previously published names: *Bryum polycladum¹, B. cirratum²*

*Ptychostomum neodamense* (Itzigs.) J. R. Spence [Clark] Spence et al. (2006)

*Ptychostomum pallens* (Sw.) J. R. Spence [Elko⁶, Lander⁶, Nye⁶, Washoe⁶] Flowers (1973¹), Heise (2000¹,⁴,⁶), Lawton (1958¹,⁴,⁶,¹³), Steere (1978¹)

Previously published name: *Bryum pallens¹*

*Ptychostomum pallescens* (Schleich. ex Schwägr.) J. R. Spence [Elko⁶, Eureka⁷, Humboldt⁷, Mineral⁸, Washoe⁶, White Pine⁷] Conard and Redfearn (1979¹),
Lawton (1958\textsuperscript{1,a,c,f}, 1971\textsuperscript{1}), Spence (1988\textsuperscript{a}), Steere (1978\textsuperscript{1}), \textit{Lavin s.n.}\textsuperscript{c} (NY), \textit{Mozingo 76-172}\textsuperscript{ab} (NY), \textit{Shevock 22101}\textsuperscript{a} (CAS, UNLV)

Previously published name: \textit{Bryum pallescens}\textsuperscript{1}

\textit{Ptychostomum pendulum} Hornsch. [Carson City\textsuperscript{a}, Clark\textsuperscript{b}, Pershing\textsuperscript{c}] Bowker et al. (2000\textsuperscript{2,b}), Cardot and Thériot (1904\textsuperscript{3,a}), Conard and Redfearn (1979\textsuperscript{5}), James (1871\textsuperscript{1,c}), Lawton (1958\textsuperscript{1,a,c}, 1971\textsuperscript{1}), Steere (1978\textsuperscript{1}), Thompson et al. (2005\textsuperscript{5,b}), Watson (1880\textsuperscript{2,c})

Previously published names: \textit{Bryum pendulum}\textsuperscript{1}, \textit{B. cernuum}\textsuperscript{2}, \textit{B. pendulum} var. \textit{nevadense}\textsuperscript{3}, \textit{B. angustirete}\textsuperscript{4}, \textit{B. algovicum}\textsuperscript{5}

\textit{Ptychostomum pseudotriquetrum} (Hedw.) J. R. Spence & H. P. Ramsay [Elko\textsuperscript{a}, Esmeralda\textsuperscript{a}, Humboldt\textsuperscript{b}, Nye\textsuperscript{d}, White Pine\textsuperscript{e}] Heise (2000\textsuperscript{1,d}), Lawton (1958\textsuperscript{1,a,c,e}, 1971\textsuperscript{1}), Steere (1978\textsuperscript{1}), \textit{Shevock 22090}\textsuperscript{b} (CAS, UNLV)

Previously published name: \textit{Bryum pseudotriquetrum}\textsuperscript{1}

\textit{Ptychostomum schleicheri} (Schwägr.) J. R. Spence [Elko\textsuperscript{a}, Humboldt\textsuperscript{b}] James (1871\textsuperscript{1,a,b}), Lesquereux and James (1884\textsuperscript{2})

Previously published names: \textit{Bryum turbinatum} var. \textit{angustifolium}\textsuperscript{1} (misapplied), \textit{B. schleicheri} var. \textit{angustatum}\textsuperscript{2}

Notes: The name for \textit{Watson 1439} (NY) has been truncated to \textit{Bryum turbinatum} (Hedw.) Turner because the variety \textit{angustifolium} cannot be found in the Index Muscorum (van der Wijk et al. 1959-1969). However, Lesquereux and James (1884) already corrected this error by referring to the plant as \textit{B. schleicheri} Schwägr. var. \textit{angustatum} Schimp. Even so, this specimen needs to be confirmed since it is an unusual record.
*Ptychostomum turbinatum* (Hedw.) J. R. Spence [Clark\(^a\), Elko\(^b\), Lincoln\(^c\), Pershing\(^d\),
Washoe\(^e\), White Pine\(^f\)] Flowers (1973\(^1\)), James (1871\(^{1,b,d}\)), Lawton (1958\(^{1,a,c,e,f}\),
1971\(^1\)), Stark and Whittemore (2000\(^{1,a,c}\)), Watson (1880\(^1\)),

Previously published name: *Bryum turbinatum*\(^1\)

*Ptychostomum weigelii* (Spreng.) J. R. Spence [Elko\(^a\), Humboldt\(^b\), Lander\(^c\), Nye\(^d\),
Washoe\(^e\), White Pine\(^f\)] Heise (2000\(^{2,c,d}\)), James (1871\(^{1,a}\)), Watson (1880\(^1,a\)), Shevock
27522\(^b\), 25972\(^e\), 27624\(^f\) (CAS, UNLV)

Previously published names: *Bryum duvalli*\(^1\), *B. weigelii*\(^2\)

*Rhizommium pseudopunctatum* (Bruch & Schimp.) T. J. Kop. [Elko] Shevock et al. (2005)

*Rhytidiadelphus squarrosus* (Hedw.) Warnst. [Elko\(^a\)] Conard and Redfearn (1979),
Lawton (1958\(^a\), 1971), Steere (1978)

Notes: The specimen reported by Lawton (1958) could not be located at WTU.

This species may need to be excluded if a specimen cannot be located and verified.

*Rhytidiadelphus triquetrus* (Hedw.) Warnst. [county not given] Conard and Redfearn
(1979)

Notes: This species may need to be excluded if a specimen cannot be located and verified.


*Rosulabryum capillare* (Hedw.) J. R. Spence [Carson City\(^a\), Clark\(^b\), Elko\(^a\), White Pine\(^e\)]
Lawton (1958\(^{1,a,c,d}\), 1971\(^1\)), Spence (1988\(^a\)), Stark *NV-13*\(^b\) (UNLV)

Previously published name: *Bryum capillare*\(^1\)

Rosulabryum laevifilum (Syed) Ochyra [Elko, Nye] Spence et al. (2006)

Rosulabryum torquescens (Bruch ex De Not.) J. R. Spence [Elko\textsuperscript{a}] James (1871\textsuperscript{1,a}), Lesquereux and James (1884\textsuperscript{1}), Spence (1988\textsuperscript{a}), Watson (1880\textsuperscript{1,a})

Previously published name: Bryum torquescens\textsuperscript{1}

Sanonia uncinata (Hedw.) Loeske [Elko\textsuperscript{a}, Washoe\textsuperscript{b}, White Pine\textsuperscript{c}] Lawton (1958\textsuperscript{1,b,c}, 1971\textsuperscript{1}), Howell 120\textsuperscript{a} (CAS, UNLV)

Previously published name: Drepanocladus uncinatus\textsuperscript{1}

Schistidium agassizii Sull. & Lesq. [Elko\textsuperscript{a}] Lavin (1981\textsuperscript{1,2,a}, 1982\textsuperscript{2,a}), Steere (1978)

Previously published names: Grimmia agassizii\textsuperscript{1}, G. alpicola var. alpicola\textsuperscript{2}

(rejected name)

Schistidium apocarpum (Hedw.) Bruch & Schimp. [Clark\textsuperscript{a}, Elko\textsuperscript{b}, Humboldt\textsuperscript{c}, Washoe\textsuperscript{d}, White Pine\textsuperscript{e}] Cao and Vitt (1986), Lawton (1958 in part\textsuperscript{1,a,c,e}, 1971\textsuperscript{1}), Lavin (1981\textsuperscript{2,b}, 1982\textsuperscript{3,b,c,d,e})

Previously published names: Grimmia apocarpa var. apocarpa\textsuperscript{1}, G. apocarpa var. ambigua\textsuperscript{2}, G. ambigua\textsuperscript{3}

Notes: According to Blom (1996) Schistidium apocarpum s. str. is not found in western North America. The above records form a complex that could include undescribed taxa. For discussions and keys see Norris and Shevock (2004a, 2004b) as well as Weber and Wittmann (2005).

Schistidium atrichum (Müll. Hal. & Kindb.) W. A. Weber [Clark\textsuperscript{a}, Elko\textsuperscript{b}] Lavin (1982\textsuperscript{1,a}), Stark and Whittemore (2000\textsuperscript{2,a} in part), Shevock 22581\textsuperscript{b} (CAS, UNLV)

Previously published names: Grimmia atricha\textsuperscript{1}, Schistidium apocarpum\textsuperscript{2} s. lat.

Notes: Stark and Whittemore (2000) reported this species as Schistidium
*apocarpum* s. lat. based on *Grimmia atricha* Müll. Hal. & Kindb. as reported by Lavin (1982).

*Schistidium cinclidodonteum* (Müll. Hal.) B. Bremer [Humboldt[a], Nye[b], Washoe[c]] Lavin (1981[a], 1982[a]), Shevock et al. (2005[b,c])

Previously published name: *Grimmia pacifica*

*Schistidium confertum* (Funck) Bruch & Schimp. [Elko[a], Pershing[b], White Pine[c]] Blom (1996[a]), James (1871[a,b]), Lavin (1982[a], Lawton (1958[c], 1971[a]), Watson (1880[a,b])

Previously published names: *Grimmia conferta*, *G. apocarpa* var. *conferta*, *G. apocarpa* var. *conferta* fo. *obtusifolia*

*Schistidium dupretii* (Thér.) W. A. Weber [county not given] Crum and Anderson (1981[a])

Previously published name: *Grimmia alpicola* var. *dupretii*

*Schistidium flaccidum* (De Not.) Ochyra [Elko[a], Humboldt[b], Washoe[c], White Pine[d]] Blom (1996[a,b,c], Lavin (1981[a,b,c,d], 1982[a,b,c,d])

Previously published name: *Grimmia flaccida*

*Schistidium occidentale* (E. Lawton) S. P. Churchill [Elko[a], Humboldt[b], Washoe[c], White Pine[d]] Lavin (1982[a,b,c,d], Lawton (1958 in part[a], 1967[a], 1971[a,c])

Previously published names: *Grimmia apocarpa* s. lat., *G. occidentalis*

Notes: Lawton (1958) reported Lawton 2655 (wtu) as *Grimmia apocarpa* Hedw. but later referred it to this species (Lawton 1967).

*Schistidium platyphyllum* (Mitt.) H. Perss. [Elko[a], Humboldt[b], White Pine[c]] Lavin (1981[a,b,c], 1982[a,b,c])

Previously published name: *Grimmia alpicola* var. *latifolia*
**Schistidium rivulare** (Brid.) Podp. [Clark\(^a\), Elko\(^b\), Washoe\(^c\)] Cao and Vitt (1986), Lavin (1981\(^{1,b}\), 1982\(^{2,b}\)), *Allen 21903* (MO), *Mozingo 74-59* (NY)

Previously published names: *Grimmia alpicola* var. *rivularis*\(^1\), *G. rivularis*\(^2\)

**Schistidium strictum** (Turner) Loeske ex Martensson [Clark\(^a\), Lincoln\(^b\)] Lavin (1982\(^{3,a,b}\)), Lawton (1958\(^{1,b}\), 1971\(^2\)), Stark and Whittemore (2000 in part\(^{4,a,b}\))

Previously published names: *Grimmia apocarpa* var. *gracilis*\(^1\), *G. apocarpa* var. *stricta*\(^2\), *G. stricta*\(^3\), *Schistidium apocarpum*\(^4\) s. lat.

Notes: Following Jones (1933), Lawton (1958) used the name *Grimmia apocarpa* Hedw. var. *gracilis* Röhl. for this taxon. Stark and Whittemore (2000) reported this species as *Schistidium apocarpum* s. lat. based on Lawton’s report of *G. a.* var. *gracilis* and Lavin’s report of *Grimmia stricta* Turner.

**Sciurohypnum nelsonii** (Grout) Ochyra & Żarnowiec [Elko\(^a\), Nye\(^b\), White Pine\(^c\)] Flowers (1973\(^1\)), Heise (2000\(^{1,b}\)), Lawton (1958\(^{1,a,c}\))

Previously published name: *Brachythecium nelsonii*\(^1\)

Notes: See Ignatov and Huttunen (2002) and Ochyra et al. (2003) for the use of the name *Sciurohypnum*.

**Sciurohypnum plumosum** (Hedw.) Ignatov & Huttunen [Esmeralda] Shevock et al. (2005\(^1\))

Previously published name: *Brachythecium plumosum*\(^1\)

**Sciurohypnum reflexum** (Starke) Ignatov & Huttunen [White Pine] Shevock et al. (2005\(^1\))

Previously published name: *Brachythecium reflexum*\(^1\)

**Sciurohypnum starkei** (Brid.) Ignatov & Huttunen [Douglas] Shevock et al. (2005\(^1\))

Previously published name: *Brachythecium starkei*\(^1\)
Scleropodium obtusifolium (Mitt.) Kindb. [Carson City, Clark, Douglas, Elko, Humboldt, Washoe] Conard and Redfearn (1979), Grout (1899, 1928), James (1871, 1871), Lawton (1958, 1971), Shevock 21966, 23639, 21990, 27473, 22671 (CAS, UNLV)

Previously published name: Limnobium sp. nov.

Notes: Lawton (1958) referred Watson 1472 (US), reported by James (1871) as Limnobium sp. nov., to this species.

Scleropodium touretii (Brid.) L. F. Koch [Douglas] Lawton (1958)

Previously published name: Scleropodium illecebrum

Scouleria aquatica Hook. [Elko] Shevock et al. (2005)


Sphagnum squarrosum Crome [Elko] Shevock et al. (2005)

Sphagnum subsecundum Nees [Washoe] Shevock et al. (2005)


Notes: This report is based on Clover 6269 (NY). Both Reese (1998) and the NY database claim this was collected in Arizona, however the label states the locality as “Virgin Basin, 5 miles NNE of Middle Point, Lake Mead.” This places it squarely in Nevada on the west shore of the Overton Arm of Lake Mead. The actual location is mapped and briefly discussed in Clover and Jotter (1941). Presumably the species was collected during the Nevills Colorado River Expedition of 1938 but not published in that report (Clover and Jotter 1944). Practical surveys for this plant would require
a boat since the shoreline in this area is rather rugged. However, given
the changes that the shoreline of Lake Mead has undergone in the nearly
70 years since this species was last collected, it may never be possible to
relocate this population.

*Stegonia latifolia* (Schwägr.) Venturi ex Broth. [county not given] Steere (1978),

Wareham (1939\(^1\))

Previously published name: *Pottia latifolia*\(^1\)

*Syntrichia bartramii* (Steere) R. H. Zander [Clark\(^a\)] Stark et al. (2002\(^a\)), Weber and

Wittmann (2005)

*Syntrichia caninervis* Mitt. [Churchill\(^a\), Clark\(^b\), Esmeralda\(^c\), Eureka\(^d\), Lincoln\(^e\), Nye\(^f\),

Pershing\(^g\), Washoe\(^b\), White Pine\(^l\)] Barker et al. (2005\(^f\)), Bowker et al. (2000\(^b\)),

Flowers (1973\(^1\)), Gallego et al. (2002\(^b\)), Lawton (1958\(^{1, b, i}\), 1971\(^1\)), Nash et al.

(1977\(^{1, f}\)), Stark and Delgadillo (2001), Stark and McLetchie (2006\(^b\)), Stark and

Whittemore (2000\(^{b, f}\)), Stark et al. (1998\(^b\), 2000\(^b\), 2001\(^b\), 2004\(^f\), 2005\(^f\)), Steere

(1978\(^1\)), Thompson et al. (2005\(^b\)), Weber and Wittmann (2005), Zander et al.

(1995\(^b\)), *Lavin s.n.*\(^{a, c}\) (NY), *Nachlinger 2498*\(^s\) (CAS, UNLV), *Shevock 26481*\(^c\) (CAS, UNLV)

Previously published name: *Tortula bistratosa*\(^1\)

*Syntrichia laevipila* Brid. [Pershing\(^g\)] James (1871\(^{1, a}\)), Lesquereux and James (1884\(^1\)),

Steere (1939\(^2\), 1940\(^2\)), Watson (1880\(^{1, a}\))

Previously published names: *Barbula laevipila*\(^1\), *Tortula laevipila*\(^2\)

*Syntrichia norvegica* F. Weber [Clark\(^a\), Lander\(^b\), White Pine\(^c\)] Heise (2000\(^{1, b}\)), Kramer

(1980\(^{1, c}\)), Lawton (1958\(^{1, a}\), 1971\(^1\)), Stark and Whittemore (2000\(^b\)), Steere (1978\(^1\))
Previously published name: *Tortula norvegica*¹

Notes: Kramer (1980) referred *Lawton 2759 (COLO)* to this species.

*Syntrichia obtusissima* (Müll. Hal.) R. H. Zander [Humboldt²] Conard and Redfearn (1979¹), Lawton (1958¹,²), Steere (1939¹, 1940¹)

Previously published name: *Tortula obtusissima*¹

*Syntrichia pagorum* (Milde) J. J. Amann [Clark⁵] Crum and Anderson (1981¹), Gallego et al. (2004²,³), Stark et al. (2002⁴)

Previously published names: *Tortula pagorum*¹, *Syntrichia laevipila*² s. lat.

Notes: Gallego et al. (2004, 2005) placed this species into synonymy with *Syntrichia laevipila* Brid. However, it differs from *S. laevipila* in being dioecious and we follow Zander (1993) and Ochyra and Bednarek-Ochyra (2005) in maintaining it as a separate species. A good discussion of the problem can be found in Barkman (1963).

*Syntrichia papillosissima* (Copp.) Loeske [Clark⁶, Humboldt⁴, Lander⁶, Nye⁶, Pershing⁶, Washoe⁴] Flowers (1973¹), Lavin (1982¹), Lawton (1958¹,²,⁶, 1971¹), Heise (2000¹,⁴), Weber and Wittmann (2005), *Brinda 553a (UNLV), Nachlinger 2490e (CAS, UNLV)*

Previously published name: *Tortula papillosissima*¹

*Syntrichia princeps* (De Not.) Mitt. [Carson City⁶, Clark⁶, Washoe⁶] Conard and Redfearn (1979²), James (1871¹,²), Lavin (1982²), Lawton (1958²,⁶, 1971²), Lesquereux and James (1884¹), Stark et al. (2002⁵), Watson (1880¹,²)

Previously published names: *Barbula muelleri*¹, *Tortula princeps*²

Notes: This is a species of concern in Clark County that is covered under the
multiple species habitat conservation plan for the county.


Previously published names: *Barbula ruralis*, *Tortula ruralis*

Notes: Here we follow Mishler (1985), who placed *Tortula ruraliformis* (Besch.) Ingham into synonymy with this species. Compare this with Gallego et al. (2002a) and Gallego (2005) where it is considered a distinct variety.

*Taylaria acuminata* Hornsch. [Pershing] Crum (1955a), James (1871a,b), Lawton (1958a, 1971), Lesquereux and James (1884a), Steere (1978), Watson (1880a)

Previously published names: *Taylaria splachnoides* (misapplied), *T. splachnoides var. acuminata*

Notes: Crum (1955) referred Watson 1417 (US) the source of James’ (1871) report to *Taylaria acuminata*. Lawton’s collection could not be located at WTT for examination and verification.

*Taylaria serrata* (Hedw.) Bruch & Schimp. [Elko] Lawton (1958a), Steere (1978)

Notes: This report is based on Lawton 2633, which was sterile. Lawton (1971) may have reconsidered her original determination since she no longer reported it for Nevada. This specimen could not be located at WTT for examination and verification.

*Timmia austriaca* Hedw. [Elko] Conard and Redfearn (1979), Flowers (1973), Ireland
(1982), Lawton (1958a, 1971), Miller and Ireland (1978a)

*Timmia bavarica* Hessl. [Clarka, Elko, Pershingc, White Pinec] Flowers (1973), James (1871b,c), Lavin (1982a), Lawton (19581,a,c,d, 19712), Stark and Whittemore (20001,a), Steere (1978), Watson (18801,c), *Shevock 22518b* (CAS, UNLV)

Previously published names: *Timmia megapolitana*1 (misapplied), *T. megapolitana* var. *bavarica*2

Notes: Lawton (1971) explained that *Timmia megapolitana* Hedw. s. str. is more or less restricted to lower elevations east of the Rocky Mountains and did not report it for Nevada. Lavin (1982) as well as Stark and Whittemore (2000) based their reports on Lawton (1958). *Mozingo 73-21c* (NY) is listed as *T. megapolitana* var. *megapolitana* but this is most likely an error. Recently Budke (2005) showed that *T. bavarica* and *T. megapolitana* form two separate clades based on molecular data supporting their recognition as separate species. See Brassard (1984) for more information on the distinctions between these two taxa although they are only given subspecies status.


*Tortula atrovirens* (Sm.) Lindb. [Clarka] Stark and Whittemore (2000a), Stark et al. (1998a, 2002a), Thompson et al. (2005a)
Tortula brevipes (Lesq.) Broth. [Carson City\(a\), Clark\(b\), Nye\(c\), Pershing\(d\)] James (1871\(^{1,a,d}\)), Lesquereux and James (1884\(^i\)), Watson (1880\(^{1,a,d}\)), Brinda 965\(^b\), 1031\(^e\) (UNLV)

Previously published name: Barbula brevipes\(^i\)

Notes: Lawton (1958) referred the basis of this report, Watson 1391 (US, NY), to Syntrichia princeps (De Not.) Mitt. However, there appears to be some confusion regarding this record since there are multiple specimens collected by Watson at NY with this number and/or name. Lawton may have examined a mixed or mislabeled specimen since Tortula brevipes and Syntrichia princeps are unlikely to be mistaken for one another.

Tortula cernua (Huebener) Lindb. [Elko\(^a\), Humboldt\(^b\)] Flowers (1973\(^i\)), Grout (1939\(^i\)), Ireland (1982\(^i\)), James (1871\(^{1,a,b}\), 1871\(^i\)), Lawton (1958\(^{1,a}\), 1971\(^i\)), Lesquereux and James (1884\(^{1,a}\)), Steere (1978\(^i\)), Watson (1880\(^{1-a}\))

Previously published name: Desmatodon cernuus\(^i\)

Tortula guepinii (Bruch & Schimp.) Broth. [Clark] Spence et al. (2006)

Tortula hoppeana (Schultz) Ochyra [Elko\(^a\), White Pine\(^b\)] James (1871\(^{1-a}\)), Lawton (1958\(^{1,2,a,b}\), 1971\(^{1,2}\)), Lesquereux and James (1884\(^2\))

Previously published names: Desmatodon latifolius var. muticus\(^1\), D. latifolius\(^2\)

Tortula inermis (Brid.) Mont. [Clark\(^a\), Nye\(^b\)] Goldman (2006\(^a\)), Lavin (1981\(^a\)), Stark (1997\(^{1,a}\), 2001a\(^a\), 2001b\(^a\), 2002\(^a\), 2005\(^a\)), Stark and Whittemore (2000\(^a\)), Stark et al. (1998\(^a\)), Steere (1939, 1940), Shevock 21585\(^b\) (CAS, UNLV)

Previously published name: Syntrichia inermis\(^i\)

Tortula mucronifolia Schwägr. [Clark\(^a\), Lincoln\(^b\), Nye\(^c\), White Pine\(^d\)] Heise (2000\(^c\)), Brinda 297\(^a\), 133\(^b\) (UNLV, CAS), Shevock 17777\(^d\) (CAS, UNLV)
**Tortula nevadensis** (Cardot & Thér.) R. H. Zander [Carson City\(^a\)] Cardot and Thériot (1904\(^{3,a}\)), Evans and Nichols (1908\(^a\)), Flowers (1973\(^3\)), James (1871\(^{1,a}\)), Lawton (1958\(^{3,a}\), 1971\(^3\)), Lesquereux and James (1884\(^{2,a}\)), McIntosh (1986\(^3\)), Wareham (1939\(^3\)), Watson (1880\(^{1,a}\))

Previously published names: *Pottia truncata* var. *subcylindrica*\(^1\) (misapplied), *P. wilsoni*\(^2\) (misapplied), *P. nevadensis*\(^3\), *P. truncatula*\(^4\) (misapplied)

Notes: Lawton (1958) referred the source of James’ (1871) report, *Watson 1381* (US), to this species. Prior to Cardot and Thériot’s (1904) publication it had remained undescribed.

**Trichostomum planifolium** (Dixon) R. H. Zander [Clark\(^a\)] Stoneburner (1985\(^1\)), *Brinda 643*\(^9\) (UNLV)

Previously published name: *Weissia perligulata*\(^1\)

Notes: Some (though perhaps not all) collections previously determined as *Trichostomum sweetii* (E. B. Bartram) L. R. Stark from Nevada are referable to *T. planifolium*. See notes below under *T. sweetii*.

**Trichostomum sweetii** (E. B. Bartram) L. R. Stark [Clark\(^a\)] Bartram (1945\(^{1,a}\)), Lawton (1958\(^{1,a}\)), Stark (1996\(^a\)), Stark and Whittemore (2000\(^9\)), Stoneburner (1985\(^{1,a}\)), Werner et al. (2005)

Previously published name: *Weissia sweetii*\(^1\)

Notes: Zander (2004) synonymized this plant with *Trichostomum planifolium* (Dixon) R. H. Zander. However, while some material in Nevada is referable *T. planifolium*, plants from Clark County often have narrower leaves than Zander (2004) allowed for that species. Molecular evidence
suggests that the elements of *Trichostomum* do not form a natural group and Werner et al. (2005) stated that this species is part of a clade separate from both *Weissia* and *Trichostomum*. They suggested that it may be better placed in the relatively new genus *Pottiopsis* (Blockeel and Smith 1998) but this does not agree with morphological data (R. H. Zander, personal communication). Therefore, we prefer to retain *T. sweetii* as a separate species until these taxonomic problems are more fully resolved. This plant is a species of concern in Clark County and an evaluation species under the multiple species habitat conservation plan for the county. While there has been doubt expressed in the past (Stark 1996), recent investigations confirm that the type of this species was collected in Clark County. The collector of the type, Nathan C. Sweet, was accompanying Philip A. Munz on a vascular plant collecting trip when he made his discovery. Sweet would later produce an excellent master’s thesis on the moss flora of southern California under Munz’s direction (Sweet 1943). It is unfortunate that Sweet’s thesis has remained unknown to bryologists until now. The bryophyte collections of Munz and his colleagues are currently being integrated into the herbarium of the University of California at Berkeley (UC).

*Trichostomum tenuirostre* (Hook. & Taylor) Lindb. [Pershing*] Britton (1913^3), Grout (1936^4), James (1871^1^a), Lawton (1958^5^a), Lesquereux and James (1884^2), Watson (1880^1^a)

Previously published names: *Didymodon cylindricus*^1^ (misapplied), *Trichodon*
Notes: The basis of all these reports, Watson 1388 (NY), has been annotated as *Trichostomum tenuirostre* and all of the above misapplied names are therefore excluded from our flora. Ireland (1978) stated that he was not able to confirm *Trichodon* as reported for this specimen from Nevada by Grout (1936). This is because the literature reports are all in error regarding this specimen; *Trichodon* is not likely to be discovered in Nevada.

*Warnstorfia exannulata* (Schimp.) Loeske [Elko*, Washoe*] Flowers (1973¹), Shevock 26130*, 25967* (CAS, UNLV)

Previously published name: *Drepanoclados exannulatus*¹

*Weissia controversa* Hedw. [Clark*, Nye*] Stark (1997¹), Stark et al. (2002¹), Shevock 21568* (CAS, UNLV)

Previously published name: *Weissia condensa*¹ (misapplied)

Excluded Species

*Grimmia unicolor* Hook. [county not given] Norris and Shevock (2004b)

Notes: This appears to have been reported in error (Roxanne Hastings, personal communication) since there is no specimen to support it as occurring in Nevada.


Notes: The dot maps in Spence (1986) report this species for the State but there
are no specimens to support it as occurring in Nevada.

Systematic Index

Systematic index to the bryophyte genera of Nevada following the classifications in Stotler and Crandall-Stotler (2005), Crandall-Stotler and Stotler (2000) and Goffinet and Buck (2004) with some changes by He-Nygrén et al. (2006) and Hill et al. (2006). The number of species in each genus is given in parentheses.

Anthocerotophyta

Anthocerotopsida

Anthocerotales
  Anthocerotaceae: Anthoceros (1)

Notothyladales
  Notothyladaceae: Phaeoceros (1)

Marchantiophyta

Marchantiopsida

Marchantiales
  Marchantiaceae: Marchantia (1)
  Conocephalaceae: Conocephalum (1)
  Targioniaceae: Targonia (1)
  Cleveaceae: Athalamia (1)
  Aytoniaceae: Asterella (3), Mannia (2), Plagiochasma (1), Reboulia (1)
  Ricciaceae: Riccia (5)

Jungermanniopsida

Fossombroniales
  Fossombroniaceae: Fossombronia (1)

Metzgeriales
  Aneuraceae: Anea (1), Riccardia (2)

Porellales
Porellaceae: *Porella* (2)
Jubulaceae: *Frullania* (1)

**Jungermanniales**
Cephaloziaceae: *Cephalozia* (2)
Cephaloziellaceae: *Cephaloziella* (1 + 1 variety)
Scapaniaceae: *Scapania* (2)
Antheliaceae: *Anthelia* (1)
Trichocoleaceae: *Blepharostoma* (2)
Geocalycaceae: *Chiloscyphus* (3)

**Bryophyta**

**Sphagnopsida**

**Sphagnales**
Sphagnaceae: *Sphagnum* (3)

**Polytrichopsida**

**Polytrichales**
Polytrichaceae: *Meiotrichum* (1), *Polytrichastrum* (1), *Polytrichum* (2)

**Bryopsida**

**Timmiales**
Timmiaeae: *Timmia* (2)

**Encalyptales**
Encalyptaceae: *Encalypta* (3)

**Funariales**

**Scouleriales**
Scouleriaceae: *Scouleria* (1)

**Grimmiales**
Grimmiaceae: *Codriophorus* (2), *Coscinodon* (1), *Grimmia* (16),
*Jaffueliobryum* (1), *Schistidium* (11)
Seligeriaceae: *Blindia* (1)

**Dicranales**
Fissidentaceae: *Fissidens* (3)
Ditrichaceae: *Ceratodon* (1), *Distichium* (2), * Ditrichum* (1)
Bruchiaceae: *Bruchia* (1)
Dicranaceae: * Orthodicranum* (1)

**Pottiales**

**Splachnales**
Splachnaceae: *Tayloria* (2)
Meesiaceae: *Leptobryum* (1), *Melesia* (2)

**Orthotrichales**
Orthotrichaceae: *Orthotrichum* (20)

**Bryales**
Mielichhoferiaceae: *Pohlia* (8)
Mniaceae: *Mnium* (3)
Cinclidiaceae: *Rhizomnium* (1)
Plagiomniaceae: *Plagiornium* (3)
Aulacomiaceae: *Aulacomnium* (2)

**Hypnales**
Fontinalaceae: *Fontinalis* (5)
Calliergonaceae: *Warnstorftia* (1)
Helodiaceae: *Helodium* (1)
Fabroniaceae: *Fabronia* (1)
Hypnaceae: *Hypnum* (2 + 1 variety)
Pterigynandraceaee: *Pterigynandrum* (1)
Hylocomiaceae: *Rhytiadelphus* (2)
Plagiotheciaceae: *Plagiothecium* (1)
Leucodontaceae: *Antitrichia* (1)
Neckeraceae: *Metaneckera* (1), *Porotrichum* (1)

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Daniel Norris and Robert Magill provided valuable comments on an earlier draft of this checklist. We thank Bill Doyle for his help confirming the likely identity of the *Phaeoceros* specimen as well as Robert Magill for providing a list of some of the specimens at MO from Nevada. We also thank Roxanne Hastings for the identification of many specimens of Nevada *Grimmia*. Daniela Schill kindly provided information on a Nevada collection of *Mannia*. Irene Holiman and Naomi Fraga at the Rancho Santa Ana Botanic Garden (RSA) provided key evidence concerning the type collection of *Trichostomum sweetii*. JCB would also like to thank the kind people (especially Marta Sorkin, Chelle Batchelor and Bill Frederick) at the UNLV library’s document delivery service for graciously processing a flood of requests for obscure publications. LRS was supported by sabbatical leave funds from the University of Nevada, Las Vegas. This project was also funded in part by a travel grant from the National Geographic Society (No. 5429–95, to LRS) and a grant from the Clark County (NV) Multiple Species Habitat Conservation Plan (Project No. 2003-NPS-331-P-2004–08, to LRS).

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CHAPTER 3

ECOLOGY OF BRYOPHYTES IN MOJAVE DESERT BIOLOGICAL SOIL CRUSTS: EFFECTS OF ELEVATED CO$_2$ ON SEX EXPRESSION, STRESS TOLERANCE, AND PRODUCTIVITY IN THE MOSS SYNTRICHIA CANINERVIS MITT.

by

John C. Brinda (first author),
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Abstract

Predicted increases in CO$_2$ will likely influence the health and composition of the biological soil crusts that perform several valuable ecosystem functions in arid regions. At the Nevada Desert Research Center (NDRC) intact patches of Mojave desert scrub were exposed for several years to experimental treatments designed to simulate predicted future conditions. Field treatments at the NDRC included a FACE (Free Air Carbon dioxide Enrichment) site where plants were exposed to experimentally elevated CO$_2$ (550 ppm). In order to determine the responses of the bryophyte component of the soil crust to elevated CO$_2$ concentrations, patches of the dominant Mojave Desert moss Syntrichia caninervis Mitt. were sampled from the FACE treatments. Shoots grown under elevated CO$_2$ expressed sex more frequently and tolerated repeated cycles of desiccation better than their ambient counterparts. In a follow-up experiment, plants were grown at both elevated and ambient CO$_2$ concentrations in the laboratory. All plants grown at elevated

CO₂ under laboratory conditions exhibited greater regenerational vigor than plants grown at ambient CO₂; however there were interaction effects between the laboratory and field treatments that suggest photosynthetic down-regulation is occurring. It appears that while they are capable of harnessing additional CO₂ for growth, in the harsh conditions of their native environment these plants preferentially allocate those added resources to sexual reproduction and stress tolerance.

Introduction

The arid shrublands and open woodlands of the North American deserts generally support a sparse vascular plant cover. In these and similar environments, the surfaces unoccupied by taller vascular plant species are often colonized by a unique assemblage of organisms collectively referred to as “biological soil crusts” (Belnap & Lange 2003). This assemblage is extremely diverse phylogenetically, including various species of cyanobacteria, algae, fungi, and lichens as well as bryophytes. These disparate species have been thrown together under one umbrella label due to the specialized niche that they inhabit. Their small size and close association with the soil surface make the term “biological soil crust” particularly appropriate.

Biological soil crusts have received a fair amount of attention and study but bryophytes represent one of the less well understood aspects of this community. In arid landscapes like the Mojave Desert, the bryophyte component in soil crusts is generally made up of mosses in the family Pottiaceae (e.g., species in the genera Syntrichia, Pterygoneurum, Crossidium, Didymodon, and Tortula). In his monographic treatment of the family, Zander (1993) states that the Pottiaceae form a conspicuous part of the
vegetation of arid, ruderal, alpine, and Arctic areas. These are also conditions under which biological soil crusts can play a prominent role. As characteristic inhabitants of these extreme environments, bryophytes of biological soil crusts exhibit many morphological and physiological adaptations to stress that remain poorly understood (Zander 1993). Where biological crusts are well developed, turf-forming bryophytes can represent a significant portion of the total ground cover, ranging from a few percent to 30% total cover or more (Thompson et al. 2005). Soil crust development can influence susceptibility to erosion, hydrology, nutrient inputs, and the associated vascular plant community structure (Belnap et al. 2003). Bryophytes make their unique contributions to this process through the growth of fine rhizoids and protonemata as well as their ability to absorb water and nutrient inputs. In systems with sandy soils, bryophytes have also been shown to influence soil formation as well as its mineral and elemental content (Carter & Arocena 2000). In the Mojave Desert, biological soil crusts are physiologically active mainly in the cooler months, when much of the annual precipitation falls. This is also when peak levels of net ecosystem exchange have been measured despite the dominant shrub species being largely dormant. Thus it is clear that the crust community has a significant effect on the overall carbon balance in this system (Jasoni et al. 2005) as has been shown in other arid areas (Zaady et al. 2000).

The well-documented rise in global atmospheric CO$_2$ levels caused by burning of fossil fuels will no doubt affect soil crust bryophytes. Because their gametophytes lack stomata, the internal CO$_2$ concentration of the main photosynthetic tissues of bryophytes depends solely upon atmospheric concentration and the rate of diffusion into the cell. Thick cell walls and external capillary water in bryophytes often slow diffusion rates
(Silvola 1990) but the process is morphologically constrained and essentially passive unlike that in vascular plants. Therefore the indirect effects of CO$_2$ on photosynthesis due to increases in water use efficiency cannot be interpreted in the same way in bryophytes. The direct effects of CO$_2$ concentration on bryophyte photochemistry have, however, been shown to largely parallel those seen in vascular plants. For example, Dilks (1976) tested the CO$_2$ compensation point for 27 bryophyte species and found it to be in the normal range for C$_3$ plants (45–160 ppm [CO$_2$] at 25 °C and 250 μmol m$^{-2}$ s$^{-1}$).

Björkman et al. (1968) grew Marchantia polymorpha at different CO$_2$ concentrations for 10 days and found a 42% increase in growth with a doubling of CO$_2$ from 320 ppm to 640 ppm; Bazzaz et al. (1970) showed rates of photosynthesis for Polytrichum juniperinum to increase by a factor of 1.4–2.3 when exposed to CO$_2$ concentrations of 450 ppm compared with 300 ppm. Proctor (1982) showed that substantial increases in CO$_2$ assimilation could be achieved by bryophytes under elevated CO$_2$ especially when combined with elevated temperature. Higher temperature optima at elevated CO$_2$ were confirmed by Silvola (1985) in both forest and peat mosses. This is particularly relevant to desert bryophytes that may be exposed to temperature extremes. Silvola (1985) also varied irradiance levels and higher photosynthetic rates were recorded in Dicranum majus at lower irradiance levels and higher CO$_2$ than at normal levels of each, effectively shifting the light compensation point. Greater photosynthetic efficiency does not necessarily translate directly into increases in bryophyte growth rates. Studies with boreal and peat mosses have shown that elevated CO$_2$ can have widely varying effects on plant height and biomass accumulation (Sonesson et al. 1996; Berendse et al. 2001; Heijmans et al. 2001; Mitchell et al. 2002; Tuba et al. 2011) that may be species-specific (van der
Heijden et al. 2000b). This is similar to the results of many experiments with vascular plants showing species-specific responses to elevated CO$_2$ (Nowak et al. 2004). Poorter (1993) showed that slow-growing vascular plant species had less biomass increase in response to elevated CO$_2$ than other faster-growing species. According to the scheme described in Grime et al. (1990), most of the dominant soil crust bryophyte species in the Mojave Desert would likely be classified as slow-growing stress-tolerators and therefore may not respond with marked growth increases under elevated CO$_2$.

Aside from growth, bryophytes can alternatively allocate excess photosynthate to stress tolerance and/or reproduction. Takács et al. (2004) suggested that elevated CO$_2$ may allow mosses to cope better with cellular damage caused by heavy metals. Coe et al. (2008) showed improved tolerance of stressful temperatures in mosses grown at elevated CO$_2$, and Tuba et al. (1998) showed enhanced photosynthesis during drying in a desiccation-tolerant moss. Restoring cellular integrity following stresses such as these requires energy that is naturally more available to plants at elevated CO$_2$. Energy released from photosynthate stored as sucrose and/or starch can be used to assemble proteins and perform other tasks even when the photosynthetic machinery is damaged. This is particularly important for desiccation-tolerant bryophytes, which upon rehydration have severely reduced photosynthetic capacity combined with considerable membrane damage (Oliver et al. 2005).

Increases in reproductive effort have been found in vascular plants grown at elevated CO$_2$ (Jablonski et al. 2002) resulting in greater seed production (Smith et al. 2000) as well an accelerated transition to reproductive maturity (LaDeau & Clark 2001). Enhancement of reproduction in bryophytes under elevated CO$_2$ has not previously been
documented but they are unlikely to differ greatly from vascular plants in this respect.

When not immediately used, excess photosynthate can also be stored as sugars and starch in the cell or translocated to other parts of the plant. Csintalan et al. (1995, 1997) reported increases in both starch and sugar content in a forest moss (*Polytrichum formosum*) grown at elevated CO$_2$ for ten months but little difference in an arid land moss (*Syntrichia ruralis*) grown at elevated CO$_2$ for four months. These stored pools of energy must naturally change over time and their response to stress in particular should be examined more closely.

Limiting factors other than CO$_2$ availability exist in every natural system and ultimately constrain plant responses to CO$_2$ within certain bounds (Oechel et al. 1994). Long-term experiments on vascular plants have shown that they eventually down-regulate photosynthesis owing to reductions in sink strength and starch accumulation (DeLucia et al. 1985) and the same is apparently also true of bryophytes (Jauhiainen et al. 1998; Tuba et al. 1999; van der Heijden et al. 2000a; Ötvös & Tuba 2005). Acclimation to elevated CO$_2$ may include changes in photosynthetic pigment content (Csintalan et al. 2005; Coe et al. 2008) and/or Rubisco activity (Wong 1979) leading to a persistent reduction in photosynthetic capacity. In this way resources (most notably nitrogen) can be reallocated to other cellular processes.

Based on these previous studies, bryophytes in desert soil crusts were predicted to exhibit greater carbon gain under elevated CO$_2$ and thus increased vegetative growth and reproductive allocation. Given that desiccation tolerance requires increased synthesis of an array of repair proteins that draw upon the overall carbon and nitrogen budget of the plants (Oliver et al. 2005), elevated CO$_2$ was predicted to enhance desiccation
tolerance. Consequently, elevated CO$_2$ should result in (i) increased frequency of sex expression (inflorescence production), (ii) greater viability and regeneration of shoots after experimental desiccation stress (as evidenced by protonemata and bud production), (iii) moderate increases in biomass accumulation rates, and (iv) a natural down-regulation of photosynthetic capacity following long-term exposure.

Methods

Field Methods

Specimens of the moss *Syntrichia caninervis* Mitt. were collected from the Nevada Desert FACE Facility (NDFF) located on Frenchman Flat, in Nye County, NV, USA (36°49′N, 115°55′W, elev. 970 m) approximately 100 km north of Las Vegas. The acronym FACE is short for Free-Air Carbon dioxide Enrichment and is used to describe experiments where large, open-air vegetation plots are exposed to elevated CO$_2$ in situ. In order to minimize disturbance, the ambient wind currents surrounding the plots are analyzed in real time and used to carry CO$_2$-enriched air across the plot. At the NDFF the CO$_2$ delivery system was terminated by upright PVC pipes surrounding the plots (Figure 2) that were individually activated depending upon the current wind direction. The NDFF plots consisted of nine rings; three of the rings used FACE technology to raise the CO$_2$ concentration in the air above the plot to 550 ppm. The remaining six rings were two sets of controls under ambient CO$_2$ conditions. More details of the operations at NDFF are described by Jordan et al. (1999). At the time of sampling, the plots had been treated with elevated CO$_2$ for approximately eight years.

Because of its location on the Nevada Test Site, a secure US Department of
Figure 2. Photo of NDFF (Nevada Desert Face Facility) site showing elevated scaffolding for access and the FACE CO$_2$ delivery system (vertical PVC pipes).
Energy facility, the area surrounding the NDFF had been kept free of grazing and most other disturbances for at least 60 years. In addition, knowledge that undisturbed biological soil crusts are an important part of this ecosystem guided site selection for the NDFF. The health of the soil crust on the plots was maintained by requiring most access to be via an elevated platform hung from scaffolding (Figure 2). Consequently the plots were representative of a relatively intact northern Mojave Desert, *Larrea tridentata* – *Ambrosia dumosa* – *Lycium* spp. vascular plant community and associated biological soil crusts (Jordan et al. 1999).

By far the most dominant bryophyte in these soil crusts is *Syntrichia caninervis*, although mosses belonging to other genera (notably *Bryum* and *Pterygoneurum*) occur in smaller numbers. Because the site is relatively flat and exposed, bryophytes are restricted to the highest-quality microsites (mostly defined by shade and/or edaphic factors) and therefore exhibit a patchy distribution across the plots. The rings also varied somewhat in the degree of crust development. Since bryophytes only occur in significant numbers in well-developed crusts, sampling was necessarily restricted to those patches and rings that could absorb the impact. In addition, dramatic variation in the size of *S. caninervis* exists in the field, and patches were selected in order to collect uniformly robust specimens that were large enough to be measured and manipulated in the laboratory. Sixteen patches of *S. caninervis* in four rings were sampled, with the patches evenly split between the control and elevated CO$_2$ treatments. Approximately 30 ramets were collected from each patch, using forceps and taking care not to destroy the entire patch. Essentially nondestructive sampling was necessary in order to maintain the integrity of the long-term FACE experiment.
Laboratory methods

A total of 216 individual, unbranched *S. caninervis* ramets were separated and cleaned of dirt and debris. Both length and biomass of the stems were measured twice, once for the entire above ground portion and again for the “green zone” only. This green zone was determined as described by Stark et al. (1998) and signifies the upper portion of the stem and attached leaves, representing the last few years of growth before the leaves and stem begin to turn brown and senesce (here inclusive of the “yellow green” portion of the shoot). The collected ramets were first trimmed with a razor blade to the above ground portion and length and biomass measurements were taken while still dry. They were then hydrated and denuded of leaves up to the green zone and trimmed with the razor blade once again this time leaving only the green zone. While hydrated, the stems were examined for evidence of sexual expression in the green zone. Green zone length and biomass measurements were taken after the ramets had dried overnight. Stem lengths were measured with electronic calipers under a dissecting microscope; biomass measurements were taken on an electronic balance to a precision of 0.01 mg. Using shoots trimmed to the green zone alone allowed standardization of the ramets along a biologically relevant axis—namely, age. In addition, the green zone of these shoots was likely made up entirely of biomass that had accumulated under the field treatment at NDFF. This might not have been the case had the shoots instead been cut to the same length.

Following the initial measurements, the relative stress tolerance of the shoots was assessed by exposing them to a series of rapid drying treatments. Three treatment levels were used: a control with no rapid drying, six rapid dry cycles, and twelve rapid
dry cycles. These rapid drying treatments simulate the stress effect of rapid desiccation while the plants are physiologically active. Prior to the treatments, the shoots underwent a dehardening treatment in order to bring them out of dormancy. During dehardening they were hydrated and placed on moist sand in well plates. The well plates were placed in a growth chamber and the shoots allowed to recover for three days. The experimental stems were then subjected to a series of rapid desiccation events followed by two-hour hydration periods. The two-hour periods gave the shoots time to expend energy repairing their photosynthetic machinery without allowing time for them to achieve a positive carbon balance. Prior experiments had shown this to be more stressful than rapid desiccation without the intervening hydration period. Rapid drying (less than 15 minutes) was achieved by removing the moss from the wet sand and placing it on dry filter paper in the open air. The shoots were then finished overnight in a desiccation chamber at c. 15% relative humidity (RH). The following day they were rehydrated in a drop of sterilized distilled water, once again placed on wet sand and the cycle repeated.

After all the cycles were complete, the shoots were planted upright on moist sand in 216 individual Petri dishes (35 mm inner diameter) and placed back in the growth chamber for a 56 day regeneration assay. The drying treatments were staggered in time such that all the shoots were transferred to Petri dishes and began the final growth period on the same day. The shoots were grown on native sandy soil collected from areas adjacent to NDFF and the sand was sifted (500 μm mesh) and dry autoclaved (60 min at 131 °C) before use. The growth chamber (Percival model E30B, Boone, IA, USA) was set to a 12 h photoperiod (20 °C day and 8 °C night) for the entire experiment. Because light intensity and relative humidity vary depending upon position inside the chamber
(30–130 μmol m$^{-2}$ s$^{-1}$, 60%–70% RH), the positions of the dishes were randomly rotated daily for the first week and weekly thereafter.

Weekly observations were made of each dish for a total of eight weeks. During these observations the start date of protonemata or regenerant bud production was noted and total buds were counted. Also at this time, sterilized distilled water was added as necessary to keep the sand moist and the shoots fully hydrated between observations. After the full eight weeks were completed a final count of regenerant buds was taken and the dishes were left open in the growth chamber to dry down. After drying, the final area of protonemata on the soil surface was measured using SPOT image analysis software (Diagnostic Instruments, Sterling Heights, MI). Protonematal area was used as it has been shown to be a good proxy for total biomass production in similar experiments (e.g., Stark et al. 2004).

A follow-up reciprocal transplant experiment was performed using an additional 192 shoots of *S. caninervis* collected and trimmed to the green zone as described above. In this experiment shoots from each of the field treatments were grown at either elevated or ambient CO$_2$ concentrations in the laboratory. This resulted in four groups of 48 shoots each: (1) both field and laboratory elevated CO$_2$, (2) field elevated and laboratory ambient CO$_2$, (3) field ambient and laboratory elevated CO$_2$, and finally (4) both field and laboratory ambient CO$_2$. The plants were grown out for 56 days; observations proceeded in a fashion similar to those described above.

**Statistical methods**

The variability of shoot biomass measures precluded their use to effectively test differences between the CO$_2$ treatments in the field (due to low power); they
were, however, useful as covariates in some of the other analyses. Since length and biomass were naturally correlated and the severed green zone was actually used, green zone biomass was selected as the only covariate in subsequent analyses. A Box–Cox transformation prior to use of green zone biomass was necessary for normality. None of the other response variables tested was normally distributed (even after attempts at transformation); therefore, generalized linear models with the appropriate distributions and survival analyses were employed.

Treatment effects on time to protonemata appearance and protonematal bud emergence were assessed by survival analysis using the Cox proportional hazards model with censoring. Logistic regression was performed to determine whether the field CO$_2$ treatments affected the likelihood of sexual expression in the green zone. Owing to zero-inflation and overdispersion, final protonematal area and total protonematal bud counts required the use of the Tweedie and negative binomial distributions, respectively. The negative binomial distribution is commonly used for overdispersed discrete count data (Zeileis et al. 2008) such as bud counts in this experiment. The Tweedie family of distributions (Jørgensen 1987) includes examples (when the power parameter is between 1 and 2) that are continuous for $y > 0$ with a positive mass at zero. These exponential dispersion models are therefore well suited to the problem of zero-inflated continuous data (final protonematal area in this case).

All statistical analyses were performed using the R software package (v2.8.0, R Development Core Team, 2008). Some R functions were performed using additional packages, including: MASS (Venables & Ripley 2002) for the negative binomial model and Box–Cox transformation, multcomp (Hothorn et al. 2008) for multiple comparisons.
between stress levels, survival (Therneau & Lumley 2008) for survival analyses, and tweedie (Dunn 2007) for Tweedie models.

Results

Shoots collected from the elevated CO$_2$ rings were nearly twice as likely to have expressed sex at least once in the green zone compared with their counterparts from the ambient rings (45 vs. 23 shoots). A logistic regression for likelihood of green zone sex expression showed both biomass and CO$_2$ treatment to be significant ($p < 0.001$, Figure 3). Of the shoots that expressed sex in the green zone, those grown in elevated CO$_2$ were significantly smaller (mean green zone biomass 0.266 mg vs. 0.383 mg, $p < 0.001$, t-test, Figure 3). Both the stress and CO$_2$ treatments had a significant effect on protonematal emergence ($p < 0.001$, Figure 4); however, in this case green zone biomass was not significant ($p = 0.87$). Multiple comparison tests showed that all three stress levels were significantly different from one another (maximum $p = 0.009$). Protonematal bud emergence times were significantly affected by the stress treatments ($p < 0.001$, Figure 5) and green zone biomass ($p = 0.011$) but not by the CO$_2$ treatments ($p = 0.38$). As with protonematal emergence, all three stress treatments were significantly different from one another (all $p < 0.001$). Stress, CO$_2$ concentration and green zone biomass all had a significant effect on final protonematal area (maximum $p = 0.003$, Figure 6) and again all three stress treatments were significantly different (maximum $p = 0.004$). In the analysis for protonematal area, two of the two-way interaction effects were significant. These were the interactions between the CO$_2$ treatments and both the stress treatments ($p = 0.006$) as well as green zone biomass ($p = 0.010$). Finally, stress, CO$_2$ concentration and green zone biomass also all had a significant effect on final protonematal bud counts ($p$
Figure 3. Logistic regression for the likelihood of sex expression in the green zone for a given biomass. The two lines show the predicted response for each of the CO$_2$ treatments. The individual data points are also shown as circles and pluses.
Figure 4. Survivorship curves for protonematal emergence within each of the given treatment levels (rd = rapid dry events). Dotted lines show 95% confidence intervals. “Survival” in this case means that protonemata have not emerged (the original condition), therefore as the curves are pushed further to the right, emergence is delayed.
Figure 5. Survivorship curves for protonematal bud emergence within each of the rapid dry (rd) treatment levels. Dotted lines show 95% confidence intervals. “Survival” in this case means that buds have not emerged (the original condition), therefore as the curves are pushed further to the right, emergence is delayed.
Figure 6. Final protonematal area (given green zone biomass) across CO$_2$ treatments (ambient, elevated) and rapid drying treatments (0, 6, 12 cycles). Trend lines are shown for reference only (they are not necessarily significant).
Figure 7. Final protonematal bud counts (given green zone biomass) across CO$_2$ treatments (ambient, elevated) and rapid drying treatments (0, 6, 12 cycles). Trend lines are shown for reference only (they are not necessarily significant).
Figure 8. Final protonematal area (given green zone biomass) across transplant treatments. Trend lines are shown for reference only (they are not necessarily significant).
Figure 9. Summary of interaction between field and laboratory CO$_2$ concentration in reciprocal transplant experiment.
< 0.001, Figure 7) and all three stress treatments were once again significantly different (all p < 0.001). In the follow-up reciprocal transplant experiment, green zone biomass (p < 0.001), laboratory CO$_2$ (p < 0.001), and field CO$_2$ (p = 0.014) all had a significant effect on final protonematal area (Figure 8). In addition there was a significant interaction effect between field CO$_2$ and green zone biomass (p = 0.008) and a marginally significant interaction between the two CO$_2$ treatments (p = 0.054, Figure 9).

Discussion

Sex expression

Stark et al. (1998) showed shoot size and sex expression to be positively correlated and yet despite the fact that they were on average slightly smaller (median green zone biomass 0.23 mg vs. 0.26 mg), shoots from the elevated CO$_2$ rings were significantly more likely to have expressed sex. Furthermore, the mean green zone biomass of the expressing shoots grown in elevated CO$_2$ was less than 70% of that of the expressing shoots grown in ambient air. This suggests that sex expression is at least partly carbon-limited in these plants. It also suggests that under normal conditions these plants depend on carbon that is either stored in and/or translocated from other parts of the shoot for sex expression. Larger shoots store and produce more photosynthate than smaller shoots and sex expression is probably triggered only once some critical capacity is achieved. Elevated CO$_2$ apparently accelerates this maturation by allowing shoots to achieve this capacity at a smaller size and consequently younger age. This is strikingly similar to findings for loblolly pine (Pinus taeda; LaDeau & Clark 2001), where elevated CO$_2$ also accelerated sexual maturation causing decreases in plant size at maturity.
It has been suggested that bryophytes may not benefit as much as vascular plants under elevated CO$_2$ owing to limited sink differentiation (Sveinbjörnsson & Oechel 1992). On the contrary, these results show that bryophytes are more likely to initiate sexual reproduction in response to increased CO$_2$, thereby developing additional carbon sinks. Sporophyte production is probably the strongest sink for excess photosynthate available to bryophytes, owing to a morphology specifically adapted for transfer of resources to the next generation (Browning & Gunning 1979). Unfortunately, maturation of sporophytes in the Mojave Desert is a somewhat rare and episodic event not captured in these results. Obviously in areas where sporophytes are more common, these results become even more interesting. For example, Baars and Edwards (2008) found increases in capsule length and spore size in *Leptobryum pyriforme* grown at elevated CO$_2$. Elevated CO$_2$ could also affect sporophyte maturation rates, spore number or how quickly the next crop of sporophytes can be produced. Changes in spore size and/or quality may also influence fitness in the next generation.

Many studies use growth rates assessed as either length or biomass increases for measuring bryophyte responses to various conditions. These results show that reproductive status can be useful in discerning population differences that are not evident using standard growth measures. In fact, since there is likely a trade-off between growth and reproduction in these mosses, one might incorrectly conclude that CO$_2$ has negative effect on growth, if growth was the only response measured. This is especially true in acrocarpous mosses (e.g., *S. caninervis*) where the apical meristem is consumed in the production of gametangia and growth must resume by branching or subfloral innovation. In these mosses, every expression event not only consumes energy but also consumes an
apical meristem, thus delaying height growth in the interim.

**Stress tolerance**

Besides sexual reproduction, bryophytes can also allocate surplus resources to improve their tolerance to various stresses. The results of this experiment show that elevated CO$_2$ has a protective effect against the most common stress that arid land mosses encounter—namely desiccation. Upon rehydration these plants have to repair their membranes and photosynthetic machinery before they can begin to grow again (Oliver et al. 2005). The weaker the plant is to begin with or the more severe the stress, the longer this repair process will take. If it takes too long, the moss will endure a sustained carbon deficit and eventually die. The resumption of growth (e.g., protonematal emergence) is a good indicator that repair is complete and in healthy, unstressed plants of *S. caninervis* it usually occurs in a few days. All of the plants in this experiment had been exposed to desiccation stress in the field, so protonemata did not begin to emerge until the second to third week of the experiment. As expected, additional laboratory desiccation stress treatments pushed the emergence times back even further; however, plants grown at elevated CO$_2$ had consistently earlier protonematal emergence times. Faster emergence naturally translated into greater protonematal area and buds produced by the end of the experiment. The enhanced regeneration demonstrated here is clearly important in bryophytes such as *Syntrichia* where asexual reproduction may be the dominant means of propagation due to the rarity of sporophyte production in the harsh desert environment (Newton & Mishler 1994). As with sex expression, these results suggest that the elevated CO$_2$ grown plants may have more stored energy but it is also likely that they have allocated more resources to repair proteins and other secondary compounds that are
used to mitigate desiccation damage and other stresses. The energy expended in building and recycling these compounds is another potential sink for carbon that is probably strengthened in bryophytes as they capture the benefits of elevated CO$_2$.

**Productivity and resource allocation**

These results illustrate that allocation of carbon and other resources in bryophytes is not simple, but rather that it is a complicated process involving trade-offs and limiting factors. Teasing apart these influences is not trivial, and it is obvious that more work needs to be done in this area. However, some of the complexities of the carbon economy of these plants are hinted at in the significant interaction effects for protonematal area presented here. Alpert (1989) showed that the xeric-adapted moss *Grimmia laevigata* was able to transport carbon away from its leaves towards other parts of the plant. He hypothesized that this ability, combined with clonal integration, allowed the plant to thrive in areas where desiccation stress might otherwise exclude it. It would appear that similar processes are at work in *S. caninervis*; for example, the effect of shoot biomass on the growth of protonemata is smaller or non-existent in plants grown at elevated CO$_2$ (Figs. 9.5 and 9.7). This suggests that in plants grown at elevated CO$_2$ the translocation of carbon from distant parts of the stem to sites of active growth is less important presumably because the supply of carbon is more plentiful throughout the plant. This also explains why the plants grown at elevated CO$_2$ begin to show some effects of biomass when additional desiccation stress is added (Figure 6, upper right). Under these experimental conditions carbon is apparently being transferred from the leaves through the stem and out to the actively growing protonemata.

Furthermore, *S. caninervis* ramets in intact soil crust often retain below-ground
connections that may allow inter-ramet transfer of carbon and other nutrients. This could serve to supplement the carbon balance of connected ramets in less optimal microsites and improve the fitness of the clone as a whole. Evidence for this would demonstrate the existence of yet another strong sink for carbon available to bryophytes, but one that operates on the scale of the entire clone. Of course, community-scale connections also exist via mycorrhizae (Zhang & Guo 2007) and pulse releases of leachate into the soil induced by rehydration damage (Wilson & Coxson 1999); therefore, downstream effects on the soil fauna and vascular plants are also possible.

Another complication in the interpretation of the responses of *S. caninervis* is photosynthetic down-regulation. Shoots of *S. caninervis* showed a dramatic step increase in productivity when moved from ambient conditions in the field to elevated CO$_2$ in the laboratory growth chamber (Figure 8, upper left, and Figure 9). This increase was not observed in plants that had already experienced elevated CO$_2$ in the field. The fact that they did not achieve the same productivity as plants from the ambient field treatments is evidence that they had already acclimated to a high CO$_2$ environment by down-regulating photosynthesis. While this might seem counterintuitive, notice that despite this reduction in maximal photosynthetic capacity, plants grown in and then transplanted to elevated CO$_2$ conditions still significantly outperform the plants grown at and remaining in ambient conditions (Figure 9). Here the plants demonstrate Liebig’s (1840) law of the minimum, which predicts that a plant’s response to changes in resource levels is fundamentally constrained by the resource that is least available (see Van der Ploeg et al. 1999). Increases in carbon availability have the effect of reshuffling the order of these limiting factors, causing plants to focus less on carbon fixation and more on overcoming
other limiting factors. The upshot of this is that when the plants down-regulate photosynthesis it allows them to up-regulate some other process or physiological pathway such as stress tolerance.

Conclusions

In the environments where *S. caninervis* is common there is tremendous evolutionary pressure for stress tolerance even at the expense of slower growth. In fact, height growth beyond that necessary to keep pace with sediment deposition can expose the plant to greater stress by removing it further from the large reservoir of moisture provided by the soil. As a result, *S. caninervis* apparently preferentially allocates resources to stress tolerance and sexual reproduction rather than increased growth. In an environment such as the Mojave Desert where bryophytes are exposed to repeated, chronic stresses (Barker et al. 2005), the protective effects of elevated CO₂ are likely to be especially important. However, not all bryophyte species may respond similarly; and when combined with other global changes such as warming and modification of precipitation patterns, elevated CO₂ may cause shifts in the competitive balance among soil crust species. Very little is known concerning species interactions and community assembly in arid land bryophytes, so the overall effect will be difficult to predict. However, the responses of biological soil crusts and their component bryophytes to various aspects of climate change, including elevated CO₂, must be understood in order to predict how arid ecosystems will change in an environment increasingly altered by human influence. It is important that we understand the effects of these changes before they occur so that informed decisions can be made regarding future resource use and
management.

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CHAPTER 4

THE BRYOPHYTE FLORA OF GRAND CANYON-PARASHANT
NATIONAL MONUMENT, ARIZONA

by

John C. Brinda (sole author)

Abstract

A baseline assessment of the bryophyte diversity on the Grand Canyon-Parashant National Monument was conducted. Collecting locations were selected in order to maximize the number of species collected and to cover the monument both geographically and ecologically. Forty-seven sites were visited and 679 voucher specimens were collected. A checklist, flora and photographic guide were prepared for the 110 species identified from among these collections.

Introduction

The primary focus of this project was a baseline assessment of the bryophyte diversity on the Grand Canyon-Parashant National Monument (GCPNM). To this end collecting locations were preselected in order to maximize the potential number of species collected at each site. Additional sites were added to this list in order to cover the monument geographically as well as include as many of the major vegetation and substrate types as possible. A total of 47 sites (Figure 10) were visited and 679 voucher specimens were collected. A checklist and keys to the taxa that have been identified from these collections follows. In addition all the taxa are photographically documented in the species accounts. All photos presented here are of plants collected on the GCPNM.
Figure 10. Map of bryophyte collecting sites on the Grand Canyon-Parashant National Monument.

Figure 11. Distribution of the monument’s bryophyte diversity among taxonomic groups.
While the monument mostly lacks the wet and humid environments usually associated with bryophytes, it offers a diverse array of geological substrates set in a varied topography. The monument’s location also allows a mixing of the Mojave Desert and Rocky Mountain floras, enhancing its diversity. These habitats promote a high diversity of xeric-adapted species especially in the Pottiales and Grimmiales (Figure 11). The new information provided by these collections shows that the bryophyte diversity on the GCPNM has been seriously underestimated in the past. The resulting checklist of 110 species represents a dramatic increase from the most recent survey of the monument (Newberry & Stark 2004) as well as that previously reported for all of Mohave County (Haring 1961). In addition, 23 taxa are apparently newly reported for the State of Arizona and our investigations yielded at least three taxa that are still undescribed or new to science. Careful taxonomic work in this region will continue to yield range extensions for well-known species and probably also species new to science.

Previous Research

Past publications of bryophyte occurrences in the region have usually lacked the information necessary in order to pinpoint their location. Therefore prior to Newberry & Stark’s (2004) report little was known regarding the bryophyte diversity on the monument. However, Haring (1961) reported 22 taxa for Mohave County:

*Brachytheciastrum fendleri* (Sull.) Ochyra & Żarnowiec

[as *Brachythecium utahense* James]

*Bryum argenteum* Hedw.

*Bryum lanatum* (P. Beauv.) Brid.

[as *Bryum argenteum* var. *lanatum* (P. Beauv.) Hampe]
Ceratodon purpureus (Hedw.) Brid. subsp. purpureus

Climacium americanum Brid.

Crossidium aberrans Holz. & E.B. Bartram

[as Crossidium spatulaefolium Holz. & E.B. Bartram]

Didymodon tophaceus (Brid.) Lisa

Dryptodon decipiens (Schultz) Loeske

[as Grimmia decipiens (Schultz) Lindb.]

Dryptodon trichophyllus (Grev.) Brid.

[as Grimmia trichophylla Grev.]

Eucladium verticillatum (Hedw.) Bruch & Schimp.

Funaria hygrometrica Hedw. var. hygrometrica

[also as Funaria hygrometrica var. utahensis Grout]

Grimmia calyptrata Drumm.

Grimmia laevigata (Brid.) Brid.

Grimmia pulvinata (Hedw.) Sm.

Plagiomnium cuspidatum (Hedw.) T.J. Kop.

[as Mnium cuspidatum Hedw.]

Platygyrium fuscoluteum Cardot

Pterygoneurum ovatum (Hedw.) Dixon

Rosulabryum capillare (Hedw.) J.R. Spence

[as Bryum capillare Hedw.]

Schistidium apocarpum (Hedw.) Bruch & Schimp.

[as Grimmia apocarpa Hedw.]
*Syntrichia caninervis* Mitt. var. *caninervis*

[as *Tortula bistratosa* Flowers]

*Syntrichia obtusissima* (Müll. Hal.) R.H. Zander

[as *Tortula obtusissima* (Müll. Hal.) Mitt.]

*Syntrichia ruralis* (Hedw.) F. Weber & D. Mohr var. *ruralis*

[as *Tortula ruralis* (Hedw.) P. Gaertn., B. Mey. & Scherb.]

To this list Newberry & Stark (2004) added the following 14 taxa that they collected on the monument (in addition *Amblystegium serpens*, *Desmatodon latifolius*, *Encalypta mutica*, *Grimmia tenerrima*, and *Orthotrichum tenellum* were reported in error—see excluded species below):

*Brachytheciastrum collinum* (Schleich. ex Müll. Hal.) Ignatov & Huttunen

[as *Brachythecium collinum* (Schleich. ex Müll. Hal.) Schimp.]

*Eurhynchiastrum pulchellum* (Hedw.) Ignatov & Huttunen var. *pulchellum*

[as *Eurhynchium pulchellum* (Hedw.) Jenn.]

*Gemmabryum caespiticium* (Hedw.) J.R. Spence

[as *Bryum caespiticium* Hedw.]

*Grimmia anodon* Bruch & Schimp.

*Grimmia montana* Bruch & Schimp.

*Grimmia orbicularis* Bruch

*Grimmia ovalis* (Hedw.) Lindb.

*Hedwigia nivalis* (Müll. Hal.) Mitt.

*Orthotrichum anomalum* Hedw.

*Orthotrichum hallii* Sull. & Lesq.
Orthotrichum laevigatum J.E. Zetterst.

Orthotrichum rupestre Schleich. ex Schwägr.

Pseudoleskeella tectorum (Funck ex Brid.) Kindb. ex Broth.

Timmia bavarica Hessl.

Current Research

After considering the two previous investigations cited above, the other 83 taxa reported in the following checklist are apparently new for Mohave County. In addition, the following 23 taxa are apparently newly reported for the State of Arizona (Spence 2007, FNA 2007):

Anacolia menziesii (Turner) Paris var. menziesii

Anoectangium handelii Schiffner

Didymodon eckeliae R.H. Zander

Didymodon nevadensis R.H. Zander

Didymodon nicholsonii Culm.

Didymodon rigidulus var. icmadophilus (Schimp. ex Müll. Hal.) R.H. Zander

Dryptodon meridionalis (Müll. Hal.) Ochyra & Żarnowiec

Gemmabryum dichotomum (Hedw.) J.R. Spence & H.P. Ramsay

Gemmabryum kunzei (Hornsch.) J.R. Spence

Gemmabryum violaceum (Crundw. & Nyholm) J.R. Spence

Grimmia jamesii Austin

Gymnostomum viridulum Brid.

Homalothecium nevadense (Lesq.) Renauld & Cardot var. nevadense

Hymenoloma mulahacenii (Höhn.) Ochyra
*Isothecium obtusatulum* Kindb.

*Pottiopsis sweetii* (E.B. Bartram) Ros & O. Werner

*Pseudocrossidium obtusulum* (Lindb.) H.A. Crum & L.E. Anderson

*Rosulabryum flaccidum* (Brid.) J.R. Spence

*Schistidium cinclidodonteum* (Müll. Hal.) B. Bremer

*Schistidium lancifolium* (Kindb.) H.H. Blom

*Syntrichia calcicola* J.J. Amann

*Syntrichia laevipila* Brid. var. *laevipila*

*Syntrichia virescens* (De Not.) Ochyra var. *virescens*

Finally, three undescribed species occur on the monument:

*Targionia* sp. nov. A.T. Whittemore ined.

*Schistidium* spp. nov. H.H. Blom in litt. (2 species)

Checklist of the Bryophytes of Grand Canyon-Parashant National Monument

Marchantiophyta Stotler & Crand.-Stotl. [4 Liverworts]

Marchantiales Limpr.

Aytoniaceae Cavers

*Asterella californica* (Hampe) Underw.

Targioniaceae Dumort.

*Targonia* sp. nov. A.T. Whittemore ined.

Radulales Stotler & Crand.-Stotl.

Radulaceae Müll. Frib.

*Radula complanata* (L.) Dumort. subsp. *complanata*
Jubulales W. Frey & M. Stech

Frullaniaceae Lorch in G. Lindau

Frullania inflata Gottsche

Bryophyta Schimp. [106 Mosses]

Timmiales Ochyra

Timmiaceae Schimp.

Timmia bavarica Hessl.

Encalyptales Dixon

Encalyptaceae Schimp.

Encalypta intermedia Jur.

Encalypta vulgaris Hedw. var. vulgaris

Funariales M. Fleisch.

Funariaceae Schwägr.

Funaria hygrometrica Hedw. var. hygrometrica

Funaria muhlenbergii var. lineata Grout

Scouleriales Goffinet & W.R. Buck

Drummondiaceae Goffinet

Hymenoloma mulahacenii (Höhn.) Ochyra

Grimmiales M. Fleisch.

Ptychomitriaceae Schimp.

Jaffueliobryum rau (Austin) Thér.

Jaffueliobryum wrightii (Sull.) Thér.

Grimmiaceae Arn.
Dryptodon meridionalis (Müll. Hal.) Ochyra & Żarnowiec

Dryptodon torquatus (Drumm.) Brid.


Grimmia anodon Bruch & Schimp.

Grimmia calytrata Drumm.

Grimmia jamesii Austin

Grimmia laevigata (Brid.) Brid.

Grimmia longirostris Hook.

Grimmia montana Bruch & Schimp.

Grimmia moxleyi R.S. Williams

Grimmia orbicularis Bruch

Grimmia ovalis (Hedw.) Lindb.

Grimmia plagiopodia Hedw.

Grimmia poecilostoma Cardot & Sebille

Grimmia pulvinata (Hedw.) Sm.

Schistidium ambiguum Sull.

Schistidium cinclidodonteum (Müll. Hal.) B. Bremer

Schistidium lancifolium (Kindb.) H.H. Blom

Schistidium sp. nov. #1 H.H. Blom ined.

Schistidium sp. nov. #2 H.H. Blom ined.

Dicranales H. Philib. ex M. Fleisch.

Fissidentaceae Schimp.

Fissidens bryoides var. pusillus (Wilson) Pursell
Fissidens exigus Sull.

Fissidens sublimbatus Grout

Pottiales M. Fleisch.

Ceratodontaceae Schimp.

Ceratodon purpureus (Hedw.) Brid. subsp. purpureus

Pottiaceae Schimp.

Trichostomoideae (Schimp.) Broth.

Anoectangium handelii Schiffner

Gymnostomum aeruginosum Sm. var. aeruginosum

Gymnostomum calcareum Nees & Hornsch. var. calcareum

Gymnostomum viridulum Brid.

Pleurochaete luteola (Besch.) Thér.

Pottiopsis sweetii (E.B. Bartram) Ros & O. Werner

Tortella alpicola Dixon

Weissia andrewsii E.B. Bartram

Weissia ligulifolia (E.B. Bartram) Grout

Barbuloideae (Herzog) Hilp.

Aloina ambigua (Bruch & Schimp.) Limpr.

Aloina bifrons (De Not.) Delgad.

Barbula unguiculata Hedw.

Bryoerythrophyllum recurvirostrum (Hedw.) P.C. Chen var. recurvirostrum

Didymodon australiasiæ (Hook. & Grev.) R.H. Zander var. australiasiæ

Didymodon brachyphyllus (Sull.) R.H. Zander
Didymodon eckeliae R.H. Zander

Didymodon nevadensis R.H. Zander

Didymodon nicholsonii Culm.

Didymodon rigidulus var. icmadophilus (Schimp. ex Müll. Hal.) Zand.

Didymodon tophaceus (Brid.) Lisa

Didymodon vinealis (Brid.) R.H. Zander var. vinealis

Microbryum starckeanum var. brachyodus (Bruch & Schimp.) Zand.

Pseudocrossidium obtusulum (Lindb.) H.A. Crum & L.E. Anderson

Pottioidae Broth.

Crossidium aberrans Holz. & E.B. Bartram

Crossidium crassinerve (De Not.) Jur. var. crassinerve

Crossidium seriatum H.A. Crum & Steere

Crossidium squamiferum var. pottioidem (De Not.) Mönk.

Crossidium squamiferum (Viv.) Jur. var. squamiferum

Desmatodon guepinii Bruch & Schimp.

Phascum cuspidatum Hedw. var. cuspidatum

Pterygoneurum ovatum (Hedw.) Dixon

Pterygoneurum subsessile (Brid.) Jur. var. subsessile

Syntrichia calcicola J.J. Amann

Syntrichia caninervis Mitt. var. caninervis

Syntrichia laevipila Brid. var. laevipila

Syntrichia pagorum (Milde) J.J. Amann

Syntrichia papillosissima (Copp.) Loeske
Syntrichia princeps (De Not.) Mitt. var. princeps

Syntrichia ruralis (Hedw.) F. Weber & D. Mohr var. ruralis

Syntrichia virescens (De Not.) Ochyra var. virescens

Tortula atrovirens (Sm.) Lindb.

Tortula brevipes (Lesq.) Broth.

Tortula inermis (Brid.) Mont.

Tortula mucronifolia Schwägr.

Tortula muralis Hedw. var. muralis

Hedwigiales Ochyra

Hedwigiaceae Schimp.

Hedwigia nivalis (Müll. Hal.) Mitt.

Bartramiales D. Quandt, N.E. Bell & M. Stech

Bartramiaceae Schwägr.

Anacolia menziesii (Turner) Paris var. menziesii

Bryales Limpr.

Bryaceae Schwägr.

Bryum argenteum Hedw. var. argenteum

Bryum lanatum (P. Beauv.) Brid.

Gemmabryum dichotomum (Hedw.) J.R. Spence & H.P. Ramsay

Gemmabryum kunzei (Hornsch.) J.R. Spence

Gemmabryum violaceum (Crundw. & Nyholm) J.R. Spence

Imbribriyum gemmiparum (De Not.) J.R. Spence

Rosulabryum capillare (Hedw.) J.R. Spence
Rosulabryum flaccidum (Brid.) J.R. Spence

Orthotrichales Dixon

Orthotrichaceae Arn.

Orthotrichum anomalum Hedw.

Orthotrichum cupulatum Hoffm. ex Brid.

Orthotrichum diaphanum Schrad. ex Brid.

Orthotrichum hallii Sull. & Lesq.

Orthotrichum laevigatum fo. macounii (Austin) E. Lawton & Vitt

Orthotrichum pumilum Sw.

Orthotrichum rupestre Schleich. ex Schwägr.

Hypnales (M. Fleisch.) W.R. Buck & Vitt

Pseudoleskeaceae Schimp.

Claopodium whippleanum (Sull.) Renauld & Cardot

Conardia compacta (Müll. Hal.) H. Rob.

Brachytheciaceae G. Roth

Brachytheciastrum collinum (Schleich. ex Müll. Hal.) Ignatov & Huttunen

Brachytheciastrum fendleri (Sull.) Ochyra & Żarnowiec

Brachytheciastrum olympicum (Jur.) Vanderpoorten et al.

Eurhynchiastrum pulchellum (Hedw.) Ignatov & Huttunen var. pulchellum

Homalotheicum nevadense (Lesq.) Renauld & Cardot var. nevadense

Lembophyllaceae Broth.

Isothecium obtusatulum Kindb.

Neckeraceae Schimp.
**Neckera pennata** Hedw.

**Pseudoleskeellaceae Ignatov & Ignatova**

*Pseudoleskea tectorum* (Funck ex Brid.) Kindb. ex Broth.

**Pylaisiaceae Schimp.**

*Stereodon revolutus* Mitt. var. *revolutus*

*Stereodon vaucheri* (Lesq.) Lindb. ex Broth.

**Excluded Species**

*Amblystegium serpens* (Hedw.) Schimp. [reported in Newberry & Stark 2004], Newberry, 23 May 2003 (!\text{unlv}) misidentified, this plant occurs in Grand Canyon National Park (T. Clark, personal communication) and may still be found on the monument

*Encalypta mutica* I. Hagen [reported in Newberry & Stark 2004], Newberry, 20, 21, 24 & 26 May 2003 (!\text{unlv}) misidentified

*Grimmia sessitana* De Not. [reported in Newberry & Stark 2004 as *Grimmia tenerrima* Renauld & Cardot], Newberry, 20 May 2003 (!\text{unlv}) misidentified, this plant occurs in Grand Canyon National Park (T. Clark, personal communication) and may still be found on the monument

*Orthotrichum tenellum* Bruch ex Brid. [reported in Newberry & Stark 2004], Newberry, 23 May 2003 (!\text{unlv}) misidentified

*Tortula hoppeana* (Schultz) Ochyra [reported in Newberry & Stark 2004 as *Desmatodon latifolius*], no voucher found, this plant may occur in Grand Canyon National Park (T. Clark, personal communication) and may still be found on the monument
Key to the Marchantiophyta (Liverworts)

1a. Plants thalloid or, if leafy, the leaves complicate-bilobed........................................2

1b. Plants leafy; leaves not complicate-bilobed...... [see “Key to the Bryophyta (Mosses)"

   2a. Plants thalloid.....................................................................................................3

   2b. Plants leafy.........................................................................................................4

3a. Air chambers relatively high and ± narrow, in more than one layer (view in cross-
   section), chlorophyllose filaments lacking (but the chambers may be subdivided by
   secondary walls); ventral scales with 2–4 appendages; sporophytes elevated on a
   stalked carpocephalum.......................................................... Asterella californica [page 177]

3b. Air chambers low and broad, in a single layer (view in cross-section), packed with
   chlorophyllose filaments attached to the chamber floor; ventral scales with a single
   appendage; sporophytes sessile at a branch apex ......... Targionia sp. nov. [page 181]

   4a. Underleaves absent........................................................ Radula complanata [page 184]

   4b. Underleaves present................................................ Frullania inflata [page 186]

Key to the Bryophyta (Mosses)

Key to the Major Groups

1a. Leaves with lamellae or filaments on the adaxial (upper) surface of the costa (not
   including propagula)......................................................... Pottiaceae [in part, page 161]

1b. Leaves without lamellae or filaments on the adaxial surface of the costa (but
   propagula sometimes present).......................................................2

   2a. Leaves with the costa short, double or lacking .................................................3

   2b. Leaves with a single costa to at least midleaf.............................................6
3a. Upper leaf cells papillose ................................................... *Hedwigia nivalis* [page 354]

3b. Upper leaf cells smooth ............................................................ 4

4a. Plants slender, thread-like; leaves mostly less than 0.5 mm long, imbricate when dry; laminal cells short, 1-3(-4) times as long as wide, subquadrate to rhombic or short-oblong; costa variable in length, sometimes spurred, double or absent entirely ......................... *Pseudoleskeella tectorum* [in part, page 414]

4b. Plants larger; leaves more than 0.5 mm long, not imbricate; laminal cells longer ........................................................................................................ 5

5b. Leaves strongly undulate ................................................. *Neckera pennata* [page 408]

5a. Leaves not undulate................................................................. *Stereodon* [page 151]

6a. Leaves appearing split at the base, consisting of two vaginant laminae, which clasp the stem and base of the leaf above .................. *Fissidens* [page 152]

6b. Leaves without vaginant laminae................................................................. 7

7a. Leaves greater than 10:1; conspicuous clusters of dark rhizoids obscuring the stem ..................................................................................................................... *Anacolia menziesii* [page 357]

7b. Leaves mostly broader; rhizoids inconspicuous or if obvious, then not obscuring the stem ........................................................................................................................................ 8

8a. Leaf cells appearing papillose in cross section due to weak longitudinal striae .............................................................................................................. *Hymenoloma mulahacenii* [page 204]

8b. Leaf cells smooth or papillose, longitudinal striae absent ......................... 9

9b. Leaf cells papillose or strongly mammillose ........................................ 10

9a. Leaf cells ± smooth (scattered prorulae sometimes present) ................ 15

10a. Leaf margins in distal portion strongly serrulate to dentate .............. 11
10b. Leaf margins entire in distal portion...............................................................13

11a. Leaf cells pluripapillose (sometimes mammillose as well)

..................................................................................................................Pottiacae [in part, page 161]

11b. Leaf cells unipapillose or only mammillose ..............................................12

12a. Leaf cells strongly mammillose, not papillose; leaf base strongly
differentiated, sheathing the stem ....................... *Timmia bavarica* [page 188]

12b. Leaf cells unipapillose; leaf base undifferentiated

........................................................................... *Claopodium whippleanum* [page 391]

13a. Costa ± homogeneous, without differentiated stereids; papillae conical

......................................................................................................................*Orthotrichum* [in part, page 154]

13b. Costa usually with differentiated stereids; papillae usually bi- to multifid...........14

14a. Calyptrae campanulate-miterate, covering entire capsule, often lobed at base;
basal leaf cells with thickened transverse walls; dry leaves not contorted, hair-
points lacking................................................................. *Encalypta* [page 152]

14b. Calyptrae cucullate, covering only operculum and capsule apex, unlobed at
base; basal leaf cells usually without thickened transverse walls; dry leaves
often contorted, hair-points often present ............Pottiacae [in part, page 161]

15a. Plants pleurocarpous (sporophytes lateral); stems mostly prostrate with lateral
branches, often mat-forming.................................................................16

15b. Plants acrocarpous (sporophytes terminal); stems erect, not branched or occasionally
branched beneath inflorescences.................................................................19

16a. Leaves imbricate when dry; laminal cells short, 1-3(-4) times as
long as wide, subquadrate to rhombic or short-oblong, smooth; costa
variable in length, sometimes spurred, double or absent entirely

.....................................................Pseudoleskeella tectorum [in part, page 414]

16b. Laminal cells longer; costa single, extending to at least midleaf ..............17

17a. Costa extending to the base of the acumen; rhizoids warty-papillose, much
branched and frequently inserted on the back of the costa or near the leaf apex

.................................................................Conardia compacta [page 393]

17b. Costa usually extending 1/2 to 3/4 of the leaf length; rhizoids never inserted along
the costa ..........................................................................................................................18

18a. Laminal cells typically less than 5:1, prorulose because of projecting cell
ends .................................................................Isothecium obtusatulum [page 405]

18b. Laminal cells typically longer, usually not prorulose

.................................................................Brachytheciaceae [page 153]

19a. Laminal cells lax, thin-walled, rhombic or short-rectangular to elongate ........20

19b. Laminal cells firm-walled, rounded to quadrate .............................................21

20a. Laminal cells mostly short-rectangular; capsules curved, asymmetric;
axillary hairs of markedly enlarged diameter toward distal end

.................................................................Funaria [page 153]

20b. Laminal cells rhombic to elongate-hexagonal; capsules straight, symmetric;
axillary hairs typically of equal diameter throughout....... Bryaceae [page 155]

21a. Costa ± homogeneous, without differentiated stereids; hyaline hairpoints rarely
present (if present, plants growing on the bark of trees); calyptra large, campanulate,
often hairy and/or plicate .............................................................Orthotrichum [in part, page 154]

21b. Costa usually heterogeneous, often with differentiated stereid band(s) and/or
hydroids; hyaline hairpoints often present; calyptra various but never hairy (only occasionally plicate)...........................................................................................................22

22a. Leaves ovate to obovate, concave or only somewhat keeled distally; long, hyaline hairpoints present; distal lamina 1-stratose, margins plane; plants autoicous; perichaetial leaves enlarged; capsule immersed; calyptra large, campanulate, covering more than half the capsule, plicate, often lobed

..........................................................................................................................Jaffueliobryum [page 153]

22b. Plants not as above................................................................................................................23

23a. Laminal cell walls often sinuose, at least in part; costa often undifferentiated or with hydroids only (but if stereids present, then the cell walls strongly sinuose)

..............................................................................................................................Grimmiaceae [page 157]

23b. Laminal cell walls not sinuose; costa usually with 1–2 strongly differentiated stereid bands (hydroids sometimes present as well).......................................................................................24

24a. Leaves ovate-lanceolate to linear, margins usually recurved most of their length and with a few minute serrulations near apex; hyaline hairpoints absent but leaves occasionally with excurrent, subulate costa; mid-laminal cells somewhat uneven in shape and size, from quadrate to irregularly angled or rounded; basal laminal cells scarcely differentiated; capsule usually deeply furrowed and sulcate when dry .........................Ceratodon purpureus [page 256]

24b. Plants not as above; hyaline hairpoints sometimes present; basal laminal cells sometimes differentiated (pellucid or hyaline); capsules smooth, never furrowed or sulcate .................................................................Pottiaceae [in part, page 161]

Key to Stereodon
1a. Leaf margins plane; quadrate alar cells very numerous 12–14(–20) along the margins

.................................................................Stereodon vaucheri [page 410]

1b. Leaf margins recurved; quadrate alar cells fewer in number

.................................................................Stereodon revolutus [page 412]

**Key to Fissidens**

1a. Laminal cells small, 6–11 μm, strongly bulging, about twice as tall as wide, ± obscure

.................................................................Fissidens sublimbatus [page 253]

1b. Laminal cells 6–18 μm, ± plane to slightly bulging, ± equally tall as wide, distinct ....2

2a. Limbidium mostly confined to the vaginant laminae, often only present on perichaetial leaves and absent entirely from the stem leaves, often becoming intramarginal at the base ...........................................Fissidens exigius [page 250]

2b. Limbidium on all laminae, usually not intramarginal at the base

.................................................................Fissidens bryoides [page 250]

**Key to Encalypta**

1a. Leaves inconspicuously keeled in upper part on abaxial surface by green, dull costa; basal laminal cells ± quadrate to 3:1 and up to 12 μm broad; capsule ± furrowed, ribs indistinct to orange; seta 1-4 mm long; calyptra rostrum 0.8-1.0 mm long, base of cylinder reaches or very nearly reaches uppermost leaves; rhizoids pale and repeatedly branched, not monopodial, mostly 10-12 μm in diameter, forming a dense cushion in leaf axils ...................................................Encalypta intermedia [page 190]

1b. Leaves prominently keeled in upper part on abaxial surface by golden to dark-brown costa; basal laminal cells mostly 3-6:1 and up to 18 μm broad; capsule ± smooth, ribs undifferentiated; seta 4-8 mm long; calyptra rostrum 1-2 mm long, base of cylinder
raised well above uppermost leaves; rhizoids red-brown, up to 35 µm in diameter, monopodially branched with branches of much smaller diameter, not densely clustered in leaf axils .......................................................Encalypta vulgaris [page 194]

Key to Jaffueliobryum

1a. Distal lamina acute to acuminate; leaves ± keeled; proximal stem leaves mostly spreading.................................................................Jaffueliobryum rau [page 207]
1b. Distal lamina broadly acute-rounded; leaves not keeled; proximal stem leaves mostly appressed.................................................................Jaffueliobryum wrightii [page 209]

Key to Funaria

1a. Capsules sulcate when dry due to vertical bands of strongly cuneate cells alternating with firm-walled, non-cuneate cells; peristome teeth fused at apices by a lattice disc; annulus compound and revoluble .........................Funaria hygrometrica [page 197]
1b. Capsules not sulcate when dry (but often with neck wrinkled), lacking alternating vertical bands of thin- and thick-walled cells; peristome teeth not fused at apices; annulus not compound or revoluble.................................Funaria muhlenbergii [page 200]

Key to the Brachytheciaceae

1a. Leaves acute or obtuse; apical cells of branch leaves oblong-rhombic, obviously shorter than mid-leaf cells; costa ending at or above 1/2 way up leaf and projecting as a dorsal spine; capsule lid long rostrate ........Eurhynchiastrum pulchellum [page 397]
1b. Leaves acuminate or abruptly apiculate to subulate from a broad apex; apical cells not different from mid-leaf cells ........................................................................................................2

2a. Leaves strongly 2-4 plicate, narrow-lanceolate; laminal cells elongated, ± uniform throughout leaf.........................Homalothecium nevadense [page 395]
2b. Leaves plicate or smooth, ovate to broad or narrow-lanceolate; laminal cells near leaf base shorter and wider than cells above.................................3

3a. Plants synoicous, capsule erect and symmetrical or nearly so, cilia usually short or rudimentary................................. Brachytheciastrum fendleri [page 401]

3b. Plants autoicous, capsule curved and asymmetrical, cilia well-developed..................4

4a. Leaves usually ± abruptly acuminate, strongly concave; branches usually julaceous and leaves closely imbricate; alar cells quadrate and forming a well-defined group; median cells of stem leaves 25–50 × 6–7 µm, 4–8:1

.............................................................. Brachytheciastrum collinum [page 399]

4b. Leaves ± gradually acuminate, less strongly concave; branches not julaceous, leaves erect to spreading; quadrate alar cells few or not forming a well-defined group; median cells of stem leaves 45–100 × 5–6 µm, 9–15:1

.......................................................... Brachytheciastrum olympicum [page 403]

Key to Orthotrichum

1a. Leaves gradually acute and ending in hyaline awn

.......................................................... Orthotrichum diaphanum [page 379]

1b. Leaves obtuse, acute, acuminate, or cuspidate, not ending in hyaline awn..............2

2a. Basal leaf cells elongate, ± nodose, thick-walled, stomata superficial ............3

2b. Basal leaf cells rectangular, not nodose, thin-walled; stomata immersed.........4

3a. Capsule cylindric, fully exserted; endostome well-developed; calyptra hairs not reaching the top.................................................. Orthotrichum laevigatum [page 375]

3b. Capsule usually oblong and immersed to emergent; endostome lacking to rudimentary; calyptra with hairs reaching over the top
4a. Exostome teeth reflexed or recurved, finely papillose, rarely striate at tips; capsule 8-ribbed; plants usually growing on the bark of trees

.......................................................................................................................... Orthotrichum pumilum [page 382]

4b. Exostome teeth erect or spreading, striate, reticulate, papillose-striate, or papillose-reticulate; capsule with 8 or 16 ribs; plants usually growing on rocks

.......................................................................................................................... 5

5a. Capsule exserted and cylindrical, mostly with 8 long ribs alternating with 8 short ones; distal laminal cells 1-stratose......................... Orthotrichum anomalum [page 384]

5b. Capsule immersed to emergent, ovate or oblong; with 8 or 16 ± uniform ribs; distal laminal cells sometimes 2-stratose.......................................................... 6

6a. Capsule with 16 ribs, ovate; leaves ovate-lanceolate, only remotely keeled, acute ................................................................. Orthotrichum cupulatum [page 386]

6b. Capsule with 8 ribs, oblong or oblong-ovate; leaves lanceolate to ligulate, distally keeled, obtuse to bluntly acute........... Orthotrichum hallii [page 388]

Key to the Bryaceae

1a. Plants silver-green or white, distal lamina hyaline, including apiculus or awn; distal lamina cells elongate hexagonal to rhomboidal, proximal cells quadrate to short-rectangular, transition often abrupt; dioicous ................................................................. 2

1b. Plants green or yellow-green; distal lamina cells short to long, proximal cells variously quadrate, short- to long-rectangular, transition abrupt or not; dioicous or monoicous .................................................................................................................. 3

2a. Plants hoary white, stems evenly foliate, slender, costa strong, excurrent
in stout awn, somewhat recurved when dry; leaf axis bulbils lacking

...........................................................................................................Bryum lanatum [page 367]

2b. Plants silver to silver-green, stems julaceous to gemmiform, costa not reaching apex, apiculus usually present or sometimes absent, irregularly incurved when dry; leaf axis bulbils present ......................................Bryum argenteum [page 365]

3a. Distal lamina cells mostly 2–4:1, the same length or shorter than the short- to long-rectangular proximal cells; stems comose, to evenly foliate; leaves twisted to strongly contorted when dry; limbidium usually present, often strong, 1- or 2-stratose; rhizoidal tubers and leaf axil filiform gemmae, sometimes present, bulbils absent ......4

3b. Distal lamina cells 3–6:1, longer than the quadrate or short-rectangular proximal cells; stems gemmiform or elongate and evenly foliate; leaves imbricate, not contorted or twisted when dry, or if somewhat twisted then rhizoidal tubers present; limbidium absent or weak, 1-stratose; rhizoidal tubers and leaf axil bulbils often present ..........5

4a. Filiform gemmae present in axils of upper innovation leaves; leaves irregularly twisted to contorted when dry... Rosulabryum flaccidum [page 361]

4b. Filiform gemmae absent; leaves regularly spirally twisted around stem when dry .................................................................Rosulabryum capillare [page 359]

5a. Plants medium-sized, stems 1–3 cm, evenly foliate; leaves 1–3.5 mm; tubers if present on rhizoids arising from leaf axils, scarce, sometimes absent

..........................................................................................................................Imbribriyum gemmiparum [page 363]

5b. Plants small, stems mostly less than 1 cm, gemmiform to evenly foliate; leaves 0.5–2.5 mm; leaf axil bulbils often present, tubers if present on long rhizoids in substratum or at base of stem, often abundant............................................................6
6a. Plants with rhizoidal tubers commonly present, often abundant, at stem base in clusters or on long rhizoids in substrate; stems comose to evenly foliate, leaves mostly slightly twisted when dry ... *Gemmabryum violaceum* [page 369]

6b. Plants with leaf axil bulbils, tubers rarely present, or gemmae absent; stems evenly foliate or gemmiform, often in two or more clumps; leaves imbricate, not twisted when dry.................................................................7

7a. Plants lacking bulbils, costa long-excurrent, sometimes ± hyaline, subalar group of inflated pink cells present on distal fertile stem leaves ................................................................................................................. *Gemmabryum kunzei* [page 371]

7b. Plants with bulbils, costa percurrent to short-excurrent as a stout awn; subalar group of inflated pink cells absent................................. *Gemmabryum dichotomum* [page 373]

**Key to the Grimmiaceae**

1a. Dioicous; costa in transverse section often possessing stereids and/or substereids; laminal cells usually consistently and strongly sinuose to sinuose-nodulose, including the elongate basal cells...........................................................................................................2

1b. Autoicous or dioicous; costa in transverse section lacking stereids (hydroids common but substereids rarely present); laminal cells often only weakly sinuose ....................3

2a. Multicellular gemmae on abaxial side of leaf lamina in distal leaves; leaves crisped and contorted when dry ...................... *Dryptodon torquatus* [page 214]

2b. Clusters of gemmae absent or in obscure clusters in leaf axils; leaves straight when dry.........................................................*Dryptodon meridionalis* [page 212]

3a. Costal cells in cross-section scarcely differentiated; capsule immersed; columella usually attached to operculum and deciduous with it; calyptra very small, not fully
covering the operculum; seta straight, not twisted when dry.................................4

3b. Costal cells in cross-section somewhat differentiated, hydroids common; capsule
immersed to exserted; columella not attached to operculum; calytra small to
covering over 1/2 the capsule; seta straight, sigmoid or arcuate, twisted when dry.....7

4a. Costa excurrent as a long, fleshy, multistratose apiculus, sometimes tipped
with a tiny denticulate awn ...............*Schistidium cinclidodonteum* [page 242]

4b. Costa sub-percurrent or excurrent as an awn, never as a fleshy, multistratose
apiculus ..........................................................................................................................5

5a. Lamina unistratose except for 1–2 rows of cells on the margins; exothecial cells in
central and lower parts of urn predominantly isodiametric and transversely elongated
........................................................................................................................................ Schistidium lancifolium [page 248]

5b. Lamina bistratose across most of the distal portion or in longitudinal striae; exothecial
cells predominantly oblong.........................................................................................6

6a. Plants bright yellowish-green; upper lamina mostly unistratose with thickened
margins and occasional bistratose striae; hyaline hairpoints long and stout
.................................................................................................................................*Schistidium ambiguum* [page 246]

6b. Plants dark-green to blackish colored; upper lamina mostly bistratose; hyaline
hairpoints absent or short and very spinose ...... *Schistidium* sp. nov. [page 244]

7a. Costae in cross-section hardly thicker than lamina with the lateral margins poorly
demarcated from the leaf lamina.................................................................................8

7b. Costae in cross-section at least twice as thick as lamina with the lateral margins well
demarcated ...................................................................................................................10

8a. Costa abruptly expanded and flattened in the unistratose basal portion of leaf;
costa at base eight or more cells wide; basal cells except for a few juxtacostal
ones not at all elongate; alar cells numerous, mostly transversely elongate
........................................................................................................... Grimmia laevigata [page 231]

8b. Costa not so expanded and flattened; basal and alar cells not transversely
elongate ........................................................................................................................................... 9

9a. Leaves ovate-lanceolate from an ovate base, rounded shoulders usually prominent;
capsules exserted .............................................................. Grimmia ovalis [page 229]

9b. Leaves oblong-ovate to oblong-lanceolate, shoulders not prominent; capsules
immersed ........................................................................ Grimmia poecilostoma [page 220]

10a. Leaf margins plane to incurved throughout with not even a trace of basal
recurvature ........................................................................................................................................ 11

10b. Leaf margins reflexed to recurved on at least one side at least near base...... 15

11a. Lamina mostly unistratose but often with bistratose margins and longitudinal striae;
autoicous; capsules common, immersed; seta sigmoid and eccentrically attached .... 12

11b. Leaves 2–3-stratose distally; dioicous (or rarely autoicous); capsules not common,
emergent to exserted; seta straight and centrally attached .............................................. 13

12a. Plants dull, olive-green; leaves ± concave, cross-section at mid-leaf almost
flat; distal lamina unistratose with uni- or bistratose margins; peristome
present; annulus absent ........................................ Grimmia plagiopodia [page 218]

12b. Plants blackish-green; leaves more prominently keeled; distal
lamina unistratose with bistratose margins (bistratose patches and
longitudinal striae also often present); peristome absent; annulus present
........................................................................................................ Grimmia anodon [page 216]
13a. Leaves spreading when moist, hydrophobic (plants rehydrate slowly); distal laminal cells often bulging; basal juxtacostal and marginal cells quadrate to short-rectangular, basal areolation relatively uniform; medial laminal cells quadrate to short-rectangular, thin-walled ............................................................................ *Grimmia alpestris* [page 222]

13b. Leaves erect-patent when moist, hydrophilic (plants rehydrate quickly); distal laminal cells not bulging; basal juxtacostal and marginal cells quadrate to long-rectangular, basal areolation uniform or heterogeneous; medial laminal cells irregularly quadrate to rounded, thick-walled .............................................................. 14

14a. Leaves linear-lanceolate; basal areolation heterogeneous, marginal cells quadrate to short-rectangular, juxtacostal cells more elongate; capsules exserted; operculum obliquely rostrate; peristome fully developed; dioicous ......................................................................................... *Grimmia montana* [page 224]

14b. Leaves ovate-lanceolate; basal areolation homogeneous, all cells ± short-rectangular; capsules emergent; operculum mammillate; peristome varously reduced or absent; probably autoicous? ............... *Grimmia jamesii* [page 224]

15a. Distal lamina mostly bistratose with wide bistratose margins; costa with four or more guide cells at insertion, reniform in cross-section; seta straight; calyptra covering only up to 1/3 of the capsule .............................................................. *Grimmia longirostris* [page 227]

15b. Distal lamina mostly unistratose with unistratose or narrowly bistratose margins; costa narrower and ± terete at insertion ..................................................................................... 16

16a. Basal marginal cells without thickened transverse walls; seta straight; calyptra large, covering at least 1/2 of capsule, campanulate-mitrate, plicate ........................................................................ *Grimmia calyptrata* [page 235]
16b. Basal marginal cells with thickened transverse walls; seta arcuate to cygneous when moist; calyptra less than 1/2 length of capsule, cucullate or mitrate, not plicate .................................................................17

17a. Basal marginal laminal cells quadrate to short-rectangular; gonioautoicous; operculum rostrate; peristome teeth mostly entire; calyptra mitrate .......................................................... Grimmia pulvinata [page 233]

17b. Basal marginal laminal cells short- to long-rectangular; cladautoicous; operculum conical to mammillate; peristome teeth cribrose; calyptra cucullate .........................18

18a. Hyaline awns present on most distal leaves; basal juxtacostal cells with thick, nodulose walls; distal lamina and margins usually unistratose; growing on basic substrates.......................................................... Grimmia orbicularis [page 238]

18b. Hyaline awns only present on the enlarged perichaetial leaves; basal juxtacostal cells with thin, straight walls; distal lamina with bistratose margins and bistratose patches; growing on acidic substrates .......................................................... Grimmia moxleyi [page 240]

Key to the Pottiaceae

1a. Leaves linear, lingulate or lanceolate, margins ± plane to incurved or involute, upper laminal cells KOH yellow to orange; costa subpercurrent to shortly excurrent as a mucro; adaxial costal epidermis without lamellae or filaments [Trichostomoideae] ....2

1b. Leaves lanceolate, ovate, ligulate or spathulate, margins usually recurved or sometimes plane; upper laminal cells KOH yellow to red; costa subpercurrent to excurrent as a long hairpoint; adaxial costal epidermis sometimes with lamellae or filaments..............................................................................................................7
2a. Adaxial surface of leaf strongly keeled, deeply grooved along the costa; costa with a single stereid band......................... *Anoectangium handelii* [page 259]

2b. Adaxial surface of leaf plane to broadly concave or only shallowly grooved along the costa; costa with two stereid bands, at least in robust plants ..........3

3a. Leaves long-ligulate, ± concave, apex rounded-obtuse to broadly acute; plants very small, dioicus, rarely fruiting; peristome absent; usually growing in calcareous seeps and springs ........................................................................................................... *Gymnostomum* [page 165]

3b. Plants larger; monoicus or dioicus; peristome often present; usually growing on dry soil or rock ........................................................................................................................................4

4a. Leaf margins usually plane to erect or weakly incurved; plants dioicus ........5

4b. Leaf margins involute or rarely merely incurved at margins; plants monoicus ..................................................................................................................................................6

5a. Distal leaf margins regularly to irregularly denticulate-serrulate; perichaetia lateral; marginal cells differentiated from both basal and distal laminal cells, rising from leaf insertion to beyond mid-leaf in a narrow band............ *Pleurochaete luteola* [page 265]

5b. Distal leaf margins ± entire; perichaetia terminal; marginal cells when differentiated comprised of basal cells usually rising ± laterally ............. *Tortella alpicola* [page 267]

6a. Annulus well-developed, formed of 2–3 rows of inflated, deciduous cells; perichaetal leaves sheathing................................. *Pottiopsis sweetii* [page 269]

6b. Annulus absent to poorly developed; perichaetal leaves sheathing or not ...................................................................................................................... *Weissia* [page 166]

7a. Leaves usually broadly lanceolate to narrowly elliptical, occasionally broadly ligulate; costa usually with two stereid bands; long hyaline hairpoints uncommon; clavate
gemmae commonly present; stem sclerodermis often well differentiated, cells of
central cylinder usually abruptly larger than other stem cells [Barbuloideae] ..........8

7b. Leaves usually broadly ligulate to spathulate, with one stereid band in the costa; long
hyaline hairpoints common; clavate gemmae rare; stem sclerodermis commonly not
or poorly differentiated, cells of central cylinder intergrade in size with cortical cells
[Pottioideae]..................................................................................................................13

8a. Costa ± flattened and adorned with many multicellular filaments

..........................................................................................................................Aloina [page 166]

8b. Costa not flattened, filaments absent........................................................................9

9a. Plants very small, less than 3 mm high, gametophyte bulbiform

..........................................................................................................................Microbryum starckeanum [page 320]

9b. Plants larger, ± evenly foliate.................................................................................10

10a. Axillary hairs with a brownish proximal cell; leaves often only
weakly papillose, proximal cells usually not well differentiated

..........................................................................................................................Didymodon [page 166]

10b. Axillary hairs usually of all clear cells; leaves usually distinctly papillose,
proximal cells often enlarged, hyaline, and thin-walled.................................11

11a. Costal adaxial cells longitudinally elongate 3:1 or more

..........................................................................................................................Barbula unguiculata [page 277]

11b. Costal adaxial cells quadrate to very short-rectangular, occasionally in many layers

..........................................................................................................................12

12a. Superficial walls of distal laminal cells (in section) strongly convex
to bulging on both sides; KOH color reaction of distal laminal cell
walls essentially yellow or orange, occasionally with red blotches

.......................................................................................... *Pseudocrossidium obtusulum* [page 275]

12b. Superficial walls of distal laminal cells (in section) flat or very

weakly convex on both sides; KOH color reaction of distal

laminal cell walls essentially red, usually a definite brick red

.......................................................................................... *Bryoerythrophyllum recurvirostrum* [page 279]

13a. Costa flattened, and often adaxially convex, stereid band usually reniform,

abaxial epidermis usually absent; lamina reacts brick-red to 2% KOH solution

................................................................................................................*Syntrichia* [page 168]

13b. Costa rounded in section or semicircular, stereid band semicircular or rounded,

abaxial epidermis usually present; lamina reacts yellow to 2% KOH solution (basal
cells blush red occasionally) ........................................................................................................14

14a. Adaxial costal epidermis differentiated as lamellae, filaments or a ±

prominent pad of cells four or more cells wide making the costa ± terete in

cross-section...............................................................................................................................15

14b. Adaxial costal epidermis not strongly differentiated, usually only two cells

wide................................................................................................................................................17

15a. Adaxial costal epidermis differentiated as a ± prominent pad of cells four or more
cells wide; laminal cells multipapillose ......................... *Tortula* [in part, page 170]

15b. Adaxial costal epidermis differentiated as lamellae or filaments; laminal cells smooth

or with a single, indistinct simple papillum per cell ...................................................................16

16a. Costa with lamellae (sometimes partly with filaments as well)

.......................................................................................................................... *Pterygoneurum* [page 169]
16b. Costa without lamellae, filaments present .................. *Crossidium* [page 169]

17a. Sporophytes immersed, capsules cleistocarpic, peristome absent

.............................................................................................................. *Phascum cuspidatum* [page 322]

17b. Sporophytes exserted, capsules stegocarpic, peristome present ......................... 18

18a. Urn < 2.5 mm, sometimes cernuous, sometimes nodding to pendant;

peristome of 16 teeth becoming divided into filaments above; spores > 13 μm,
coarsely papillose to verrucose-tuberculate .... *Desmatodon guepinii* [page 351]

18b. Urn usually 2.5–6 mm, erect; peristome of 32 ± twisted teeth, usually with

high basal membrane .................................................. *Tortula* [in part, page 170]

**Key to Gymnostomum**

1a. Cauline long-rectangular or long-elliptical to broadly lanceolate, apex

often acute, 0.5–1.5(–2) mm; distal adaxial costal epidermal cells quadrate
to very short-rectangular, obscure; plants usually not forming a dense
turf; exothecial cells flat or weakly convex, usually 20–25(–30) μm wide

.............................................................................................................. *Gymnostomum aeruginosum* [page 262]

1b. Cauline leaves long-rectangular to short-elliptic, usually 0.3–0.6 mm; distal adaxial
costal epidermal cells short-rectangular to elongate (occasionally short-rectangular or
quadrate in robust plants); plants often forming a dense turf; exothecial cells usually
bulging, commonly 30–40 μm wide ................................................................. 2

2a. Gemmae nearly always present in leaf axils, biseriate, elliptical to obovate;

leaves short-elliptic or ovate, 0.3–0.4(–0.6) mm; plants dark green above;
capsules short-cylindric, wide-mouthed, lacking a circumstomal collar; leaves

.................................................................................................................. *Gymnostomum viridulum* [page 262]
2b. Gemmae very rare, uniseriate; leaves rectangular to elliptic, occasionally ovate, 0.4–0.6 mm; plants light green above, capsules elliptic, narrow-mouthed, with a distinct circumstomal collar

..............................................................................................................*Gymnostomum calcareum* [page 262]

**Key to Weissia**

1a. Capsules without peristome, epiphragm present; leaves long-elliptic or ligulate, base little wider than distal lamina, apex rounded-acute; papillae low, about 1.5–2.5 μm high; costa 40–65(–84) μm wide at base .................. *Weissia ligulifolia* [page 272]

1b. Capsules with at least a rudimentary peristome, epiphragm lacking; leaves ovate-lanceolate, apex acute to narrowly acute; costa (60−)70–100 μm wide near base

.....................................................................................................................*Weissia andrewsii* [page 272]

**Key to Aloina**

1a. Leaf apex piliferous, with whitish hairpoint 0.2–1.6 mm long; costa undifferentiated, stereid band absent...............................................................*Aloina bifrons* [page 300]

1b. Leaf apex cucullate, hairpoint lacking; costa strongly differentiated, formed by 3–6 abaxial stereid layers.........................................................*Aloina ambigua* [page 298]

**Key to Didymodon**

1a. Costa with elongate superficial adaxial cells; leaves ligulate to ovate-lanceolate, apex often obtuse; laminal cells unistratose, usually smooth or rarely weakly papillose; plants usually growing in calcareous springs and seeps

.....................................................................................................................*Didymodon tophaceus* [page 295]

1b. Costa with quadrate or occasionally short-rectangular superficial adaxial cells (or if elongate then distal laminal cells bistratose); plants mostly growing on dry soil or
2a. Leaves adaxially very widely channeled medially or merely slightly concave across leaf, apex seldom apiculate by a conical cell, costa percurrent or excurrent as a multicellular, stout mucro, margins plane to recurved below mid-leaf.  

2b. Leaves adaxially with a narrow medial channel about the width of the costa at least at leaf apex, apex often apiculate by one or more conical cells, costa usually percurrent, margins usually recurved, often to near the apex.  

3a. Distal lamina bistratose totally or just along margins; basal cells strongly differentiated, hyaline, thin-walled and ± inflated; plants usually blackish-green with leaves strongly contorted when dry.  

3b. Distal lamina unistratose or occasionally bistratose in small patches; basal cells usually not differentiated; plants usually bluish-green with leaves only somewhat twisted when dry.  

4a. Leaves deltoid to short-lanceolate or ovate, to 1.5 or rarely to 2 mm, margins recurved or revolute to near apex, propagula sometimes present.  

4b. Leaves short- to long-lanceolate or long-triangular, to 4 mm, margins recurved near base or up to proximal 2/3 of leaf, propagula rare.  

5a. Costal section showing adaxial epidermal cells thin-walled, remainder of costa thick-walled; costa blunt apically, costa wider at mid-leaf than below, with a bulging adaxial surface forming a long-elliptic unistratose pad of cells, guide cells in 2(–3) layers, leaf margins loosely revolute.  

5b. Costal section showing all cells about equally thickened; costa often with an apical
conical cell or costa short-excurrent, costa gradually narrowing distally, adaxial surface nearly flat and not forming a wide pad of cells (but costa occasionally thickened and bulging adaxially), guide cells usually in one layer, leaf margins narrowly to loosely recurved ............................... *Didymodon brachyphyllus* [page 281]

6a. Leaves mostly unistratose (sometimes bistratose in small areas or patches marginally) ........................................................... *Didymodon vinealis* [page 287]

6b. Leaves bistratose marginally or medially or both.........................................................7

7a. Leaves long-ovate to broadly lanceolate, seldom narrowly acute, apex usually blunt to broadly acute, not caducous, margins smooth and bistratose marginally in one to several rows or rarely across leaf in distal leaf half or occasionally only in patches
........................................................................................................... *Didymodon nicholsonii* [page 283]

7b. Leaves long-lanceolate, apex narrowly acute, sometimes ± caducous, margins bistratose in 1–2 rows distally to near base, often evenly and broadly crenulate beyond leaf base or weakly notched ....................... *Didymodon eckeliae* [page 285]

**Key to Syntrichia**

1a. Plants with clusters of brood leaves (asexual propagules) at shoot apex
........................................................................................................... *Syntrichia pagorum* [page 304]

1b. Plants lacking clusters of brood leaves .................................................................2

2a. Leaf lamina bistratose to multistratose throughout or in patches, especially on the margins or in the upper third............... *Syntrichia caninervis* [page 309]

2b. Leaf lamina unistratose throughout ........................................................................3

3a. Costa with hydroids; stem with central strand (sometimes weakly developed) ..........4

3b. Costa without hydroids; stem without central strand.............................................5
4a. Hair point ± smooth; plants autoicous; usually growing on wood

.................................................................Syntrichia laevipila [page 306]

4b. Hair point spinose; plants synoicous; substrates various

.................................................................Syntrichia princeps [page 315]

5a. Costa in transverse section with 1–2(–3) dorsal stereid rows; leaves sometimes
constricted at midleaf; margins plane to slightly recurved, the recurvature usually
ending well below the apex............................................Syntrichia virescens [page 302]

5b. Costa in transverse section with (2–)3–6 dorsal stereid rows; leaves not constricted at
midleaf; margins recurved up to the upper third or up to the leaf apex...............6

6a. Papillae on mid-lamina cells pedicellate, 5–12.5(–15) µm high

.................................................................Syntrichia papillosissima [page 313]

6b. Papillae on mid-lamina cells not pedicellate, 2.5–5 µm high.........................7

7a. Leaf margins revolute up to the upper third or sometimes less; leaves usually
spreading or patent when wet; hyaline leaf base smaller, 1/5–1/4 the leaf length

.................................................................Syntrichia calcicola [page 318]

7b. Leaf margins revolute up to the apex or near the apex, leaves usually
squarrose-recurved when wet; hyaline leaf base large, 1/3–1/4 the leaf length

.................................................................Syntrichia ruralis [page 311]

Key to Pterygoneurum

1a. Capsule immersed in leaves or emergent on a very short seta

.................................................................Pterygoneurum subsessile [page 348]

1b. Capsule exerted above leaves on an elongate seta...Pterygoneurum ovatum [page 348]

Key to Crossidium
1a. Upper and median cells of lamina thick-walled, the lumens nearly obliterated toward leaf margin; terminal cell of filament conical with 1–5 high papillae .................2

1b. Upper and median cells of lamina not thick-walled, the lumens not obliterated; terminal cell of filament variable .................................................................3

2a. Capsule ovoid-cylindric; peristome teeth 250–1160 µm long, strongly twisted; operculum long-rostrate; seta 7–20 mm long, loosely twisted; leaves sometimes with distinct basal margin of elongated, thin-walled cells ........................................... Crossidium squamiferum var. squamiferum [page 343]

2b. Capsule short-cylindrical; peristome 198–520 µm long, cribose, nearly straight; operculum short-conical; seta (3.9–)5–8(–9.0) mm long, ridged, strongly twisted; marginal cells similar to adjacent cells, not forming a distinct margin ......................... Crossidium squamiferum var. pottioideum [page 345]

3a. Upper cells of lamina with 4–6(–8) usually bifurcate papillae; terminal cell of filament generally subspherical........................................ Crossidium seriatum [page 335]

3b. Upper cells of lamina with 1–2(–3) usually simple papillae; terminal cell of filament subspherical or not .................................................................4

4a. Supracostal filaments 1–2(–3) cells high ....... Crossidium aberrans [page 338]

4b. Supracostal filaments up to 12 cells high..... Crossidium crassinerve [page 340]

Key to Tortula

1a. Adaxial costal epidermis not strongly differentiated, usually only two cells wide........2

1b. Adaxial costal epidermis with a prominent pad four or more cells wide making the costa ± terete in cross-section .................................................................3

2a. Leaf margins recurved from near the base to the apex; upper and middle
laminal cells densely papillose.......................... *Tortula inermis* [page 325]

2b. Leaf margins recurved only near the base; upper and middle laminal cells ± smooth (rarely with inconspicuous papillae) ... *Tortula mucronifolia* [page 327]

3a. Costal pad many cells wide, consisting of a single layer of rectangular cells much taller than wide................................................................. *Tortula atrovirens* [page 329]

3b. Costal pad 4 to many cells wide, consisting of 2–4 layers of ± quadrate or irregularly shaped cells .................................................................................................................... 4

4a. Costal pad with short, irregular filament-like growths, free from each other for a few cells in height ..............................................[see *Crossidium*, page 169]

4b. Costal pad lacking filament-like growths, merely bulging adaxially, the cells not free of each other .................................................................................................................. 5

5a. Peristome basal membrane 150–200 μm; spores ca. 10–13 μm; leaf border absent; usually growing on soil........................................ *Tortula brevipes* [page 332]

5b. Peristome basal membrane to 50 μm; spores 8–12 μm; leaf border sometimes present; usually growing on rock.......................... *Tortula muralis* [page 332]

Collecting Locations

14-May-2007; South Ridge of Lime Kiln Mountain, Virgin Mountains (Sandstone hoodoos east of monument boundary sign on county 242); UTM: 11S 0767216E 4058950N (NAD83, ±0.8m); Elev: 1491.6 m; Habitat: Pinyon-Juniper-Apache Plume

14-May-2007; South Ridge of Lime Kiln Mountain, Virgin Mountains (Draw below sandstone hoodoos east of monument boundary sign on county 242); UTM: 11S
0767217E 4058918N (NAD83, ±3.4m); Elev: 1483.7 m; Habitat: Pinyon-Juniper-
Apache Plume-Manzanita

14-May-2007; East Virgin Peak Ridge, Virgin Mountains (Sandstone-limestone junction
on hillside west of monument boundary sign); UTM: 11S 0767156E 4058729N
(NAD83, ±6m); Elev: 1519 m; Habitat: Pinyon-Juniper-Manzanita

15-May-2007; East Virgin Peak Ridge, Virgin Mountains (Quartzite boulder on ridge
south of Lime Kiln Canyon); UTM: 11S 0765248E 4058178N (NAD83, ±3m);
Elev: 1729.5 m; Habitat: Pinyon-Juniper-Ceanothus

15-May-2007; East Virgin Peak Ridge, Virgin Mountains (North-facing limestone cliffs
on ridge south of Lime Kiln canyon); UTM: 11S 0765342E 4058120N (NAD83,
±4m); Elev: 1768.7 m; Habitat: Pinyon-Rock Spirea

15-May-2007; Springs Above Hecs Hole, Virgin Mountains (Old guzzler and cottonwood
at stream junction); UTM: 11S 0764410E 4058021N (NAD83, ±3m); Elev: 1655
m; Habitat: Chaparral-Riparian

15-May-2007; Springs Above Hecs Hole, Virgin Mountains (Fin of metamorphic rock);
UTM: 11S 0764816E 4057852N (NAD83, ±4m); Elev: 1594 m; Habitat: Pinyon-
Juniper-Riparian

15-May-2007; Springs Above Hecs Hole, Virgin Mountains; UTM: 11S 0764892E
4057592N (NAD83, ±3m); Elev: 1528.6 m; Habitat: Chaparral-Riparian

16-May-2007; Gypsum Outcrop Along County Road 101, Hungry Valley; UTM: 12S
0232119E 4051945N (NAD83, ±2m); Elev: 1172.4 m; Habitat: Joshua Tree-
Blackbrush

16-May-2007; N of the Cockscomb Along County Road 111, Hungry Valley; UTM:
12S 0231675E 4041763N (NAD83, ±3m); Elev: 988.6 m; Habitat: Joshua Tree-Creosote Bush

16-May-2007; Cutbank along Road to Tassi Spring, Grand Wash Valley; UTM: 12S 0233130E 4019024N (NAD83, ±3m); Elev: 538 m; Habitat: Creosote Bush

17-May-2007; North-facing Side Canyon to Snap Canyon, Grand Wash Cliffs; UTM: 12S 0245653E 4011943N (NAD83); 995 m; Habitat: Acacia-Riparian-Selaginella

17-May-2007; N-facing Cliffs at Mouth of Snap Canyon, Grand Wash Cliffs; UTM: 12S 0242858E 4012485N (NAD83, ±9m); Elev: 771.8 m; Habitat: Creosote-Acacia

18-May-2007; North-facing Cliffs Along BLM Road 1007, Grand Wash Valley; UTM: 12S 0235116E 4030469N (NAD83, ±4m); Elev: 631 m; Habitat: Creosote-Ambrosia

18-May-2007; Narrow Side Canyon Along BLM Road 1007, Black Canyon; UTM: 12S 0251020E 4057146N (NAD83); 1195 m; Habitat: Riparian-Cliff

29-May-2007; Draw Southeast of Summit of Mt. Trumbull, Uinkaret Mountains; UTM: 12S 0308847E 4030078N (NAD83, ±3m); Elev: 2286.1 m; Habitat: Ponderosa Pine-Oak

29-May-2007; N-facing Cliffs Along Summit of Mt. Trumbull, Uinkaret Mountains; UTM: 12S 0309099E 4031424N (NAD83, ±6m); Elev: 2350.8 m; Habitat: Oak-Cliff

29-May-2007; Upper Section of Mount Trumbull Trail, Uinkaret Mountains; UTM: 12S 0308393E 4031405N (NAD83, ±10m); Elev: 2412.3 m; Habitat: Ponderosa Pine Forest

29-May-2007; Lower Section of Mount Trumbull Trail, Uinkaret Mountains; UTM: 12S
0307619E 4029530N (NAD83, ±10m); Elev: 2065.7 m; Habitat: Pinyon-Juniper Forest

30-May-2007; Southeast Slopes of Mount Logan, Uinkaret Mountains; UTM: 12S
0303480E 4025455N (NAD83, ±3m); Elev: 2208.7 m; Habitat: Pine-Oak Forest

30-May-2007; East-facing Cliffs of Mount Logan, Uinkaret Mountains; UTM: 12S
0302468E 4025764N (NAD83, ±5m); Elev: 2286.8 m; Habitat: Oak-Cliff

31-May-2007; N-facing Cliffs Along Summit of Mt. Logan, Uinkaret Mountains; UTM: 12S
0301963E 4026449N (NAD83, ±8m); Elev: 2324.6 m; Habitat: Oak-Cliff

31-May-2007; Campsite Southeast of Mount Logan, Uinkaret Mountains; UTM: 12S
0302615E 4025599N (NAD83, ±7m); Elev: 2269.5 m; Habitat: Ponderosa Pine Forest

1-Jun-2007; Draw East of Petty Knoll, Uinkaret Mountains; UTM: 12S 0304055E 4023606N (NAD83, ±7m); Elev: 2086.9 m; Habitat: Pinyon-Juniper Forest

1-Jun-2007; North End of Little Spring Lava Flow, Uinkaret Mountains; UTM: 12S
0305997E 4028116N (NAD83, ±2m); Elev: 2013.6 m; Habitat: Lava Bed

24-Jun-2007; Death Valley Lake, Sawmill Mountains; UTM: 12S 0298209E 4026466N (NAD83, ±4m); Elev: 2087.9 m; Habitat: Pine-Oak Forest

25-Jun-2007; Death Valley Spring, Sawmill Mountains; UTM: 12S 0297086E 4027733N (NAD83, ±5m); Elev: 1979.5 m; Habitat: Pine-Oak-Riparian

25-Jun-2007; Wash at South End of Hurricane Cliffs, Sawmill Mountains; UTM: 12S
0295662E 4030867N (NAD83, ±3m); Elev: 1885.5 m; Habitat: Pinyon Pine-Oak

25-Jun-2007; South End of Hurricane Cliffs; UTM: 12S 0295770E 4031572N (NAD83, ±9m); Elev: 1892 m; Habitat: Pinyon-Juniper
26-Jun-2007; Whitmore Trail Near Monument Boundary, Whitmore Canyon; UTM: 12S 0301526E 4002839N (NAD83, ±8m); Elev: 771.6 m; Habitat: Creosote-Ocotillo-Ferrocactus

26-Jun-2007; Cane Spring Canyon, West Fork; UTM: 12S 0298033E 4003456N (NAD83, ±4m); Elev: 894.4 m; Habitat: Creosote-Acacia

26-Jun-2007; Cane Spring, Cane Spring Canyon; UTM: 12S 0298349E 4003369N (NAD83, ±8m); Elev: 895.6 m; Habitat: Springhead

27-Jun-2007; Whitmore Canyon Narrows, Whitmore Canyon; UTM: 12S 0300559E 4005268N (NAD83, ±10m); Elev: 864.8 m; Habitat: Acacia-Cliff

29-Jun-2007; Parashant Canyon Narrows, Parashant Canyon; UTM: 12S 0290183E 4003707N (NAD83, ±6m); Elev: 774 m; Habitat: Acacia-Sandbar

30-Jun-2007; Parashant Canyon Narrows at Copper Mountain Mine Tributary; UTM: 12S 0290722E 4004501N (NAD83, ±15m) m; Habitat: Elev: 822.8; Acacia-Sandbar

30-Jun-2007; Parashant Canyon Narrows below Frog Spring; UTM: 12S 0291348E 4004835N (NAD83, ±16m); Elev: 847 m; Habitat: Sandbar with Beargrass

30-Jun-2007; Frog Spring, Parashant Canyon; UTM: 12S 0292554E 4004970N (NAD83, ±4m); Elev: 962.6 m; Habitat: Mixed Shrub

30-Jun-2007; Stock Tank Along Road to Frog Spring above Cane Spring Canyon; UTM: 12S 0296895E 4003814N (NAD83, ±3m); Elev: 1152 m; Habitat: Leaky Stock Tank Wall

1-Jul-2007; Basalt Outcrop near Bundy Cabin, Whitmore Canyon; UTM: 12S 0299614E 4007563N (NAD83, ±6m); Elev: 1038.8 m; Habitat: Creosote-Ephedra

1-Jul-2007; Upper Trail Canyon, Shivwits Plateau; UTM: 12S 0290664E 4019979N
24-Aug-2007; Rocks near Summit of Mt. Dellenbaugh, Shivwits Plateau; UTM: 12S 0271222E 3999018N (NAD83, ±6m); Elev: 2132.6 m; Habitat: Pinyon-Juniper

25-Aug-2007; Upper Snap Canyon, Shivwits Plateau; UTM: 12S 0253117E 4005388N (NAD83, ±7m); Elev: 1725 m; Habitat: Pinyon-Oak-Juniper

25-Aug-2007; Upper Pigeon Canyon, Shivwitz Plateau; UTM: 12S 0264100E 4017836N (NAD83, ±6m); Elev: 1719.2 m; Habitat: Pinyon-Oak-Juniper

26-Aug-2007; Last Chance Knoll, Hidden Hills; UTM: 12S 0256480E 4031705N (NAD83, ±6m); Elev: 2055.2 m; Habitat: Pinyon-Juniper

26-Aug-2007; Upper Hidden Canyon, Shivwitz Plateau; UTM: 12S 0269206E 4032388N (NAD83, ±3m); Elev: 1805 m; Habitat: Pinyon-Juniper

27-Aug-2007; Sandstone Bluffs near Red Rock Spring, Hungry Valley; UTM: 11S 0765808E 4050029N (NAD83, ±4m); Elev: 1218.3 m; Habitat: Pinyon-Juniper

28-Aug-2007; Rocks near Summit of Black Rock Mountain, Virgin Mountains; UTM: 12S 0249636E 4073428N (NAD83, ±9m); Elev: 2210.9 m; Habitat: Ponderosa Pine-Oak-Pinyon-Juniper Ecotone
Species Accounts

Marchantiophyta

Asterella californica (Hampe) Underw.

Distribution

Arizona, California, Mexico, Nevada and Oregon

Habitat

chaparral, oak woodlands and desert canyons

Distinctive Characters

thalloid growth form, elevated carpocephala with large longitudinally slit pseudoperianth

Similar Species

The only other thalloid liverwort found on the monument was Targionia which is easily separated by the large 2-valved apical involucres that are usually present.

Other similar species in the genera Mannia and Reboulia are usually separated by the appendages of the ventral scales.

Illustrations

Figure 12 – Figure 14, Howe (1899)
Figure 12. Habit, dry (Brinda, 1677)
Figure 13. Habit, wet (Brinda, 1677)
Figure 14. Old carpocephala, showing pseudoperianth (Brinda, 1677)
Targonia sp. nov. A.T. Whittemore ined.

Distribution

Mojave Desert

Habitat

chaparral, oak woodlands and desert canyons

Distinctive Characters

thalloid growth form, large 2-valved apical involucres

Similar Species

The distinctive involucres are only found in species of Targonia. Although usually included in the widespread species T. hypophylla, Mojave Desert populations actually represent an undescribed species (Whittemore 2009). There appear to be cryptic species in this complex that will require more detailed work in order to understand them (Bączkiewicz et al. 2005, Boisselier-Dubayle & Bischler 1999).

Illustrations

Figure 15 – Figure 16, Schuster (1992b)
Figure 15. Dry habit, showing involucres (Brinda, 1679)
Figure 16. Habit, wet (Brinda, 1679)
Radula complanata (L.) Dumort. subsp. complanata

Distribution

widespread throughout the northern hemisphere

Habitat

epiphytic or saxicolous (found here on shaded rock)

Distinctive Characters

single large oil body per cell, marginal gemmae, underleaves lacking

Similar Species

Frullania is similar but has underleaves.

Illustrations

Figure 18 – Figure 17, Damsholt (2002)
Figure 17. Habit, dry (Brinda, 1802)

Figure 18. Leaf margin, showing gemmae and large oil bodies (Brinda, 1802)
Frullania inflata Gottsche

Distribution

temperate and subtropical northern hemisphere

Habitat

epiphytic or saxicolous (found here on shaded rock)

Distinctive Characters

complicate-bilobed leaves with bilobed underleaves

Similar Species

Radula is similar but lacks underleaves.

Illustrations

Figure 19, Schuster (1992a)
Figure 19. Habit, dry (Brinda, 1763)
Bryophyta

*Timmia bavarica* Hessl.

**Distribution**

temperate northern hemisphere

**Habitat**

shaded organic soil

**Distinctive Characters**

large, dark green, crisped leaves; one of the larger mosses on the monument

**Similar Species**

Reminiscent of Polytrichaceae in the field but lacking leaf lamellae.

**Illustrations**

Figure 20, Flowers (1973)

**Synonyms**

*Timmia megapolitana* subsp. *bavarica* (Hessl.) Brassard

Budke & Goffinet (2006) provide good evidence for recognizing *T. bavarica* at
the species level.
Figure 20. Habit, dry (Brinda, 1849)
*Encalypta intermedia* Jur.

**Distribution**
western North America and central Asia (true extent unclear due to confusion with other species)

**Habitat**
montane areas at intermediate elevations; usually in rock crevices

**Distinctive Characters**
large calyptra that encloses the capsule when young; leaves never with an elongate hairpoint; very small, quadrate to oblate interior basal cells

**Similar Species**
*Encalypta vulgaris* has a similar leaf shape but the interior basal cells are more elongate. Also sometimes confused with *Encalypta rhaptocarpa* but in that species the leaves are apiculate to long awned and the peristome is ± well-developed.

**Illustrations**
Figure 21 – Figure 25, Agnew & Vondráček (1975)

**Synonyms**
*Encalypta vulgaris* var. *mutica* sensu Flowers (1973, pl. 41, figs. 6-12)
Figure 21. Stems, dry (Brinda, 2133)
Figure 22. Leaf (Brinda, 2133)

Figure 23. Basal cells of leaf (Brinda, 2133)

Figure 24. Closer view of basal cells (Brinda, 2133)
Figure 25. Habit, dry (Brinda, 2133)
*Encalypta vulgaris* Hedw. var. *vulgaris*

**Distribution**

widespread in temperate regions

**Habitat**

montane areas at intermediate elevations; usually on soil

**Distinctive Characters**

large calyptra that encloses the capsule when young; leaves never with an elongate hairpoint; rectangular to elongate interior basal cells

**Similar Species**

*Encalypta intermedia* has a similar leaf shape but the interior basal cells are very small and quadrate to oblate. Also sometimes confused with *Encalypta rhaptocarpa* but in that species the leaves are apiculate to long awned and the peristome is ± well-developed.

**Illustrations**

Figure 26 – Figure 28, Agnew & Vondráček (1975), Horton (1994)
Figure 26. Habit, dry (Brinda, 2041)

Figure 27. Basal cells of leaf (Brinda, 2041)
Figure 28. Leaf (Brinda, 2041)
Funaria hygrometrica Hedw. var. hygrometrica

Distribution

truly cosmopolitan (found on all seven continents)

Habitat

in desert areas restricted to wet springs and seeps

Distinctive Characters

long, often twisted setae and sulcate capsules with oblique mouth

Similar Species

Funaria muhlenbergii var. lineata is much smaller and its capsules are not sulcate.

In Funaria calvescens the capsules are often nearly erect and have a noticeably wider mouth.

Illustrations

Figure 29 – Figure 32, Flowers (1973)
Figure 29. Capsule, dry (Brinda, 1629)

Figure 30. Peristome teeth (Brinda, 1629)
Figure 31. Habit, dry (Brinda, 1629)

Figure 32. Leaf (Brinda, 1792)
*Funaria muhlenbergii* var. *lineata* Grout

**Distribution**

the variety *lineata* may be restricted to the desert southwest

**Habitat**

seasonally moist soil

**Distinctive Characters**

small, ephemeral plants with capsules bent at a 90° angle

**Similar Species**

This plant is related to *Entosthodon pulchellus* but has a less developed capsule and peristome (Brugués 2000, Crundwell & Nyholm 1974, Fife 1985).

**Illustrations**

Figure 33 – Figure 36, Flowers (1973)
Figure 33. Capsule, dry (Brinda, 1629)
Figure 34. Peristome teeth (Brinda, 1629)
Figure 35. Habit, dry (Brinda, 1629)  
Figure 36. Leaf (Brinda, 1792)
**Hymenoloma mulahacenii** (Höhn.) Ochyra

**Distribution**

western North America, Europe, and central Asia

**Habitat**

on rock and wood in montane forests

**Distinctive Characters**

longitudinal striae on leaf lamina (reliably present but sometimes faint); bistratose lamina

**Similar Species**

*Dicranoweisia cirrata* lacks striae while *Hymenoloma crispulum* has a unistratose lamina. Flowers (1956) noted the distinctness of these plants but most workers up until the present (Schofield 2007) have not given them taxonomic status. Ochyra et al. (2008) noted that plants with bistratose lamina referred to *Dicranoweisia crispula* by North American authors actually represent *Hymenoloma mulahacenii*.

**Illustrations**

Figure 37 – Figure 39, Abramova & Abramova (1972, as *Dicranoweisia intermedia*), Rams Sanchez (2008)

**Synonyms**

*Oreoweisia mulahacenii* Höhn., *Dicranoweisia intermedia* J.J. Amann

*Dicranoweisia contermina* Renauld & Cardot is probably also a synonym, the name *Hymenoloma mulahacenii* has priority.
Figure 37. Habit, dry (Brinda, 1906)

Figure 38. Leaf, cross-section (Brinda, 1906)
Figure 39. Capsule, dry (Brinda, 1776)
*Jaffueliobryum rauui* (Austin) Thér.

**Distribution**
western North America

**Habitat**
dry rock (found here on sandstone)

**Distinctive Characters**
immersed capsules with large calyptrae; bright green, ovate leaves

**Similar Species**
The leaves of *Jaffueliobryum wrightii* are more abruptly rounded to a longer hairpoint. Species of Grimmiaceae often have laminal cells walls that are sinuose, at least in part.

**Illustrations**
Figure 40, Spence (2007)

**Synonyms**
*Grimmia rauui* Austin, *Coscinodon rauui* (Austin) Lesq. & James, *Grimmia wrightii* var. *rauui* (Austin) Habeeb
Figure 40. Leaf (Brinda, 1569)
**Jaffueliobryum wrightii** (Sull.) Thér.

**Distribution**

North and South America, Asia

**Habitat**

dry rock (here prefering volcanic substrates)

**Distinctive Characters**

immersed capsules with large calyptrae; bright green, ovate leaves

**Similar Species**

The leaves of *Jaffueliobryum raui* are more gradually tapered to a shorter hairpoint. Species of Grimmiaceae often have laminal cells walls that are sinuose, at least in part.

**Illustrations**

Figure 41 – Figure 42, Spence (2007)

**Synonyms**

*Coscinodon wrightii* Sull., *Grimmia wrightii* (Sull.) Austin
Figure 41. Habit, dry (Brinda, 1725)
Figure 42. Leaf (Brinda, 1725)
*Dryptodon meridionalis* (Müll. Hal.) Ochyra & Žarnowiec

**Distribution**

Mediterranean Europe (not usually separated from *Dryptodon trichophyllus* in North America)

**Habitat**

dry rock (found here on sandstone)

**Distinctive Characters**

dioicous sexuality, strongly sinuose laminal cells, and keeled leaves

**Similar Species**

This species is similar to *Dryptodon trichophyllus* but the guide cells in the costa are narrowly elliptical and arranged obliquely to the leaf axis (Maier 2002, 2010). *Dryptodon* is a segregate genus of *Grimmia* with strong molecular support (Hernández-Maqueda et al. 2008a, 2008b).

**Illustrations**

Figure 43, Maier (2002, 2010; as *Grimmia meridionalis*)

**Synonyms**

*Grimmia trichophylla var. meridionalis* Müll. Hal., *Grimmia meridionalis* (Müll. Hal.) E. Maier
Figure 43. Habit, dry (Brinda, 2213)
Dryptodon torquatus (Drumm.) Brid.

Distribution

widespread in the Northern Hemisphere (but nowhere abundant)

Habitat

shaded rock (here found on basalt)

Distinctive Characters

yellow-green contorted leaves and brown gemmae

Similar Species

Grimmia incurva also has contorted leaves but it lacks gemmae. Dryptodon is a segregate genus of Grimmia with strong molecular support (Hernández-Maqueda et al. 2008a, 2008b).

Illustrations

Figure 44, Ignatova & Muñoz (2004, as Grimmia torquata)

Synonyms

Grimmia torquata Drumm.
Figure 44. Habit, dry (Brinda, 1770)
*Grimmia anodon* Bruch & Schimp.

**Distribution**

sub-cosmopolitan (mostly northern hemisphere)

**Habitat**

dry calcareous rock

**Distinctive Characters**

immersed capsules, lacking peristome and with setae attached off-center; lamina with bistratose patches or striae

**Similar Species**

*Grimmia plagiopodia* has a well-developed peristome and a mostly unistratose lamina.

**Illustrations**

Figure 45, Ignatova & Muñoz (2004)
Figure 45. Habit, dry (Brinda, 2124)
Grimmia plagiopodia Hedw.

Distribution

sub-cosmopolitan (widespread but scattered)

Habitat

dry calcareous rock (preferring sandstone)

Distinctive Characters

immersed capsules, with peristome and setae attached off-center; lamina
unistratose or bistratose on margins only

Similar Species

Grimmia americana also has a well-developed peristome but the leaf lamina is
entirely bistratose.

Illustrations

Figure 46, Ignatova & Muñoz (2004)
Figure 46. Habit, dry (Brinda, 2184)
Grimmia poecilostoma Cardot & Sebille

Distribution

widespread but scattered in the northern hemisphere

Habitat

neutral to acidic rock (here found on sandstone)

Distinctive Characters

wide, flattened, and bright white hairpoints strongly contrasting with thick, blackish-green leaves

Similar Species

Separation from Grimmia tergestina is not possible without sporophytes (these were not found on the monument), however G. tergestina has yet to be confirmed for North America.

Illustrations

Figure 47 – Figure 48, Ignatova & Muñoz (2004)

Synonyms

Grimmia tergestina var. poecilostoma (Cardot & Sebille) Loeske, Grimmia crinitoleucophaea Cardot

FNA (2007) uses the name Grimmia crinitoleucophaea but this is incorrect according to R. Hastings (personal communication).
Figure 47. Field aspect, dry (Brinda, 1570)

Figure 48. Habit, dry (Brinda, 1570)

**Distribution**

widespread in the northern hemisphere

**Habitat**

acidic rock

**Distinctive Characters**

dense cushions of glaucous-green plants; homogeneous, short rectangular basal cells

**Similar Species**

*Grimmia montana* is darker green and its basal cells are heterogeneous. Plants of *G. montana* also more readily absorb water on rehydration while *G. alpestris* is somewhat hydrophobic.

**Illustrations**

Figure 49 – Figure 50, Ignatova & Muñoz (2004)
Figure 49. Habit, dry (Brinda, 1780)

Figure 50. Basal cells of leaf (Brinda, 1780)
Grimmia montana Bruch & Schimp. & Grimmia jamesii Austin

Distribution
widespread in the northern hemisphere

Habitat
dry acidic rock

Distinctive Characters
dense cushions of blackish-green plants; heterogeneous, rectangular basal cells

Similar Species
Grimmia jamesii is used here to refer to plants in the Grimmia montana complex with basal cells that are more or less uniform, are cladautoicous, have mamillate opercula, and variously reduced peristomes. These plants were referred to Grimmia ungeri Jur. by Muñoz (1998), however Greven (2003) illustrates G. ungeri as gonioautoicous and claims it is endemic to Cyprus. Grimmia jamesii would appear to be the name with priority if G. ungeri is excluded from North America (Muñoz & Pando 2000).

Illustrations
Figure 51 – Figure 52 (Grimmia montana) Figure 53 (Grimmia jamesii), Ignatova & Muñoz (2004)

Synonyms
Grimmia montana var. truncata Lesq. & James, Grimmia brachyodon Austin,
Grimmia montana var. brachyodon (Austin) Lesq. & James, Grimmia montana var. idahensis Renauld & Cardot, Grimmia microtricha Müll. Hal. & Kindb., Grimmia pseudomontana Cardot & Thér.
Figure 51. Habit, dry (Brinda, 1760)

Figure 52. Basal cells of leaf (Brinda, 1760)
Figure 53. Basal cells of leaf (Brinda, 2228)
Grimmia longirostris Hook.

Distribution
sub-cosmopolitan

Habitat
neutral and acidic rock

Distinctive Characters
autoicous and usually bearing numerous exserted, cylindrical capsules; lamina bistratose

Similar Species
Grimmia ovalis is dioicous and its leaves have more well-defined shoulders.

Illustrations
Figure 54, Ignatova & Muñoz (2004)

Synonyms
Grimmia affinis Hornsch.
Figure 54. Habit, dry (Brinda, 1830)
Grimmia ovalis (Hedw.) Lindb.

**Distribution**

widespread in the northern hemisphere

**Habitat**

dry acidic rock

**Distinctive Characters**

flattened, weakly differentiated costa; leaves ovate-lanceolate

**Similar Species**

See notes under *Grimmia longirostris* and *G. laevigata*.

**Illustrations**

Figure 55, Ignatova & Muñoz (2004)
Figure 55. Habit, dry (Brinda, 1764)
Grimmia laevigata (Brid.) Brid.

**Distribution**
sub-cosmopolitan

**Habitat**
dry acidic rock

**Distinctive Characters**
flattened, weakly differentiated costa; leaves oblong to ovate with quadrate to tranversely elongate basal cells

**Similar Species**
The leaves of *Grimmia ovalis* have well-defined shoulders and rectangular basal cells.

**Illustrations**
Figure 56, Ignatova & Muñoz (2004)
Figure 56. Habit, dry (Brinda, 2058)
Grimmia pulvinata (Hedw.) Sm.

Distribution

sub-cosmopolitan

Habitat

dry rock

Distinctive Characters

elliptic, keeled leaves with long awns; usually bearing numerous arcuate sporophytes

Similar Species

The leaves of Grimmia orbicularis are completely unistratose and have more elongate basal cells.

Illustrations

Figure 57, Ignatova & Muñoz (2004)
Figure 57. Habit, dry (Brinda, 1868)
*Grimmia calyptrata* Drumm.

**Distribution**
western North America

**Habitat**
dry rock

**Distinctive Characters**
sporophytes with large calyptra covering over half the capsule; elongate, thin-walled inner basal cells

**Similar Species**
Sterile plants can be confused with *Grimmia pulvinata* but have elongate, thin-walled inner basal cells.

**Illustrations**
Figure 58 – Figure 59, Hastings (1999, as *Coscinodon calyptratus*)

**Synonyms**

*Coscinodon calyptratus* (Drumm.) C.E.O. Jensen

*Grimmia calyptrata* appears to be unrelated to the plicate-leaved *Coscinodon cribrosus* and is better placed in the genus *Grimmia* despite its unusual calyptra (Hernández-Maqueda et al. 2008a, 2008b).
Figure 58. Habit, dry (Brinda, 1794)
Figure 59. Habit, dry (Brinda, 1794)
*Grimmia orbicularis* Bruch

**Distribution**

sub-cosmopolitan

**Habitat**

usually on dry calcareous rock (here also found on gypsum and highly calcareous soils)

**Distinctive Characters**

leaf unistratose throughout; usually bearing numerous arcuate sporophytes

**Similar Species**

*Grimmia moxleyi* has awns only on the perichaetial leaves and its lamina is partly bistratose.

**Illustrations**

Figure 60, Ignatova & Muñoz (2004)
Figure 60. Habit, dry (Brinda, 1685)
Grimmia moxleyi R.S. Williams

Distribution

southwestern United States, Baja California, and northwestern Mexico

Habitat

dry acidic rock

Distinctive Characters

muticous leaves contrasting sharply with the long-awned perichaetial leaves

Similar Species

The lamina of Grimmia orbicularis is unistratose throughout and most of its leaves bear long awns.

Illustrations

Figure 61, Hastings & Greven (2007)
Figure 61. Habit, dry (Brinda, 1712)
Schistidium cinclidodonteum (Müll. Hal.) B. Bremer

**Distribution**

western North America and Europe

**Habitat**

seasonally wet rock

**Distinctive Characters**

long falcate leaves with thick, fleshy apiculus; lamina bistratose distally with bistratose strips extending to the leaf base along the costa

**Similar Species**

The lamina of Schistidium occidentale is mostly unistratose.

**Illustrations**

Figure 62, Flowers (1973)

**Synonyms**

Grimmia cinclidodonte Müll. Hal., Grimmia pacifica E. Lawton
Figure 62. Habit, dry (Brinda, 1761)
Schistidium sp.nov. H.H. Blom ined.

**Distribution**

unclear, but at least in California, Nevada, and Arizona

**Habitat**

dry rock in desert canyons

**Distinctive Characters**

blackish-green plants; awns (when present) short, stout and very spinose; leaves with mostly bistratose lamina and often somewhat squarrose when wet

**Similar Species**

According to H. Blom (personal communication) several species in the southwest mountains await formal description and clarification—until then identification is tentative. He has identified specimens from the monument as belonging to what are probably two undescribed species. The plants bear some resemblance to Schistidium crassipilum but more study is required in order to understand their taxonomic status.

**Illustrations**

Figure 63
Figure 63. Habit, dry (Brinda, 1728)
Schistidium ambiguum Sull.

Distribution

southwestern US (but true extent not yet well known)

Habitat

dry rock

Distinctive Characters

bright green, waxy-looking plants with stout, terete, whitish awns

Similar Species

Similar to some species in the Schistidium confertum group but usually with much more prominent awns.

Illustrations

Figure 64, Sullivant (1864)

Synonyms

Grimmia ambiguа (Sull.) Sull., Grimmia apocarpa var. ambiguа (Sull.) G.N. Jones
Figure 64. Habit, dry (Brinda, 1929)
Schistidium lancifolium (Kindb.) H.H. Blom

Distribution
widespread in the northern hemisphere

Habitat
dry rock

Distinctive Characters
dull, olive-green plants with awns mostly lacking or very short

Similar Species
Related to Schistidium apocarpum but with shorter peristome teeth. In Schistidium canadense the costa is excurrent as a yellowish, chlorophyllose awn (Ignatova et al. 2010).

Illustrations
Figure 65, Blom (1996)

Synonyms
Grimmia pseudorivularis subsp. lancifolia Kindb.
Figure 65. Habit, dry (Brinda, 1781)
**Fissidens bryoides** var. *pusillus* (Wilson) Pursell

**Fissidens exiguus** Sull.

### Distribution
widespread in the northern hemisphere

### Habitat
moist soil and seasonally wet rock

### Distinctive Characters
complanate leaves and vaginant lamina; clear, non-bulging laminal cells

### Similar Species
*Fissidens exiguus* is smaller than *F. bryoides* and striking in its complete lack of a marginal border. *Fissidens exiguus* may only be a form of *F. bryoides* var. *pusillus* (Pursell 1997). It shares with that species the clear, non-bulging laminal cells but is smaller and striking in its complete lack of a marginal border. *Fissidens obtusifolius* is an eastern North American species in which the costa often ends well below the more rounded apex. *Fissidens sublimbatus* on the other hand has obscure, bulging cells and a narrow marginal border on most leaves.

### Illustrations
Figure 66 – Figure 67 (*Fissidens bryoides*), Figure 68 (*Fissidens exiguus*), Crum & Anderson (1981)
Figure 66. Habit, dry (Brinda, 2241)

Figure 67. Leaf apex of *Fissidens bryoides* (Brinda, 2241)
Figure 68. Leaf apex of *Fissidens exigus* (Brinda, 1678)
*Fissidens sublimbatus* Grout

**Distribution**

western North America, South America, and Africa

**Habitat**

deeply shaded soil and seasonally wet rock

**Distinctive Characters**

small, bulging laminal cells and often truncate dorsal lamina

**Similar Species**

*Fissidens crispus* also has bulging cells but is larger and the leaves are craspate when dry.

**Illustrations**

Figure 69 – Figure 70, Pursell (1994)
Figure 69. Leaf apex (Brinda, 1637b)
Figure 70. Leaf (Brinda, 1637b)
*Ceratodon purpureus* (Hedw.) Brid. subsp. *purpureus*

**Distribution**

widespread in the northern hemisphere

**Habitat**

weedy species of various substrates but absent from low desert environments

**Distinctive Characters**

remarkably polymorphic and often fooling experienced bryologists; look for smooth, quadrate to irregularly shaped laminal cells and a slightly serrate margin near the leaf apex

**Similar Species**

Might be confused with *Didymodon* species but the laminal cells are smooth and the sporophytes distinctive.

**Illustrations**

Figure 71 – Figure 72, Flowers (1973)
Figure 71. Habit, dry (Brinda, 1863)
Figure 72. Sporophyte (Brinda, 1858)
Anoectangium handelii Schiffner

**Distribution**

southwestern US, Europe, and Asia

**Habitat**

rock crevices (usually sandstone)

**Distinctive Characters**

dense turfs of tiny plants growing in rock crevices; leaves with deep groove along the costa

**Similar Species**

Gymnostomum species grow in similar habitats but lack the deep costal groove of these plants.

**Illustrations**

Figure 73 – Figure 74, Zander & Weber (2005)
Figure 73. Habit, dry (Brinda, 1971)
Figure 74. Leaf (Brinda, 1971)
Gymnostomum aeruginosum Sm. var. aeruginosum

Gymnostomum calcareum Nees & Hornsch. var. calcareum

Gymnostomum viridulum Brid.

**Distribution**

sub-cosmopolitan

**Habitat**

rock crevices, usually where there is seasonal seepage of water

**Distinctive Characters**

dense turfs of tiny plants growing in rock crevices; leaves concave to ± flat

**Similar Species**

Because sporophytes are rare the three species of Gymnostomum are separated based of leaf size/shape and the presence/absence of asexual gemmae (refer to Zander et al. 2007).

**Illustrations**

Figure 75 & Figure 77 (Gymnostomum calcareum), Figure 78 (Gymnostomum aeruginosum), Figure 76 (Gymnostomum viridulum), Zander et al. (2007)
Figure 75. Habit, dry (Brinda, 1740)

Figure 76. Leaf (Brinda, 2008)

G. viridulum

Figure 76. Leaf (Brinda, 2008)
Figure 77. Leaf (Brinda, 1740)

Figure 78. Leaf (Brinda, 2029)
*Pleurochaete luteola* (Besch.) Thér.

**Distribution**

southern US to South America

**Habitat**

thin soil over calcareous rock (locally abundant on limestone ledges)

**Distinctive Characters**

large plants with undulate-crisped leaves; basal marginal cells strongly differentiated in a band that gradually tapers distally

**Similar Species**

*Tortella tortuosa* is similar but much smaller and its basal cells are differentiated the whole width of the leaf at its insertion.

**Illustrations**

Figure 79, Eckel (2007)

**Synonyms**

*Pleurochaete squarrosa* var. *luteola* (Besch.) R.H. Zander

*Pleurochaete* is closely related to *Tortella* and may belong to that genus (Grundmann et al. 2006).
Figure 79. Habit, dry (Brinda, 1962)
Tortella alpicola Dixon

Distribution

apparently widespread but actual distribution still not well known

Habitat

dry rock and rock crevices

Distinctive Characters

long, subulate leaf apices breaking off into several small pieces that serve as asexual propagules; stems with a central strand

Similar Species

The subula of Tortella fragilis falls as a single piece and its stems lack a central strand.

Illustrations

Figure 80, Eckel (1998)

Synonyms

Sarconeurum tortelloides S.W. Green, Tortella tortelloides (S.W. Greene) H. Rob., Tortella fragilis var. tortelloides (S.W. Greene) R.H. Zander & Hoe
Figure 80. Habit, dry (Brinda, 1872)
Pottiopsis sweetii (E.B. Bartram) Ros & O. Werner

Distribution

southwestern US

Habitat

shaded soil and rock crevices

Distinctive Characters

autoicous; leaf margins ± plane to erect near the apex; sheathing perichaetial leaves; well-developed annulus

Similar Species

Weissia species are similar but have inrolled margins and the annulus is absent or poorly-developed.

Illustrations

Figure 81 – Figure 83, Flowers (1973, as Weissia perligulata)

Synonyms

Weissia sweetii E.B. Bartram, Trichostomum sweetii (E.B. Bartram) L.R. Stark,

Weissia perligulata Flowers ex H.A. Crum, Trichostomum perligulatum (Flowers ex H.A. Crum) R.H. Zander

Zander (2007c) synonymized this species with Trichostomum planifolium (Dixon) R.H. Zander. However Ros & Werner (2007) showed the species to be distinct from both Trichostomum and Weissia and transferred it to the segregate genus Pottiopsis.
Figure 81. Habit, dry (Brinda, 2027)
Figure 82. Leaf (Brinda, 2027)

Figure 83. Perichaetial leaf (Brinda, 2027)
**Weissia andrewsii** E.B. Bartram

**Weissia ligulifolia** (E.B. Bartram) Grout

**Distribution**

southwestern US and adjacent Mexico

**Habitat**

shaded soil and rock crevices

**Distinctive Characters**

leaves incurved and contorted when dry, their margins inrolled; autoicous and often fruiting

**Similar Species**

The widespread *Weissia controversa* can be confused with *W. andrewsii* but its leaves are more lanceolate and the costa narrower.

**Illustrations**

Figure 84 – Figure 85 (*Weissia andrewsii*), Zander et al. (1994), Figure 86 (*Weissia ligulifolia*), Flowers (1973)

**Synonyms**

*Weissia andrewsii* is probably only a variety of *W. controversa*, however it differs enough from the typical expression of *W. controversa* to deserve some sort of taxonomic recognition. The thick costa and broader leaves have probably resulted in misidentification as *W. condensa* in the past but it is probably more closely related to *W. controversa* var. *crispata* (Bartram 1927, Nyholm 1956, Zander 1994).
Figure 84. Habit, dry (Brinda, 1643)
Figure 85. Leaf (Brinda, 1643)  

Figure 86. Leaf (Brinda, 2166)
Pseudocrossidium obtusulum (Lindb.) H.A. Crum & L.E. Anderson

Distribution
widespread but scattered in the northern hemisphere

Habitat
calcareous rock and soil

Distinctive Characters
tiny yellow-green plants with ovate leaves and revolute leaf margins

Similar Species
Pseudocrossidium replicatum also has revolute leaf margins but is larger and the leaves are lingulate to oblong-lanceolate. The leaves of P. crinitum have a stout yellowish awn.

Illustrations
Figure 87, Zander (2007a)

Synonyms
Pseudocrossidium revolutum var. obtusulum (Lindb.) B.C. Tan, R.H. Zander & J. Taylor
Figure 87. Habit, dry (Brinda, 2018)
Barbula unguiculata Hedw.

Distribution

sub-cosmopolitan

Habitat

on soil or gravel, often in disturbed areas

Distinctive Characters

leaves abruptly apiculate and contorted when dry

Similar Species

This plant could possibly be confused with species of Tortula but the leaves are more lanceolate.

Illustrations

Figure 88, Flowers (1973)
Figure 88. Habit, dry (Brinda, 1894)
Bryoerythrophyllum recurvirostrum (Hedw.) P.C. Chen var. recurvirostrum

Distribution
sub-cosmopolitan

Habitat
soil or rock

Distinctive Characters
large plants with distinct brick-red color and differentiated basal cells of the leaf

Similar Species
This plant could be confused with Didymodon species but the basal cells of the leaf are more strongly differentiated and the leaves are occasionally toothed near the apex.

Illustrations
Figure 89, Flowers (1973)
Figure 89. Habit, dry (Brinda, 1771)
Didymodon brachyphyllus (Sull.) R.H. Zander

**Distribution**

widespread but scattered

**Habitat**

soil and rock in arid regions

**Distinctive Characters**

plants with small ovate to ovate-lanceolate leaves and often bearing axillary gemmae

**Similar Species**

*Didymodon nicholsonii* is similar but lacks gemmae and the leaf is more strongly bistratose.

**Illustrations**

Figure 90, Zander & Ochyra (2001)

**Synonyms**

*Didymodon vinealis* var. *brachyphyllus* (Sull.) R.H. Zander
Figure 90. Habit, dry (Brinda, 2057b)
Didymodon nicholsonii Culm.

Distribution
widespread in the northern hemisphere

Habitat
soil and rock (possibly preferring more neutral to acidic substrates, here found on basalt)

Distinctive Characters
bistratose leaves with blunt to broadly acute apices

Similar Species
Didymodon eckelitae also has bistratose leaves but they are long-lanceolate with narrowly acute apices.

Illustrations
Figure 91, Smith (2004)

Synonyms
Didymodon trifarius subsp. nicholsonii (Culm.) Wijk & Margad., Didymodon vinealis var. nicholsonii (Culm.) R.H. Zander
Figure 91. Habit, dry (Brinda, 1853)
*Didymodon eckeliae* R.H. Zander

**Distribution**

western North America and Europe but possibly more widespread

**Habitat**

soil over rock and the bases of trees

**Distinctive Characters**

long-lanceolate leaves with notched, bistratose margins

**Similar Species**

*Didymodon vinealis* is similar but the leaf margins are entire and usually unistratose.

**Illustrations**

Figure 92, Zander (2001, 2007a)
Figure 92. Habit, dry (Brinda, 1768)
*Didymodon vinealis* (Brid.) R.H. Zander var. *vinealis*

**Distribution**

widespread in the northern hemisphere

**Habitat**

soil and rock

**Distinctive Characters**

triangular leaf shape; apex acute and usually capped with a single clear, conical cell

**Similar Species**

Might be confused with *Ceratodon* but the laminal cells are usually papillose and it occurs in lower desert environments than *Ceratodon*.

**Illustrations**

Figure 93, Zander et al. (1994)
Figure 93. Habit, dry (Brinda, 2049)
*Didymodon nevadensis* R.H. Zander

**Distribution**

western North America

**Habitat**

in our area restricted to soils with a high gypsum content

**Distinctive Characters**

plants twisted in tight coils and bearing a large costal pad reminiscent of *Tortula atrovirens*

**Similar Species**

*Pseudocrossidium crinitum* has a similarly coiled appearance but its leaves bear stout awns. *Tortula atrovirens* has a similar costal pad but the plants are rosulate and regularly fruiting.

**Illustrations**

Figure 94 – Figure 95, Zander et al. (1995)
Figure 94. Habit, dry (Brinda, 2045)

Figure 95. Field aspect (Brinda, 1650)
Didymodon rigidulus var. icmadophilus (Schimp. ex Müll. Hal.) R.H. Zander

Distribution
sub-cosmopolitan

Habitat
calcareous rock or sandy soil

Distinctive Characters
lanceolate leaves with the costa excurrent as a long subula

Similar Species

Didymodon rigidulus var. gracilis is similar but the subulae are shorter and more rigid.

Illustrations

Figure 96, Zander et al. (1994)

Synonyms

Didymodon icmadophila (Schimp. ex Müll. Hal.) K. Saito, Didymodon acutus var. icmadophila (Schimp. ex Müll. Hal.) R.H. Zander
Figure 96. Habit, dry (Brinda, 2044)
Didymodon australasiae (Hook. & Grev.) R.H. Zander var. australasiae

Distribution
sub-cosmopolitan

Habitat
soil and rock ledges (here more common in low desert environments)

Distinctive Characters
small, blackish-green plants with distinctly spirally twisted leaves

Similar Species
Didymodon umbrosus is similar but the leaves are long-lanceolate, smooth or weakly papillose, and with differentiated basal marginal cells.

Illustrations
Figure 97, Zander et al. (1994)

Synonyms
Trichostomopsis australasiae (Hook. & Grev.) H. Rob., Trichostomopsis fayae Grout
Figure 97. Habit, dry (Brinda, 1661)
*Didymodon tophaceus* (Brid.) Lisa

**Distribution**

sub-cosmopolitan

**Habitat**

wet seeps and springs

**Distinctive Characters**

blunt-leaved plants often growing in tufaceous deposits around springs

**Similar Species**

*Gymnostomum* and *Eucladium* also form tufaceous deposits but their leaves are generally more lanceolate.

**Illustrations**

Figure 98 – Figure 99, Zander et al. (1994)

**Synonyms**

*Didymodon trifarius* var. *tophaceus* (Brid.) Mont.
Figure 98. Dry habit, showing calcium deposits on old leaves (Brinda, 1642)
Figure 99. Field aspect (Brinda, 1642)
*Aloina ambigua* (Bruch & Schimp.) Limpr.

**Distribution**

sub-cosmopolitan

**Habitat**

calcareous rock and soil in arid regions

**Distinctive Characters**

thick, succulent leaves with ventral surface covered in filaments; hairpoint absent

**Similar Species**

*Aloina rigida* is similar but has differentiated basal marginal cells. The European *A. aloides var. aloides* has a peristome with basal membrane nearly absent and teeth frequently paired from base.

**Illustrations**

Figure 100 – Figure 101, Smith (2004)

**Synonyms**

*Aloina aloides var. ambigua* (Bruch & Schimp.) E.J. Craig
Figure 100. Habit, dry (Brinda, 2024)

Figure 101. Habit, wet (Brinda, 2024)
Aloina bifrons (De Not.) Delgad.

Distribution
sub-cosmopolitan

Habitat
soil in arid regions (here preferring strongly calcareous soils such as gypsum)

Distinctive Characters
thick, succulent leaves with ventral surface covered in filaments; hairpoint present; costa lacking stereid band

Similar Species
Crossidium species have hairpoints but the filaments on their leaves emanate from a narrower costa.

Illustrations
Figure 102, Flowers (1973)

Synonyms
Aloina pilifera (De Not.) H.A. Crum & Steere
Figure 102. Habit, dry (Brinda, 1652)
*Syntrichia virescens* (De Not.) Ochyra var. *virescens*

**Distribution**

widespread in the northern hemisphere (but generally not recognized as occurring in North America)

**Habitat**

here usually a species of rock crevices and shaded rock overhangs at mid elevations

**Distinctive Characters**

small, blackish-green plants with weakly recurved margins, weak costal stereid band, and lacking hydroids

**Similar Species**

*Syntrichia bartramii* is similar but its lamina is bistratose in patches.

**Illustrations**

Figure 103, Kramer (1988)

**Synonyms**


Kramer (1988) reported *Syntrichia virescens* from North America [as *Tortula virescens*] but this has unfortunately been mostly ignored by North American authors (Mishler 2007).
Figure 103. Habit, dry (Brinda, 1795)
*Syntrichia pagorum* (Milde) J.J. Amann

**Distribution**

sub-cosmopolitan

**Habitat**

usually epiphytic but occasionally on rock or soil

**Distinctive Characters**

rosulate plants bearing many small brood leaves at the stem apices; dioicous

**Similar Species**

*Syntrichia laevipila* is closely related but is autoicous and typically lacks brood leaves.

**Illustrations**

Figure 104 – Figure 105, Zander et al. (1994)

**Synonyms**


Recently this species has been synonymized with *Syntrichia laevipila* (Gallego et al. 2004, Mishler 2007) however the two species are not difficult to separate in our area and there are still good reasons for recognizing them both (Stone 1971).
Figure 104. Habit, dry (Brinda, 2211)

Figure 105. Brood leaf (Brinda, 2211)
Syntrichia laevipila Brid. var. laevipila

Distribution

sub-cosmopolitan

Habitat

bark of trees (here found on decaying wood)

Distinctive Characters

epiphytic habit and the long, smooth to faintly spinose awn

Similar Species

Syntrichia papillosa is also epiphytic and blackish-green but bears spherical gemmae on the adaxial costal surface and the cells are unipapillose only on the abaxial surface.

Illustrations

Figure 106 – Figure 107, Zander (1993)

Synonyms

Tortula laevipila (Brid.) Schwägr., Syntrichia ruralis var. laevipila (Brid.) Spreng.
Figure 106. Habit, dry (Brinda, 1923)
Figure 107. Leaf (Brinda, 1923)
*Syntrichia caninervis* Mitt. var. *caninervis*

**Distribution**

sub-cosmopolitan

**Habitat**

calcareous soils

**Distinctive Characters**

bistratose lamina; costa with substereids; dorsal surface of costa near apex with tall papillae

**Similar Species**

Depauperate plants of *Syntrichia ruralis* differ in costal anatomy and have unistratose leaves.

**Illustrations**

Figure 108, Mishler (2007)

**Synonyms**

*Tortula caninervis* (Mitt.) Broth., *Tortula bistratosa* Flowers
Figure 108. Habit, dry (Brinda, 1671)
Syntrichia ruralis (Hedw.) F. Weber & D. Mohr var. ruralis

Distribution
sub-cosmopolitan

Habitat
soil, thin soil on rocks, and the bases of trees

Distinctive Characters
leaves spirally twisted when dry and rather strongly squarrose-recurved when moist

Similar Species
Syntrichia papillosissima is larger and has very tall antleroid papillae.

Illustrations
Figure 109, Crum & Anderson (1981)

Synonyms
Tortula ruralis (Hedw.) P. Gaertn., B. Mey. & Scherb.
Figure 109. Habit, dry (Brinda, 2082)
*Syntrichia papillosissima* (Copp.) Loeske

**Distribution**

widespread in the northern hemisphere

**Habitat**

soil and rock

**Distinctive Characters**

large plants with tall antleroid papillae creating a glaucous or frosted appearance

**Similar Species**

The recently described *Syntrichia sucrosa* also bears pedicellate papillae but has hydroids in its costa.

**Illustrations**

Figure 110 – Figure 111, Flowers (1973)

**Synonyms**

*Tortula papillosissima* (Copp.) Broth., *Tortula ruralis* var. *hirsuta* (Venturi) Paris,

*Syntrichia ruralis* var. *hirsuta* (Venturi) Podp.
Figure 110. Habit, dry (Brinda, 2209)

Figure 111. Cross-section of leaf showing the tall, antleroid papillae (Brinda, 2209)
**Syntrichia princeps** (De Not.) Mitt. var. *princeps*

**Distribution**

sub-cosmopolitan

**Habitat**

various substrates, here found mostly on soil

**Distinctive Characters**

large cell size, synoicous inflorescence, lingulate leaves, and costa with hydroids

**Similar Species**

*Syntrichia obtusissima* also has large cells but is autoicous and the back of the costa is ± smooth.

**Illustrations**

Figure 112-Figure 114, Flowers (1973)

**Synonyms**

*Tortula princeps* De Not.
Figure 112. Leaf (Brinda, 1644)
Figure 113. Habit, dry (Brinda, 1644)

Figure 114. Synoicous inflorescence (Brinda, 1644)
Syntrichia calcicola J.J. Amann

**Distribution**

widespread in the northern hemisphere (but generally not recognized as occurring in North America)

**Habitat**

on soil or rock (here found at higher elevations in forested areas)

**Distinctive Characters**

a weak costal stereid band making the leaves flexuose when dry and only patent to spreading when moist

**Similar Species**

*Syntrichia norvegica* is also found at higher elevations but it differs in its red hairpoints and the costal stereid band becoming so weak that near the leaf apex it often completely disappears.

**Illustrations**

Figure 115, Kramer (1988)

**Synonyms**

*Tortula calcicolens* W.A. Kramer, *Tortula ruralis* var. *calcicola* (J.J. Amann)

**Barkman**

Kramer (1988) reported *Syntrichia calcicola* from North America [as *Tortula calcicolens*] but this has unfortunately been mostly ignored by North American authors (Mishler 2007).
Figure 115. Habit, dry (Brinda, 2129)
Microbryum starkeanum var. brachyodus (Bruch & Schimp.) R.H. Zander

**Distribution**

arid regions in the northern hemisphere

**Habitat**

calcareous soil

**Distinctive Characters**

small, scattered, sporophytic plants on soil; reddish in 2% KOH solution

**Similar Species**

Small *Tortula* species are similar but actually not closely related. *Microbryum* is separated most easily from these species by its reddish reaction to a 2% KOH solution.

**Illustrations**

Figure 116, Zander (2007b)

**Synonyms**

*Pottia starckeana* (Hedw.) Müll. Hal., *Pottia arizonica* Wareham
Figure 116. Habit, dry (Brinda, 1676)
Phascum cuspidatum Hedw. var. cuspidatum

Distribution

sub-cosmopolitan

Habitat

on soil, often in disturbed areas

Distinctive Characters

ephemeral plants with immersed, cleistocarpous capsules

Similar Species

Stegonia hyalinotricha is similar but has whitish leaves like Bryum argenteum.

Illustrations

Figure 117 – Figure 118, Flowers (1973)

Synonyms

Tortula acaulon (With.) R.H. Zander, Phascum acaulon With., Pottia cuspidata (Hedw.) Mitt., Tortula atherodes R.H. Zander
Figure 117. Sporophyte (Brinda, 1895)
Figure 118. Habit, dry (Brinda, 1895)
Tortula inermis (Brid.) Mont.

**Distribution**

widespread in the northern hemisphere

**Habitat**

soil or rock (seems to prefer less calcareous substrates here)

**Distinctive Characters**

lingulate leaves without hairpoint that are strongly twisted around the stem when dry

**Similar Species**

*Tortula mucronifolia* is similar but its cells are smooth or very weakly papillose and the leaves usually have a short, yellowish mucro of variable length.

**Illustrations**

Figure 119, Flowers (1973)

**Synonyms**

*Syntrichia inermis* (Brid.) Bruch, *Tortula subulata* var. *inermis* (Brid.) Spruce
Figure 119. Habit, dry (Brinda, 1734)
Tortula mucronifolia Schwägr.

Distribution

widespread in the northern hemisphere

Habitat

soil or rock

Distinctive Characters

lingulate leaves with short yellowish mucro that are strongly twisted around the stem when dry

Similar Species

Tortula subulata is similar but its cells are more papillose and its leaves are bordered by thicker-walled cells. The leaves are shiny-green in contrast to the dull-green of Tortula inermis

Illustrations

Figure 120, Flowers (1973)

Synonyms

Syntrichia mucronifolia (Schwägr.) Brid., Tortula subulata var. mucronifolia (Schwägr.) Röhl.
Figure 120. Habit, dry (Brinda, 1635)
Tortula atrovirens (Sm.) Lindb.

Distribution
sub-cosmopolitan

Habitat
soil and rock

Distinctive Characters
small, rosulate plants with brownish leaves strongly twisted around the stem when dry; the massive costal pad is easily visible when wet

Similar Species
Superficially similar to Aloina ambigua when dry, although in that species the leaves are incurved, not spirally twisted around the stem.

Illustrations
Figure 121 – Figure 122, Zander (1993)

Synonyms
Desmatodon convolutus (Brid.) Grout
Figure 121. Habit, dry (Brinda, 1718)
Figure 122. Leaf (Brinda, 1718)
*Tortula muralis* Hedw. var. *muralis*

*Tortula brevipes* (Lesq.) Broth.

**Distribution**

sub-cosmopolitan (*Tortula muralis*), western North America (*Tortula brevipes*)

**Habitat**

rock (*Tortula muralis*), soil (*Tortula brevipes*)

**Distinctive Characters**

small plants on calcareous substrates with long, smooth, hyaline awns

**Similar Species**

*Tortula brevipes* is segregated from *T. muralis* based on the high basal membrane of its peristome and its preference for soil as a substrate. *Tortula plinthobia* is similar but has a reduced peristome of only 16 teeth and is found in fruit less frequently.

**Illustrations**

Figure 123 (*Tortula muralis*), Figure 124 (*Tortula brevipes*), Flowers (1973)
Figure 123. Habit, dry (Brinda, 2188)
Figure 124. Sporophyte of *T. brevipes* showing high basal membrane (Brinda, 1690)
Crossidium seriatum H.A. Crum & Steere

Distribution

western North America (reports from Europe are probably referable to Tortula brevissima)

Habitat

here restricted to highly calcareous soil (gypsum and tufa deposits of ancient springs)

Distinctive Characters

pluripapilllose cells combined with a pad of loose cells on the costa much like in Crossidium aberrans

Similar Species

This species is probably related to Tortula muralis but the costal pad of loose cells is more like that found in Crossidium.

Illustrations

Figure 125 – Figure 126, Delgadillo M. (2007)
Figure 125. Habit, dry (Brinda, 1669)
Figure 126. Leaf (Brinda, 1669)
Crossidium aberrans Holz. & E.B. Bartram

Distribution
widespread but scattered in the northern hemisphere

Habitat
soil and rock in arid regions

Distinctive Characters
cells smooth or with weak, simple papillae; costal pad of loose cells forming short filaments

Similar Species
Crossidium seriatum is similar but the cells are clearly pluripapillose.

Illustrations
Figure 127 – Figure 128, Zander et al. (1994)

Synonyms
Crossidium spatulifolium Holz. & E.B. Bartram
Figure 127. Habit, dry (Brinda, 2010a)

Figure 128. Leaf, showing filaments (Brinda, 2010a)
*Crossidium crassinerve* (De Not.) Jur. var. *crassinerve*

**Distribution**

widespread in the northern hemisphere

**Habitat**

soil and rock in arid regions

**Distinctive Characters**

leaves with long filaments borne on the costa; upper laminal cells not much differentiated

**Similar Species**

*Crossidium squamiferum* also has long filaments but its upper laminal cells have very thick walls.

**Illustrations**

Figure 129 – Figure 130, Delgadillo M. (2007)

**Synonyms**

*Crossidium desertorum* Holz. & E.B. Bartram, *Crossidium erosum* Holz. & E.B. Bartram
Figure 129. Leaf apex, showing filaments (Brinda, 1723a)
Figure 130. Leaf, showing filaments (Brinda, 1723a)
Crossidium squamiferum (Viv.) Jur. var. squamiferum

Distribution

widespread in the northern hemisphere

Habitat

soil and rock in arid regions

Distinctive Characters

leaves with long filaments borne on the costa; upper laminal cells differentiated with very thick cell walls obscuring the lumen; basal marginal cells elongate; seta > 7 mm and capsule cylindric

Similar Species

The variety pottioides has a shorter seta, ovoid-cylindric capsule, and lacks the elongate cells of the basal margin.

Illustrations

Figure 131 – Figure 132, Delgadillo M. (1975)

Synonyms

Crossidium succulentum Holz. & E.B. Bartram
Figure 131. Basal cells of leaf (Brinda, 2032)  

Figure 132. Sporophyte (Brinda, 2032)
Crossidium squamiferum var. pottioideum (De Not.) Mönk.

Distribution
widespread in the northern hemisphere

Habitat
soil and rock in arid regions

Distinctive Characters
leaves with long filaments borne on the costa; upper laminal cells differentiated with very thick cell walls obscuring the lumen; basal marginal cells not differentiated; seta 5-8 mm and capsule ovoid-cylindric

Similar Species
The bulbiform plants with succulent leaves are superficially similar to Pterygoneurum species but the leaves of Pterygoneurum bear lamellae.

Illustrations
Figure 133 – Figure 134, Delgadillo M. (1975)

Synonyms
Crossidium griseum (Jur.) Jur.
Figure 133. Sporophyte (Brinda, 1584)
Figure 134. Leaf (Brinda, 1584)
*Pterygoneurum ovatum* (Hedw.) Dixon

*Pterygoneurum subsessile* (Brid.) Jur. var. *subsessile*

**Distribution**

sub-cosmopolitan

**Habitat**

on soil

**Distinctive Characters**

small bulbiform plants with succulent leaves bearing lamellae on the costa;

usually forming dense, hoary turfs on exposed soil

**Similar Species**

In *Pterygoneurum subsessile* the capsules are immersed on very short setae.

**Illustrations**

Figure 135 (*Pterygoneurum ovatum*), Figure 136 (*Pterygoneurum cf. subsessile*),

Flowers (1973)
Figure 135. Dry habit, showing emergent sporophyte (Brinda, 1896)
Figure 136. Leaf (Brinda, 1668)
Desmatodon guepinii Bruch & Schimp.

Distribution

western North America and Europe

Habitat

on soil at low elevations

Distinctive Characters

small Tortula-like plants with a stout yellow to orangish awn; species of Desmatodon have a peristome of 16 teeth that become divided into filaments above

Similar Species

This species is smaller and the leaf border less papillose than in Desmatodon latifolius.

Illustrations

Figure 137 – Figure 138, Zander et al. (1994)

Synonyms

Tortula guepinii (Bruch & Schimp.) Broth.
Figure 137. Habit, dry (Brinda, 1662b)
Figure 138. Leaf (Brinda, 1662b)
*Hedwigia nivalis* (Müll. Hal.) Mitt.

**Distribution**

widespread, but with a more southern distribution

**Habitat**

here restricted to basalt outcrops at higher elevations

**Distinctive Characters**

blue-green plants with bright white leaf tips; immersed capsules with ciliate perichaetial leaves

**Similar Species**

*Hedwigia detonsa* of California is similar but has entire perichaetial leaves. Plants of *H. ciliata* var. *leucophaea* also have prominent, whitish leaf tips but their calyptrae are hairy and the upper leaf margins less incurved (Allen 2010).

**Illustrations**

Figure 139 – Figure 141, Allen (2010)

**Synonyms**

*Hedwigia subrevoluta* (Müll. Hal.) Mitt.
Figure 139. Habit, dry (Brinda, 2104)

Figure 140. Leaf (Brinda, 2104)
Figure 141. Apex of perichaetial leaf (Brinda, 2104)
Anacolia menziesii (Turner) Paris var. menziesii

Distribution
western North America

Habitat
rock or thin soil over rock

Distinctive Characters
clusters of dark rhizoids obscuring the stem; long-lanceolate, appressed leaves;
stems somewhat curved when dry

Similar Species
While difficult to distinguish gametophytically, Anacolia baueri has smaller
spores, a more cylindric capsule, and a different chromosome number.

Illustrations
Figure 142, Flowers (1952)

Synonyms
Bartramia menziesii Turner
Figure 142. Habit, dry (Brinda, 1765)
Rosulabryum capillare (Hedw.) J.R. Spence

Distribution

sub-cosmopolitan

Habitat

on shaded soil or rotting wood

Distinctive Characters

bordered, obovate leaves that are twisted around the stem when dry

Similar Species

Rosulabryum flaccidum is similar but bears filiform gemmae in the leaf axils and the leaves are not twisted around the stem when dry.

Illustrations

Figure 143 – Figure 144, Syed (1973), Zolotov (2000)

Synonyms

Bryum capillare Hedw., Plagiobryum capillare (Hedw.) N. Pedersen
Figure 143. Habit, dry (Brinda, 1693)

Figure 144. Dry habit, showing characteristic twisted leaves (Brinda, 1693)
*Rosulabryum flaccidum* (Brid.) J.R. Spence

**Distribution**

North America

**Habitat**

here found mainly on shaded rock or soil

**Distinctive Characters**

plants with filiform gemmae in the leaf axils and ovate leaves

**Similar Species**

*Rosulabryum laevifilum* is similar but is usually found on bark and has obovate leaves.

**Illustrations**

Figure 145, Spence (2011b)

**Synonyms**

*Bryum flaccidum* Brid., *Bryum capillare* var. *flaccidum* (Brid.) Bruch & Schimp.
Figure 145. Habit, dry (Brinda, 1832)
*Imbrityum gemmiparum* (De Not.) J.R. Spence

**Distribution**

North America and Mediterranean Europe

**Habitat**

calcareous springs and seeps

**Distinctive Characters**

dense turfs of yellow-green plants with broadly acute, imbricate leaves usually associated with desert seeps and springs

**Similar Species**

*Plagiobryoides* species are also found in springs (especially hot springs) but their areolation is more lax and the leaves are not imbricate when dry.

**Illustrations**

Figure 146, Flowers (1973)

**Synonyms**

*Bryum gemmiparum* De Not., *Bryum alpinum* subsp. *gemmiparum* (De Not.) Kindb.
Figure 146. Habit, dry (Brinda, 1628)
Bryum argenteum Hedw. var. argenteum

Distribution

duly cosmopolitan (found on all seven continents)

Habitat

soil, soil over rock, or rock crevices (often in disturbed areas)

Distinctive Characters

whitish or silvery appearance due to hyaline upper lamina; leaves apiculate but the costa not reaching the apex

Similar Species

In Bryum lanatum the costa is excurrent as a stout awn that is ± recurved when dry.

Illustrations

Figure 147, Spence (2011a)
Figure 147. Habit, dry (Brinda, 1645)
Bryum lanatum (P. Beauv.) Brid.

**Distribution**

probably cosmopolitan (but still unclear due to confusion with Bryum argenteum)

**Habitat**

soil, soil over rock, or rock crevices in arid regions

**Distinctive Characters**

whitish or silvery appearance due to hyaline upper lamina; leaves with costa excurrent in a stout awn that is ± recurved when dry

**Similar Species**

Other Bryaceae species from exposed sites that have chlorotic apices are regularly misidentified as Bryum argenteum s.lat.; these can usually be distinguished by their more yellowish coloration, especially in species with stout awns.

**Illustrations**

Figure 148, Spence & Ramsay (2002, as Anomobryum lanatum)

**Synonyms**

Bryum argenteum var. lanatum (P. Beauv.) Hampe, Anomobryum lanatum (P. Beauv.) J.R. Spence & H.P. Ramsay
Figure 148. Habit, dry (Brinda, 1898)
*Gemmabryum violaceum* (Crundw. & Nyholm) J.R. Spence

**Distribution**

probably widespread but incompletely known

**Habitat**

on soil, usually in disturbed areas

**Distinctive Characters**

weedy plants with small, red-purple to orange tubers contrasting with violet rhizoids

**Similar Species**

*Gemmabryum valparaisense* is similar but both the rhizoids and tubers are brownish.

**Illustrations**

Figure 150 – Figure 149, Zolotov (2000)

**Synonyms**

*Bryum violaceum* Crundw. & Nyholm, *Bryum radiculosum* fo. *violaceum*

(Crundw. & Nyholm) Margad. & During
Figure 150. Habit, dry (Brinda, 1899)

Figure 149. Rhizoidal tuber (Brinda, 1899)
Gemmabryum kunzei (Hornsch.) J.R. Spence

Distribution
probably widespread but incompletely known

Habitat
on exposed to shaded soil

Distinctive Characters
small plants forming dense yellow-green turfs on exposed soil; leaves imbricate with a stout, straight awn

Similar Species
Gemmabryum caespiticium is usually larger and has elongate median-distal laminal cells, to 4:1 or more (vs. 2-3:1 in G. kunzei).

Illustrations
Figure 151, Zolotov (2000)

Synonyms
Bryum kunzei Hornsch., Ptychostomum kunzei (Hornsch.) J.R. Spence, Bryum caespiticium subsp. kunzei (Hornsch.) Podp.
Figure 151. Habit, dry (Brinda, 1596)
*Gemmabryum dichotomum* (Hedw.) J.R. Spence & H.P. Ramsay

**Distribution**

sub-cosmopolitan

**Habitat**

on soil, usually in disturbed areas

**Distinctive Characters**

small plants forming loose yellow-green turfs on exposed soil; large bulbils borne singly in the leaf axils

**Similar Species**

*Gemmabryum kunzei* is similar but has more prominent awns and lacks bulbils.

**Illustrations**

Figure 152, Zolotov (2000)

**Synonyms**

*Bryum dichotomum* Hedw., *Bryum bicolor* Dicks., *Gemmabryum bicolor* (Dicks.)

J.R. Spence
Figure 152. Habit, dry (Brinda, 1697)
Orthotrichum laevigatum fo. macounii (Austin) E. Lawton & Vitt

Distribution
western North America (other forms also in Europe and Asia)

Habitat
acidic rock in coniferous forests

Distinctive Characters
robust plants with exserted, smooth, cylindrical capsules; basal cells elongate and nodulose

Similar Species
The typical form of Orthotrichum laevigatum has more obtuse leaves and lower papillae.

Illustrations
Figure 153, Flowers (1973, as Orthotrichum macounii)

Synonyms

Orthotrichum macounii Austin

Vitt (2009) synonymized Orthotrichum macounii with O. laevigatum. The plants examined from the monument have the leaf characters of O. macounii and may be better recognized as a variety of O. laevigatum.
Figure 153. Habit, dry (Brinda, 1612)
*Orthotrichum rupestre* Schleich. ex Schwägr.

**Distribution**
sub-cosmopolitan

**Habitat**
acidic rock in coniferous forests

**Distinctive Characters**
robust plants with immersed to emergent, smooth, oblong capsules; basal cells elongate and nodulose

**Similar Species**
Plants from our area belong to the form recognized by some authors as *Orthotrichum texanum* that differs from the typical form in peristome ornamentation.

**Illustrations**
Figure 154, Flowers (1973, as *Orthotrichum texanum*)

**Synonyms**
*Orthotrichum texanum* Sull. & Lesq.

Vitt (2009) synonymized *Orthotrichum texanum* with *O. rupestre*. The plants examined from the monument have the peristome characters of *O. texanum* and may be better recognized as a variety of *O. rupestre*. 
Figure 154. Habit, dry (Brinda, 1755)
Orthotrichum diaphanum Schrad. ex Brid.

**Distribution**

widespread in the northern hemisphere

**Habitat**

here restricted to the trunks of oak trees

**Distinctive Characters**

small epiphytic plants with short hyaline awns; septate gemmae usually abundant

**Similar Species**

*Orthotrichum pumilum* is similar but lacks the hyaline awn.

**Illustrations**

Figure 155 – Figure 157, Vitt (1994)

**Synonyms**

Orthotrichum garretti Grout & Flowers
Figure 155. Habit, dry (Brinda, 1922)

Figure 156. Habit, dry (Brinda, 1922)
Figure 157. Leaf (Brinda, 1922)
Orthotrichum pumilum Sw.

**Distribution**

widespread in the northern hemisphere

**Habitat**

here restricted to the trunks of oak trees

**Distinctive Characters**

small epiphytic plants; septate gemmae usually abundant

**Similar Species**

Orthotrichum pallens is similar but has more exposed stomata and smaller leaf cells.

**Illustrations**

Figure 158, Lewinsky-Haapasaari (1995)
Figure 158. Habit, dry (Brinda, 1891)
*Orthotrichum anomalum* Hedw.

**Distribution**

widespread in the northern hemisphere

**Habitat**

dry rock (here commonly on basalt)

**Distinctive Characters**

exserted ribbed capsules; leaf lamina unistratose

**Similar Species**

In *Orthotrichum hallii* the capsules are immersed and the leaves commonly bistratose.

**Illustrations**

Figure 159, Vitt (2009)
Figure 159. Habit, dry (Brinda, 1837)
*Orthotrichum cupulatum* Hoffm. ex Brid.

**Distribution**

widespread in the northern hemisphere

**Habitat**

dry rock

**Distinctive Characters**

cup-like capsules with 16 ribs; tall papillae giving the leaves a frosted appearance; acute leaf apices

**Similar Species**

*Orthotrichum pellucidum* also has tall papillae but the capsules have 8 ribs and the leaf apices are more obtuse.

**Illustrations**

Figure 160, Vitt (2009)
Figure 160. Habit, dry (Brinda, 1647)
Orthotrichum hallii Sull. & Lesq.

Distribution
western North America (possibly also in central Asia)

Habitat
dry rock

Distinctive Characters
capsules with 8 ribs; papillae low and conical; lamina usually distinctly bistratose

Similar Species
The capsules of Orthotrichum cupulatum have 16 ribs and the leaves are more strongly papillose.

Illustrations
Figure 161 – Figure 162, Flowers (1973)
Figure 161. Habit, dry (Brinda, 1822)
Figure 162. Leaf (Brinda, 1822)
*Claopodium whippleanum* (Sull.) Renauld & Cardot var. *whippleanum*

**Distribution**
western North America, Hawaii, Europe

**Habitat**
soil or soil over rock (here found as isolated stems intermixed with other mosses)

**Distinctive Characters**
bordered, toothed leaves with a single large papillum per cell

**Similar Species**
*Claopodium crispifolium* is similar but in that species the leaves have hairpoints.

**Illustrations**
Figure 163 – Figure 165, Harpel (2010)

**Synonyms**
*Hypnum whippleanum* Sull.
Figure 163. Habit, dry (Brinda, 1769b)

Figure 164. Leaf (Brinda, 1769b)

Figure 165. Leaf (Brinda, 1769b)
Conardia compacta (Müll. Hal.) H. Rob.

Distribution
widespread in the northern hemisphere

Habitat
calcareous springs, wet cliffs, and the bases of trees

Distinctive Characters
small pleurocarpous moss with warty-papillose, much branched rhizoids that are frequently inserted on the back of the costa or near the leaf apex (Figure 167 – Figure 168)

Similar Species
Amblystegium species are similar though probably not closely related; their rhizoids are smooth and never appear on the surface of the leaf.

Illustrations
Figure 166 – Figure 168, Hedenäs (2003)

Synonyms
Hypnum compactum Müll. Hal., Amblystegium compactum (Müll. Hal.) Austin
Figure 166. Habit, dry (Brinda, 1630)

Figure 167. Leaf (Brinda, 1630)

Figure 168. Leaf (Brinda, 1630)
*Homalothecium nevadense* (Lesq.) Renauld & Cardot subsp. *nevadense*

**Distribution**
western North America

**Habitat**
on rocks and soil (here found on basalt)

**Distinctive Characters**
large golden-yellow plants with imbricate leaves and stems curved when dry

**Similar Species**
The closely related *Homalothcium aeneum* has a curved capsule with well-developed cilia and a larger, less obscure alar region.

**Illustrations**
Figure 169, Hofmann (1998)

**Synonyms**

*Hypnum nevadense* Lesq., *Camptothecium nevadense* (Lesq.) Macoun & Kindb.
Figure 169. Habit, dry (Brinda, 1766)
Eurhynchiastrum pulchellum (Hedw.) Ignatov & Huttunen var. pulchellum

Distribution
widespread in the northern hemisphere

Habitat
soil, rock, decaying wood, and tree bases

Distinctive Characters
broadly triangular leaves and blunt apices with cells shorter than the adjacent lamina

Similar Species
The other species of Brachytheciaceae found in our area have more acute apices.

Illustrations
Figure 170, Ignatov (2009)

Synonyms
Hypnum pulchellum Hedw., Eurhynchium pulchellum (Hedw.) Jenn.
Figure 170. Habit, dry (Newberry, s.n.)
Brachytheciastrum collinum (Schleich. ex Müll. Hal.) Ignatov & Huttunen

Distribution

widespread in the northern hemisphere

Habitat

on shaded soil or thin soil over rock

Distinctive Characters

pleurocarpous plants that are autoicous, with curved capsules and well-developed cilia; leaves somewhat concave and abruptly acuminate with a well-defined alar region

Similar Species

Brachytheciastrum fendleri has narrower leaves, is synoicous and has erect capsules with reduced cilia.

Illustrations

Figure 171 – Figure 172, Flowers (1973)

Synonyms

Hypnum collinum Schleich. ex Müll. Hal., Brachythecium collinum (Schleich. ex Müll. Hal.) Schimp. var. collinum
Figure 171. Sporophyte (Brinda, 1785)

Figure 172. Habit, dry (Brinda, 1785)
Brachytheciastrum fendleri (Sull.) Ochyra & Żarnowiec

**Distribution**
western North America, Europe (but probably more widespread)

**Habitat**
on soil and thin soil over rock

**Distinctive Characters**
pleurocarpous plants that are synoicous with erect capsules and reduced cilia

**Similar Species**

*Brachytheciastrum olympicum* has a similar leaf shape but with a less well-defined alar region and is autoicous with curved capsules and well-developed cilia.

**Illustrations**
Figure 173, Flowers (1973)

**Synonyms**

*Hypnum fendleri* (Sull. & Lesq., *Brachythecium fendleri* (Sull.) A. Jaeger,

*Brachythecium utahense* James
Figure 173. Dry habit, showing the erect capsules (Brinda, 1848)
Brachytheciastrum olympicum (Jur.) Vanderpoorten, Ignatov, Huttunen & Goffinet

Distribution

probably widespread in the northern hemisphere

Habitat

soil, soil over rock, and the bases of trees

Distinctive Characters

pleurocarpous plants that are autoicous with curved capsules and well-developed cilia; leaves gradually acuminate with a poorly-defined alar region

Similar Species

Brachytheciastrum velutinum is similar but has somewhat falcate leaves and setae that are rough throughout their entire length.

Illustrations

Figure 174, Lawton (1971, as Brachythecium venustum), Flowers (1973, as Brachythecium suberythrorrhizon)

Synonyms

Brachythecium olympicum Jur., Brachythecium venustum De Not., Brachythecium suberythrorrhizon Renauld & Cardot
Figure 174. Habit, dry (Brinda, 1772)
 Isothecium obtusatulum Kindb.

**Distribution**

western North America

**Habitat**

dry rock and fallen logs

**Distinctive Characters**

pleurocarpous plants with creeping stems and leaves with acute, toothed apices;
distal ends of some laminal cells projecting as spines

**Similar Species**

Isothecium stoloniferum is similar but the leaves are larger and more acuminate.

**Illustrations**

Figure 175 – Figure 176, Allen & Whittemore (1996)
Figure 175. Habit, dry (Brinda, 1784)
Figure 176. Leaf (Brinda, 1784)
Neckera pennata Hedw.

Distribution
sub-cosmopolitan

Habitat
shaded rock and the bases of trees

Distinctive Characters
pleurocarpous plants with complanate, undulate leaves; costa short, double or lacking

Similar Species
Neckera menziesii is similar but has a strong, single costa for 3/4 of the leaf length.

Illustrations
Figure 177, Crum & Anderson (1981)
Figure 177. Habit, dry (Brinda, 1888)
Stereodon vaucheri (Lesq.) Lindb. ex Broth.

**Distribution**

widespread in the northern hemisphere, South America

**Habitat**

calcareous rock, soil, and tree bases

**Distinctive Characters**

pleurocarpous plants, often pinnately branched with leaves sometimes falcate

secund; leaf margins plane throughout; alar region of small, thick-walled cells

**Similar Species**

*Hypnum cupressiforme* is similar but its leaves are more gradually acuminate with

more elongate cells.

**Illustrations**

Figure 178, Flowers (1973, as *Hypnum vaucheri*)

**Synonyms**

*Hypnum vaucheri* Lesq., *Hypnum cupressiforme var. vaucheri* (Lesq.) Boulay
Figure 178. Habit, dry (Brinda, 2078)
Stereodon revolutus Mitt. var. revolutus

Distribution

sub-cosmopolitan

Habitat

rock, soil, and tree bases

Distinctive Characters

pleurocarpous plants, often pinnately branched with leaves ± falcate secund; leaf margins revolute their entire length; alar region of small, thick-walled cells

Similar Species

Stereodon vaucheri is similar but lacks the revolute leaf margins and its alar cells are more numerous.

Illustrations

Figure 179, Flowers (1973, as Hypnum revolutum)

Synonyms

Hypnum revolutum (Mitt.) Lindb.
Figure 179. Habit, dry (Brinda, 1886)
Pseudoleskeella tectorum (Funck ex Brid.) Kindb. ex Broth.

Distribution
widespread in the northern hemisphere

Habitat
rock or tree bases

Distinctive Characters
thin mats of tiny, dark green plants; the costa is usually weak but variable and sometimes completely absent

Similar Species
Homomallium mexicanum is larger and the leaves have more elongate cells.

Illustrations
Figure 180, Wilson & Norris (1989)

Synonyms
Hypnum tectorum Funck ex Brid., Leskea tectorum (Funck ex Brid.) Lindb., Leskeella tectorum (Funck ex Brid.) I. Hagen, Pseudoleskea tectorum (Funck ex Brid.) Schimp.
Figure 180. Habit, dry (Brinda, 1845)
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