

MOSSES OF THE ROCKY MOUNTAINS IN WYOMING, U.S.A.:
NEW ALTITUDINAL RECORDS FOR NORTH AMERICA

МХИ СКАЛИСТЫХ ГОР ВАЙОМИНГА, США:

НОВЫЕ РЕКОРДЫ ВЫСОТ ДЛЯ СЕВЕРНОЙ АМЕРИКИ

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Abstract

Remarkable extensions of upper elevation limits for 37 species and one variety of mosses in North America are reported from Wyoming, U.S.A. The bryophyte inventory research was conducted in the two national forests in the state, Medicine Bow and Shoshone National Forests, lying in the high country of the Rocky Mountains. The study area spans about 13700 km² and ranges in elevation from approx. 1700 to over 3650 m. A total of 13 families in the author's herbarium, collected within the period of 2003-2014, were analyzed, namely Amblystegiaceae, Bartramiaceae, Brachytheciaceae, Calliergonaceae, Dicranaceae, Hedwigiaceae, Hypnaceae, Mniaceae, Plagiotheciaceae, Polytrichaceae, Pottiaceae, Scouleriaceae and Sphagnaceae. Selected specimens are cited representing taxa from the highest known elevations of Wyoming. The new information, supplemented by earlier works of the U.S. Rocky Mountains moss flora researchers, essentially updates altitudinal ranges of the taxa, provided in the recently published Volumes 27 & 28 of the Flora of North America.

Резюме

37 видов и 1 разновидность мхов зарегистрированы на значительных и рекордных высотах в Скалистых Горах Вайоминга, США. Инвентаризация бриофлоры проводилась на территории двух высокогорных национальных лесов штата – Medicine Bow & Shoshone National Forests. Район исследований охватил площадь 13700 км² в пределах высот от 1700 до 3650 м. На основе гербария, собранного автором в течение 2003-2014 гг., было изучено высотное распределение видов из 13 семейств: Amblystegiaceae, Bartramiaceae, Brachytheciaceae, Calliergonaceae, Dicranaceae, Hedwigiaceae, Hypnaceae, Mniaceae, Plagiotheciaceae, Polytrichaceae, Pottiaceae, Scouleriaceae и Sphagnaceae и выявлены таксоны с верхними высотными лимитами, превышающими показатели, ранее известные для Северной Америки. Цитируются наиболее интересные образцы из Вайомингских высокогорий. Новые данные, дополненные литературными сведениями по бриофлоре Скалистых Гор, вносят существенные коррективы в соответствующие разделы недавно опубликованных томов 27 и 28 Флоры Северной Америки.

KEYWORDS: Mosses, Wyoming, Rocky Mountains, elevations, North America.

INTRODUCTION

Wyoming is a state unique in terms of its topography: the western two thirds of it is covered mostly with the mountain ranges and rangelands in the foothills of the Rocky Mountains, the major mountain system in western North America, while the eastern third is high elevation prairie known as the Great Plains. Surface elevation in Wyoming ranges from the summit of Gannett Peak in the Wind River Range, at 4207 m, to the Belle Fourche River valley in the state's northeast corner, at 939 m, with an average height of 2030 m (Knight, 1994). Thus, according to the elevation scale of Flora of North America (2007, 2014), the altitudinal range of Wyoming may be considered as "moderate to high elevations". Sit-

uated within the northerly latitude of 41°–45° N and the longitude of 104° 3'–111° 3' W, isolated from the ocean by the Rockies in its mid-continental location, Wyoming has a generally semi-arid climate. Much of the land receives less than 250 mm of rainfall per year and hence, may hardly be described as a land of "bryological paradise". Even so, Wyoming's national forests lying in the high country of the Rocky Mountains harbor some of the greatest topographic variation, wettest climates and geological complexity of federal lands in the state, and therefore favor bryophyte diversity.

Two national forests of Wyoming were bryologically studied by the author within the period of 2003-2014: Shoshone National Forest and Medicine Bow National

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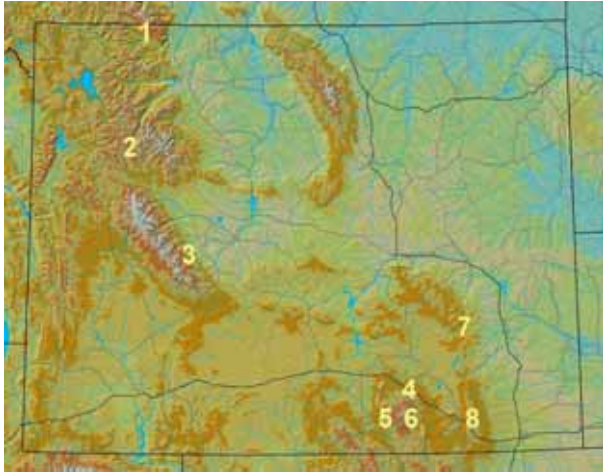


Fig. 1. Map of the study area in Wyoming. Shoshone National Forest: 1 - Beartooth Plateau; 2 - SW Absaroka Range; 3 - E Wind River Range. Medicine Bow National Forest: 4-6 - Medicine Bow Mts., including Snowy Range (5); 7 - Laramie Range; 8 - Pole Mts. Fig. 2. The author and her herbarium of the Wyoming bryophytes. Photo M. Kirkpatrick.

Forest (Figs. 1-2). The former lies in the northwest corner of Wyoming in the lee of the massive Absaroka and Wind River Ranges and Beartooth Plateau (Central Rockies); the latter embraces mountains in the southeastern portion of the state: Sierra Madre, Pole Mts., Laramie Range and Medicine Bow Mts., including the peaks of Snowy Range (Southern Rockies). The study area spans about 13700 km² and ranges in elevation from approx. 1700 to over 3650 m. Four elevation zones can be generally delimited here: 1) the foothills (from 1700 to approx. 2100 m; semi-arid zone of sagebrush grasslands and shrublands / scrublands dominated by *Artemisia tridentata* Nutt., *Cercocarpus* spp., *Purshia tridentata* (Pursh.) DC., etc.); 2) the montane zone (approx. 2100-2600 m; the middle-altitude, relatively dry forested zone, with a wide expanse of pine (*Pinus contorta* Dougl. ex Loud. var. *latifolia* Engelm. ex Wats., *P. flexilis* James and *P. ponderosa* Laws. & Laws.), Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco var. *glauca* (Beissn.) Franco) and aspen (*Populus tremuloides* Michx.); 3) the subalpine zone (approx. 2600-3050...3300 m; spruce-fir (*Picea engelmannii* Parry ex Engelm. - *Abies*

bifolia A. Murray) forested zone below the limit of trees, mixed with *Pinus contorta* and *Populus tremuloides*, and interspersed by broad open meadows, called "parks") and 4) the alpine zone (from 3050...3300 m to snow-capped peaks; the rugged terrain above timberline with alpine meadows, fens and tundra populated with a variety of dwarf shrubs (e.g., *Salix* spp., *Kalmia microphylla* (Hook.) Heller, etc.), perennial forbs (e.g., *Geum rossii* (R. Br.) Ser., *Silene acaulis* (L.) Jacq., *Draba* spp., *Phlox pulvinata* (Wherry) Cronq., etc.), graminoids (e.g., *Carex aquatilis* Wahl., *C. scopulorum* Holm., *Festuca* spp., *Juncus* spp., *Poa* spp., etc.), bryophytes and lichens; the zone includes a number of interesting habitats, e.g., talus slopes, cliffs, late snow melt areas, patterned ground, rock outcrops and debris of different, including volcanic, glacial, etc., origin: granites, limestones, conglomerates, quartzites, etc.). *Salix* spp. thickets adjacent to streams, rivers and lakes are found throughout from the foothills to the alpine zone. (Daubenmire, 1943; Knight, 1994; author's data). Some landscapes of the study area are shown in Figs. 3-10.

A total of 11 years of bryophyte collecting within the

Figs. 3-4. Summits of Wyoming's Beartooth Plateau, alt. 3300 m. Alpine tundra of the Plateau with outcrops of granite bedrock, which is the highest known habitat of *Amblystegium serpens* and *Dicranum spadiceum* in North America. It is also home for the actively sporogone-forming *Stegonia latifolia*, a worldwide rare arctic-alpine moss. Photos by R. Anderson and Y. Kosovich-Anderson. August 2008.

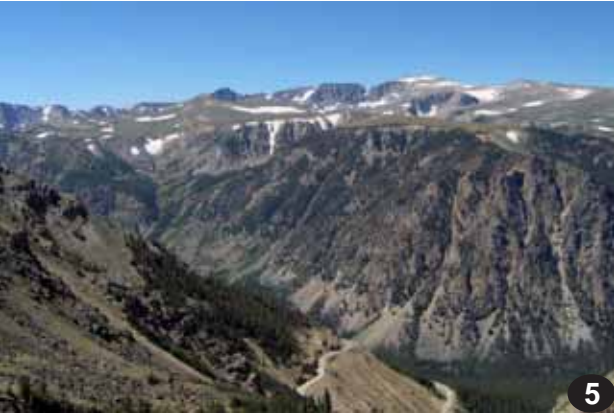
Figs. 5-6. Montane and subalpine forests of the Beartooth Plateau, alt. 2300-3000 m. *Dicranella palustris*, *Dicranum bonjeanii*, *Mnium spinulosum* and *Rhizomnium pseudopunctatum* are likely to establish altitudinal records here. Photos Y. Kosovich-Anderson. August, 2008.

Fig. 7. Snowy Range, Medicine Bow Mts. of Wyoming, with the highest peak reaching 3662 m. In the niches of its quartzite cliffs, at elevations of over 3300 m, *Dicranoweisia crispula* was found. Photo Y. Kosovich-Anderson. July, 2007.

Fig. 8. Upper subalpine landscape of the Snowy Range. Spruces and firs at upper treeline have the krummholz growth form, with dense lower branches. On nearby windswept open slopes, *Polytrichum piliferum* occurs, forming dense sods on gravelly soil. Photo Y. Kosovich-Anderson. August, 2014.

Fig. 9. In the vicinity of one of the glacial lakes of the Snowy Range, in wet alpine tundra, at an elevation above 3300 m, *Brachythecium turgidum* with numerous sporogones was collected. Photo Y. Kosovich-Anderson. August, 2013.

Fig. 10. South French Creek valley, alt. 3200 m; a view from the Snowy Range Scenic Byway. Late snow-melt areas of NE-facing slopes of the deep valley is a habitat of an interesting form of *Philonotis fontana* var. *americana*, with unusual coarsely mammillose costa of leaves. Photo Y. Kosovich-Anderson. August, 2008.



study area has resulted in an accumulation of material of as many as 17,000 voucher specimens, all with GPS location data, containing a great deal of new information on the distribution and ecology of many taxa in the Wyoming Rocky Mountains (Kosovich-Anderson, 2014 a, b).

The goal of the present study was to reveal upper altitudinal levels reached by the bryophytes in the mountains of Wyoming, based on the author's herbarium. The interest in this kind of research was caused by the dearth of publications on North America bryophytes, containing precise elevation information on the taxa. Elevations often are omitted from herbarium specimen labels, especially in earlier collections, which prevents the objective estimation of the taxa elevation limits. Some mountain areas of Wyoming, especially the Medicine Bow Mts. located about 30 mi west of the University of Wyoming in Laramie, has undergone rather intensive bryophyte collecting (by A. Nelson, C.L. Porter and others), however, the works of these researchers, unfortunately, only in rare cases contain elevation data, and the label information of specimens is sketchy.

RESULTS

The analysis of elevation data of specimens of a total of 13 families in the author's herbarium, namely Amblystegiaceae, Bartramiaceae, Brachytheciaceae, Calliergonaceae, Dicranaceae, Hedwigiaceae, Hypnaceae, Mniaceae, Plagiotheciaceae, Polytrichaceae, Pottiaceae,

Scouleriaceae and Sphagnaceae, was conducted. The comparison with the data from the newly published Flora of North America (2007, 2014) revealed 38 taxa establishing "new records" of their upper elevation limits in the high-elevation sites of the national forests of Wyoming. The author's data on these taxa also surpass elevation levels indicated in a recently revised web compilation on Wyoming mosses by Eckel (2013).

For a more objective estimation, also taken into account was the information from earlier publications omitted by some of the authors of FNA, among which is the fundamental work of Elva Lawton on the Pacific Northwest (Lawton, 1971) and also general and brief local publications on the U.S. Rocky Mountain region by Flowers (1973), Hermann (1969, 1987), Elliott & Moore (1989), Lenz (2006) and Weber & Wittmann (2002, 2007). Also, the following recent works were analyzed: Lemly et al. (2007), Andrus & Kosovich-Anderson (2011), Kosovich-Anderson (2011) and Romig & Allred (2013). The results of comparisons are represented in the table 1.

The new data, supplemented by earlier works of the U.S. Rocky Mountains moss flora researchers, essentially updates altitudinal ranges of the taxa, provided in the recently published Volumes 27 & 28 of the Flora of North America.

All cited voucher specimens are housed in RM and the author's herbarium (if duplicates are elsewhere the herbaria are noted).

Table 1. Revised altitudinal ranges of 27 North American moss taxa based on the authors's collections from Wyoming, U.S.A. Symbols and abbreviations: * – taxon not indicated for Wyoming in Flora of North America (2007, 2014), but well represented in the Wyoming herbarium of the author; FNA – Flora of North America north of Mexico; MBNF – Medicine Bow National Forest; SNF – Shoshone National Forest; [1], [2], ... – location on the map (Fig. 1).

Taxa	In North America, published	In WY, author's data	Localities in Wyoming
<i>Amblystegium serpens</i> (Hedw.) Schimp.	{0-3000} m (FNA 28: 301)	3310 m	SNF, Park Co., Beartooth Plateau, summits, wet alpine tundra, on shaded soil at base of granite rock, 19/8/2008, YK-A 3371. [1]
<i>Brachytheciastrum leibergii</i> (Grout) Ignatov & Huttunen	{800-2300} m (FNA 28: 411)	2800 m	SNF, Fremont Co., SW Absaroka Range, Brooks Lake boggy valley, on humus soil, 23/7/2013, YK-A 15585. [2]
<i>Brachythecium acutum</i> (Mitt.) Sull.	{0-1000} m (FNA 28: 423)	2770 m	MBNF, Carbon Co., Medicine Bow Mts., US FS Rd. 105, boggy shore of glacial subalpine lake, on soaked peaty soil, 3/7/2009, YK-A 4506 (MHA, MO), det. M. Ignatov. [4]
* <i>Campylophyllum hispidulum</i> (Brid.) Hedenäs	{0-1700} m (FNA 28: 316)	2800 m	SNF, Fremont Co., E Wind River Range, Dickinson Park, Sandy Creek, on duff near streamside, 2/8/2012, YK-A 12742. [3]
* <i>Dicranella palustris</i> (Dicks.) E.F. Warburg	{0-1599} m (FNA 27: 388)	2350 m	SNF, Beartooth Plateau (Kosovich-Anderson, 2011). [1]
* <i>Dicranoweisia cirrata</i> (Hedw.) Lindb.	{1-1900} m (FNA 27: 396)	2900 m	SNF, Fremont Co., E Wind River Range, Dickinson Park, Twin Parks Creek valley, N-facing slope, on a layer of soil in fissures of granite rocks, gemmae, 7/8/2012, YK-A 13247 (RM). [3]
<i>Dicranum bonjeanii</i> De Not.	{60-1300} m (FNA 27: 404)	2900 m	SNF, Park Co., Beartooth Plateau, Fantan Lake, swampy <i>Picea engelmannii</i> forest, on soil, 29/7/2010, YK-A 6874 (MO, RM, US), det. R. Ireland. [1]
<i>D. muehlenbeckii</i> Bruch & Schimp.	{10-3100} m (FNA 27: 414)	3250 m	SNF, Park Co., Beartooth Plateau, Littlerock Creek, mounds of alpine <i>Salix planifolia</i> - Bryidae fen, on peaty soil, 21/8/2008, YK-A 3597 (US). [1]

<i>D. scoparium</i> Hedw.	{ 50-2900 } m (FNA 27: 403); 3050-3140 m (Flowers, 1973)	3250 m	SNF, Park Co., Beartooth Plateau, Littlerock Creek, mounds of alpine <i>Salix planifolia</i> - Bryidae fen, on humus and duff, 21/8/2008, <i>YK-A 3554</i> [1]
<i>D. spadiceum</i> J.E. Zetterst.	{ 10-2300 } m (FNA 27: 414); 2870 m (Hermann, 1987)	3300 m	SNF, Park Co., Beartooth Plateau, summit, wet alpine tundra dominated by <i>Geum rossii</i> , on soil, 12/8/2008, <i>YK-A 2348</i> (MO, US). [1]
<i>Hedwigia ciliata</i> (Hedw.) P. Beauv.	{ 0-2300 } m (FNA 28: 86)	2520 m	MBNF, Albany Co., Pole Mts., Middle Branch of Lodgepole Creek, N-facing slope, on N surface of massive granite outcrop in <i>Pinus contorta</i> forest, S+, 23/6/2012, <i>YK-A 12086</i> . [8]
<i>Hygroamblystegium varium</i> (Hedw.) Mönk., s. str.	{ 0-2500 } m (FNA 28: 304)	3300 m	MBNF, Albany Co., Snowy Range, Libby Creek, on rock in fast-flowing water, 16/9/2007, <i>YK-A 1670</i> (COLO), det. W. Weber. [5]
<i>Hygrohypnum luridum</i> (Hedw.) Jenn.	{ 400-3200 } m (FNA 28: 276)	3310 m	MBNF, Albany Co., Snowy Range, Gap Lakes Trail, Lewis Lake, on quartzite debris in streamlet, beneath <i>Salix</i> sp., 19/08/2007, <i>YK-A 1331</i> (COLO). [5].
<i>Mnium marginatum</i> (Dicks. ex With.) P. Beauv.	{ 0-1599 } m (FNA 28: 226); 2960 m (Weber & Wittmann, 2007); to about 3000 m (Lawton, 1971)	3100 m	MBNF, Albany Co., Medicine Bow Mts., Bear Lake vicinity, Libby Creek, ditch in subalpine <i>Salix</i> sp. + <i>Carex</i> spp. fen, on moist clayey soil, 2/9/2012, <i>YK-A 13737</i> [6]
* <i>M. spinulosum</i> Bruch & Schimp.	{ 0-1599 } m (FNA 28: 228); to about 2200 m (Lawton, 1971)	2350 m	SNF, Park Co., Beartooth Plateau, outlet of Lily Lake, wet <i>Picea engelmannii</i> (- <i>Alnus incana</i> - <i>Linnaea borealis</i> - Bryidae) forest, on rotten wood, 31/7/2010, <i>YK-A 7490</i> . [1]
* <i>Philonotis fontana</i> (Hedw.) Brid. var. <i>americana</i> (Dism.) Flowers ex H.A. Crum	{ 0-3000 } m (FNA 28: 112)	3200 m	MBNF, Carbon Co., Snowy Range, South French Creek valley, NE-facing exposed seepage slope, late snow-melt area, 15/9/2007, <i>YK-A 1527</i> (CAS, COLO, DUKE, H, MO). The leaves of plants have coarsely mammillose costa. [5]
<i>Polytrichum commune</i> Hedw., s. str.	{ 0-1599 } m (FNA 27: 136); 2600 m (Hermann, 1987); 2650 m (Flowers, 1973)	2950 m	MBNF, Albany Co., Medicine Bow Mts., boggy shore of unnamed lake, forested with <i>Picea engelmannii</i> & <i>Pinus contorta</i> , on soaked peaty soil, 4/7/2009, <i>YK-A 4713</i> . [4]
<i>P. piliferum</i> Hedw.	{ 0-1599 } m (FNA 27: 140); to over 3300 m (Lawton, 1971)	3370 m	MBNF, Albany Co., Snowy Range, Gap Lakes Trail, South Gap Lake, on gravelly soil beneath <i>Salix</i> sp., forms dense sods, 30/8/2014, <i>YK-A 18620</i> . [5]
<i>Pterygoneurum subsessile</i> (Brid.) Jur., s.str.	{ 600-1700 } m (FNA 27: 609)	2500 m	MBNF, Albany Co., Pole Mts., Telephone Canyon, open SSE-facing slope, ledge of sandstone outcrop, S+, 27/5/2012, <i>YK-A 11979</i> . [8]
<i>Rhizomnium magnifolium</i> (Horik.) T. J. Kop.	{ 0-1599 } m (FNA 28: 240)	3270 m	SNF, Park Co., Beartooth Plateau, summit, NF Trail 623, alpine <i>Caltha leptosepala</i> + <i>Sedum rhodanthum</i> + <i>Carex</i> spp. - Bryidae fen in small depression, 19/8/2008, <i>YK-A 3434</i> (H, MO), det. T. Koponen [1]
<i>R. pseudopunctatum</i> (Bruch & Schimp.) T.J. Kop.	{ 0-1599 } m (FNA 28: 242); 2800 m (Hermann, 1987)	2980 m	SNF, Park Co., Beartooth Plateau, Little Bear Creek, <i>Picea engelmannii</i> stands along boggy creek bank, on moist soil, 14/8/2008, <i>YK-A 2703</i> . [1]
<i>R. punctatum</i> (Hedw.) T.J. Kop.	{ 0-1599 } m (FNA 28: 242)	2740 m	SNF, Park Co., Beartooth Plateau, S-facing <i>Pinus contorta</i> forested slopes along HWY 212, brook bank, on wet humus soil, 23/8/2008, <i>YK-A 3905</i> [1]
<i>Sarmentypnum tundrae</i> (Arnell) Hedenäs	{ 0-1600 } m (FNA 28: 400); 2827 m (Lenz, 2006)	3200 m	SNF, Park Co., Beartooth Plateau, Wyoming Creek, around alpine pools, on moist mineral soil, 20/8/2009, <i>YK-A 5087</i> . [1]

<i>Scouleria aquatica</i> Hook.	{0-1900} m (FNA 27: 313); 2680-2740 m (Flowers, 1973)	2730 m	SNF, Park Co., Beartooth Plateau, Beartooth Creek, on granite boulders in running water, fully submerged, 23/8/2009, YK-A 5424 (CAS, COLO, DUKE, MONTU, RM). [1]
* <i>Sphagnum jensenii</i> H. Lindb.	{0-1599} m (FNA 27: 69)	2925 m	MBNF, Medicine Bow Mts. (Andrus & Kosovich-Anderson, 2011). [4]
* <i>S. riparium</i> Ångstr.	{0-1599} m (FNA 27: 75); 1799 m (Elliott & Moore, 1989); 2500 m (Lemly et al., 2007)	2900 m	SNF, Park Co., Beartooth Plateau, Morrison Heep Trail, boggy shore of Lower Top Lake, on soaked peaty soil, 1/8/2010, YK-A 7657 (CAS, COLO, RM). The stations in the NW Wyoming represent southernmost occurrences of the species in the Rocky Mountains. [1]
<i>Tortula mucronifolia</i> Schwägr.	{0-2700} m (FNA 27: 601)	2900 m	SNF, Fremont Co., E Wind River Range, Dickinson Park, on wet soil along the shore of shallow drying lake, S+, 6/8/2012, YK-A 13234. [3]

There are also eleven species whose published altitudinal records much exceeded those listed in FNA, but not the highest reported altitudinal records in North America. These are:

Brachythecium turgidum (Hartm.) Kindb.: FNA 28: 427: 0-1300 m, while reported at approx. 2200 m (Hermann, 1969), to 3900 m (!) (Weber & Wittmann, 2002), and collected in WY at 3310 m [5];

* *Dichodontium pellucidum* (Hedw.) Schimp.: FNA 27: 385 – {0-2300} m, while reported to 4020 m (!) (Weber & Wittmann, 2007), and collected in WY at 3100 m [6];

Dicranoweisia crispula (Hedw.) Milde: FNA 27: 396 – 10-2000 m; reported to 4115 m (!) (Weber & Wittmann, 2002) and collected in WY at 3320 m [5];

Dicranum tauricum Sapjegin: FNA 27: 418 – 150-2200 m; reported at 2724 m (!) (Romig & Allred, 2013) and collected in WY at 2450 m [7];

* *Hypnum pratense* Koch ex Spruce: FNA 28: 546 – 0-3000 m; reported at 3200 m (Flowers, 1973); to 3500 m (!) (Weber & Wittmann, 2007) and collected in WY at 3250 m [1].

Isopterygiopsis pulchella (Hedw.) Z. Iwats: FNA 28: 551 – 10-2300 m; reported to 4115 m (!) (Weber & Wittmann, 2002) and collected in WY at 3170 m [1];

Leptodictyum riparium (Hedw.) Warnst.: FNA 28: 291 – {0-1599} m; reported at 2300 m (Hermann, 1987); to about 3000 m (!) (Lawton, 1971) and collected in WY at 2850 m [3];

Plagiomnium ellipticum (Brid.) T.J. Kop.: FNA 28: 233 – {0-199} m; reported to 4115 m (!) (Weber & Wittmann, 2002) and collected in WY at 3300 m [5];

Plagiothecium denticulatum (Hedw.) Schimp.: FNA 28: 487 – 50-2700 m; reported to 4115 m (!) (Weber & Wittmann, 2002) and collected in WY at 3350 m [1];

Sphagnum warnstorffii Russ.: FNA 27: 101 – {0-1599} m; reported at 3300 m (Hermann, 1987) and collected in WY at 3250 m [1]. Plants of *S. warnstorffii* from the Rocky Mountains of Wyoming have several morphological features: 1) unclear 5-ranked arrangement in branch leaves vs. distinctively 5-ranked in typical form; 2) ruptures and elliptic pore-like wall thinning (sometimes typical pores of small size) at the distal ends of the cells of stem hyalodermis vs. absent pores in typical form; 3) fibrillose hyaline cells in distal portion of stem leaves vs. efibrillose in typical form. Eva Mikulášková, a Czech researcher, was studying the genetic structure of six samples of *S. warnstorffii* from the Wyoming Rocky Mountains (all six are duplicates of the author's col-

lections, kept at DUKE); she found that they appeared to be pretty typical *S. warnstorffii* (J. Shaw, pers. comm. March 2013).

Stegonia latifolia (Schwägr.) Venturi ex Broth., s. str.: FNA 27: 605 – 40-1800 m; reported to about 3700 m (Lawton, 1971); 4115 m (!) (Weber & Wittmann, 2002) and found in WY at 3340 m [1].

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