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LICHENS OF SOIL CRUST COMMUNITIES IN THE INTERMOUNTAIN AREA OF THE WESTERN UNITED STATES

Larry L. St. Clair¹,², Jeffrey R. Johansen³, and Samuel R. Rushforth¹

ABSTRACT.—Lichens are common components of microbiotic soil crusts. A total of 34 species from 17 genera are reported from soil crust communities throughout the Intermountain Area. Distribution of terricolous lichens is determined by various physical and biological factors: physical and chemical characteristics of the soil, moisture regimes, temperature, insolation, and development and composition of the vascular plant community. Some species demonstrate a broad ecological amplitude while others have a more restricted distribution. All growth forms are represented; however, the vast majority of soil crust lichens are squamulose (minutely foliose). Fruticose species are least abundant. In exposed, middle-elevation sites vagrant (detached) species are common. This paper describes and discusses terricolous lichen communities of desert habitats of the Intermountain Western United States. Effects of various human-related activities including grazing, wildfire, air pollution, and recreation vehicles on soil crust lichens are discussed. Gypsoplaca macrophylla (Zahlbr.) Timdal, a rare squamulose lichen which occurs on gypsiferous soils, was recently collected in Emery County, Utah, and is reported as new to the state.

Key words: lichens, cryptogamic crusts, microbiotic crusts.

Lichens are common components of soil crust communities. In some habitats lichens account for a significant percentage of the ground cover, often stabilizing the soil surface and enhancing soil fertility. Over the last 25 years extensive studies have been undertaken in arid and semi-arid western North America in an effort to better understand the ecological role of microbiotic soil crusts. Initial studies described various biological components (Anderson and Rushforth 1976, Johansen et al. 1981). Other studies considered various ecological aspects of soil crust communities (Anderson, Harper, and Holmgren 1982, Brotherson and Rushforth 1983, Kleiner and Harper 1977, St. Clair et al. 1984, Skujins and Klubek 1978). Human-induced damage to soil crust communities has also been studied (Johansen et al. 1984, Johansen and St. Clair 1986). Some research has investigated recovery and reclamation/restoration of damaged soil crust communities (Anderson, Harper, and Rushforth 1982, St. Clair et al. 1986).

Several lichen floras and checklists for the Intermountain Area have been published (Egan 1972, Nash and Johnsen 1975, Newberry 1991, St. Clair and Newberry 1991, Schroeder et al. 1975, Shushan and Anderson 1969). However, very few studies have dealt directly with soil lichens. Anderson and Rushforth (1976) published the only list of lichens from desert soils in the Intermountain West. They collected lichens from 34 sites in three distinct areas of southern Utah. Most of the sites (27) were located in the Great Basin. Five were in gypsiferous habitats in Washington County, while the remaining sites were located in pristine, open grassy areas in Canyonlands National Park. They reported a total of 17 species in 11 genera; however, 3 of the species were saxicolous and 6 of the remaining species were misidentified. Nash and Sigal (1981) published a checklist of the lichens of Zion National Park in connection with a preliminary air-quality survey for the park. They reported a total of 159 species in 53 genera from their collections. Nine of the species were terricolous lichens from middle-elevation desert habitats. Two recent monographic works (Thomson 1987, 1989, Timdal 1986) have added significant taxonomic and ecological information about two of the more abundant soil genera in western North America (Psora and Catapyrenium). St. Clair and

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Wanick (1981) reported Acarospora nodulosa (Duf.) Hue. v. nodulosa, a squamulose soil lichen collected from gypsiferous soils in southwestern Utah, as a new record for North America. Timdal (1990) described a new and rare squamulose lichen genus and family (Gypsoplaca of the Gypsoplacaceae) from gypsiferous soils in southwestern Colorado. Timdal included with his description a list of 21 soil crust species commonly associated with Gypsoplaca macrophylla. Many species on Timdal's list are commonly found on gypsiferous soils throughout the Colorado Plateau. Recently, Newberry (1991) characterized the lichen flora of the Uinta Mountains of northeastern Utah, listing a total of 291 taxa in 95 genera from his collections. As part of his study he made extensive collections of soil crust lichens along the northern border of the Colorado Plateau. Rosentreter and McCune (1992) described distribution patterns of vagrant species of the foliose genus Dermatocarpon in Idaho, Montana, Wyoming, and eastern Oregon and Washington.

The purpose of this paper is to characterize the lichen component of desert soil crust communities in intermountain western North America. This paper is based on a careful review of the literature as well as unpublished observations and collections made by the authors and others throughout the Intermountain Area over the last 14 years.

RESULTS AND DISCUSSION

Soil Crust Community Structure

Most soil crust lichens are either squamulose or foliose (79%). Squamulose (minutely foliose) species are particularly common. Of the 34 species currently known from soil crust communities in the Intermountain Area, 59% are squamulose, 21% foliose, 12% crustose, and 9% fruticose (Table 1). Of the 20 squamulose species, 9 are in the genus Psora.

All fruticose and most foliose species are vagrant (unattached), the only exceptions being Xanthoparmelia wyomingica, which is loosely adnate over rocky soils, and X. idahoensis, which is often loosely attached to the soil surface. All vagrant forms tend to become entangled either with vascular plants or with detritus, and during wet periods they may even become temporarily attached to the soil. Rogers (1977) suggested that many vagrant forms "are simply detached fragments of normally attached species." Careful evaluation of the vagrant lichens of the Intermountain Area shows that Rogers's conclusion is probably accurate for at least some species. For example, Rhizoplaca haydenii is commonly collected from habitats in which adjacent rocks are covered with the attached, umbilicate lichen R. melanophthalma. This situation has led some lichenologists to seriously question whether R. haydenii is simply a detached form of R. melanophthalma. Rosentreter and McCune (1992) have also reviewed the status of the vagrant lichen Dermatocarpon vagans. After carefully comparing D. vagans with D. reticulatum and D. miniatum, they concluded that the vagrant form is simply detached fragments of D. reticulatum and D. miniatum. Similar discussions have taken place concerning Agrestia hispida, with some lichenologists (Weber 1967) suggesting that A. hispida is simply an environmental modification of the attached crustose lichen Aspicilia calcarea. The only exception to this general pattern may be Xanthoparmelia chlorochroa, which at least in some habitats seems to be a true vagrant with no local attached members. However, in other habitats vagrant specimens of X. chlorochroa occur sympatrically with several species of Xanthoparmelia that grow over rocks and onto the soil. The issue is somewhat confusing; however, Rogers's conclusion is probably correct, at least in some cases.

Squamulose and crustose lichens dominate open Great Basin sites with vagrant forms conspicuously absent. The three most common lichen species from the Great Basin are Collema tenax, Catapyrenium lachneum, and Caloplaca tominii (Table 1). Development and distribution of soil crust communities in the Great Basin seem to be correlated with the occurrence of vascular plants. Intershrub spaces are dominated by cyanobacterial and lichen crusts while the area immediately beneath shrubs is dominated by various moss and vascular species. A combination of several factors, including moisture, insolation, and perhaps even allelopathic activity (Schlatterer and Tisdale 1969), seems to be dictating this pattern.

Gypsiferous soils have the best developed lichen communities, often with 100% lichen cover. Species diversity is also very high at gypsiferous sites, with several rare species (e.g., Acarospora nodulosa var. nodulosa and Gypsoplaca macrophylla) becoming common to abundant. The most abundant species on
Table 1. Distribution of terricolous lichen species from the Intermountain Region of western United States. Growth form: Cr = crustose, Fo = foliose, Fr = fruticose, Sq = squamulose. Habit: A = attached, V = vagrant. Relative abundance: A = abundant, C = common, R = rare.

<table>
<thead>
<tr>
<th>Species</th>
<th>Growth form</th>
<th>Habit</th>
<th>Great Basin</th>
<th>Gypsiferous</th>
<th>Steppe</th>
<th>Upland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acarospora nodulosa (Dufour) Hue</td>
<td>Sq</td>
<td>A</td>
<td>C-A</td>
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<tr>
<td>Acarospora nodulosa var. reagens (Zahlbr.) Clauz. &amp; Roux</td>
<td>Sq</td>
<td>A</td>
<td>R-C</td>
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<tr>
<td>Agrostis hispida (Mereshchk.) Hale &amp; Culb.</td>
<td>Fr</td>
<td>V</td>
<td>C-A R-C</td>
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<tr>
<td>Aspicilia reptans (Looman) Wetm.</td>
<td>Fr</td>
<td>V</td>
<td>R</td>
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<td>Aspicilia sp.</td>
<td>Fr</td>
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<td>C-A</td>
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<tr>
<td>Buellia elegans Poelt</td>
<td>Sq</td>
<td>A</td>
<td>R-C</td>
<td>C-A</td>
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<tr>
<td>Caloplaca tominii Savicz</td>
<td>Cr</td>
<td>A</td>
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<td>Catapyrenium dacaleum (Krempelh.) B. Stein</td>
<td>Sq</td>
<td>A</td>
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<tr>
<td>Catapyrenium lachneum (Ach.) R. Sant.</td>
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<td>A</td>
<td>C-A C-A C</td>
<td>C</td>
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<tr>
<td>Collema tenax (Swartz) Ach.</td>
<td>Sq</td>
<td>A</td>
<td>C-A C</td>
<td>R-C R-C</td>
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<tr>
<td>Dermatocarpus minutus (L.) Mann</td>
<td>Fo</td>
<td>V</td>
<td>R-C</td>
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<tr>
<td>Dermatocarpus reticulatum Magn.</td>
<td>Fo</td>
<td>V</td>
<td>R-C</td>
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<td>Diploschistes diacapsis (Ach.) Lumbsch</td>
<td>Cr</td>
<td>A</td>
<td>A</td>
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<tr>
<td>Endocarpon pusillum Hedwig</td>
<td>Sq</td>
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<td>R</td>
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<td>Fulgensis desertorum (Tomin) Poelt</td>
<td>Cr</td>
<td>A</td>
<td>C</td>
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<td>Fulgensis fulgens (Swartz) Elenkin</td>
<td>Sq</td>
<td>A</td>
<td>R-C</td>
<td>R-C</td>
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<tr>
<td>Gypsoplaca macrophylla (Zahlbr.) Timdal</td>
<td>Sq</td>
<td>A</td>
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<tr>
<td>Psora cerebriformis W. Weber</td>
<td>Sq</td>
<td>A</td>
<td>R-C</td>
<td>C-A</td>
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<tr>
<td>Psora crenata (Taylor) Reinke</td>
<td>Sq</td>
<td>A</td>
<td>C</td>
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<tr>
<td>Psora decipiens (Hedwig.) Hoffm.</td>
<td>Sq</td>
<td>A</td>
<td>C-A C</td>
<td>C</td>
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<tr>
<td>Psora globifera (Ach.) Massal.</td>
<td>Sq</td>
<td>A</td>
<td>R</td>
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<tr>
<td>Psora icterica (Mont.) Muell.</td>
<td>Sq</td>
<td>A</td>
<td>C</td>
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<tr>
<td>Psora luteola (Tuck.) Fink</td>
<td>Sq</td>
<td>A</td>
<td>R</td>
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<tr>
<td>Psora montana Timdal</td>
<td>Sq</td>
<td>A</td>
<td>R</td>
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<tr>
<td>Psora russellii (Tuck.) A. Schneider</td>
<td>Sq</td>
<td>A</td>
<td>R</td>
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<tr>
<td>Psora tuckermanii R. Anderson ex Timdal</td>
<td>Sq</td>
<td>A</td>
<td>C-A</td>
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<tr>
<td>Rhizoplaca haydenii (Tuck.) W. Weber</td>
<td>Fo</td>
<td>V</td>
<td>C-A</td>
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<tr>
<td>Squamarina lentigera (Weber) Poelt</td>
<td>Sq</td>
<td>A</td>
<td>C-A R-C</td>
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<td>R</td>
<td></td>
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<tr>
<td>Toninia caeruleonigricans (Lightf.) Th. Fr.</td>
<td>Cr</td>
<td>A</td>
<td>R-C R-C</td>
<td></td>
<td>R</td>
<td></td>
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<tr>
<td>Toninia tristis (Th. Fr.) Th. Fr.</td>
<td>Sq</td>
<td>A</td>
<td>R</td>
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<tr>
<td>Xanthoparmelia chlorochroa (Tuck.) Hale</td>
<td>Fo</td>
<td>V</td>
<td>C-A</td>
<td>R-C</td>
<td></td>
<td></td>
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<tr>
<td>Xanthoparmelia idahoensis Hale</td>
<td>Fo</td>
<td>AV</td>
<td>R-C</td>
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<tr>
<td>Xanthoparmelia lipchorochroa Hale &amp; Elix</td>
<td>Fo</td>
<td>V</td>
<td>C-A</td>
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<tr>
<td>Xanthoparmelia wyomingica (Gyelnik) Hale</td>
<td>Fo</td>
<td>A</td>
<td>C-A</td>
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</table>

Gypsiferous soils are *Diploschistes diacapsis* and *Squamarina lentigera* (Table 1). Vagrant species are also missing from gypsiferous sites.

Upland, sandy sites in pinyon-juniper woodlands are dominated by various species of the genus *Psora*, including *P. cerebriformis*, *P. tuckermanii*, and *P. decipiens*. *Catapyrenium lachneum* and *Endocarpon pusillum* are also found at these sites (Table 1). Vagrant species are present but rare in upland sites. *Xanthoparmelia chlorochroa* and *Agrostis hispida* have been collected from this habitat type.

Dry, upland steppe sites dominated by various *Artemisia* spp. often have well-developed vagrant lichen floras including *Xanthoparmelia chlorochroa*, *Rhizoplaca haydenii*, *Dermatocarpus reticulatum*, and *Agrostis hispida*. The squamulose species *Catapyrenium lachneum*...
and Collema tenax are also commonly found in this type of habitat (Table 1).

Some species of soil crust lichens are both broadly distributed and generally abundant, occurring throughout the full range of soil crust habitats in the Intermountain Area. For example, the squamulose lichens Psora decipiens and Catapyrenium lachneum are common components of all desert habitats in the Intermountain Area, occurring on calcareous, gypsiferous, and sandy upland soils. They are also common components of alpine tundra habitats throughout Intermountain North America. Both species have also been collected worldwide from Australia, Africa, Asia, and Europe (Rogers and Lange 1972). Other species are broadly distributed but are much less abundant. Such taxa include Endocarpon pusillum, Toninia caeruleonigricans, and Buellia elegans. Gelatinous lichens (e.g., Collema sp. and Peccania sp.) are abundant but not particularly well known from western soil crust communities. More careful analysis of this group, particularly on gypsiferous soils, will invariably yield several additional species. Presently, the taxon Collema tenax is probably overused.

One group of lichens conspicuously missing from the intermountain deserts is the genus Cladonia. Although this genus occurs commonly on the Great Plains, in the boreal forest, and on the alpine tundra, it is not represented by a single species in the soil crust communities of the Great Basin or Colorado Plateau.

Affinities of Intermountain Area Soil Crust Lichens

Very little descriptive or ecological information is available for the lichen component of soil crust communities in the Intermountain Area. Looman (1964), whose work was the first to specifically characterize terricolous lichen communities in North America, focused on the Prairie Provinces of Canada and adjacent parts of the northern Great Plains. He specifically described the Parmelietum chlorochroae lichen association, a steppe community with arctic-alpine affinities. Floristically, this association is very similar to the lichen soil crust communities of the Intermountain Area. This association includes several vagrant species (e.g., Xanthoparmelia chlorochroa, Agrestia hispida, Rhizoplaca haydenii, and Aspicilia reptans) that are also common components of the short-grass-shrubland steppe of western Wyoming, Idaho, eastern Montana, northwestern Utah, and northeastern Colorado. Other species included in this association, namely Catapyrenium lachneum, Endocarpon pusillum, Collema tenax, Psora decipiens, Toninia caeruleonigricans, Fulgensia fulgens, Buellia elegans, and Squamarina lentigera, also occur in the Intermountain Area. Some species occur in both the Great Basin and the Colorado Plateau, while others are limited to one or the other. Other taxa included in Looman's Parmelietum chlorochroae association (e.g., Cladonia pocillum, Phaeorrhiza nimbosa, and Acarospora schleicheri) are absent from the middle-elevation deserts of the Intermountain Area but are commonly found in intermountain boreal and/or alpine tundra habitats.

European lichenologists have described two lichen associations, Fulgensietum fulgentis and Parmelietum vagantis, which are very similar to the soil lichen communities of the Great Basin and Colorado Plateau (Klement 1955, 1958). The combined species list for the two European associations is virtually identical to Looman's Parmelietum chlorochroae association list. Floristically, the Fulgensietum fulgentis association is more closely related to the Great Basin and Colorado Plateau soil lichen communities, while Parmelietum vagantis more closely resembles the short-grass-shrubland steppe community of western Wyoming, Idaho, eastern Montana, northeastern Utah, and northwestern Colorado. The Intermountain Area seems to have four distinctive soil lichen associations (Table 1): calcareous Great Basin soil crusts, sandy Colorado Plateau soil crusts, gypsiferous soil crusts, and northern steppe soil crusts. Some species are found in all four associations, while other species are unique to a given association (Table 1).

Annotated List of Soil Crust Taxa

Acarospora nodulosa (Dufour) Hue var. nodulosa. A squamulose species locally abundant on gypsiferous soils. This species was reported new to North America by St. Clair and Warrick in 1987. Original collections of this species were made in Washington County, Utah, with subsequent collections from similar habitats in Emery County, Utah, and northwestern Arizona.

Acarospora nodulosa (Dufour) Hue var. reagens. A squamulose lichen collected from Montrose and San Miguel counties in southwestern Colorado. Locally common on gypsiferous soils. This species has not been collected in Utah; however, more careful examination of gypsiferous soil habitats...
in the state will likely confirm its occurrence in Utah and perhaps even the northwestern corner of Arizona.

Agrestia hispida (Mereschk.) Hale & Culb. A fruticose, vagrant lichen that demonstrates tremendous morphological plasticity. This species is part of a complicated group of related species that should be carefully compared with similar material reported from comparable habitats in Russia. It has been commonly collected from middle-elevation, calcareous, shrubland habitats dominated by Arctisbiosa spp. and/or Atriplex spp. in Utah, Wyoming, Idaho, and Colorado. Weber (1967) suggested this species is an environmental modification of Aspicilia calcarea. Roger Rosentreter’s work on the vagrant Aspicilia/Agrestia spp. of western North America will undoubtedly show that there are at least several new species records for North America from this group.

Aspicilia reptans (Looman) Wetm. A fruticose, semi-vagrant species collected from middle-elevation calcareous sites in Idaho and Wyoming and alpine tundra sites in Utah. This species is commonly overlooked because it blends in with detritus that tends to accumulate in the above-mentioned habitats. This species represents one extreme of the Agrestia-Aspicilia complex, a group requiring serious monographic treatment.

Aspicilia sp. A fruticose, vagrant species collected from short-grass-shrubland steppe sites in Wyoming and Idaho. This species most closely resembles Agrestia hispida; however, this taxon has a more substantial central thallus with short, blunt lobes rather than the densely and finely branched thalli typical of Agrestia hispida. In addition, A. hispida has better developed and more prominent pseudocyphellae. Thalli of Aspicilia sp. are also more compact and tend to be more spherical in shape. Roger Rosentreter’s work comparing North American members of this group with similar Russian taxa likely result in an epithet for this species.

Buellia elegans Poelt. A squamulose species with prominent lobes. This species is broadly distributed, reaching its best development in sites protected from trampling. It has been collected from protected sandy soils in Emery County, Utah, as well as gypsiferous soils in Colorado, Utah, and northwestern Arizona, and less commonly from protected calcareous soils in the Great Basin.

Caloplaca tominii Savicz. A crustose, sorediate species that occurs commonly on calcareous soils throughout the Great Basin. This species was first reported by Nimis (1981) as new to North America. His collections were from the Kluane region of the Canadian Yukon, an area in some respects strikingly similar to the open shrublands of the Great Basin.

Catapyrenium daedaleum (Krempelelh.) B. Stein in Cohn. A rather rare squamulose species collected from middle- to higher-elevation, calcareous sites in Colorado, Wyoming, and Utah.

Catapyrenium lachneum (Ach.) R. Sant. This squamulose lichen is one of the most broadly distributed terricolous species in the Intermountain Area. It commonly occurs on calcareous soils in the Great Basin, middle-elevation pinyon-juniper sites, gypsiferous soils of the Colorado Plateau, and alpine tundra soils. This species has an incredible ecological amplitude and demonstrates substantial morphological variation.

Collema tenax (Swartz) Ach. This isidiate, squamulose lichen is one of the most common terricolous lichens of the Intermountain Region. It occurs on calcareous soils in the Great Basin and also on gypsiferous soils on the Colorado Plateau. This species recovers very rapidly following perturbation (e.g., fire or grazing disturbance). Its capacity for quick recovery is likely related to the fact that it produces abundant vegetative propagules (isidia) (Johansen et al. 1984, Johansen and St. Clair 1986).

Dermatocarpon miniatum (L.) Mann. This foliose, usually attached saxicolous lichen occasionally becomes detached and occurs as a vagrant on the soil. According to Rosentreter and McCune (1992) most vagrant Dermatocarpon species are collected from poorly drained basalt flats dominated by Artemisia rigida in western Idaho and eastern Washington and Oregon. After careful study Rosentreter and McCune have determined that vagrant species of Dermatocarpon are detached fragments of either D. reticulatum or D. miniatum; therefore, they recommend that the epithet for the vagrant form of this species (Dermatocarpon vagans) no longer be used.

Dermatocarpon reticulatum Magn. This foliose, usually attached saxicolous species is reported as a vagrant soil lichen from northwestern Wyoming, western Idaho, and eastern Oregon. See related discussion under Dermatocarpon miniatum.

Diploschistes diacapsis (Ach.) Lumbsch. A crustose lichen commonly collected on gypsiferous soils in southern Utah, southeastern Colorado, and northwestern Arizona. This species is the single most abundant lichen collected from gypsiferous soils in the Intermountain Area.

Endocarpon pusillum Hedw. This squamulose species is broadly distributed but not particularly common. It is found on calcareous soils in the Great Basin and occasionally on undisturbed, sandy soils in pinyon-juniper communities. The fact that this species is rather uncommon may, at least in some measure, be related to a relatively low tolerance for grazing and fire disturbance.

Fulgensia desertorum (Tomin) Poelt. This granular-sorediate lichen occurs commonly on gypsiferous soils in Arizona, Colorado, and Utah.
**Fulgensia fulgens** (Swartz) Elenkin. A squamulose species with well-developed lobes. It is frequently collected from calcareous soils of the Colorado Plateau, gypsiferous soils, and less commonly from undisturbed calcareous soils in the Great Basin.

**Gypsoplasca macrophylla** (Zahhr.) Timdal. This rather rare squamulose lichen has recently been collected from gypsiferous soils in southwestern Colorado and was reported as new to North America by Timdal (1990). Likely, with additional collections and more careful analysis of existing collections, other species will be added to this genus. This taxon was also collected from gypsiferous soils on the San Rafael Swell in Emery County, Utah, during the fall of 1992 and represents a new species record for the state (BRY C21698).


**Psora crenata** (Taylor) Reinke. A squamulose lichen with prominent, marginal apothecia. This species is rare to common on calcareous and gypsiferous soils in Arizona, Colorado, New Mexico, and Utah.

**Psora decipiens** (Hedwig) Hoffm. This squamulose lichen, along with *Catapyrenium lachneum*, is the most broadly distributed terricolous lichen in western North America. It has been commonly collected from calcareous soils in the Great Basin, gypsiferous soils on the Colorado Plateau, and high-elevation alpine tundra sites throughout the Rocky Mountains. It occurs less commonly on soils in pinyon-juniper habitat.

**Psora globifera** (Ach.) Massal. A squamulose lichen that generally occurs in fissures of calcareous rocks. It also occasionally occurs on calcareous soils in Arizona, Colorado, Idaho, Nevada, Utah, and Wyoming.

**Psora icterica** (Mont.) Müll. Arg. A squamulose soil lichen commonly collected in the arid areas of the western United States. In the Intermountain Area it has been reported from Arizona, New Mexico, and Colorado. It often occurs in pinyon-juniper habitat on sandy, undisturbed soils.

**Psora luridella** (Tuck.) Fink. A rare, squamulose soil lichen reported from Colorado, New Mexico, Nevada, and Utah. Because *P. luridella* is morphologically very similar to *P. globifera*, the two species are often confused.

**Psora montana** Timdal. A squamulose soil lichen occasionally collected below timberline. It is reported to occur in Colorado, Utah, and Wyoming.

**Psora russellii** (Tuck.) A. Schneider. This squamulose lichen occurs in arid areas of the southwestern United States. In the Intermountain Area it has been reported from Arizona and southwestern Colorado.

**Psora tuckermanii** R. Anderson ex Timdal. This broadly distributed, squamulose soil lichen has been reported for Arizona, Colorado, Idaho, Nevada, New Mexico, Utah, and Wyoming. *P. tuckermanii* shows extensive morphological variation and is commonly confused with several other species of *Psora*. It has been commonly collected from calcareous soils in the Great Basin as well as on soil over rock on the Colorado Plateau.

**Rhizoplasca haydenii** (Tuck.) W. Weber. A vagrant soil lichen collected from calcareous shrubland habitats in Idaho, Utah, and Wyoming. This species demonstrates substantial morphological variation ranging from robust spherical thalli (typical of lower-elevation sites) to finely branched flattened thalli (typical of higher-elevation sites). The genus *Rhizoplasca* needs attention and is presently under review by Bruce Ryan.

**Squamarina lentigera** (Weber) Poelt. This squamulose soil lichen has prominent lobes. *S. lentigera* is one of the more abundant lichens collected from gypsiferous habitats in northern Arizona, southwestern Colorado, and southern Utah. It has also been collected from undisturbed, sandy soils in pinyon-juniper habitat.

**Toninia caeruleonigricans** (Lightf.) Th. Fr. A convoluted, crustose to squamulose soil lichen commonly collected from calcareous soils in the Great Basin and Colorado Plateau. This species is one of the more broadly distributed soil lichens, occurring in Arizona, Colorado, Idaho, Nevada, New Mexico, Utah, and Wyoming.

**Toninia tristis** (Th. Fr.) Th. Fr. A convoluted, squamulose soil lichen. This species occurs on calcareous soils and has been collected rarely from protected habitats in pinyon-juniper communities. It has been reported from Arizona, Colorado, New Mexico, and Utah.

**Xanthoparmelia chlorochroa** (Tuck.) Hale. A foliose, vagrant lichen that occurs abundantly on soils of shrubland-steppe communities and less commonly in pinyon-juniper communities. The distribution of this species seems to be positively correlated with grazing impact (McCracken et al. 1983). It commonly occurs with *Agrestia hispida* and has been reported from Arizona, Colorado, New Mexico, Nevada, Utah, and Wyoming. Recently, this group has been split into several closely related species based on subtle morphological and chemical differences (Hale 1990). Only one of the chemical segregates is included here (*X. lipochlorochroa*). Further evaluation of vagrant *Xanthoparmelia* in the Intermountain Area will ultimately yield several additional species.

**Xanthoparmelia idahoensis** Hale. A loosely attached to vagrant, foliose to sub-fruticose lichen
collected from calcareous lacustrine ash soils near
Salmon, Idaho. This rare but locally abundant lichen has
been reported only from the type locality. Examination of similar habitats elsewhere should reveal a
broader distribution pattern.

*Xanthoparmelia lipochlorochroa* Hale & Elix. A rare, vagrant soil lichen that is a fatty acid
chemotype of *X. chlorochroa*. The two species inter­
mix in the desert shrublands of southwestern Wy­
oming. Careful examination of the chemistry of
collections of *X. chlorochroa* will likely demonstrate
a much broader distribution pattern for *X. lipo­
chlorochroa*.

*Xanthoparmelia wyomingica* (Gyelnik) Hale.
A loosely attached, foliose lichen common on rocky
soils in middle- to higher-elevation sites in Colorado,
Idaho, Utah, and Wyoming. Hale (1990) indicates
that this species does not occur below 3000 m and
does not occur sympatrically with *X. chlorochroa*.
However, I (St. Cl.) have personally collected this
species from higher-latitude sites below 3000 m
(northern Colorado, Idaho, and Wyoming); I have
also observed that it often occurs sympatrically with *X. chlorochroa* in many of the higher-latitude sites.

Human-related Impact on
Soil Crust Communities

Lichens are important components of soil
Crust communities in the intermountain west­
ern United States, especially in areas protected
from domestic grazing, wildfire, and off-road
vehicle activity. Soil crusts in general and the
lichen component in particular tend to be very
sensitive to human-related perturbation. These
complex, sensitive communities thrived for
years prior to the advent of modern humans.
They provide 40–100% of the ground cover in
an area with relatively sparse vascular plant
cover. They also effectively reduce wind and
water erosion while significantly increasing soil
fertility. However, over the last 150 years a sig­
nificant portion of the soil crust communities of
the Great Basin and Colorado Plateau has been
heavily damaged, mostly due to intensive graz­ing
by cattle and sheep. Soil crust communities are
generally slow to recover, often requiring
many years for full recovery (Anderson, Harper

Soil crust community structure in the Inter­
mountain Area evolved without significant im­
pact from large herds of grazing animals (i.e.,
bison) and with little or no impact from wildfire
(Mack and Thompson 1982). Impact from herds
of deer, antelope, and elk was minimized due to
the smaller size and number of herds and the
time of the year they inhabited semiarid regions
of the Great Basin and Colorado Plateau. These
herds always occupied lower-elevation sites dur­ing
the winter and early spring months when soil
Crusts were wet because of seasonal precipita­tion and thus less vulnerable to the effects of
trampling. However, as the drier summer
months approached and soil crusts became dry
and brittle, and thus more vulnerable to tram­
ping, wild grazing animals moved back into the
mountainous areas of the region. In contrast,
modern humans have maintained larger herds
of domestic animals in greater numbers and
have grazed the basin and plateau regions well
into the summer months or even continuously.
Furthermore, modern humans have introduced
alien vascular plant species that now make it
possible to sustain large wildfires in a region
where wildfire was not particularly common.
The end result has been extensive damage to soil
Crust communities with a concomitant increase
in soil erosion and decline in soil fertility.

Many species of lichens are sensitive to vari­
ous types of air pollutants (Nash and Wirth
1988). Recently, they have been used to bio­
monitor the effects of air pollution in protected
habitats such as wilderness areas and national
parks (St. Clair 1989). Unfortunately, very little
is known about the effects of air pollutants on
soil crust lichens. It is generally thought that the
basic soils of the Intermountain Area ameliorate
the effects of air pollution, especially acid-gen­
erating pollutants. Even though no empirical
evidence supports this hypothesis, researchers
have shown that lichens growing on calcareous
substrates do have a higher tolerance for acid
pollution. Currently, a study is in progress to
evaluate the effects of emissions from a toxic
waste incinerator in central Utah on soil crust
communities. Baseline community data and
toxic element concentrations from the soil were
obtained prior to operation of the incinerator.
Follow-up studies will show whether or not toxic
emissions accumulate in the soil and/or nega­
tively impact soil crust communities. Research
is also needed to accurately evaluate the effects
of acid precipitation on soil crust communities
in general and the lichen component in particu­
ar. Failure to document air pollution effects
could further jeopardize a resource that has
already sustained significant damage from inten­sive grazing and wildfire.
LITERATURE CITED


