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Lichens of soil crust communities in the Intermountain Area of the western United States

Larry L. St. Clair
Brigham Young University

Jeffrey R. Johansen
John Carroll University, University Heights, Ohio

Samuel R. Rushforth
Brigham Young University

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

Larry L. St. Clair[1,2], Jeffrey R. Johansen[3], and Samuel R. Rushforth[1]

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 gypsifersous 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 semiarid 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 communites 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

[1]Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.
[2]Address for reprints.
[3]Department of Biology, John Carroll University, University Heights, Ohio 44118.

Warrick (1987) reported *Acarospora nodulosa* (Duf.) Hue. v. *nodulosa*, a squamulose soil lichen collected from gypsiferous soils in southern Utah, as a new record for North America. Timdal (1990) described a new and rare squamiform 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 *Dermatocapon* 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.

			Intermountain Area soil lichen habitats			
Species	Growth form	Habit	Great Basin	Gypsiferous	Steppe	Upland
Acarospora nodulosa (Dufour) Hue	Sq	A		C-A		
Acarospora nodulosa var. *reagens* (Zahlbr.) Clauz. & Roux	Sq	A		R-C		
Agrestia hispida (Mereschk.) Hale & Culb.	Fr	V			C-A	R-C
Aspicilia reptans (Looman) Wetm.	Fr	V			R	
Aspicilia sp.	Fr	V			C-A	
Buellia elegans Poelt	Sq	A	R-C	C-A		R
Caloplaca tominii Savicz	Cr	A	C			R
Catapyrenium daedaleum (Krempelh.) B. Stein	Sq	A				R
Catapyrenium lachneum (Ach.) R. Sant.	Sq	A	C-A	C-A	C	C
Collema tenax (Swartz) Ach.	Sq	A	C-A	C	R-C	R-C
Dermatocarpon miniatum (L.) Mann	Fo	V			R-C	
Dermatocarpon reticulatum Magn.	Fo	V			R-C	
Diploschistes diacapsis (Ach.) Lumbsch	Cr	A	A			
Endocarpon pusillum Hedwig	Sq	A	R			R
Fulgensia desertorum (Tomin) Poelt	Cr	A		C		
Fulgensia fulgens (Swartz) Elenkin	Sq	A	R-C			R-C
Gypsoplaca macrophylla (Zahlbr.) Timdal	Sq	A		R-C		
Psora cerebriformis W. Weber	Sq	A	R-C			C-A
Psora crenata (Taylor) Reinke	Sq	A		C		
Psora decipiens (Hedwig.) Hoffm.	Sq	A	C-A	C	C	C
Psora globifera (Ach.) Massal.	Sq	A	R			
Psora icterica (Mont.) Muell.	Sq	A				C
Psora luridella (Tuck.) Fink	Sq	A	R			
Psora montana Timdal	Sq	A				R
Psora russellii (Tuck.) A. Schneider	Sq	A				R
Psora tuckermanii R. Anderson *ex* Timdal	Sq	A	C-A			C
Rhizoplaca haydenii (Tuck.) W. Weber	Fo	V			C-A	
Squamarina lentigera (Weber) Poelt	Sq	A		C-A		R
Toninia caeruleonigricans (Lightf.) Th. Fr.	Cr	A	R-C	R-C		R
Toninia tristis (Th. Fr.) Th. Fr.	Sq	A				R
Xanthoparmelia chlorochroa (Tuck.) Hale	Fo	V			C-A	R-C
Xanthoparmelia idahoensis Hale	Fo	A/V				R-C
Xanthoparmelia lipchlorochroa Hale & Elix	Fo	V			C-A	
Xanthoparmelia wyomingica (Gyelnik) Hale	Fo	A			C-A	

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. tuckermanni*, 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 *Agrestia 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*, *Dermatocarpon reticulatum*, and *Agrestia 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 *Artemisia* 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 will 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 **(Krempelh.) 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* Imsh.) 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 dicussion 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 **Hedwig.** 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-subsorediate 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.

***Gypsoplaca macrophylla* (Zahlbr.) 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 cerebriformis* W. Weber.** A robust, squamulose lichen frequently collected from pinyon-juniper and shrubland habitat in Arizona, Colorado, Idaho, Nevada, New Mexico, Utah, and Wyoming.

***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 calciferous 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.

***Rhizoplaca 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 *Rhizoplaca* 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 communites. 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 *Xanthoparmelias* 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 intermix in the desert shrublands of southwestern Wyoming. Careful examination of the chemistry of collections of *X. chlorochroa* will likely demonstrate a much broader distribution pattern for *X. lipochlorochroa*.

***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 western 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 significant 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 and Rushforth 1982, Johansen et al. 1984).

Soil crust community structure in the Intermountain Area evolved without significant impact 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 trampling, 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 various types of air pollutants (Nash and Wirth 1988). Recently, they have been used to biomonitor 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-generating 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 negatively 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 particular. Failure to document air pollution effects could further jeopardize a resource that has already sustained significant damage from intensive grazing and wildfire.

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