FIELD GUIDE TO

BIOLOGICAL SOIL CRUSTS

OF BANDELIER NATIONAL MONUMENT



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Introduction

Biological soil crusts (biocrusts) are present in drylands worldwide. Biocrust communities are made up of lichens, mosses, cyanobacteria, fungi, and algae living on and in the top ~ 2 cm of the soil surface. These communities perform multiple ecosystem functions, including serving as a main source of soil stability in some drylands and contributing to the cycling of nutrients, specifically carbon and nitrogen. (Belnap, Büdel & Lange 2003). Biocrust presence has been documented within Bandelier National Monument, NM (e.g. Chong, 1993; DeCoster & Swan 2009) and on mesa tops directly adjacent to Bandelier (e.g. Reid et al. 1999). Other than noting presence however, few studies have examined the role of biocrust within Bandelier National Monument.

We found only two studies that directly examined the functional role of biocrusts within the Monument. One study examined the potential of biocrusts to contribute nitrogen to forest soils after a disturbance. It was found that biocrust cover does in fact contribute nitrogen to soils within Bandelier, with annual input estimates ranging from 3.6-27 kg ha-1yr-1, although this contribution was found to depend on the abundance and activity of the biocrust organisms (Loftin & White 1994). The second study explored the influence of biocrusts in stabilizing hillslope erosion 15 years following a fire found that the presence of biocrusts increased soil roughness and water infiltration thereby reducing the concentration of precipitation in drainages and incised channels (White 1994).

Although limited in number, these studies point to the importance of biocrust for contributing to ecological function within Bandelier. To help increase our understanding of the role biocrusts play within Bandelier we developed a field guide for lichen and moss biocrust

species in the Monument. The goal of this guide is to aid in biocrust identification and monitoring efforts. After surveying 8 sites we identified 24 different species of lichens and mosses. Included in this guide are photos of biocrusts from Bandelier, brief descriptions of each species, and general descriptions where each species was found. The guide groups species my life form and morphological group. Lichens and mosses are grouped separately, and lichens are broken down in morphological categories. These categories include squamulose, crustose, foliose, and gelatinous. We have found these morphological groups helpful in trying to identify and monitor biocrusts. While this is not an exhaustive list of all biocrust lichen and moss species within Bandelier, it is an example of the diversity of biocrust species present and provides the first taxa list that can built upon in future work.

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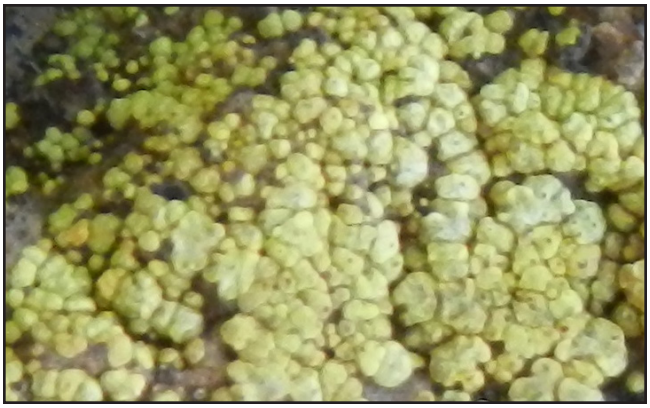
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Acarospora schleicheri - cracked lichen



Description:
Thallus squamulose, 1-2 mm wide. Color can range from yellow to sulfur green. Margins may be lobed or simple. Apothecia are immersed reddish brown or darker.



Habitat:
Common throughout the Southwest and in piñon-juniper areas around Bandelier. These lichens are late successional. May grow alongside and parasitze *Diploshistes.* Indicator of low calcium carbonate.



Similar Speices:
This species is the only common yellow-greenish lichen growing on soils in Bandelier. Other genera with yellow lichens include *Candelariella.*

Psora sp.



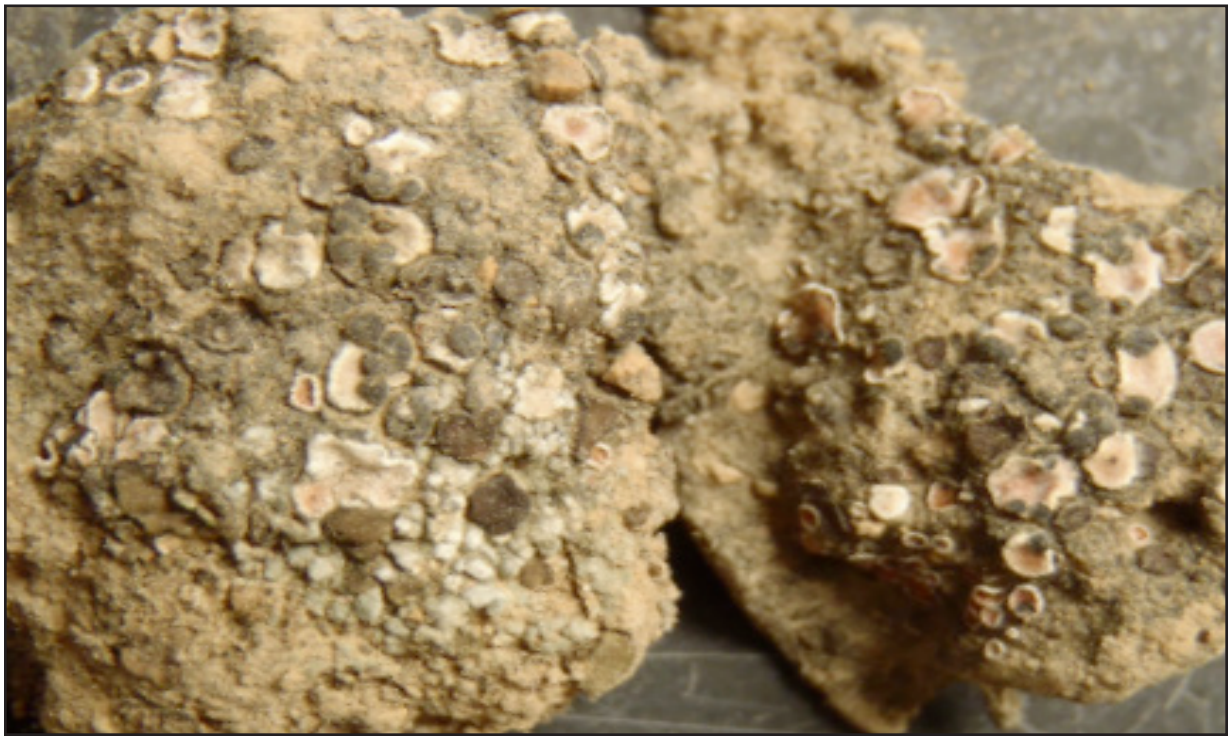
Description:
Psora species charac-terized by squamulose thalli, rang-ing from 2-10 mm wide. Photobiont is algal.



Habitat:
Grows on diverse soil habitats around the Southwest and in multiple regions of Bandelier. This specimen was found in a piñon-juniper woodland.

Similar species:
The *Psora* pictured here may be *P. montana* or *P. globifera*, however without reproductive features it is difficult to tell in the field. Squamules pictured here are 1-2 mm in wide. Other *Psora* in Bandelier include *P. decipiens*

Psora decipiens - blushing scale



Description:
Thallus squamulose, light pink to red, ~ 1 mm wide. Generally round to lobate and pruinose, especially near squamule margins. Margins white. Apothecia black and convex 0.7-2 mm in diameter.



Habitat:
Common soil lichen, can be accompanied by *Collema tenax*, and may indicate local presence of carbonate or gypsum. Found in piñon-juniper woodlands in Bandelier.

Similar Speices:
Many *Psora* species look similar, however *P. decipiens* is distinguished by the combination of pink, white-rimmed squamules and marginal apothecia.



Heppia sp.



Description: *Heppia* species range in morphology from squamulose, crustose to peltate, and can be olive, brownish, gray, or blackish**.**



Habitat:
Heppia occurs in a wide range of habitats. This specimen was found in a piñon-juniper woodland in Bandelier.

Similar species:
Heppia is a wide ranging genus that can easily be confused with *Peltula.* The *Heppia sp.* pictured here can not be identified without the presence of reproductive parts. The lichen in this picture is about 4 mm wide.

Placidium squamulosum - stipplescale lichen



Description:
Thallus squamules, ~1-3 mm wide (can range up to 7 mm). Brown when dry, greenish when wet (bot-tom photo). Perithecia frequent as upraised black pores on thallus. Attached by rhizoidal hyphae.





Habitat:
Found in a variety of habitats. Common in piñon-juniper, blue grama woodlands around Bandelier.

Similar Speices:
This species is very similar to *Placidium lacinulatum*. The two are almost indistinguishable in the field. Destructive harvest can reveal *P. squamulosa* lacks rhizines while *P. lacinulatum* has thick rhizines.

Placidium lacinulatum - brown stipplescale



Description:
Thallus squamules ~1-3 mm wide (but can range up to 6 mm). Brown. Perithecia frequent as upraised black dots on the thalli surface. Anchored by thick rhizines.

Habitat:
Found in a variety of habitats. Common in piñon-juniper, blue grama woodlands around Bandelier.

Similar species:
This species is very similar to *Placidium squamulosum*. The two are almost indistinguishable in the field. Destructive harvest can reveal *P. squamulosa* lacks rhizines while *P. lacinulatum* has thick rhizines. Can also be confused with *Peltula* species.





Peltula richardii - Richards' peltula

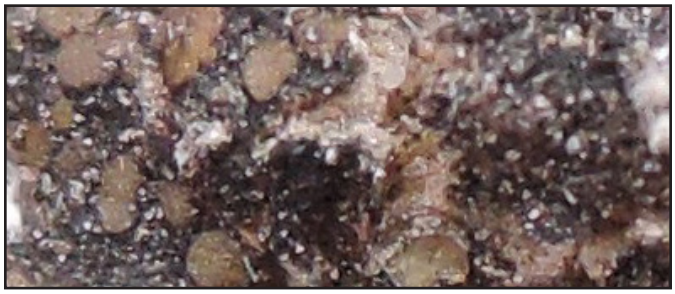


Description:
Squamulose thalli 1-3 mm in diameter (can be as wide at 6 mm). Dark olive to olive-brown. Apothecia sunken into center and large (0.3-2 mm), dark red.



Habitat:
Occurs in multiple habitis, but often in places were water runs. This specimen was found co-occuring with *Collema* in a piñon-juniper woodland in Bandelier.

Similar Speices:
Species within the *Peltula* genus are often hard to differentiate between. Similar species include *P. obscurans* and *P. patellata*. *Heppia* and *Placidium* can also look similar to *Peltula*.



Heppia sp.



Description:
Thallus squamulose, margins smooth and slightly upturned. Grayish-olive green. Immersed black apothecia, up to several per squamule. Squamules turning red when wet (see bottom photo).



Habitat: *Peltula* is a widely dispered genus. This specimen was found in piñon-juniper, blue grama woodlands in Bandelier.

Similar species:
The genus *Peltula* has many species, many of which are difficult to distinquish from one another in the field. The *Peltula sp.* pictured here can not be confirmed, but resembles *P. patellata* which generally has only one apothecium per squamule. This genus is easily confused with *Heppia* and *Placidium*.



Peltula c.f. patellata



Description:
Squamulose, margins smooth and slightly upturned. Grayish-olive green. Apothecia generally red.



Habitat:
Peltula is a widely distributed genus. This specimen was found in piñon-juniper, blue grama woodlands in Bandelier.

Similar Speices:
The genus *Peltula* has multiple species, many of which are difficult to distinquish from one another in the field. The *Peltula sp.* pictured here can not be be confirmed, however, it resembles *P. patellata*, which generally has red apothecia. Squamule pictured in this photos are around 0.5 mm to 1 mm. This genus is easily confused with *Heppia* and *Placidium.*



Squamarina lentigera - rim lichen



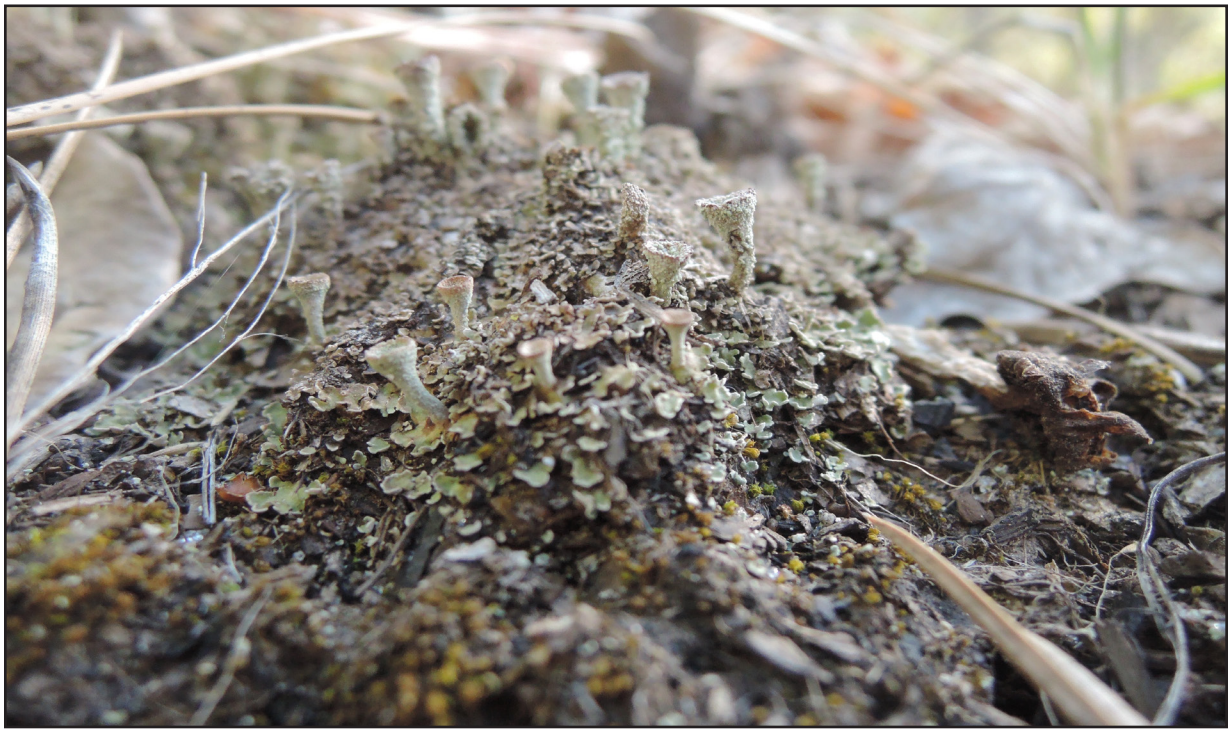
Description:
Thallus foliose with lobed margins. Specimen pictured here is 1 cm in diameter (can get above 6 cm in diameter). Greenish cortex with white pruina covering. Apothecia are tan colored.



Habitat:
Not abundant on non-gypsum containing soils. Can be found with *Diploschistes* and *Psora.* Found within a piñon-juniper woodland in Bandelier

Similar species:
This lichen is very distinct and is not likely to be confused with other species. Lobed margins slightly resemble *Physconia muscigena,* but the greenish color of *S. lentigera* is singular.

Cladonia chlorphaea - cup lichen







Description:
Thallus squamulose with wavy margins and often overlapping, brownish-white to light green. When present, podetia arise from squa-mules and are cup forming. Cups are initially narrow, then widen to ~ 3 mm wide and 5 mm tall. Cup broadly flaring.

Habitat:
This genus is most common in cooler sites. In Bandelier, this species was found in a ponderosa pine forest.

Similar Speices:
There are two similar looking species of *Cladonia* in Bandelier. *C. chlorphaea* can be differentiated from *C. fimbriata* by broad flaring (chalice like) morphology here, and narrow trumpet like morphol-

Cladonia fimbriata - trumpet lichen



Description:
Thallus squamulose, between 0.5-6 mm wide with wavy-toothed margins. Podetia stalks ~3 mm tall (up to 30 mm). Cups~ 1 mm wide. Soredia are common.



Habitat:
Grows in cooler sites, can be on wood or in partial shade. This species was found in a ponderosa pine forest in Bandelier.

Similar species:
There are two similar looking species of *Cladonia* in Bandelier. *C. chlorphaea* can be differentiated from *C. fimbriata* by broad flaring (chalice like) morphology in *C. chlorphaea*, and narrow trumpet like morphology here.



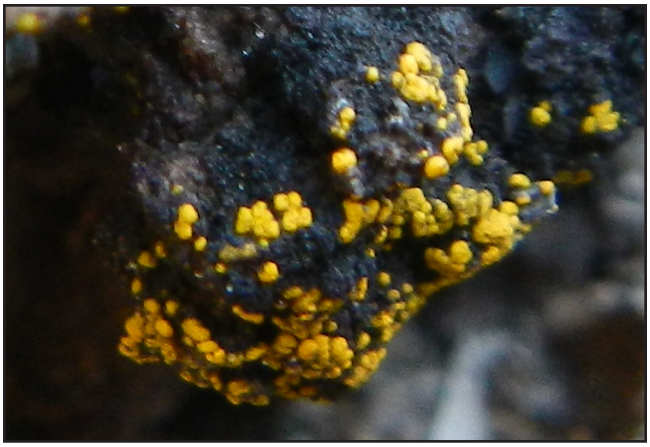
Candelariella citrina - egg yolk lichen

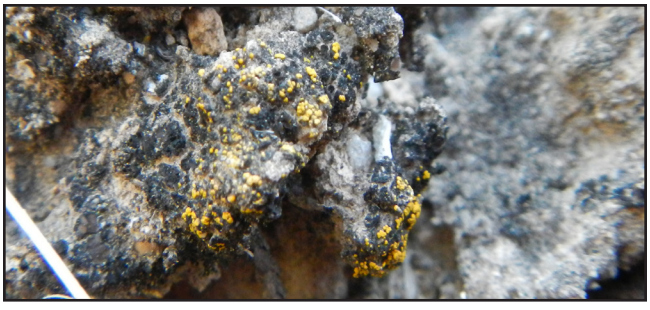


Description:
Thallus crustose or squamulose. Bright yellow to yellow-orange, turning greenish-yellow when wet. Generally appears as scattered yellow dots on soil. Each yellow dot in these photso is about 0.5 mm wide.

Habitat:
Occurs on soils, but also on organic matter or dying vegetation. Found in piñon-juniper woodland in Bandelier.

Similar Speices:
The yellow-orange coloration and discontinuous, fragile thallus makes it distinct. *Caloplaca spp.* were not sampled in Bandelier, but if present could easily be confused with *Candelariella* and are distinguishable by chemical tests.





Diploschistes muscorum - cowpie lichen



Description:
Crustose lichen, light gray-white. Areolae pictured here are around 0.5-1 mm in diameter. Apothecia are immersed and black.



Habitat:
Co-occurs with *Cladonia fimbriata* or *C. chlorophaea,* which it can parasitize. Can also co-occur with *Acarospora schleicheri*, which may may parasitize it. Indicator of low calcium carbonate. Found in piñon-juniper woodlands in Bandelier

Similar species:
The crustose morphology of *Diploschistes* makes it a distinct genus. Other genus with whitish thalli include *Toninia.*

Peltigera rufescens - felt lichen



Description:
Foliose thallus, gray when dry, becoming dark green when wet. pruinose, and felt-like. 5 cm wide or more. Lobed edges around 4 mm wide. Apothecia common.



Habitat:
A common species that can be found at the base of shrubby vegetation, on mineral soils, or bare ground. Found in both piñon-juniper woodlands and ponderosa pine forests in Bandelier.

Similar species:
The large size and distinct foliose thalli of this lichen makes it very distinct. It may be confused with other *Peltigera spp*. such as *P. kristinsonii* or *P. canina.*

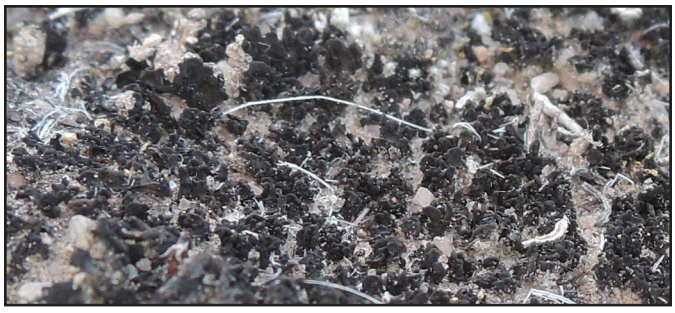
Collema tenax - soil jelly lichen



Description:
Gelatinous thalli that appear micro-foliose or lobate along thallus margins. Can occur in a rosette shape. Thallus black. Round isidia that look like small balls under a hand lense may be present. Expands when wet (see middle photo).

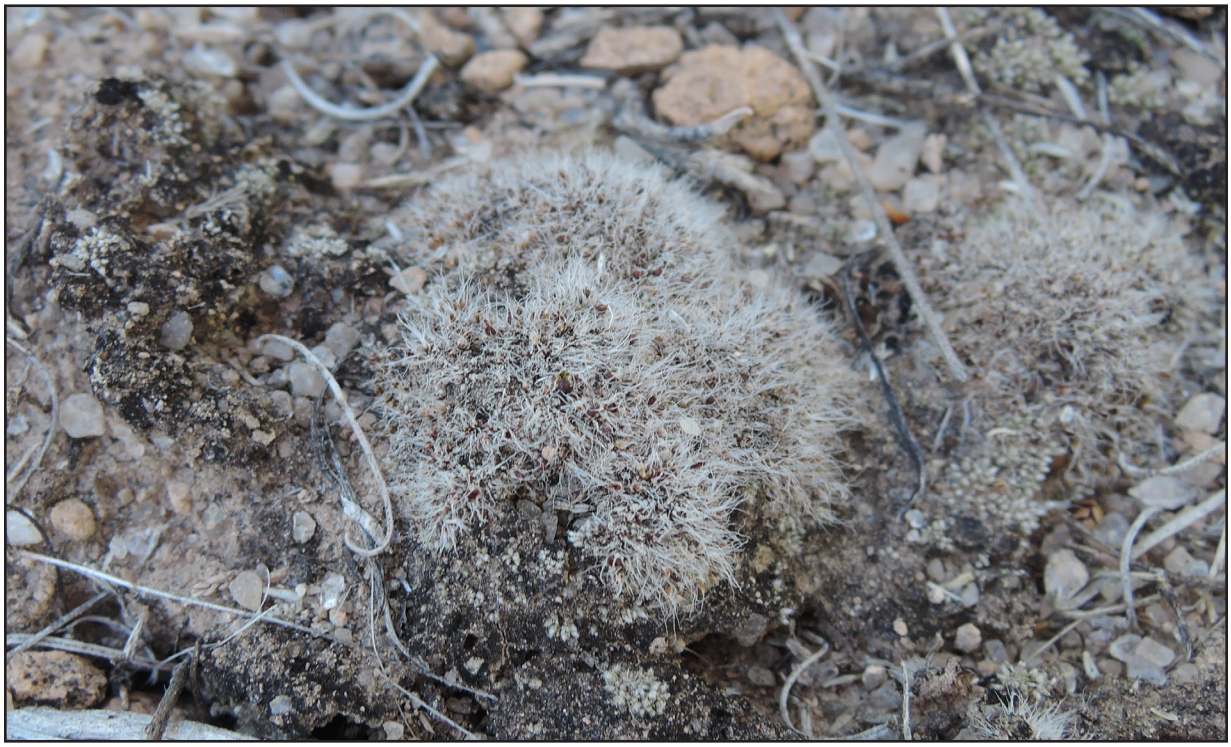


Habitat:
Very common in Bandelier. Found in both ponderosa pine and piñon-juniper forests. Can often be found between the squamules of other species.



Similar Speices:
Very similar to *Collema coccophorum.* with which it can co-occur. The two can be differentiated by the rosette forming morphology of *C. tenax* and its more lobed margins.

Pterygoneurum subsessile - wolly caterpillar moss



Description:
Can form dense cushions or be scattered among other biocrust species. Stems are often paritally buried and no more than 0.5 mm tall. Leaves have long distinct white awns. Bulbous when wet (see middle photo).

Habitat:
Found in diverse habitats in mid elevations. Found widely in piñon-juniper forests within Bandelier.

Similar Speices:
The distinct white awns of this species makes it very distinct from other mosses growing on soils. *Pterygoneurum ovatum* and *P. lamellatum* could also be present, but have sporophytes that rise above the moss cushion.





Bryum argenteum - silver-tipped moss



Description:
Unbranched upright moss, leaves usually silvery green to almost white. Stems are shaped like bulbs ~.5-1 mm tall. Can end in short point or awn. Sporophyte rare.



Habitat:
Common in many areas across elevations. Can be in open areas or in partial shade. Found in a piñon-juniper forest and a ponderosa forest within Bandelier.



Similar species:
This is a very easily distinguishable moss. Morphologically it is similar to other *Bryum sp.*, but the silver-green to white color easily distinguishes it.

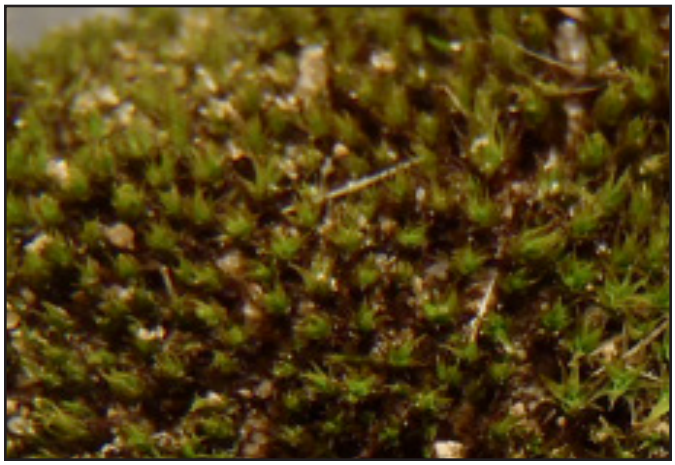
Didymodon vinealis - screw moss



Description:
Forms dense cushions, often branched. Almost black when dry, emerald green when wet (see bottom photo). Leaves lance-shaped and not twisted. Lacking awn. Sporophytes rare.

Habitat:
Mid to higher elevations. Found in a ponderosa pine forest in Bandelier.

Similar Speices:
Similar to *Syntrichia ruralis* in color and stature, but has more slender plants and lacks awns. Distinguishable from *Ceratodon purpureus* by slender, tall stems, darker color, and rarity of sporophytes.





Syntrichia ruralis - twisted moss



Description:
Upright and simple or branched. Looks brownish-red to black when dry and bright green with reddish tints when wet (see middle photo). Stem 0.5-2 mm tall. Leaves twisted around stem when dry. Prominent white awn at the end of the leaf.

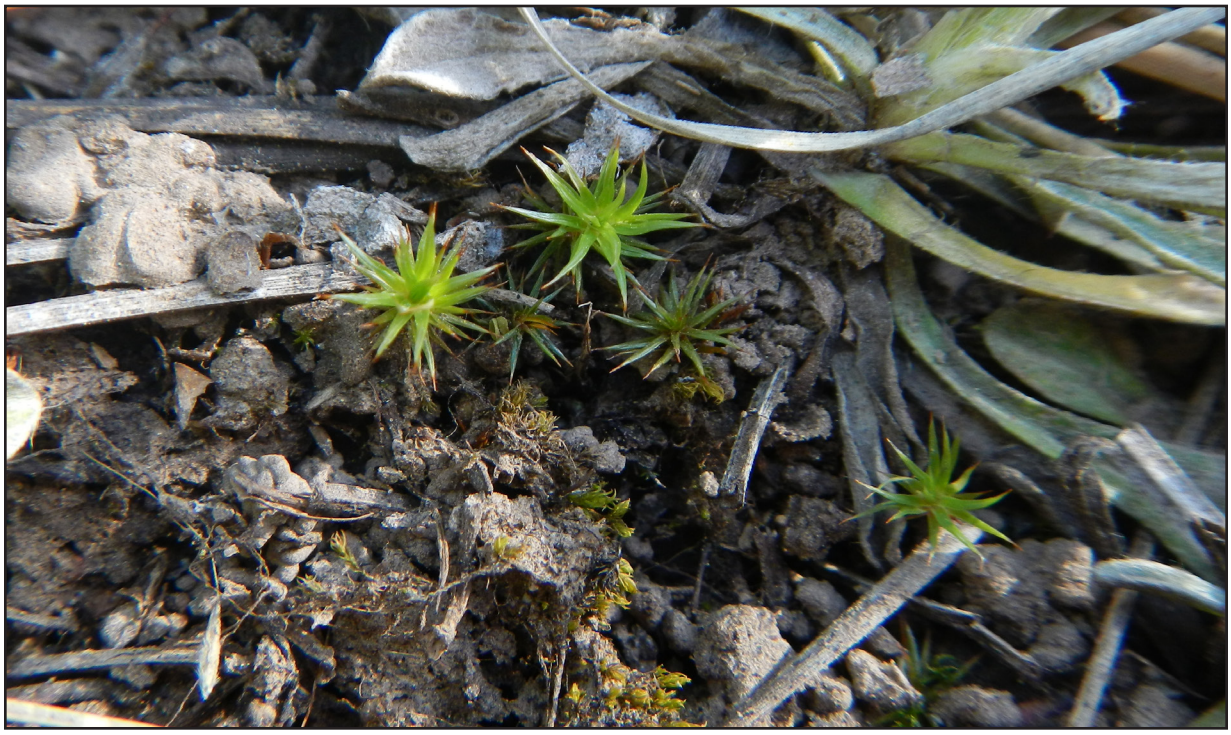


Habitat:
Occurs on various soils at low to mid elevations. Found in a piñon-juniper forest within Bandelier.

Similar species:
Very similar in appearance to *Syntrichia caninervis*. *S. ruralis* is generally taller than 1 cm and has leaves twisted around the stem when dry. The leaf mid-rib of *S. ruralis* is distinctly red.



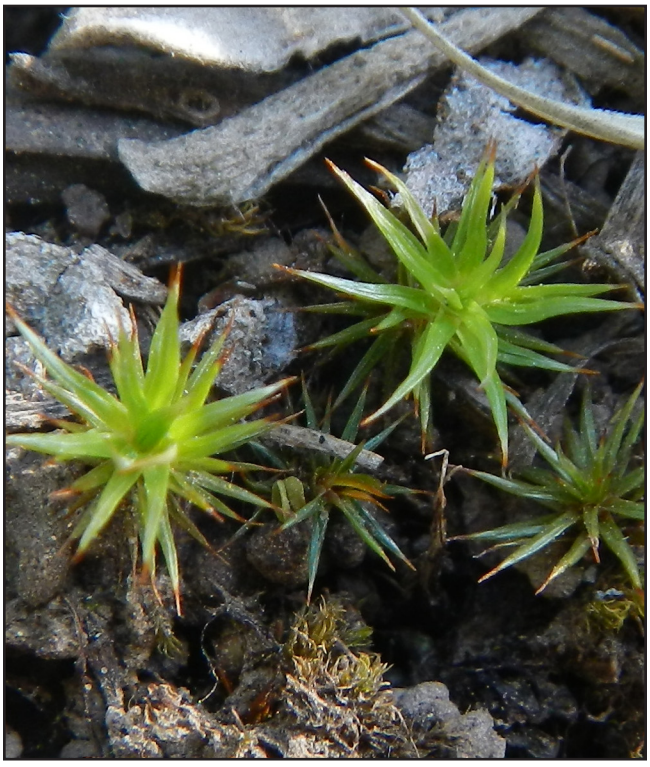
Polytrichum juniperinum - Juniper haircap moss



Description:
Observed occuring individually in Bandelier, though can occur in dense mats. ~ 2 cm tall, though can reach up to 10 cm. Leaves green with red tapering hair points. Sporophytes common with upright reddish capsules.

Habitat:
Occurs at higher elevation habitats and can become common after fires. Found within a ponderosa pine forest in Bandelier.

Similar Speices:
The height and distinct long leaves with red points makes this a very easily recognized species.



Homalothecium sp.



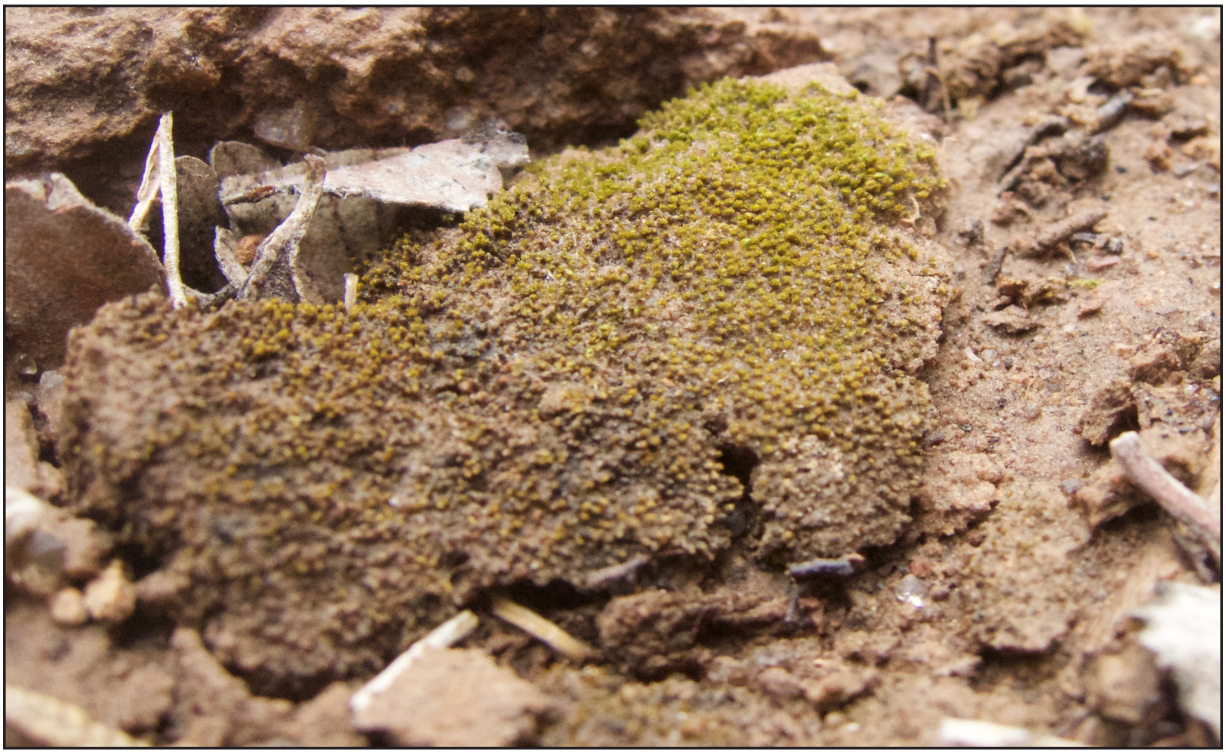
Description:
Forms in loose to dense mats, spreading laterally across the soil surface. Goldenish to green. Leaves usually pinnate. Stems can reach up to 15 cm.

Habitat:
Usually occuring in moister habitats. Found in Bandelier in a ponderosa pine forest.

Similar species:
The genus *Homalothecium* has many species. Differences between species can be determined through stem and leaf characteristics and capsules when present.



Bryum caespiticium - dry calcareous bryum moss

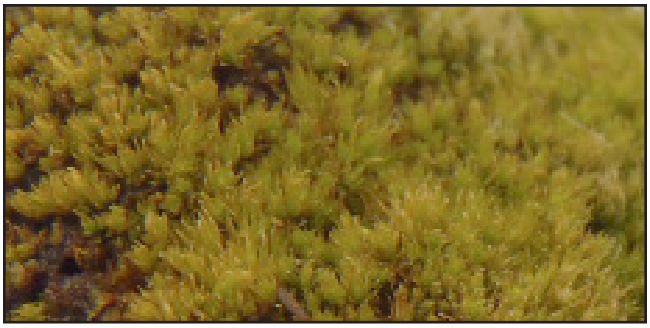


Description:
Forming dense mats. Generally unbrached with dull yellowish to green leaves when dry and greenish-golden yellow when wet (see bottom photo). Stems are bright red when wet and around 0.5 -1 m tall. Sporophytes rare.



Habitat:
Occurs in various areas in mid to high elevation sites. Found in both ponderosa pine and piñon-juniper foersts in Bandelier.

Similar Speices:
May be confused with *Ceratodon purpureus*. This species can be differentiated by it's yellowish color and lack of awn.



Ceratodon purpureus - fire moss



Description:
Upright and usually unbranched, 0.5-2 mm tall forming dense cushions. Olive green with reddish undersides when dry, green when wet. Leaves imbricate and 0.5-1 mm long. Setae reddish 1-2.5 cm long, with capsules that angle downward from the seta.



Habitat:
Usually occurs at higher elevations and after fires. Found within a ponderosa pine forest in Bandelier.



Similar species:
Commonly associated with *Bryum caespiticium* and *Syntrichia ruralis*. The dense cushioning and lack of awn makes this species distinct, along with frequent abundant sporophyte production.

Definitions

Apothecia: A disk or cup-shaped spore-producing organ

Areolate: Patches of the thallus showing cracks in the thallus surface

Awn: Bristle or hair the top of a moss leaf

Capsule: Structure at the end of the moss sporophyte containing spores

Cortex: The outermost layer of the thallus

Crustose: Lichens that are closely attached to their substrate

Foliose: Having margins or lobes that are leaf-like

Gelatinous: Having a jellylike consistency

Globose: Ball or sphere shaped

Isidia: Small, asexual reproductive structures on lichens covered with a cortex and containing photobiont **Margins:** The outer edge of a lichen thalli or the outer boundary of the apothecia

Mid-rib: A large vein along the midline of a leaf

Pinnate: Leaf structures occurring on either side of the stem

Podetia: The upright stalk formed by an elongated apothecium

Pruinose: Having a frosted appearance due to a powdery frost-like deposit composed of calcium oxalate

Seta: The stalk of a moss sporophyte that supports the capsule

Simple: Leaf blades that are undivided

Soredia: Asexual reproductive structures, powdery to granular containing both fungal and photo-biont components

Sporophyte: Spore-producing structure of mosses containing a seta and capsule