Biological Soil Crust Survey of the Birch Creek Area, Malheur County, Oregon

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Introduction

The Birch Creek area in southeast Oregon's Malheur County is known for its spectacular geology as well as serving as the primary take-out for floaters on the lower section of the Owyhee Wild and Scenic River. Birch Creek is also the location of the Birch Creek Historic Ranch, whose buildings and remains offer a glimpse of the earliest Euro-American settlement in the Owyhee Canyonlands.

Although the rhyolite spires and volcanic tuff of Birch Creek are much less extensive than those found to the northeast in Leslie Gulch, they are spectacular and unique nonetheless. Consolidated volcanic ash (known as Leslie Gulch Tuff) makes up the bulk of these formations. It is a rhyolite ash that erupted from the Mahogany Mountain caldera (a large volcanic depression nearby) in a series of violent explosions about 15.5 million years ago. Much of the material fell back into the volcano as a gaseous deposit of fine ash and rock fragments up to 1,000 feet thick. About 100,000 years later, volcanic eruptions from the Three Fingers caldera, located to the northeast, deposited another layer of rhyolite tuff in Birch Creek and surrounding areas. Today the tuff is beautifully displayed as steep slopes and vertical towers weathered by time.

Because of the unique geology found in Birch Creek and Leslie Gulch, a number of unusual or rare plant species have evolved in these areas. Consequently, their vascular plant floras have interested botanists for many years and they have been relatively well explored. This has not been the case for the lower plants (lichens, bryophytes, liverworts), or for the fungi. Even less emphasis has been placed on these organisms when they occupy the soil, often collectively known as biological soil crusts.

Biological soil crusts are a close association between soil particles and cyanobacteria, microfungi, algae, lichens, and bryophytes (mosses, liverworts) which live within or on top of the uppermost millimeters of soil (Belnap et al. 2001). They are found in all dryland regions of the world and in all vegetation types within these lands, including the arid and semi-arid regions of North America (Rosentreter et al. 2007). Also known as cryptobiotic crusts, biotic crusts, microbiotic crusts, and cryptogamic crusts, biological soil crusts are often overlooked and are thus seldom collected. Due to the small size and fragility of the specimens, they can be difficult to return to the lab intact and suitable for species determination. However, the ecological importance of these organisms in nutrient cycling, moisture storage, and soil stabilization has been well documented (Belnap et al. 2001, Hilty et al. 2004, Deines et al. 2007, Ponzetti et al. 2007, Rosentreter et al. 2007, Serpe et al. 2007), and will not be further discussed in this report.

The objectives of this project were to: (1) identify which lichen and bryophyte species are present in the Birch Creek area, (2) determine differences (if any) between habitats and soil types, (3) provide reference specimens for future agency inventory and monitoring training needs, and (4) prepare a report summarizing these findings.

Methods

Several days were spent traveling to and collecting lichens and bryophytes in the remote Birch Creek drainage (Figure 1). The area is accessed via Highway #95. From Highway 95, either 8 miles north of Jordan Valley, Oregon or 40 miles southwest of Marsing, Idaho, turn west at the Jordan Craters sign onto Cow Creek Road. Then follow the Bureau of Land Management Owyhee River access signs 28 miles to get to the Owyhee River.

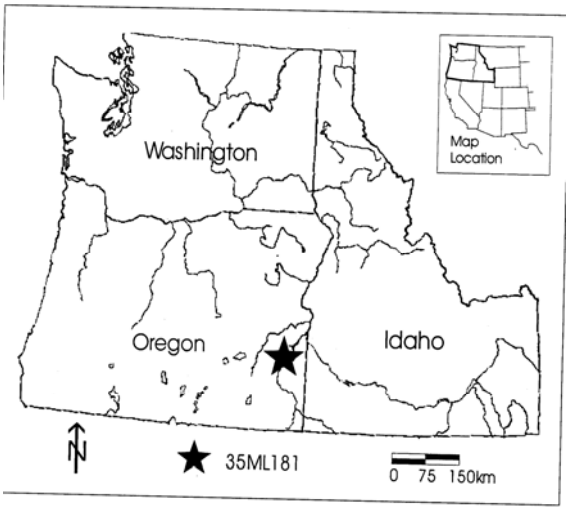

Figure 1. Location of the project area.

Forest Health Monitoring protocols were loosely followed, whereby a minimum of 30 minutes and a maximum of 2 hours were spent examining plots with a 35 m radius within a given habitat or vegetation type (McCune et al. 1997). As best as could be determined in the field (biological soil crusts are notoriously difficult to field identify, particularly when conditions are dry as they were in August), each different species encountered within a site was carefully collected and numbered. Only soil-occurring species were sampled (ie. wood and rock occurring species were not collected). Other data recorded at each site included GPS coordinates, elevation, aspect, slope, and associated vascular species.

Seven representative vegetation types were selected for sampling. These included:

1. non-native annual dominated sites (ie. previously burned, little to no shrub component, primarily occupied by *Bromus tectorum*, *Salsola;* these were *Pseudoroegneria spicata-Artemisia tridentata* ssp. *tridentata* sites historically).

2. sparsely vegetated tuffaceous ash outcrops dominated by *Salvia dorrii, Eriogonum microthecum,* and *Achnatherum hymenoides.*

3. gravelly disturbed river benches dominated by *Atriplex canescens, Bromus tectorum, Sarcobatus vermiculatus*, and *Artemisia tridentata* ssp. *tridentata.*

4. densely vegetated *Artemisia tridentata* ssp. *tridentata - Pseudoroegneria spicata* site, NW aspect.

5. rocky cliffs dominated by *Pseudoroegneria spicata* with scattered *Artemisia tridentata* ssp. *tridentata,* west aspect.

6. steep *Pseudoroegneria spicata* slope (with minimal exposed rock) in good condition, scattered *Artemisia tridentata* ssp. *tridentata*, north aspect.

7. *Artemisia arbuscula* site with relatively rich forb diversity on the flats above the drainage proper; this area was sampled for comparison purposes.

Collected specimens were returned to the lab and curated using standard bryological and lichenological techniques (Brodo et al. 2001, McCune and Rosentreter 2007). Species were identified using the floras listed in the References section.

Results

Forty-seven lichen, bryophyte, and cyanobacteria biological soil crust species were collected during the field survey. There are 34 lichen, 12 bryophyte (mosses and liverworts), and one cyanobacteria species among the total of 70 specimens (Table 1). None of the species are considered uncommon or rare. Without a doubt, additional species would be found should more time be spent in the area, as there are certainly microhabitats, and even macrohabitats, that could be further explored. However, given the remoteness and difficult access of the region, the information gained during the project is a good start on a baseline inventory for Birch Creek.

As might be expected, sites with the lowest diversity of biological soil crusts were those dominated by non-native annuals (Figure 2, Table 2). Three sites meeting this description, all *Artemisia tridentata* ssp. *tridentata - Pseudoroegneria spicata* sites that burned and are now invaded by *Bromus tectorum, Sisymbrium altissimum, Erodium cicutarium*, and *Salsola* sp., were sampled for biological soil crust diversity. Their slopes varied from 2% to 25%; aspects were east, southwest, and southeast. No lichen or bryophyte species were observed within the 3 sites. However, at one of the localities, the moss *Syntrichia ruralis* was immediately encountered upon leaving the old burn.

At Horse Heaven Hill in eastern Washington, biological soil crust species richness and cover were inversely related to cheatgrass cover, and positively related to cover of native bunchgrasses (Ponzetti et al. 2007). The integrity of the soil crust was more strongly related to cheatgrass than to fire. Crusts recovered following fire, but only in those areas dominated by perennial bunchgrasses (Ponzetti et al. 2007). The resilience of the biological soil crust at this location was attributed to the low abundance of cheatgrass, low amounts of soil disturbance, and high moss cover (Ponzetti et al. 2007).

A single bryophyte species was observed at two of the seven sampling locations (*Syntrichia ruralis* on the gravelly river bench; *S. caninervis* on the tuffaceous ash outcrop). The gravelly river bench site and its immediate area have experienced extensive historic and on-going disturbances. This location is within the existing Birch Creek Ranch infrastructural boundary and in proximity to the Owyhee River take-out (see photo below). The dense cover of

Bromus tectorum amongst the scattered shrubs (*Sarcobatus vermiculatus, Atriplex canescens*) leaves little space for biological soil crust colonization. *Syntrichia ruralis* was only occasionally observed at this site and only beneath shrub canopies. This species, often referred to as "twisted moss", is amongst the tallest and most common of biological soil crust mosses and likely plays an important functional role in the hydrological cycle and in the germination of vascular plant seeds (Rosentreter et al. 2007, Serpe et al. 2004).

The low diversity of the tuffaceous outcrop is less clear. Bare ground was extensive amongst the *Salvia dorrii, Eriogonum microthum,* and *Achnatherum hymenoides,* and cheatgrass was patchy or scattered, but biological soil crusts were mostly absent within the interspaces. Only a single moss species, *Synthrichia caninervis*, was collected. It is possible that the chemistry of the ash at this location was a deterrent to colonization by most species. I have observed significant variation in colonization by biological soil crusts on ash outcrops at other locations (ie. Succor Creek, McBride Creek). The species observed on the ash, *Synthrichia caninervis*, or short twisted moss, is frequently a dominant in the drier warm deserts to the south (Rosentreter et al. 2007). It is largely replaced by *Syntrichia ruralis* in the Great and Columbia River basins (Rosentreter et al. 2007).

In central and eastern Oregon, Ponzetti and McCune (2001) found that differences in biological soil crust community composition were most strongly related to soil pH, electrical conductivity, and the calcium carbonate content of the soils. Other important variables included elevation, precipitation, temperature, and aspect. Total crust cover was found to be highest at sites with lower electrical conductivity, pH, and calcium carbonate (Ponzetti and McCune 2001). In the Birch Creek area, type of vegetation, aspect, and lack of disturbance and cheatgrass appear to be the most important variables determining biological soil crust cover.

Ten species (8 lichen, 1 moss, 1 cyanobacteria) were collected from the *Artemisia arbuscula* (low sagebrush) site (Figure 2, Table 2). This area had lower diversity but slightly greater cover of biological soil crusts than the dense basin big sagebrush site discussed below.

Biological soil crust cover in low sagebrush sites has not been reported in the literature, despite it being a common vegetation type in western North America.

As with the vascular plants, dominant biological soil crust species differed markedly at the low sagebrush site, with 9 of the 10 species unique to this locality (Table 2). The ephemeral spring flooding that characterizes low sagebrush sites results in high calcium carbonate concentrates at the soil surface (personal communication, Darwin Jepson, BLM soil scientist). Of the nine species unique to this site, three (*Aspicilia hispida, Caloplaca tominii, Phaeorrhiza sareptana*) are indicators of high calcium carbonate (McCune and Rosentreter 2007).

The site with the highest diversity, 19 species (15 lichen, 4 bryophyte), also had the highest percent biological soil crust cover (Figure 2, Table 2). It was the only site where percent cover was noted, as it was so noticeable at 50-80%. Seven of the species collected were unique to this location. This north-facing, steep (60%) slope dominated by *Pseudoroegneria spicata* (bluebunch wheatgrass) was in good ecological condition, with little to no cheatgrass. This again supports the conclusions from studies in eastern Washington that biological soil crust species richness and cover are inversely related to cheatgrass cover, and positively related to cover of native bunchgrasses (Ponzetti et al. 2007).

Sixteen species were collected at the site with high *Artemisia tridentata* ssp. *tridentata* (basin big sagebrush) cover relative to the one described above (Figure 2, Table 2). This area had a northwest aspect, was much less steep (25-35% slope), and had cheatgrass intermittent within the understory vegetation. Because its slope was relatively gradual compared to the steep bluebunch wheatgrass site described above, this area was certainly more accessible to livestock. In a comparison of grazed and long-ungrazed sites in central and eastern Oregon, overall community composition of biological soil crust species differed (Ponzetti and McCune 2001). Lower cover of biological soil crusts, nitrogen-fixing lichens, and crust-dominated soil surface roughness and lower species richness were found in grazed transects vs. long-ungrazed transects (Ponzetti and McCune 2001). These authors concluded that biological soil crusts are sensitive indicators of disturbance in Oregon shrub-steppe communities. The Birch Creek area appears to support these findings, though the sample size was too small to be definitive.

Conclusion

During this brief field survey of the Birch Creek area, 47 biological soil crust species were recorded, represented by 34 lichens, 12 bryophytes (moss and liverworts), and one cyanobacteria. Sites invaded by non-native annuals (namely cheatgrass) had the lowest biological soil crust diversity, while those dominated by native bunchgrasses, shrubs, and forbs were more diverse. Further work in the Birch Creek area would undoubtedly detect additional biological soil crust species, but these findings are an excellent start at increasing our knowledge base of these overlooked organisms and their indicator value in arid ecosystems.

Acknowledgments

I would like to thank Kelli VanNorman for proposing the project, understanding its value, and following up with funding. Jean Findley, retired Vale botanist, enthusiastically encouraged me to take on the project, while Gillian Wigglesworth assisted with the final agency paperwork wrap-up. Dr. Bruce McCune graciously identified several of the problematic specimens. This work could not have been completed without the valuable assistance and recommendations of Roger Rosentreter, local soil crust expert.

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Attachments

1. **Collection Notebook**. This portion of the document includes label and species data for each site. DeBolt collection numbers range from 2300 to 2370.

2. **Table 1.** Excel spreadsheet. Alphabetical list of the species with their respective collection number(s), number of specimens for each collection, and life form (ie. bryophyte or lichen).

3. **Table 2.** Excel spreadsheet. Alphabetical list of species by ecological site.

4. **Figure 2.** Graph of biological soil crust diversity by ecological site.

COLLECTION NOTEBOOK
BIRCH CREEK AREA, MALHEUR COUNTY, OREGON
AUGUST 30-31, 2008

Malheur County, Oregon On soil over rhyolite. Approx. 2 km south of the Owyhee River in the Birch Creek drainage. West-facing slope above creek. Approx. 30 air miles NW of Jordan Valley, OR. Associated vegetation: *Atriplex confertiflora, Eriogonum* sp., *Artemisia tridentata tridentata, Stephanomeria exigua, Bromus tectorum, Pseudoroegneria spicata*
N 43.2123' W 117.504' 859 m (2820 feet elevation) 30 August 2008
(this site was not included in the diversity graph, as it was an incomplete sample)

2300 Syntrichia ruralis (Hedw.) Web. & Mohr
2301a Grimmia alpestris (Weber & Mohr) Schleicher (in same packet as 2301b)
2301b Xanthoparmelia plittii (Gyeln.) Hale (in same packet as 2301a)

Malheur County, Oregon Birch Creek area, approx. 30 air miles NW of Jordan Valley, OR. Approx. 100 m south of the Owyhee River. Gravelly soil texture. Associated vegetation: *Atriplex canescens, Artemisia tridentata tridentata, Bromus tectorum, Sarcobatus vermiculatus* Highly disturbed site N 43.225' W 117.494' 836 m (2745 feet elevation) 30 August 2008

2302 Syntrichia ruralis (Hedw.) Web. & Mohr

Malheur County, Oregon Approx. 1 km south of the Owyhee River in the Birch Creek area, and 30 air miles NW of Jordan Valley, OR. Associated species include *Achillea millefolium, Lomatium dissectum, Poa secunda, Bromus tectorum*. NW-facing slope
N 43.216' W 117.4978' 30 August 2008 834 m (2738 feet elevation)
***Syntrichia ruralis* was common but no specimen was taken at this site.**

2303 Encalyptra vulgaris Hedw.
2304 xxxx
2305 Cladonia fimbriata (L.) Fr. (ver. B. McCune 11/08) (in same packet as #2306)
2306 Amandinea punctata (Hoffm.) Coppins & Scheid. (in same packet as #2305)
2307 Collema tenax (Sw.) Ach. (fertile)
2308 Cladonia pocillum (Ach.) Grognot
2309 Leptogium lichenoides (L.) Zahlbr.
2310 xxxxx
2311a Leptochidium albociliatum (Desmaz.) M. Choisy (2311a-c all in same packet)
2311b Xanthoparmelia plittii (Gyeln.) Hale (2311a-c all in same packet)
2311c Bryum argenteum Hedw. (2311a-c all in same packet)
2312a Coscinodon calyptratus (Hook.) C.E.O. Jensen ex Kindb. (fertile) (Det. B. McCune 11/08))
2312b Xanthoparmelia plittii (Gyeln.) Hale
2313 Cladonia fimbriata (L.) Fr.
2314 Collema tenax (Sw.) Ach.
2315 Dermatocarpon reticulatum H. Magn. (on rock)
2316 xxxxx
2317 Lecanora sp.
2318 Lecanora muralis (Schreb.) Rabenh. (on organic matter and rock)
2319a Endocarpon pusillum Hedw. (mixed with 2319b)
2319b Arthonia glebosa Tuck. (mixed with 2319a) (ver. B. McCune 11/08)
2320 Bryum argenteum Hedw.
2321 Physconia enteroxantha (Nyl.) Poelt (Det. B. McCune 11/08)

2322 Cladonia pocillum (Ach.) Grognot
2323 xxxxx
2324 xxxxx
2325 xxxxx

Malheur County, Oregon Approx. 1 km south of the Owyhee River in the Birch Creek area, and 30 air miles NW of Jordan Valley, OR. Rocky, steep, sheltered west-facing *Pseudoroegneria spicata - Artemisia tridentata tridentata* site at the base of a rhyolite cliff.
N 43.215' W 117.499' 30 August 2008 841 m (2759 feet elevation)
***Cladonia fimbriata, Lecanora muralis,* and *Syntrichia ruralis* were also present at this site but no specimen was taken.**

2326 Homalothecium aeneum (Mitt.) E. Lawton (ecotone moss)
2327 Peltigera rufescens (Weis.) Mudd (growing over soil and moss)
2328 Peltigera didactyla (With.) J.R. Laundon (soredia present)
2329 Leptogium lichenoides (L.) Zahlbr.
2330 Cladonia pyxidata (L.) Hoffm.
2331 Collema tenax (Sw.) Ach.
2332 Lepraria sp.
2333a Physconia muscigena (Ach.) Poelt (mixed with 2333b)
2333b Melanelia subaurifera (Nyl.) Essl. (mixed with 2333a)
2333c Endocarpon pusillum Hedw. (pure collection)
2334 Physconia enteroxantha (Nyl.) Poelt
2335a Leptogium lichenoides (L.) Zahlbr. (1 pure collection and 1 mixed with 2335b)
2335b Leptochidium albociliatum (Desmaz.) M. Choisy (1 pure collection and 1 mixed with 2335a)
2335c Polychidium muscicola (Sw.) Gray (pure collection)
2336 Ceratodon purpureus (Hedw.) Brid.
2337 Diploschistes muscorum (Scop.) R. Sant.
2338 Physconia perisidiosa (Erichsen) Moberg
2339 xxxxxx
2340 xxxxxx

Malheur County, Oregon Approx. 1 km south of the Owyhee River. Birch Creek area, about 30 air miles NW of Jordan Valley, OR. North-facing, steep (60%), open slope extensively dominated by *Pseudoroegneria spicata,* with scattered *Artemisia tridentata tridentata.* Much less rocky than the previous PSSP-ARTRTR site (which had more ARTRTR). This site has a very high lichen-moss cover estimated at 50-80%.
N 43.214' W 117.5009' 31 August 2008 830 m (2725 feet elevation)

2341 Peltigera rufescens (Weis.) Mudd (dark rhizines)
2342 Ceratodon purpureus (Hedw.) Brid.
2343 Leptochidium albociliatum (Desmaz.) M. Choisy (fertile)
2344 Lecanora hagenii (Ach.) Ach. (det. B. McCune 12/08)
2345 Brachythecium collinum (Schleich. ex Müll. Hal.) Schimp. (Det. B. McCune 11/08)
this is the smallest *Brachythecium* species
2346 Encalyptra vulgaris Hedw. (in same packet as #2347)
2347 Collema tenax (Sw.) Ach. (fertile) (in same packet as #2346)
2348 Ceratodon purpureus (Hedw.) Brid.
2349 Physconia enteroxantha (Nyl.) Poelt
2350 Caloplaca jungermanniae (Vahl) Th.Fr.
2351 Placynthiella icmalea (Ach.) Coppins & P. James
2352 Peltigera didactyla (With.) J.R. Laundon

2353a Aspicilia mastrucata (Wahlenb.) Th.Fr. (Leptochidium albociliatum mixed in this packet)
2353b Candelariella aggregata M. Westberg (in same packet as 2353c)
2353c Lecanora sp. (in same packet as 2353b)
2354 Cephaloziella byssacea (Roth) Warnst.
2355 Arthonia glebosa Tuck.
2356 Diploschistes muscorum (Scop.) R. Sant.
2357 Cladonia pocillum (Ach.) Grognot
2358 Endocarpon pusillum Hedw.
2359 xxxxxx

Malheur County, Oregon Approx. 3 km south of the Birch Creek Ranch and the Owyhee River, and 30 air miles NW of Jordan Valley, OR. North-northeast facing tuffaceous ash slope dominated by *Salvia dorrii, Phlox hoodii, Eriogonum microthecum, Guiterrezia sarothrae, Achnatherum hymenoides, Poa secunda, Bromus tectorum,* and occasional *Pseudoroegneria spicata*. Approx. 20% slope.
N 43.2091' W 117.5033' 31 August 2008 896 m (2940 feet elevation)

2360 Synthrichia caninervis Mitten

Malheur County, Oregon On soil. Approx. 12 km southeast of Birch Creek Ranch and the Owyhee River, and 25 air miles NW of Jordan Valley, OR. *Artemisia arbuscula* site on the bench above the drop into Birch Creek. Other associated species: *Lomatium* sp., *Poa secunda, Elymus elymoides, Taeniatherum caput-medusae, Crepis* sp. Basalt rock on the surface and prevalent throughout the site. N 43.1723 W 117.4602 1385 m (4545 ft)
31 August 2008 *Grimmia* was common here on rock and occasionally occurred on the soil.

2361 Aspicilia hispida Mereschk.
2362 Phaeorrhiza sareptana (Tomin) H. Mayrh. & Poelt (K+ purple)
2363 Caloplaca tominii Savicz
2364 Pterygoneurum ovatum (Hedw.) Dix. (fertile)
2365 Aspicilia desertorum form terrestris (Tomin) Tomin
2366 Psora montana Timdal
2367 Placidium lacinulatum (Ach.) Breuss
2368 Candelariella aggregata M. Westberg (K-; fertile)
2369 Candelariella vitellina (Hoffm.) Műll. Arg. (K-)
2370 Microcoleus vaginatus (Vaucher) Gomont

Table 1. Alphabetical List of Species Collected in the Birch Creek Area.

Species	Collection Number	Number of Specimens for Each Collection Number	Lichen (L), Bryophyte (B), Other
Amandinea punctata (Hoffm.) Coppins & Scheid.	2306	1	B
Arthonia glebosa Tuck.	2319b, 2355	1; 2	L
Aspicilia desertorum form *terrestris*(Tomin) Tomin	2365	1	L
Aspicilia hispida Mereschk.	2361	1	L
Aspicilia mastrucata (Wahlenb.) Th.Fr.	2353a	1	L
Brachythecium collinum (Schleich. ex Müll. Hal.) Schimp.	2345	1	B
Bryum argenteum Hedw.	2311c , 2320	2; 1	B
Caloplaca jungermanniae (Vahl) Th.Fr.	2350	1	L
Caloplaca tominii Savicz	2363	1	L
Candelariella aggregata M. Westberg	2353b; 2368	1; 1	L
Candelariella vitellina (Hoffm.) Műll. Arg.	2369	2	L
Cephaloziella byssacea (Roth) Warnst.	2354	1	B
Ceratodon purpureus (Hedw.) Brid.	2336, 2342, 2348	1; 2; 2	B
Cladonia fimbriata (L.) Fr.	2305, 2313	1; 2	L
Cladonia pocillum (Ach.) Grognot	2308, 2322, 2357	2; 1; 1	L
Cladonia pyxidata (L.) Hoffm.	2330	1	L
Collema tenax (Sw.) Ach.	2307, 2314, 2347	1; 2; 1	L
Coscinodon calyptratus (Hook.) C.E.O. Jensen ex Kindb.	2312a	1	B
Dermatocarpon reticulatum H. Magn.	2315	2	L
Diploschistes muscorum (Scop.) R. Sant.	2337, 2356	1; 1	L
Encalyptra vulgaris Hedw.	2303, 2346	1; 1	B
Endocarpon pusillum Hedw.	2319a, 2333c, 2358	1; 1; 1	L
Grimmia alpestris (Weber & Mohr) Schleicher	2301a	2	B
Homalothecium aeneum (Mitt.) E. Lawton	2326	1	B
Lecanora hagenii (Ach.) Ach.	2344	1	L
Lecanora muralis (Schreb.) Rabenh.	2318	1	L
Lecanora sp.	2317	1	L
Lecanora sp.	2353c	1	L
Lepraria sp.	2332	1	L
Leptochidium albociliatum (Desmaz.) M. Choisy	2311a, 2335b, 2343	2; 1; 2	L
Leptogium lichenoides (L.) Zahlbr.	2309, 2329, 2335a	1; 2; 1	L
Melanelia subaurifera (Nyl.) Essl.	2333b	1	L
Microcoleusvaginatus(Vaucher) Gomont	2370	1	Cyanobacteria
Peltigera didactyla (With.) J.R. Laundon	2328, 2352	2; 1	L
Peltigera rufescens (Weis.) Mudd	2327, 2341	2; 2	L
Phaeorrhiza sareptana (Tomin) H. Mayrh. & Poelt	2362	2	L
Physconia enteroxantha (Nyl.) Poelt	2321, 2334a, 2349	1; 1; 1	L
Physconia muscigena (Ach.) Poelt	2333a	1	L
Physconia perisidiosa (Erichsen) Moberg	2338	1	L
Placidium lacinulatum (Ach.) Breuss	2367	1	L
Placynthiella icmalea (Ach.) Coppins & P. James	2351	1	L
Polychidium muscicola (Sw.) Gray	2335c	1	L
Psora montana Timdal	2366	2	L
Pterygoneurum ovatum (Hedw.) Dix	2364	1	B
Synthrichia caninervis Mitten	2360	2	B
Syntrichia ruralis (Hedw.) Web. & Mohr	2300, 2302	2 1	B
Xanthoparmelia plittii (Gyeln.) Hale	2301b, 2311b, 2312b	1; 2; 1	L

Table 2. Alphabetical List of Species Collected in the Birch Creek Area.
An "x" indicates which species were collected at a given site.

Species	Collection Number	steep bluebunch slope with sparse basin big sagebrush, N aspect	rocky cliff area, bluebunch with basin big sagebrush, W aspect	dense basin big sagbrush-bluebunch, NW aspect	low sagebrush	gravelly river bench with four-wing saltbush, cheatgrass, greasewood	sparsely vegetated tuffaceous outcrop	disturbed, dominated by non-native annuals
Amandinea punctata (Hoffm.) Coppins & Scheid.	2306			x				
Arthonia glebosa Tuck.	2319b, 2355	x		x				
Aspicilia desertorum form *terrestris* (Tomin) Tomin	2365				x			
Aspicilia hispida Mereschk.	2361				x			
Aspicilia mastrucata (Wahlenb.) Th.Fr.	2353a	x						
Brachythecium collinum (Schleich. ex Müll. Hal.) Schimp.	2345	x						
Bryum argenteum Hedw.	2311c , 2320			x				
Caloplaca jungermanniae (Vahl) Th.Fr.	2350	x						
Caloplaca tominii Savicz	2363				x			
Candelariella aggregata M. Westberg	2353b; 2368	x			x			
Candelariella vitellina (Hoffm.) Műll. Arg.	2369				x			
Cephaloziella byssacea (Roth) Warnst.	2354	x						
Ceratodon purpureus (Hedw.) Brid.	2336, 2342, 2348	x	x					
Cladonia fimbriata (L.) Fr.	2305, 2313			x				
Cladonia pocillum (Ach.) Grognot	2308, 2322, 2357	x		x				
Cladonia pyxidata (L.) Hoffm.	2330		x					
Collema tenax (Sw.) Ach.	2307, 2314, 2347	x	x	x				
Coscinodon calyptratus (Hook.) C.E.O. Jensen ex Kindb.	2312a			x				
Dermatocarpon reticulatum H. Magn.	2315			x				
Diploschistes muscorum (Scop.) R. Sant.	2337, 2356	x	x					
Encalyptra vulgaris Hedw.	2303, 2346	x		x				
Endocarpon pusillum Hedw.	2319a, 2333c, 2358	x	x	x				
**Grimmia alpestris* (Weber & Mohr) Schleicher	2301a							
Homalothecium aeneum (Mitt.) E. Lawton	2326		x					
Lecanora hagenii (Ach.) Ach.	2344	x						
Lecanora muralis (Schreb.) Rabenh.	2318		x	x				
Lecanora sp.	2317			x				
Lecanora sp.	2353c	x						
Lepraria sp.	2332		x					
Leptochidium albociliatum (Desmaz.) M. Choisy	2311a, 2335b, 2343	x	x	x				
Leptogium lichenoides (L.) Zahlbr.	2309, 2329, 2335a		x	x				

Species	Collection Number	steep bluebunch slope with sparse basin big sagebrush, N aspect	rocky cliff area, bluebunch with basin big sagebrush, W aspect	dense basin big sagbrush-bluebunch, NW aspect	low sagebrush	gravelly river bench with four-wing saltbush, cheatgrass, greasewood	sparsely vegetated tuffaceous outcrop	disturbed, dominated by non-native annuals
Melanelia subaurifera (Nyl.) Essl.	2333b		x					
Microcoleus vaginatus (Vaucher) Gomont	2370				x			
Peltigera didactyla (With.) J.R. Laundon	2328, 2352	x	x					
Peltigera rufescens (Weis.) Mudd	2327, 2341	x	x					
Phaeorrhiza sareptana (Tomin) H. Mayrh. & Poelt	2362				x			
Physconia enteroxantha (Nyl.) Poelt	2321, 2334a, 2349	x	x	x				
Physconia muscigena (Ach.) Poelt	2333a		x					
Physconia perisidiosa (Erichsen) Moberg	2338		x					
Placidium lacinulatum (Ach.) Breuss	2367				x			
Placynthiella icmalea (Ach.) Coppins & P. James	2351	x						
Polychidium muscicola (Sw.) Gray	2335c		x					
Psora montana Timdal	2366				x			
Pterygoneurum ovatum (Hedw.) Dix	2364				x			
Synthrichia caninervis Mitten	2360						x	
Syntrichia ruralis (Hedw.) Web. & Mohr	2300, 2302					x		
Xanthoparmelia plittii (Gyeln.) Hale	2301b, 2311b, 2312b			x				
Totals:		**19**	**17**	**16**	**10**	**1**	**1**	**0**

* Grimmia alpestris (#2301a) was collected at an incompletely sampled site; for this reason it is not included in the diversity graph; G. alpestris was also likely the species commonly observed at the low sagebrush site, most frequently on rock but occasionally growing on soil; it is not included in that site list because no sample was taken and its identity cannot be confirmed.

Figure 2. Diversity of Biological Soil Crusts by Ecological Site