Preliminary Inventory Results of the Bryophytes & Lichens of Steens Mt.

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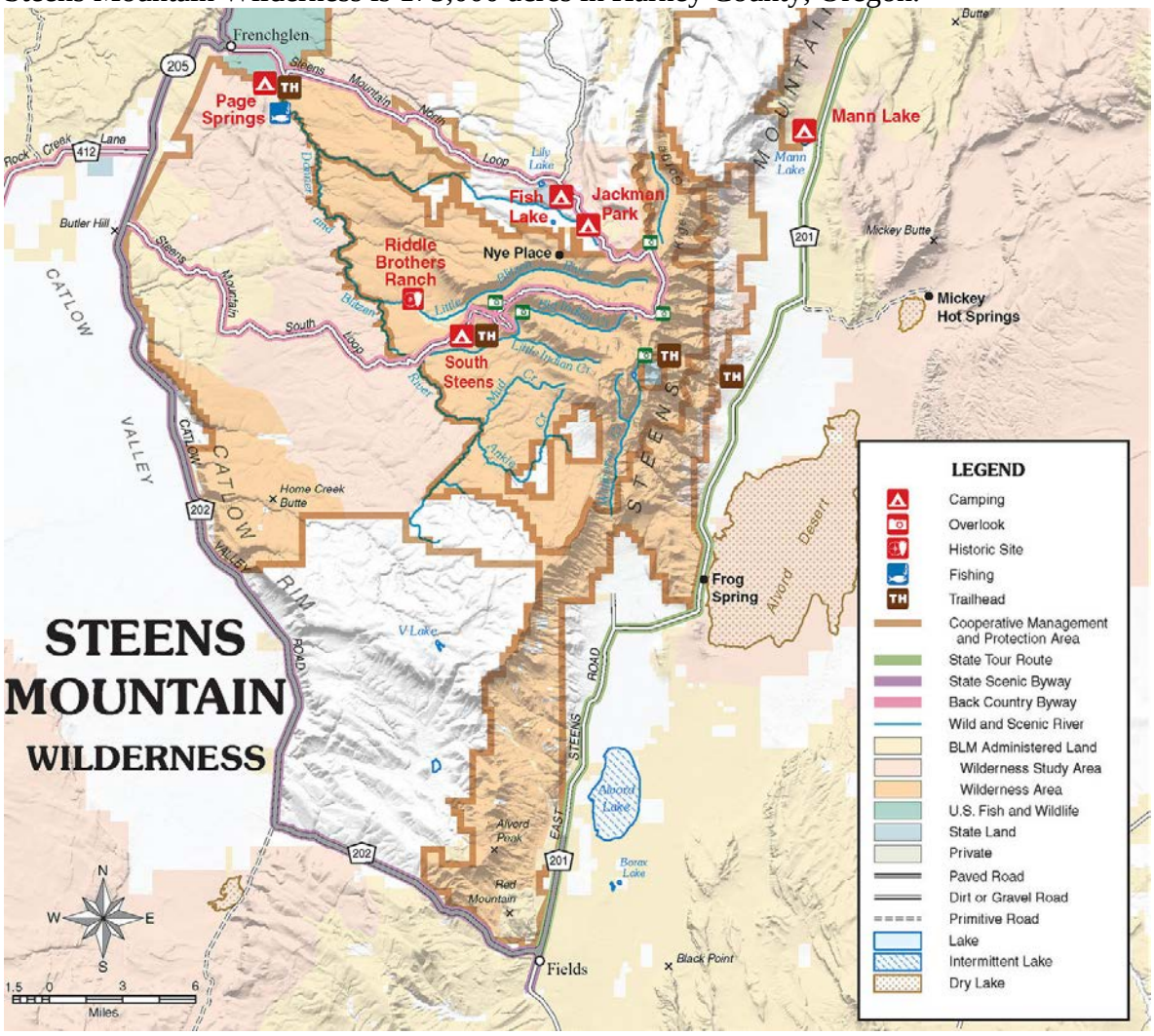
ABSTRACT
Inventory efforts of Steens Mt. Wilderness started by systematically making collections across two summer seasons of fieldwork totaling 51 field days. These focused on the four major gorges, Big Indian, Kiger, Little Blitzen, and Wildhorse, and other places to visit an array of habitats, conditions, and geographically dispersed locations. A total of 1,239 specimens were collected, 759 of which were identified. Mosses totaled 145 species, subspecies, and varieties. Ten species of liverworts were identified and one hornwort. Thus far 37 species of macrolichens have been identified. Of all bryophytes and lichens, 35 species and three varieties are either listed for the state, represent range extensions, disjuncts, are new to the state, or new to science. There are a high number of calciphiles present, a third species of Grimmia *forming moss balls is reported for North America, and species not previously known to have gemmae or nematogens are reported. Floristic patterns suggest that Steens Mt. is a place of convergence between the Rockies, Sierras/Great Basin, and Cascades. The common occurrence of atypical specimens of widespread species has been caused by the mountain's isolation.*

INTRODUCTION

Steens Mt. was chosen to study because of its isolation, elevation, diversity of habitats, and general unexplored non-vascular flora of the Northern Great Basin in Oregon.

Study Site

Steens Mountain Wilderness is 175,000 acres in Harney County, Oregon.



Physically, Steens Mt. is the northernmost fault-block mountain in the hydrographic Great Basin and largest north of 40°N latitude (Mansfield, 2000). It stretches more than 35 miles from the southwest to the northeast, slopes gradually towards the west, and drops as an escarpment to the east for more than a mile. It rises from 4,200 ft., to 9,733 ft.

Physical forces such as volcanism, faulting, glaciation, and erosion have formed Steens Mt. Successive floods of Steens Basalt (and others) 20 million years ago preceded the uplift of Steens Mt. but are revealed in profile of the glaciated gorges, eroded river canyons, and escarpments. Among these features are:

Ridge crests
Arêtes
Cirques
Tarns
Waterfalls
Headwalls
Cliffs
Terraces
Drainages
Talus fields
Rimrock
Hoodoos
Dikes
Slopes
Lakes
Springs
Bajadas

These in turn, depending on elevation, aspect, moisture, and light produce a wide array of life zones, habitats and conditions:

Alpine
Tundra
Montane
Fir forests
Meadows
Fens
Riparian corridors
Calcareous/base-rich seeps
Vernal pools
Juniper woodland
Sage steppe
Scablands

These qualitative ecological niches further diversify the flora especially the bryophytes and lichens. These small, hardy, pioneering non-vascular plants have the additional ability of occupying small rocky physical niches of which, quantitatively, there are an almost infinite amount at Steens Mt.

The final valuable factors of this mountain are its isolation and elevation. Mountains taller than Steens Mt. only exist as far away as the Central Cascades, Wallowas, Sierras, and Rockies. Additionally, the massiveness that is inherent to fault-block mountains is extant at Steens Mt. as 47 mi^2 of area are above 8,000 ft. (Mansfield, 2000). In this way Steens Mt. with its high relief over the surrounding sage steppe, functions as a sky island in a desert sea. Principles of island biology are functioning because of this and allow for endemic species. There are six endemic species of vascular plants, all restricted to rocky alpine situations (Mansfield, 2000).

METHODS

This study was funded for two field seasons for collecting and two indoor seasons for identification, data management, and report writing.

During field seasons, two vehicles were used at various points throughout the study area. A camper usually remained stationary at a campground (South Steens, Fish Lake, Page Springs) acting as basecamp. From these campgrounds survey areas were accessed either directly by foot or by high clearance four-wheel drive vehicle.

Site selection for botanical exploration was based on observations of quality and diversity of habitats, as well as a variety of aspects, moisture regimes, elevations, and substrates. Additionally sampling was sought to achieve an overall broad distribution of sites throughout the study area (e.g. extreme southern tip, east escarpment, Catlow Rim).

Field survey methods employed intuitive control meander. Multiple challenges and hazards inherent in this environment were prepared for and avoided. An example of a not uncommon series of days included descending from near the top of Steens Mt. (~10,000') down 2,500' to the bottom of a gorge, surveying for small scale plants in nooks and crannies throughout the day then ascending back out from 7,500' while warding off dehydration, sun exposure, high temperatures, the effects of high elevation, thick regional wildfire smoke, unstable footing, navigation, caution not to get "cliffed-out" on a terrace, close monitoring of the sky for quick forming thunderstorms and their lightening, and in places below 6,500' watching every single footfall for rattlesnakes.

Field processing of specimens included drying wet specimens on the dashboard of the stationary camper with windows open just 2.54 cm. This warm ventilated environment efficiently dried specimens each day. However, moist liverwort material was refrigerated in plastic until sufficient quantities warranted a session of counting the ephemeral character of liverwort oil bodies before they dried and dissipated. They are helpful in the identification of liverworts. This was done with a set of field microscopes in the camper on days off from collecting.



Above left: drying specimens. Above right: counting and recording oil body data before they dissipate.

About 300 dried specimens were packed per 17"x13"x13" box that were periodically shipped back to the lab from the Burns Post Office.

Back at the lab, after the completion of field season, specimens were numbered with the collector's collection number. Waypoints were downloaded and transferred onto a spreadsheet that would become the attached spreadsheet and the core of the data from this inventory ("Steens Bryos & Lichens Kofranek 5-6-19"). Photographs from the field were uploaded. The field notebooks were photographed and uploaded.

Identification of the specimens commenced throughout the winters of 2017-2018 and 2018-2019 using standard microscope techniques. Specimen identification focused on one family or genus at a time. Un-identifiable specimens were sent to national or

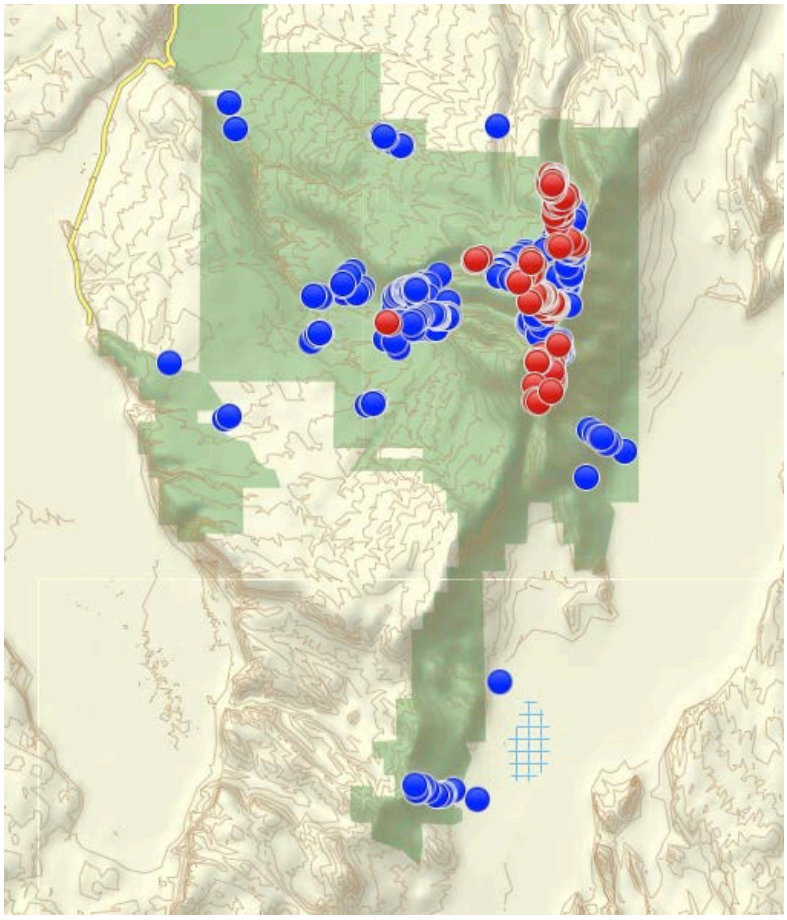
international experts for their opinions. Completed identifications and other associated data were entered into the spreadsheet. Packet information was compiled for listed and other rare species for entry into the BLM GeoBOB database. Field notes were transformed into this report.

RESULTS

The 2017 field season totaled 19 field days collecting between August 19 – September 13. This resulted in 456 specimens (Kofranek collection numbers 7341-7797, annual waypoint numbers 263-456).

The 2018 season totaled 32 field days collecting between July 9 – September 5. This resulted in 783 specimens (Kofranek collection numbers 7809-8594, annual waypoint numbers 046-312).

Collecting efforts resulted in a total of 51 field days; nearly double the original proposed amount of 26. The total number of collections was 1,239 of which 759 were identified. Mosses totaled 145 species, subspecies, and varieties. Ten species of liverworts were identified. The hornwort, *Anthoceros fusiformis*, was found at 7,657 ft. Thus far 37 species of macrolichens have been identified.



Above: 193 waypoints in 2017 (red) and 266 waypoints in 2018 (blue) totaling 459 waypoints, almost all of them collection sites.

The selected survey sites were based on habitat, general area or formation type (i.e. gorges), elevation, vascular plant community type, aspect, light, and moisture regime.

Because of the large number of collections and time constraints, not all collections were identified. To be efficient those that were identified were completed genus-by-genus or family-by-family. Hence the resulting species list is unbalanced in relation to the overall diversity present in the study area and throughout the specimen collections. However, the genera or families that were identified are an accurate representation of that genus or family in the study area. Unknowns were sent to national or international experts for their opinions. Therefore, although the array of diversity is incomplete the identifications of the genera and families that were captured are very representative and accurate including subspecific taxonomic levels such as subspecies, varieties, forms, and *sensu stricto*.

Completed taxonomic groups: all mosses except for most Bryaceae and *Pohlia*, and half of the macrolichens. Incomplete taxonomic groups: most liverworts, half of the macrolichens, all microlichens and biological soil crust lichens.

Moss nomenclature follows Flora of North America vols. 27 & 28. Liverwort and hornwort nomenclature follow Wagner, 2016, 2012, respectively. Lichen nomenclature follows McCune & Geiser, 2009, with deviations as updates to some cyanolichens. Vascular plant nomenclature follows Mansfield, 2000, without attempts to update.

Bryophyte and lichens species of Steens Mt.

Normal font = no status in OR.
Bold font = rare/special status sp.
Gray font = tentative field identification.
MOSSES
Amblystegium serpens
Amphidium lapponicum
Aulocomnium palustre
Barbula convoluta var. *eustegia*
Bartramia ithyphylla
Blindia acuta
Brachytheciastrum collinum
Brachytheciastrum velutinum var. salicinum
Brachythecium albicans
Brachythecium erythrorrhizon var. erythrorrhizon
Brachythecium frigidum
Brachythecium rivulare
Brachythecium salebrosum
Brachythecium turgidum
Bryoerythrophyllum recurvirostrum
Bryum argenteum
Bryum calobryoides
Bryum s.s. sp.
Campylium stellatum
Ceratodon purpureus ssp. *conicus*
Coscinodon calyptratus
Cratoneuron filicinum
Dichodontium olympicum
Dichodontium pellucidum
Dicranella subulata
Dicranoweisia crispula
Didymodon australasiae
Didymodon bistratosus
Didymodon brachyphyllus
Didymodon californicus
Didymodon eckeliae
Didymodon insulanus

Didymodon norrisii
Didymodon rigidulus* var. *subulatus
Didymodon sp. #1
Didymodon vinealis
Distichium capillaceum
Ditrichum flexicaule
Drepanocladus aduncus
Elodium blandowii
Encalypta alpina
Encalypta procera
Encalypta rhaptocarpa
Eurhynchiastrum pulchellum var. pulchellum
Fissidens bryoides
Fontinalis antipyretica
Fontinalis neomexicana
Funaria hygrometrica var. *hygrometrica*
Gemmabryum caespiticeum
Grimmia caespiticia
Grimmia montana
Grimmia nevadensis
Gymnostomum aeruginosum
Homalothecium aeneum
Homalothecium aureum
Homalothecium nevadense
Hygroamblystegium varium
Hygrohypnum bestii
Hygrohypnum luridum
Hygrohypnum molle
Hygrohypnum ochraceum
Hygrohypnum smithii
Hypnum revolutum var. ravaudii
Hypnum revolutum var. *revolutum*
Imbribryum mildeanum
Imbribryum sp.
Leptobryum pyriforme
Leptodyctium riparium
Meesia uliginosa
Meiotrichum lyallii
Mnium arizonicum
Mnium marginatum
Mnium thomsonii
Myurella julacea
Oncophorus virens
Orthotrichum affine
Orthotrichum alpestre
Orthotrichum cupulatum
Orthotrichum euryphyllum
Orthotrichum holzingeri
Orthotrichum laevigatum
Orthotrichum lyellii
Orthotrichum pellucidum
Orthotrichum rupestre
Orthotrichum shawii
***Orthotrichum* sp. #1**
Orthotrichum spjutii
Palustriella falcata
Philonotis fontana var. *americana*
Philonotis fontana var. *fontana*
Philonotis fontana var. *pumila*
Plagiobryum zieri
Plagiomnium ellipticum
Plagiomnium medium
Plagiothecium denticulatum
Platydictya jungermannioides
Pohlia annotina
Pohlia bolanderi
Pohlia cruda
Pohlia tundrae
Polytrichastrum sexangulare var. sexangulare
Polytrichum juniperinum
Polytrichum piliferum
Pseudoleskea cf. tribulosa
Pseudoleskea incurvata var. incurvata
Pseudoleskea patens
Pseudoleskeella tectorum
Pterygoneurum ovatum
Ptychostomum pseudotriquetrum s.l.
Ptychostomum schleicheri
Ptychostomum subneodamense

Ptychostomum weigelii
Rhizomnium magnifolium
Roellobryon roellii
Rosulabryum elegans
Rosulabryum laevifilum
Rosulabryum sp.
Sanionia uncinata
Sarmentypnum exannulatum
Sarmentypnum trichophyllum
Schistidium atrichum
Schistidium cinclidodonteum
Schistidium confertum
Schistidium flaccidum
Schistidium frigidum
Schistidium heterophyllum
Schistidium occidentale
Schistidium rivulare
***Schistidium* sp. #2**
Schistidium squarrosum
Sciuro-hypnum latifolium
Scleropodium obtusifolium
Scouleria aquatica
Stegonia latifolia* var. *pilifera
Syntrichia bartramii
Syntrichia norvegica
Syntrichia papillosissima
Syntrichia ruralis
***Syntrichia* sp. #1**
Syntrichia virescens
Timmia austriaca
Tortella fragilis
Tortula hoppeana
Warnstorfia fluitans
Weisia controversa
HORNWORTS
Anthoceros fusiformis
LIVERWORTS
Cephaloziella divaricata
Chiloscyphus sp.
Harpanthus flotovianus
Jungermannia cordifoia
Lophozia s.l. spp.
Marchantia polymorpha
Pellia endivifolia
Porella sp.
Riccia cavernosa
Scapania irrigua
LICHENS
Bryoria fuscescens
Bryoria pseudofuscescens
Collema undulatum
Dermatocarpon bachmannii
Dermatocarpon miniatum
Dermatocarpon reticulatum
Dermatocarpon rivulorum
Enchylium polycarpon
Evernia prunastri
Hypogymnia imshaugii
Lathagrium fuscovirens
Lempholemma cladodes
Lempholemma polyanthes
Leptochidium albociliatum
Leptogium saterninum
Nodobryoria oregana
Parmelia barronoae
Parmelia hygrophila
Parmelia sulcata
Peltigera canina
Peltigera didactyla
Peltigera kristinssonii
Peltigera malacea
Peltigera ponojensis
Peltigera praetextata
Peltigera rufescens
Peltigera venosa
Rhizoplaca melanopthalma ssp. *crispa*
Scytinium gelatinosum
Scytinium intermedium

Scytinium lichenoides	*Umbilicaria hyperborea*
Scytinium rivale	*Umbilicaria phaea*
Scytinium subaridum	*Umbilicaria polaris*
Solorina spongiosa	*Umbilicaria virginis*

There are apparently three undescribed species of mosses. A specimen of *Syntrichia* and one of *Schistidium* were not identifiable by their respective experts, Zander and McIntosh. Unique specimens of an *Orthotrichum* taxon collected on Steens Mt. matches others (DK coll. #6125) collected on the Malheur National Forest in 2008. All three of these are being further studied with the aim to describe them, which could result as the first endemic non-vascular plants for Steens Mt.

It should be mentioned that someone other than the author collected one of the rare taxa found, ***Didymodon rigidulus* var. *subulatus***. Summer Kofranek collected (coll. #208) the variety new to the state. Outside Arizona and Texas there is one questionable record from California so it is uncertain whether it is disjunct, but is a northerly range extension. ***D. r.* var. *subulatus*** is much more distinct than the other varieties of that species and sometime in the future it could be elevated to species rank.

Summary of rare species

MOSSES	LISTED SPECIES	RANGE EXTENTION	DISJUNCT	NEW TO OREGON	NEW TO SCIENCE
Brachythecium turgidum				X	
Dichodontium olympicum	X				
Dicranella subulata				X	
Didymodon bistratosus		X		X	
Didymodon californicus		X		X	
Didymodon rigidulus var. *subulatus*		X	X	X	
Ditrichum flexicaule	X				
Encalypta alpina				X	
Grimmia nevadensis		X		X	
Meesia uliginosa	X				
Mnium arizonicum		X		X	
Myurella julacea	X				
Orthotrichum euryphyllum	X				
Orthotrichum holzingeri	X				
Orthotrichum pellucidum	X				
Orthotrichum shawii		X	?	X	
Orthotrichum sp. #1				X	X
Plagiobryum zieri	X				
Pohlia bolanderi	X				
Polytrichastrum sexangulare var. sexangulare	X				

MOSSES	LISTED SPECIES	RANGE EXTENTION	DISJUNCT	NEW TO OREGON	NEW TO SCIENCE
Pseudoleskea cf. tribulosa		X		X	
Pseudoleskeella tectorum	X				
Ptychostomum subneodamense		X	X	X	
Sarmentypnum trichophyllum		X	X	X	
Schistidium cinclidodonteum	X				
Schistidium squarrosum		X			
Schistidium sp. #2					X
Sciuro-hypnum latifolium					
Stegonia latifolia var. *pilifera*		X		X	
Syntrichia bartramii		X			
Syntrichia virescens		X		X	
Syntrichia sp. #1					X
Tortella fragilis	X				
LIVERWORTS					
Harpanthus flotovianus	X	X			
LICHENS					
Collema undulatum	X				
Lempholemma cladodes		X		X	
Lempholemma polyanthes		X		X	
Solorina spongiosa	X				

Survey Sites

The four main gorges are described below in fine detail. Because twice as much fieldwork was conducted not all of those results could be treated. Other areas surveyed but not described are: the summit and ridge crest, sage steppe (lowlands), fir forest, minor river canyons, Pike Creek, and Alvord Peak.

Little Blitzen Gorge

Little Blitzen Gorge is a glacially carved U-shaped gorge, about a mile wide, eight miles long, and over a third of mile deep. It drains mostly straight from east to west. It was accessed for multiple days by the mouth via the trail. The four other access points were the Wet Blanket Trail, the neighboring drainage to the west, Nye Place, and descending directly down the headwall.

Little Blitzen River is a class 2-3 stream within a narrow but densely vegetated riparian corridor. Conditions are mostly shaded throughout. Boulders of various sizes are present from 2-3m^3 down to cobble and gravel. The river has pools, small cascades, and fluctuates from high levels in early spring runoff to lower levels in late summer. Areas along the river with high bryophyte and lichen diversity were sporadic with commonly colonized substrates being boulders and peaty embankments. Species growing on these substrates often did so in narrow ranges in relation to water levels and direction of flow. Rare species found here are: ***Orthotrichum holzingeri, Pseudoleskeella tectorum***. Species typical of this habitat are: *Scouleria aquatica, Scleropodium obtusifolium, Mnium marginatum, Didymodon insulanum, Leptodyctium riparium, Amblystegium serpens, Brachythecium salebrosum, Sanionia uncinata, Dermatocarpon miniatum, D. rivulorum, Scytinium intermedium* (syn. *Leptogium intermedium*).



Above left: waypoint 73, 2018 showing bank of organic soil and boulders with bryophytes. Above right: waypoint 58, 2018 where trail crosses river, another example of riparian corridor.

Along the foot-slope of the south gorge wall is a grove of large *Cercocarpus ledifolius* shrubs. They have formed a closed canopy and have created perhaps the most "forested" conditions on the mountain. Although other local species such as *Juniperus occidentalis*, *Populus tremuloides,* and *Abies concolor* can provide similar situations, these species do not seem to grow dense enough or achieve a canopy as closed as much as some *Cercocarpus* groves can. In all of these cases, grass is often the dominant ground layer. In the example of the *Cercocarpus* grove (waypoints 64-80, 2018) seven species of macrolichens were found only here. While these are often ubiquitous in other parts of the region (e.g. West Cascades), here they were "hard earned" and should not be overlooked on the species list. Unique conditions of the site that they are responding to are the close proximity to the humid riparian corridor, shade, north aspect, and lower elevation.

Bryoria fuscescens
Evernia prunastri
Hypogymnia imshaugii
Nodobryoria oregana
Parmelia barronoae
Parmelia hygrophyila
Parmelia sulcata



Above: *Cercocarpus* grove at waypoint 64, 2018.

Perhaps the best area of Little Blitzen Gorge for bryophytes and lichens is the base of a dramatic 30m high cliff face (waypoints 87, 88, 92, 93, 94, 2018). On the south wall of the gorge, it faces 320 °, only receives a limited amount of light at the end of the day, and seeps with base-rich water. Below the cliff face is a talus field with a somewhat thick but limited growth of species (*Prunus virginiana, Rosa woodsii, Actaea rubra, Symphoricarpos rotundifolius, Urtica dioica, Bromus*) taking advantage of the groundwater provided by the seeping cliff. Rare species encountered here were: ***Pseudoleskeella tectorum*** was abundant here, especially forms predominantly of flagelliform branches *sensu* Lawton 1971; ***Schistidium heterophyllum,*** although listed, is perhaps not necessarily rare; ***Syntrichia sp. #1,*** apparently an undescribed species. ***Didymodon eckeliae,*** although listed, is perhaps not necessarily rare.

Other noteworthy species include: *Enchylium polycarpon* (syn. *Collema polycarpon*) a widespread calciphile (McCune & Geiser, 2009), but is not necessarily common in Oregon*; Scytinium gelatinosum* (syn. *Leptogium gelatinosum*) distinctive specimens approaching that of *S. platynum*, infrequent East Cascades (McCune & Geiser, 2009); *Orthotrichum alpestre* another calciphile.

Above: cliff face at waypoints 87, 88, 92, 93, 94, 2018.


Above left: cliff base, waypoint 87, 2018. Above right: cliff base showing calcareous precipitate, waypoint 94, 2018.


Above left: cliff composed of Steens Basalt with plagioclase (feldspar) crystals, waypoint 94, 2018. Above right: close up of calcareous precipitate, waypoint 94, 2018.


Above left: ***Pseudoleskeella tectorum*** waypoint 87, 2018. Above right: *Enchylium polycarpon* (syn. *Collema polycarpon*) waypoint 93, 2018.

The Wet Blanket Trail is one of the few established trails on Steens Mt. It provides access to the eastern end of the Little Blitzen Gorge. In 2017 it was used to survey the associated stream, upper rimrock wall, and a fen at the bottom of the gorge (waypoints 368-379, 2017).

Above left: Wet Blanket Trailhead along Steens Loop Rd (waypoint 368, 2017). Above right: upper Wet Blanket Trail on left of photo, upper middle of photo with rimrock are locations of waypoints 369-371, 2017.

Along the upper end of the trail the rimrock wall had the listed lichen, ***Collema undulata*** at waypoint 369, 2017, and the rare moss, ***Syntrichia bartramii*** at waypoint 370 & 371, 2017.


Above left: waypoints 369-371, 2017 with ***Collema undulata*** and ***Syntrichia bartramii***. Above right: waypoints 373 upper left with ***Mnium arizonicum***, 374 upper right with ***Orthotrichum spjutii*** and ***O. pellucidum*.**


Above left: stream along Wet Blanket Trail with previously listed lichen, *Scytinium rivale* (syn. *Leptogium rivale*) submerged as small black patches on bedrock of streambed (waypoint 375, 2017). Above right: lower Wet Blanket Trail on left in distance paralleling drainage.

In 2018 a loop was surveyed from descending down a steep narrow drainage about a mile west of the Wet Blanket Trail to the gorge bottom, east along the Little Blitzen Gorge Trail, and back up the Wet Blanket Trail (waypoints 151-166, 2018). Significant finds were the mosses ***Schistidium squarosum*** and ***Didymodon norrisii***.

Schistidium squarosum was recently described as a widespread and long overlooked species. McIntosh et al. (2015) cite only one occurrence for it in Oregon, in Klamath County. This apparently is the second record for the state. ***Didymodon norrisii*** is also widespread (Kofranek, 2016, 2019) but is much more common. Both occurred at waypoint 158 (2018) along an unnamed drainage between Nye Place and Wet Blanket Trail at mid slope of the north wall of the glacially carved gorge. They were on rock within seasonal runoff. The surrounding area is xeric, in full sun, at 225° aspect, 84+% slope, and at 7,029 ft. They were with *Juniperus communis, Artemisia tridentata* ssp. *vaseyana, Cercocarpus ledifolius, Symphoricarpos rotundifolius, Eriogonum* sp.

Above left: approximate location of waypoint 158, 2018, along unnamed drainage.
Above right: general habitat type of ***Schistidium squarosum*** and ***Didymodon norrisii***.

The headwall had many interesting upper elevation species including the mosses ***Dicranella subulata*** and ***Mnium arizonicum***. Both are new to the state.

Headwall area of Little Blitzen Gorge looking from south to west.


Above left: habitat of ***Dicranella subulata***, waypoint 176, 2018. Above right: closer view of same habitat and location, waypoint 176, 2018.

Dicranella subulata is known from all surrounding states and provinces except Nevada. It was found growing in open alpine conditions on the near-level surface of a bulge of bedrock facing north along the backslope of the headwall. It was on thin dry organic soil within a complex of meadow, tundra, talus, and a stream at 8,556 ft. Associated species include *Salix, Carex, Dugaldia hoopesii, Mimulus tilingii, M. lewisii, Ligusticum grayii, Veratrum californicum, Hygrohypnum luridum.*


Above left: habitat (in foreground) of ***Dicranella subulata***, waypoint 176, 2018. Above right: cross section of leaf of *D. subulata* (DK #8242).


Above left: habitat of ***Mnium arizonicum*** looking west, waypoint 186, 2018. Above right: closer view of same habitat and location but looking east, waypoint 186, 2018.

Mnium arizonicum is known from all surrounding states and provinces except Washington. It was found on soil over rock of weathered and vegetated rock complex with many shelves, pockets, and micro-niches partially shaded in tundra-like conditions at the footslope of the north-facing south wall of the gorge on an 84% sloping ridge at 7,917 ft. Associated species include *Pentaphylloides fruticosa, Juniperus communis,* bunchgrass, *Grimmia caespiticia, Schistidium atrichum, Ceratodon purpureus* ssp. *conicus,* and biological soil crusts.

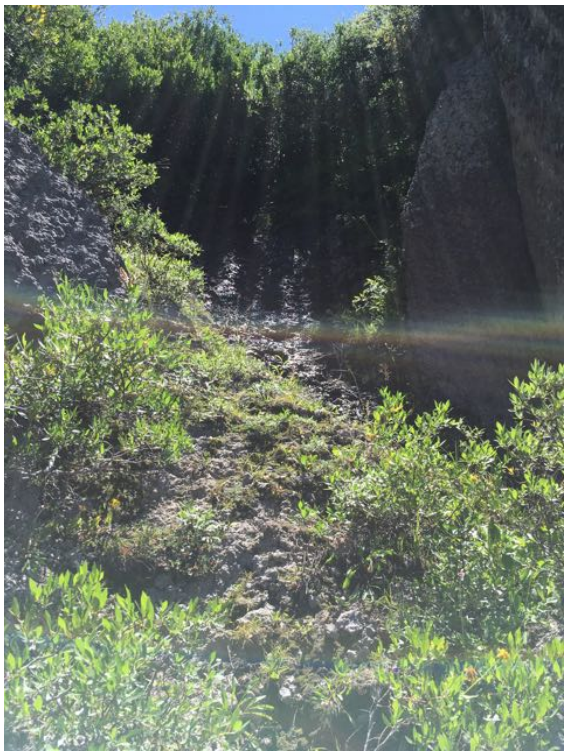
The upper east end of Little Blitzen Gorge is excellent alpine tundra habitat for species of mosses such as ***Encalypta alpina*** (state 1st)**, *Polytrichastrum sexangulare* var. *sexangulare, Mnium arizonicum, Plagiobryum zierii, Ditrichum flexicaule, Campylium stellatum.*** Other noteworthy species are the liverwort, *Anthelia juratzkana,* the moss *Oncophorus virens* (on rock), and the lichen, *Peltigera kristinssonii.*

These locations (waypoints 336-366, 2017) are on an upper terraced hill slope with low relief rock outcrop complexes alternating with benches of gravel/cobble ground. The hotspots are all north facing, ≥ 8,488 ft., in channels of interrupted rimrock walls (basalt) providing protection and cool, shaded, and wet conditions from seeping late snowmelt.


Above left: excellent habitat of north facing upper east end of Little Blitzen Gorge. Above right: close up of specific location (circled in red) at waypoints 345-346, 357-363, 2017.


Above left: continuation of habitat described above, example of near crest of upper slope (waypoint 349, 2017). Above right: ***Plagiobryum zierii*** at waypoint 346, 2017.


Above left: habitat of ***Campylium stellatum*** and *Anthelia juratzkana.* Above right: close up of bluish/glaucous minute leafy liverwort, *A. juratzkana.* (waypoint 345, 2017)

Above left: habitat of ***Encalypta alpina*** and *Anthelia juratzkana* at waypoint 357, 2017. Above right: habitat of ***Polytrichastrum sexangulare* var. *sexangulare*** at waypoint 358, 2017.

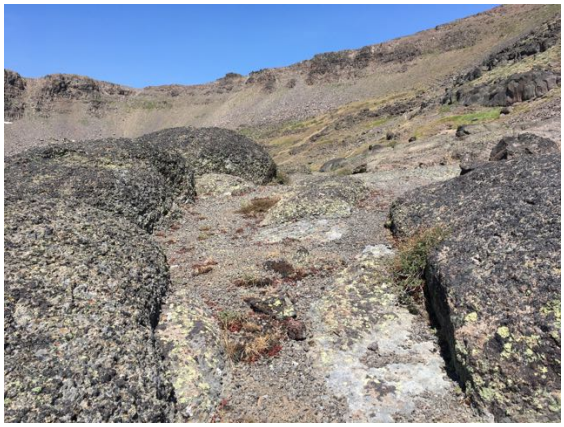

Above left: habitat of ***Polytrichastrum sexangulare* var. *sexangulare*** at waypoint 361, 2017. Above right: ***Polytrichastrum sexangulare* var. *sexangulare*** at waypoint 361, 2017.

Greater Wildhorse Area

Wildhorse Lake

Wildhorse Lake is a tarn just below the summit proper of the mountain. The lake, at 8,400 ft., drains to the south through glacially carved Wildhorse Canyon. This snow-fed basin supports numerous streamlets and lush wildflower meadows that are intermixed with rocky, sparsely vegetated areas such as cliff walls and talus fields.

There is a high concentration of rich habitats here: lakeshore, streams, dry rock outcrops and calcareous seeps. This makes for relatively high diversity but lower frequency per individual species. Bryophytes are especially well-represented here because of the available water.



Above left: (pillow?) basalt rock outcrop complex at waypoint 268, 2017. Above right: atop same outcrop with gravel where ***Grimmia nevadensis***, new to Oregon, was found. The vagrant lichen, *Dermatocarpon bachmannii* is also present here.


Above left: crevice at base of pillow basalt outcrop waypoint 270, 2017. Above right: close-up of crevice with the listed moss, ***Tortella fragilis***. Also present *Distichium capillaceum* and *Amblystegium serpens.*

Along the east and south lakeshore of Wildhorse Lake is 0.5m tall band of stable, perennially moist, organic soil that is excellent habitat for liverworts. It is an ecotone at the margin of a lush alpine meadow with the lake and is kept moist by the high water table. *Anthelia juratzkana* is here and the listed moss, ***Campylium stellatum***. These conditions and rich habitats are also found along the stream banks in this area. Along the west shoreline is the terminus of a toe-slope of an active (eroding from above) talus field that continues to renew the rocky shoreline there and thus preventing soil formation that would lead to these conditions.



Above left: excellent liverwort habitat along east and south lakeshore. Above right: close-up of habitat. Perennially moist organic soil ledge covered with mostly liverworts at waypoints 265, 273-278, 282, 2017.

The alpine lake habitats of Wildhorse (8,400 ft.) and Little Wildhorse Lakes (8,943 ft.) are certainly unique. It would be interesting to know where and how far away the next closest lakes at these elevations are to here.

A tributary to the lake was followed upstream to a two-meter tall punch bowl waterfall. The lower walls of the two-meter diameter pool are within the splash zone covered with bryophytes such as the mosses ***Dichodontium olympicum***, *Eurhynchiastrum pulchellum var. pulchellum, Palustriella falcata* (calciphile), *Philonotis fontana,* and the liverwort ***Harpanthus flotovianus*** (only location). There is a high amount of constant moisture mostly protected under a canopy of *Salix* but exposed to the west. Also here *Dugaldia hoopesii, Veratrum californicum, Saxifraga odontoloma,* and ***Botrychium cf. minganense*.**


Above: waypoint 281, 2017.

At the base of the rock wall overlooking the lake are eroded cavities at waypoints 283-286, 2017. These east-facing alcoves provide cool, shaded, protected, conditions and seeping base-rich water. The largest of these is 15m wide x 7m tall x 5m deep (waypoint 286, 2017).

Above: alcove at waypoint 286, 2017.

Above: alcove at waypoint 286, 2017.

There are four moss calciphiles at these locations with *Gymnostomum aeruginosum* being the most abundant forming dense cushions of narrow-leaved plants across the ceilings and walls. This high elevation calciphile is not listed but by no means is it common throughout Oregon.

Above: alcove with *Gymnostomum aeruginosum* as dark patches in upper right at waypoint 283, 2017.

In the back of the largest alcove is another alcove about $1m^3$ where the listed moss, ***Myurella julacea***, is growing in close association with *G. aeruginosum.* This location is the second record for the state of this julaceous (worm-like) northern calciphile.

Above left: small alcove within large alcove with ***Myurella julacea*** and *Saxifraga odontoloma.* Above right: close-up of ***M. julacea*** (elongate light green shoots) with *Gymnostomum aeruginosum* (dark green lower down) waypoint 286, 2017.

Cratoneuron filicinum is more common in streams at Steens Mt. but it is here also because of the base-rich moisture. Other species here are *Amphidium lapponicum,* which is very similar to *G. aeruginosum* and a facultative calciphile, ***Campylium stellatum*** was on moist soil. *Philonotis fontana var. pumila* is an arctic-alpine species, and *Grimmia caespiticia* was found on the same Steens Basalt but without calcareous influence.


Above left: close-up of *Cratoneuron filicinum* at waypoint 283, 2017. Above right: close-up of *Philonotis fontana var. pumila* at waypoint 284, 2017.

Wildhorse Canyon

This glacially carved canyon drains the lake as Wildhorse Creek to the south. This exploration started with an unnamed pond 320m south of Wildhorse Lake. Other than the thallose liverwort, *Riccia* sp., the pond did not have much diversity or biomass perhaps partly due to the soft loamy shoreline that is probably susceptible to disturbance from frost heaving and thawing every spring.

Nearby at waypoint 289, 2017, in a rock crevice the northern moss species, ***Ptychostomum subneodamense*** turned up. Farther south the ground and low relief rock outcrops offer tundra conditions in which there are the lichen, *Umbilicaria virginis*, and the moss, *Mnium thomsonii*, a calciphile.


Above left: *Umbilicaria virginis* (waypoint 291, 2017). Above right: *Mnium thomsonii* (waypoint 292, 2017).


Wildhorse Creek anastomoses and is dry for long stretches. Then water resurfaces in some areas. From waypoint 295 to 296, 2017, there is good riparian edge habitat. Just above the water surface, such as along the east and south shore of Wildhorse Lake, is colonized by liverworts. Conversely, some lengths of the creek are eroding in which cases the only bryophytes that can be supported are pioneering species before the embankments eventually slough into the water. What factor(s) can this be attributed to?


Above left: example of good liverwort habitat just above water level and below overhanging wet alpine meadow species (waypoints 295 to 296, 2017). Above right: example eroding creek bank limiting bryophyte colonization.

Wildhorse Creek drops as waterfalls over the large scale tiers of the canyon. Often on the rocks of these falls are the aquatic pleurocarpous mosses, *Palustriella falcata, Cratoneuron filicinum* (both calciphiles), and *Hygrohypnum bestii.*



Above left: falls with *Cratoneuron* and *Hygrohypnum bestii* at waypoint 301, 2017.
Above right: *Palustriella falcata* at waypoint 302, 2017.

Little Wildhorse Lake
A loop was hiked from the summit parking area to Little Wildhorse Lake, down Little Wildhorse Creek to Wildhorse Canyon, then north up that canyon, and past Wildhorse Lake returning to the parking lot. For more information about the route: https://fastestknowntime.com/route/little-wildhorse-lakes-loop-or

Little Wildhorse Lake is a small (< 1 ac.) tarn at nearly 9,000 ft. surrounded by relatively low slopes but draining to the south southwest.



Above left: Little Wildhorse Lake (waypoints 304-308, 2017). Above right: example of habitat and substrate diversity along the east shore (waypoints 305, 306, 2017).

A remarkable disjunct species from Alaska and northern Canada was found here: ***Sarmentypnum trichophyllum***. It is a pleurocarpous wetland moss new to the state. On the damp ground is *Ptychostomum weigelii* which is expected in this type of habitat, however, the red form here was unknown outside of Colorado (Spence, 2014). *Meiotrichum lyallii* is present in the crevices of a rock outcrop. It is better known as an *Abies* forest floor moss in montane situations. Among the wet *Carex* is the widespread *Drepanocladus aduncus* and an unusual form of *Plagiomnium ellipticum* that was very difficult to identify because of the minimally developed marginal teeth etc.

The rock outcrops toward the outflow are sheet draining and have *Schistidium occidentale* and *Schistidium rivulare.* The ubiquitous alpine *Grimmia caespiticia* is also present.


Above left: close-up of red form of *Ptychostomum weigelii* (waypoint 305, 2017). Above right: *Meiotrichum lyallii*.

Little Wildhorse Creek

Above: looking south, Little Wildhorse Creek.

Near the confluence of Little Wildhorse Creek and Wildhorse Creek proper, there is a waterfall with *Philonotis fontana* var. *fontana* and a trace amount of the only collection of *P. f.* var. *americana.* Traversing around the lower ridge that separates the two Wildhorse Creeks the moss, ***Didymodon bistratosus*** was found at waypoint 312, 2017. Growing on a dry rock formation, it is the first time it has been found outside of California.

Above left: waterfall along Little Wildhorse Creek. (waypoint 311, 2017). Above right: different location but same habitat for ***Didymodon bistratosus***.

Kiger Gorge

Kiger Gorge is a similarly deep and broad glacially carved gorge that drains to the north. Much of the south end of the gorge was accessed by a faint trail. Part way down surveys contoured paralleling the slope usually along the bases of seeping cliffs. In these habitats (waypoints 393-395, 2017) the moss, ***Plagiobryum zieri*** is present on saturated organic soil closely associated with *Nostoc* colonies. It is distinctive in having silvery-pinkish julaceous (worm-like) shoots, and elongate zygomorphic (asymmetrical) gibbous (drooping) capsules. The populations here are much larger, more numerous, and fertile compared to the only other place it is known from on the mountain, the upper southeast end of Little Blitzen Gorge. It is also expected to be on the upper southeast end of Big Indian Gorge.


Above left and right: ***Plagiobryum zieri.***

Also present here are two even more rare species. The lichen***, Solorina spongiosa***, a boreal species of calcareous seeps more common from Alaska to Montana, which represents the only site between Wallowa Co. (The Matterhorn), Oregon and the southern Sierras. Otherwise it is a species of the northern Rockies with a few populations extending down into Utah, New Mexico, Colorado, and Nevada.

Finally, the pleurocarpous moss, ***Brachythecium turgidum***, an arctic-alpine species more common to the north was also found here in this same habitat (waypoint 395, 2017). Although there are some dubious records of it from Washington, California, and maybe Idaho, there are no previous records of it for Oregon.


Above left: rich habitat at waypoints 393-395, 2017. Above right: close-up of same habitat at waypoint 395, 2017.

In this same habitat but at a different location (waypoint 400, 2017) the moss, ***Sciuro-hypnum latifolium*** (syn. *Brachythecium nelsonii*), is present on a moist shaded rock wall face below a seep. This represents the third record of the species in the state. The previous two are from Malheur National Forest to the north (Kofranek #'s 6568, 6631).

On the backslope of the headwall of Kiger Gorge is a convex area of terrain, or bulge, formed by a complex of low relief rock outcrops. This limited area of excellent habitat is crowded with diversity. There are well-developed communities especially of leafy liverworts and *Cladonia* squamules forming an expansive cryptogamic crust over organic soil that suggest its old and pristine condition. The rare, *Salix nivalis*, is present and indicative of areas of snow accumulation (Mansfield, 2000). When not buried in snow this area is perennially wet to damp, faces 340°, and subjected regularly to wind.



Above: the bulge. Two different views of the same location, waypoint 406, 2017.


Above: *Salix nivalis* at waypoint 406, 2017.

Solorina spongiosa and ***Plagiobryum zieri*** are here (waypoint 406, 2017). The moss, *Timmia austriaca* is abundant in these conditions.


Above left: close-up of ***Solorina spongiosa*** with yellow-green leafy liverworts. Above right: large old 0.5m^2 colony (black, white, gray areas) of ***S. spongiosa*** (waypoint 406, 2017).


Above: examples of high coverage of leafy liverworts (waypoint 406, 2017).

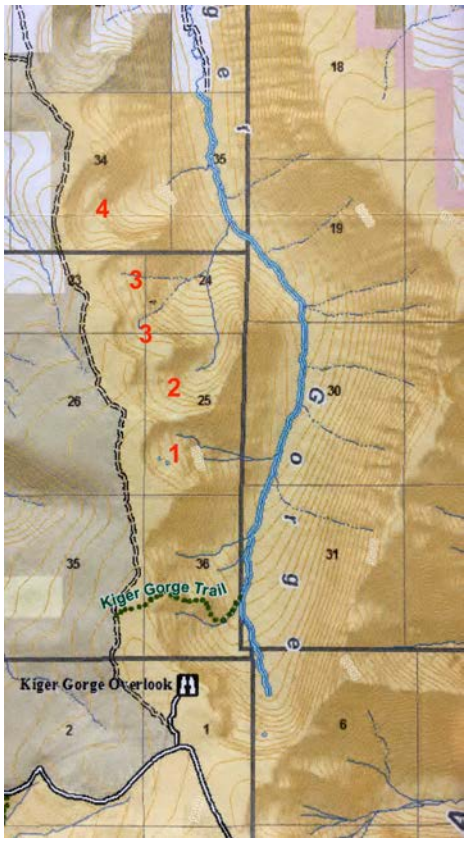

Above left: the listed moss, ***Pohlia bolanderi***. Above right: close-up with pentangular growth form of shoots (waypoint 406, 2017).

Shortly down slope from the bulge is the headwaters of Kiger Creek, which in part is a fen (waypoint 407, 2017). Within the fen is a population of ***Elodium blandowii*** (syn. *Helodium blandowii*) about 15m^2 in diameter at 20% coverage. It is growing with *Salix, Carex, Sarmentypnum exannulatum,* and *Aulocomnium palustre*.

Above: fen at headwaters of Kiger Creek (waypoint 407, 2017).


Above left: ***Elodium blandowii*** in middle of photo. Above right: close-up of ***E. blandowii*** (waypoint 407, 2017).

The cirques along the west wall of Kiger Gorge are each very interesting and unique unto themselves. A total of four cirques proper were surveyed.

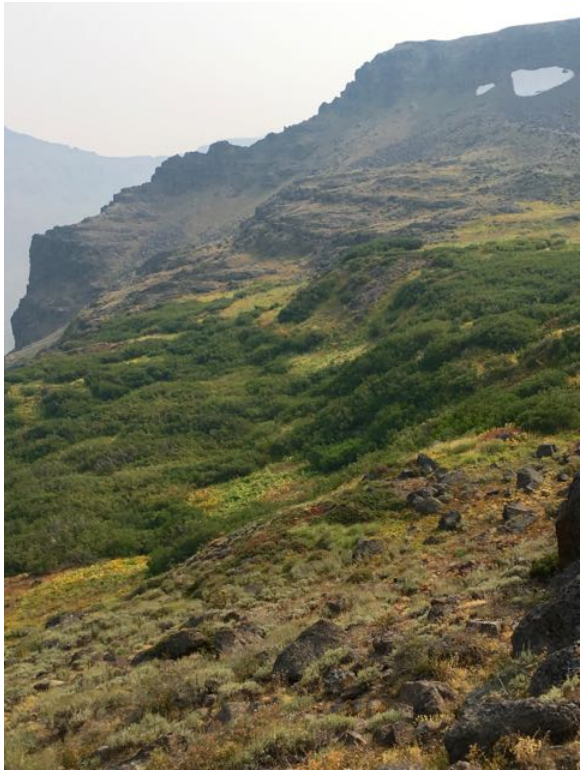


Above: surveyed cirques of Kiger Gorge with reference numbers **1-4**.

Cirque #1 is about 600m across and is a series of benches with the uppermost occupied by two pond-sized tarns. These are at the base of a talus field. The larger is 20m in diameter, surrounded by *Salix* spp., and with low-sloping, damp, loamy soil about 2m broad. Lichens are virtually absent here and bryophytes are minimal although two were collected. Field identifications are *Riccia* sp., *Anomobryum* sp., and *Polytrichum juniperinum.* The smaller tarn is more exposed, has less *Salix*, and is at waypoint 412, 2017.

Above left: cirque #1 with tarn in middle of photo. Above right: close view of tarn at waypoint 411, 2017.

Below the tarns, to the east, terraces are covered with spring-fed fens intermixed with *Salix* thickets. ***Elodium blandowii*** and ***Sciuro-hypnum latifolium*** (syn. *Brachythecium nelsonii*) were found here. Both species were in perennially moist conditions at the bases of vascular plants.




Above left: terraced habitat of fen/meadow-Salix complex at mid to lower area of cirque #1. Above right: ***Elodium blandowii*** at extreme bottom center of photo (waypoint 414, 2017).

Above: close-up of ***Elodium blandowii*** (waypoint 414, 2017).


Above left: ***Sciuro-hypnum latifolium*** forming a deep cushion and intermixed with vascular plants (waypoint 415, 2017). Above right: close-up of ***S. latifolium*** (waypoint 415, 2017).

Cirque #2 is elongate and curves to the north. It also is terraced with fens occupying the benches with the exception of a tarn at one of them (waypoint 424, 2017). This small tarn is surrounded by some *Salix* thickets, *Populus tremuloides,* and almost overgrown by *Carex cf. utriculata*. No aquatic bryophytes or lichens were seen in this water.

Above: upper cirque #2 from waypoint 420, 2017.


Above left: mid elevation cirque #2 with tarn with *Carex cf. utriculata* at waypoint 424, 2017. Above right: close-up of same tarn.

The hornwort, ***Anthoceros fusiformis***, was found along a 1m wide stream that drains the tarn at an ecotone between a grove of *Populus tremuloides* and an herbaceous meadow of *Veratrum californicum, Heracleum lanatum*. ***A. fusiformis*** was occupying a typical situation on recently disturbed mineral soil of the eroded stream channel. ***A. fusiformis*** is the most common species in the state but any species of hornwort on the east side of the Cascades is rare. Additionally the elevation at which it was found, 7,657 ft., is one of the highest documented. According to herbarium records and Spence et al. (2006) this has not been recorded above 8,000 ft. and appears to be conservatively the fifth highest recorded in North America.

Above left: habitat of ***Anthoceros fusiformis***, specifically at the extreme lower right corner of photo. Above right: close-up of same habitat (waypoint 428, 2017).

Above: lower cirque #2 looking back up towards the southwest and waypoint 433, 2017 in the distance from waypoint 430, 2017.

On the hike back out of cirque #2 a particularly rich face of a basalt wall was encountered. Here were the mosses, ***Meesia uliginosa*** and *Oncophorus virens* (each only the second of two locations on the mountain), growing with *Salix nivalis*. ***M. uliginosa*** is a species of fens and *O. virens* usually grows on logs, but both were growing on saturated organic soil over rock irrigated by a seep (waypoint 433, 2017).

Cirque #3 (waypoints 434-441, 2017) is over a half mile wide, double the width of the others, but similarly terraced. The slopes between each bench are rich areas whether they are seeping rock faces, slots, crevices, or damp, shaded, earthen embankments. However, this is perhaps the least interesting of the cirques because although it has the features described above, the fens here are limited in size and number. Instead drainages are mostly narrow and plunge directly downslope. The lower slopes of this cirque look lush with *Populus tremuloides* and to the south there are very tall walls. Both of these areas are worth exploring in the future but from the bottom of the gorge upwards.

Above: Cirque #3.

No rare or listed species were found in cirque #3, but it did have typical species of mid to upper elevations including the liverwort *Anthelia juratzkana*.

Above: common upper elevation moss, *Grimmia caespiticia* at waypoint 437, 2017).

Above: Cirque #4 (waypoints 442-454, 2017).

No rare or listed species were found in Cirque #4 but it is still an interesting area. There is a beaver pond on its lower slopes at waypoint 445, 2017. There was recent evidence of their gnawing trees. Associated plants are *Salix, Carex cf. utriculata, Angelica arguta,*

and *Solidago canadensis.* Conditions are open but lush with tall forbs and graminoids. The surrounding *Populus tremuloides* provide a source of coarse woody debris in this habitat. Some of it is decayed enough and perennially moist from the standing water to support *Meesia uliginosa,* but it is conspicuously and peculiarly absent. Perhaps *M. uliginosa* is too choked-out by the herbaceous plants and graminoids.

Above: beaver pond at cirque #4.

Above: beaver pond at cirque #4.

Above: beaver pond at cirque #4.

Above: the lichen, *Peltigera ponojensis*, probably the most common *Peltigera* on the mountain. A particularly well-developed specimen growing in protected conditions (waypoint 453, 2017).

At the footslope of the west wall of Kiger Gorge are portions of rock walls parallel to Kiger Creek. In some places here the columnar basalt is horizontal, better facilitating the base-rich groundwater reaching the surface. The calcareous precipitate is visible as accumulations on the “cut ends” of the “stack of logs.” Likely because of these stronger calcareous conditions, the lichen, ***Lempholemma cladodes*** (identified by Matthias Schultz) is here. It is a calciphile of the Rockies not previously known from Oregon and has only one record from Washington.

Above: seasonal calcareous seep through horizontal columnar basalt with ***Lempholemma cladodes*** at waypoint 242, 2018.

About 35m away in similar conditions are two more calciphile cyanolichens ***Collema undulatum***, *Enchylium polycarpon,* and the moss, ***Schistidium flaccidum*** (facultative calciphile?) at waypoint 243, 2018.

Big Indian Gorge

Above: Big Indian trailhead sign at South Steens Campground, waypoint 98, 2018.

Above: Big Indian Gorge from overlook along Steens Mt. Loop Rd.

Big Indian Gorge is the same magnitude in size as the others and drains from east to west.

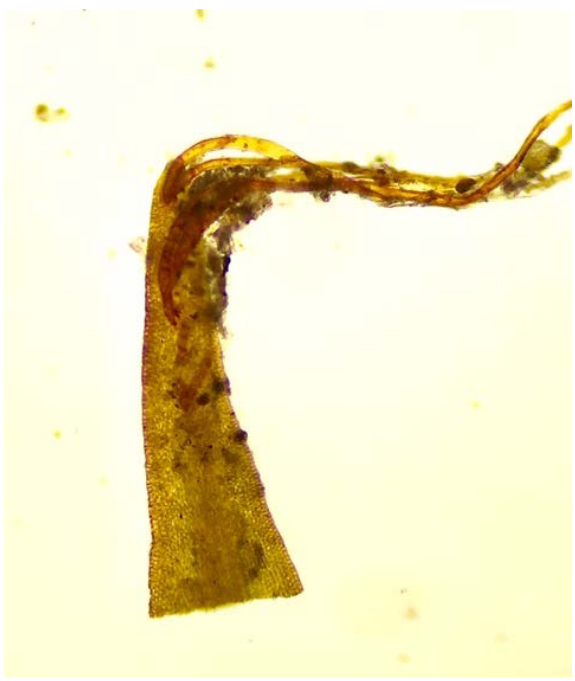
The moss ***Orthotrichum spjutii*** was found on a large triangular rock outcrop not far from the mouth of the Big Indian Gorge. Long considered an endemic to California, there may not be more than one record from Nevada. Steens Mt. is the first location for Oregon.

Above: ***Orthotrichum spjutii*** at waypoint 126, 2018.

Also in the vicinity is the listed moss ***Didymodon norrisii***. It is a western endemic always associated with water to some degree, and here is no exception. It is in a narrow channel of seasonal drainage (waypoint 129, 2018).


Above left: habitat of ***Didymodon norrisii*** at lower middle. Above right: close-up of habitat. Dark patches are ***D. norrisii,*** yellow color is dead moss (waypoint 129, 2018).

The moss, ***Didymodon californicus*** was found outside the mouth of Big Indian Gorge on the foot-slope of the west-facing escarpment in grassland with scattered *Juniperus occidentalis*. This species was described recently in 2014 as endemic to California until this discovery at Steens Mt. It occupies small, seasonal, rocky streams with the listed moss, ***Schistidium cinclidodonteum.*** Additionally, the Steens Mt. specimens have the characteristic of rhizoids originating from distal adaxial costal surface that lacks an epidermis. It is homologous to the nematogens that give rise to rhizoids in *Calliergon* (Calliergonaceae). Hardly any species of mosses do this and since *Leptodontium excelsum* has been placed into its own family, Streptotrichaceae (Zander, 2017), this leaves these specimens of this species the only ones to do so in the Pottiaceae (Zander, 2019).

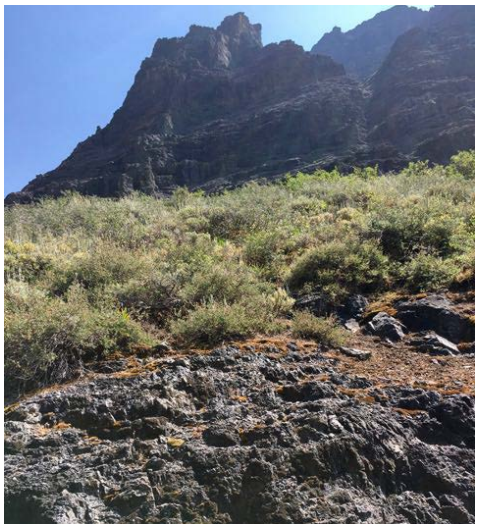



Above left: habitat of ***Didymodon californicus*** and ***Schistidium cinclidodonteum*** at waypoint 108, 2018. Above right: rhizoids growing from cutoff leaf tip of ***D. californicus***, DK coll. #7795.

The Big Indian headwall area was explored for two days. It is unique and interesting because of its wide variety of habitats and land and rock formations. Big Indian Creek has a narrow but lush band of growth along it including *Populus balsamifera* ssp. *trichocarpa, Populus tremuloides, Salix,* many forbs, graminoids, and five species of the Brachytheciaceae moss family (waypoint 217, 2018). Upstream from there, the creek has severely down-cut 7-10m, forming a slot canyon along what could be a collapsed lava tube (waypoint 215, 2018). There is a subalpine scabland (waypoint 211, 2018) with thin sparsely vegetated gravelly soil over moraine.


Above left: slot canyon at waypoint 215, 2018. Above right: subalpine scabland waypoint 211, 2018.

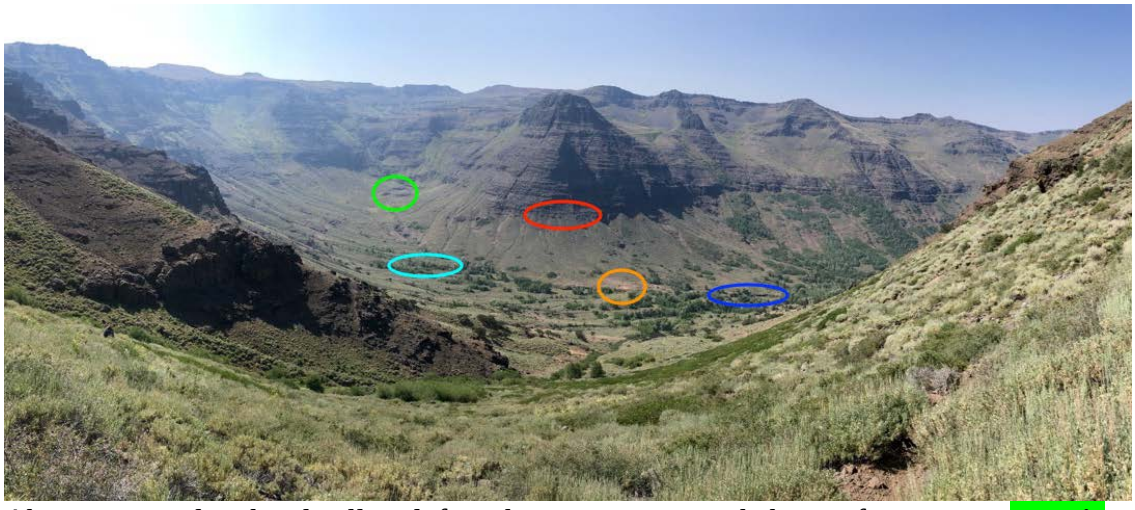
There is a grove of *Populus tremuloides* not associated with the creek but situated on a low rise between two arroyo-type drainages. The grove is 50m x 30m, of mature seral stout trees with 0.5+m D.B.H. at 7,200 ft. On bark, at the base of one of these trees the listed moss ***Pseudoleskeella** cf. **tectorum*** was found. This species is typically saxicolous and this specimen (DK coll. #8337) is unusual in other regards. The expert, John Spence, is currently studying it. The uppermost reaches of Big Indian Gorge make a tight turn to the south. The rocky promontory around which it turns has the listed moss, ***Orthotrichum spjutii*** at its base. Around the bend, the gorge ends at the base of a tall, snow-fed waterfall with the aquatic moss, *Hygrohypnum smithii*.

Above left: *Populus tremuloides* grove with ***Pseudoleskeella** cf. **tectorum*** at waypoint 218, 2018. Above right: habitat of ***Orthotrichum spjutii*** at base of rock formation in background at waypoint 213, 2018.

The listed moss, ***Meesia uliginosa***, was found in the crevices of a low-relief bedrock wall with a spring above on the wet shelf and seeping over the north-facing ledge. Associated forbs and graminoids are lush. ***M. uliginosa*** is typically a fen moss but here it persists because of the perennially wet, organic soil on which is grows.


Above left: habitat of ***Meesia uliginosa*** at waypoint 219, 2018. Above right: close-up of habitat of ***M. uliginosa*** at waypoint 219, 2018.



Above: Big Indian headwall on left with various species, habitats, formations: ***Meesia uliginosa***, ***Pseudoleskeella cf. tectorum,*** ***Orthotrichum spjutii***, **scabland**, **slot canyon**. The north facing cirques in the upper right of the photo should be searched for ***Polytrichastrum sexangulare var. sexangulare.***

DISCUSSION

Emerging Bryophyte and Lichen Floristic Trends

Because almost all of the mosses that were collected were identified, this group is the most informative in terms of any floristic patterns inherent to Steens Mt. Not enough liverworts or lichens have been identified yet to offer similar information.

The most represented families with the highest number of genera and species.

FAMILY	# OF GENERA	# OF SPECIES
Pottiaceae	10	23
Bryaceae	6	14 (conservative estimation)
Brachytheciaceae	6	14
Grimmiaceae	3	14
Amblystegiaceae	10	14 (may only be 7 genera (FNA, 2014))
Orthotrichaceae	2	13

These combined six families total 92 taxa out of an overall 150 taxa (61%). The remaining 19 other families only total 58 taxa. This equates to 24% (6/25 genera) of the families contain 61% of the taxa. Or about a quarter of the families contain over half of the taxa.

What are the characteristics of these six families?

Syntrichia (Pottiaceae), *Grimmia*, *Schistidium* (Grimmiaceae), and *Orthotrichum* (Orthotrichaceae) are good examples of "stress tolerators" (Vitt, 2008). They are genera that do not necessarily face high competition but have to withstand harsh conditions (Zander, 1993) such as exposed rock. They do this by their upright acrocarpous, cushion-

forming growth form. Additionally, their leaf cells are often textured. All of which aid in water retention in places such as vertical rock faces. Specifically, species of *Orthotrichum* "are highly evolved xerophytes that have reduced their peristome complexity because of unneeded hydrophytic activity in the arid climates they inhabit. These species lack the long setae necessary to elevate spores for better dispersal because these plants usually colonize vertical rock surfaces that don't impede spores from spreading" (Kofranek, 2018).

Conversely, *Brachythecium* and *Homalothecium* (Brachytheciaceae) are in protected moister conditions such as stream corridors and below canopies but have to face higher competition, which they do with their prostrate spreading pleurocarpous habit. They are long-lived and can attain great quantities of biomass (Vitt, 2008). Their seta have elongated and elevating inclined capsules with hydrophytic diplolepideous peristomes. This aids spore dispersal from horizontal surfaces.

The breadth of the Bryaceae encompasses a mix of adaptive strategies. *Bryum argenteum* and *Gemmabryum caespiticium* are examples of ruderal species, early successional plants that colonize recently disturbed or exposed surfaces in harsh conditions. Many species in this family have various forms of asexual propagules that aid in doing this. This contrasts with turfs of *Ptychostomum,* a genus of cold and periodically wet conditions. (Vitt, 2008. Spence, 2014)

What can we infer about the landscape through the characteristics of these predominant families?

The predominance of the Pottiaceae, Grimmiaceae, and Orthotrichaceae bespeaks of an arid climate that includes high solar radiation, wind, heat, and freezing. It also shows an abundant amount of rock substrate, both acidic and basic.

The Pottiaceae contains many species that are ruderal and terricolous, however they are not highly represented here. Instead most of the diversity in this family are species of wet and dry rock faces.

"Most species of *Grimmia* prefer dry and temperate or cold environments… Nearly all species of *Grimmia* are saxicolous with a marked preference for acidic bedrock" (Hastings & Greven, 2007). With this said and considering the desert massif of basalt of Steens Mt., one would expect a high diversity of *Grimmia* from here, but this is not the case. There certainly is high biomass of *Grimmia,* but of only two species (a third is present but only known from one site). As it turns out most of the diversity of the Grimmiaceae is from *Schistidium* (10 species) a genus of "occasional submergence" within sheet drainages of rock outcrops (Norris & Shevock, 2004). This attests to the vast areas of snow accumulation and their subsequent melting.

The species of the Bryaceae represent three different habitat types; biological soil crusts, rock faces within seeps or snowmelt, and wetlands. All three of these habitats are widespread and abundant on Steens Mt.

The high diversity of the Brachytheciaceae and Amblystegiaceae further shows there is at least a sufficient amount of water on Steens Mt. as fens, seeps, streams, creeks, rivers, and lakes, though there are often vast xeric areas in between them. Therefore in these localized wet habitats competition among them is high. An example of this is where the trail down from upper Big Indian crosses Big Indian Creek at the bottom of the gorge where there are five species of Brachytheciaceae in a $2m^2$ area.

Above: Big Indian Creek with rich location of pleurocarpous mosses at waypoint 217, 2018.

Asexual reproduction

There is a relatively high number of species of mosses, nearly 10%, with asexual propagules. In arid regions monoicous species are more prevalent than dioicous (Schofield, 1985) because of the scarcity of water to facilitate in fertilization. Perhaps the use of asexual propagules is a related life strategy to cope with aridity.

SPECIES	PROPAGULE TYPE
Barbula convoluta	Rhizoidal tubers & uniseriate rhizoidal gemmae.
Bryoerythrophyllum recurvirostrum	Gemmae on leaves (needs confirmation).
Didymodon eckeliae	Fragmenting leaf tips.
Encalypta procera	Filamentous rhizoidal gemmae.
Leptobryum pyriforme	Axillary brood bodies.
Orthotrichum lyellii	Gemmae on leaves.
Philonotis fontana var. *pumila*	Caducous slender brood branches.
Pohlia annotina	Axillary gemmae.
Pohlia bolanderi	Fragmenting stems.
Pseudoleskeella tectorum	Flagelliform branches.
Rosulabryum laevifolum	Axillary uniseriate gemmae.
Tortula hoppeana	Axillary uniseriate gemmae (needs confirmation).

Converging floristics

Steens Mt. is isolated, but it is also surrounded by other mountain ranges, even if it is distantly so. The majority of the species have a widespread range. However, as with the

vascular plants (Mansfield, 2000) some of the floristic elements of the bryophytes and lichens generally come from three different mountain ranges/regions.

ROCKIES/NORTHERN	SIERRAS/GREAT BASIN	CASCADES
Brachythecium turgidum	*Didymodon bistratosus*	*Didymodon eckeliae*
Collema unduatum	*Didymodon californicus*	*Didymodon norrisii*
Dicranella subulata	*Grimmia nevadense*	*Homalothecium aureum*
Encalypta alpina	*Orthotrichum spjutii*	*Orthotrichum lyellii*
Enchynium polycarpon		*Scytinium gelatinosum*
Lempholemma cladodes		
Lempholemma polyanthes		
Peltigera kristinssonii		
Sarmentypnum trichophyllum		
Solorina spongiosa		

Atypical phenotypes (and genotypes?)

The identification of the specimens was an immediate and prolonged challenge because many were atypical of their species. This may be explained by the flora's isolation for millennia and one species originating from two disparate mountain ranges/regions. Patterns of this with the vascular plants include species boundaries that have dissolved and now form a broad continuum of characteristics between two species. Another is that what remains is a species unlike it is elsewhere throughout its overall range. Or that the species that is present is typical but sporadically reveals atypical genes (Mansfield, 2000).

The presence of gemmae on species not previously known to have them may be an example of this. Throughout the hundreds of specimens identified thus far, certain specimens of the following species were memorable in their difficulty to recognize. These were annotated as "atypical". The *Grimmia caespiticia* fits the above example of a species boundary dissolving, in this case with *G. alpestris.* Very typical *G. caespiticia* was collected and therefore that species is positively present. However, throughout many of the other 28 collections an uninterrupted spectrum exists from that specimen to those that could be *G. alpestris.* Applying a conservative approach, this was interpreted as a variable *G. caespiticia* rather than trying to separate *G. alpestris* out.

Species of atypical specimens

Didymodon californicus	*Plagiomnium ellipticum*
Grimmia caespiticia	Pottiaceae, various
Oncophorus virens	*Pseudoleskea cf. tribulosa*
Orthotrichum rupestre	*Schistidium* sp. #2
Orthotrichum sp. #1	*Syntrichia* sp. #1
Peltigera praetextata	*Warnstorfia fluitans*
Philonotis fontana (an unbelievable breadth of variety)	

Calciphiles
Calcareous conditions are common in the Great Basin, but overall in Oregon they are rare. Numerous calciphiles are present on Steens Mt., but there is no limestone there. Therefore, how does thousands of feet deep, siliceous basalt support calciphiles?

"… the rocks, although almost entirely silicates, have plenty of calcium-rich alteration products within them —and much of the water has abundant CO_2, which can combine with the Ca and other cations." (Miller, 2019). Furthermore, presumably, when these products are flushed out of the basalt as seeps, they are concentrated through evaporation and in some places precipitate, forming white residue on rock wall faces etc.

Steens Mt. calciphiles

MOSSES	LICHENS
Encalypta procera	*Collema undulata*
Gymnostomum aeruginosum	*Enchynium polycarpon*
Hypnum revolutum	*Lempholemma cladodes*
Mnium thomsonii	*Lempholemma polyanthes*
Myurella julacea	*Peltigera kristinssonii*
Orthotrichum alpestre	
Orthotrichum cupulatum	
Orthotrichum pellucidum	
Palustriella falcata	
Pseudoleskeella tectorum	
Schistidium atrichum	

Scabland vagrants
Vagrant lichens and a moss were found in scabland habitats: open, level terrain with minimal vascular plants, scattered boulders, and soil that is pebble-size rock or much finer. These organisms start by growing on rock then eventually they detach and get blown around enough to grow evenly all over and attain a spherical or cylindrical shape.

Waypoints 123, 194, 201, 2018, are some of the best examples of scablands.



Above left: vagrant *Dermatocarpon bachmannii* in "tumbleweed" form (waypoint 194, 2018). Above right: *Grimmia montana* pinching off from rock (waypoint 123, 2018).

This habitat and vagrant forms are uncommon. Other species of vagrant lichens at Steens Mt. are *Rhizoplaca melanopthalma* ssp. *crispa* and *Aspicilia.* Moss balls are even less common and were first reported for North America by Hardman (2010). That species was *G. ovalis* from Union and Umatilla Counties. Since then another instance of it was encountered in Umatilla Co. (Kofranek, 2016) as *G. trichophylla*. These Steens Mt. occurrences represent the third species to form moss balls, *G. montana*.


Above: moss balls in foreground, source rock in background (waypoint 201, 2018).

Suggested target species for future surveys

Future inventory efforts should target the list of species below. Despite Malheur National Forest being more forested and lower elevation, the checklist of bryophytes and lichens from there (Smith & Rausch, 2015) should be closely consulted for additional potential species.

LICHENS
Aspicilia rogeri: type locality is Zumwalt Prairie.
Sarcogyne squamosa: described from Hart Mountain 2013.
Staurothele: aquatic crust.
Verrucarria: aquatic crust.
MOSSES
Brachytheciastrum leibergii: from Malheur N.F.
Buxbaumia aphylla: from Malheur N.F.
Coscinodon cribrosa
Crossidium
Dicranum sp: not too probable but would be significant if present.
Dicranum tauricum: needs coarse woody debris.
Didymodon tophaceous: Too high of elevation?
Ditrichum flexicaule: search for more, trace amount from upper Little Blitzen Gorge.
Fissidens spp: search for more, trace amounts from L. Blitz R. & upper Big Indian Crk.
Grimmia anodon: at Mickey Hot Spings on calc. deposits DK coll. #6827. Search east side.
Mielichhoferia mielichhoferi
Philonotis capillaris
Plagiopus oederianus
Polytrichum commune: Fish Lake, Pate Lake, Lilly Lake.
Pseudocrossidium: lower elevation undisturbed sage steppe.
Schistidium tenerum: highly likely, from Malheur N.F.

The next steps for inventorying would be to continue surveying sites that have not been visited yet. A detailed list of these locations has already been formed and is available upon request.

Eventually, implementing randomized locations to visit would complement the areas already surveyed and those already noted as well as ensuring a greater degree of species capture and contributing to the inventory's completeness.

Further study should be done of Island Biology and applying those principals to the bryophytes and lichens of Steens Mt. to more deeply understand its contemporary composition and its formative past.

These preliminary results of the bryophyte and lichen inventory of Steens Mt. greatly exceeded the author's expectations and have been encouraging to a point of committing to continuing inventory efforts by searching for other sources of funding. The two years spent inventorying thus far have been a focused start of what could take ten years to complete (Mansfield, 2000). It was learned and stated long ago that the Northern Great Basin is unexplored at least bryologically (Christy & Harpel, 1997). These preliminary results are evidence that this is still true. When more survey efforts are completed, or at

least identifying the 480 remaining collections from 2017 and 2018, then it is hoped that the resultant work will act as a reference from which to explore other interesting areas nearby such as the Trout Creek Mts., Pueblo Mts., and Hart Mt.

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Above: Steens Mt. Task Force at Astrologer's Flat.

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STEENS MOUNTAIN
COOPERATIVE MANAGEMENT
AND PROTECTION AREA
PRIVATE AND PUBLIC LANDS