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PC

FINAL REPORT

SUBMITTED TO

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HYDROLOGIST AND AIR QUALITY SPECIALIST
MANTI-LA SAL NATIONAL FOREST**

REGARDING

**ESTABLISHMENT OF A LICHEN AIR QUALITY BIOMONITORING PROGRAM
AND BASELINE FOR SELECTED SITES IN THE MANTI LA SAL NATIONAL
FOREST, UTAH**

SUBMITTED BY

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EXECUTIVE SUMMARY

During the 1994 - 1997 field seasons a total of 15 lichen air quality biomonitoring reference sites were established in the Manti La Sal National Forest. To date 143 lichen species in 48 genera have been identified from our collections. Typical of Intermountain Area lichen floras most of the species from the Manti La Sal National Forest are of the crustose growth form (51% or 73 species). During the course of our study lichen specimens were collected from five substrates (rocks, bark/lignum, soil, moss/detritus, and other lichens), with most species occurring on rock substrates (57% or 82 species). A total of 33 elemental analysis samples have been collected from the 15 air quality biomonitoring reference sites. Included in this collection are a total of 10 sensitive indicator species collected from two substrates (rock and bark). An average of 10.1 (range: 3-14) sensitive indicator species were collected from each reference site. This compares with an average of 6.3 along the Wasatch Front; 8.0 in the Bridger Wilderness Area (western Wyoming); and 10.3 in the High Uintas Wilderness Area (northeastern Utah). However, there are some discrepancies in the average number of sensitive indicator species per reference site between the Monticello-Moab districts (11.8) and the Price, San Pete, and Ferron districts (8.9). This difference is likely related, at least in part, to the general proximity of the Price, San Pete, and Ferron sites to the air pollution problems of the Wasatch Front.

Elemental analysis data suggest several areas of concern. Sulfur concentrations in lichen tissues from four sites (Rilda Canyon, Pine Ridge, Elk Ridge, and Dark Canyon) were elevated (0.196-0.27%). Furthermore, thallus concentrations of arsenic, nickel, and chromium are among the highest reported for the entire Intermountain Area. Lead concentrations are generally well within background levels; however, four samples from three sites (Chris' Canyon, Great Basin Experiment Station, and South of Wales Top) were somewhat elevated (52.9-78.7 ppm), especially when compared with most other Rocky Mountain reference sites. Copper/zinc ratios were well within background levels (≤ 0.5) at all sites (0.054 - 0.39). However, Fe/Ti ratios were slightly elevated in four samples (343, 447, 491, and 492), moderately elevated in 3 samples (339, 340, and 453); and elevated in one sample (450), ranging between 8.46 and 11.07 with background levels generally falling between 6 and 8. Elemental analysis data suggest three general areas of concern: 1) Rilda Canyon in Carbon County with elevated sulfur and a moderately elevated Fe/Ti ratio; 2) Pine Ridge, Elk Ridge, and Dark Canyon in San Juan County with elevated sulfur; 3) Chris' Canyon, Great Basin Experiment Station, South of Wales Top, and Orange-Olsen Guard Station in San Pete County with some combination of elevated heavy metals including lead, chromium, and arsenic; as well as elevated Fe/Ti ratios. Overall, this pattern of pollutant element accumulation by lichens is remarkably similar to data collected at air quality biomonitoring reference sites established in the Uinta National Forest along the heavily populated and industrialized Wasatch Front. It appears that at least some of the reference sites in the Manti-La Sal National Forest may be experiencing some air pollution-related impact, with reference sites in the San Pete, Ferron, and Price ranger districts demonstrating accumulation of selected heavy metals and at least somewhat elevated Fe/Ti ratios. While reference sites in the Monticello District show elevated sulfur concentrations.

High species diversity, the general absence of bleached and/or necrotic thalli, and the moderately high average number of sensitive indicator species per site (10.1) suggests that overall the lichen flora of the Manti-LaSal National Forest has not been heavily impacted by air pollution. Generally, reevaluation of pollutant levels in tissues of sensitive indicator species should be conducted every 5-8 years. However, some sites with elevated pollutant levels and/or reduced numbers of sensitive indicator species (i.e. Rilda Canyon, Wales Top, Great Basin Experimental Range Station, Chris' Canyon, Pine Ridge, Elk Ridge, and Dark Canyon) should be reevaluated every 3-5 years. To insure better long term coverage and greater sensitivity to potential air pollution problem areas, several additional air quality biomonitoring reference sites should be established in the forest (see recommendations section for details).

INTRODUCTION

PROJECT OBJECTIVES:

1. Establish 15 air quality biomonitoring reference sites in the Manti La Sal National Forest.
2. Collect, curate, and identify lichen species from various habitats and substrates at each reference site.
3. Identify 1-3 pollution sensitive lichen species at each reference site. Collect enough tissue of at least one sensitive indicator species (approximately 3-6 grams dry weight) from each reference site for elemental analyses. Rare species will not be collected for analysis, but their distribution will be noted.
4. Determine baseline thallus concentrations of 20 potential pollutant elements (including sulfur, selenium, arsenic, copper, bromine, manganese, lead, vanadium, potassium, iron, etc.), using replicate samples of at least one documented pollution-sensitive species collected at each reference site. Samples will be analyzed using Proton Induced X-ray Emission (PIXE) techniques.
5. Prepare and submit the final report by 31 December 2000.

LICHENS AS BIOLOGICAL INDICATORS OF AIR QUALITY:

Lichens have been used extensively as bioindicators of air quality (Fields & St. Clair 1984; St. Clair 1989; Richardson 1992). Hale (1983) noted that lichens have been used in three basic ways to monitor the effects of air pollution on biological communities: 1) elemental analysis of lichen tissues, 2) mapping of all (or selected) lichen species found in areas adjacent to pollution sources, and 3) transplant studies. Currently, the most common approach involves a floristic survey along with elemental analyses of sensitive indicator species (St. Clair and Newberry 1995; Wetmore 1989).

As lichens accumulate a variety of pollutants from atmospheric outwash, lichen tissues provide a record of the kinds and relative quantities of air pollutants in any particular airshed (Schutte 1977; Wetmore 1989; Rope & Pearson 1990). Pollutant accumulation patterns for specific elements have been monitored over time by correlating thallus growth rates with pollutant concentrations in precisely excised portions of lichen thalli (Lawrey & Hale 1981). Changes in lichen physiological parameters indicate pollution-related damage long before other, more easily discernible characteristics such as changes in thallus color, morphology, or community structure become apparent (Fields & St. Clair 1984).

Lists of pollution-sensitive lichen species are frequently published in conjunction with floristic and ecological surveys (Rushforth et al. 1982; Wetmore 1989). As certain lichen species are inherently more sensitive to airborne contaminants, air quality can be effectively monitored by occasionally reevaluating lichen community and/or physiological parameters. Air pollution-related changes can then be documented by comparing follow up data with original baseline data.

GENERAL HABITAT DESCRIPTION FOR THE MANTI-LA SAL NATIONAL FOREST, UTAH:

The Manti La Sal National Forest administers a wide variety of natural landscapes, ranging from alpine tundra to lowlands dominated by various desert shrub species. The forest consists of four distinct land areas two located in central Utah and contained within the triangle formed by interstate highways 15 and 70 on the west and south respectively and U.S. Highway 6 on the east. The western most central Utah unit is technically in the Uinta National Forest but is administered by the Manti La Sal National Forest. In addition two units are located in the southeast corner of the

state one east of Moab and the other west of Monticello. The Moab unit encompasses much of the La Sal Mountains, a cluster of partially eroded laccolith domes formed from intrusive igneous rocks; while the Monticello unit contains the Abajo Mountains, which were formed in much the same way.

The two central Utah areas lie within the geographical region generally referred to as the Wasatch Plateau, which is part of the much larger Colorado Plateau region. While the other two areas are located in the Paradox Fold Belt of the Colorado Plateau. Habitat types range from mesic riparian communities along canyon streams to drier upland communities including desert shrubland to pinyon-juniper woodland to mixed mountain brush to subalpine coniferous forests to alpine tundra. The geology of the forest is variable and complex and includes sandstones, conglomerates, shales, and volcanics. To date a total of 15 reference sites have been established in the forest (Figure 1).

LICHEN BIOMONITORING REFERENCE SITES IN THE MANTI-LA SAL NATIONAL FOREST, UTAH:

During the 1994 - 1997 field seasons a total of 15 air quality biomonitoring reference sites were established in Manti-La Sal National Forest. Specifically, reference sites have been established at the following locations:

- SITE #1:** 7 September 1994. Utah, Carbon County, Manti-La Sal National Forest, along U.S. Forest Service Road No. 122, and Pontown Creek near forest boundary at 39° 47.545' north latitude; 111° 11.597' west longitude. Elevation: 2364 m (7800 feet).
- SITE #2:** 14 September 1994. Utah, Emery County, Manti-La Sal National Forest, Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage at 39° 23.986' north latitude; 111° 09.742' west longitude. Elevation: 2515 m (8300 feet).
- SITE #3:** 20 September 1994. Utah, Emery County, Manti-La Sal National Forest, vicinity Orange-Olsen Guard Station at 39° 18.198' north latitude; 111° 18.002' west longitude. Elevation: 2212 m (7300 feet).
- SITE #4:** 28 September 1994. Utah, Utah County, Manti-La Sal National Forest, along U.S. Forest Service Road No. 070 (Lake Fork Creek) at 39° 57.968' north latitude; 111° 27.528' west longitude. Elevation: 1879 m (6200 feet).
- SITE #5:** 7 September 1995. Utah, Sanpete County, Manti-La Sal National Forest, vicinity of Great Basin Experimental Range Station at 39° 18.660' north latitude; 111° 29.260' west longitude. Elevation: 2774 m (9100 feet).
- SITE #6:** 13 September 1995. Utah, Sanpete County, Uinta National Forest (administered by Manti-LaSal National Forest), South of Wales Top (~1km) along U.S. Forest Service Road No. 157 at 39° 28.113' north latitude; 111° 42.451' west longitude. Elevation: 2438 m (8000 feet).
- SITE #7:** 13 September 1995. Utah, Juab County, Uinta National Forest (administered by Manti-LaSal National Forest), mouth of Chris' Canyon, at Confluence of Chicken Creek and Chris' Canyon at 39° 31.105' north latitude; 111° 44.009' west longitude. Elevation: 2164 m (7100 feet).
- SITE #8:** 28 September 1995. Utah, Emery County, Manti-La Sal National Forest, Ferron-Price Ranger District, top of East Mountain above Wilberg and Deer Creek Coal Mines at 39° 20.329' north latitude; 111° 08.850' west longitude. Elevation: 2599 m (9590 feet).

MANTI-LA SAL NATIONAL FOREST

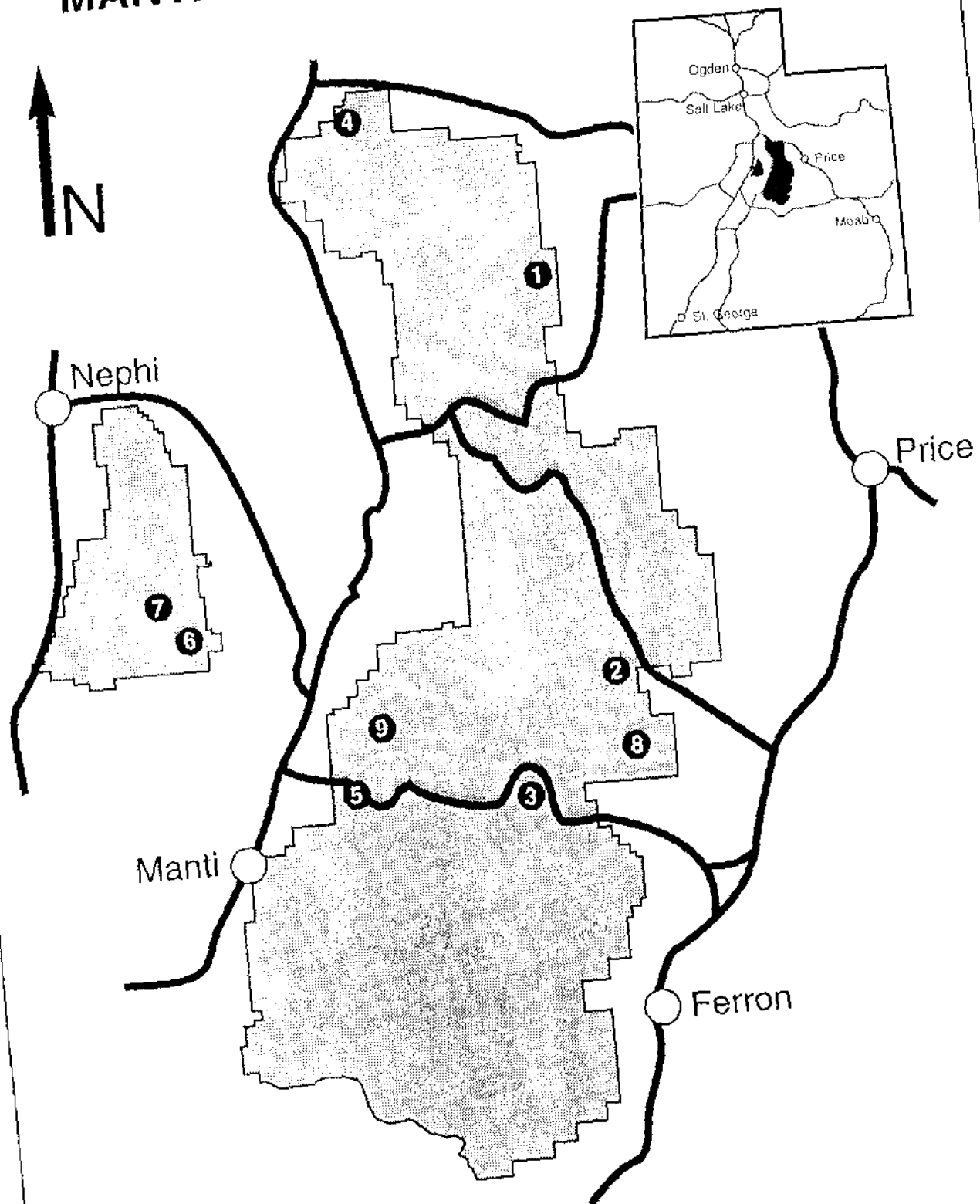


Figure 1a.

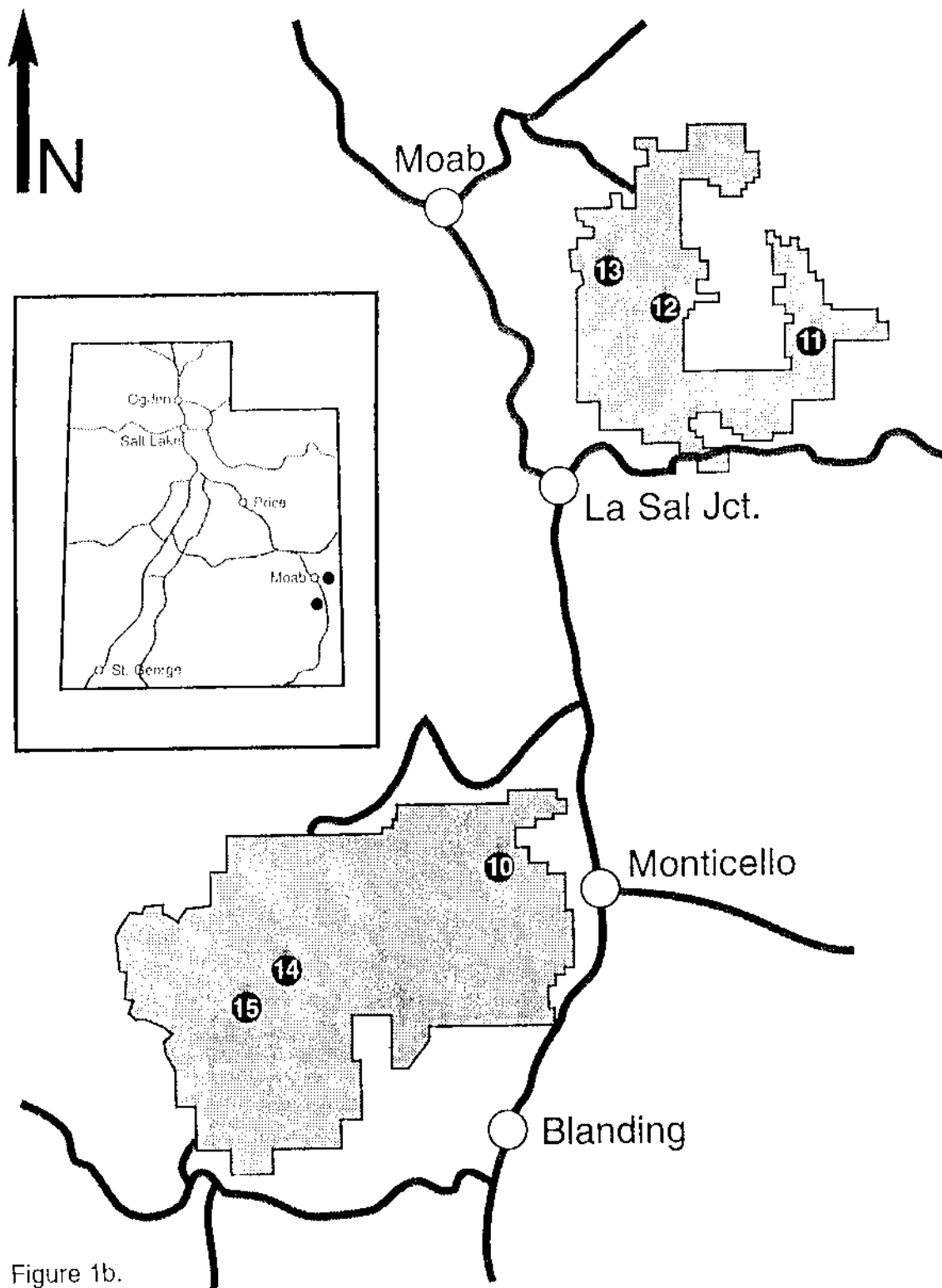


Figure 1b.

SITE #9: 30 September 1995. Utah, Sanpete County, Manti-La Sal National Forest, along Skyline Drive, ridge west of Horseshoe Flat at 39° 21.571' north latitude; 111° 26.236' west longitude. Elevation: 3261 m (10700 feet).

SITE #10: 27 June 1996. Utah, San Juan County, Manti-La Sal National Forest, along U.S. Forest Service Road No. 105, vicinity of Pine Ridge at 37° 53.521' north latitude; 109° 27.471' west longitude. Elevation: 2652 m (8700 feet).

SITE #11: 28 June 1996. Colorado, Montrose County, Manti La Sal National Forest, vicinity of Buckeye Reservoir at 38° 26.319' north latitude; 109° 01.604' west longitude. Elevation: 2377 m (7800 feet).

SITE #12: 28 June 1996. Utah, San Juan County, Manti La Sal National Forest, 1 km west of Geyser Pass, along U.S. Forest Service Road No. 071 at 38° 28.930' north latitude; 109° 14.125' west longitude. Elevation: 3231 m (10600 feet).

SITE #13: 29 June 1996. Utah, Grand County, Manti La Sal National Forest, near junction of U.S. Forest Service roads Nos. 062 and 067 at 38° 31.323' north latitude; 109° 20.361' west longitude. Elevation: 2408 m (7900 feet).

SITE #14: 19 June 1997. Utah, San Juan County, Manti La Sal National Forest, Elkridge, immediately north of Duck Lake, along U.S. Forest Road No. 088 at 37° 48.876' north latitude; 109° 46.418' west longitude. Elevation: 2621 m (8600 feet).

SITE #15: 20 June 1997. Utah, San Juan County, Manti La Sal National Forest, Dark Canyon Wilderness Area, along U.S. Forest Service Road No. 089 at 37° 46.841' north latitude; 109° 51.523' west longitude. Elevation: 2042 m (6700 feet).

METHODS

COLLECTION, CURATION, IDENTIFICATION AND DEPOSITION OF LICHEN SPECIMENS:

Because lichen distribution is influenced by substrate, moisture, and sunlight all available substrates and habitats at each reference site were carefully examined. Small amounts of each lichen species were either removed directly from the substrate, or depending on the species, with a small amount of the substrate (bark, wood, soil, or rock).

All specimens were placed in carefully labeled paper sacks and taken back to the BYU Herbarium of Nonvascular Cryptogams, where they were curated, identified, placed in permanent herbarium packets, and labeled with the current epithets and authors' names as well as detailed information about the collection site, habitat, and substrate. Herbarium (BRY C-) and collection numbers have been assigned to each specimen.

Species were identified using standard lichen keys and taxonomic treatises. Chemical spot tests and, where necessary, thin-layer chromatography techniques were used to finalize species identifications.

One set of specimens collected from each reference site will be permanently housed at the BYU Herbarium of Nonvascular Cryptogams in Provo, Utah. A second set of voucher specimens will be sent to any herbarium designated by the U.S. Forest Service.

COLLECTION OF SENSITIVE INDICATOR SPECIES FOR ELEMENTAL ANALYSES:

After careful consideration of species, substrates, growth forms, documented/suspected pollution sensitivities, and general distribution patterns one to several pollution sensitive indicator

species were collected and returned to BYU where elemental analyses were performed using PIXE technology.

At each reference site sufficient material of at least one sensitive indicator species was collected for elemental analyses (3-6 grams dry weight). Elemental analysis samples were placed in Nasco sterile plastic bags (to avoid contamination) and transported back to the BYU Herbarium of Nonvascular Cryptogams. Excess elemental analysis material is permanently stored in Nasco sterile plastic bags in the elemental analysis collection at the BYU Herbarium of Nonvascular Cryptogams. This material is available for additional testing upon request.

DETERMINATION OF ELEMENTAL CONCENTRATIONS IN LICHEN TISSUES:

In the laboratory, surface debris and dust were removed from all elemental analysis samples. Clean, 1/2 gram samples of at least one sensitive indicator species from each reference site were delivered to the Elemental Analysis Laboratory at Brigham Young University.

Samples were prepared for PIXE analysis using the methods of Duflou et al. (1987). Lichen samples were placed in Teflon containers with a teflon coated steel ball, cooled to liquid nitrogen temperature, powdered by brittle fracture using a Braun Mikro-Dismemberator II, and then dried in an Imperial IV Microprocessor Oven for 14 hours at 80°C. Subsamples weighing 150 mg were then placed into teflon containers and spiked with 1 ml of a 360 ppm yttrium solution. The samples were then oven dried again for 14 hours at 80°C. Samples were then homogenized again using the micro-dismemberator. Approximately 1 mg of the powdered lichen was then carefully weighed onto a thin polycarbonate film in an area of 0.5 cm². A 1.5% solution of polystyrene in toluene was used to secure the sample to the film.

Samples were analyzed using a 2 MV Van de Graaff accelerator with a 2.28 MeV proton beam which passed through a 1.1 mg/cm² pyrolytic graphite diffuser foil. The proton beam was collimated to irradiate an area of 0.38 cm² on the sample. Typically, 10-100 nA proton beam currents were used. X-rays were detected using a Tracor X-ray Spectrometer, model TX-3/48-206, with a 10 mm² by 3 mm thick Si(Li) detector positioned at 90° to the proton beam. Samples were analyzed twice using different X-ray absorbers between the samples and the detector. One was a 49 mg/cm² mylar absorber with a 0.27 mm² pinhole (2.8% of detector area). The mylar was backed with an 8.5 mg/cm² beryllium foil. A 98 mg/cm² mylar absorber was also used.

To insure adequate quality control, samples of NIST SRM 1571 orchard leaves, and other standards were prepared and analyzed using the same procedures.

RESULTS, OBSERVATIONS AND RECOMMENDATIONS

LICHEN MATERIAL COLLECTED FOR ELEMENTAL ANALYSES:

A total of 32 samples including 10 species and 6 genera from 2 substrates (rock and bark) were collected for elemental analysis. Proton Induced X-ray Emission (PIXE) techniques were used to analyze all samples. Below is a list of the elemental analysis samples by sample number, species, substrate and collection site (the first number represents the storage drawer and the second number represents the specific storage bag). All samples are stored in Nasco sterile plastic bags in the Elemental Analysis Collection at the Herbarium of Nonvascular Cryptogams at Brigham Young University, Provo, Utah.

Sample #	Taxa	Substrate	Reference Site
37-338	Rhizoplaca melanophthalma	rock	1
37-339	Xanthoria elegans	rock	2
37-340	Xanthoria elegans	rock	4
37-341	Xanthoparmelia cumberlandia	rock	4
37-342	Rhizoplaca melanophthalma	rock	4

Sample #	Taxa	Substrate	Reference Site
37-343	Xanthoria elegans	rock	3
45-445	Xanthoparmelia cumberlandia	rock	7
45-446	Xanthoria elegans	rock	7
45-447	Rhizoplaca melanophthalma	rock	7
45-448	Physcia dubia	rock	5
45-449	Xanthoria fallax	bark	5
45-450	Xanthoria elegans	rock	6
45-451	Caloplaca trachyphylla	rock	6
45-452	Xanthoria elegans	rock	8
45-453	Xanthoria elegans	rock	9
47-486	Xanthoparmelia cumberlandia	rock	12
47-487	Xanthoria polycarpa	bark	13
47-488	Xanthoparmelia coloradoensis	rock	11
47-489	Xanthoparmelia cumberlandia	rock	13
47-490	Rhizoplaca melanophthalma	rock	13
48-491	Usnea subfloridana	bark	12
48-492	Usnea hirta	bark	11
48-493	Rhizoplaca melanophthalma	rock	11
48-494	Xanthoria elegans	rock	10
48-495	Rhizoplaca melanophthalma	rock	10
48-496	Xanthoparmelia cumberlandia	rock	10
48-497	Xanthoria polycarpa	bark	10
49-529	Rhizoplaca melanophthalma	rock	15
49-530	Xanthoparmelia cumberlandia	rock	15
49-531	Rhizoplaca melanophthalma	rock	14
49-532	Xanthoparmelia cumberlandia	rock	14
49-533	Xanthoria polycarpa	bark	14
49-547	Xanthoria polycarpa	bark	15

LIST OF POLLUTION SENSITIVE INDICATOR SPECIES BY REFERENCE SITE:

vicinity of Buckeye Reservoir:

Amandinea punctata (intermediately sensitive to sulfur dioxide)
Candelariella vitellina (intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Melanelia exasperatula (intermediately sensitive to sulfur dioxide)
Melanelia subolivacea (intermediately sensitive to ozone)
Peltigera rufescens (sensitive to intermediately sensitive to sulfur dioxide)
Physcia caesia (intermediately sensitive to sulfur dioxide)
Physcia stellaris (intermediately sensitive to sulfur dioxide)
Rhizoplaca melanophthalma (sensitive to sulfur dioxide)
Usnea hirta (sensitive to intermediately sensitive to sulfur dioxide and ozone)
Xanthoria fallax (intermediately sensitive to sulfur dioxide; sensitive to NO_x/PAN)
Xanthoria polycarpa (intermediately sensitive to sulfur dioxide)

mouth of Chris' Canyon:

Amandinea punctata (intermediately sensitive to sulfur dioxide)
Phaeophyscia sciastra (sensitive to ozone)
Physcia adscendens (intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Physcia caesia (intermediately sensitive to sulfur dioxide)
Physcia dubia (sensitive to intermediately sensitive to fluoride)
Rhizocarpon geographicum (sensitive to fluoride)
Rhizoplaca melanophthalma (sensitive to sulfur dioxide)

Xanthoria fallax (intermediately sensitive to sulfur dioxide; sensitive to NO_x/PAN)
Xanthoria elegans (intermediately sensitive to sulfur dioxide)
Xanthoria polycarpa (intermediately sensitive to sulfur dioxide)

Dark Canyon Wilderness Area (Peavine Canyon):

Amandinea punctata (intermediately sensitive to sulfur dioxide)
Candelariella vitellina (intermediately sensitive to sulfur dioxide)
Collema polycarpon (sensitive to intermediately sensitive to ozone)
Melanelia subolivacea (intermediately sensitive to ozone)
Phaeophyscia sciastra (sensitive to ozone)
Physcia caesia (intermediately sensitive to sulfur dioxide)
Physcia dubia (sensitive to intermediately sensitive to fluoride)
Physcia stellaris (intermediately sensitive to sulfur dioxide)
Rhizoplaca chrysoleuca (sensitive to sulfur dioxide)
Rhizoplaca melanophthalma (sensitive to sulfur dioxide)
Xanthoria elegans (intermediately sensitive to sulfur dioxide)
Xanthoria polycarpa (intermediately sensitive to sulfur dioxide)

vicinity of Duck Lake:

Amandinea punctata (intermediately sensitive to sulfur dioxide)
Caloplaca holocarpa (intermediately sensitive to sulfur dioxide)
Lecanora saligna (intermediately sensitive to sulfur dioxide)
Melanelia subolivacea (intermediately sensitive to ozone)
Peltigera canina (sensitive to ozone)
Peltigera rufescens (sensitive to intermediately sensitive to sulfur dioxide)
Phaeophyscia orbicularis (intermediately sensitive to sulfur dioxide; sensitive to ozone and fluoride)
Physcia adscendens (intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Physcia caesia (intermediately sensitive to sulfur dioxide)
Physcia dubia (sensitive to intermediately sensitive to fluoride)
Physcia stellaris (intermediately sensitive to sulfur dioxide)
Rhizoplaca melanophthalma (sensitive to sulfur dioxide)
Xanthoparmelia cumberlandia (sensitive to sulfur dioxide)
Xanthoria polycarpa (intermediately sensitive to sulfur dioxide)

top of East Mountain:

Amandinea punctata (intermediately sensitive to sulfur dioxide)
Caloplaca holocarpa (intermediately sensitive to sulfur dioxide)
Candelariella vitellina (intermediately sensitive to sulfur dioxide)
Lecanora saligna (intermediately sensitive to sulfur dioxide)
Melanelia exasperatula (intermediately sensitive to sulfur dioxide)
Melanelia subolivacea (intermediately sensitive to ozone)
Physcia alipolia (intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Physcia dubia (sensitive to intermediately sensitive to fluoride)
Physcia stellaris (intermediately sensitive to sulfur dioxide)
Xanthoria fallax (intermediately sensitive to sulfur dioxide; sensitive to NO_x/PAN)
Xanthoria elegans (intermediately sensitive to sulfur dioxide)
Xanthoria polycarpa (intermediately sensitive to sulfur dioxide)

vicinity of Geyser Pass:

Amandinea punctata (intermediately sensitive to sulfur dioxide)
Cladonia coniocraea (intermediately sensitive to sulfur dioxide)
Lecanora saligna (intermediately sensitive to sulfur dioxide)

Melanelia exasperatula (intermediately sensitive to sulfur dioxide)
Melanelia subolivacea (intermediately sensitive to sulfur dioxide and ozone)
Peltigera aphthosa (intermediately sensitive to sulfur dioxide)
Peltigera canina (sensitive to ozone)
Physcia adscendens (intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Physcia caesia (intermediately sensitive to sulfur dioxide)
Physcia dubia (sensitive to intermediately sensitive to fluoride)
Rhizocarpon geographicum (sensitive to fluoride)
Usnea subfloridana (sensitive to intermediately sensitive to sulfur dioxide)
Xanthoparmelia cumberlandia (sensitive to sulfur dioxide)
Xanthoria polycarpa (intermediately sensitive to sulfur dioxide)

vicinity of Great Basin Experimental Range Station:

Amandinea punctata (intermediately sensitive to sulfur dioxide)
Caloplaca holocarpa (intermediately sensitive to sulfur dioxide)
Cladonia coniocraea (intermediately sensitive to sulfur dioxide)
Lecanora saligna (intermediately sensitive to sulfur dioxide)
Melanelia subolivacea (intermediately sensitive to ozone)
Physcia adscendens (intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Physcia caesia (intermediately sensitive to sulfur dioxide)
Physcia stellaris (intermediately sensitive to sulfur dioxide)
Xanthoria candelaria (sensitive to ozone)
Xanthoria fallax (intermediately sensitive to sulfur dioxide; sensitive to NO_x/PAN)
Xanthoria polycarpa (intermediately sensitive to sulfur dioxide)

vicinity of Horseshoe Flat (along Skyline Drive):

Candelariella vitellina (intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Physcia adscendens (intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Xanthoria elegans (intermediately sensitive to sulfur dioxide)
Xanthoria fallax (intermediately sensitive to sulfur dioxide; sensitive to NO_x/PAN)
Xanthoria polycarpa (intermediately sensitive to sulfur dioxide)

along Lake Fork Creek:

Collema polycarpon (sensitive to intermediately sensitive to ozone)
Melanelia substygia (intermediately sensitive to ozone)
Phaeophyscia nigricans (intermediately sensitive to sulfur dioxide)
Phaeophyscia sciastra (sensitive to ozone)
Physcia adscendens (intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Physcia caesia (intermediately sensitive to sulfur dioxide)
Physcia dubia (sensitive to intermediately sensitive to fluoride)
Physcia stellaris (intermediately sensitive to sulfur dioxide)
Physconia detersa (intermediately sensitive to sulfur dioxide)
Rhizoplaca melanophthalma (sensitive to sulfur dioxide)
Xanthoria candelaria (sensitive to ozone)
Xanthoria elegans (intermediately sensitive to sulfur dioxide)
Xanthoria fallax (intermediately sensitive to sulfur dioxide; sensitive to NO_x/PAN)
Xanthoria polycarpa (intermediately sensitive to sulfur dioxide)

junction of La Sal Mountain Loop Road and U.S. Forest Service Road No. 067:

Melanelia subolivacea (intermediately sensitive to sulfur dioxide and ozone)
Physcia stellaris (intermediately sensitive to sulfur dioxide)
Rhizoplaca chrysoleuca (sensitive to sulfur dioxide)
Rhizoplaca melanophthalma (sensitive to sulfur dioxide)

Xanthoparmelia cumberlandia (sensitive to sulfur dioxide)
Xanthoria elegans (intermediately sensitive to sulfur dioxide)
Xanthoria polycarpa (intermediately sensitive to sulfur dioxide)

vicinity of Orange-Olsen Guard Station:

Candelariella vitellina (intermediately sensitive to sulfur dioxide)
Melanelia substygia (intermediately sensitive to ozone)
Physcia adscendens (intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Physcia stellaris (intermediately sensitive to sulfur dioxide)
Xanthoria candelaria (sensitive to ozone)
Xanthoria elegans (intermediately sensitive to sulfur dioxide)
Xanthoria polycarpa (intermediately sensitive to sulfur dioxide)

vicinity of Pine Ridge:

Amandinea punctata (intermediately sensitive to sulfur dioxide)
Candelariella vitellina (intermediately sensitive to sulfur dioxide)
Lecanora saligna (intermediately sensitive to sulfur dioxide)
Melanelia exasperatula (intermediately sensitive to sulfur dioxide)
Melanelia subolivacea (intermediately sensitive to ozone)
Peltigera rufescens (sensitive to intermediately sensitive to sulfur dioxide)
Physcia caesia (intermediately sensitive to sulfur dioxide)
Physcia dubia (sensitive to intermediately sensitive to fluoride)
Physcia stellaris (intermediately sensitive to sulfur dioxide)
Rhizocarpon geographicum (sensitive to fluoride)
Rhizoplaca melanophthalma (sensitive to sulfur dioxide)
Xanthoria elegans (intermediately sensitive to sulfur dioxide)
Xanthoria polycarpa (intermediately sensitive to sulfur dioxide)

near Pontown Creek along forest Boundary:

Candelariella vitellina (intermediately sensitive to sulfur dioxide)
Cladonia fimbriata (sensitive to intermediately sensitive to sulfur dioxide)
Collema polycarpon (sensitive to intermediately sensitive to ozone)
Peltigera rufescens (sensitive to intermediately sensitive to sulfur dioxide)
Physcia adscendens (intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Physcia caesia (intermediately sensitive to sulfur dioxide)
Physcia dubia (sensitive to intermediately sensitive to fluoride)
Rhizoplaca melanophthalma (sensitive to sulfur dioxide)
Xanthoria elegans (intermediately sensitive to sulfur dioxide)
Xanthoria fallax (intermediately sensitive to sulfur dioxide; sensitive to NO_x/PAN)
Xanthoria polycarpa (intermediately sensitive to sulfur dioxide)

Rilda Canyon:

Candelariella vitellina (intermediately sensitive to sulfur dioxide)
Melanelia exasperatula (intermediately sensitive to sulfur dioxide)
Melanelia substygia (intermediately sensitive to ozone)
Physcia stellaris (intermediately sensitive to sulfur dioxide)
Physconia detersa (intermediately sensitive to sulfur dioxide)
Xanthoria candelaria (sensitive to ozone)
Xanthoria polycarpa (intermediately sensitive to sulfur dioxide)

south of Wales Top:

Candelariella vitellina (intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Xanthoria elegans (intermediately sensitive to sulfur dioxide)

Xanthoria polycarpa (intermediately sensitive to sulfur dioxide)

CHECKLIST OF LICHEN SPECIES FROM SELECTED SITES IN THE MANTI LA SAL NATIONAL FOREST, UTAH

Information for each species includes: Growth form, substrate(s), collection sites, relative abundance, pollution sensitivity (if known), and location of herbarium specimens. The scale of relative abundance is rare < common < abundant. Assignment of relative abundance categories is based on the following criteria: rare = 1-2 encounters, common = 3-9 encounters, and abundant \geq 10 encounters.

Acarospora bullata Anzi

Growth form: crustose-squamulose

Substrate: rock

Site(s): near junction of U.S. Forest Service roads 067 and 062

Relative abundance: rare to locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C32814

Acarospora badiofusca (Nyl.) Th. Fr.

Growth form: crustose

Substrate: rock

Site(s): vicinity of Duck Lake

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C34460

Acarospora fuscata (Schrader) Arnold

Growth form: crustose

Substrate: rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, Orange-Olsen Guard Station, along USFS road #070 (Lake Fork Creek), South of Wales Top, near junction of U.S. Forest Service roads 067 and 062, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26967, BRY C-27077, BRY C-27095, BRY C-27116, BRY C-31927, BRY C-31945, BRY C-31960, BRY C-32798, BRY C-34524

Acarospora stapfiana (Müll. Arg.) Hue

Growth form: crustose

Substrate: rock, often growing over Caloplaca trachyphylla

Site(s): along USFS road #122 and Pontown Creek near forest boundary, Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, South of Wales Top, near junction of U.S. Forest Service roads 067 and 062, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26971, BRY C-27033, BRY C-31951, BRY C-32826, BRY C-34534

Acarospora strigata (Nyl.) Jatta

Growth form: crustose

Substrate: rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, Orange-Olsen Guard Station, South of Wales Top, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26975, BRY C-27021, BRY C-27084, BRY C-31932, BRY C-31935, BRY C-34518

Amandinea punctata (Hoffm.) Coppins ex Scheid.

Growth form: crustose

Substrate: bark, lignum

Site(s): mouth of Chris' Canyon, vicinity of Great Basin Experimental Range Station, top of East Mountain, vicinity of Geyser Pass, vicinity of Buckeye Reservoir, vicinity of Pine Ridge, vicinity of Duck Lake, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: common

Pollution sensitivity: intermediately sensitive to sulfur dioxide (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32014, BRY C-32022, BRY C-31907, BRY C-32123, BRY C-32132, BRY C-32133, BRY C-32767, BRY C-32750, BRY C-32693, BRY C-34497, BRY C-34815

Aspicilia cinerea (L.) Körber

Growth form: crustose

Substrate: rock

Site(s): along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, vicinity of Geyser Pass

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27117, BRY C-27143, BRY C-31974b, BRY C-32771

Aspicilia desertorum (Kremp.) Mereschk.

Growth form: crustose

Substrate: rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, Horseshoe Flat (along Skyline Drive), near junction of U.S. Forest Service roads 067 and 062, vicinity of Buckeye Reservoir, vicinity of Pine Ridge, vicinity of Duck Lake

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26950, BRY C-27126, BRY C-27140, BRY C-31985, BRY C-32799, BRY C-32711, BRY C-32651, BRY C-34447

Buellia disciformis (Fr.) Mudd

Growth form: crustose (scant)

Substrate: lignum

Site(s): vicinity of Pine Ridge

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32690

Buellia erubescens Arnold

Growth form: crustose

Substrate: bark

Site(s): vicinity of Duck Lake

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-34594

Caloplaca arizonica H. Magn.

Growth form: crustose

Substrate: lignum, bark

Site(s): top of East Mountain, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32113, BRY C-32124, BRY C-32140,
BRY C-34818

Caloplaca atroalba (Tuck.) Zahlbr.

Growth form: crustose (scant)

Substrate: rock

Site(s): vicinity of Buckeye Reservoir

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32735

Caloplaca cerina (Hedwig) Th. Fr.

Growth form: crustose (scant)

Substrate: bark

Site(s): vicinity of Duck Lake, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare to locally common

Pollution sensitivity:

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-34500b, BRY C-34823b

Caloplaca cladodes (Tuck.) Zahlbr.

Growth form: minutely fruticose

Substrate: soil over rock

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, vicinity of Pine Ridge

Relative abundance: rare to locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27028, BRY C-32695

Caloplaca decipiens (Arnold) Blomb. & Forss.

Growth form: crustose

Substrate: rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, along USFS road #070 (Lake Fork Creek)

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26972, BRY C-27139

Caloplaca durietzii H. Magn.

Growth form: crustose

Substrate: bark, lignum

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, top of East Mountain, vicinity of Duck Lake

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27027, BRY C-32111, BRY C-34500a

Caloplaca epithallina Lynge

Growth form: crustose (scant to absent)

Substrate: over thalli of crustose lichens, rock

Site(s): near junction of U.S. Forest Service roads 067 and 062, vicinity of Duck Lake

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32835, BRY C-34455

Caloplaca flavovirescens (Wulfen) Dalla Torre & Sarnth.

Growth form: crustose

Substrate: rock

Site(s): vicinity of Duck Lake

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-34493

Caloplaca fraudans (Th. Fr.) H. Olivier

Growth form: crustose (absent)

Substrate: rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, Orange-Olsen Guard Station, South of Wales Top, vicinity of Geyser Pass, vicinity of Buckeye Reservoir, near junction of U.S. Forest Service roads 067 and 062, vicinity of Pine Ridge, vicinity of Duck Lake

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26943, BRY C-27003, BRY C-27074, BRY C-27080, BRY C-31931, BRY C-32762, BRY C-32710, BRY C-32829, BRY C-32663, BRY C-34456

Caloplaca holocarpa (Hoffm. ex Ach.) M. Wade

Growth form: crustose

Substrate: lignum, bark

Site(s): vicinity of Great Basin Experimental Range Station, top of East Mountain, vicinity of Duck Lake

Relative abundance: common

Pollution sensitivity: intermediately sensitive to sulfur dioxide (Wetmore 1987)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-31913, BRY C-32139, BRY C-34604

Caloplaca modesta (Zahlbr.) Fink

Growth form: crustose

Substrate: rock

Site(s): South of Wales Top

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-31946

Caloplaca saxicola (Hoffm.) Nordin

Growth form: crustose

Substrate: rock

Site(s): mouth of Chris' Canyon

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-31987

Caloplaca trachyphylla (Tuck.) Zahlbr.

Growth form: crustose (with effigurate margins)

Substrate: rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, Orange-Olsen Guard Station, South of Wales Top, Horseshoe Flat (along Skyline Drive), near junction of U.S. Forest Service roads 067 and 062, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: abundant

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26970, BRY C-26991, BRY C-26995, BRY C-27015, BRY C-27076, BRY C-27082, BRY C-31926, BRY C-32805, BRY C-34506

Candelariella aurella (Hoffm.) Zahlbr.

Growth form: crustose

Substrate: rock, soil over rock

Site(s): near junction of U.S. Forest Service roads 067 and 062, vicinity of Duck Lake, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32824, BRY C-34451, BRY C-34530

Candelariella deflexa (Nyl.) Zahlbr.

Growth form: crustose (absent)

Substrate: lignum, bark

Site(s): Orange-Olsen Guard Station, vicinity of Duck Lake, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27055, BRY C-34583, BRY C-34813

Candelariella rosulans (Müll. Arg.) Zahlbr.

Growth form: crustose

Substrate: over moss, rock

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, Orange-Olsen Guard Station, along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, near junction of U.S. Forest Service roads 067 and 062, vicinity of Pine Ridge

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26986, BRY C-27089, BRY C-27115, BRY C-31994b, BRY C-32001, BRY C-32800, BRY C-32654

Candelariella subdeflexa (Nyl.) Lettau

Growth form: crustose

Substrate: lignum

Site(s): vicinity of Duck Lake

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-34480

Candelariella vitellina (Hoffm.) Müll. Arg.

Growth form: crustose

Substrate: moss, rock, soil over rock, lignum, bark

Site(s): along USFS road #122 and Pontown Creek near forest boundary, Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, Orange-Olsen Guard Station, South of Wales Top, top of East Mountain, Horseshoe Flat (along Skyline Drive), vicinity of Buckeye Reservoir, vicinity of Pine Ridge, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: common

Pollution sensitivity: intermediately sensitive to sulfur dioxide; sensitive to fluoride (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26941, BRY C-26997, BRY C-27032, BRY C-27073, BRY C-27083, BRY C-31956, BRY C-32105, BRY C-32112, BRY C-32146, BRY C-32707, BRY C-32689, BRY C-34832

Catapyrenium compactum (Massal.) R. Sant.

Growth form: squamulose

Substrate: rock

Site(s): top of East Mountain

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32108

Catapyrenium tuckermanni (Rav. ex Mont.) Thomson

Growth form: squamulose

Substrate: lignum

Site(s): Orange-Olsen Guard Station

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27053

Catapyrenium zahlbruckneri (Hasse) Thomson

Growth form: squamulose

Substrate: rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, Orange-Olsen Guard Station

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26965, BRY C-26998, BRY C-27002 BRY C-27071

Cladonia cariosa (Ach.) Sprengel

Growth form: squamulose (with podetia)

Substrate: soil

Site(s): vicinity of Geyser Pass, vicinity of Buckeye Reservoir

Relative abundance: rare to locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32774, BRY C-32771

Cladonia coniocraea (Flörke) Sprengel

Growth form: squamulose (with podetia)

Substrate: decomposing wood

Site(s): vicinity of Great Basin Experimental Range Station, vicinity of Geyser Pass

Relative abundance: rare to locally common

Pollution sensitivity: intermediately sensitive to sulfur dioxide (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-31924, BRY C-32769

Cladonia fimbriata (L.) Fr.

Growth form: squamulose (with podetia)

Substrate: decomposing wood

Site(s): along USFS road #122 and Pontown Creek near forest boundary

Relative abundance: common

Pollution sensitivity: sensitive to intermediately sensitive to sulfur dioxide (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26985

Cladonia pyxidata (L.) Hoffm.

Growth form: squamulose (with podetia)

Substrate: decomposing wood

Site(s): vicinity of Geyser Pass, vicinity of Buckeye Reservoir

Relative abundance: locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32778, BRY C-32725

Cladonia sulphurina (Michaux) Fr.

Growth form: squamulose (with podetia)

Substrate: decomposing wood

Site(s): vicinity of Geyser Pass

Relative abundance: rare to locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32793

Collema cristatum (L.) F.H. Wigg.

Growth form: foliose

Substrate: rock

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, along USFS road #070 (Lake Fork Creek)

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26992, BRY C-27128

Collema polycarpon Hoffm.

Growth form: foliose

Substrate: rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, along USFS road #070 (Lake Fork Creek), Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: common

Pollution sensitivity: sensitive to intermediately sensitive to ozone (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26976, BRY C-27130, BRY C-34542

Collema tenax (Sw.) Ach.

Growth form: crustose

Substrate: soil

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27018

Dermatocarpon intestiniforme (Körber) Hasse

Growth form: foliose (umbilicate)

Substrate: rock

Site(s): mouth of Chris' Canyon, vicinity of Pine Ridge

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-31992, BRY C-32658a

Dermatocarpon miniatum (L.) W. Mann

Growth form: foliose (umbilicate)

Substrate: rock

Site(s): vicinity of Buckeye Reservoir, vicinity of Pine Ridge, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32742, BRY C-32658b, BRY C-34525

Dermatocarpon reticulatum H. Magn.

Growth form: foliose (umbilicate)

Substrate: rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon

Relative abundance: abundant

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26974, BRY C-27016, BRY C-27029, BRY C-27136, BRY C-27179, BRY C-31970, BRY C-31991

Dimelaena oreina (Ach.) Norman

Growth form: crustose (with effigurate margins)

Substrate: rock

Site(s): mouth of Chris' Canyon, near junction of U.S. Forest Service roads 067 and 062,
Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32007, BRY C-32811, BRY C-34522

Diploschistes actinostomus (Ach.) Zahlbr.

Growth form: crustose

Substrate: rock

Site(s): mouth of Chris' Canyon

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-31990

Diploschistes scruposus (Schreber) Norman

Growth form: crustose

Substrate: rock

Site(s): along USFS road #070 (Lake Fork Creek)

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27149

Endocarpon pusillum Hedwig

Growth form: crustose

Substrate: rock

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27040

Evernia divaricata (L.) Ach.

Growth form: fruticose

Substrate: bark

Site(s): vicinity of Geyser Pass, vicinity of Buckeye Reservoir, vicinity of Pine Ridge

Relative abundance: locally common to abundant

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32780, BRY C-32746, BRY C-32682

Fulgensia bracteata (Hoffm.) Räsänen

Growth form: squamulose

Substrate: soil

Site(s): Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare to locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-34552

Heteropladidium acarosporoides (Zahlbr.) Breuss

Growth form: crustose

Substrate: rock

Site(s): Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare to locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-34516

Lecanora argopholis (Ach.) Ach.

Growth form: crustose

Substrate: rock

Site(s): mouth of Chris' Canyon, near junction of U.S. Forest Service roads 067 and 062,
vicinity of Buckeye Reservoir, vicinity of Duck Lake

Relative abundance: locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-31989, BRY C-32807, BRY C-32740,
BRY C-34457

Lecanora bicincta Ramond

Growth form: crustose

Substrate: rock

Site(s): mouth of Chris' Canyon

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32011

Lecanora cenisia Ach.

Growth form: crustose

Substrate: rock

Site(s): along USFS road #070 (Lake Fork Creek), vicinity of Buckeye Reservoir

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27113, BRY C-32714

Lecanora crenulata Hook.

Growth form: crustose (scant)

Substrate: rock

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, Orange-Olsen Guard Station, South of Wales Top, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27024, BRY C-27081, BRY C-31929, BRY C-31930, BRY C-34509

Lecanora dispersa (Pers.) Sommerf.

Growth form: crustose (often lacking)

Substrate: rock

Site(s): top of East Mountain

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32141

Lecanora garovaglii (Körber) Zahlbr.

Growth form: crustose (with effigurate margins)

Substrate: rock

Site(s): mouth of Chris' Canyon, South of Wales Top, near junction of U.S. Forest Service roads 067 and 062, vicinity of Duck Lake, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-31997, BRY C-32000, BRY C-31936, BRY C-32825, BRY C-34464, BRY C-34514

Lecanora hageni (Ach.) Ach.

Growth form: crustose (scant)

Substrate: lignum, bark

Site(s): Orange-Olsen Guard Station, along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, vicinity of Great Basin Experimental Range Station, top of East Mountain, vicinity of Duck Lake, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27058, BRY C-27170, BRY C-31893b, BRY C-31903, BRY C-31912, BRY C-32110, BRY C-32145, BRY C-34577, BRY C-34814

Lecanora mughicola Nyl.

Growth form: crustose (scant)

Substrate: lignum

Site(s): vicinity of Pine Ridge

Relative abundance: locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32692

Lecanora muralis (Schreber) Rabenh.

Growth form: crustose (with effigurate margins)

Substrate: rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, Pine Ridge, near junction of U.S. Forest Service roads 067 and 062, vicinity of Duck Lake, Dark Canyon Wilderness Area

Relative abundance: abundant

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26952, BRY C-27114, BRY C-27123, BRY C-31982, BRY C-32655, BRY C-32802, BRY C-34445, BRY C-34547

Lecanora novomexicana H. Magn.

Growth form: crustose (with effigurate margins)

Substrate: rock

Site(s): mouth of Chris' Canyon, near junction of U.S. Forest Service roads 067 and 062, vicinity of Geyser Pass, vicinity of Duck Lake, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare to locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32004, BRY C-32834, BRY C-32755, BRY C-34491, BRY C-34521

Lecanora phaedrophthalma Poelt

Growth form: crustose (with effigurate margins)

Substrate: rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, Orange-Olsen Guard Station, vicinity of Pine Ridge

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26956, BRY C-27090, BRY C-32655

Lecanora piniperda Körber

Growth form: crustose

Substrate: bark

Site(s): top of East Mountain

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32128

Lecanora polytropia (Hoffm.) Rabenh.

Growth form: crustose (scant)

Substrate: rock

Site(s): vicinity of Great Basin Experimental Range Station, vicinity of Geyser Pass, vicinity of Buckeye Reservoir

Relative abundance: locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-31917, BRY C-32764, BRY C-32709

Lecanora rupicola (L.) Zahlbr.

Growth form: crustose

Substrate: rock

Site(s): vicinity of Geyser Pass

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32772

Lecanora saligna (Schrader) Zahlbr.

Growth form: crustose (scant)

Substrate: bark, lignum

Site(s): vicinity of Great Basin Experimental Range Station, top of East Mountain, vicinity of Geyser Pass, vicinity of Pine Ridge, vicinity of Duck Lake

Relative abundance: rare

Pollution sensitivity: intermediately sensitive to sulfur dioxide (Wetmore 1987)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-31918, BRY C-32129, BRY C-32768, BRY C-32691, BRY C-34481

Lecanora valesiaca (Müll. Arg.) Stizenb.

Growth form: crustose (with effigurate margins)

Substrate: rock

Site(s): Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare to locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-34539

Lecanora varia (Hoffm.) Ach.

Growth form: crustose (scant)

Substrate: lignum, bark

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, Orange-Olsen Guard Station, mouth of Chris' Canyon, vicinity of Geyser Pass, vicinity of Duck Lake

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27010, BRY C-27063, BRY C-32015, BRY C-32766, BRY C-34585

Lecidea atrobrunnea (Ramond ex Lam. & DC.) Schaerer

Growth form: crustose

Substrate: rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, Pine Ridge, near junction of U.S. Forest Service roads 067 and 062, vicinity of Geyser Pass, vicinity of Buckeye Reservoir, vicinity of Pine Ridge, vicinity of Duck Lake

Relative abundance: locally abundant

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26946, BRY C-27121, BRY C-31986, BRY C-32005, BRY C-32652, BRY C-32803, BRY C-32770, BRY C-32715, BRY C-32652, BRY C-34446

Lecidea leucothallina Arnold

Growth form: crustose

Substrate: rock

Site(s): vicinity of Duck Lake

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-34467

Lecidea plana (J. Lahm) Nyl.

Growth form: crustose (scant)

Substrate: rock

Site(s): vicinity of Pine Ridge

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32696

Lecidea tessellata Flörke

Growth form: crustose (well developed to scant)

Substrate: rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, Orange-Olsen Guard Station, along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, South of Wales Top, Horseshoe Flat (along Skyline Drive), near junction of U.S. Forest Service roads 067 and 062, vicinity of Geyser Pass, vicinity of Buckeye Reservoir, vicinity of Pine Ridge, vicinity of Duck Lake, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: locally abundant

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26969, BRY C-27092, BRY C-27122, BRY C-27145, BRY C-31995, BRY C-31947, BRY C-32809, BRY C-32756, BRY C-32712, BRY C-32661a, BRY C-34448, BRY C-34504

Lecidella carpathica Körber

Growth form: crustose

Substrate: rock

Site(s): vicinity of Buckeye Reservoir

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32727

Lecidella euphorea (Flörke) Hertel

Growth form: crustose

Substrate: lignum

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, vicinity of Duck Lake

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27026, BRY C-34476

Lecidella stigmata (Ach.) Hertel & Leuckert

Growth form: crustose

Substrate: rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, mouth of Chris' Canyon, vicinity of Geyser Pass, vicinity of Pine Ridge, vicinity of Duck Lake

Relative abundance: locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26942, BRY C-31981, BRY C-31993, BRY C-32002, BRY C-32757, BRY C-32661b, BRY C-34449

Leptogium gelatinosum (With.) J.R. Laundon

Growth form: foliose

Substrate: moss over rock

Site(s): along USFS road #070 (Lake Fork Creek)

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27157

Lobothallia alphoplaca (Wahlenb.) Hafellner

Growth form: crustose (with effigurate margins)

Substrate: rock

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, near junction of U.S. Forest Service roads 067 and 062

Relative abundance: common to locally abundant

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27023, BRY C-27112, BRY C-27118, BRY C-31999, BRY C-32830

Megaspora verrucosa (Ach.) Hafellner & V. Wirth

Growth form: crustose

Substrate: bark

Site(s): top of East Mountain

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32137

Melanelia elegantula (Zahlbr.) Essl.

Growth form: foliose

Substrate: moss over rock, bark, rock, lignum

Site(s): along USFS road #122 and Pontown Creek near forest boundary, Orange-Olsen Guard Station, along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, vicinity of Great Basin Experimental Range Station, South of Wales Top, top of East Mountain, vicinity of Buckeye Reservoir, vicinity of Duck Lake

Relative abundance: common to locally abundant

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26983, BRY C-27065, BRY C-27155, BRY C-27161, BRY C-27174, BRY C-31968, BRY C-31996, BRY C-32013, BRY C-32016, BRY C-31895, BRY C-31911a, BRY C-31911b, BRY C-31919, BRY C-31942, BRY C-32130, BRY C-32134, BRY C-32747, BRY C-34574

Melanelia exasperatula (Nyl.) Essl.

Growth form: foliose

Substrate: bark

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, top of East Mountain, vicinity of Geyser Pass, vicinity of Buckeye Reservoir, vicinity of Pine Ridge

Relative abundance: common

Pollution sensitivity: intermediately sensitive to sulfur dioxide (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27009, BRY C-32136, BRY C-32783, BRY C-32744, BRY C-32705

Melanelia subolivacea (Nyl.) Essl.

Growth form: foliose

Substrate: bark

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, Orange-Olsen Guard Station, along USFS road #070 (Lake Fork Creek), vicinity of Great Basin Experimental Range Station, top of East Mountain, near junction of U.S. Forest Service roads 067 and 062, vicinity of Geyser Pass, vicinity of Buckeye Reservoir, vicinity of Pine Ridge, vicinity of Duck Lake, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: common to locally abundant

Pollution sensitivity: intermediately sensitive to sulfur dioxide and ozone (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27042, BRY C-27060, BRY C-27173, BRY C-31897, BRY C-32126, BRY C-32135, BRY C-32815, BRY C-32782, BRY C-32745, BRY C-32665, BRY C-34575, BRY C-34822

Melanelia tominii (Oksner) Essl.

Growth form: foliose

Substrate: rock

Site(s): along USFS road #070 (Lake Fork Creek), Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare to locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27147, BRY C-27151, BRY C-34550

Mycobilimbia berengeriana (Massal.) Hafellner & V. Wirth

Growth form: crustose

Substrate: soil

Site(s): vicinity of Geyser Pass

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32794

Peltigera apthosa (L.) Willd.

Growth form: foliose

Substrate: soil

Site(s): vicinity of Geyser Pass

Relative abundance: locally common

Pollution sensitivity: intermediately sensitive to sulfur dioxide (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32791

Peltigera canina (L.) Willd.

Growth form: foliose

Substrate: soil

Site(s): vicinity of Geyser Pass, vicinity of Duck Lake

Relative abundance: locally common

Pollution sensitivity: sensitive to ozone

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32775, BRY C-34471

Peltigera rufescens (Weiss) Humb.

Growth form: foliose

Substrate: soil

Site(s): along USFS road #122 and Pontown Creek near forest boundary, vicinity of Buckeye Reservoir, vicinity of Pine Ridge, vicinity of Duck Lake

Relative abundance: common

Pollution sensitivity: sensitive to intermediately sensitive to sulfur dioxide

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26984, BRY C-32722, BRY C-32659, BRY C-34462

Peltigera venosa (L.) Hoffm.

Growth form: foliose
Substrate: soil
Site(s): vicinity of Geyser Pass
Relative abundance: rare
Pollution sensitivity: unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-32795

Phaeophyscia cernohorskyi (Nádv.) Essl.

Growth form: foliose
Substrate: bark
Site(s): vicinity of Duck Lake
Relative abundance: rare to locally common
Pollution sensitivity: unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-34606

Phaeophyscia decolor (Kashiw.) Essl.

Growth form: foliose
Substrate: moss over rock
Site(s): vicinity of Buckeye Reservoir
Relative abundance: rare to locally common
Pollution sensitivity: unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-32738

Phaeophyscia endococcina (Körber) Moberg

Growth form: foliose
Substrate: moss over rock
Site(s): along USFS road #070 (Lake Fork Creek)
Relative abundance: common
Pollution sensitivity: unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-27150, BRY C-27152

Phaeophyscia nigricans (Flörke) Moberg

Growth form: foliose
Substrate: bark
Site(s): along USFS road #070 (Lake Fork Creek)
Relative abundance: common
Pollution sensitivity: intermediately sensitive to sulfur dioxide (Wetmore 1987)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-27165, BRY C-27166

Phaeophyscia orbicularis (Necker) Moberg

Growth form: foliose
Substrate: bark
Site(s): vicinity of Duck Lake
Relative abundance: rare
Pollution sensitivity: intermediately sensitive to sulfur dioxide, sensitive to ozone and fluoride (Ryan 1990)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-34501

Phaeophyscia sciastra (Ach.) Moberg

Growth form: foliose

Substrate: moss over rock, rock

Site(s): along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, Dark Canyon
Wilderness Area (Peavine Canyon)

Relative abundance: locally common

Pollution sensitivity: sensitive to ozone (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27103, BRY C-27108, BRY C-27148,
BRY C-27163, BRY C-31975, BRY C-34533

Physcia adscendens (Fr.) H. Olivier

Growth form: foliose

Substrate: bark

Site(s): along USFS road #122 and Pontown Creek near forest boundary, Orange-Olsen Guard
Station, along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, vicinity of
Great Basin Experimental Range Station, Horseshoe Flat (along Skyline Drive), vicinity of
Geyser Pass, vicinity of Duck Lake

Relative abundance: common

Pollution sensitivity: intermediately sensitive to sulfur dioxide; sensitive to fluoride (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26979, BRY C-26982, BRY C-27057,
BRY C-27062, BRY C-27164, BRY C-27168, BRY C-31894, BRY C-31901, BRY C-
31910, BRY C-32784, BRY C-34580

Physcia aipolia (Ehrh. ex Humb.) Fűrnr.

Growth form: foliose

Substrate: lignum

Site(s): top of East Mountain

Relative abundance: common

Pollution sensitivity: intermediately sensitive to sulfur dioxide; sensitive to fluoride (Ryan
1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32115

Physcia biziana (Massal.) Zahlbr.

Growth form: foliose

Substrate: rock

Site(s): mouth of Chris' Canyon

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-31973

Physcia caesia (Hoffm.) F  rn  r.

Growth form: foliose

Substrate: moss over rock, rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, vicinity of Great Basin Experimental Range Station, vicinity of Geyser Pass, vicinity of Buckeye Reservoir, vicinity of Pine Ridge, vicinity of Duck Lake, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: locally common

Pollution sensitivity: intermediately sensitive to sulfur dioxide (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26949, BRY C-27099, BRY C-27131, BRY C-31965, BRY C-31976, BRY C-31925, BRY C-32760, BRY C-32736, BRY C-32660, BRY C-34496, BRY C-34519

Physcia dubia (Hoffm.) Lettau

Growth form: foliose

Substrate: rock, bark, lignum

Site(s): along USFS road #122 and Pontown Creek near forest boundary, along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, top of East Mountain, Pine Ridge, vicinity of Geyser Pass, vicinity of Pine Ridge, vicinity of Duck Lake, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare to locally common

Pollution sensitivity: sensitive to intermediately sensitive to fluoride (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26977, BRY C-27110, BRY C-27158, BRY C-27177, BRY C-27178, BRY C-31983, BRY C-32020, BRY C-32021, BRY C-32143a, BRY C-32657, BRY C-32765, BRY C-32657, BRY C-34450, BRY C-34816a

Physcia magnussonii Frey

Growth form: foliose

Substrate: rock

Site(s): near junction of U.S. Forest Service roads 067 and 062

Relative abundance: rare to locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32812

Physcia stellaris (L.) Nyl.

Growth form: foliose

Substrate: bark, lignum

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, Orange-Olsen Guard Station, along USFS road #070 (Lake Fork Creek), vicinity of Great Basin Experimental Station, top of East Mountain, near junction of U.S. Forest Service roads 067 and 062, vicinity of Buckeye Reservoir, vicinity of Pine Ridge, vicinity of Duck Lake, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: common

Pollution sensitivity: intermediately sensitive to sulfur dioxide (Wetmore 1987)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27035, BRY C-27061, BRY C-27172, BRY C-31898, BRY C-32119, BRY C-32127, BRY C-32136a, BRY C-32817, BRY C-32751, BRY C-32668, BRY C-34499, BRY C-34816b

Physciella chloantha (Ach.) Essl.

Growth form: foliose

Substrate: bark

Site(s): top of East Mountain, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32121, BRY C-34820

Physconia detersa (Nyl.) Poelt

Growth form: foliose

Substrate: moss over bark, rock

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, along USFS road #070 (Lake Fork Creek)

Relative abundance: rare

Pollution sensitivity: intermediately sensitive to sulfur dioxide (Wetmore 1987)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27037, BRY C-27102, BRY C-27142, BRY C-27154

Physconia enteroxantha (Nyl.) Poelt

Growth form: foliose

Substrate: moss, soil over rock, rock

Site(s): along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27109, BRY C-27141, BRY C-31971

Physconia isidiigera (Zahlbr.) Essl.

Growth form: foliose

Substrate: moss over rock

Site(s): mouth of Chris' Canyon

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-31978

Placidium squamulosum

Growth form: squamulose

Substrate: soil, soil over rock

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, vicinity of Buckeye Reservoir, vicinity of Pine Ridge, vicinity of Duck Lake, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27019, BRY C-32729, BRY C-32698, BRY C-34463, BRY C-34531

Protoparmelia badia (Hoffm.) Hafellner

Growth form: crustose

Substrate: rock

Site(s): vicinity of Buckeye Reservoir

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32718

Psora cerebriiformis W.A. Weber

Growth form: squamulose

Substrate: soil

Site(s): Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare to locally common

Pollution sensitivity: unknown

Deposition of specimens: BYU Herbarium: BRY C- 34548

Psora decipiens (Hedwig) Hoffm.

Growth form: squamulose

Substrate: soil over rock

Site(s): Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare

Pollution sensitivity: unknown

Deposition of specimens: BYU Herbarium: BRY C- 34543

Psora globifera (Ach.) A. Massal.

Growth form: squamulose

Substrate: on soil over rock

Site(s): vicinity of Buckeye Reservoir, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare to locally common

Pollution sensitivity: unknown

Deposition of specimens: BYU Herbarium: BRY C- 32730, BRY C-34528

Psora luridella (Tuck.) Fink

Growth form: squamulose

Substrate: on soil over rock

Site(s): mouth of Chris' Canyon, vicinity of Duck Lake

Relative abundance: rare

Pollution sensitivity: unknown

Deposition of specimens: BYU Herbarium: BRY C- 31984, BRY C-34472

Psora nipponica (Zahlbr.) Gotth.

Growth form: squamulose

Substrate: on soil/moss over rock

Site(s): vicinity of Buckeye Reservoir

Relative abundance: rare

Pollution sensitivity: unknown

Deposition of specimens: BYU Herbarium: BRY C- 32737

Psora tuckermanii R. Anderson ex Timdal

Growth form: squamulose

Substrate: soil over rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, Orange-Olsen Guard Station, along USFS road #070 (Lake Fork Creek), top of East Mountain, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: locally common to abundant

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26963, BRY C-26987, BRY C-27031, BRY C-27068, BRY C-27100, BRY C-27107, BRY C-32104, BRY C-34511

Psoroma hypnorum (Vahl) Gray

Growth form: squamulose

Substrate: soil

Site(s): vicinity of Geyser Pass

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32776

Pyrrhospora elabens (Fr.) Hafellner

Growth form: crustose

Substrate: bark

Site(s): top of East Mountain

Relative abundance: rare

Pollution sensitivity: unknown

Comments: This is new species record for the state of Utah

Deposition of specimens: BYU Herbarium: BRY C-32138

Ramalina sinensis Jatta

Growth form: fruticose

Substrate: bark

Site(s): vicinity of Geyser Pass, vicinity of Pine Ridge, vicinity of Duck Lake, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare to locally common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32779, BRY C-32664, BRY C-34498, BRY C-34825

Rhizocarpon disporum (Nägeli ex Hepp) Müll. Arg.

Growth form: crustose

Substrate: rock

Site(s): along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, near junction of U.S. Forest Service roads 067 and 062, vicinity of Buckeye Reservoir, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27133, BRY C-27144, BRY C-27146, BRY C-31974a, BRY C-31988, BRY C-32012, BRY C-32806, BRY C-32732, BRY C-34545

Rhizocarpon geographicum (L.) DC.

Growth form: crustose

Substrate: rock

Site(s): mouth of Chris' Canyon, vicinity of Geyser Pass, vicinity of Pine Ridge

Relative abundance: common

Pollution sensitivity: sensitive to fluoride (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-31998, BRY C-32010, BRY C-32759, BRY C-32662

Rhizocarpon superficiale (Schaerer) Vainio

Growth form: crustose

Substrate: rock

Site(s): vicinity of Geyser Pass

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32773

Rhizoplaca chryssoleuca (Sm.) Zopf

Growth form: foliose (umbilicate)

Substrate: rock

Site(s): near junction of U.S. Forest Service roads 067 and 062, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare to locally common

Pollution sensitivity: sensitive to sulfur dioxide (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32838, BRY C-34520

Rhizoplaca melanophthalma (DC.) Leuckert & Poelt

Growth form: foliose (umbilicate)

Substrate: rock, lignum

Site(s): along USFS road #122 and Pontown Creek near forest boundary, along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, near junction of U.S. Forest Service roads 067 and 062, vicinity of Buckeye Reservoir, vicinity of Pine Ridge, vicinity of Duck Lake, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: locally common to abundant

Pollution sensitivity: sensitive to sulfur dioxide (Ryan 1990)

Comments: lignum is an unusual substrate for this species

Deposition of specimens: BYU Herbarium: BRY C-26947, BRY C-27106, BRY C-31967, BRY C-32797, BRY C-32731b, BRY C-32686, BRY C-34469, BRY C-34505

Rhizoplaca peltata (Ramond) Leuckert & Poelt

Growth form: foliose (umbilicate)

Substrate: rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, near junction of U.S. Forest Service roads 067 and 062, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: locally common to abundant

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26953, BRY C-27119, BRY C-31969, BRY C-32832, BRY C-34512

Rinodina castanomela (Nyl.) Arnold

Growth form: crustose

Substrate: rock

Site(s): Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare

Pollution sensitivity: unknown

Deposition of specimens: BYU Herbarium: BRY C- 34527

Sarcogyne dakotensis H. Magn.

Growth form: crustose

Substrate: rock

Site(s): top of East Mountain

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32102

Sarcogyne regularis Körber

Growth form: crustose (scant)

Substrate: rock

Site(s): vicinity of Buckeye Reservoir

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32720

Squamarina lentigera (Weber) Poelt

Growth form: squamulose

Substrate: soil

Site(s): Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare to locally common

Pollution sensitivity: unknown

Deposition of specimens: BYU Herbarium: BRY C- 34551

Staurothele areolata (Ach.) Lettau

Growth form: crustose

Substrate: rock

Site(s): mouth of Chris' Canyon, vicinity of Great Basin Experimental Range Station, near junction of U.S. Forest Service roads 067 and 062, vicinity of Buckeye Reservoir, vicinity of Pine Ridge, vicinity of Duck Lake, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-31980, BRY C-31906, BRY C-32831, BRY C-32733, BRY C-32653, BRY C-34452, BRY C-34502

Staurothele drummondii (Tuck.) Tuck.

Growth form: crustose

Substrate: rock

Site(s): Orange-Olsen Guard Station, vicinity of Great Basin Experimental Range Station,
South of Wales Top, top of East Mountain, Horseshoe Flat (along Skyline Drive), near
junction of U.S. Forest Service roads 067 and 062

Relative abundance: locally common to abundant

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27067, BRY C-31905, BRY C-31958,
BRY C-31963, BRY C-32143b, BRY C-32804

Staurothele elenkinii Oksner

Growth form: crustose (scant)

Substrate: rock

Site(s): South of Wales Top, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimen: BYU Herbarium: BRY C-31928, BRY C-34510

Tephromela atra (Hudson) Hafellner

Growth form: crustose

Substrate: lignum

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27025

Toninia candida (Weber) Th. Fr.

Growth form: squamulose

Substrate: soil over rock

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27001

Toninia sedifolia (Scop.) Timdal

Growth form: squamulose

Substrate: soil

Site(s): Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: rare to locally common

Pollution sensitivity: unknown

Deposition of specimens: BYU Herbarium: BRY C- 34532

Toninia tristis (Th. Fr.) Th. Fr.

Growth form: squamulose

Substrate: soil over rock

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26988

Umbilicaria virginis Schaerer

Growth form: foliose (umbilicate)

Substrate: rock

Site(s): mouth of Chris' Canyon

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-31966

Usnea hirta (L.) F.H. Wigg.

Growth form: fruticose

Substrate: bark

Site(s): vicinity of Buckeye Reservoir

Relative abundance: rare to locally common

Pollution sensitivity: sensitive to intermediately sensitive to sulfur dioxide and ozone (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32743

Usnea subfloridana Stirton

Growth form: fruticose

Substrate: bark

Site(s): vicinity of Geyser Pass

Relative abundance: rare to locally common

Pollution sensitivity: sensitive to intermediately sensitive to sulfur dioxide (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32781

Xanthoparmelia coloradoensis (Gyelnik) Hale

Growth form: foliose

Substrate: rock

Site(s): mouth of Chris' Canyon, vicinity of Buckeye Reservoir

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32003, BRY C-32731a

Xanthoparmelia cumberlandia (Gyelnik) Hale

Growth form: foliose

Substrate: rock

Site(s): near junction of U.S. Forest Service roads 067 and 062, vicinity of Geyser Pass, vicinity of Duck Lake

Relative abundance: locally common

Pollution sensitivity: sensitive to sulfur dioxide (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-32808, BRY C-32758, BRY C-34495

Xanthoparmelia mexicana (Gyelnik) Hale

Growth form: foliose

Substrate: rock

Site(s): Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: locally common

Pollution sensitivity: unknown

Deposition of specimens: BYU Herbarium: BRY C-34553

Xanthoparmelia plittii (Gyelnik) Hale

Growth form: foliose

Substrate: rock

Site(s): along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27111, BRY C-271531, BRY C-32009

Xanthoria candelaria (L.) Th. Fr.

Growth form: foliose

Substrate: bark, lignum

Site(s): Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, Orange-Olsen Guard Station, along USFS road #070 (Lake Fork Creek), vicinity of Great Basin Experimental Range Station

Relative abundance: rare

Pollution sensitivity: sensitive to ozone (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27044, BRY C-27051, BRY C-27159, BRY C-27176a, BRY C-32017, BRY C-31909

Xanthoria elegans (Link) Th. Fr.

Growth form: foliose

Substrate: rock, lignum, moss over rock

Site(s): along USFS road #122 and Pontown Creek near forest boundary, Orange-Olsen Guard Station, along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, South of Wales Top, top of East Mountain, Horseshoe Flat (along Skyline Drive), near junction of U.S. Forest Service roads 067 and 062, vicinity of Pine Ridge, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: locally common to abundant

Pollution sensitivity: intermediately sensitive to sulfur dioxide (Ryan 1990)

Comments: lignum is an unusual substrate for this species

Deposition of specimens: BYU Herbarium: BRY C-26945, BRY C-26958, BRY C-27059, BRY C-27079, BRY C-27101, BRY C-27132, BRY C-31964, BRY C-31977, BRY C-31979, BRY C-31957, BRY C-32100, BRY C-32103, BRY C-32144, BRY C-32813, BRY C-32687, BRY C-34503

Xanthoria fallax (Hepp in Arnold) Arnold

Growth form: foliose

Substrate: bark

Site(s): along USFS road #122 and Pontown Creek near forest boundary, along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, vicinity of Great Basin Experimental Range Station, top of East Mountain, Horseshoe Flat (along Skyline Drive), vicinity of Buckeye Reservoir

Relative abundance: abundant

Pollution sensitivity: sensitive to intermediately sensitive to sulfur dioxide; sensitive to NOx/PAN (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26978, BRY C-27167, BRY C-27169, BRY C-27176b, BRY C-32019, BRY C-31892, BRY C-31900, BRY C-31911, BRY C-31921, BRY C-32118, BRY C-32142, BRY C-32749

Xanthoria polycarpa (Hoffm.) Rieber

Growth form: foliose

Substrate: bark

Site(s): along USFS road #122 and Pontown Creek near forest boundary, Rilda Canyon along Rilda Creek (left fork) -ephemeral drainage, Orange-Olsen Guard Station, along USFS road #070 (Lake Fork Creek), mouth of Chris' Canyon, vicinity of Great Basin Experimental Range Station, South of Wales Top, top of East Mountain, Horseshoe Flat (along Skyline Drive), near junction of U.S. Forest Service roads 067 and 062, vicinity of Geyser Pass, vicinity of Buckeye Reservoir, vicinity of Pine Ridge, vicinity of Duck Lake, Dark Canyon Wilderness Area (Peavine Canyon)

Relative abundance: locally common to abundant

Pollution sensitivity: intermediately sensitive to sulfur dioxide (Ryan 1990)

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-26980, BRY C-26981, BRY C-27020, BRY C-27036, BRY C-27041, BRY C-27043, BRY C-27045, BRY C-27046, BRY C-27047, BRY C-27056, BRY C-27064, BRY C-27066, BRY C-27175, BRY C-32018, BRY C-31896, BRY C-31902, BRY C-31904, BRY C-31923, BRY C-31941, BRY C-31943, BRY C-32125, BRY C-32816, BRY C-32785, BRY C-32748, BRY C-32667, BRY C-34572, BRY C-34817

Xanthoria soredata (Vainio) Poelt

Growth form: foliose

Substrate: rock

Site(s): mouth of Chris' Canyon

Relative abundance: rare

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-31972

Xylographa parallela (Ach. Fr.) Behlen & Desberg

Growth form: crustose (endoxyllic)

Substrate: lignum

Site(s): Orange-Olsen Guard Station

Relative abundance: common

Pollution sensitivity: unknown

Comments: none

Deposition of specimens: BYU Herbarium: BRY C-27050

OBSERVATIONS AND CONCLUSIONS:

1. Lichen species collected at selected reference sites in the Manti-La Sal National Forest make up a diverse and well developed flora. From our collections at the 15 air quality biomonitoring reference sites we have identified a total of 143 species in 48 genera. All growth forms are represented; however the flora is dominated by crustose species (51%, 73 species), followed by foliose species (31%, 45 species). Squamulose lichens make up 15% of the flora (21 species); while fruticose species comprise only 3% of the flora with 5 species. This growth form pattern is typical of other Intermountain Area lichen floras which are characteristically dominated by crustose species (e.g. 48% in the Bridger Wilderness Area, and 50% in the High Uintas Wilderness Area; with foliose species representing 28% and 29% of the lichen flora in those wilderness areas). A similar study conducted at several sites along the Wasatch Front yielded an even higher percentage of crustose species (60%, 91 out of 155 species). The abundance of crustose species along the Wasatch Front (a growth form generally thought to be more tolerant of air pollution) suggests that other more sensitive growth forms (especially fruticose and foliose species) may have over time been reduced in numbers due to declining air quality. The proximity of some of the Manti-La Sal National Forest reference sites to the Wasatch Front suggests the need for careful monitoring of sensitive indicator species and growth form distribution patterns.
2. Lichen specimens were collected from 5 basic substrates: rocks, lignum/bark, moss/detritus, soil, and other lichens. A total of 82 species (57% of the flora) were collected from various rock substrates. Species on bark and lignum substrates were next in abundance, totaling 40 species (28% of the flora). One species (1% of the flora) was collected from moss and detritus substrates, while 19 species (13% of the flora) were collected from soil substrates. Finally, 2 species (1%) occurred on other lichens. Intermountain Area lichen floras are typically dominated by rock species. For example, 37% (67 species) of the lichen flora from the High Uintas Wilderness Area (northeastern Utah) are from rock substrates with only 23% (41 species) from corticolous (bark and lignum) substrates. The Bridger Wilderness Area, in western Wyoming, shows a similar pattern with 51% (76 species) reported from rock substrates and 23% (35 species) from bark and lignum.
3. Total species diversity (143 species in 48 genera) suggests that overall the lichen communities in the Manti-La Sal National Forest have not been heavily impacted by air pollution. Furthermore, the relatively high average number of sensitive indicator species per reference site (10.1 species) also suggests little or no air pollution-related impact in the Manti-La Sal National Forest. This compares to 10.3 for the High Uintas Wilderness area, 8.0 for the Bridger Wilderness area, and 6.3 for sites along the Wasatch Front. However, there are some discrepancies in the average number of sensitive indicator species per reference site between the Monticello-Moab districts (11.8) and the Price, San Pete, and Ferron districts (8.9). This difference might be related, at least in part, to the general proximity of the Price, San Pete, and Ferron sites to the air pollution problems of the Wasatch Front.
4. Necrotic and/or bleached thalli (typical signs of air pollution-related impact) were generally absent.
5. Baseline concentrations of potential pollutant elements were determined by analyzing the tissues of at least one sensitive indicator species from each reference site (Table 1). Pollutant element concentrations in several samples exceeded background levels (Figure 2). For example, four samples (339, 494, 533, and 547) showed elevated levels of sulfur (0.196-0.27%). It is generally thought that sulfur concentrations in lichen thalli of .2% or higher indicate significant sulfur accumulation, which may interfere with sensitive metabolic activities such as photosynthesis, cellular respiration and nitrogen fixation. One sample,

TABLE #1: Mean concentrations of potential pollutant elements in sensitive indicator species from air quality biomonitoring reference sites in the Manti-La Sal National Forest.

Species and Collection Site	Elements (ppm except where indicated)									
	S%	Cl	K%	Ca%	Ti	V	Cr	Ni	Cu	Zn
<i>Rhizoplaca melanophthalma</i> , Pontown Creek, Sample #338, on rock	0.096	725	0.298	1.13	305	6.23	4.76	4.08	6.53	22.8
<i>Xanthoria elegans</i> , Rilda Canyon, Sample #339, on rock	0.227	1050	0.591	1.8	490	12.8	15.9	10.4	9.43	41.8
<i>Xanthoria elegans</i> , Lake Fork Creek, Sample #340, on rock	0.157	886	0.567	0.465	474	14.1	9.75	12.2	14.6	41.1
<i>Xanthoparmelia cumberlandia</i> , Lake Fork Creek, Sample #341, on rock	0.133	1200	0.597	7.78	437	14.1	8.89	5.15	9.23	45.5
<i>Rhizoplaca melanophthalma</i> , Lake Fork Creek, Sample #342, on rock	0.103	966	0.413	7.96	415	11.6	10.4	4.39	9.16	29.2
<i>Xanthoria elegans</i> , Orange-Olsen Guard Station, Sample #343, on rock	0.113	685	0.48	1.68	409	10.1	8.56	4.58	7.43	52.1
<i>Xanthoparmelia cumberlandia</i> , Chris' Canyon, Sample #445, on rock	0.095	475	0.445	3.02	653	26.3	8.49	5.29	15.6	72.4
<i>Xanthoria elegans</i> , Chris' Canyon, Sample #446, on rock	0.141	758	0.668	0.334	699	27	14.2	6.45	11.4	47.9
<i>Rhizoplaca melanophthlama</i> , Chris' Canyon, Sample #447, on rock	0.078	563	0.269	5.95	319	13.8	4.17	3.4	6.69	24.9
<i>Physcia dubia</i> , Great Basin Exper. Station, Sample #448, on rock	0.104	716	0.594	0.687	966	29.9	25.9	13.6	17.5	77.8
<i>Xanthoria fallax</i> , Great Basin Exper. Station, Sample #449, on White Fir	0.175	674	0.973	1	871	35.8	13.3	7.44	24.6	107
<i>Xanthoria elegans</i> , South of Wales Top, Sample #450, on rock	0.107	535	0.817	1.61	1400	64.2	23.4	11.6	24.4	62.6

TABLE #1: Mean concentrations of potential pollutant elements in sensitive indicator species from air quality biomonitoring reference sites in the Manti-La Sal National Forest.

Species and Collection Site	Elements (ppm except where indicated)									
	Pb	Mn	Fe	Co	As	Se	Br	Rb	Sr	Al
<i>Rhizoplaca melanophthalma</i> , Pontown Creek, Sample #338, on rock	14.2	34.5	1950	n.d.	2.83	n.d.	4.72	6.76	20.2	-
<i>Xanthoria elegans</i> , Rilda Canyon, Sample #339, on rock	10.1	84.9	4570	n.d.	3.5	0.95	14.8	16.1	39	-
<i>Xanthoria elegans</i> , Lake Fork Creek, Sample #340, on rock	9.28	92.7	4290	n.d.	4.19	n.d.	13.7	13.5	25	-
<i>Xanthoparmelia cumberlandia</i> , Lake Fork Creek, Sample #341, on rock	13.7	88.7	3450	11.1	3.91	n.d.	14.8	11.1	152	-
<i>Rhizoplaca melanophthalma</i> , Lake Fork Creek, Sample #342, on rock	22.4	60.2	3150	13.3	5.15	n.d.	6.19	9.84	86	-
<i>Xanthoria elegans</i> , Orange-Olsen Guard Station, Sample #343, on rock	6.82	70.8	3500	n.d.	3.7	n.d.	6.96	17.5	45.9	-
<i>Xanthoparmelia cumberlandia</i> , Chris' Canyon, Sample #445, on rock	78.7	191	5390	n.d.	5.84	n.d.	17.9	17.4	112	-
<i>Xanthoria elegans</i> , Chris' Canyon, Sample #446, on rock	13.6	160	5640	n.d.	8.49	n.d.	21.1	19.8	46.7	-
<i>Rhizoplaca melanophthalma</i> , Chris' Canyon, Sample #447, on rock	29.6	57.6	2820	n.d.	n.d.	n.d.	9.32	13.3	134	-
<i>Physcia dubia</i> , Great Basin Exper. Station, Sample #448, on rock	60.7	416	6770	n.d.	4.43	n.d.	22.6	33.4	55.7	-
<i>Xanthoria fallax</i> , Great Basin Exper. Station, Sample #449, on White Fir	67.9	230	6930	n.d.	6.78	n.d.	33.2	31.9	77.1	-
<i>Xanthoria elegans</i> , South of Wales Top, Sample #450, on rock	52.9	298	15500	n.d.	19.1	n.d.	52.9	49.7	124	-

TABLE #1: Mean concentrations of potential pollutant elements in sensitive indicator species from air quality biomonitoring reference sites in the Manti-La Sal National Forest.

Species and Collection Site	Elements (ppm except where indicated)				
	Si	P	Ba	Cu/Zn	Fe/Ti
<i>Rhizoplaca melanophthalma</i> , Pontown Creek, Sample #338, on rock	-	955	32.1	0.286	6.39
<i>Xanthoria elegans</i> , Rilda Canyon, Sample #339, on rock	-	1620	64.1	0.226	9.33
<i>Xanthoria elegans</i> , Lake Fork Creek, Sample #340, on rock	-	1630	56.1	0.355	9.05
<i>Xanthoparmelia cumberlandia</i> , Lake Fork Creek, Sample #341, on rock	-	1670	75.5	0.203	7.89
<i>Rhizoplaca melanophthalma</i> , Lake Fork Creek, Sample #342, on rock	-	1210	n.d.	0.314	7.59
<i>Xanthoria elegans</i> , Orange-Olsen Guard Station, Sample #343, on rock	-	767	93	0.143	8.56
<i>Xanthoparmelia cumberlandia</i> , Chris' Canyon, Sample #445, on rock	-	712	105	0.215	8.25
<i>Xanthoria elegans</i> , Chris' Canyon, Sample #446, on rock	-	928	90.7	0.238	8.07
<i>Rhizoplaca melanophthalma</i> , Chris' Canyon, Sample #447, on rock	-	536	n.d.	0.269	8.84
<i>Physcia dubia</i> , Great Basin Exper. Station, Sample #448, on rock	-	1150	130	0.225	7.01
<i>Xanthoria fallax</i> , Great Basin Exper. Station, Sample #449, on White Fir	-	2030	166	0.23	7.96
<i>Xanthoria elegans</i> , South of Wales Top, Sample #450, on rock	-	297	270	0.39	11.07

TABLE #1: Mean concentrations of potential pollutant elements in sensitive indicator species from air quality biomonitoring reference sites in the Manti-La Sal National Forest.

Species and Collection Site	Elements (ppm except where indicated)									
	S%	Cl	K%	Ca%	Ti	V	Cr	Ni	Cu	Zn
<i>Caloplaca trachyphylla</i> , South of Wales Top, Sample #451, on rock	0.0714	330	0.88	2.27	2570	68.4	23.8	6.55	16.7	44.9
<i>Xanthoria elegans</i> , Top of East Mountain, Sample #452, on rock	0.133	483	0.618	3.77	1220	46.3	16.3	8.76	11.2	37.9
<i>Xanthoria elegans</i> , Horseshoe Flat, Sample #453, on rock	0.157	628	0.639	3.62	888	33.1	15.7	7.47	13.9	35.5
<i>Xanthoparmelia</i> sp., Geyser Pass, Sample #486, on rock	0.082	3300	0.5	1.84	720	13	6	4.2	12.7	55
<i>Xanthoria polycarpa</i> , F.S. Rds. 62 & 67, Sample #487, on Gambel Oak	0.2	2900	1.12	0.33	380	12.5	5	3	9.3	84
<i>Xanthoparmelia</i> sp., Buckeye Reservoir, Sample #488, on rock	0.065	350	0.56	1.8	970	18.3	6.4	4.8	12	45
<i>Xanthoparmelia</i> sp., F.S. Rds. 62 & 67, Sample #489, on rock	0.127	3300	0.68	4.9	1000	22	15.3	4.6	13.6	55
<i>Rhizoplaca melanophthalma</i> , F.S. Rds. 62 & 67, Sample #490, on rock	0.123	3400	0.35	1.79	280	11.9	3.6	1.6	6.7	27
<i>Usnea</i> sp., Geyser Pass, Sample #491, on Engelmann Spruce	0.095	1670	0.33	0.167	26	3.4	1.12	0.61	2.8	22
<i>Usnea</i> sp., Buckeye Reservoir, Sample #492, on Ponderosa Pine	0.069	1910	0.34	0.66	22	5.6	1.67	0.47	2.7	31
<i>Rhizoplaca melanophthalma</i> , Buckeye Reservoir, Sample #493, on rock	0.058	1950	0.37	8.6	510	13.7	4.7	3.6	3.8	18.1
<i>Xanthoria elegans</i> , Pine Ridge, Sample #494, on rock	0.196	3500	0.66	0.47	840	15.9	7.1	4.4	15.9	69

TABLE #1: Mean concentrations of potential pollutant elements in sensitive indicator species from air quality biomonitoring reference sites in the Manti-La Sal National Forest.

Species and Collection Site	Elements (ppm except where indicated)									
	Pb	Mn	Fe	Co	As	Se	Br	Rb	Sr	Al
<i>Caloptaca trachyphylla</i> , South of Wales Top, Sample #451, on rock	26.8	141	10100	n.d.	7.42	n.d.	9.04	52.6	176	-
<i>Xanthoria elegans</i> , Top of East Mountain, Sample #452, on rock	12.8	223	8590	n.d.	5.99	n.d.	14.5	38.4	92.7	-
<i>Xanthoria elegans</i> , Horseshoe Flat, Sample #453, on rock	19.1	211	8250	n.d.	6.8	n.d.	19.5	31.2	93.1	-
<i>Xanthoparmelia</i> sp., Geyser Pass, Sample #486, on rock	43	160	4400	15.9	2.9	1.9	16.7	16.3	70	6100
<i>Xanthoria polycarpa</i> , F.S. Rds. 62 & 67, Sample #487, on Gambel Oak	6.8	550	2700	14.1	2.2	1.9	14.6	12	36	3600
<i>Xanthoparmelia</i> sp., Buckeye Reservoir, Sample #488, on rock	33	48	4200	19.5	3.3	1.7	22	22	73	7300
<i>Xanthoparmelia</i> sp., F.S. Rds. 62 & 67, Sample #489, on rock	26	157	5300	24	3.5	1.8	14.2	23	79	7000
<i>Rhizoplaca melanophthalma</i> , F.S. Rds. 62 & 67, Sample #490, on rock	9.8	25	1660	8.5	2.8	1.6	3.3	7.3	28	1890
<i>Usnea</i> sp., Geyser Pass, Sample #491, on Engelmann Spruce	3.3	52	220	2	1.19	1.54	15.6	3	9.9	194
<i>Usnea</i> sp., Buckeye Reservoir, Sample #492, on Ponderosa Pine	4.8	84	194	2.6	1.89	1.56	2.7	3.4	17	112
<i>Rhizoplaca melanophthalma</i> , Buckeye Reservoir, Sample #493, on rock	16.1	85	2200	14	6.7	1.8	1.17	9.7	88	7100
<i>Xanthoria elegans</i> , Pine Ridge, Sample #494, on rock	18.4	87	4600	21	4.8	1.7	11.9	18.7	29	3900

TABLE #1: Mean concentrations of potential pollutant elements in sensitive indicator species from air quality biomonitoring reference sites in the Manti-La Sal National Forest.

Species and Collection Site	Elements (ppm except where indicated)				
	Si	P	Ba	Cu/Zn	Fe/Ti
<i>Caloplaca trachyphylla</i> , South of Wales Top, Sample #451, on rock	-	231	273	0.372	3.93
<i>Xanthoria elegans</i> , Top of East Mountain, Sample #452, on rock	-	294	205	0.296	7.04
<i>Xanthoria elegans</i> , Horseshoe Flat, Sample #453, on rock	-	655	103	0.392	9.29
<i>Xanthoparmelia</i> sp., Geyser Pass, Sample #486, on rock	26000	1090	106	0.231	6.11
<i>Xanthoria polycarpa</i> , F.S. Rds. 62 & 67, Sample #487, on Gambel Oak	17500	2500	84	0.111	7.11
<i>Xanthoparmelia</i> sp., Buckeye Reservoir, Sample #488, on rock	53000	810	99	0.267	4.33
<i>Xanthoparmelia</i> sp., F.S. Rds. 62 & 67, Sample #489, on rock	42000	1550	127	0.247	5.3
<i>Rhizoplaca melanophthalma</i> , F.S. Rds. 62 & 67, Sample #490, on rock	9400	1160	61	0.248	5.93
<i>Usnea</i> sp., Geyser Pass, Sample #491, on Engelmann Spruce	760	490	30	0.127	8.46
<i>Usnea</i> sp., Buckeye Reservoir, Sample #492, on Ponderosa Pine	650	850	37	0.087	8.82
<i>Rhizoplaca melanophthalma</i> , Buckeye Reservoir, Sample #493, on rock	26000	900	78	0.21	4.31
<i>Xanthoria elegans</i> , Pine Ridge, Sample #494, on rock	18900	1320	98	0.23	5.48

TABLE #1: Mean concentrations of potential pollutant elements in sensitive indicator species from air quality biomonitoring reference sites in the Manti-La Sal National Forest.

Species and Collection Site	Elements (ppm except where indicated)									
	S%	Cl	K%	Ca%	Ti	V	Cr	Ni	Cu	Zn
<i>Rhizoplaca melanophthalma</i> , Pine Ridge Mountain, Sample #495, on rock	0.101	3300	0.3	2.6	280	8.6	2.3	2.1	5.8	39
<i>Xanthoparmelia</i> sp., Pine Ridge, Sample #496, on rock	0.108	4300	0.45	0.25	580	14.6	3.4	2.8	9.6	44
<i>Xanthoria polycarpa</i> , Pine Ridge, Sample #497, on Gambel Oak	0.138	4400	0.89	0.49	460	12.9	2.6	2.2	6.6	65
<i>Rhizoplaca melanophthalma</i> , Peavine Canyon, Sample #529	0.065	123	0.157	6.2	190	8.7	3.2	2.6	3.5	13.5
<i>Xanthoparmelia cumberlandia</i> , Peavine Canyon, Sample #530	0.093	260	0.39	8.6	580	14.5	8.6	5.5	9.9	28
<i>Rhizoplaca melanophthalma</i> , Elk Ridge, Sample #531, on rock	0.086	167	0.29	2	300	12	5	2.3	4.5	22
<i>Xanthoparmelia</i> sp., Elk Ridge, Sample #532, on rock	0.108	470	0.54	4	1020	18.4	6.9	4.1	8.9	62
<i>Xanthoria polycarpa</i> , Elk Ridge, Sample #533, on Salix sp.	0.27	1000	0.8	0.25	520	14.8	5.7	3.2	12.4	127
<i>Xanthoria polycarpa</i> , Dark Canyon, Sample #547, on Populus angustifolia	0.24	920	1	0.58	680	18.6	5.6	6.1	8.7	160

TABLE #1: Mean concentrations of potential pollutant elements in sensitive indicator species from air quality biomonitoring reference sites in the Manti-La Sal National Forest.

Species and Collection Site	Elements (ppm except where indicated)									
	Pb	Mn	Fe	Co	As	Se	Br	Rb	Sr	Al
<i>Rhizoplaca melanophthalma</i> , Pine Ridge Mountain, Sample #495, on rock	19.3	37	1580	7.5	2	1.36	0.77	3.7	34	1620
<i>Xanthoparmelia sp.</i> , Pine Ridge, Sample #496, on rock	22	58	3200	14	3	1.9	14.6	12.6	46	4000
<i>Xanthoria polycarpa</i> , Pine Ridge, Sample #497, on Gambel Oak	7.3	220	2200	9.8	1.5	1.8	14	22	33	2200
<i>Rhizoplaca melanophthalma</i> , Peavine Canyon, Sample #529	22	16.5	1170	6.6	2.8	3.5	2.5	4.3	44	1580
<i>Xanthoparmelia cumberlandia</i> , Peavine Canyon, Sample #530	15.9	49	2800	12.7	4	3	10	13.6	129	4700
<i>Rhizoplaca melanophthalma</i> , Elk Ridge, Sample #531, on rock	9.8	29	1690	8.9	2.7	1.46	2.8	7.3	42	2500
<i>Xanthoparmelia sp.</i> , Elk Ridge, Sample #532, on rock	20	82	5500	31	3.9	3.1	22	21	90	9600
<i>Xanthoria polycarpa</i> , Elk Ridge, Sample #533, on Salix sp.	7	61	3200	14.3	5.2	2.9	9.3	18.9	22	5000
<i>Xanthoria polycarpa</i> , Dark Canyon, Sample #547, on Populus angustifolia	10.5	94	3600	20	3.4	2.8	12.5	14.5	41	-

TABLE #1: Mean concentrations of potential pollutant elements in sensitive indicator species from air quality biomonitoring reference sites in the Manti-La Sal National Forest.

Species and Collection Site	Elements (ppm except where indicated)					
	Si	P	Ba	Cu/Zn	Fe/Ti	
<i>Rhizoplaca melanophthalma</i> , Pine Ridge Mountain, Sample #495, on rock	7400	1260	63	0.149	5.64	
<i>Xanthoparmelia</i> sp., Pine Ridge, Sample #496, on rock	19200	1590	70	0.218	5.52	
<i>Xanthoria polycarpa</i> , Pine Ridge, Sample #497, on Gambel Oak	9700	1540	158	0.102	4.78	
<i>Rhizoplaca melanophthalma</i> , Peavine Canyon, Sample #529	9500	880	58	0.259	6.16	
<i>Xanthoparmelia cumberlandia</i> , Peavine Canyon, Sample #530	54000	1180	88	0.354	4.83	
<i>Rhizoplaca melanophthalma</i> , Elk Ridge, Sample #531, on rock	15400	1050	64	0.205	5.63	
<i>Xanthoparmelia</i> sp., Elk Ridge, Sample #532, on rock	37000	1490	118	0.144	5.39	
<i>Xanthoria polycarpa</i> , Elk Ridge, Sample #533, on Salix sp.	21000	2400	76	0.098	6.15	
<i>Xanthoria polycarpa</i> , Dark Canyon, Sample #547, on Populus angustifolia	-	3100	126	0.054	5.29	

Figure 2: Lichen Biomonitoring Program and Baseline

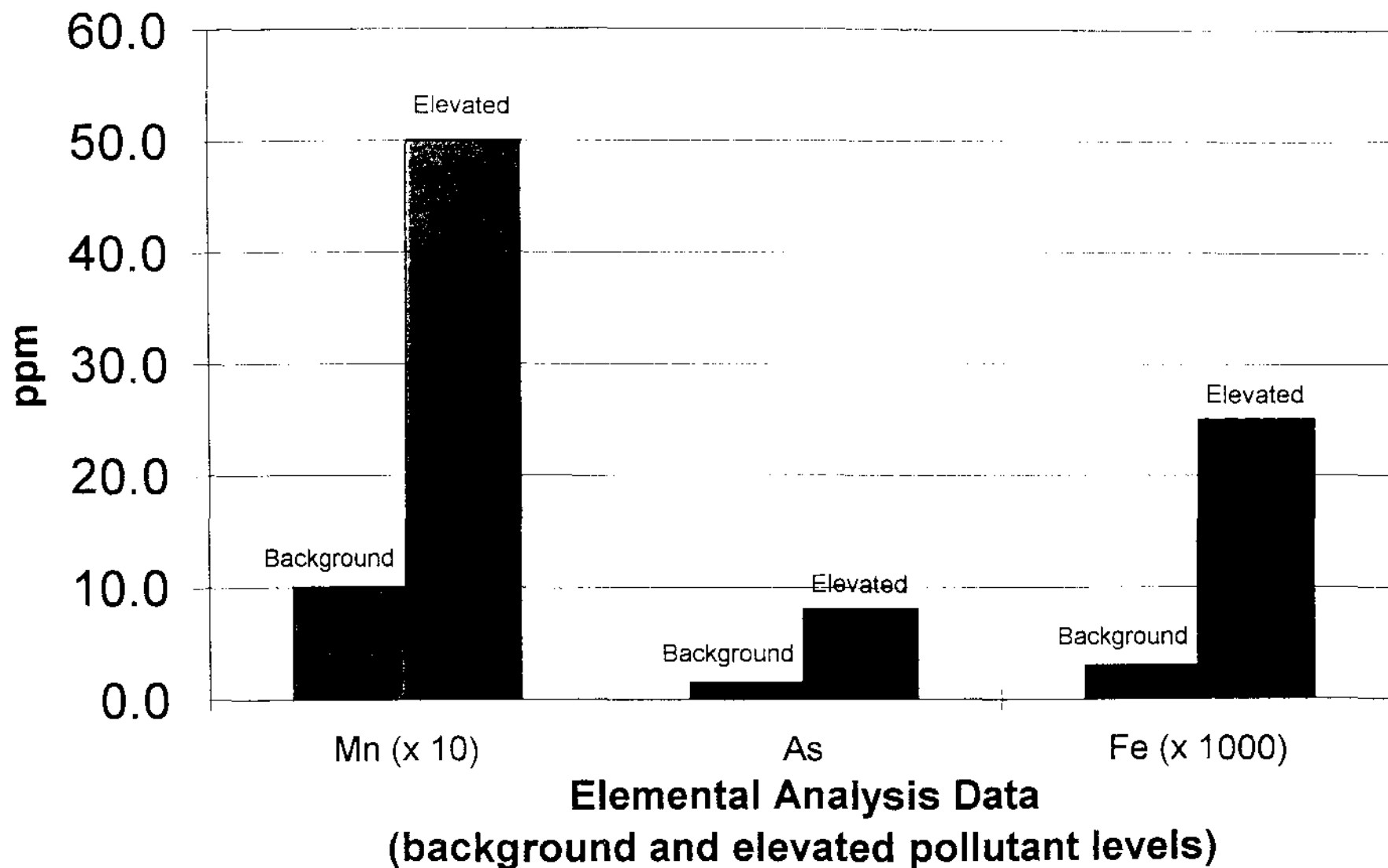


Fig. 2 cont.: Lichen Biomonitoring Program and Baseline

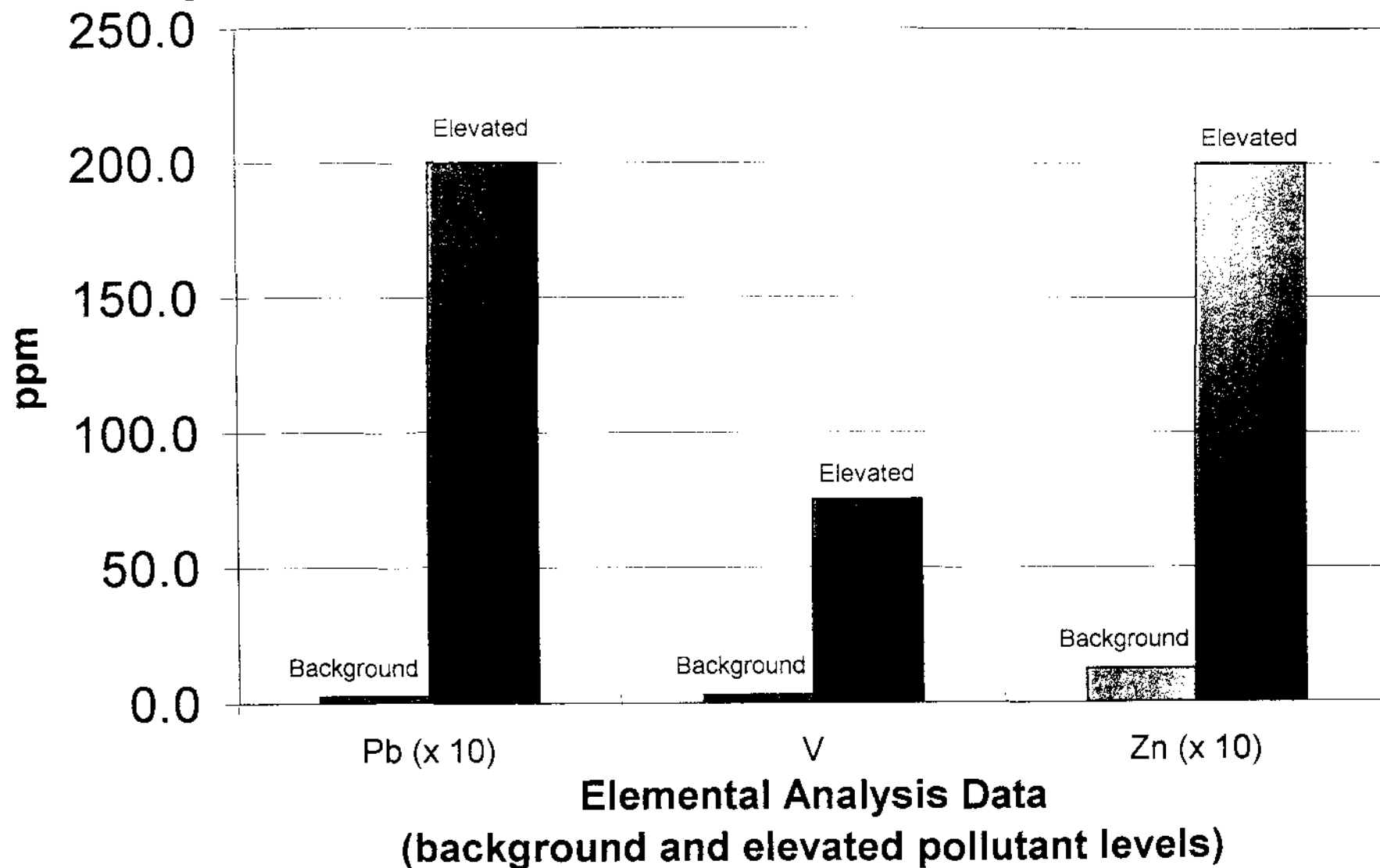
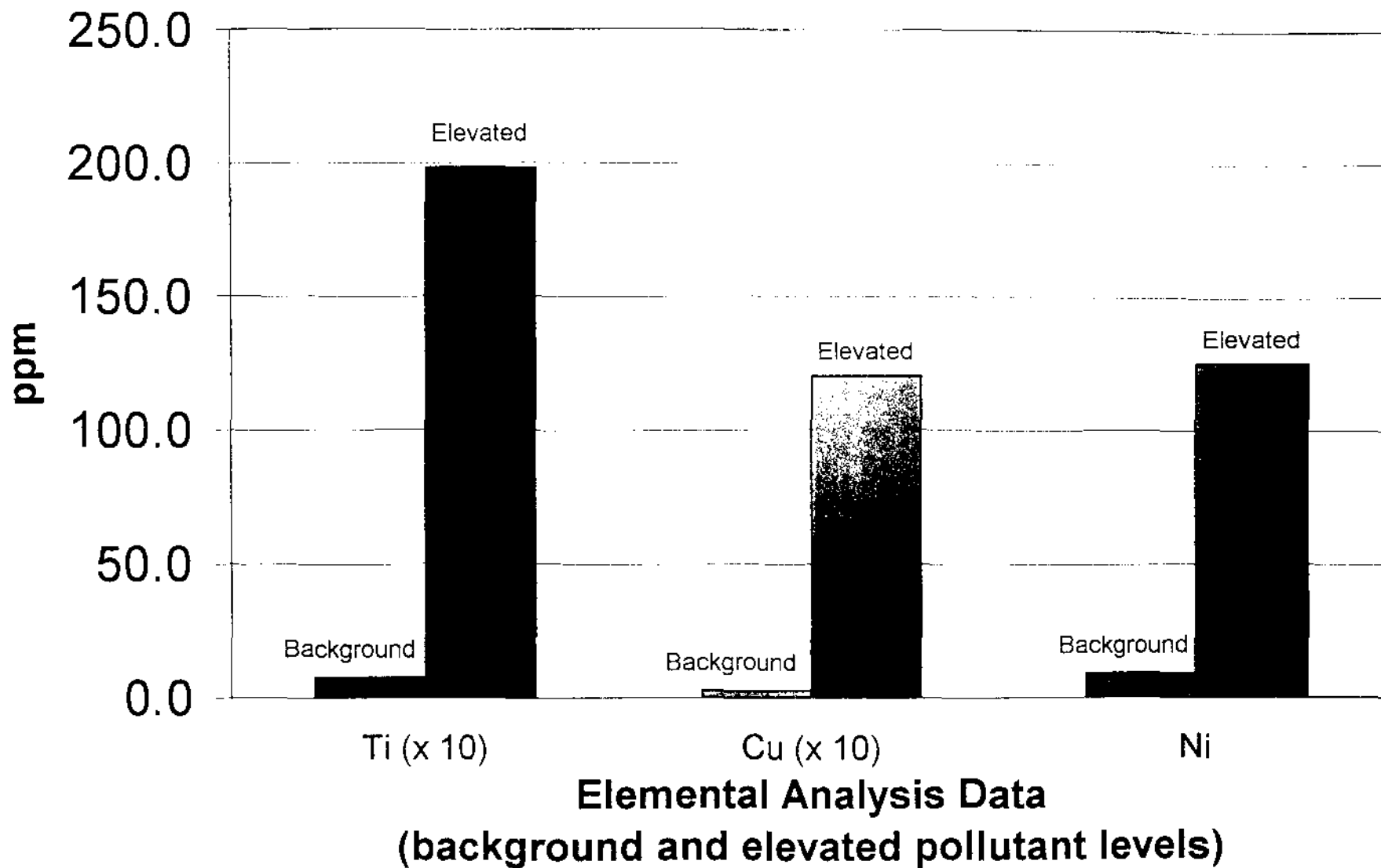


Fig. 2 cont.: Lichen Biomonitoring Program and Baseline



from Rilda Canyon in Emery County (339), was collected near one of the exhaust fans of the Deer Creek coal mine. The other three samples (494, 533, and 547), all from southeastern Utah in the Monticello District, may be accumulating fallout from sulfur-rich emissions generated by local coal-fired power plants. Across almost all reference sites (28/33) thallus concentrations of arsenic (2.2 ppm to 19.1 ppm) were moderately elevated to elevated and certainly on the average exceeded values reported for most other Intermountain Area reference sites. Overall, nickel concentrations (4.08 ppm to 13.6 ppm) were higher than values reported for most other locations in the Rocky Mountain Region; however, they are still within background levels. Chromium concentrations were elevated in three samples (448, 450, and 451), ranging from 23.4 ppm to 25.9 ppm. Lead concentrations are generally well within background levels; however, four samples (445, 448, 449, and 450) were somewhat elevated (52.9-78.7 ppm), especially when compared with most other Rocky Mountain reference sites. Copper/zinc ratios were well within background levels (≤ 0.5) at all sites (0.054 – 0.39). However, Fe/Ti ratios were slightly elevated in four samples (343, 447, 491, and 492), moderately elevated in 3 samples (339, 340, and 453); and elevated in one sample (450), ranging between 8.46 and 11.07 with background levels generally falling between 6 and 8. Elemental analysis data suggest three general areas of concern: 1) Rilda Canyon in Carbon County with elevated sulfur and a moderately elevated Fe/Ti ratio; 2) Pine Ridge, Elk Ridge, and Dark Canyon in San Juan County with elevated sulfur; 3) Chris' Canyon, Great Basin Experiment Station, South of Wales Top, and Orange-Olsen Guard Station in San Pete County with some combination of elevated heavy metals including lead, chromium, and arsenic; as well as elevated Fe/Ti ratios. Overall, this pattern of pollutant element accumulation in lichen tissues is remarkably similar to data collected at air quality biomonitoring reference sites established in the Uinta National Forest along the heavily populated and industrialized Wasatch Front. It appears that at least some of the reference sites in the Manti-La Sal National Forest may be experiencing some air pollution-related impact, with reference sites in the San Pete, Ferron, and Price ranger districts demonstrating accumulation of selected heavy metals and at least somewhat elevated Fe/Ti ratios. While reference sites in the Monticello District showing elevated sulfur concentrations.

RECOMMENDATIONS:

1. Usually, review of pollutant concentrations in sensitive indicator species should be performed every 5 to 8 years. However, because thallus concentrations of several critical pollutants already exceed background levels, sensitive indicator species from at least some of the reference sites should probably be reevaluated on a three to five year schedule.
2. Reevaluation of the lichen flora at existing reference sites is generally unnecessary, unless over time sensitive indicator species begin to show either increasing levels of pollutant elements or significant changes in relative abundance. At this point reevaluation of the lichen communities at the reference sites in the Manti-La Sal National Forest does not appear to be necessary.
3. Over time additional reference sites should be established in other parts of the forest. These should be set up to reflect the range of habitat types across the forest, as well as general proximity to potential air pollution sources. Possible locations for additional reference sites might include 1) San Pete Ranger District (3): west of Fountain Green, east of Mayfield, and vicinity of Johnson Ridge; 2) Price Ranger District (1): vicinity of Stuart Guard Station; 3) Ferron Ranger District (2): Ferron Canyon and northwest of Emery; 4) Moab Ranger District (1) northeast of La Sal; and 5) Monticello Ranger District (2): vicinity of Maverick Point and northeast of Natural Bridges National Monument.

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