



Taxonomic Paper

The "Martian" flora: new collections of vascular plants, lichens, fungi, algae, and cyanobacteria from the Mars Desert Research Station, Utah

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Abstract

The Mars Desert Research Station is a Mars analog research site located in the desert outside of Hanksville, Utah, U.S.A. Here we present a preliminary checklist of the vascular plant and lichen flora for the station, based on collections made primarily during a two-week simulated Mars mission in November, 2014. Additionally, we present notes on the endolithic chlorophytes and cyanobacteria, and the identification of a fungal genus also based on these collections. Altogether, we recorded 38 vascular plant species from 14 families, 13 lichen species from seven families, six algae taxa including both chlorophytes and cyanobacteria, and one fungal genus from the station and surrounding area. We discuss this floristic diversity in the context of the ecology of the nearby San Rafael Swell and the desert areas of Wayne and Emery counties in southeastern Utah.

Keywords

Analog Research; Floristics; Astrobiology

Introduction

*"Hell yeah I'm a botanist! Fear my botany powers!" - Mark Watney
(The Martian, by Andy Weir).*

The Mars Desert Research Station (MDRS) (<http://mdrs.marssociety.org/>) is a Mars analog research site located in the desert approximately 9 km outside of Hanksville, in Wayne County, Utah, U.S.A. at 38°24'23.12"N, 110°47'30.94"W (Figs 1, 2). The station is located 5 km north of Utah State Route 24 along Cow Dung Road, which continues north for another 5 km to the Burpee Dinosaur Quarry, a recently described bone bed from the Jurassic Morrison Formation (Mathews et al. 2009).

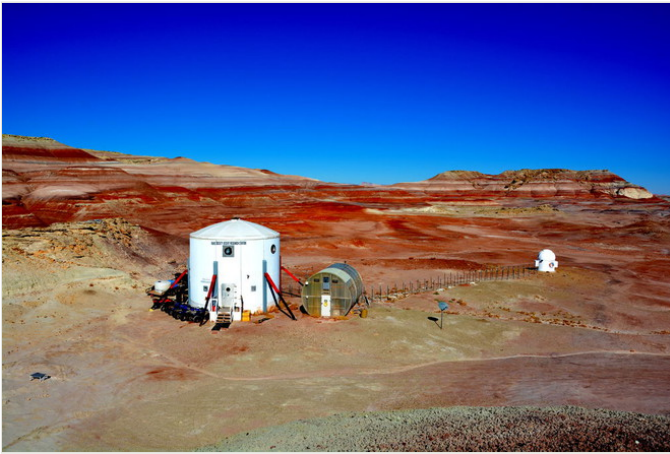


Figure 1.

The Mars Desert Research Station near Hanksville, Utah. The large white building on the left is the primary living and working structure (commonly known as the "hab"). To the right of the hab is the station's greenhouse (the "GreenHab"). This photo shows the original GreenHab, burned down on December 29th, 2014, and has since been replaced. The white building to the right is the Musk Observatory. Photo by P.C. Sokoloff. Photo taken on November 16th, 2014.

Constructed by the Mars Society (<http://www.marssociety.org/>) in 2002 and operated continuously ever since, MDRS, and its Arctic counterpart, the Flashline Mars Arctic Research Station (FMARS) (<http://fmars.marssociety.org/>), on Devon Island, Nunavut, Canada, are designed as testbeds for future manned missions to Mars (Bamsey et al. 2009). Visiting crews from multiple scientific and engineering disciplines conduct research at the stations on how to live and work on Mars without having to leave Earth.

Astrobiology, the study of the evolution and distribution of life throughout the universe (including Earth), is a field increasingly represented at MDRS. Professionals in the field seek to refine techniques to detect life on other worlds, and to answer outstanding questions about the origins of life here on Earth (Thiel et al. 2011). At MDRS, astrobiologists have conducted studies ranging from the detection of biomarkers (Martins et

al. 2011) and extremophiles (Direito et al. 2011) in the local soils, to the automated detection of life using computer algorithms (Gross et al. 2009), and more. This search for life in extreme environments on Earth is an excellent analog to the search for life on Mars. During their studies, astrobiologists, soil specialists, geologists and other scientists working at MDRS frequently come across, or seek out, vascular plants, lichens, algae, cyanobacteria, and fungi while conducting field research.



Figure 2.

Location of the Mars Desert Research Station habitat and our study area, including 11 collection sites (orange dots, ten are from 2014, one is from 2015), northwest of Hanksville, Utah, U.S.A. Inset map of Utah at top right indicates extent of map (smaller white outlined area). Map data courtesy of Google, SIO, NOAA, U.S. Navy, NGA, GEBCO, and Landsat.

Utah is a floristically diverse state, with some 2995 vascular plant species and infrataxa distributed in diverse ecosystems (Welsh et al. 1993). The cool deserts of southeastern Utah, where MDRS is located, possess diverse vascular plant (Andersen 1996) and biological soil crust communities (Belnap 2002). The distribution of these communities is determined primarily by the underlying geology, elevation, and moisture, all of which vary across the deserts of the region (Coles et al. 2009).

There is a long history of floristic work in southeastern Utah. Complete vascular plant inventories exist for two ecologically similar areas close to MDRS: Capitol Reef National Park (Heil et al. 1993, Fertig 2009) and Glen Canyon National Recreation Area (Hill and Ayers 2009). The latter location contains the Orange Cliffs, which have a well-studied vascular plant flora (Shultz et al. 1987). Fertig (2009) presents a comprehensive overview of previous vascular plant collection efforts throughout the region. The closest and best studied flora near MDRS is that of the San Rafael Swell, approximately 23 km northwest of the station. Harris (1983) compiled a vascular plant inventory, including 478 species, for this large geological feature that dominates southeastern Utah.

The inventories of vascular plants from the San Rafael Swell and Capitol Reef National Park provide a useful comparison to our own study region at MDRS. All three sites share common geological characteristics, notably the Mancos Shale and Morrison Formation (Coles et al. 2009, Direito et al. 2011, Gilluly 1929). These locations also share many common vascular plant communities based on this underlying geology.

For example, the vascular plant communities of the desert flats immediately surrounding MDRS correspond well to the description of the "Salt Desert Shrub Zone" in Harris (1983), which is characteristic of the Mancos Shale (Coles et al. 2009). The vegetation found on nearby sandstone outcrops and plateaus relate to the "Mixed Desert Shrub Zone" (Harris 1983). The alkaline clay soils of the station area are dominated by *Achnatherum hymenoides*, *Atriplex* sp., *Eriogonum inflatum*, and *Kali tragus*, while the sandstone outcrops support communities of *Artemisia* sp., *Ephedra viridis*, and *Dasyochloa pulchella*. Where these two ecological zones meet north of MDRS near Kent's Reservoir (a small pond immediately west of Cow Dung Road at 38°25'27.70"N, 110°47'17.01"W), there is an ecological gradient, including water-intensive stands of *Tamarix ramosissima* on wet alkaline soils of the Salt Desert Zone, mixed with *Artemisia* and *Ericameria nauseosa*, both characteristic of the Mixed Desert zone (Harris 1983). Further north along Cow Dung Road, the floodplains of a seasonally wet creek support healthy stands of *Sarcobatus vermiculatus* and other species that are known from the floodplains of the Salt Desert Zone (Harris 1983). This wide variety of habitat types, all differentiated by water availability and geological substrate, support a diverse vascular plant flora around MDRS.

The lichen flora of eastern Wayne County, in which MDRS is located, and adjacent eastern Emery County includes approximately 61 species. This is an estimate based on a catalogue of the lichens of Utah (St. Clair et al. 1991), notes on the state's lichen flora (Newberry and St. Clair 1991, St. Clair et al. 1995), and a flora of the terricolous lichens of the San Rafael Swell (Rajvanshi et al. 1998). A large part of this regional flora was found on soil (28) or rock (26). Of the total, seven species from Capitol Reef National Park in Wayne Co. were collected on either *Juniperus*, which was not observed in the study area, or on wood (e.g., dead shrubs), which was not examined for lichens during this study. The number of 61 reported lichen species for the reference region is dated and therefore likely a conservative estimate of the potential number of species to be found in the study area.

Given the diverse local flora, and the increasing prevalence of biological studies at MDRS, our primary objective for this study was to collect and identify the vascular plants, lichens, fungi, and endolithic cyanobacteria and algae (sub-surface photosynthetic life) at MDRS. These endolithic taxa are of particular interest to astrobiologists as model systems in the search for life on Mars (Direito et al. 2011). A secondary objective of our fieldwork was to practice and evaluate the techniques needed to collect biological samples during simulated Martian fieldwork.

Materials and methods

Fieldwork

From November 15–30, 2014, Paul Sokoloff participated in MDRS Expedition 143 (<http://mdrs.marssociety.org/home/crew-143>) as Crew Biologist, and was part of a six-person crew staying at MDRS for an 11-day simulated mission to Mars. Over the course of five extra-vehicular activities (EVAs: all activities that take place outside the "hab" while in simulation), representing approximately 20 hours of collecting time, all vascular plant, lichen, fungi, and endolithic cyanobacteria and algae species encountered (except for completely dead, unidentifiable vascular plants), were collected by Paul Sokoloff with the assistance of other crew members (typically one other crew member per trip). In each area visited, as many microhabitats as possible were explored for unique plants and lichens. EVA teams wore simulated spacesuits, consisting of overalls, hiking boots with gaiters, thick gloves, a backpack containing a fan (the simulated oxygen supply), and a clear bubble helmet. These simulated suits let field teams practice standard field work activities while having to cope with restricted vision and movement, both obstacles that would have to be overcome on a real mission to Mars (Fig. 3).



Figure 3.

MDRS Expedition 143 Commander Paul Knightly walking through stands of *Ericameria nauseosa* (Sokoloff 284, large yellow shrubs) and *Ephedra viridis* (wiry green shrub at centre of photo) at Kent's Reservoir while wearing a simulated spacesuit. Photo by P.C. Sokoloff.

While on EVAs we used standard collection techniques: plant samples were dug out at the roots or clipped from larger trunks, crustose lichens and cyanobacteria were chiseled away from rocky substrates, material was placed in numbered sample bags, coordinates were logged using a standard GPS receiver, and collection site notes were recorded. Owing to their fragile nature and the requirement for special collecting techniques, no effort was made to collect any of the soil crust lichens that might be found at MDRS. Specimens were

pressed and processed as appropriate inside the lab at MDRS (where simulated spacesuits were not required).

Where possible, photographs of the specimen *in situ* and of the habitat were taken at the time of collection. These photos are included in the species accounts below. Photos by C.E. Freebury, P.B. Hamilton, and those in Figures 8 and 10 by P.C. Sokoloff were taken under laboratory conditions in Ottawa. All other photographs were taken in the field. Photographs of vouchered lichen and vascular plant specimens include the collection number, while photographs of plants that were not collected include the location at which the photo was taken and the date.

In total, we collected 46 vascular plant specimens, 18 lichen samples (some of which were subdivided upon return to Ottawa), three rock samples containing endolithic cyanobacteria and algae, and one fungus from 10 collection sites during Expedition 143 (Fig. 2). These collection sites were chosen based on satellite images and topographical maps as representatives of the common habitat types around MDRS, so as to maximize the number of different species collected. The Mars Desert Research Station is situated in the southwest corner of this study area: our furthest north (five km from the "hab") and east (two km from the "hab") collection sites delimit an approximately 10 km² area covered by this study.

A follow-up visit was made to the study area from September 19–20, 2015, during which Paul Sokoloff collected three additional vascular plant specimens from one existing and one new collection site, and photo-documented one vascular plant species. These activities were not carried out under simulated Martian conditions.

Vascular Plant and Lichen Identification

With the exception of the fungus specimen, which was sent to the National Mycological Herbarium at Agriculture and Agri-Food Canada (DAOM) in Ottawa, the entire set of 71 specimens was deposited at the National Herbarium of Canada (CAN - vascular plants, CANL - lichens, CANA - algae), Canadian Museum of Nature. A duplicate set of 50 specimens was deposited at the Intermountain Herbarium at Utah State University (UTC).

All authors identified a subset of the collections reported here, as noted in the collection data for each specimen. Where appropriate, species accounts include analysis and discussion for each taxon. Vascular plant species were identified using the Flora of North America (chapters cited in species accounts), A Utah Flora (Welsh et al. 1993), and various primary literature sources cited in the species accounts below. For each vascular plant species we report whether or not the species is recorded in the nearby, well-studied San Rafael Swell (Harris 1983).

Lichen species were identified using the methods and keys provided in Lichens of North America Brodo et al. (2001) and Brodo et al. (2016). One lichen specimen (*Sokoloff 307*) was not identifiable, and is not treated here. All mounted and processed vascular plant and

lichen specimens at CAN and CANL were scanned and/or photographed, and are presented here as supplemental files, as cited in the species descriptions.

Algae and Cyanobacteria Identification

Selected fractured rock samples (*Sokoloff 249, 290, 301*) were examined at the Canadian Museum of Nature lab with an Olympus SZX12 dissecting microscope. Observed zones of endolithic algae and cyanobacteria were sampled by selectively isolating the algae from associated granular stone particles. Stone fragments with algae and/or cyanobacteria were picked and either cultured or placed on a microscope slide and squashed for direct examination. Culturing was conducted using 5 ml of sterile BBM Medium in 50 ml falcon tubes held at 22°C under natural and ambient light during the day. After two weeks the cultures were examined. Compound microscope examinations of original and cultured squash samples were initiated after stone fragments were removed from the slides before a semi-permanent slide mount was prepared. A Leica DMR HC microscope with differential interference contrast (DIC), phase contrast and bright field optics was used with a 100x Plan Apo (NA 1.35) objective for all microscopic examinations. Identifications were primarily based on the taxonomic treatments of Komárek and Anagnostidis (1999) and Ettl and Gärtner (2014).

Algae and Cyanobacteria Collections

Phylum Chlorophyta and Phylum Cyanobacteria

Notes: Six taxa of endolithic and endophytic algae and cyanobacteria were identified in this study. Two taxa independently (*Trebouxia* sp. 1 & *Gloeocapsa* sp.) formed a mixed layer (predominantly *Gloeocapsa* sp.) 1–4 mm below the surface within one sandstone sample (*Sokoloff 290*, Figs 4, 5). In a quartz sample (*Sokoloff 301*), *Gloeocapsa* sp. was the dominant taxon growing on the underside of a quartz rock found embedded in desert sand, along with an unknown chlorophyte (Chaetophorales) within crevices of the rock. In another sample, *Trebouxia* sp. 1 was also observed as a distinct layer 1–4 mm below the sandstone surface (*Sokoloff 249*). On average, there was 1–6 sand grains of varying shapes, sizes and orientation between the outer surface and the endolith. The algae layer varied from 0.5 to 1.5 mm in thickness and ranged from disrupted to continuous. In the three samples collected, the expanse of these layers ranged from 0.5 cm² to 2.5 cm². In two samples (*Sokoloff 249, 290*) lichens (*Lecanora* cf. *garovaglii*, *Acarospora strigata*) were scattered across the surface with subsurface expansions of the fungi into the sandstone (Fig. 6d, Fig. 7). Scattered fungi were also observed within the endolithic algae layers (Fig. 5). In two lichen samples examined for photobionts, *Heteroplacidium compactum* (*Sokoloff 296*) and *Placidium acarosporoides* (*Sokoloff 305*), the alga *Myrmecia* sp. was observed within the lichens.

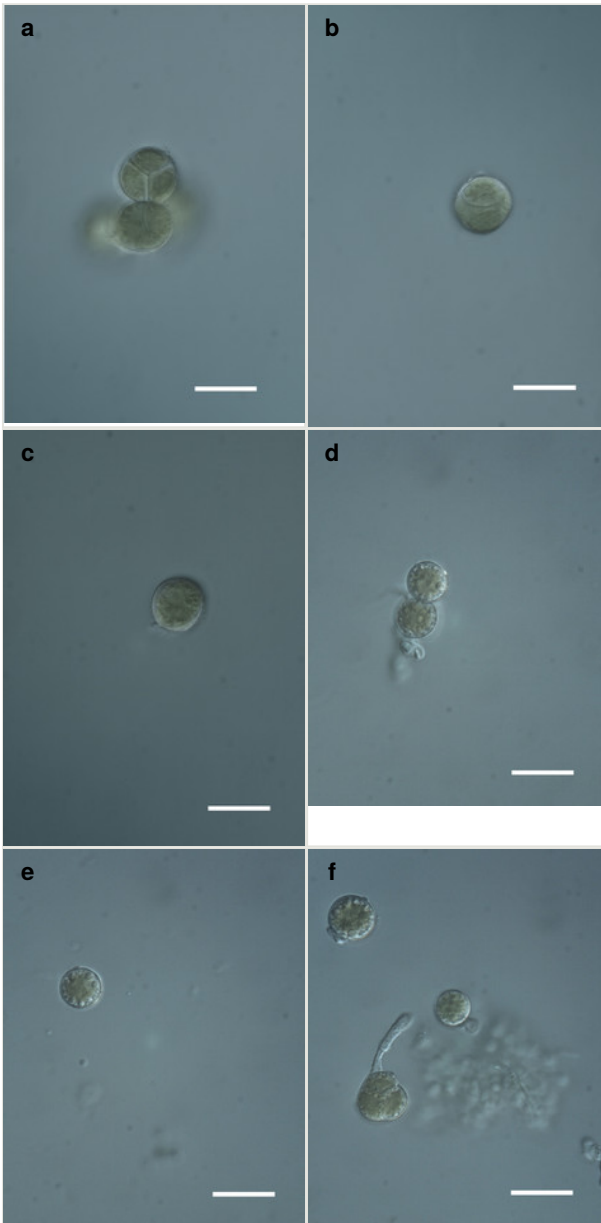


Figure 4.

Endolithic algae from sandstone. Scale bar = 20 μm . Photos by P.B. Hamilton.

- a:** *Trebouxia* sp. 1. Endolithic cells from sandstone.
- b:** *Trebouxia* sp. 1. Cultured spherical cells showing single and colony forming cells.
- c:** *Trebouxia* sp. 1. Cultured single cell showing lobed chloroplast plate with central pyrenoid.
- d:** *Trebouxia* sp. 4. Two cells grouped together.
- e:** *Trebouxia* sp. 4. Single cell showing lobed chloroplast with one to 5+ pyrenoids.
- f:** *Trebouxia* sp. 4. Fungal hyphae associated with cells.

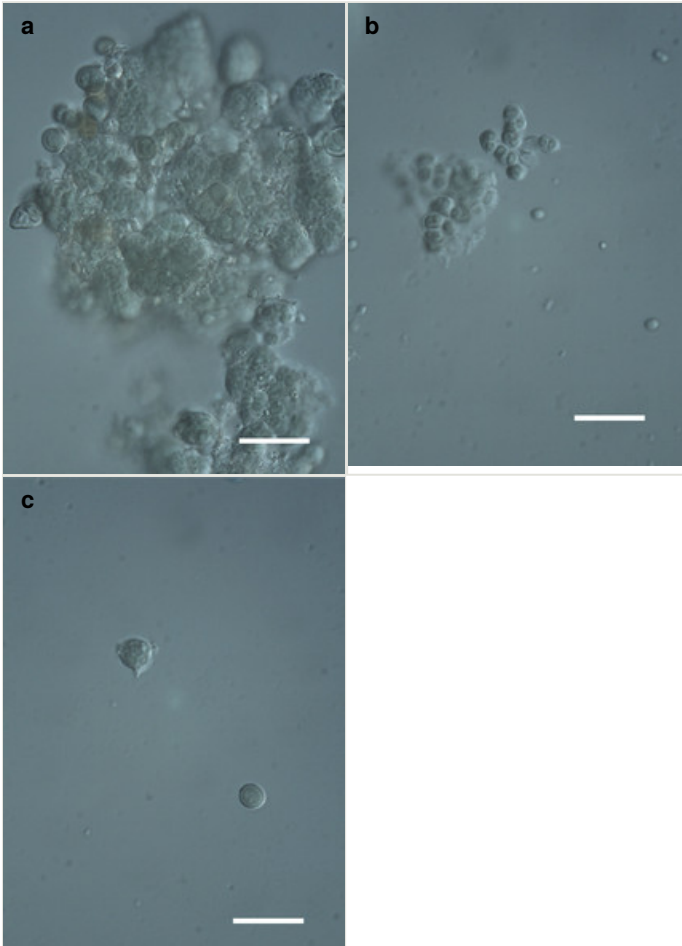


Figure 5.

Endolithic cyanobacteria from sandstone. Scale bar = 20 μm . Photos by P.B. Hamilton.

a: *Gloeocapsa* sp. Compact rectangular to sub-rectangular colonies with scattered single cells.

b: *Gloeocapsa* sp. Small colonies less than or equal to 4 cells. Wall sheath thick.

c: *Gloeocapsa* sp. Single cell and small colony showing thick sheath.

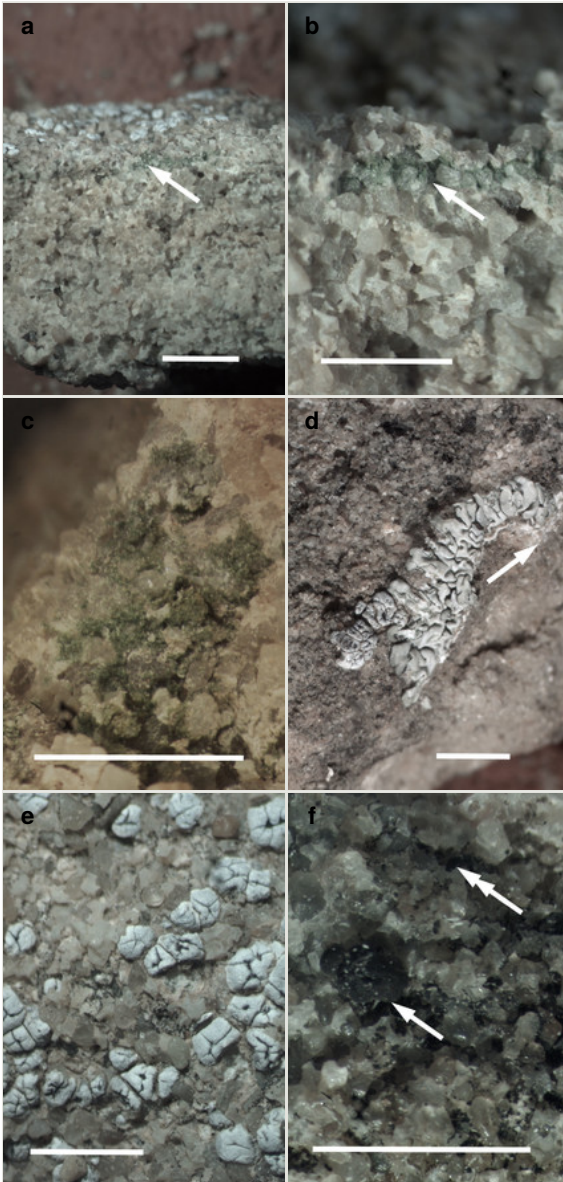


Figure 6.

Sandstones showing endolithic and epilithic algae, with associated lichens. Photos by P.B. Hamilton.

a: Endolithic subsurface layer of *Trebouxia* sp. 1 (Sokoloff 249, arrow). Scale bar = 5 mm.

b: Endolithic subsurface layer of *Gloeocapsa* sp. 1 (Sokoloff 290, arrow). Scale bar = 2.5 mm.

c: Exposed *Trebouxia* sp. Scale bar = 2.5 mm.

d: *Lecanora garovaglii* with residual fungal hyphae (arrow). Scale bar = 5 mm.

e: Lichen, Verrucariaceae family, scattered squamules. Scale bar = 2.5 mm.

f: Partial unidentified lichen ball (single arrow). Fine residual hyphae, identity unknown (double arrow). Scale bar = 2.5 mm.

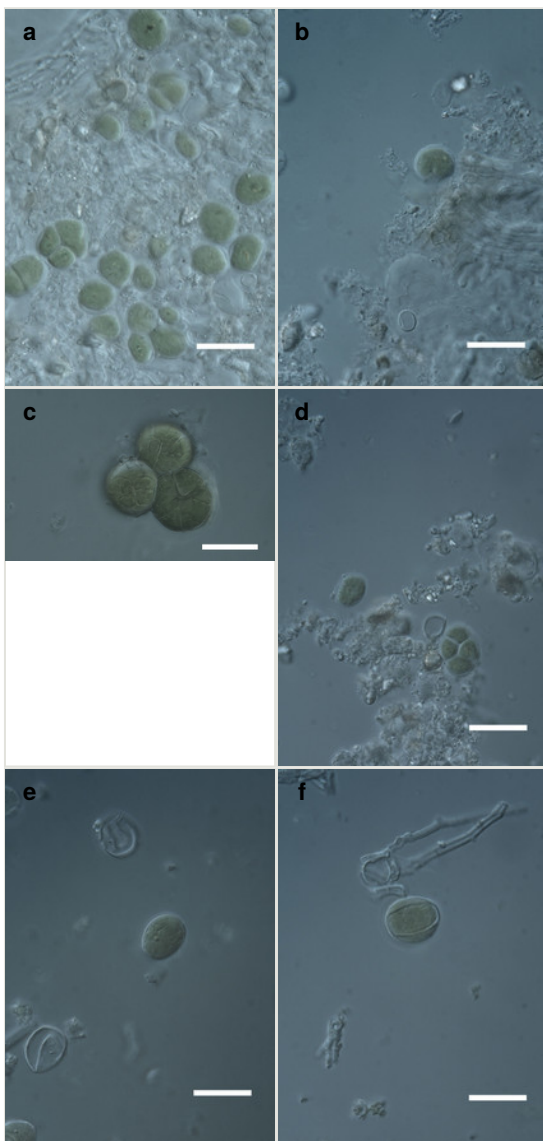


Figure 7.

Photobionts (algae). a-d: *Trebouxia* sp. 2 within *Acarospora strigata*. e-f: *Trebouxia* sp. 2 within *Lecanora* cf. *garovaglii*. Scale bar = 20 μm . Photos by P.B. Hamilton.

a: Cell squash highlighting *Trebouxia* sp. 2 with solid flattened chloroplast plates extending across the cell. Pyrenoid present in 6 cells. Cell wall <0.8 μm thick.

b: Chloroplast poorly discoid or a flattened plate. Pyrenoid present in a few cells. Cell wall up to 1 μm in thickness.

c: Cultured cells showing larger size, single cells and colony with pie-shaped cells.

d: Colonial form within the lichen, cells with flattened plate-like chloroplast and thick cell walls.

e: Squash showing single cells with a solid chloroplast and thin cell walls.

f: *Trebouxia* sp. 2 with hyphae of *Lecanora* cf. *garovaglii*.

Phylum Chlorophyta

Trebouxia sp. 1

Nomenclature:

[*T. cf. anticipata* Ahm./ *T. cf. gelatinosa* Ahm./ *T. cf. aggregata* (Arch.) Gärtner]

Material

- a. kingdom: Plantae; phylum: Chlorophyta; class: Trebouxiophyceae; order: Trebouxiales; family: Trebouxiaceae; genus: *Trebouxia*; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Vicinity of the Mars Desert Research Station, Hanksville, Utah, 500 m radius of "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°24'23.2"N; verbatimLongitude: 110° 47'31.1"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 17, 2014; habitat: Sandstone; recordNumber: 249; recordedBy: Sokoloff, Paul C.; identifiedBy: Hamilton, Paul B.; dateIdentified: 2016; institutionID: CMN; collectionID: CANA 117864; collectionCode: CANA, UTC; basisOfRecord: Dried Specimen

Notes: Cells spherical to weakly elliptical, 8–15.0 µm in diameter (Fig. 4 a-c; Fig. 6 a). In culture cells were spherical, up to 19 µm in diameter, the cell wall sheath <0.5 µm. Chloroplast plate-like, sometimes lobed, covering most of the cell. One pyrenoid present, at times difficult to distinguish. In the natural population the cell wall sheath was thick, up to 1.5 µm. Colonies of daughter cells tightly packed, forming wedge-shaped colonies in spherical to elliptical clusters. Endolithic, forming a fine linear layer (flake-like) 0.1–0.4 mm below surface of sandstone.

Trebouxia sp. 2

Nomenclature:

[*T. cf. gelatinosa* Ahm./ *T. cf. aggregata* (Arch.) Gärtner]

Materials

- a. kingdom: Plantae; phylum: Chlorophyta; class: Trebouxiophyceae; order: Trebouxiales; family: Trebouxiaceae; genus: *Trebouxia*; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Vicinity of the Mars Desert Research Station, Hanksville, Utah 500 m, radius of "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°24'23.2"N; verbatimLongitude: 110° 47'31.1"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 17, 2014; habitat: Sandstone; recordNumber: 249; recordedBy: Sokoloff, Paul C.; identifiedBy: Hamilton, Paul B.; dateIdentified: 2016; institutionID: CMN; collectionID: CANA 117864; collectionCode: CANA, UTC; basisOfRecord: Dried Specimen
- b. kingdom: Plantae; phylum: Chlorophyta; class: Trebouxiophyceae; order: Trebouxiales; family: Trebouxiaceae; genus: *Trebouxia*; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm

check" hill, 1.7 km north of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'3.15"N; verbatimLongitude: 110° 46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Sandstone at crest of *Artemisia* and *Ephedra* dominated hilltop; recordNumber: 290; recordedBy: Sokoloff, Paul C.; identifiedBy: Hamilton, Paul B.; dateIdentified: 2016; institutionID: CMN; collectionID: CANA 117865; collectionCode: CANA; basisOfRecord: Dried Specimen

Notes: Cells elliptical to spherical, 7–21.0 µm in diameter (Fig. 7 a-f). In culture cells were spherical, up to 19–22 µm in diameter and the cell wall sheath was <0.5 µm. Chloroplast large, plate-like to lobed, covering most of the cell. One pyrenoid present, at times difficult to distinguish. In the natural population, the cell wall sheath was <1.5 µm. Colonies of daughter cells tightly packed, forming wedge-shaped colonies in spherical to elliptical clusters. This was found in two lichen species (*Acarospora strigata* and *Lecanora* cf. *garovaglii*) forming a fine linear layer 5–100 µm thick, approximately 75–100 µm below the lichen surface.

Trebouxia sp. 3

Nomenclature:

[*T. cf. gelatinosa* Ahm./ *T. cf. aggregata* (Arch.) Gärtner]

Material

- a. kingdom: Plantae; phylum: Chlorophyta; class: Trebouxiophyceae; order: Trebouxiales; family: Trebouxiaceae; genus: *Trebouxia*; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm check" hill, 1.7 km north of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'3.15"N; verbatimLongitude: 110° 46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Sandstone at crest of *Artemisia* and *Ephedra* dominated hilltop; recordNumber: 290; recordedBy: Sokoloff, Paul C.; identifiedBy: Hamilton, Paul B.; dateIdentified: 2016; institutionID: CMN; collectionID: CANA 117865; collectionCode: CANA; basisOfRecord: Dried Specimen

Notes: Cells spherical to weakly elliptical, 7.0–15.0 µm in diameter (Fig. 8 a-c). Chloroplast plate-like, covering most of the cell. Culturing of this taxon was not successful. Pyrenoid difficult to distinguish. Cell wall sheath 1–2+ µm thick. Small clusters of cells, or colonies of daughter cells. Endophytic within an unidentified lichen (brown-black spheres) from the Verrucariaceae family (Fig. 8).

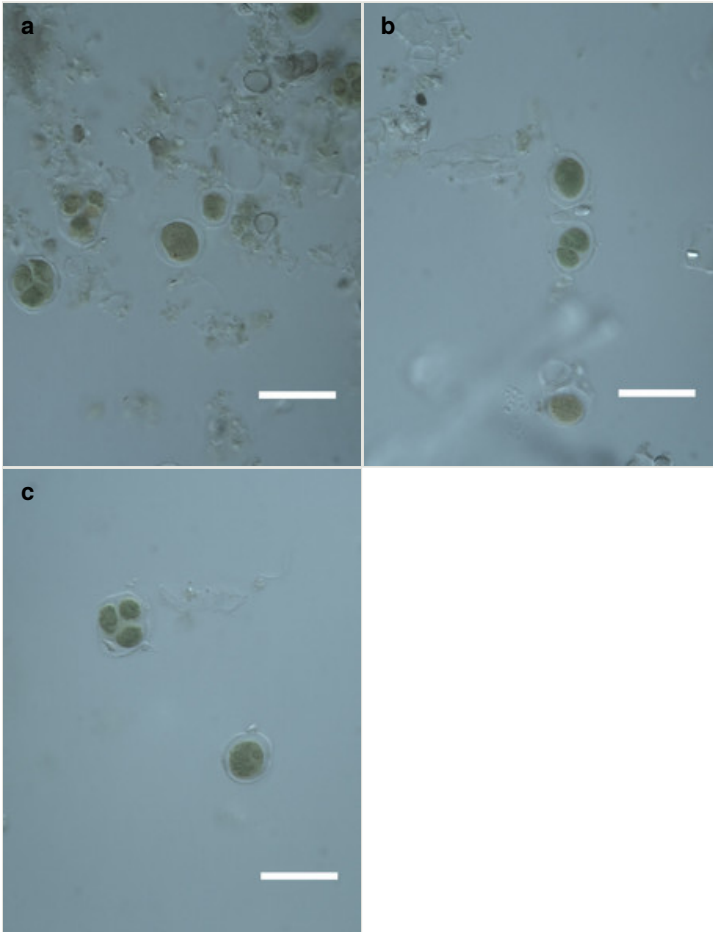


Figure 8.

Trebouxia sp. 3 within an unidentified lichen. Scale bar = 20 μ m. Photos by P.B. Hamilton.

a: Squash showing single cells of small colonies.

b: Squash showing single cells of small colonies.

c: Cells with a broad flattened plate and very thick sheath (>1.5 μ m).

***Trebouxia* sp. 4**

Nomenclature:

[*T. cf. usneae* (Hildreth & Ahm.) Gärtner/ *T. cf. potteri* Ahm. ex. Gärtner]

Material

- a. kingdom: Plantae; phylum: Chlorophyta; class: Trebouxiophyceae; order: Trebouxiales; family: Trebouxiaceae; genus: *Trebouxia*; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm

check" hill, 1.7 km north of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'3.15"N; verbatimLongitude: 110° 46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Sandstone at crest of *Artemisia* and *Ephedra* dominated hilltop; recordNumber: 290; recordedBy: Sokoloff, Paul C.; identifiedBy: Hamilton, Paul B.; dateIdentified: 2016; institutionID: CMN; collectionID: CANA 117865; collectionCode: CANA; basisOfRecord: Dried Specimen

Notes: Cells spherical to weakly elliptical, 12–15.0 μm in diameter (Fig. 4 e-f). Chloroplast lobed, covering most of the cell. One to many pyrenoids present, at times difficult to distinguish. In the natural population the cell wall sheath was thin $<0.8 \mu\text{m}$. Small colonies of daughter cells tightly packed in forming broad wedge-shaped colonies in spherical to elliptical clusters. Endolithic, scattered with *Gloeocapsa* sp. 0.1–0.4 mm below the sandstone surface.

***Myrmecia* sp.**

Materials

- a. kingdom: Plantae; phylum: Chlorophyta; class: Trebouxiophyceae; order: Trebouxiales; family: Trebouxiaceae; taxonRank: Species; genus: *Myrmecia*; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Roadside along ATV trail 2 km east of Mars Desert Research Station; verbatimElevation: 1348 m; verbatimLatitude: 38°24'53.8"N; verbatimLongitude: 110° 46'18"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 23 2014; habitat: Sandstone rubble and sandy plains.; recordNumber: 296; recordedBy: Sokoloff Paul C.; identifiedBy: Hamilton Paul B.; dateIdentified: 2015; institutionID: CMN; collectionID: CANL 127964; collectionCode: CANL, UTC; basisOfRecord: Dried Specimen
- b. kingdom: Plantae; phylum: Chlorophyta; class: Trebouxiophyceae; order: Trebouxiales; family: Trebouxiaceae; taxonRank: Species; genus: *Myrmecia*; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Alluvial plain and dry creekbed directly opposite turnout to Mars Desert Research Station on Cow Dung Road; verbatimElevation: 1357 m; verbatimLatitude: 38° 24'19.2"N; verbatimLongitude: 110°47'20"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 24 2014; habitat: Calcareous sandstone; recordNumber: 305; recordedBy: Sokoloff Paul C.; identifiedBy: Hamilton Paul B.; dateIdentified: 2016; institutionID: CMN; collectionID: CANL 127965; collectionCode: CANL, UTC; basisOfRecord: Preserved Specimen

Notes: Cells elliptical, length 6.5–15.5 μm , width 5–12 μm (Fig. 9). Chloroplast plate-like (1-many), covering most of the cell. Pyrenoid absent. Cell mucilage 0.5–1.5 μm thick. Endophytic, within two species of lichen in family Verrucariaceae (Fig. 9). Earlier descriptions of *M. biatorellae* indicated a broad range in cell size, however a more recent treatment of the genus (Ettl and Gärtner 2014) suggests that cells of *M. biatorellae* are larger than the cells observed here.

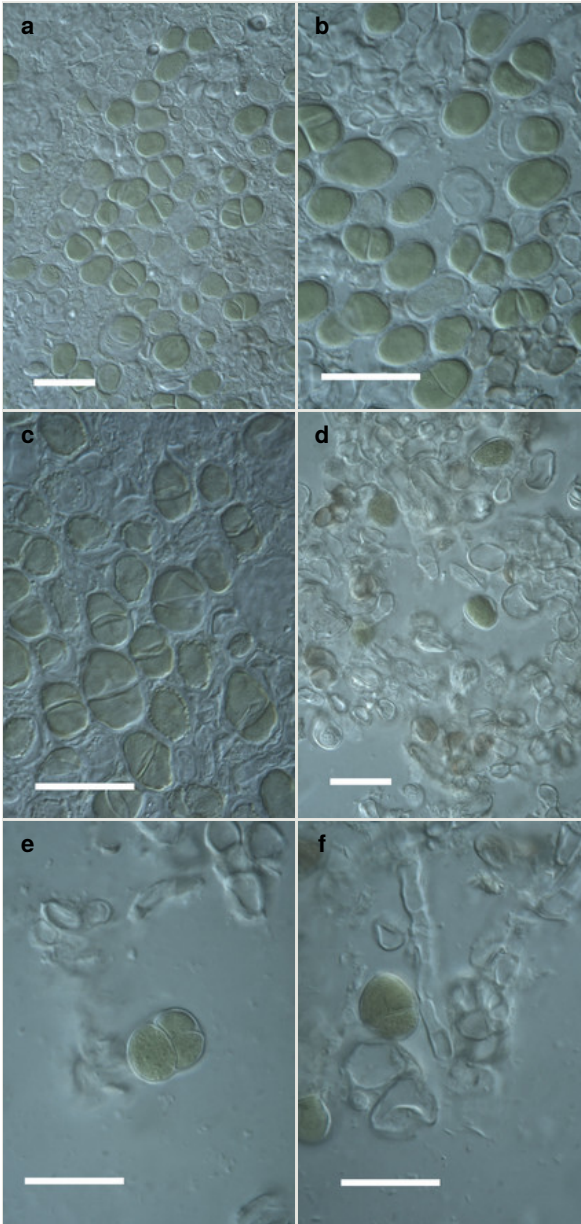


Figure 9.

Photobionts (algae). Scale bars = 20 μ m. Photos by P.B. Hamilton.

a: *Myrmecia* sp. in *Heteropladidium compactum*.

b: *Myrmecia* sp. in *Heteropladidium compactum*.

c: *Myrmecia* sp. in *Heteropladidium compactum*.

d: *Myrmecia* sp. in *Placidium acarosporoides*.

e: *Myrmecia* sp. in *Placidium acarosporoides*.

f: *Myrmecia* sp. in *Placidium acarosporoides*.

Phylum Cyanobacteria

Gloeocapsa sp.

Nomenclature:

[*G. cf. coracina* Kütz.]

Materials

- a. kingdom: Eubacteria; phylum: Cyanobacteria; class: Cyanophyceae; order: Chroococcales; family: Microcystaceae; genus: *Gloeocapsa*; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm check" hill, 1.7 km north of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'3.15"N; verbatimLongitude: 110°46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Sandstone at crest of *Artemisia* and *Ephedra* dominated hilltop; recordNumber: 290; recordedBy: Sokoloff, Paul C.; identifiedBy: Hamilton, Paul B.; dateIdentified: 2016; institutionID: CMN; collectionID: CANA 117865; collectionCode: CANA; basisOfRecord: Dried Specimen
- b. kingdom: Eubacteria; phylum: Cyanobacteria; class: Cyanophyceae; order: Chroococcales; family: Microcystaceae; genus: *Gloeocapsa*; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Alluvial plain and dry creekbed directly opposite turnoff to Mars Desert Research Station on Cow Dung Road; verbatimElevation: 1357 m; verbatimLatitude: 38°24'19.2"N; verbatimLongitude: 110°47'20"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 24 2014; habitat: Sandstone rubble and sandy plains; recordNumber: 301; recordedBy: Sokoloff, Paul C.; identifiedBy: Hamilton, Paul B.; dateIdentified: 2016; institutionID: CMN; collectionID: CANA 117866; collectionCode: CANA; basisOfRecord: Dried Specimen

Notes: Cells small ovals, found as single cells, two cell clusters or in small clusters of daughter cells within thin firm colourless sheaths. Length 2.5–5(6) μm by 1.5–3 μm wide, cell wall sheath thickness 0.8–1.6 μm . Mats of cells form as a collection of single cells or clusters of daughter cells closely packed together. Layer occurring 0.1–0.4 mm below the sandstone surface, or on the underside of quartzite rocks (Fig. 10).



Figure 10.

Gloeocapsa sp (Sokoloff 301). A blue-green layer of cyanobacteria (and an unknown chorophyte) growing on the underside of quartzite stone (stone has been flipped and the surface previously exposed is at the bottom of this photograph). Photo by P.C. Sokoloff.

Fungus Collections

Family Agaricaceae

Tulostoma sp.

Material

- a. kingdom: Fungi; phylum: Basidiomycota; class: Agaricomycetes; order: Agaricales; family: Agaricaceae; taxonRank: Genus; genus: *Tulostoma*; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Sandstone plateau immediately southwest of Mars Desert Research Station, alongside ATV trail; verbatimElevation: 1412 m; verbatimLatitude: 38°24'22.4"N; verbatimLongitude: 110°47'40.3"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 24, 2014; habitat: Dry conglomerate sandstone; recordNumber: 308; recordedBy: Sokoloff, Paul C.; identifiedBy: Redhead, Scott; dateIdentified: 2015; institutionID: AAFC; collectionCode: DAOM; basisOfRecord: Preserved Specimen

Notes: This is a diverse woody mushroom genus common in deserts of the southwestern United States (Hernandez Caffot et al. 2011). This specimen was found growing on sandy soils on top of the plateau immediately southwest of MDRS. Unfortunately, the specimen was too old and degraded for anything other than a generic determination (Scott A. Redhead, personal communication) (Fig. 11).



Figure 11.

Tulostoma sp. (Sokoloff 308). Photo by P.C. Sokoloff.

Lichen Collections

Family Acarosporaceae

Acarospora peliscypha Th. Fr.

Material

- a. scientificName: *Acarospora peliscypha* Th. Fr.; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Acarosporales; family: Acarosporaceae; taxonRank: Species; genus: *Acarospora*; specificEpithet: *peliscypha*; scientificNameAuthorship: Th. Fr.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm check" hill, 1.7 km north of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'3.15"N; verbatimLongitude: 110°46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Conglomerate sandstone hilltop dominated by *Artemisia* and *Ephedra*; recordNumber: 286; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; identificationRemarks: Additional specimens examined: Utah: Grand County, Sharnoff & Sharnoff 1635.01 (CANL), on partially calcareous sandstone. Colorado: Boulder County, Shushan & Weber S3363 (CANL), on acidic sandstone.; institutionID: CMN; collectionID: CANL 127960; collectionCode: CANL, UTC; basisOfRecord: Preserved Specimen

Notes: *Acarospora peliscypha* is an epruinose species; the whitish material on this specimen, as shown on the right side of Fig. 12, is not pruina but represents an accumulation of necrotic material. Although we were unable to find previous published reports of this species from Utah, we did examine one previous collection from that

state. This species has been described from the Sonoran Desert as growing on granite only (Knudsen 2007), however we found the species on partially calcareous sandstone.



Figure 12.

Acarospora peliscypha (Sokoloff 286). Habit. On partially calcareous sandstone. Photo by C.E. Freebury.

Supplemental File: CANL 127960 (Suppl. material 1).

Acarospora rosulata (Th. Fr.) H. Magn.

Material

- a. scientificName: *Acarospora rosulata* (Th. Fr.) H. Magn.; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Acarosporales; family: Acarosporaceae; taxonRank: Species; genus: *Acarospora*; specificEpithet: *rosulata*; scientificNameAuthorship: (Th. Fr.) H. Magn.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Alluvial plain and dry creekbed directly opposite turnoff to Mars Desert Research Station on Cow Dung Road; verbatimElevation: 1357 m; verbatimLatitude: 38°24'19.2"N; verbatimLongitude: 110°47'20"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 24, 2014; habitat: Sandstone rubble on sandy plain; recordNumber: 303; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; identificationReferences: Knudsen et al. (2010); institutionID: CMN; collectionID: CANL 127968; collectionCode: CANL; basisOfRecord: Preserved Specimen

Notes: Medulla KC+ pink, C+ pink (gyrophoric acid); on limestone. *Acarospora rosulata* has been previously reported from Utah as *Acarospora bullata* by Newberry and St. Clair (1991) (Sevier County), Leavitt and St. Clair (2008) (Wayne County) and Knudsen et al. (2010) (San Juan County and Sevier County).

Supplemental File: CANL 127968 (Suppl. material 2).

Acarospora stapfiana (Müll. Arg.) Hue

Material

- a. scientificName: *Acarospora stapfiana* (Müll. Arg.) Hue; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Acarosporales; family: Acarosporaceae; taxonRank: Species; genus: *Acarospora*; specificEpithet: *stapfiana*; scientificNameAuthorship: (Müll. Arg.) Hue; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Dry streambed approx 500 m northeast of Mars Desert Research Station "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°24'27.7"N; verbatimLongitude: 110°47'20"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 20, 2014; habitat: Rock-strewn hill with bird-perch boulder; recordNumber: 270; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; identificationRemarks: Parasitic on *C. trachyphylla*; institutionID: CMN; collectionID: CANL 127958; collectionCode: CANL, UTC; basisOfRecord: Preserved Specimen

Notes: This lichen was encountered growing on sandstone and parasitically on *Caloplaca trachyphylla* (Fig. 13) in the shade of a large rock due northeast of MDRS. *Acarospora stapfiana* has been previously reported from Capitol Reef National Park (St. Clair et al. 1995).

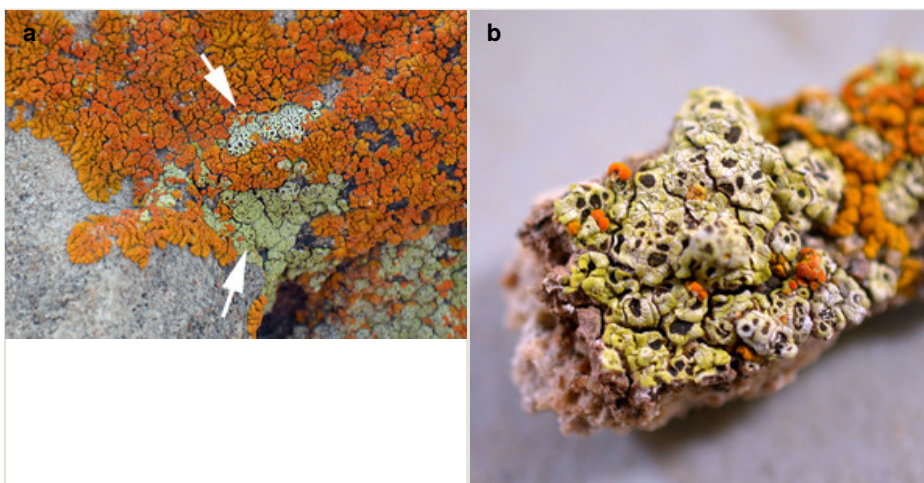


Figure 13.

Acarospora stapfiana. Photos by P.C. Sokoloff.

a: Habit, growing on sandstone and parasitic on *Caloplaca trachyphylla* (orange lichen). Vicinity of Mars Desert Research Station, November 20, 2014.

b: Thallus detail (Sokoloff 270).

Supplemental File: CANL 127958 (Suppl. material 3).

Acarospora strigata (Nyl.) Jatta

Materials

- a. scientificName: *Acarospora strigata* (Nyl.) Jatta; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Acarosporales; family: Acarosporaceae; taxonRank: Species; genus: *Acarospora*; specificEpithet: *strigata*; scientificNameAuthorship: (Nyl.) Jatta; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Vicinity of the Mars Desert Research Station, Hanksville, Utah, 500 m radius of "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38° 24'23.2"N; verbatimLongitude: 110°47'31.1"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 17, 2014; habitat: Conglomerate sandstone hilltop; recordNumber: 248; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; institutionID: CMN; collectionID: CANL 127953; collectionCode: CANL, UTC; basisOfRecord: Preserved Specimen
- b. scientificName: *Acarospora strigata* (Nyl.) Jatta; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Acarosporales; family: Acarosporaceae; taxonRank: Species; genus: *Acarospora*; specificEpithet: *strigata*; scientificNameAuthorship: (Nyl.) Jatta; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm check" hill, 1.7 km north of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'3.15"N; verbatimLongitude: 110°46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Conglomerate sandstone hilltop dominated by *Artemisia* and *Ephedra*; recordNumber: 288; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; institutionID: CMN; institutionCode: CANL 127962; collectionCode: CANL; basisOfRecord: Preserved Specimen
- c. scientificName: *Acarospora strigata* (Nyl.) Jatta; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Acarosporales; family: Acarosporaceae; taxonRank: Species; genus: *Acarospora*; specificEpithet: *strigata*; scientificNameAuthorship: (Nyl.) Jatta; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Alluvial plain and dry creekbed directly opposite turnout to Mars Desert Research Station on Cow Dung Road; verbatimElevation: 1357 m; verbatimLatitude: 38°24'19.2"N; verbatimLongitude: 110°47'20"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 24, 2014; habitat: Sandstone rubble on sandy plain; recordNumber: 304; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; institutionID: CMN; collectionID: CANL 127969; collectionCode: CANL, UTC; basisOfRecord: Preserved Specimen
- d. scientificName: *Acarospora strigata* (Nyl.) Jatta; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Acarosporales; family: Acarosporaceae; taxonRank: Species; genus: *Acarospora*; specificEpithet: *strigata*; scientificNameAuthorship: (Nyl.) Jatta; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Sandstone plateau immediately southwest of Mars Desert Research Station, alongside ATV trail; verbatimElevation: 1412 m; verbatimLatitude: 38°24'22.4"N; verbatimLongitude: 110°47'40.3"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 24, 2014; habitat: Rock-strewn hill; recordNumber: 306; recordedBy: Sokoloff, Paul C.; identifiedBy:

Freebury, Colin E.; dateIdentified: 2015; institutionID: CMN; collectionID: CANL 127952; collectionCode: CANL, UTC; basisOfRecord: Preserved Specimen

Notes: This greyish-white crustose lichen was commonly encountered growing on sandstone rocks surrounding MDRS (Fig. 14). The species was previously reported from eastern Wayne County by St. Clair et al. (1991).

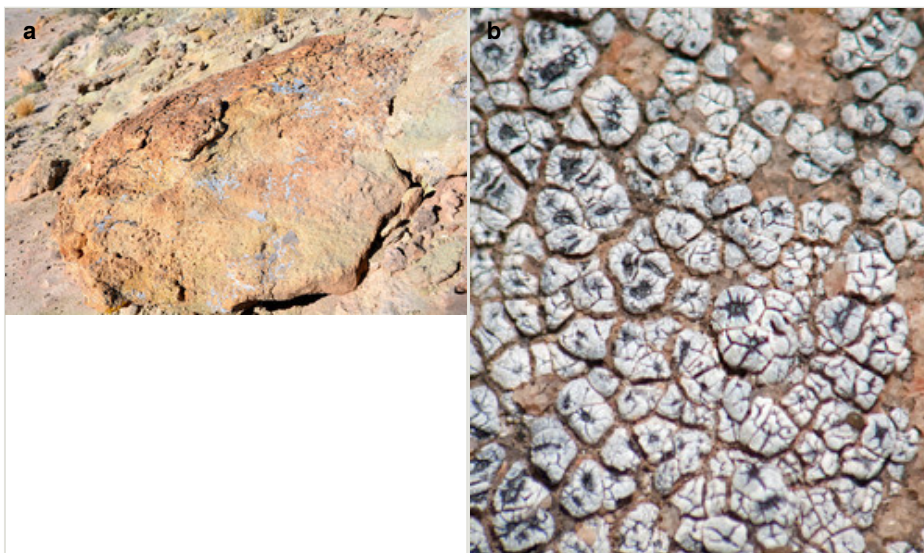


Figure 14.

Acarospora strigata (Sokoloff 248). Photos by P.C. Sokoloff (A) and C.E. Freebury (B).

a: Habitat on sandstone.

b: Habit.

Supplemental Files: CANL 127953 (Suppl. material 4), CANL 127962 (Suppl. material 5), CANL 127969 (Suppl. material 6), CANL 127966 (Suppl. material 7).

***Polysporina gyrocarpa* (H. Magn.) N. S. Golubk.**

Materials

- a. scientificName: *Polysporina gyrocarpa* (H. Magn.) N. S. Golubk.; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Acarosporales; family: Acarosporaceae; taxonRank: Species; genus: *Polysporina*; specificEpithet: *gyrocarpa*; scientificNameAuthorship: (H. Magn.) N. S. Golubk.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Vicinity of the Mars Desert Research Station, Hanksville, Utah, 500 m radius of "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°24'23.2"N; verbatimLongitude: 110° 47'31.1"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 17, 2014; habitat: Sandstone rubble on sandy plain; recordNumber: 247; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; identificationReferences:

- Knudsen and Kocourková (2009); institutionID: CMN; collectionID: CANL 127952; collectionCode: CANL, UTC; basisOfRecord: Preserved Specimen
- b. scientificName: *Polysporina gyrocarpa* (H. Magn.) N. S. Golubk.; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Acarosporales; family: Acarosporaceae; taxonRank: Species; genus: *Polysporina*; specificEpithet: *gyrocarpa*; scientificNameAuthorship: (H. Magn.) N. S. Golubk.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Vicinity of the Mars Desert Research Station, Hanksville, Utah, 500 m radius of "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°24'23.2"N; verbatimLongitude: 110°47'31.1"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 17, 2014; habitat: Sandstone rubble on sandy plain; recordNumber: 250; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; institutionID: CMN; collectionID: CANL 127954; collectionCode: CANL; basisOfRecord: Preserved Specimen
- c. scientificName: *Polysporina gyrocarpa* (H. Magn.) N. S. Golubk.; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Acarosporales; family: Acarosporaceae; taxonRank: Species; genus: *Polysporina*; specificEpithet: *gyrocarpa*; scientificNameAuthorship: (H. Magn.) N. S. Golubk.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm check" hill, 1.7 km northeast of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'3.15"N; verbatimLongitude: 110°46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Conglomerate sandstone hilltop dominated by *Artemisia* and *Ephedra*; recordNumber: 286b; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; institutionID: CMN; collectionID: CANL 127970; collectionCode: CANL; basisOfRecord: Preserved Specimen
- d. scientificName: *Polysporina gyrocarpa* (H. Magn.) N. S. Golubk.; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Acarosporales; family: Acarosporaceae; taxonRank: Species; genus: *Polysporina*; specificEpithet: *gyrocarpa*; scientificNameAuthorship: (H. Magn.) N. S. Golubk.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Along Cow Dung Road north of the Mars Desert Research Station; verbatimElevation: 1371 m; verbatimLatitude: 38°25'19.35"N; verbatimLongitude: 110°47'5.4"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Moist desert flats; recordNumber: 289; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; institutionID: CMN; collectionID: CANL 127963; collectionCode: CANL, UTC; basisOfRecord: Preserved Specimen

Notes: This species was commonly encountered growing on sandstone rocks and outcrops surrounding MDRS; the black, dot-like apothecia stand out well on tan-coloured sandstone (Fig. 15). *Polysporina gyrocarpa* was previously reported from Wayne County as *Sarcogyne oligospora* H. Magn. (St. Clair et al. 1991) and as *Polysporina oligospora* (H. Magn.) K. Knudsen (Knudsen and Lendemer 2005), and from the San Rafael Swell (Knudsen and Kocourková 2009).



Figure 15.

Polysporina gyrocarpa (Sokoloff 247). Habit. Photo by P.C. Sokoloff.

Supplemental Files: CANL 127952 (Suppl. material 8), CANL 127954 (Suppl. material 9), CANL 127963 (Suppl. material 10), CANL 127970 (Suppl. material 11).

Family Candelariaceae

Candelariella rosulans (Müll. Arg.) Zahlbr.

Materials

- a. scientificName: *Candelariella* cf. *rosulans* (Müll. Arg.) Zahlbr.; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Candelariales; family: Candelariaceae; taxonRank: Species; genus: *Candelariella*; specificEpithet: *rosulans*; scientificNameAuthorship: (Mull. Arg.) Zahlbr.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Vicinity of the Mars Desert Research Station, Hanksville, Utah, 500 m radius of "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°24'23.2"N; verbatimLongitude: 110°47'31.1"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 17, 2014; habitat: Rocky soil; reproductiveCondition: without fruiting bodies; recordNumber: 251; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; identificationQualifier: cf.; institutionID: CMN; collectionID: CANL 127955; collectionCode: CANL, UTC; basisOfRecord: Preserved Specimen
- b. scientificName: *Candelariella rosulans* (Müll. Arg.) Zahlbr.; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Candelariales; family: Candelariaceae; taxonRank: Species; genus: *Candelariella*; specificEpithet: *rosulans*; scientificNameAuthorship: (Mull. Arg.) Zahlbr.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm check" hill, 1.7 km northeast of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'3.15"N; verbatimLongitude:

110°46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Conglomerate sandstone hilltop dominated by *Artemisia* and *Ephedra*; recordNumber: 288b; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; identificationReferences: Westberg (2007); institutionID: CMN; collectionID: CANL 127971; collectionCode: CANL; basisOfRecord: Preserved Specimen

Notes: Asci 8-spored, ascospores narrowly ellipsoid to oblong, 13-15 × (4-)5(-6) μm. This yellow lichen species (Fig. 16) is known from throughout much of western North America (Westberg 2007). It was previously reported from Wayne County by Westberg (2007) and Leavitt and St. Clair (2008).

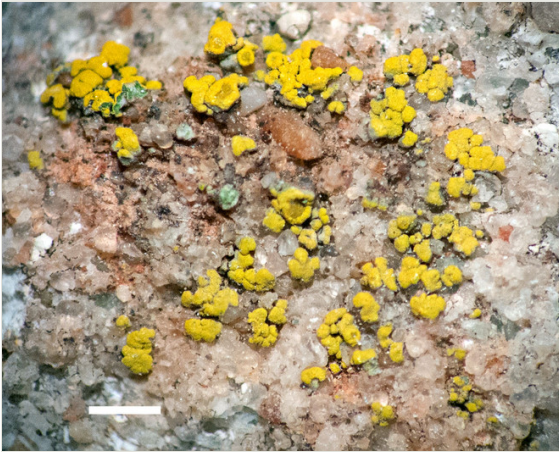


Figure 16.

Candelariella rosulans (Sokoloff 288b). Habit. Scale bar = 1 mm. Photo by C.E. Freebury.

Supplemental Files: CANL 127955 (Suppl. material 12), CANL 127971 (Suppl. material 13).

Family Collemataceae

Enchylium tenax (Sw.) Gray

Material

- a. scientificName: *Enchylium tenax* (Sw.) Gray; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Lecanorales; family: Collemataceae; taxonRank: Species; vernacularName: Soil jelly lichen; genus: *Enchylium*; specificEpithet: *tenax*; scientificNameAuthorship: (Sw.) Gray; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Alluvial plain and dry creekbed directly opposite turnoff to Mars Desert Research Station on Cow Dung Road; verbatimElevation: 1357 m; verbatimLatitude: 38°24'19.2"N; verbatimLongitude: 110° 47'20"W; geodeticDatum: WGS84; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 24, 2014; habitat: Sandstone rubble on sandy plain;

reproductiveCondition: Apothecia absent; recordNumber: 305b; recordedBy: Sokoloff Paul C.; identifiedBy: Brodo, I. M.; dateIdentified: 2016; identificationRemarks: Additional specimen examined: Utah: Emery County, San Rafael Swell; on soil. S. & S.D. Sharnoff 1181.21 (CANL).; institutionID: CMN; collectionID: CANL 127973; collectionCode: CANL; basisOfRecord: Preserved Specimen

Notes: Small sample, ca. 2 cm diam.; on sandy soil. *Enchylium tenax* (syn. *Collema tenax* (Sw.) Ach.) (Otálora et al. 2013) is a cosmopolitan species that is widely variable in terms of habit, color and isidia (Schultz et al. 2004). This particular specimen (Fig. 17) has somewhat ascending lobes and lacks apothecia. The species was previously reported as *Collema tenax* from the San Rafael Swell by Rajvanshi et al. (1998).



Figure 17.

Enchylium tenax (Sokoloff 305b). Habit. Scale bar = 3 mm. Photo by C.E. Freebury.

Supplemental File: CANL 127937 (Suppl. material 14).

Family Lecanoraceae

Lecanora garovaglii (Körber) Zahlbr.

Material

- a. scientificName: *Lecanora garovaglii* (Körber) Zahlbr.; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Lecanorales; family: Lecanoraceae; taxonRank: Species; genus: *Lecanora*; specificEpithet: *garovaglii*; scientificNameAuthorship: (Körber) Zahlbr.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm check" hill, 1.7 km north of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'3.15"N; verbatimLongitude: 110°46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Conglomerate sandstone hilltop dominated by *Artemisia* and *Ephedra*;

recordNumber: 287; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; identificationRemarks: Additional specimen examined: Utah: Carbon County, B. D. Ryan 18077, on sandstone (CANL).; institutionID: CMN; collectionID: CANL 127961; collectionCode: CANL, UTC; basisOfRecord: Preserved Specimen

Notes: Cortex KC+ gold (usnic & isousnic acids). *Lecanora garovaglii* (Fig. 18) is common throughout the semi-arid regions of central North America (Brodo et al. 2001). It has been previously reported from Boulder Mt. Plateau, Wayne County by Leavitt and St. Clair (2008).



Figure 18.

Lecanora garovaglii (Sokoloff 287). Habit. Scale bar = 1 cm. Photo by C.E. Freebury.

Supplemental File: CANL 127961 (Suppl. material 15).

Family Physciaceae

Buellia abstracta (Nyl.) H. Olivier

Material

- a. scientificName: *Buellia abstracta* (Nyl.) H. Olivier; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Teloschistales; family: Physciaceae; taxonRank: Species; genus: *Buellia*; specificEpithet: *abstracta*; scientificNameAuthorship: (Nyl.) H. Olivier; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Dry streambed approx 500 m northeast of Mars Desert Research Station "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38° 24'27.7"N; verbatimLongitude: 110°47'20"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 20, 2014; habitat: Hills with scattered sandstone boulders; recordNumber: 271; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; institutionID: CMN; collectionID: CANL 127959; collectionCode: CANL, UTC; basisOfRecord: Preserved Specimen

Notes: *Buellia abstracta* has sometimes been treated incorrectly as *Buellia sequax* (Nyl.) Zahlbr. (Bungartz et al. 2007, Giralt et al. 2011), and it has been reported as such from southwestern Utah (Bungartz et al. 2004). We have been unable to find reports of the species from the San Rafael Swell or other nearby areas.

Supplemental File: CANL 127959 (Suppl. material 16).

Family Teloschistaceae

Caloplaca trachyphylla (Tuck.) Zahlbr.

Materials

- a. scientificName: *Caloplaca trachyphylla* (Tuck.) Zahlbr.; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Teloschistales; family: Teloschistaceae; taxonRank: Species; genus: *Caloplaca*; specificEpithet: *trachyphylla*; scientificNameAuthorship: (Tuck.) Zahlbr.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Vicinity of the Mars Desert Research Station, Hanksville, Utah, 500 m radius of "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°24'23.2"N; verbatimLongitude: 110°47'31.1"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 17, 2014; habitat: Rocks on soil within a covered passageway; recordNumber: 252; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; institutionID: CMN; collectionID: CANL 127956; collectionCode: CANL, UTC; basisOfRecord: Preserved Specimen
- b. scientificName: *Caloplaca trachyphylla* (Tuck.) Zahlbr.; kingdom: Fungi; phylum: Ascomycota; class: Lecanoromycetes; order: Teloschistales; family: Teloschistaceae; taxonRank: Species; genus: *Caloplaca*; specificEpithet: *trachyphylla*; scientificNameAuthorship: (Tuck.) Zahlbr.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Dry streambed approx. 500 m northeast of Mars Desert Research Station "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°24'27.7"N; verbatimLongitude: 110°47'20"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 20, 2014; habitat: Hilltop sandstone boulder, a bird perch; recordNumber: 269; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; institutionID: CMN; collectionID: CANL 127957; collectionCode: CANL, UTC; basisOfRecord: Preserved Specimen

Notes: This species was one of the most conspicuous lichens encountered on EVAs (Fig. 19). One specimen (*Sokoloff 252*) was collected on a rock inside the passageway connecting the MDRS "hab" with the Musk Observatory. Though we follow Brodo et al. (2001) in treating this species as a member of *Caloplaca*, some authors treat this species as *Xanthomendoza trachyphylla* (Tuck.) Frödén, Arup & Søchting (Arup et al. 2013). *Caloplaca trachyphylla* is common in western North America (Brodo et al. 2001).

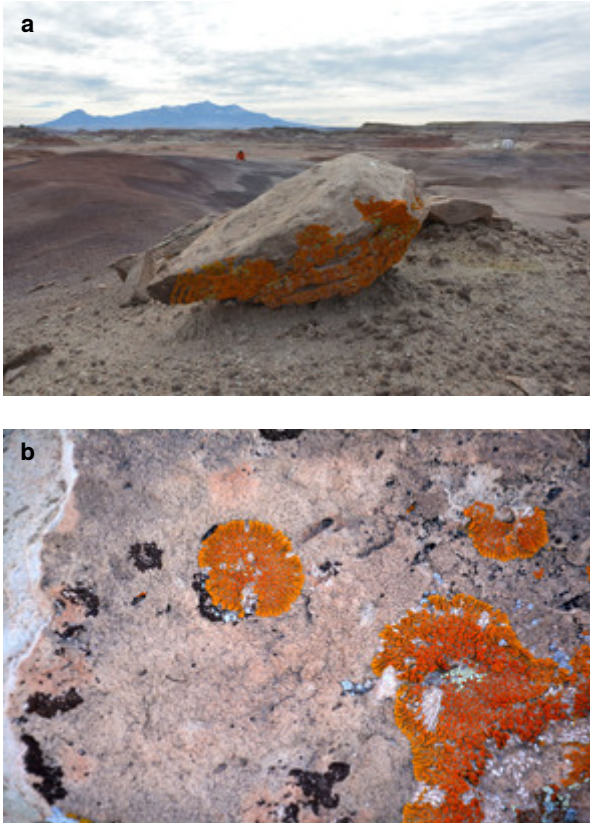


Figure 19.

Caloplaca trachyphylla. Photos by P.C. Sokoloff.

a: Habitat, rock-strewn hill northeast of the Mars Desert Research Station (visible at right), November 20, 2014.

b: Habit (Sokoloff 252).

Supplemental Files: CANL 127956 (Suppl. material 17), CANL 127957 (Suppl. material 18).

Family Verrucariaceae

Heteropladidium compactum (A. Massal.) Gueidan & Cl. Roux

Material

- a. scientificName: *Heteropladidium compactum* (A. Massal.) Gueidan & Cl. Roux; kingdom: Fungi; phylum: Ascomycota; class: Eurotiomycetes; order: Verrucariales; family: Verrucariaceae; taxonRank: Species; genus: *Heteropladidium*; specificEpithet: *compactum*; scientificNameAuthorship: (A. Massal.) Gueidan & Cl. Roux; continent: North

America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Roadside along ATV trail 2 km east of Mars Desert Research Station; verbatimElevation: 1348 m; verbatimLatitude: 38°24'53.8"N; verbatimLongitude: 110°46'18"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 23, 2014; habitat: Sandstone rubble on sandy plain; recordNumber: 296; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; identificationReferences: Breuss, O. (2007); identificationRemarks: Additional specimen examined: Saskatchewan: Grasslands National Park: Freebury 1335, independent on sandstone, parasitically on *Verrucaria inficiens* (CANL).; institutionID: CMN; collectionID: CANL 127964; collectionCode: CANL, UTC; basisOfRecord: Preserved Specimen

Notes: *Heteroplacidium compactum* is widely distributed worldwide. It was previously reported from Utah as *Catapyrenium compactum* (A. Massal.) R. Sant. by St. Clair et al. (1991). This lichen begins as a parasite on other lichens, and then grows independently. Fig. 20 shows our specimen growing partly scattered among and likely parasitic on *Caloplaca trachyphylla*.



Figure 20.

Heteroplacidium compactum (arrows) (Sokoloff 296), growing among *Caloplaca trachyphylla* (orange). The whitish (pruinose) lichen is *Acarospora stapfiana*, which is also a facultative parasite. Photo by C.E. Freebury.

Supplemental File: CANL 127964 (Suppl. material 19).

Placidium acarosporoides (Zahlbr.) Breuss

Material

- a. scientificName: *Placidium acarosporoides* (Zahlbr.) Breuss; kingdom: Fungi; phylum: Ascomycota; class: Eurotiomycetes; order: Verrucariales; family: Verrucariaceae; taxonRank: Species; genus: *Placidium*; specificEpithet: *acarosporoides*; scientificNameAuthorship: (Zahlbr.) Breuss; continent: North America; country: United

States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Alluvial plain and dry creekbed directly opposite turnoff to Mars Desert Research Station on Cow Dung Road; verbatimElevation: 1357 m; verbatimLatitude: 38°24'19.2"N; verbatimLongitude: 110°47'20"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 24, 2014; habitat: Sandstone rubble on sandy plain; recordNumber: 305; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, C.E.; dateIdentified: 2015; identificationReferences: Bruss (2002), Thomson (1987); identificationRemarks: Additional specimen examined: California: Riverside Co., Mojave Desert: S. & S.D. Sharnoff 1598.25, on granitic rock (CANL).; institutionID: CMN; collectionID: CANL 127965; collectionCode: CANL, UTC; basisOfRecord: Preserved Specimen

Notes: *Placidium acarosporoides* was found growing on calcareous sandstone in the vicinity of MDRS (Fig. 21). It has been reported previously from eastern Wayne County by Thomson (1987) as *Catapyrenium acarosporoides* (Zahlbr.) J.W. Thomson.

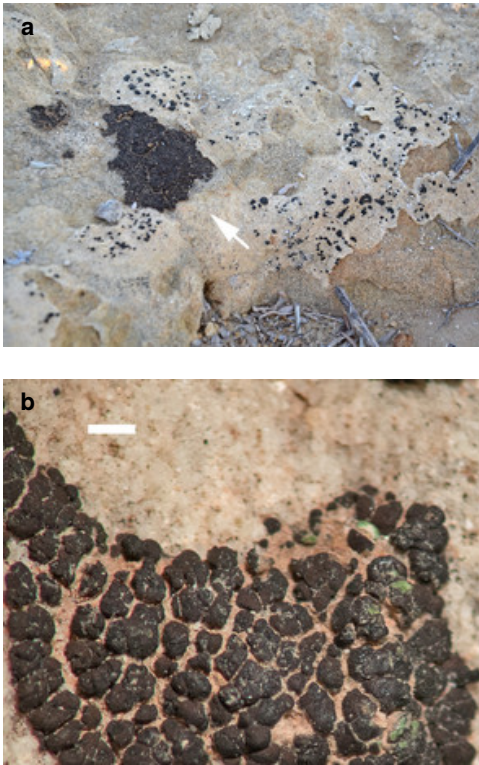


Figure 21.

Placidium acarosporoides. Photos by P.C. Sokoloff (A) and C.E. Freebury (B).

a: Habit. Vicinity of Mars Desert Research Station, Utah, November 29, 2014.

b: Convex squamules forming an areolate-looking thallus (Sokoloff 305). Scale bar = 1 mm.

Supplemental File: CANL 127965 (Suppl. material 20).

Placidium lachneum (Ach.) Breuss

Material

- a. scientificName: *Placidium lachneum* (Ach.) Breuss; kingdom: Fungi; phylum: Ascomycota; class: Eurotiomycetes; order: Verrucariales; family: Verrucariaceae; taxonRank: Species; genus: *Placidium*; specificEpithet: *lachneum*; scientificNameAuthorship: (Ach.) Breuss; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Alluvial plain and dry creekbed directly opposite turnoff to Mars Desert Research Station on Cow Dung Road; verbatimElevation: 1357 m; verbatimLatitude: 38°24'19.2"N; verbatimLongitude: 110°47'20"W; geodeticDatum: WGS84; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 24, 2014; habitat: Sandstone rubble on sandy plain; recordNumber: 305c; recordedBy: Sokoloff, Paul C.; identifiedBy: Freebury, Colin E.; dateIdentified: 2015; institutionID: CMN; collectionID: CANL 127972; collectionCode: CANL; basisOfRecord: Preserved Specimen

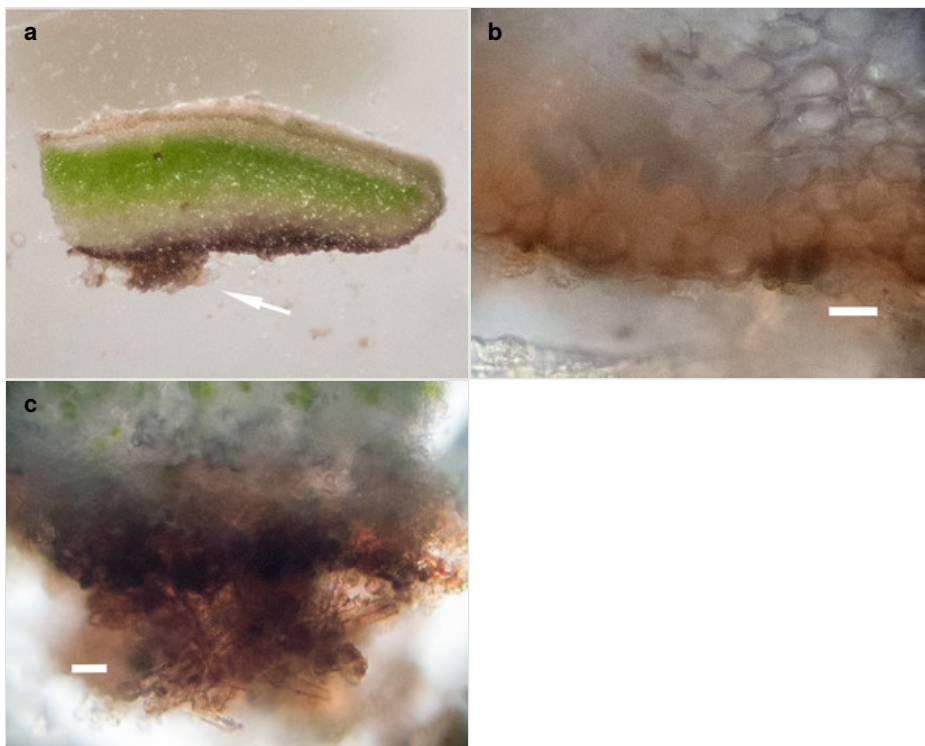


Figure 22.

Placidium lachneum (Sokoloff 305c). Photos by C.E. Freebury.

- a: Squamule section showing distinct lower cortex and hyphal weft (arrow).
 b: Lower cortex cells in +/- vertical alignment. Scale bar = 10 μ m.
 c: Hyphal weft incorporating soil granules. Scale bar = 20 μ m.

Notes: This soil crust lichen is common in the Great Basin desert shrub lands and on the Colorado Plateau (St. Clair et al. 1991). The lower cortex is comprised of a distinct layer of globular cells, 20-70 μm high, with the lowermost cells brown to black. Breuss (2002) describes the lower cortex with angular cells in distinct vertical columns. McCune and Rosentreter (2007) provide a photo that shows +/- globular cells in a non-aligned pattern. Brodo et al. (2016) describe the cells of the lower cortex as spherical and sometimes in vertical columns, which corresponds well with our specimen (Fig. 20b). Other key characteristics of *Placidium lachneum* include the presence of marginal pycnidia and hyphal wefts that help to attach the lichen to the soil, as shown in Fig. 22c.

Supplemental File: CANL 127972 (Suppl. material 21).

Vascular Plant Collections

Family Amaranthaceae

Atriplex confertifolia (Torr. & Frém.) S. Watson

Material

- a. scientificName: *Atriplex confertifolia* (Torr. & Frém.) S. Watson; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Caryophyllales; family: Amaranthaceae; taxonRank: Species; genus: *Atriplex*; specificEpithet: *confertifolia*; scientificNameAuthorship: (Torr. & Frém.) S. Watson; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Sandstone plateau immediately southwest of Mars Desert Research Station, alongside ATV trail; verbatimElevation: 1412 m; verbatimLatitude: 38°24'22.4"N; verbatimLongitude: 110°47'40.3"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 24, 2014; habitat: Dry conglomerate sandstone; preparations: Silica gel collection; recordNumber: 313; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607477; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: Common on dry saline soils (Welsh 2003), *Atriplex confertifolia* was abundant along a seasonally wet streambed north of MDRS. This widely distributed species readily hybridizes with other congeneric taxa, including *Atriplex corrugata* and *A. gardneri* (Stutz 1978), both of which are found in the study area. This species is known from the nearby San Rafael Swell (Harris 1983).

Supplemental File: CAN 607477 (Suppl. material 22).

Atriplex corrugata S. Watson

Material

- a. scientificName: *Atriplex corrugata* S. Watson; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Caryophyllales; family: Amaranthaceae; taxonRank: Species; genus: *Atriplex*; specificEpithet: *corrugata*; scientificNameAuthorship: S. Watson; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Seasonally wet stream crossing on Cow Dung Road, 1.6 km northeast of Mars Desert Research Station; verbatimElevation: 1371 m; verbatimLatitude: 38°25'55.39"N; verbatimLongitude: 110°47'30.2"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Desert slopes; preparations: Silica gel collection; recordNumber: 273; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607503; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: Common on the Mancos shale formation of eastern Utah and western Colorado (Welsh 2003), *Atriplex corrugata* was abundant at a seasonally wet streambed north of MDRS. This species was previously reported in the nearby San Rafael Swell (Harris 1983).

Supplemental File: CAN 607503 (Suppl. material 23).

Atriplex gardneri var. *cuneata* (A. Nelson) S.L. Welsh

Materials

- a. scientificName: *Atriplex gardneri* (Moq.) D. Dietr. var. *cuneata* (A. Nelson) S.L. Welsh; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Caryophyllales; family: Amaranthaceae; taxonRank: Variety; genus: *Atriplex*; specificEpithet: *gardneri*; infraspecificEpithet: *cuneata*; scientificNameAuthorship: (A. Nelson) S.L. Welsh; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Vicinity of the Mars Desert Research Station, Hanksville, Utah, 500 m radius of "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°24'23.2"N; verbatimLongitude: 110°47'31.1"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 17, 2014; habitat: Sandy washes and outcrops surrounding MDRS; preparations: Silica gel collection; recordNumber: 256; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607507; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen
- b. scientificName: *Atriplex gardneri* (Moq.) D. Dietr. var. *cuneata* (A. Nelson) S.L. Welsh; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Caryophyllales; family: Amaranthaceae; taxonRank: Variety; genus: *Atriplex*; specificEpithet: *gardneri*; infraspecificEpithet: *cuneata*; scientificNameAuthorship: (A. Nelson) S.L. Welsh; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Vicinity of the Mars Desert Research Station,

Hanksville, Utah, 500 m radius of "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38° 24'23.2"N; verbatimLongitude: 110°47'31.1"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 17, 2014; habitat: Sandy washes and outcrops surrounding MDRS; preparations: Silica gel collection; recordNumber: 259; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607505; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen



Figure 23.

Atriplex gardneri var. *cuneata*. Photos by P.C. Sokoloff.

a: Habit (Sokoloff 266).

b: Desert flats dominated by *Atriplex gardneri* var. *cuneata* and grasses. Northeast of Mars Desert Research Station, Utah, November 23, 2014.

- c. scientificName: *Atriplex gardneri* (Moq.) D. Dietr. var. *cuneata* (A. Nelson) S.L. Welsh; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Caryophyllales; family: Amaranthaceae; taxonRank: Variety; genus: *Atriplex*; specificEpithet: *gardneri*; infraspecificEpithet: *cuneata*; scientificNameAuthorship: (A. Nelson) S.L. Welsh; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Dry streambed approx 500 m northeast of Mars

Desert Research Station "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38° 24'27.7"N; verbatimLongitude: 110°47'20"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 20, 2014; habitat: Silty dry streambed; preparations: Silica gel collection; recordNumber: 266; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607506; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: This was one of the most commonly encountered species in the vicinity of MDRS (Fig. 23), and was seen on sandy desert flats throughout the study area. This species displays a great deal of phenotypic plasticity throughout its range, and hybridizes readily with other sympatric species of *Atriplex*, complicating taxonomic delimitation (Stutz 1978). Previously recorded in the nearby San Rafael Swell as *Atriplex cuneata* A. Nelson (Harris 1983), here we follow Welsh (2003) in treating this taxon at the subspecies level.

Supplemental Files: CAN 607507 (Suppl. material 24), CAN 607505 (Suppl. material 25), CAN 607506 (Suppl. material 26).

***Halogeton glomeratus* (M. Bieb.) C.A. Mey.**

Materials

- a. scientificName: *Halogeton glomeratus* (M. Bieb.) C.A. Mey.; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Caryophyllales; family: Amaranthaceae; taxonRank: Species; genus: *Halogeton*; specificEpithet: *glomeratus*; scientificNameAuthorship: (M. Bieb.) C.A. Mey.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Vicinity of the Mars Desert Research Station, Hanksville, Utah, 500 m radius of "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°24'23.2"N; verbatimLongitude: 110°47'31.1"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 17, 2014; habitat: Sandy washes and outcrops surrounding MDRS; recordNumber: 254; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607484; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen
- b. scientificName: *Halogeton glomeratus* (M. Bieb.) C.A. Mey.; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Caryophyllales; family: Amaranthaceae; taxonRank: Species; genus: *Halogeton*; specificEpithet: *glomeratus*; scientificNameAuthorship: (M. Bieb.) C.A. Mey.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Dry streambed approx 500 m northeast of Mars Desert Research Station "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°24'27.7"N; verbatimLongitude: 110°47'20"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 20, 2014; habitat: Rocky sandstone desert; recordNumber: 267; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607485; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: This introduced species is highly invasive in the western United States, flourishing in disturbed habitats and alkaline soils (Holmgren 2003). It was commonly encountered along Cow Dung Road, and has flourished in the disturbed areas immediately surrounding MDRS (Fig. 24). This species was previously recorded for the nearby San Rafael Swell (Harris 1983).

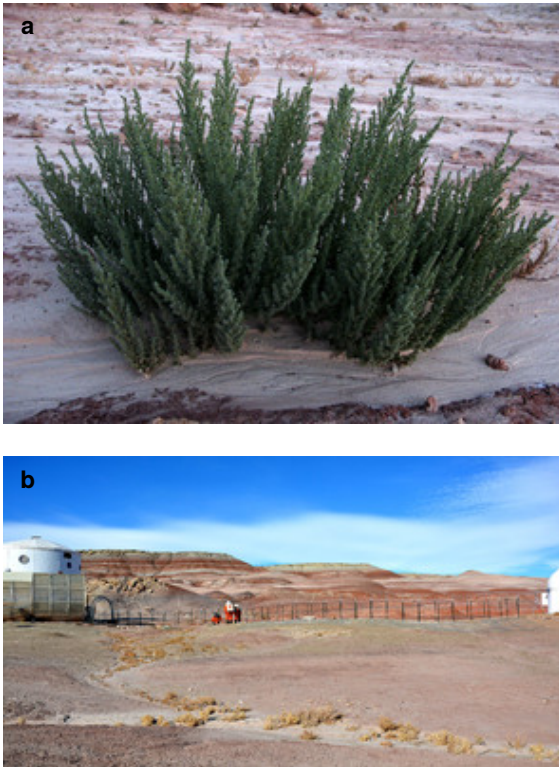


Figure 24.

Halogeton glomeratus. Photos by P.C. Sokoloff.

a: Habit. Vicinity of Mars Desert Research Station, Utah, September 20, 2015.

b: *Halogeton glomeratus* and *Atriplex gardneri* var. *cuneata* habitat (foreground) immediately east of the Mars Desert Research Station, Utah, November 26, 2014.

Supplemental Files: CAN 607484 (Suppl. material 27), CAN 607485 (Suppl. material 28).

***Kali tragus* (L.) Scop.**

Notes: This species was observed and photographed on a sandstone outcrop approximately 1 km northeast of MDRS on September 20, 2015 (Fig. 25), however this plant was not collected due to time and equipment constraints. Common on sandy plateaus and *Gutierrezia-Bromus* dominated scrub near MDRS, this species is a

noxious weed found throughout the southwestern United States (Welsh et al. 1993). This species was previously reported for the nearby San Rafael Swell (Harris 1983) as *Salsola iberica* Sennen & Pau, which was later synonymized under *Salsola tragus* L. (Mosyakin 2003). Further phylogenetic work has transferred this species to the genus *Kali* (Akhani et al. 2007), now placed in the expanded Amaranthaceae (APG III 2009)

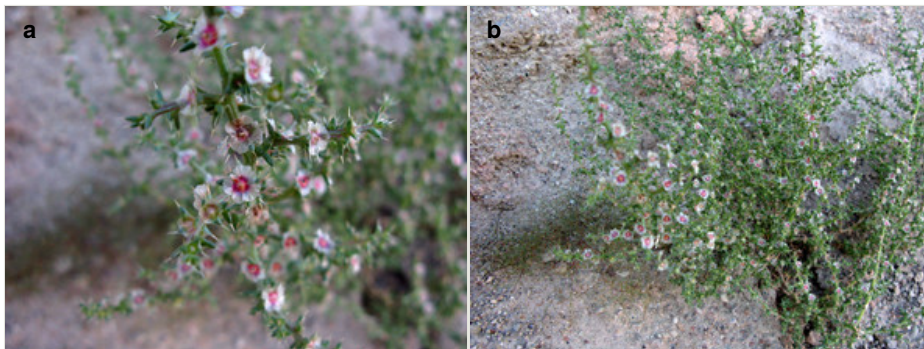


Figure 25.

Kali tragus. Vicinity of Mars Desert Research Station, Utah, September 20, 2015. Photos by P.C. Sokoloff.

a: Inflorescence.

b: Habit.

Family Asteraceae

Artemisia filifolia Torr.

Material

- a. scientificName: *Artemisia filifolia* Torr.; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Asterales; family: Asteraceae; taxonRank: Species; genus: *Artemisia*; specificEpithet: *filifolia*; scientificNameAuthorship: Torr.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm check" hill, 1.7 km northeast of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'3.15"N; verbatimLongitude: 110°46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Conglomerate sandstone hilltop dominated by *Artemisia* and *Ephedra*; preparations: Silica gel collection; recordNumber: 282; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607478; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: Common on the plateau just west of the MDRS (Fig. 26) this species is abundant on sandy substrates of the region (Shultz 2006), and was previously reported for the nearby San Rafael Swell (Harris 1983).



Figure 26.

Artemisia filifolia. Habit. Vicinity of Mars Desert Research Station, Utah, September 19, 2015. Photo by P.C. Sokoloff.

Supplemental File: CAN 607478 (Suppl. material 29).

***Chaenactis douglasii* var. *douglasii* (Hook.) Hook. & Arn.**

Material

- a. scientificName: *Chaenactis douglasii* (Hook.) Hook. & Arn. var. *douglasii*; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Asterales; family: Asteraceae; taxonRank: Variety; genus: *Chaenactis*; specificEpithet: *douglasii*; infraspecificEpithet: *douglasii*; scientificNameAuthorship: (Hook.) Hook. & Arn.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Approx. 200 m past fork on Cow Dung Road, down eastern fork, 1.9 km northeast of Mars Desert Research Station; verbatimElevation: 1381 m; verbatimLatitude: 38°25'3.2"N; verbatimLongitude: 110°46'29.7"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 23, 2014; habitat: *Artemisia*-dominated desert scrub; preparations: Silica gel collection; recordNumber: 291; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607472; collectionCode: CAN; basisOfRecord: Preserved Specimen

Notes: Found in desert shrub communities alongside the ATV trails north of MDRS, this widespread species was not recorded previously for the nearby San Rafael Swell (Harris 1983), though it is known to occur in nearby Capitol Reef National Park (Coles et al. 2009), and in the Four Corners region further southeast (Heil and O'Kane 2003). Though Welsh et al. (1993) did not recognize varieties, our specimen would be considered *C. douglasii* var. *douglasii* following Morefield (2006).

Supplemental File: CAN 607472 (Suppl. material 30).

Dieteria canescens var. *canescens* (Pursh) Nutt.

Material

- a. scientificName: *Dieteria canescens* (Pursh) Nutt. var. *canescens*; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Asterales; family: Asteraceae; taxonRank: Variety; genus: *Dieteria*; specificEpithet: *canescens*; infraspecificEpithet: *canescens*; scientificNameAuthorship: (Pursh) Nutt.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Parking lot of Burpee Dinosaur Quarry, end of Cow Dung Road; verbatimElevation: 1377 m; verbatimLatitude: 38°27'8.24"N; verbatimLongitude: 110°47'27.384"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: September 19, 2015; habitat: Dry sandstone bluffs; recordNumber: 366; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607522; basisOfRecord: Preserved Specimen

Notes: This species was recorded for the nearby San Rafael Swell as *Machaeranthera canescens* (Pursh) Gray (Harris 1983); the currently accepted name for this taxon is *Dieteria canescens* (Morgan 2006) based on molecular analysis and reclassification of the polyphyletic genus *Machaeranthera* (Morgan et al. 2009).

Supplemental File: CAN 607552 (Suppl. material 31).

Ericameria nauseosa (Pall. ex Pursh) G.L. Nesom & G.I. Baird

Material

- a. scientificName: *Ericameria nauseosa* (Pall. ex Pursh) G.L. Nesom & G.I. Baird; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Asterales; family: Asteraceae; taxonRank: Species; genus: *Ericameria*; specificEpithet: *nauseosa*; scientificNameAuthorship: (Pall. ex Pursh) G.L. Nesom & G.I. Baird; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Kent's Reservoir, 1.14 km north of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'28.4"N; verbatimLongitude: 110°47'17.29"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Moist desert flats; preparations: Silica gel collection; recordNumber: 284; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; identificationRemarks: Unable to determine to variety as no stigmatic appendages present; institutionID: CMN; collectionID: CAN 607481; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: *Ericameria nauseosa* was abundant along Cow Dung Road due north of MDRS, in the lowlands between rocky outcrops between MDRS and the Burpee Dinosaur Quarry (Fig. 27). Welsh et al. (1993) treats this species as *Chrysothamnus nauseosus* (Pallas ex Pursh) Britton, with 14 varieties in Utah. Four of these varieties (*C. nauseosus* var. *consimilis* (Greene) Hall, *C. nauseosus* var. *gnaphaloides* (Greene) Hall, *C. nauseosus* var. *junceus* (Greene) Hall, and *C. nauseosus* var. *leiospermus* (Gray) Hall) were previously reported for the nearby San Rafael Swell (Harris 1983). Urbatsch et al.

(2006), whose treatment we follow here, accept 21 varieties in North America; however we were unable to identify our specimen to variety as the diagnostic phyllaries were missing.



Figure 27.

Ericameria nauseosa (Sokoloff 284). Photos by P.C. Sokoloff.

a: Desert lowland habitat dominated by *Ericameria nauseosa* (large yellow shrub in centre and bottom-right of photo), *Atriplex* sp., *Achnatherum hymenoides*, and *Halogeton glomeratus*.

b: Habit.

Supplemental File: CAN 607481 (Suppl. material 32).

Gaillardia spathulata A. Gray

Material

- a. scientificName: *Gaillardia spathulata* A. Gray; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Asterales; family: Asteraceae; genus: *Gaillardia*; specificEpithet: *spathulata*; scientificNameAuthorship: A. Gray; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Sandstone plateau immediately southwest of Mars Desert Research Station, alongside ATV trail; verbatimElevation: 1412 m; verbatimLatitude: 38°24'22.4"N; verbatimLongitude: 110°47'40.3"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: September 19, 2015; habitat: Dry sandy soil; recordNumber: 367; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607524; collectionCode: CAN; basisOfRecord: PreservedSpecimen

Notes: A common plant of sandy desert soils (Strother 2006a), this species was abundant on the plateau immediately southwest of MDRS. This species was previously recorded for the nearby San Rafael Swell (Harris 1983).

Supplemental File: CAN 607524 (Suppl. material 33).

Gutierrezia sarothrae (Pursh) Britton & Rusby

Materials

- a. scientificName: *Gutierrezia sarothrae* (Pursh) Britton & Rusby; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Asterales; family: Asteraceae; taxonRank: Species; genus: *Gutierrezia*; specificEpithet: *sarothrae*; scientificNameAuthorship: (Pursh) Britton & Rusby; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Vicinity of the Mars Desert Research Station, Hanksville, Utah, 500 m radius of "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38° 24'23.2"N; verbatimLongitude: 110°47'31.1"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 17, 2014; habitat: Sandy washes and outcrops surrounding MDRS; preparations: Silica gel collection; recordNumber: 253; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607462; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen
- b. scientificName: *Gutierrezia sarothrae* (Pursh) Britton & Rusby; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Asterales; family: Asteraceae; taxonRank: Species; genus: *Gutierrezia*; specificEpithet: *sarothrae*; scientificNameAuthorship: (Pursh) Britton & Rusby; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Vicinity of the Mars Desert Research Station, Hanksville, Utah, 500 m radius of "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38° 24'23.2"N; verbatimLongitude: 110°47'31.1"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 17, 2014; habitat: Sandy washes and outcrops surrounding MDRS; preparations: Silica gel collection; recordNumber: 257; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607469; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen
- c. scientificName: *Gutierrezia sarothrae* (Pursh) Britton & Rusby; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Asterales; family: Asteraceae; taxonRank: Species; genus: *Gutierrezia*; specificEpithet: *sarothrae*; scientificNameAuthorship: (Pursh) Britton & Rusby; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Sandstone plateau immediately southwest of Mars Desert Research Station, alongside ATV trail; verbatimElevation: 1412 m; verbatimLatitude: 38°24'22.4"N; verbatimLongitude: 110°47'40.3"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 24, 2014; habitat: Dry conglomerate sandstone; preparations: Silica gel collection; recordNumber: 311; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607463; collectionCode: CAN; basisOfRecord: Preserved Specimen

Notes: Abundant on the rocky outcrops, desert shrub communities (Fig. 28), and plateaus surrounding MDRS, this species is well adapted to disturbance in Utah's desert rangelands (Welsh et al. 1993). *Gutierrezia sarothrae* was previously reported from the nearby San Rafael Swell as *Xanthocephalum sarothrae* (Pursh) Shinnars (Harris 1983). *Gutierrezia* is now segregated into a distinct genus (Nesom 2006).



Figure 28.

Gutierrezia sarothrae. Habit. Vicinity of Mars Desert Research Station, Utah, September 19, 2015. Photo by P.C. Sokoloff.

Supplemental Files: CAN 607462 (Suppl. material 34), CAN 607469 (Suppl. material 35), CAN 607463 (Suppl. material 36).

Hymenoxys cooperi (A. Gray) Cockerell

Material

- a. scientificName: *Hymenoxys cooperi* (A. Gray) Cockerell; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Asterales; family: Asteraceae; taxonRank: Species; genus: *Hymenoxys*; specificEpithet: *cooperi*; scientificNameAuthorship: (A. Gray) Cockerell; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Sandstone plateau immediately southwest of Mars Desert Research Station, alongside ATV trail; verbatimElevation: 1412 m; verbatimLatitude: 38°24'22.4"N; verbatimLongitude: 110°47'40.3"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 24, 2014; habitat: Dry conglomerate sandstone; preparations: Silica gel collection; recordNumber: 312; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607483; collectionCode: CAN; basisOfRecord: Preserved Specimen

Notes: This species, collected on the plateau west of MDRS, was not recorded in the previous floristic survey of the nearby San Rafael Swell Harris (1983) but there is a record of this species occurring in the Glen Canyon Recreational Area to the south (Hill and Ayers 2009). A shorter form with fewer heads is sometimes recognized as *H. cooperi* var. *canescens* (D.C. Eaton) K. F. Parker; however Welsh et al. (1993) did not recognize varieties in Utah, and Bierner (2006) did not recognize varieties in this species whatsoever.

Supplemental File: CAN 607483 (Suppl. material 37).

Scabrethia scabra (Hook.) W.A. Weber

Material

- a. scientificName: *Scabrethia scabra* (Hook.) W.A. Weber; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Asterales; family: Asteraceae; taxonRank: Species; genus: *Scabrethia*; specificEpithet: *scabra*; scientificNameAuthorship: (Hook.) W.A. Weber; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm check" hill, 1.7 km northeast of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'3.15"N; verbatimLongitude: 110°46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Conglomerate sandstone hilltop dominated by *Artemisia* and *Ephedra*; recordNumber: 280; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; identificationRemarks: Unable to determine to subspecies, as no phyllaries present; institutionID: CMN; collectionID: CAN 607479; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: Previously reported for the nearby San Rafael Swell as *Wyethia scabra* Hook. (Harris 1983), we follow Weber (2006), who had previously placed this species in *Scabrethia* (Weber 1998). We were unable to identify this specimen to subspecies as the diagnostic phyllaries were missing (Fig. 29).

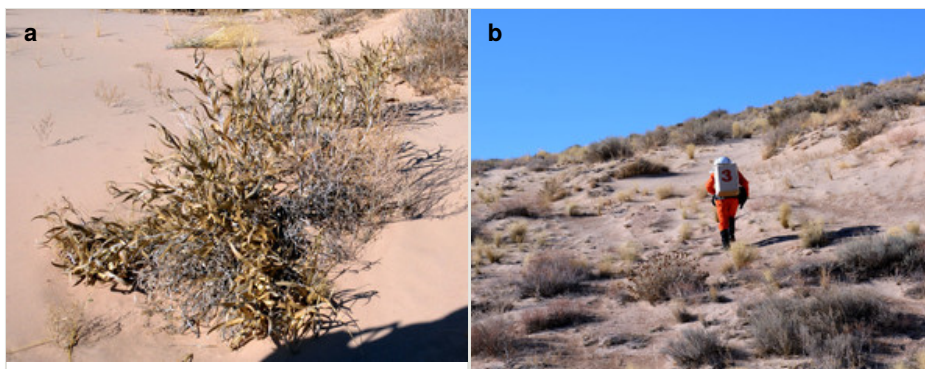


Figure 29.

Scabrethia scabra (Sokoloff 280). Photos by P.C. Sokoloff.

a: Habit.

b: Habitat.

Supplemental File: CAN 607479 (Suppl. material 38).

Thelesperma subnudum A. Gray

Material

- a. scientificName: *Thelesperma subnudum* A. Gray; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Asterales; family: Asteraceae; taxonRank: Species; genus: *Thelesperma*; specificEpithet: *subnudum*; scientificNameAuthorship: A. Gray; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm check" hill, 1.7 km northeast of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'3.15"N; verbatimLongitude: 110°46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Conglomerate sandstone hilltop dominated by *Artemisia* and *Ephedra*; preparations: Silica gel collection; recordNumber: 281; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607470; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: Common on sandstone bluffs in the region (Fig. 30) this species was previously reported for the nearby San Rafael Swell (Harris 1983). Welsh et al. (1993) described several varieties of this species in Utah, all of which have been subsumed under the broadly circumscribed *T. subnudum* of Strother (2006b).



Figure 30.

Thelesperma subnudum. Basal leaves. Vicinity of Mars Desert Research Station, Utah, September 20, 2015. Photo by P.C. Sokoloff.

Supplemental File: CAN 607470 (Suppl. material 39).

Family Boraginaceae

Cryptantha humilis (Greene) Payson

Material

- a. scientificName: *Cryptantha humilis* (Greene) Payson; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; family: Boraginaceae; taxonRank: Species; genus: *Cryptantha*; specificEpithet: *humilis*; scientificNameAuthorship: (Greene) Payson; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Sandstone plateau immediately southwest of Mars Desert Research Station, alongside ATV trail; verbatimElevation: 1412 m; verbatimLatitude: 38°24'22.4"N; verbatimLongitude: 110°47'40.3"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 24, 2014; habitat: Dry conglomerate sandstone; preparations: Silica gel collection; recordNumber: 314; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607504; collectionCode: CAN; basisOfRecord: Preserved Specimen

Notes: This species was previously recorded for the nearby San Rafael Swell as *Cryptantha humilis* var. *nana* (Eastw.) L.C. Higgins (Harris 1983). Welsh et al. (1993) suggests that while var. *humilisnana* might be applied to plants from the Uinta Basin (north of the study area), however they assert that variation of intraspecific diagnostic characters from across the range of *C. humilis* does not support the treatment of varieties.

Supplemental File: CAN 607504 (Suppl. material 40).

Family Brassicaceae

Lepidium montanum Nutt.

Materials

- a. scientificName: *Lepidium montanum* Nutt.; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Brassicales; family: Brassicaceae; taxonRank: Species; genus: *Lepidium*; specificEpithet: *montanum*; scientificNameAuthorship: Nutt.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Vicinity of the Mars Desert Research Station, Hanksville, Utah, 500 m radius of "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°24'23.2"N; verbatimLongitude: 110°47'31.1"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 17, 2014; habitat: Sandy washes and outcrops surrounding MDRS; preparations: Silica gel collection; recordNumber: 261; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607467; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

- b. scientificName: *Lepidium montanum* Nutt.; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Brassicales; family: Brassicaceae; taxonRank: Species; genus: *Lepidium*; specificEpithet: *montanum*; scientificNameAuthorship: Nutt.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Dry streambed approx 500 m northeast of Mars Desert Research Station "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°24'27.7"N; verbatimLongitude: 110°47'20"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 20, 2014; habitat: Rocky sandstone desert; preparations: Silica gel collection; recordNumber: 263; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607471; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: This species was commonly encountered in the sandy washes immediately surrounding MDRS (Fig. 31). Widely variable across its range, Welsh et al. (1993) report nine named varieties in Utah, and Harris (1983) reports *L. montanum* var. *jonesii* (Rydb.) C.L. Hitch. from the nearby San Rafael Swell. Al-Shebaz and Gaskin (2010) subsume these varieties into *L. montanum sensu lato* pending a thorough study of infraspecific delimitation; we follow their treatment here.

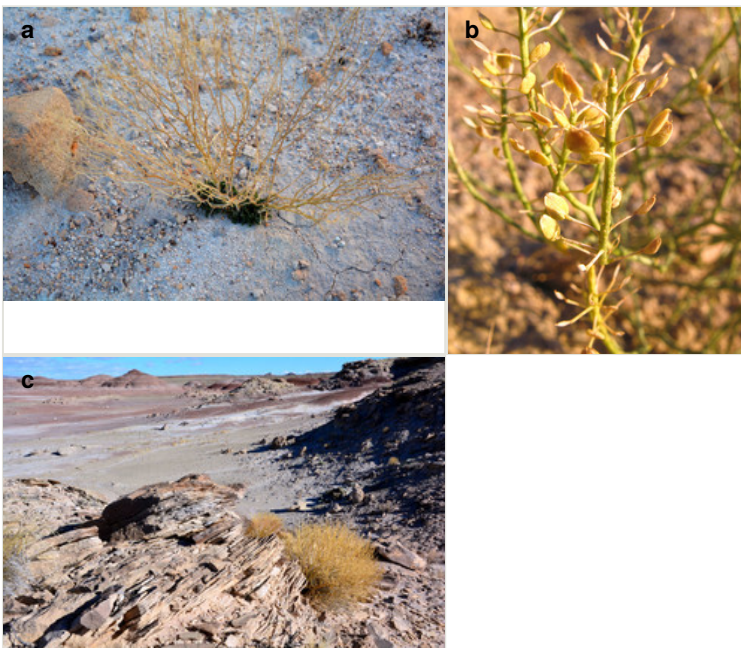


Figure 31.

Lepidium montanum. Photos by P.C. Sokoloff.

a: Habit (Sokoloff 261).

b: Fruits. Vicinity of Mars Desert Research Station, Utah, September 20, 2015

c: Habitat. Vicinity of Cow Dung Road, Utah, November 24, 2014.

Supplemental Files: CAN 607467 (Suppl. material 41), CAN 607471 (Suppl. material 42).

Family Cactaceae

Opuntia basilaris var. *basilaris* Engelm. & J.M. Bigelow

Material

- a. scientificName: *Opuntia basilaris* Engelm. & J.M. Bigelow var. *basilaris*; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Caryophyllales; family: Cactaceae; taxonRank: Variety; genus: *Opuntia*; specificEpithet: *basilaris*; infraspecificEpithet: *basilaris*; scientificNameAuthorship: Engelm. & J.M. Bigelow; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Seasonally wet stream crossing on Cow Dung Road, 1.6 km northeast of Mars Desert Research Station; verbatimElevation: 1371 m; verbatimLatitude: 38° 25'55.39"N; verbatimLongitude: 110°47'30.2"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Desert slopes; preparations: Silica gel collection; recordNumber: 272; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607488; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: This species was common along the banks of a seasonally wet stream crossing due northeast of MDRS (Fig. 32). This species was previously recorded from the nearby San Rafael Swell as *Opuntia basilaris* (without infraspecific rank) (Harris 1983). Morphological variability and hybridization have hindered infraspecific delineation in this species, and many named varieties appear in the literature, including four in Welsh et al. (1993), and a different set of four in Pinkava (2003); here we follow the latter treatment.



Figure 32.

Opuntia basilaris var. *basilaris* (Sokoloff 272). Habit. Photo by P.C. Sokoloff.

Supplemental File: CAN 607488 (Suppl. material 43).

***Opuntia polyacantha* var. *polyacantha* Haw.**

Material

- a. scientificName: *Opuntia polyacantha* Haw. var. *polyacantha*; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Caryophyllales; family: Cactaceae; taxonRank: Variety; genus: *Opuntia*; specificEpithet: *polyacantha*; infraspecificEpithet: *polyacantha*; scientificNameAuthorship: Haw.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Approx. 200 m past fork on Cow Dung Road, down eastern fork, 1.9 km northeast of Mars Desert Research Station; verbatimElevation: 1381 m; verbatimLatitude: 38°25'3.2"N; verbatimLongitude: 110°46'29.7"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 23, 2014; habitat: *Artemisia*-dominated desert scrub; preparations: Silica gel collection; recordNumber: 293; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607489; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: *Opuntia polyacantha* was the more common of the two *Opuntia* species recorded near the station, and was frequently encountered in the *Ephedra-Atriplex-Achnatherum* shrubland deserts north of MDRS (Fig. 33). Like *O. basilaris*, *O. polyacantha* is morphologically variable and hybridizes readily. This has resulted in a proliferation of variety names in *O. polyacantha*, including four in Welsh et al. (1993). We follow Pinkava (2003) here, who delineates *O. polyacantha* into five varieties across its range. This species was previously recorded for the nearby San Rafael Swell as *Opuntia polyacantha* (without infraspecific rank) (Harris 1983).



Figure 33.

Opuntia polyacantha var. *polyacantha* (Sokoloff 293). Habitat. Photo by P.C. Sokoloff.

Supplemental File: CAN 607489 (Suppl. material 44).

Family Ephedraceae

Ephedra viridis Colville

Materials

- a. scientificName: *Ephedra viridis* Colville; kingdom: Plantae; phylum: Gnetophyta; class: Gnetopsida; order: Ephedrales; family: Ephedraceae; taxonRank: Species; genus: *Ephedra*; specificEpithet: *viridis*; scientificNameAuthorship: Colville; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm check" hill, 1.7 km northeast of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'3.15"N; verbatimLongitude: 110°46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Conglomerate sandstone hilltop dominated by *Artemisia* and *Ephedra*; preparations: Silica gel collection; recordNumber: 275; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607468; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen



Figure 34.

Ephedra viridis. Habit. Vicinity of Mars Desert Research Station, Utah, September 19, 2015. Photo by P.C. Sokoloff.

- b. scientificName: *Ephedra viridis* Colville; kingdom: Plantae; phylum: Gnetophyta; class: Gnetopsida; order: Ephedrales; family: Ephedraceae; genus: *Ephedra*; specificEpithet: *viridis*; scientificNameAuthorship: Colville; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Parking lot of Burpee Dinosaur Quarry, end of Cow Dung Road; verbatimElevation: 1377 m; verbatimLatitude: 38°27'8.24"N; verbatimLongitude: 110°47'27.384"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: September 19, 2015; habitat: Dry sandstone bluffs; recordNumber: 365; recordedBy: Sokoloff, Paul C.; identifiedBy:

Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607523; collectionCode: CAN; basisOfRecord: Preserved Specimen

Notes: A common species of dry hills and desert slopes (Stevensen 1993), we collected this species along mesa tops and desert scrub communities north of MDRS along Cow Dung Road (Fig. 34). This species was previously reported for the nearby San Rafael Swell (Harris 1983).

Supplemental File: CAN 607468 (Suppl. material 45), CAN 607523 (Suppl. material 46).

Family Euphorbiaceae

Euphorbia fendleri Torr. & A. Gray

Material

- a. scientificName: *Euphorbia fendleri* Torr. & A. Gray; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Malpighiales; family: Euphorbiaceae; taxonRank: Species; genus: *Euphorbia*; specificEpithet: *fendleri*; scientificNameAuthorship: Torr. & A. Gray; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm check" hill, 1.7 km northeast of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'3.15"N; verbatimLongitude: 110°46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Conglomerate sandstone hilltop dominated by *Artemisia* and *Ephedra*; recordNumber: 279; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607464; collectionCode: CAN; basisOfRecord: Preserved Specimen

Notes: Widespread throughout Utah (Welsh et al. 1993); a sometimes-used combination exists for this species in *Chamaesyce* (*Chamaesyce fendleri* (Torr. & A. Gray) Small), however molecular evidence firmly places this species within *Euphorbia* (Yang and Berry 2011). This species was previously reported for the nearby San Rafael Swell (Harris 1983).

Supplemental File: CAN 607464 (Suppl. material 47).

Family Fabaceae

Astragalus amphioxys A. Gray

Materials

- a. scientificName: *Astragalus amphioxys* A. Gray; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Fabales; family: Fabaceae; taxonRank: Species; genus: *Astragalus*; specificEpithet: *amphioxys*; scientificNameAuthorship: A. Gray; continent: North

America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm check" hill, 1.7 km northeast of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'3.15"N; verbatimLongitude: 110°46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Conglomerate sandstone hilltop dominated by *Artemisia* and *Ephedra*; preparations: Silica gel collection; recordNumber: 276; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607473; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

- b. scientificName: *Astragalus amphioxys* A. Gray; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Fabales; family: Fabaceae; taxonRank: Species; genus: *Astragalus*; specificEpithet: *amphioxys*; scientificNameAuthorship: A. Gray; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Approx. 200 m past fork on Cow Dung Road, down eastern fork, 1.9 km northeast of Mars Desert Research Station; verbatimElevation: 1381 m; verbatimLatitude: 38°25'3.2"N; verbatimLongitude: 110°46'29.7"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 23, 2014; habitat: *Artemisia*-dominated desert scrub; preparations: Silica gel collection; recordNumber: 292; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607474; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: This species was common on sandy soil in *Atriplex-Ephedra* communities due north of MDRS (Fig. 35). Harris (1983) reported two varieties of this species from the nearby San Rafael Swell: *Astragalus amphioxys* var. *amphioxys* and *Astragalus amphioxys* var. *vespertinus* (E. Sheld.) M.E. Jones. Both varieties are recognized in Barneby (1964) and Welsh (2006), which follow a nearly identical taxonomy, however we were unable to determine these collections to variety as the plants were neither flowering nor fruiting.



Figure 35.

Astragalus amphioxys (Sokoloff 276). Habit. Photo by P.C. Sokoloff.

Supplemental Files: CAN 607473 (Suppl. material 48), CAN 607474 (Suppl. material 49).

***Astragalus desperatus* M.E. Jones**

Material

- a. scientificName: *Astragalus desperatus* M.E. Jones; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Fabales; family: Fabaceae; taxonRank: Species; genus: *Astragalus*; specificEpithet: *desperatus*; scientificNameAuthorship: M.E. Jones; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Roadside along ATV trail 2 km northeast of Mars Desert Research Station; verbatimElevation: 1348 m; verbatimLatitude: 38°24'53.8"N; verbatimLongitude: 110°46'18"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 23, 2014; habitat: Sandstone rubble and sandy plains; preparations: Silica gel collection; recordNumber: 295; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607476; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: Harris (1983) reported two varieties of this species from the nearby San Rafael Swell: *Astragalus desperatus* var. *desperatus* and *Astragalus desperatus* var. *petrophilus* M.E. Jones. Both varieties are accepted in Welsh (2006). Barneby (1964) treats this species as containing var. *desperatus* and var. *conspectus* Barneby, the later of which is synonymous with Welsh's *Astragalus barnebyi* S.L. Welsh & N.D. Atwood (Welsh 2006). As our collection was vegetative, we were unable to identify it to variety.

Supplemental File: CAN 607476 (Suppl. material 50).

***Astragalus lentiginosus* Douglas**

Material

- a. scientificName: *Astragalus lentiginosus* Douglas; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Fabales; family: Fabaceae; taxonRank: Species; genus: *Astragalus*; specificEpithet: *lentiginosus*; scientificNameAuthorship: Douglas; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Roadside along ATV trail 2 km northeast of Mars Desert Research Station; verbatimElevation: 1348 m; verbatimLatitude: 38°24'53.8"N; verbatimLongitude: 110°46'18"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 23, 2014; habitat: Dry sandy streambed, grass-dominated community; preparations: Silica gel collection; recordNumber: 299; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607475; collectionCode: CAN; basisOfRecord: Preserved Specimen

Notes: This species was only encountered once in the MDRS vicinity, due northwest of MDRS (Fig. 36). Harris (1983) reported two varieties of this species from the nearby San Rafael Swell: *Astragalus lentiginosus* var. *araneosus* (E. Sheld.) Barneby and

Astragalus lentiginosus var. *palans* (M.E. Jones) M.E. Jones. Both of these varieties are accepted in both Barneby (1964) and Welsh (2006) however, we were unable to determine our collection to variety as this specimen was vegetative.



Figure 36.

Astragalus lentiginosus (Sokoloff 299). Habit. Photo by P.C. Sokoloff

Supplemental File: CAN 607475 (Suppl. material 51).

Family Juncaceae

Juncus bufonius L.

Material

- a. scientificName: *Juncus bufonius* L.; kingdom: Plantae; phylum: Angiosperms; class: Monocots; order: Poales; family: Juncaceae; taxonRank: Species; genus: *Juncus*; specificEpithet: *bufonius*; scientificNameAuthorship: L.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Dry streambed approx 500 m northeast of Mars Desert Research Station "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°24'27.7"N; verbatimLongitude: 110°47'20"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 20, 2014; habitat: Summit of rocky hill; recordNumber: 265; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607487; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: Harris (1983) did not record this species within the nearby San Rafael Swell, but it is reported for both the Glen Canyon National Recreation Area (Hill and Ayers 2009), and Capitol Reef National Park (Fertig 2009). Though common throughout North America (Brooks and Clemants 2000), it is seemingly uncommon in the vicinity of

MDRS; this species was only encountered on one low dune directly northeast of the station.

Supplemental File: CAN 607487 (Suppl. material 52).

Family Malvaceae

Sphaeralcea coccinea (Nutt.) Rydb.

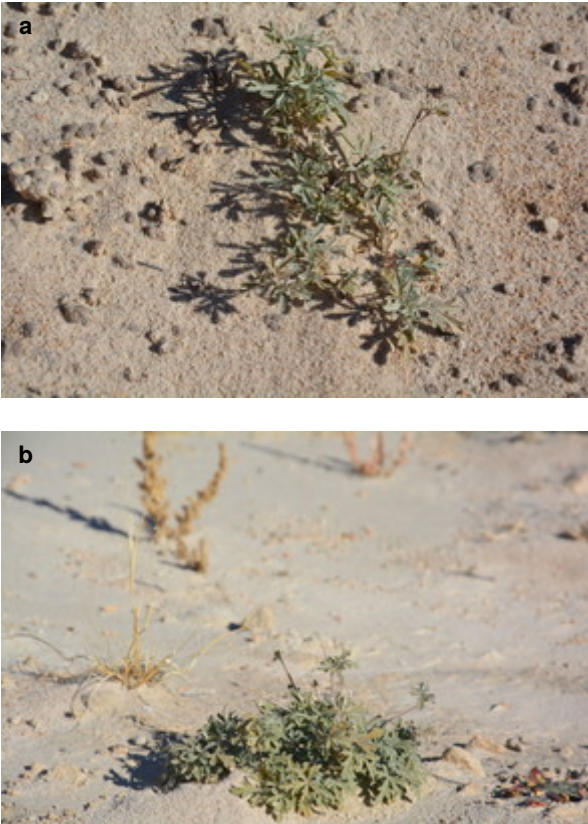


Figure 37.

Sphaeralcea coccinea (Sokoloff 260). Photos by P.C. Sokoloff.

a: Habit.

b: Habitat.

Material

- a. scientificName: *Sphaeralcea coccinea* (Nutt.) Rydb.; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Malvales; family: Malvaceae; taxonRank: Species; genus: *Sphaeralcea*; specificEpithet: *coccinea*; scientificNameAuthorship: (Nutt.) Rydb.; continent: North America; country: United States of America; countryCode: USA;

stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Vicinity of the Mars Desert Research Station, Hanksville, Utah, 500 m radius of "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38° 24'23.2"N; verbatimLongitude: 110°47'31.1"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 17, 2014; habitat: Sandy washes and outcrops surrounding MDRS; preparations: Silica gel collection; recordNumber: 260; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607480; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: Common in *Atriplex-Ephedra* communities (Welsh et al. 1993), this species was found growing in the disturbed sandy areas immediately surrounding MDRS (Fig. 37). This species was previously recorded in the nearby San Rafael Swell (Harris 1983).

Supplemental File: CAN 607480 (Suppl. material 53).

Sphaeralcea parviflora A. Nelson

Material

- a. scientificName: *Sphaeralcea parviflora* A. Nelson; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Malvales; family: Malvaceae; taxonRank: Species; genus: *Sphaeralcea*; specificEpithet: *parviflora*; scientificNameAuthorship: A. Nelson; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Approx. 200 m past fork on Cow Dung Road, down eastern fork, 1.9 km northeast of Mars Desert Research Station; verbatimElevation: 1381 m; verbatimLatitude: 38°25'3.2"N; verbatimLongitude: 110°46'29.7"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 23, 2014; habitat: *Artemisia*-dominated desert scrub; preparations: Silica gel collection; recordNumber: 294; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607482; collectionCode: CAN; basisOfRecord: Preserved Specimen

Notes: This species was previously reported for the nearby San Rafael Swell (Harris 1983), and is common in desert shrub communities (Welsh et al. 1993).

Supplemental File: CAN 607482 (Suppl. material 54).

Family Onagraceae

Oenothera cespitosa var. *navajoensis* (W.L. Wagner, Stockh. & W.M. Klein)

Cronquist

Materials

- a. scientificName: *Oenothera cespitosa* Nutt. var. *navajoensis* (W.L. Wagner, Stockh. & W.M. Klein) Cronquist; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Myrtales; family: Onagraceae; taxonRank: Variety; genus: *Oenothera*; specificEpithet:

cespitosa; infraspecificEpithet: *navajoensis*; scientificNameAuthorship: (W.L. Wagner, Stockh. & W.M. Klein) Cronquist; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Vicinity of the Mars Desert Research Station, Hanksville, Utah, 500 m radius of "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°24'23.2"N; verbatimLongitude: 110°47'31.1"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 17, 2014; habitat: Sandy washes and outcrops surrounding MDRS; preparations: Silica gel collection; recordNumber: 258; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607493; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

- b. scientificName: *Oenothera cespitosa* Nutt. var. *navajoensis* (W.L. Wagner, Stockh. & W.M. Klein) Cronquist; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Myrtales; family: Onagraceae; taxonRank: Variety; genus: *Oenothera*; specificEpithet: *cespitosa*; infraspecificEpithet: *navajoensis*; scientificNameAuthorship: (W.L. Wagner, Stockh. & W.M. Klein) Cronquist; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm check" hill, 1.7 km northeast of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'3.15"N; verbatimLongitude: 110°46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Desert plains; preparations: Silica gel collection; recordNumber: 283; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607499; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen



Figure 38.

Oenothera cespitosa var. *navajoensis*. Habit. Vicinity of Mars Desert Research Station, Utah, September 20, 2015. Photo by P.C. Sokoloff.

Notes: Common on disturbed sands and desert shrub communities in the vicinity of MDRS (Fig. 38), this species was previously recorded in the nearby San Rafael Swell as *Oenothera caespitosa* Nutt. (Harris 1983). Here we follow Welsh et al. (1993) and

treat these specimens as var. *navajoensis*, based on the characteristic fringe of trichomes on the leaf margin.

Supplemental Files: CAN 607493 (Suppl. material 55), CAN 607499 (Suppl. material 56).

Family Poaceae

Achnatherum hymenoides (Roem. & Schult.) Barkworth



Figure 39.

Achnatherum hymenoides. Vicinity of Mars Desert Research Station, Utah, September 20, 2015. Photos by P.C. Sokoloff.

- a:** Habit.
b: Inflorescence.
c: Habitat.

Material

- a. scientificName: *Achnatherum hymenoides* (Roem. & Schult.) Barkworth; kingdom: Plantae; phylum: Angiosperms; class: Monocots; order: Poales; family: Poaceae; taxonRank: Species; genus: *Achnatherum*; specificEpithet: *hymenoides*; scientificNameAuthorship: (Roem. & Schult.) Barkworth; continent: North America;

country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm check" hill, 1.7 km northeast of Mars Desert Research Station, just west of Cow Dung Road.; verbatimElevation: 1381 m; verbatimLatitude: 38° 25'3.15"N; verbatimLongitude: 110°46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Desert plains; recordNumber: 277; recordedBy: Sokoloff, Paul C.; identifiedBy: Saarela, Jeffery M.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607491; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: Recorded from the nearby San Rafael Swell as *Oryzopsis hymenoides* (Roem. & Schult.) Ricker ex Piper (Harris 1983), and treated as *Stipa hymenoides* Roem. & Schult in Welsh et al. (1993) here we follow Barkworth (2007) who recognize the taxon in *Achnatherum*. Common across our study area, we encountered this species throughout the deserts surrounding MDRS (Fig. 39).

Supplemental File: CAN 607491 (Suppl. material 57).

***Aristida purpurea* var. *longiseta* (Steud.) Vasey**

Material

- a. scientificName: *Aristida purpurea* var. *longiseta* (Steud.) Vasey; kingdom: Plantae; phylum: Angiosperms; class: Monocots; order: Poales; family: Poaceae; taxonRank: Variety; genus: *Aristida*; specificEpithet: *purpurea*; infraspecificEpithet: *longiseta*; scientificNameAuthorship: (Steud.) Vasey; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Sandstone plateau immediately southwest of Mars Desert Research Station, alongside ATV trail; verbatimElevation: 1412 m; verbatimLatitude: 38°24'22.4"N; verbatimLongitude: 110°47'40.3"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 24, 2014; habitat: Dry conglomerate sandstone; recordNumber: 310; recordedBy: Sokoloff, Paul C.; identifiedBy: Saarela, Jeffery M.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607496; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: This species was previously reported for the nearby San Rafael Swell (Harris 1983). While Welsh et al. (1993) did not recognize subspecies of this taxon in Utah, following Allred (2003) our specimen is identifiable as var. *longiseta*.

Supplemental File: CAN 607496 (Suppl. material 58).

***Bouteloua barbata* var. *barbata* Lag.**

Material

- a. scientificName: *Bouteloua barbata* Lag. var. *barbata*; kingdom: Plantae; phylum: Angiosperms; class: Monocots; order: Poales; family: Poaceae; taxonRank: Variety; genus: *Bouteloua*; specificEpithet: *barbata*; infraspecificEpithet: *barbata*; scientificNameAuthorship: Lag.; continent: North America; country: United States of

America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Roadside along ATV trail 2 km northeast of Mars Desert Research Station; verbatimElevation: 1348 m; verbatimLatitude: 38°24'53.8"N; verbatimLongitude: 110°46'18"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 23, 2014; habitat: Dry sandy streambed, grass-dominated community; recordNumber: 300; recordedBy: Sokoloff, Paul C.; identifiedBy: Saarela, Jeffery M.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607492; collectionCode: CAN; basisOfRecord: Preserved Specimen

Notes: Though not previously reported in a survey of the nearby San Rafael Swell flora (Harris 1983), this species was recorded for nearby Capitol Reef National Park (Fertig 2009). This species was collected once in an old, dried wash northeast of MDRS, and photographed in the vicinity of the Burpee Dinosaur quarry at the northern end of Cow Dung Road (Fig. 40). Varieties in *B. barbata* are recognized by both Wipff (2005) and Welsh et al. 1993. The latter treatment asserts that all Utah plants to belong to var. *barbata*.



Figure 40.

Bouteloua barbata var. *barbata*. Habit. Vicinity of Mars Desert Research Station, Utah, September 19, 2015. Photo by P.C. Sokoloff.

Supplemental File: CAN 607492 (Suppl. material 59).

***Bromus tectorum* L.**

Material

- a. scientificName: *Bromus tectorum* L.; kingdom: Plantae; phylum: Angiosperms; class: Monocots; order: Poales; family: Poaceae; taxonRank: Species; genus: *Bromus*; specificEpithet: *tectorum*; scientificNameAuthorship: L.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality:

Roadside along ATV trail 2 km northeast of Mars Desert Research Station; verbatimElevation: 1348 m; verbatimLatitude: 38°24'53.8"N; verbatimLongitude: 110°46'18"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 23, 2014; habitat: Dry sandy streambed, grass-dominated community; recordNumber: 297; recordedBy: Sokoloff, Paul C.; identifiedBy: Saarela, Jeffery M.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607495; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: A noxious weed common throughout the southwestern United States (Pavlick and Anderton 2007), this species was previously reported for the nearby San Rafael Swell (Harris 1983), and was common in the immediate vicinity of MDRS.

Supplemental File: CAN 607495 (Suppl. material 60).

Dasyochloa pulchella (Kunth) Willd. ex Rydb.

Material

- a. scientificName: *Dasyochloa pulchella* (Kunth) Willd. ex Rydb.; kingdom: Plantae; phylum: Angiosperms; class: Monocots; order: Poales; family: Poaceae; taxonRank: Species; genus: *Dasyochloa*; specificEpithet: *pulchella*; scientificNameAuthorship: (Kunth) Willd. ex Rydb.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Sandstone plateau immediately southwest of Mars Desert Research Station, alongside ATV trail; verbatimElevation: 1412 m; verbatimLatitude: 38°24'22.4"N; verbatimLongitude: 110°47'40.3"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 24, 2014; habitat: Dry conglomerate sandstone; recordNumber: 309; recordedBy: Sokoloff, Paul C.; identifiedBy: Saarela, Jeffery M.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607497; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: This species was commonly encountered on the plateau immediately southwest of MDRS. Previously reported for the nearby San Rafael Swell as *Erioneuron pulchellum* (Kunth) Tateoka (Harris 1983), recent work has placed this species in the monotypic genus *Dasyochloa* (Caro 1981, Valdés-Reyna 2003).

Supplemental File: CAN 607497 (Suppl. material 61).

Hilaria jamesii (Torr.) Benth.

Material

- a. scientificName: *Hilaria jamesii* (Torr.) Benth.; kingdom: Plantae; phylum: Angiosperms; class: Monocots; order: Poales; family: Poaceae; taxonRank: Species; genus: *Hilaria*; specificEpithet: *jamesii*; scientificNameAuthorship: (Torr.) Benth.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Vicinity of the Mars Desert Research Station, Hanksville, Utah, 500 m radius of "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°24'23.2"N; verbatimLongitude: 110°47'31.1"W; coordinateUncertaintyInMeters: 50;

verbatimEventDate: November 17, 2014; habitat: Sandy washes and outcrops surrounding MDRS; recordNumber: 255; recordedBy: Sokoloff, Paul C.; identifiedBy: Saarela, Jeffery M.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607498; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: This desert grass is endemic to the southwestern United States (Barkworth 2005), and was common in the vicinity of MDRS (Fig. 41). This species was previously reported for the nearby San Rafael Swell (Harris 1983).

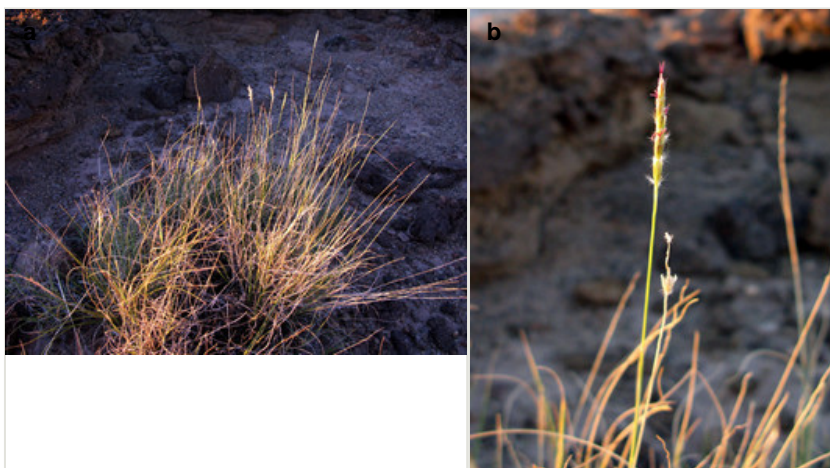


Figure 41.

Hilaria jamesii. Vicinity of Mars Desert Research Station, Utah, September 20, 2015. Photos by P.C. Sokoloff.

a: Habit.

b: Inflorescence.

Supplemental File: CAN 607498 (Suppl. material 62).

***Sporobolus airoides* (Torr.) Torr.**

Material

- a. scientificName: *Sporobolus airoides* (Torr.) Torr.; kingdom: Plantae; phylum: Angiosperms; class: Monocots; order: Poales; family: Poaceae; taxonRank: Species; genus: *Sporobolus*; specificEpithet: *airoides*; scientificNameAuthorship: (Torr.) Torr.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Roadside along ATV trail 2 km northeast of Mars Desert Research Station; verbatimElevation: 1348 m; verbatimLatitude: 38°24'53.8"N; verbatimLongitude: 110°46'18"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 23, 2014; habitat: Dry sandy streambed, grass-dominated community; recordNumber: 298; recordedBy: Sokoloff, Paul C.; identifiedBy: Saarela, Jeffery M.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607494; collectionCode: CAN; basisOfRecord: Preserved Specimen

Notes: This species was previously reported for the San Rafael Swell (Harris 1983), and was encountered on sandy soils north of MDRS (Fig. 42). Welsh et al. (1993) recognize two varieties in *S. airoides*, however Peterson et al. (2003) do not. We follow the latter treatment here.



Figure 42.

Sporobolus airoides. Habit. Vicinity of Mars Desert Research Station, Utah, September 20, 2015. Photo by P.C. Sokoloff.

Supplemental File: CAN 607494 (Suppl. material 63).

Sporobolus contractus Hitchc.

Materials

- a. scientificName: *Sporobolus contractus* Hitchc.; kingdom: Plantae; phylum: Angiosperms; class: Monocots; order: Poales; family: Poaceae; taxonRank: Species; genus: *Sporobolus*; specificEpithet: *contractus*; scientificNameAuthorship: Hitchc.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Dry streambed approx 500 m northeast of Mars Desert Research Station "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°24'27.7"N; verbatimCoordinateSystem: 110°47'20"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 20, 2014; habitat: Rocky sandstone desert; recordNumber: 264; recordedBy: Sokoloff, Paul C.; identifiedBy: Saarela, Jeffery M.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607501; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen
- b. scientificName: *Sporobolus contractus* Hitchc.; kingdom: Plantae; phylum: Angiosperms; class: Monocots; order: Poales; family: Poaceae; taxonRank: Species; genus: *Sporobolus*; specificEpithet: *contractus*; scientificNameAuthorship: Hitchc.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: "Comm check" hill, 1.7 km northeast of Mars Desert Research Station,

just west of Cow Dung Road; verbatimElevation: 1381 m; verbatimLatitude: 38°25'3.15"N; verbatimLongitude: 110°46'54.59"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Conglomerate sandstone hilltop dominated by *Artemisia* and *Ephedra*; recordNumber: 278; recordedBy: Sokoloff, Paul C.; identifiedBy: Saarela, Jeffery M.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607500; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: Common in the desert shrub communities near MDRS (Fig. 43), and typical of sandy soils and salt deserts (Peterson et al. 2003), this species was previously reported for the nearby San Rafael Swell (Harris 1983).

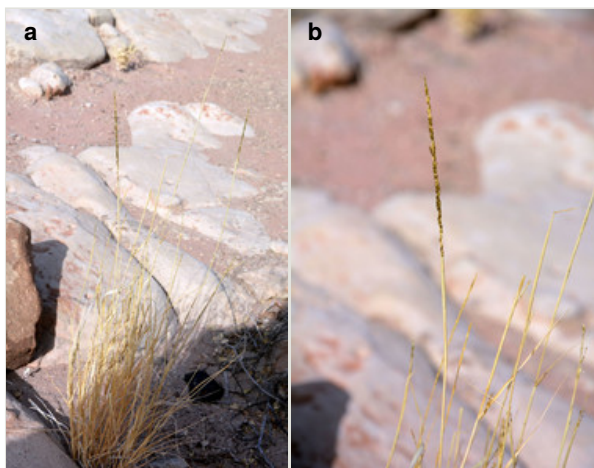


Figure 43.

Sporobolus contractus (Sokoloff 264). Photos by P.C. Sokoloff.

a: Habit.

b: Inflorescence.

Supplemental Files: CAN 607501 (Suppl. material 64), CAN 607500 (Suppl. material 65).

Family Polygonaceae

Eriogonum inflatum Torr. & Frém.

Materials

- a. scientificName: *Eriogonum inflatum* Torr. & Frém.; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Caryophyllales; family: Polygonaceae; taxonRank: Species; genus: *Eriogonum*; specificEpithet: *inflatum*; scientificNameAuthorship: Torr. & Frém.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Dry streambed approx 500 m northeast of Mars Desert Research Station "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38°

24°27.7"N; verbatimLongitude: 110°47'20"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 20, 2014; habitat: Eroded elbows of dry streambeds; recordNumber: 262; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607465; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

- b. scientificName: *Eriogonum inflatum* Torr. & Frém.; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Caryophyllales; family: Polygonaceae; taxonRank: Species; genus: *Eriogonum*; specificEpithet: *inflatum*; scientificNameAuthorship: Torr. & Frém.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Dry streambed approx 500 m northeast of Mars Desert Research Station "hab"; verbatimElevation: 1371 m; verbatimLatitude: 38° 24'27.7"N; verbatimLongitude: 110°47'20"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 20, 2014; habitat: Silty dry streambed; recordNumber: 268; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607486; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: This species is known from the nearby San Rafael Swell as two varieties: *Eriogonum inflatum* var. *inflatum* and *Eriogonum inflatum* var. *fusiforme* (Small) Reveal (Harris 1983). These two varieties have been differentiated by substrate (fine textured shales on the Colorado Plateau in var. *fusiforme*, vs. coarse sandstone in var. *inflatum*), root and caudex size, and annual vs. perennial life history (Harris 1983). Reveal (2005), who we follow here, ascribe var. *fusiforme* to an "annual phase", and do not recognize these varieties. *Eriogonum inflatum* was common in the deserts surrounding MDRS (Fig. 44).



Figure 44.

Eriogonum inflatum (Sokoloff 262). Habit. Photo by P.C. Sokoloff.

Supplemental Files: CAN 607465 (Suppl. material 66), CAN 607486 (Suppl. material 67).

Eriogonum shockleyi S. Watson

Material

- a. scientificName: *Eriogonum shockleyi* S. Watson; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Caryophyllales; family: Polygonaceae; taxonRank: Species; genus: *Eriogonum*; specificEpithet: *shockleyi*; scientificNameAuthorship: S. Watson; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Sandstone plateau immediately southwest of Mars Desert Research Station, alongside ATV trail; verbatimElevation: 1412 m; verbatimLatitude: 38°24'22.4"N; verbatimLongitude: 110°47'40.3"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 24, 2014; habitat: Dry conglomerate sandstone; preparations: Silica gel collection; recordNumber: 315; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607502; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: This prostrate plant was encountered on the plateau immediately southwest of MDRS (Fig. 45). This species was previously recorded for the nearby San Rafael Swell as *Eriogonum shockleyi* var. *longilobum* (M.E. Jones) S. Stokes (Harris 1983), though varieties are not recognized in later treatments (Welsh et al. 1993, Reveal 2005).



Figure 45.

Eriogonum shockleyi (Sokoloff 315). Habit. Photo by P.C. Sokoloff.

Supplemental File: CAN 607502 (Suppl. material 68).

Family Sarcobataceae

Sarcobatus vermiculatus (Hook.) Torr.

Material

- a. scientificName: *Sarcobatus vermiculatus* (Hook.) Torr. ; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Caryophyllales; family: Sarcobataceae; taxonRank: Species; genus: *Sarcobatus*; specificEpithet: *vermiculatus*; scientificNameAuthorship: (Hook.) Torr.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Seasonally wet stream crossing on Cow Dung Road, 1.6 km northeast of Mars Desert Research Station; verbatimElevation: 1371 m; verbatimLatitude: 38°25'55.39"N; verbatimLongitude: 110°47'30.2"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Desert slopes; preparations: Silica gel collection; recordNumber: 274; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607490; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: A common species on alkaline habitats (Hils et al. 1993), *Sarcobatus vermiculatus* was found in greatest abundance along the banks of a seasonally wet stream crossing due northeast of MDRS (Fig. 46). Previously placed within the Chenopodiaceae, *Sarcobatus* is now recognized as the sole genus within the Sarcobataceae (Behnke 1997; APG III 2009). This species was previously recorded for the nearby San Rafael Swell (Harris 1983).



Figure 46.

Sarcobatus vermiculatus (Sokoloff 274). Habit. Photo by P.C. Sokoloff

Supplemental File: CAN 607490 (Suppl. material 69).

Family Tamaricaceae

Tamarix ramosissima Ledeb.

Material

- a. scientificName: *Tamarix ramosissima* Ledeb.; kingdom: Plantae; phylum: Angiosperms; class: Eudicots; order: Caryophyllales; family: Tamaricaceae; taxonRank: Species; genus: *Tamarix*; specificEpithet: *ramosissima*; scientificNameAuthorship: Ledeb.; continent: North America; country: United States of America; countryCode: USA; stateProvince: Utah; county: Wayne County; municipality: Hanksville; locality: Mars Desert Research Station; verbatimLocality: Kent's Reservoir, 1.14 km north of Mars Desert Research Station, just west of Cow Dung Road; verbatimElevation: 1371 m; verbatimLatitude: 38°25'28.4"N; verbatimLongitude: 110°47'17.29"W; coordinateUncertaintyInMeters: 50; verbatimEventDate: November 22, 2014; habitat: Moist desert flats; preparations: Silica gel collection; recordNumber: 285; recordedBy: Sokoloff, Paul C.; identifiedBy: Sokoloff, Paul C.; dateIdentified: 2015; institutionID: CMN; collectionID: CAN 607466; collectionCode: CAN, UTC; basisOfRecord: Preserved Specimen

Notes: *Tamarix chinensis* and *Tamarix ramosissima* are both highly invasive within the western U.S.A. (Gaskin and Kazmer 2009). *Tamarix ramosissima* is often treated as a synonym of *T. chinensis* (Welsh et al. 1993), however genetic evidence supports their treatment as distinct species, albeit with extensive introgression and hybridization across its introduced range in the United States (Gaskin and Kazmer 2009). Plants sampled previously from southeastern Utah have been identified as either back-crossed *T. ramosissima* or F₂ hybrids (Gaskin and Kazmer 2009); it seems extremely likely that our material would possess a similar genotype.



Figure 47.

Tamarix ramosissima (Sokoloff 285). Habit and habitat. The large shrub to the centre-right of the photo is *Tamarix ramosissima*, the yellow shrubs to the left are *Ericamerica nauseosa*. Photo by P.C. Sokoloff.

This species has previously been reported for the nearby San Rafael Swell (Harris 1983). Only one population was encountered in the vicinity of MDRS, consisting of three shrubby trees and multiple seedlings, around Kent's Reservoir - a pond on the west side of Cow Dung Road north of MDRS (Fig. 47).

Supplemental File: CAN 607466 (Suppl. material 70).

Analysis

Based on our 2014 and 2015 collections, we recorded 38 vascular plant species from 14 families, 13 lichen species from seven families, five chlorophytes, one cyanobacterium, and one fungus from the MDRS study area (Table 1).

Table 1.

Summary of terrestrial algae (chlorophyta), cyanobacteria, fungi, lichens, and vascular plant species collected at the Mars Desert research Station (MDRS) for the current study. For the vascular plant taxa, presence at one of three nearby, well collected sites (the San Rafael Swell, Capitol Reef National Park, and Glen Canyon Recreational Area) is noted with an x. x¹: expected to occur within Glen Canyon Recreational Area, but no voucher was located during the study.

Higher taxon	Family	Species recorded for the Mars Desert Research Station (MDRS) study area	Present in the San Rafael Swell (Harris 1983)	Present at Capitol Reef National Park (Fertig 2009)	Present at Glen Canyon Recreational Area (Hill et al. 2009)
Chlorophyta	Trebouxiaceae	<i>Trebouxia</i> sp. 1	-	-	-
		<i>Trebouxia</i> sp. 2	-	-	-
		<i>Trebouxia</i> sp. 3	-	-	-
		<i>Trebouxia</i> sp. 4	-	-	-
		<i>Myrmecia</i> sp.	-	-	-
Cyanobacteria	Microcystaceae	<i>Gloeocapsa</i> sp.	-	-	-
Fungi	Agaricaceae	<i>Tulostoma</i> sp.	-	-	-
Lichen	Acarosporaceae	<i>Acarospora peliscypha</i> Th. Fr.	-	-	-
		<i>Acarospora rosulata</i> (Th. Fr.) H. Magn.	-	-	-
		<i>Acarospora stapfiana</i> (Müll. Arg.) Hue	-	-	-
		<i>Acarospora strigata</i> (Nyl.) Jatta	-	-	-
		<i>Polysporina gyrocarpa</i> (H. Magn.) N. S. Golubk.	-	-	-

	Candelariaceae	<i>Candelariella rosulans</i> (Müll. Arg.) Zahlbr.	-	-	-
	Collembataceae	<i>Enchylium tenax</i> (Sw.) Gray	-	-	-
	Lecanoraceae	<i>Lecanora garovaglii</i> (Körber) Zahlbr.	-	-	-
	Physicaceae	<i>Buellia abstracta</i> (Nyl.) H. Olivier	-	-	-
	Teloschistaceae	<i>Caloplaca trachyphylla</i> (Tuck.) Zahlbr.	-	-	-
	Verrucariaceae	<i>Heteropladidium</i> <i>compactum</i> (A. Massal.) Gueidan & Cl. Roux	-	-	-
		<i>Placidium</i> <i>acarosporoides</i> (Zahlbr.) Breuss	-	-	-
		<i>Placidium lachneum</i> (Ach.) Breuss	-	-	-
Vascular Plant	Amaranthaceae	<i>Atriplex confertifolia</i> (Torr. & Frém.) S. Watson	x	x	x
		<i>Atriplex corrugata</i> S. Watson	x	x	x
		<i>Atriplex gardneri</i> (Moq.) D. Dietr. var. <i>cuneata</i> (A. Nelson) S.L. Welsh	x	x	x
		<i>Halogeton glomeratus</i> (M. Bieb.) C.A. Mey.	x	x	x
		<i>Kali tragus</i> (L.) Scop.	x	x	x
	Asteraceae	<i>Artemisia filifolia</i> Torr.	x	x	x
		<i>Chaenactis douglasii</i> (Hook.) Hook. & Arn. var. <i>douglasii</i>		x	
		<i>Dieteria canescens</i> (Pursh) Nutt. var. <i>canescens</i>	x	x	x
		<i>Ericameria nauseosa</i> (Pall. ex Pursh) G.L. Nesom & G.I. Baird	x	x	x
		<i>Gaillardia spathulata</i> A. Gray	x	x	x ¹
		<i>Gutierrezia sarothrae</i> (Pursh) Britton & Rusby	x	x	x
		<i>Hymenoxys cooperi</i> (A. Gray) Cockerell	x		x

	<i>Scabrethia scabra</i> (Hook.) W.A. Weber	x	x	x
	<i>Thelesperma subnudum</i> A. Gray	x	x	x
Boraginaceae	<i>Cryptantha humilis</i> (Greene) Payson	x	x	x
Brassicaceae	<i>Lepidium montanum</i> Nutt.	x	x	x
Cactaceae	<i>Opuntia basilaris</i> Engelm. & J.M. Bigelow var. <i>basilaris</i>	x	x	x
	<i>Opuntia polyacantha</i> Haw. var. <i>polyacantha</i>	x	x	x
Ephedraceae	<i>Ephedra viridis</i> Colville	x	x	x
Euphorbiaceae	<i>Euphorbia fendleri</i> Torr. & A. Gray	x	x	x
Fabaceae	<i>Astragalus amphioxys</i> A. Gray	x	x	x
	<i>Astragalus desperatus</i> M.E. Jones	x	x	x
	<i>Astragalus lentiginosus</i> Douglas	x	x	x
Juncaceae	<i>Juncus bufonius</i> L.		x	x
Malvaceae	<i>Sphaeralcea coccinea</i> (Nutt.) Rydb.	x	x	x
	<i>Sphaeralcea parviflora</i> A. Nelson	x	x	x
Onagraceae	<i>Oenothera cespitosa</i> Nutt. var. <i>navajoensis</i> (W.L. Wagner, Stockh. & W.M. Klein) Cronquist	x	x	x
Poaceae	<i>Achnatherum</i> <i>hymenoides</i> (Roem. & Schult.) Barkworth	x	x	x
	<i>Aristida purpurea</i> var. <i>longiseta</i> (Steud.) Vasey	x	x	x
	<i>Bouteloua barbata</i> Lag. var. <i>barbata</i>		x	x
	<i>Bromus tectorum</i> L.	x	x	x
	<i>Dasyochloa pulchella</i> (Kunth) Willd. ex Rydb.	x	x	x
	<i>Hilaria jamesii</i> (Torr.) Benth.	x	x	x
	<i>Sporobolus airoides</i> (Torr.) Torr.	x	x	x

		<i>Sporobolus contractus</i> Hitchc.	x	x	x
	Polygonaceae	<i>Eriogonum inflatum</i> Torr. & Frém.	x	x	x
		<i>Eriogonum shockleyi</i> S. Watson	x	x	x
	Sarcobataceae	<i>Sarcobatus vermiculatus</i> (Hook.) Torr.	x	x	x ¹
	Tamaricaceae	<i>Tamarix ramosissima</i> Ledeb.	x	x	x

Discussion

Vascular Plants

The most species-rich vascular plant families reported from MDRS included the Asteraceae (nine species), and the Poaceae (eight species). These two plant families were also the largest reported for nearby Capitol Reef National Park (Heil et al. 1993). The most species-rich genera in the study area were *Atriplex* and *Astragalus*, both of which are extremely diverse throughout the southwestern states (Stutz 1978, Welsh et al. 1993). We recorded three species in each of these two genera at the site.

In our survey of the vascular plants of MDRS we recorded four species not previously reported for the nearby San Rafael Swell (the best-studied local flora currently available): *Chaenactis douglasii* var. *douglasii*, *Hymenoxys cooperi*, *Juncus bufonius*, and *Bouteloua barbata* var. *barbata*. These records fill out the known distribution of these plant species in southeastern Utah east of Capitol Reef National Park (for *Chaenactis douglasii* var. *douglasii*, *Juncus bufonius*, and *Bouteloua barbata* var. *barbata*) (Fertig 2009), and north from Glen Canyon Recreation Area (for *Hymenoxys cooperi*) (Hill and Ayers 2009), and contribute to the growing body of knowledge on vascular plant distribution in this region.

Crews at MDRS often must balance multiple research, habitat maintenance, and outreach activities while in simulation. Time spent on EVA is therefore tightly controlled to accomplish these diverse goals, to simulate realistic work pacing, and because radiation exposure will likely limit EVA time on an actual mission to Mars. Therefore, many studies at MDRS take place within close proximity to the hab, and the species present at the hab are likely of primary interest to most investigators. Within the desert flats in the immediate area of the MDRS hab we recorded ten vascular plant species: *Atriplex gardneri* var. *cuneata*, *Halogeton glomeratus*, *Gutierrezia sarothrae*, *Juncus bufonius*, *Lepidium montanum*, *Sphaeralcea coccinea*, *Eriogonum inflatum*, *Juncus bufonius*, *Sporobolus contractus*, and *Oenothera cespitosa* var. *navajoensis*.

On the plateau immediately southwest and on sandstone outcrops immediately north of MDRS, we recorded eight vascular plant species: *Aristida purpurea* var. *longiseta*, *Atriplex confertifolia*, *Cryptantha humilis*, *Dasyochloa pulchella*, *Eriogonum shockleyi*, *Gaillardia*

spathulata, *Gutierrezia sarothrae*, and *Hymenoxys cooperi*. We observed higher vascular plant diversity, and many examples of completely dead, unidentifiable (and therefore not collected) plant species on this plateau than on the desert flats surrounding the station. Therefore researchers at MDRS should take care when identifying vascular plant species from the plateau, as they may not be treated here.

Future floristic work at MDRS should focus on collecting in warmer seasons, when vascular plants are flowering, as this will undoubtedly yield new records for the station. This would also ensure that geophytes, if present, would be recorded. Geophytes are vascular plant species which die back each year and lay dormant underground (Dafni et al. 1981), and are therefore unlikely to be found during a fall/winter survey such as ours. Several geophyte species, notably the sego lily (*Calochortus nuttallii*) have been recorded from both the San Rafael Swell (Harris 1983), and Capitol Reef National Park (Fertig 2009), and thus may be present at MDRS.

Lichens

Overall, we collected 13 lichen species from nine genera. Given the lichen diversity documented from nearby sites (i.e. Rajvanshi et al. 1998, St. Clair et al. 1991), these 13 species likely represent a small sample of the true lichen diversity at MDRS. Further exploration will be required to generate a more comprehensive local checklist.

The following ten species were collected from the desert flats and outcrops within a 500-meter radius of the research station: *Acarospora rosulata*, *A. stapfiana*, *A. strigata*, *Buellia abstracta*, *Caloplaca trachyphylla*, *Candelariella rosulans*, *Enchylium tenax*, *Placidium acarosporoides*, *P. lachneum*, and *Polysporina gyrocarpa*. *Acarospora strigata* was also collected on the rim of the plateau about 400 meters southwest of, and about 34 meters in altitude above the station. Another three species, *Acarospora peliscypha*, *Heteropladidium compactum* and *Polysporina gyrocarpa*, were collected along Cow Dung Road between 1.5 and two kilometres north of the station. Ten species were growing on rock, while *Enchylium tenax* and *Placidium lachneum* were collected on sandy soil. Two species, *Acarospora stapfiana* and *Heteropladidium compactum*, were found growing independently on rock and parasitically on other lichens. We were unable to find previous published reports of *Acarospora peliscypha* for Utah, and the two specimens reported here may represent new records for the state.

The gypsiferous soils of southeastern Utah are well-known habitats for lichen soil crusts (St. Clair et al. 1991) and provide future opportunities to add to the flora of the research area and practice the techniques required to collect delicate species on fragile substrates. As well, lower sagebrush (*Artemisia*) branches on desert flats, and soil in protected, shaded microhabitats should also offer good possibilities of adding to the checklist list of species. Care should be taken to collect good-sized samples with fruiting bodies to aid in making determinations.

Algae and Cyanobacteria

The rarity of epilithic algae in the Utah desert is not surprising due to the high-to-extreme level of desiccation and light exposure (Rahmonov and Piatek 2007); however the relative abundance of endolithic (cryptoendolithic and chasmoendolithic) algae and photobiont algae was notable from three endolithic samples and two lichen samples. Environmental DNA (eDNA) markers have shown a wide diversity of life forms, from bacteria to eutrophs, in MDRS sub-terrestrial habitats (Direito et al. 2011). This abundance of diversity has also been observed genetically in extreme dry and cold environments (de la Torre et al. 2003, Pointing et al. 2009) and hot thermal environments (Walker et al. 2005). In the Utah desert, endolithic algae layers were close to the substrate surface (<4mm), allowing for adequate light penetration (Matthes et al. 2001). In addition, periods of long dormancy in endolithic microenvironments could further stabilize species-rich communities and niche diversity (Knoll and Grotzinger 2006).

In sandstone microhabitats, the majority of the cells did not show signs of desiccation or stress. *Trebouxia* sp. (Chlorophyceae) had well developed chloroplasts extending across most of the cell. The lobed or plate-like structures of the chloroplasts were often difficult to discern, but occasionally observed. Cultures of these algae from samples *Sokoloff 249* and *Sokoloff 290* also showed well developed chloroplasts that were also difficult to identify (Fig. 4). The central pyrenoid, lobed plate-like chloroplast and thickened cell wall distinguished these *Trebouxia* from other genera, such as *Neochloris* and *Myrmecia*; these latter two genera have similar valve morphologies and genetically similar 18S sequences. Therefore a definitive identification even to the genus is problematic (Komárek and Fott 1983, Friedl and Büdel 2008). Comparable taxa include *N. minuta* Arce & Bold, *N. alveolaris* Bold, *N. pseudoalveolaris* Deason & Bold, *M. astigmatica* Vinatzer, and *M. biatorellae* (Tschermak-Woess. & Plessl) Boye-Pet.

The number of *Trebouxia* taxa was difficult to discern in this study; four possible taxa were observed based on size, wall sheath thickness, general chloroplast structure and the number of pyrenoids. These taxa likely belong to the *Trebouxia anticipata/gelatinosa* ITS rDNA clade (Komárek and Fott 1983, Friedl and Büdel 2008). Lobe and parietal plate-like chloroplast, cell size, wall thickness, and number of pyrenoids are diagnostic for this clade. Zoospores were not observed for any of the chlorophytes.

Gloeocapsa sp. (Chroococcales, Microcystaceae) was prominent as a fine layer within the sandstone of *Sokoloff 290* (Fig. 5a, b, c). This cyanobacterium was also dominant as a sub-surface crust (along with a small, prostrate, thallus-forming epiphytic chlorophyte in the Chaetophorales) on the bottom of a quartzite rock found embedded in desert sand near MDRS (*Sokoloff 301*, Fig. 10). Quartzite rocks were infrequently encountered in the deserts surrounding MDRS, and the stone collected likely provided a protected habitat for the cyanobacterial crust while still allowing light transmittance through the translucent mineral of the quartz. Similar stones around MDRS may harbour similar microbial communities.

Gloeocapsa colonies form by cell division and binary fusion (Komárek and Anagnostidis 1999). In the two samples collected here (endolithic and epilithic), colonies were densely

packed often forming rectangular masses. The multilayered wall sheath characteristic for *Gloeocapsa* was evident in isolated cell clusters (Fig. 5. Cell morphology is very similar to genera within the family Xenococcaceae, but distinguished from them by the absence of multiple fission and baeocyte formation (Komárek and Anagnostidis 1999). Early 16S rDNA results show that *Gloeocapsa* is separated from *Myxosarcina* and *Xenococcus*, which is further separated from *Chroococcidiopsis* (Friedl and Büdel 2008). We did not observe baeocytes (motile or nonmotile), and this combined with the general rectangular-cube formation of the colonies, widely separated cells in the colonies, layers of surrounding sheath and single cells with thick sheaths, leads us to identify this taxon as *Gloeocapsa* sp. This differentiation and identification is subject to challenge with recent DNA studies suggesting that the other genera *Myxosarcina* and *Chroococcidiopsis* are somewhat related (Friedl and Büdel 2008). The DNA results further highlight potential problematic identifications in cultures used for the study, indicating the difficulty in determining differences between taxa in *Gloeocapsa*, *Chroococcidiopsis* and *Myxosarcina*. A number of studies have identified *Chroococcidiopsis* sp. (*sensu lato*) in addition to *Gloeocapsa* sp. as prominent endolithic or epilithic genera (Friedmann 1961, Friedmann 1971, Friedmann et al. 1967, Friedmann and Ocampo-Friedmann 1984, Dor and Danin 1996). In the present study, colony morphology, cell size and form would indicate that we have *Gloeocapsa* sp. Many taxa within *Gloeocapsa* are classified as sub-areal and epilithic. Comparable species include *Gloeocapsa coracina*, *G. decorticans* (A. Braun) Richter, *G. caldariorum* Raben., *G. atrata* Kütz. and *G. bituminosa* (Bory) Kütz..

Two lichen species had hyphae associated with endolithic *Trebouxia* algae layers in our samples (*Lecanora* cf. *garovaglii*, *Acarospora strigata*). Two other lichen taxa (*Placidium acarosporoides* and *Heteroplacidium compactum*) had *Myrmecia* sp. as the associated alga with endolithic algae layers and endolithic hyphae in proximity to the surface lichens. The subsurface penetration and sporadic association of fungal threads with the endolithic algae support the observation that biological interactions within the sandstone are part of the ongoing development of lichen taxa (de la Torre et al. 1991). In addition, *Heteroplacidium compactum* is partly parasitic on other crustose lichens, as well as growing independently on rock (Breuss 2007, Prieto et al. 2012).

The primary survival mechanism displayed by endolithic algae in hot conditions is to “hide” from the extreme environment. Like other plant groups, extreme heat causes cellular water loss, which at some point will cause the cell to die. Xeric algae typically have thick sheaths to minimize water loss and environmental abrasion. Many studies have shown the effective tolerance of plant, fungi, and algae cells to desiccation, and the ability to remain viable for long periods of drought in both extreme hot and cold conditions (e.g. Beckett et al. 2008 and references within). Most xeric plants, fungi, and algae have thick cuticles, or protective carbon based coverings for water retention as well as UV protection. The rate of water loss is also critical, if cells are not able to adapt to the environment and their cellular structure (e.g. leaky membranes) cannot control the water loss. In addition to water loss heat can denature functional proteins, while light and heat can induce the cellular production of reactive oxygen species (ROS). Beckett et al. (2008) define many of the ROS as free oxygen radicals. ROS are unstable and a threat to all cellular macromolecules (Fridovich

1999). At least eight ROS species (eg. superoxide O_2^- and hydrogen peroxide H_2O_2), are potentially harmful to cellular structure. For an excellent review of general ROS damaging processes to cells refer to Beckett et al. (2008). The endolithic algae observed here do not appear to be stressed and there is no visual evidence of membrane and micro-molecule damage. These algae have either created adapted processes to combat ROS stress or have selected a perfect microhabitat for survival and growth.

With new developments in taxonomy using DNA sequencing, it would not be surprising to find that endolithic algae communities are more diverse than currently reported. This notion is in contrast to the traditional idea that only a few endolithic algae groups and species are present in the environment (Friedmann et al. 1967). Gerrath et al. (2000) for example, observed 22 endolithic taxa from 180 rock samples along the Niagara escarpment (Ontario, Canada). Already, molecular studies have shown that more than one algae species can be present in one lichen host (Kroken and Taylor 2000), thus more endolithic taxa may be present at MDRS given the number and taxonomic diversity of crustose lichen taxa reported in this study. However, the difficulty in identifying xeric algae based on cell morphology is still problematic without additional culturing and future DNA work, as observed here and in other publications (Friedmann et al. 1967, Thüs et al. 2011). The biological complexity of algae development within the rock, between the rock and surface biota, and the facultative transfer of algae taxa between species illustrates the interwoven connectivity of life in this extreme environment.

Biological Sampling at MDRS

While we found it unnecessary to modify standard collection techniques for vascular plant and lichen species, we did note several improvements that would streamline biological sample collection while wearing a simulated spacesuit.

The thick gloves that simulate pressurized material made it difficult to write notes in a fieldbook and operate a handheld GPS receiver. We improvised better collecting workflows during the expedition by using a clipboard and paper datasheets instead of a fieldbook. We kept the GPS receiver on continuously, rather than attempting to operate the touchpad, which was not designed for heavy gloves.

While digital cameras were relatively easy to operate while wearing gloves, it was not possible to use the viewfinder on a DSLR camera while wearing a helmet; we used live view mode on the rear screen of the camera body to compose photographs. Future expeditions may benefit from technological data capture methods, like the voice operated "Mobile Agents" of Clancey et al. (2004), for example.

The presence of an on-site laboratory at MDRS greatly assisted in the processing of plant and lichen samples in a clean, controlled environment, and the availability of microscopes and electronic literature databases allowed us to accurately identify a subset of the vascular plant species during the simulation. The *in situ* facilities allowed us to share preliminary data with mission control, and to decide if follow-up collections at the same site would be required during our mission. This highlights the importance of the laboratory to

MDRS, and the utility of including a well-designed laboratory space on a future manned mission to Mars, where efficient execution of a field science program would be of paramount importance.

Conclusions

In the deserts surrounding MDRS and throughout the southwestern United States of America, the diversity and distribution of vascular plants, lichens, fungi, algae and cyanobacteria are dependent on various factors, including underlying geology (Schenk et al. 2003), the availability of water (Ehleringer et al. 1991) and nutrients (Schlesinger et al. 1996), and the presence of other biological organisms, including vascular plant (Schlesinger and Pilmanis 1998) and soil crust communities (Harper and Belnap 2001). The taxonomic groups treated in this study all possess various adaptations to life in this harsh desert environment, including (but not limited to) thick, moisture retaining cell walls (Holzinger and Karsten 2013) and an endolithic habit (Thielen and Garbary 1999) in algae and cyanobacteria, resistance to UV radiation and desiccation in lichens (de Vera et al. 2002), and C4 carbon fixation in vascular plants (Mulroy and Rundel 1977). These adaptations have allowed a diverse floristic community to thrive in various microhabitats throughout southeastern Utah, and continued exploration will undoubtedly yield many species not documented here.

Therefore, while our present checklist is not an exhaustive inventory of the MDRS site (greater sampling effort would be necessary to capture all local diversity), it can serve as a first-line reference for identifying vascular plants and lichens at MDRS, and serves as a starting point for future floristic and ecological work at the station. Other useful field references to the MDRS flora include the *Desert Plants of Utah* (Andersen 1996), and *A Field Guide to Biological Soil Crusts of the Western U.S. Drylands* (Rosentreter et al. 2007).

Acknowledgements

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Supplementary materials

Suppl. material 1: CANL 127960, *Acarospora peliscypha* (Sokoloff 286)

Authors: PC Sokoloff

Data type: image

Filename: CANL127960.JPG - [Download file](#) (2.23 MB)

Suppl. material 2: CANL 127968, *Acarospora rosulata* (Sokoloff 303)

Authors: PC Sokoloff

Data type: image

Filename: CANL127968.JPG - [Download file](#) (2.64 MB)

Suppl. material 3: CANL 127958, *Acarospora stapfiana* (Sokoloff 270)

Authors: PC Sokoloff

Data type: image

Filename: CANL127958.JPG - [Download file](#) (2.44 MB)

Suppl. material 4: CANL 127953, *Acarospora strigata* (Sokoloff 248)

Authors: PC Sokoloff

Data type: image

Filename: CANL127953.JPG - [Download file](#) (2.78 MB)

Suppl. material 5: CANL 127962, *Acarospora strigata* (Sokoloff 288)

Authors: PC Sokoloff

Data type: image

Filename: CANL127962.JPG - [Download file](#) (2.67 MB)

Suppl. material 6: CANL 127969, *Acarospora strigata* (Sokoloff 304)

Authors: PC Sokoloff

Data type: image

Filename: CANL127969.JPG - [Download file](#) (2.45 MB)

Suppl. material 7: CANL 127966, *Acarospora strigata* (Sokoloff 306)

Authors: PC Sokoloff

Data type: image

Filename: CANL127966.JPG - [Download file](#) (2.38 MB)

Suppl. material 8: CANL 127952, *Polysporina gyrocarpa* (Sokoloff 247)

Authors: PC Sokoloff

Data type: image

Filename: CANL127952.JPG - [Download file](#) (2.79 MB)

Suppl. material 9: CANL 127954, *Polysporina gyrocarpa* (Sokoloff 250)

Authors: PC Sokoloff

Data type: image

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Suppl. material 10: CANL 127963, *Polysporina gyrocarpa* (Sokoloff 289)

Authors: PC Sokoloff

Data type: image

Filename: CANL127963.JPG - [Download file](#) (2.36 MB)

Suppl. material 11: CANL 127970, *Polysporina gyrocarpa* (Sokoloff 286b)

Authors: PC Sokoloff

Data type: image

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Suppl. material 12: CANL 127955, *Candelariella cf. rosulans* (Sokoloff 251)

Authors: PC Sokoloff

Data type: image

Filename: CANL127955.JPG - [Download file](#) (2.67 MB)

Suppl. material 13: CANL 127971, *Candelariella rosulans* (Sokoloff 288b)

Authors: PC Sokoloff

Data type: image

Filename: CANL127971.JPG - [Download file](#) (2.40 MB)

Suppl. material 14: CANL 127973, *Enchylium tenax* (Sokoloff 305b)

Authors: PC Sokoloff

Data type: image

Filename: CANL127973.JPG - [Download file](#) (2.40 MB)

Suppl. material 15: CANL 127961, *Lecanora garovaglii* (Sokoloff 287)

Authors: PC Sokoloff

Data type: image

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Suppl. material 16: CANL 127959, *Buellia abstracta* (Sokoloff 271)

Authors: PC Sokoloff

Data type: image

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Suppl. material 17: CANL 127956, *Caloplaca trachyphylla* (Sokoloff 252)

Authors: PC Sokoloff

Data type: image

Filename: CANL127956.JPG - [Download file](#) (2.45 MB)

Suppl. material 18: CANL 127957, *Caloplaca trachyphylla* (Sokoloff 269)

Authors: PC Sokoloff

Data type: image

Filename: CANL127957.JPG - [Download file](#) (2.43 MB)

Suppl. material 19: CANL 127964, *Heteropladidium compactum* (Sokoloff 296)

Authors: PC Sokoloff

Data type: image

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Suppl. material 20: CANL 127965, *Placidium acarosporoides* (Sokoloff 305)

Authors: PC Sokoloff

Data type: image

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Suppl. material 21: CANL 127972, *Placidium lachneum* (Sokoloff 305c)

Authors: PC Sokoloff

Data type: image

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Suppl. material 22: CAN 607477, *Atriplex confertifolia* (Sokoloff 313)

Authors: PC Sokoloff

Data type: image

Filename: CAN607503_hr.jpg - [Download file](#) (8.65 MB)

Suppl. material 23: CAN 607503, *Atriplex corrugata* (Sokoloff 273)

Authors: PC Sokoloff

Data type: image

Filename: CAN607503_hr.jpg - [Download file](#) (9.20 MB)

Suppl. material 24: CAN 607507, *Atriplex gardneri* var. *cuneata* (Sokoloff 256)

Authors: PC Sokoloff

Data type: image

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Suppl. material 25: CAN 607505, *Atriplex gardneri* var. *cuneata* (Sokoloff 259)

Authors: PC Sokoloff

Data type: image

Filename: CAN607505_hr.jpg - [Download file](#) (8.06 MB)

Suppl. material 26: CAN 607506, *Atriplex gardneri* var. *cuneata* (Sokoloff 266)

Authors: PC Sokoloff

Data type: image

Filename: CAN607506_hr.jpg - [Download file](#) (9.05 MB)

Suppl. material 27: CAN 607484, *Halogeton glomeratus* (Sokoloff 254)

Authors: PC Sokoloff

Data type: image

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Suppl. material 28: CAN 607485, *Halogeton glomeratus* (Sokoloff 267)

Authors: PC Sokoloff

Data type: image

Filename: CAN607485_hr.jpg - [Download file](#) (7.63 MB)

Suppl. material 29: CAN 607478, *Artemisia filifolia* (Sokoloff 282)

Authors: PC Sokoloff

Data type: image

Filename: CAN607487_hr.jpg - [Download file](#) (9.46 MB)

Suppl. material 30: CAN 607472, *Chaenactis douglasii* var. *douglasii* (Sokoloff 291)

Authors: PC Sokoloff

Data type: image

Filename: CAN607472_hr.jpg - [Download file](#) (8.11 MB)

Suppl. material 31: CAN 607522, *Dieteria canescens* var. *canescens* (Sokoloff 366)

Authors: PC Sokoloff

Data type: image

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Suppl. material 32: CAN 607481, *Ericameria nauseosa* (Sokoloff 284)

Authors: PC Sokoloff

Data type: image

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Suppl. material 33: CAN 607524, *Gaillardia spathulata* (Sokoloff 367)

Authors: PC Sokoloff

Data type: image

Filename: CAN607524_hr.jpg - [Download file](#) (7.40 MB)

Suppl. material 34: CAN 607462, *Gutierrezia sarothrae* (Sokoloff 253)

Authors: PC Sokoloff

Data type: image

Filename: CAN607462_hr.jpg - [Download file](#) (9.42 MB)

Suppl. material 35: CAN 607469, *Gutierrezia sarothrae* (Sokoloff 257)

Authors: PC Sokoloff

Data type: image

Filename: CAN607469_hr.jpg - [Download file](#) (8.26 MB)

Suppl. material 36: CAN 607463, *Gutierrezia sarothrae* (Sokoloff 311)

Authors: PC Sokoloff

Data type: image

Filename: CAN607463_hr.jpg - [Download file](#) (8.14 MB)

Suppl. material 37: CAN 607483, *Hymenoxys cooperi* (Sokoloff 312)

Authors: PC Sokoloff

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Filename: CAN607483_hr.jpg - [Download file](#) (7.96 MB)

Suppl. material 38: CAN 607479, *Scabrethia scabra* (Sokoloff 280)

Authors: PC Sokoloff

Data type: image

Filename: CAN607479_hr.jpg - [Download file](#) (7.99 MB)

Suppl. material 39: CAN 607470, *Thelesperma subnudum* (Sokoloff 281)

Authors: PC Sokoloff

Data type: image

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Suppl. material 40: CAN 607504, *Cryptantha humilis* (Sokoloff 314)

Authors: PC Sokoloff

Data type: image

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Suppl. material 41: CAN 607467, *Lepidium montanum* (Sokoloff 261)

Authors: PC Sokoloff

Data type: image

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Suppl. material 42: CAN 607471, *Lepidium montanum* (Sokoloff 263)

Authors: PC Sokoloff

Data type: image

Filename: CAN607471_hr.jpg - [Download file](#) (7.49 MB)

Suppl. material 43: CAN 607488, *Opuntia basilaris* var. *basilaris* (Sokoloff 272)

Authors: PC Sokoloff

Data type: image

Filename: CAN607488_hr.jpg - [Download file](#) (8.31 MB)

Suppl. material 44: CAN 607489, *Opuntia polyacantha* var. *polyacantha* (Sokoloff 293)

Authors: PC Sokoloff

Data type: image

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Suppl. material 45: CAN 607468, *Ephedra viridis* (Sokoloff 275)

Authors: PC Sokoloff

Data type: image

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Suppl. material 46: CAN 607523, *Ephedra viridis* (Sokoloff 365)

Authors: PC Sokoloff

Data type: image

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Suppl. material 47: CAN 607464, *Euphorbia fendleri* (Sokoloff 279)

Authors: PC Sokoloff

Data type: image

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Suppl. material 48: CAN 607473, *Astragalus amphioxys* (Sokoloff 276)

Authors: PC Sokoloff

Data type: image

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Suppl. material 49: CAN 607474, *Astragalus amphioxys* (Sokoloff 292)

Authors: PC Sokoloff

Data type: image

Filename: CAN607474_hr.jpg - [Download file](#) (8.01 MB)

Suppl. material 50: CAN 607476, *Astragalus desperatus* (Sokoloff 295)

Authors: PC Sokoloff

Data type: image

Filename: CAN607476_hr.jpg - [Download file](#) (8.26 MB)

Suppl. material 51: CAN 607475, *Astragalus lentiginosus* (Sokoloff 299)

Authors: PC Sokoloff

Data type: image

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Suppl. material 52: CAN 607487, *Juncus bufonius* (Sokoloff 265)

Authors: PC Sokoloff

Data type: image

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Suppl. material 53: CAN 607480, *Sphaeralcea coccinea* (Sokoloff 260)

Authors: PC Sokoloff

Data type: image

Filename: CAN607480_hr.jpg - [Download file](#) (8.00 MB)

Suppl. material 54: CAN 607482, *Sphaeralcea parviflora* (Sokoloff 294)

Authors: PC Sokoloff

Data type: image

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Suppl. material 55: CAN 607493, *Oenothera cespitosa* var. *navajoensis* (Sokoloff 258)

Authors: PC Sokoloff

Data type: image

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Suppl. material 56: CAN 607499, *Oenothera cespitosa* var. *navajoensis* (Sokoloff 283)

Authors: PC Sokoloff

Data type: image

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Suppl. material 57: CAN 607491, *Achnatherum hymenoides* (Sokoloff 277)

Authors: PC Sokoloff

Data type: image

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Suppl. material 58: CAN 607496, *Aristida purpurea* var. *longiseta* (Sokoloff 310)

Authors: PC Sokoloff

Data type: image

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Suppl. material 59: CAN 607492, *Bouteloua barbata* var. *barbata* (Sokoloff 300)

Authors: PC Sokoloff

Data type: image

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Suppl. material 60: CAN 607495, *Bromus tectorum* (Sokoloff 297)

Authors: PC Sokoloff

Data type: image

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Suppl. material 61: CAN 607497, *Dasyochloa pulchella* (Sokoloff 309)

Authors: PC Sokoloff

Data type: image

Filename: CAN607497_hr.jpg - [Download file](#) (9.05 MB)

Suppl. material 62: CAN 607498, *Hilaria jamesii* (Sokoloff 255)

Authors: PC Sokoloff

Data type: image

Filename: CAN607498_hr.jpg - [Download file](#) (9.64 MB)

Suppl. material 63: CAN 607494, *Sporobolus airoides* (Sokoloff 298)

Authors: PC Sokoloff

Data type: image

Filename: CAN607494_hr.jpg - [Download file](#) (9.55 MB)

Suppl. material 64: CAN 607501, *Sporobolus contractus* (Sokoloff 264)

Authors: PC Sokoloff

Data type: image

Filename: CAN607500_hr.jpg - [Download file](#) (9.79 MB)

Suppl. material 65: CAN 607500, *Sporobolus contractus* (Sokoloff 278)

Authors: PC Sokoloff

Data type: image

Filename: CAN607500_hr.jpg - [Download file](#) (8.91 MB)

Suppl. material 66: CAN 607465, *Eriogonum inflatum* (Sokoloff 262)

Authors: PC Sokoloff

Data type: image

Filename: CAN607465_hr.jpg - [Download file](#) (8.88 MB)

Suppl. material 67: CAN 607486, *Eriogonum inflatum* (Sokoloff 268)

Authors: PC Sokoloff

Data type: image

Filename: CAN607486_hr.jpg - [Download file](#) (7.37 MB)

Suppl. material 68: CAN 607502, *Eriogonum shockleyi* (Sokoloff 315)

Authors: PC Sokoloff

Data type: image

Filename: CAN607502_hr.jpg - [Download file](#) (8.45 MB)

Suppl. material 69: CAN 607490, *Sarcobatus vermiculatus* (Sokoloff 274)

Authors: PC Sokoloff

Data type: image

Filename: CAN607490_hr.jpg - [Download file](#) (8.10 MB)

Suppl. material 70: CAN 607466, *Tamarix ramosissima* (Sokoloff 285)

Authors: PC Sokoloff

Data type: image

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